2015 OASDI Trustees Report

2. Estimates as a Percentage of Gross Domestic Product

This section contains long-range projections of the operations of the theoretical combined Old-Age and Survivors Insurance and Disability Insurance (OASI and DI) Trust Funds and of the Hospital Insurance (HI) Trust Fund, expressed as a percentage of gross domestic product (GDP). While expressing fund operations as a percentage of taxable payroll is a very useful approach for assessing the financial status of the programs (see section IV.B.1), expressing them as a percentage of the total value of goods and services produced in the United States provides an additional perspective.

Table VI.G4 shows non-interest income, total cost, and the resulting balance of the combined OASI and DI Trust Funds, of the HI Trust Fund, and of the combined OASI, DI, and HI Trust Funds, expressed as percentages of GDP on the basis of each of the three alternative sets of assumptions. Table VI.G4 also contains estimates of GDP. For OASDI, non-interest income consists of payroll tax contributions, proceeds from taxation of benefits, and reimbursements from the General Fund of the Treasury, if any. Cost consists of scheduled benefits, administrative expenses, financial interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries. For HI, non-interest income consists of payroll tax contributions (including contributions from railroad employment), up to an additional 0.9 percent tax on earned income for relatively high earners, proceeds from taxation of OASDI benefits, and reimbursements from the General Fund of the Treasury, if any. Cost consists of outlays (benefits and administrative expenses) for insured beneficiaries. The Trustees show income and cost estimates on a cash basis for the OASDI program and on an incurred basis for the HI program.

The Trustees project the OASDI annual balance (non-interest income less cost) as a percentage of GDP to be negative throughout the projection period under the intermediate and high-cost assumptions, and to be negative for all years except 2079-88 under the low-cost assumptions. Under the low-cost assumptions the OASDI annual deficit as a percentage of GDP decreases through 2019. After 2021, deficits increase to a peak in 2033, decrease through 2053, increase again through 2070, and decrease through 2078. Annual balances are positive from 2079 through 2088 and negative thereafter. Under the intermediate assumptions, annual deficits decrease from 2015 to 2017, increase through 2038, decrease from 2038 through 2050, and mostly increase thereafter. Under the high-cost assumptions, annual deficits increase throughout the projection period.

The Trustees project that the HI balance as a percentage of GDP will be positive throughout the projection period under the low-cost assumptions. Under the intermediate assumptions, the HI balance is negative for each year of the projection period except for 2016-21. After 2021, annual deficits increase through 2045, decline through 2063, and remain relatively stable thereafter. Under the high-cost assumptions, the HI balance is negative for all years of the projection period. Annual deficits reach a peak in 2075 and decline slowly thereafter.

The combined OASDI and HI annual balance as a percentage of GDP is negative throughout the projection period under both the intermediate and high-cost assumptions. Under the low-cost assumptions, the combined OASDI and HI balance is negative through 2016, positive from 2017 through 2029, negative from 2030 through 2033, and then positive and mostly rising thereafter. Under the intermediate assumptions, combined OASDI and HI annual deficits decline from 2015 through 2017, increase from 2017 through 2040, and decrease through 2053. After 2053, annual deficits generally rise, reaching 1.96 percent of GDP by 2089. Under the high-cost assumptions, combined annual deficits rise throughout the projection period.

By 2089, the combined OASDI and HI annual balances as percentages of GDP range from a positive balance of 0.87 percent for the low-cost assumptions to a deficit of 6.39 percent for the high-cost assumptions. Balances differ by a much smaller amount for the tenth year, 2024, ranging from a positive balance of 0.15 percent for the low-cost assumptions to a deficit of 1.85 percent for the high-cost assumptions.

The summarized long-range (75-year) balance as a percentage of GDP for the combined OASDI and HI programs varies among the three alternatives by a relatively large amount, from a positive balance of 0.62 percent under the low-cost assumptions to a deficit of 3.98 percent under the high-cost assumptions. The 25-year summarized balance varies by a smaller amount, from a positive balance of 0.39 percent to a deficit of 2.10 percent. Summarized rates are calculated on a present-value basis. They include the trust fund balances on January 1, 2015 and the cost of reaching a target trust fund level equal to 100 percent of the following year's annual cost at the end of the period. (See section IV.B.4 for further explanation.)

Table VI.G4.—OASDI and HI Annual and Summarized Income, Cost, and Balance as a Percentage of GDP, Calendar Years 2015-90

Calendar year	Percentage of GDP: OASDI Income[1]	OASDI Cost	OASDI Balance	HI Income[a]	HI Cost	HI Balance	Combined Income[a]	Combined Cost	Combined Balance	GDP in dollars (billions)
Intermediate:										
2015	4.52	4.98	-0.46	1.47	1.49	-0.02	5.99	6.47	-0.48	$18,163
2016	4.54	4.89	-.35	1.49	1.48	.01	6.03	6.38	-.35	19,216
2017	4.61	4.96	-.35	1.51	1.47	.04	6.12	6.43	-.31	20,311
2018	4.65	5.02	-.37	1.53	1.48	.05	6.18	6.50	-.32	21,415
2019	4.68	5.10	-.41	1.54	1.50	.05	6.23	6.59	-.37	22,537
2020	4.71	5.17	-.46	1.56	1.53	.03	6.27	6.70	-.43	23,687
2021	4.74	5.23	-.50	1.57	1.56	.01	6.31	6.80	-.49	24,861
2022	4.76	5.31	-.55	1.58	1.60	-.02	6.34	6.92	-.57	26,042
2023	4.78	5.41	-.62	1.59	1.64	-.04	6.38	7.04	-.67	27,234
2024	4.80	5.50	-.70	1.60	1.67	-.07	6.41	7.17	-.76	28,472
2025	4.80	5.57	-.77	1.61	1.74	-.13	6.41	7.31	-.90	29,765
2030	4.80	5.87	-1.07	1.64	1.90	-.26	6.44	7.77	-1.33	37,089
2035	4.78	6.02	-1.24	1.67	2.05	-.38	6.45	8.07	-1.62	46,085
2040	4.77	6.03	-1.26	1.69	2.13	-.45	6.46	8.16	-1.71	57,462
2045	4.75	5.97	-1.22	1.71	2.17	-.46	6.46	8.14	-1.68	71,742
2050	4.74	5.93	-1.19	1.73	2.17	-.44	6.47	8.10	-1.63	89,342

2055	4.73	5.96	-1.23	1.76	2.16	-.40	6.49	8.12	-1.63	110,936
2060	4.71	6.03	-1.32	1.78	2.15	-.37	6.50	8.18	-1.68	137,548
2065	4.69	6.09	-1.40	1.81	2.17	-.36	6.50	8.26	-1.76	170,579
2070	4.67	6.15	-1.48	1.82	2.20	-.38	6.49	8.35	-1.86	211,683
2075	4.65	6.18	-1.53	1.84	2.23	-.39	6.49	8.41	-1.92	262,889
2080	4.62	6.15	-1.53	1.85	2.23	-.39	6.47	8.38	-1.92	326,408
2085	4.60	6.16	-1.56	1.86	2.23	-.37	6.46	8.38	-1.92	404,758
2090	4.59	6.20	-1.62	1.87	2.22	-.35	6.46	8.42	-1.97	501,306
Summarized rates: [2]										
25-year:										
2015-39	5.32	5.83	-.51	1.65	1.85	-.20	6.97	7.68	-.71	
50-year:										
2015-64	5.07	5.87	-.80	1.69	1.98	-.29	6.76	7.85	-1.09	
75-year:										
2015-89	4.96	5.92	-.96	1.73	2.03	-.30	6.69	7.95	-1.26	
Low-cost:										
2015	4.50	4.91	-.41	1.47	1.45	.02	5.98	6.36	-.38	18,376
2016	4.59	4.74	-.15	1.49	1.40	.09	6.08	6.14	-.06	19,776
2017	4.62	4.72	-.11	1.51	1.36	.15	6.13	6.08	.05	21,261
2018	4.67	4.73	-.07	1.53	1.34	.19	6.20	6.07	.12	22,749
2019	4.71	4.76	-.05	1.54	1.33	.21	6.26	6.09	.16	24,245
2020	4.75	4.80	-.05	1.55	1.33	.22	6.30	6.13	.17	25,767
2021	4.78	4.83	-.05	1.56	1.33	.23	6.34	6.17	.18	27,333
2022	4.82	4.87	-.06	1.57	1.34	.23	6.39	6.21	.17	28,970
2023	4.85	4.92	-.08	1.58	1.34	.24	6.43	6.26	.16	30,694
2024	4.87	4.97	-.10	1.59	1.34	.25	6.47	6.32	.15	32,504
2025	4.88	5.01	-.13	1.60	1.38	.22	6.48	6.39	.09	34,408
2030	4.88	5.16	-.28	1.64	1.37	.28	6.52	6.52	[3]	45,697
2035	4.88	5.19	-.31	1.68	1.34	.34	6.56	6.53	.03	60,563
2040	4.88	5.10	-.23	1.72	1.27	.45	6.59	6.37	.22	80,726
2045	4.88	4.98	-.10	1.76	1.19	.57	6.63	6.17	.47	108,017
2050	4.89	4.91	-.02	1.79	1.12	.68	6.68	6.02	.66	144,330
2055	4.89	4.91	-.01	1.83	1.06	.77	6.72	5.97	.75	192,279
2060	4.90	4.94	-.04	1.86	1.04	.82	6.76	5.98	.78	255,850
2065	4.90	4.96	-.06	1.89	1.05	.84	6.79	6.01	.78	340,834
2070	4.90	4.97	-.07	1.91	1.07	.84	6.81	6.04	.77	454,976
2075	4.89	4.94	-.05	1.93	1.09	.84	6.82	6.03	.80	608,502
2080	4.89	4.86	.02	1.94	1.10	.85	6.83	5.96	.87	813,923
2085	4.89	4.85	.04	1.96	1.10	.86	6.85	5.95	.90	1,086,422
2090	4.90	4.92	-.02	1.98	1.10	.88	6.88	6.02	.86	1,446,970
Low-cost (Cont.):										
Summarized rates: b										
25-year:										

2015-39	5.35	5.22	.14	1.65	1.40	.25	7.01	6.62	.39	
50-year:										
2015-64	5.15	5.08	.07	1.72	1.26	.45	6.86	6.34	.52	
75-year:										
2015-89	5.08	5.02	.06	1.78	1.22	.56	6.86	6.24	.62	
High-cost:										
2015	4.54	5.07	-.53	1.47	1.55	-.08	6.02	6.62	-.61	17,880
2016	4.52	5.11	-.59	1.49	1.58	-.10	6.01	6.69	-.68	18,516
2017	4.60	5.24	-.65	1.51	1.60	-.09	6.10	6.84	-.74	19,246
2018	4.63	5.36	-.73	1.53	1.64	-.11	6.16	7.00	-.84	20,019
2019	4.66	5.49	-.83	1.55	1.70	-.15	6.20	7.18	-.98	20,795
2020	4.68	5.61	-.94	1.56	1.77	-.20	6.24	7.38	-1.14	21,575
2021	4.69	5.72	-1.03	1.58	1.84	-.27	6.27	7.57	-1.29	22,376
2022	4.71	5.84	-1.13	1.59	1.93	-.33	6.31	7.77	-1.46	23,181
2023	4.73	5.97	-1.24	1.61	2.01	-.40	6.34	7.98	-1.64	23,979
2024	4.75	6.12	-1.37	1.62	2.09	-.47	6.37	8.21	-1.85	24,738
2025	4.75	6.23	-1.48	1.63	2.22	-.60	6.37	8.45	-2.08	25,543
2030	4.73	6.70	-1.97	1.65	2.66	-1.01	6.38	9.36	-2.99	29,888
2035	4.70	7.00	-2.30	1.67	3.14	-1.48	6.37	10.15	-3.78	34,863
2040	4.68	7.15	-2.47	1.68	3.61	-1.93	6.36	10.76	-4.40	40,679
2045	4.65	7.20	-2.55	1.69	3.99	-2.30	6.33	11.19	-4.85	47,436
2050	4.62	7.24	-2.62	1.69	4.24	-2.55	6.31	11.48	-5.17	55,079
2055	4.59	7.33	-2.74	1.70	4.39	-2.68	6.29	11.72	-5.43	63,679
2060	4.56	7.46	-2.90	1.71	4.46	-2.75	6.27	11.93	-5.65	73,474
2065	4.52	7.59	-3.07	1.72	4.50	-2.78	6.25	12.09	-5.85	84,697
2070	4.49	7.74	-3.26	1.73	4.54	-2.81	6.22	12.28	-6.06	97,561
2075	4.45	7.86	-3.42	1.74	4.57	-2.83	6.19	12.44	-6.24	112,331
2080	4.41	7.92	-3.51	1.75	4.55	-2.80	6.15	12.47	-6.32	129,209
2085	4.37	7.97	-3.60	1.75	4.51	-2.75	6.12	12.48	-6.36	148,465
2090	4.34	8.02	-3.68	1.76	4.47	-2.71	6.10	12.49	-6.39	170,494
Summarized rates: b										
25-year:										
2015-39	5.31	6.56	-1.25	1.66	2.51	-.85	6.96	9.07	-2.10	
50-year:										
2015-64	5.01	6.84	-1.84	1.67	3.22	-1.54	6.68	10.06	-3.38	
75-year:										
2015-89	4.88	7.05	-2.18	1.69	3.50	-1.81	6.57	10.55	-3.98	

1 Income for individual years excludes interest on the trust funds. Interest is implicit in all summarized values.

2 Summarized rates are calculated on a present-value basis. They include the value of the trust funds on January 1, 2015 and the cost of reaching a target trust fund level equal to 100 percent of annual cost at the end of the period.

3 Between -0.005 and 0 percent of GDP.

Note: Totals do not necessarily equal the sums of rounded components.

To compare trust fund operations expressed as percentages of taxable payroll and those expressed as percentages of GDP, table VI.G5 displays ratios of OASDI taxable payroll to GDP. HI taxable payroll is about 25 percent larger than the OASDI taxable payroll throughout the long-range period; see section 1 of this appendix for a detailed description of the difference. The cost as a percentage of GDP is equal to the cost as a percentage of taxable payroll multiplied by the ratio of taxable payroll to GDP.

Table VI.G5.—Ratio of OASDI Taxable Payroll to GDP, Calendar Years 2015-90

Calendar year	Intermediate	Low-cost	High-cost
2015	0.353	0.353	0.352
2016	.353	.356	.352
2017	.357	.358	.355
2018	.360	.362	.357
2019	.362	.365	.358
2020	.363	.368	.359
2021	.365	.370	.360
2022	.366	.372	.360
2023	.367	.374	.361
2024	.368	.376	.361
2025	.367	.375	.360
2030	.365	.374	.356
2035	.362	.373	.352
2040	.361	.373	.349
2045	.360	.374	.347
2050	.359	.374	.344
2055	.357	.375	.341
2060	.356	.375	.338
2065	.354	.375	.334
2070	.351	.375	.330
2075	.349	.374	.326
2080	.347	.374	.323
2085	.346	.375	.319
2090	.344	.375	.316

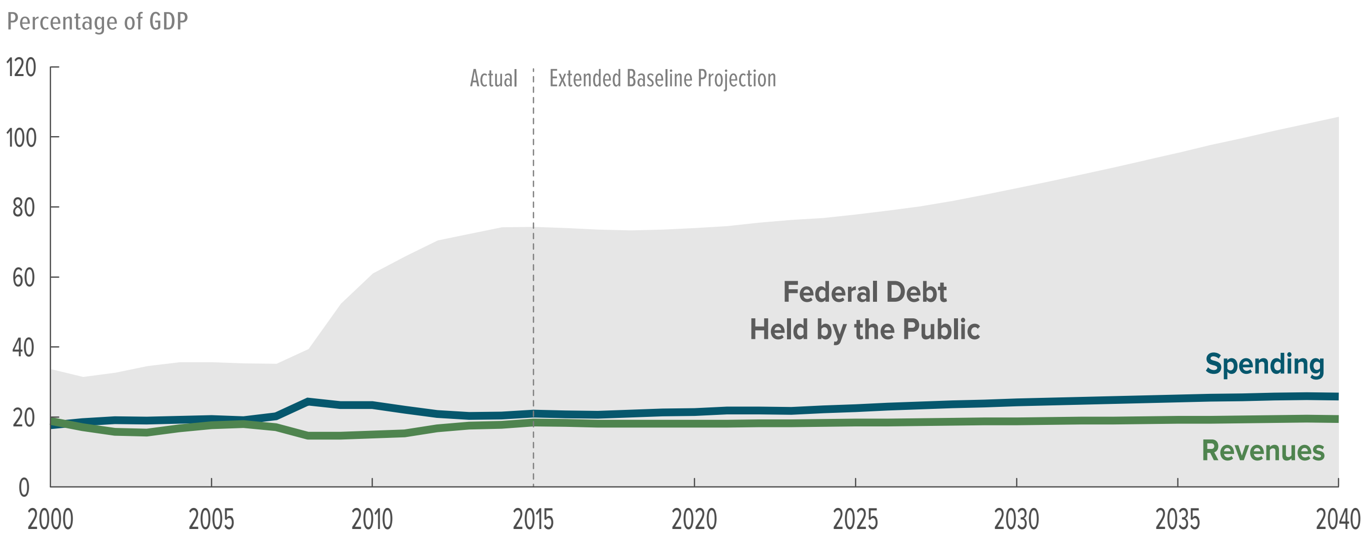
Projections of GDP reflect projected increases in U.S. employment, labor productivity, average hours worked, and the GDP deflator. Projections of taxable payroll reflect the components of growth in GDP along with assumed changes in the ratio of worker compensation to GDP, the ratio of earnings to worker compensation, the ratio of OASDI covered earnings to total earnings, and the ratio of taxable to total covered earnings.

Over the long-range period, the ratio of OASDI taxable payroll to GDP is projected to decline mostly due to a projected decline in the ratio of wages to employee compensation. Over the last five complete economic cycles, the ratio of wages to employee compensation declined at an average annual rate of 0.23 percent. Over the 65-year period ending in 2089, the ratio of wages to employee compensation is projected to decline at an average annual rate of 0.09 and 0.19 percent for the intermediate and high-cost assumptions, respectively, and to increase at an average annual rate of 0.01 percent for the low-cost assumptions.

CONGRESS OF THE UNITED STATES
CONGRESSIONAL BUDGET OFFICE

CBO

The 2015 Long-Term Budget Outlook



If Lawmakers Aimed for Debt in 2040 to Equal . . .

Its 50-Year Average of **38%** of GDP. . .

How Much Would They Need to Increase Revenues or Reduce Noninterest Spending per Year?

2.6% of GDP, which is equal to a **14%** Increase in **Revenues** or **13%** Cut in **Spending**

Its Current Level of **74%** of GDP. . .

How Much Would They Need to Increase Revenues or Reduce Noninterest Spending per Year?

1.1% of GDP, which is equal to a **6%** Increase in **Revenues** or **5½%** Cut in **Spending**

JUNE 2015

Notes

Unless otherwise indicated, the years referred to in most of this report are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end. In Chapters 6 and 7, budgetary values, such as the ratio of debt or deficits to gross domestic product, are presented on a fiscal year basis, whereas economic variables, such as gross national product or interest rates, are presented on a calendar year basis.

Numbers in the text, tables, and figures of this report may not add up to totals because of rounding. Also, some values are expressed as fractions to indicate numbers rounded to amounts greater than a tenth of a percentage point.

As referred to in this report, the Affordable Care Act comprises the Patient Protection and Affordable Care Act and the health care provisions of the Health Care and Education Reconciliation Act of 2010, as affected by subsequent judicial decisions, statutory changes, and administrative actions.

The figure on the cover shows federal revenues, spending, and debt held by the public under CBO's extended baseline.

Additional data—including the data underlying the figures in this report, supplemental budget projections, and the demographic and economic variables underlying those projections—are posted along with the report on CBO's website.

www.cbo.gov/publication/50250

Contents

Summary

The long-term outlook for the federal budget has worsened dramatically over the past several years, in the wake of the 2007–2009 recession and slow recovery. Between 2008 and 2012, financial turmoil and a severe drop in economic activity, combined with various policies implemented in response to those conditions, sharply reduced federal revenues and increased spending. As a result, budget deficits rose: They totaled $5.6 trillion in those five years, and in four of the five years, they were larger relative to the size of the economy than they had been in any year since 1946. Because of the large deficits, federal debt held by the public soared, nearly doubling during the period. It is now equivalent to about 74 percent of the economy's annual output, or gross domestic product (GDP)—a higher percentage than at any point in U.S. history except a seven-year period around World War II.[1]

If current law remained generally unchanged in the future, federal debt held by the public would decline slightly relative to GDP over the next few years, the Congressional Budget Office projects. After that, however, growing budget deficits—caused mainly by the aging of the population and rising health care costs—would push debt back to, and then above, its current high level. The deficit would grow from less than 3 percent of GDP this year to more than 6 percent in 2040. At that point, 25 years from now, federal debt held by the public would exceed 100 percent of GDP.

Moreover, debt would still be on an upward path relative to the size of the economy. Consequently, the policy changes needed to reduce debt to any given amount would become larger and larger over time. The rising debt could not be sustained indefinitely; the government's creditors would eventually begin to doubt its ability to cut spending or raise revenues by enough to pay its debt obligations, forcing the government to pay much higher interest rates to borrow money.

What Is the Outlook for the Budget in the Next 10 Years?

The economy's gradual recovery from the recession, the waning budgetary effects of policies enacted in response to the weak economy, and other changes to tax and spending laws will cause the deficit to shrink in 2015 to its smallest percentage of GDP since 2007, CBO projects—2.7 percent, a much smaller percentage than the recent peak of nearly 10 percent in 2009.[2] Throughout the next decade, however, an aging population, rising health care costs per person, and an increasing number of recipients of exchange subsidies and Medicaid benefits attributable to the Affordable Care Act would push up spending for some of the largest federal programs if current laws governing those programs remained unchanged. Moreover, CBO expects interest rates to rebound in coming years from their current unusually low levels, raising the government's interest payments on debt.

1. When analyzing changes in spending, revenues, deficits, and debt, CBO usually measures those amounts relative to economic output. That approach automatically incorporates inflation and growth in population, output, and income, providing context for understanding the size of the government's activities at different points in time and their effects on the sustainability of the budget.

2. The projections in this report are consistent with CBO's March 2015 budget projections after adjustments are made to incorporate the effects of recently enacted legislation. The most important such adjustment was to incorporate the estimated effect of Public Law 114-10, the Medicare Access and CHIP [Children's Health Insurance Program] Reauthorization Act of 2015, which became law on April 16, 2015. For information on the March baseline budget projections, see Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), www.cbo.gov/publication/49973.

Budget deficits would not substantially increase at first, but eventually they would begin to rise. They would approach 4 percent of GDP toward the end of the 10-year period spanned by CBO's baseline budget projections, the agency anticipates. Deficits over the entire period would total about $7.4 trillion.

With deficits projected to remain close to their current percentage of GDP for the next few years, federal debt held by the public would remain at a very high level, between 73 percent and 74 percent of GDP, from 2016 through 2021. Thereafter, the larger deficits would boost debt—to 78 percent of GDP by the end of 2025.

What Is the Outlook for the Budget Through 2040?

To analyze the state of the budget in the long term, CBO has extrapolated its 10-year baseline projections through 2040, yielding a set of *extended* baseline projections that span a total of 25 years. (Both sets of projections generally incorporate the assumption that current law will not change.) Mainly because of the aging of the population and rising health care costs, the extended baseline projections show revenues that fall well short of spending over the long term, producing a substantial imbalance in the federal budget. As a result, budget deficits are projected to rise steadily and, by 2040, to raise federal debt held by the public to a percentage of GDP seen at only one previous time in U.S. history—the final year of World War II and the following year.

The harmful effects that such large debt would have on the economy would worsen the budget outlook. The projected increase in debt relative to the size of the economy, combined with a gradual increase in effective marginal tax rates (that is, the rates that would apply to an additional dollar of income), would make economic output lower and interest rates higher than CBO projected when producing the extended baseline. Those macroeconomic effects would, in turn, feed back into the budget, leading to lower federal revenues and higher interest payments on the debt. (The harm that growing debt would cause to the economy was not factored into CBO's detailed long-term budgetary projections, and it is generally not reflected in the discussion of the extended baseline elsewhere in this summary, but it is addressed in further analysis presented in Chapter 6.)

In the extended baseline projections, before those feedback effects are considered, federal spending rises from 20.5 percent of GDP this year to 25.3 percent of GDP by 2040 (see Summary Table 1). (Its average over the past 50 years has been 20.1 percent.) The projected increase reflects the following paths for various types of spending:

- Federal spending for Social Security and the government's major health care programs—Medicare, Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through the exchanges created by the Affordable Care Act—would rise sharply, to 14.2 percent of GDP by 2040, if current law remained generally unchanged. That percentage would be more than twice the 6.5 percent average seen over the past 50 years. The boost in spending is projected to occur because of the aging of the population; growth in per capita spending on health care; and, to a lesser extent, an increased number of recipients of exchange subsidies and Medicaid benefits attributable to the Affordable Care Act.

- The government's net outlays for interest would grow to 4.3 percent of GDP by 2040, CBO projects. That percentage would be higher than the 2.0 percent average of the past 50 years, because federal debt would be much larger.

- In contrast, other noninterest spending—that is, spending on everything other than Social Security, the major health care programs, and net interest—would decline to 6.9 percent of GDP by 2040, which would be well below the 11.6 percent average of the past 50 years.

Federal revenues would also increase relative to GDP under current law, but much more slowly than federal spending would. Revenues would equal 19.4 percent of GDP by 2040, CBO projects, which would be higher than the 50-year average of 17.4 percent. That increase would occur mainly because people's income grew more rapidly than inflation, pushing more income into higher tax brackets over time.[3]

3. One consequence is that individual income and payroll taxes as a share of income would grow for many households. For example, a married couple with two children earning the median income in 2014 and filing a joint tax return would have paid about 16 percent of their income in individual income and payroll taxes. Under current law, a similar couple earning the median income 25 years from now would pay about 19 percent of their income in individual income and payroll taxes.

Summary Table 1.

Key Projections Under CBO's Extended Baseline

Percentage of Gross Domestic Product

	2015	2025	2040
		Without Macroeconomic Feedback[a]	
Revenues			
Individual income taxes	8.4	9.5	10.4
Payroll taxes	5.9	5.7	5.7
Corporate income taxes	1.8	1.8	1.8
Other sources of revenues	1.7	1.2	1.5
Total Revenues	**17.7**	**18.3**	**19.4**
Spending			
Mandatory			
Social Security	4.9	5.7	6.2
Major health care programs[b]	5.2	6.1	8.0
Other mandatory programs	2.6	2.3	1.8
Subtotal	12.7	14.1	16.0
Discretionary	6.5	5.1	5.1
Net interest	1.3	3.0	4.3
Total Spending	**20.5**	**22.2**	**25.3**
Deficit	-2.7	-3.8	-5.9
Debt Held by the Public at the End of the Year	74	78	103
		With Macroeconomic Feedback	
Deficit	-2.7	-3.8	-6.6
Debt Held by the Public at the End of the Year	74	78	107
Memorandum:			
Social Security[a]			
Revenues[c]	4.4	4.3	4.3
Spending	4.9	5.7	6.2
Net increase (-) in deficit	-0.5	-1.4	-1.9
Medicare[a]			
Revenues[c]	1.5	1.6	1.7
Spending	3.5	4.4	6.3
Offsetting receipts	-0.5	-0.8	-1.2
Net increase (-) in deficit	-1.5	-2.0	-3.4
Tax Expenditures	8.1	n.a.	n.a.
Gross Domestic Product (Billions of dollars)[a]	18,016	27,456	50,800

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

n.a. = not available.

a. These projections do not reflect the macroeconomic feedback of the policies underlying the extended baseline after 2025. (For an analysis of those effects and their impact on debt, see Chapter 6.)

b. Net of offsetting receipts for Medicare.

c. Revenues include payroll taxes other than those paid by the federal government for federal employees, which are intragovernmental transactions. Revenues also include income taxes paid on Social Security benefits, which are credited to the trust funds.

By 2040, in CBO's projections that do not account for macroeconomic feedback effects, the deficit equals 5.9 percent of GDP, a higher percentage than in any year between 1947 and 2008. The resulting debt reaches 103 percent of GDP in 2040, more than in any year except 1945 and 1946.

Under the extended baseline with feedback effects included, CBO's estimate of the deficit in 2040 is higher—6.6 percent of GDP—and so is its estimate of federal debt held by the public: 107 percent of GDP.

What Consequences Would a Large and Growing Federal Debt Have?

How long the nation could sustain such growth in federal debt is impossible to predict with any confidence. At some point, investors would begin to doubt the government's willingness or ability to meet its debt obligations, requiring it to pay much higher interest costs in order to continue borrowing money. Such a fiscal crisis would present policymakers with extremely difficult choices and would probably have a substantial negative impact on the country. Unfortunately, there is no way to predict confidently whether or when such a fiscal crisis might occur in the United States. In particular, as the debt-to-GDP ratio rises, there is no identifiable point indicating that a crisis is likely or imminent. But all else being equal, the larger a government's debt, the greater the risk of a fiscal crisis.[4]

Even before a crisis occurred, the high and rising debt that CBO projects in the extended baseline would have macroeconomic effects with significant negative consequences for both the economy and the federal budget:

- The large amount of federal borrowing would draw money away from private investment in productive capital over the long term, because the portion of people's savings used to buy government securities would not be available to finance private investment. The result would be a smaller stock of capital, and therefore lower output and income, than would otherwise have been the case, all else being equal. (Despite those reductions, output and income per person, adjusted for inflation, would be higher in the future than they are now, thanks to the continued growth of productivity.)

- Federal spending on interest payments would rise, thus requiring the government to raise taxes, reduce spending for benefits and services, or both to achieve any targets that it might choose for budget deficits and debt.

- The large amount of debt would restrict policymakers' ability to use tax and spending policies to respond to unexpected challenges, such as economic downturns or financial crises. As a result, those challenges would tend to have larger negative effects on the economy and on people's well-being than they would otherwise. The large amount of debt could also compromise national security by constraining defense spending in times of international crisis or by limiting the country's ability to prepare for such a crisis.

What Effects Would Alternative Fiscal Policies Have?

Again, most of the projections in this report are based on the assumption that federal tax and spending policies will generally not differ from what current law specifies. (CBO makes that assumption not because it expects current law to remain the same, but because the budgetary and economic implications of current law are a useful benchmark for policymakers when they consider changing laws.) However, if tax and spending policies differed significantly from those specified in current law, budgetary and economic outcomes could differ significantly as well. To illustrate some possible differences, CBO analyzed the effects of three additional sets of fiscal policies: an extended alternative fiscal scenario, which would result in more debt than in the extended baseline; and two illustrative scenarios, which would result in less.

Under the extended alternative fiscal scenario, certain policies that are now in place but that are scheduled to change under current law are assumed to continue; some provisions of law that might be difficult to sustain for a long period are assumed to be modified; and federal revenues and certain kinds of federal spending are assumed to be maintained at or near their historical shares of GDP. If those changes to current law occurred, deficits (excluding interest payments) would be about $2 trillion higher over the next decade than they are in CBO's baseline; in subsequent years, such deficits would exceed those projected in the extended baseline by rapidly growing amounts. The harmful effects on the economy from the resulting increase in federal debt would be partly offset by the lower marginal tax rates that would be in place under

4. For further discussion, see Congressional Budget Office, *Federal Debt and the Risk of a Fiscal Crisis* (July 2010), www.cbo.gov/publication/21625.

the scenario. Nevertheless, in the long term, economic output would be lower and interest rates would be higher under the scenario than they would be if current law remained in place. After including the effects of those macroeconomic changes, CBO projects that federal debt held by the public would rise sharply—to about 175 percent of GDP in 2040.

Under the first of the two illustrative scenarios, budget deficits would be smaller than those projected under current law. Deficit reduction would be phased in so that deficits (excluding interest payments) would be a total of $2 trillion smaller through 2025 than they are in CBO's baseline; thereafter, deficits would be reduced each year by the same percentage of GDP by which they had been reduced in 2025. If that scenario occurred, output would be higher and interest rates would be lower in the long term than they would be if current law remained unchanged. Factoring in the effects of those macroeconomic changes on the budget, CBO projects that federal debt held by the public would equal about 72 percent of GDP in 2040, close to its percentage in 2013.

Under the other illustrative scenario, one with twice as much deficit reduction as in the previous scenario—a total decrease of $4 trillion in deficits (excluding interest payments) through 2025—CBO projects that federal debt held by the public would fall to 39 percent of GDP in 2040. That percentage would be close to the average ratio of debt to GDP over the past 50 years (38 percent). As in the preceding scenario, output would be higher and interest rates would be lower in the long term than they would be if current law did not change.

The fiscal policies in the three scenarios would also affect the economy in the short term, reflecting the short-term impact of tax and spending policies on the overall demand for goods and services. The first scenario, by making spending higher and taxes lower than they would be under current law, would increase demand and thereby raise output and employment over the next few years. By contrast, the deficit reduction that would take place under the other scenarios would decrease demand and thus reduce output and employment over the next few years.

How Uncertain Are the Long-Term Budget Projections?

Even if future tax and spending policies did not vary from what current law specifies, budgetary outcomes would undoubtedly differ from CBO's projections because of unexpected changes in the economy, demographics, and other factors.

To illustrate the uncertainty of its projections, CBO examined how varying its estimates of four factors—future mortality rates, productivity growth, interest rates on federal debt, and federal spending on Medicare and Medicaid—would affect the projections in a version of the extended baseline that included the macroeconomic effects of fiscal policies on the budget. In that version of the extended baseline, CBO's central estimate is that federal debt will equal 107 percent of GDP in 2040. The degree of variation in the four factors was based on their past variation as well as on possible future developments. For instance, during recent 25-year periods, beginning in the 1950–1974 period and ending in the 1990–2014 period, the average growth rate of total factor productivity—the average real output per unit of combined capital and labor—varied by about 1 percentage point. CBO therefore projected economic and budgetary outcomes if total factor productivity grew by 0.8 percent per year or by 1.8 percent per year over the next 25 years—that is, 0.5 percentage points more slowly or more quickly than the 1.3 percent projected for the extended baseline. The estimates show the following:

- In cases in which CBO varied only one of the four factors, federal debt held by the public after 25 years ranged from 18 percent of GDP below the agency's central estimate to 23 percent above it.
- In a case in which all four factors varied simultaneously in a way that raised projected deficits, but varied only 60 percent as much as in the individual cases just mentioned, federal debt after 25 years was projected to be about 37 percent of GDP higher than the agency's central estimate. Conversely, in a case in which all four factors varied in a way that lowered deficits but, again, by only 60 percent as much as in the individual cases, debt after 25 years was projected to be lower than CBO's central estimate by 31 percent of GDP.

Those calculations do not cover the full range of possible outcomes, nor do they address other sources of uncertainty in the budget projections, such as the risk of an economic depression or major war or the possibility of unexpected changes in birthrates, immigration, or labor force participation. Nonetheless, they show that the main implication of this report applies under a wide range of possible values for some key factors that influence federal spending and revenues. That is, in 25 years, if current law remained generally unchanged, federal debt—which is already high by historical standards—would probably be at least as high as it is today and would most likely be much higher.

What Choices Do Policymakers Have?

The unsustainable nature of the federal tax and spending policies specified in current law presents lawmakers and the public with difficult choices. Unless substantial changes were made to the major health care programs and Social Security, spending for those programs would equal a much larger percentage of GDP in the future than in the past. Federal spending as a whole would rise rapidly—even though, under current law, spending for all other federal benefits and services would make up a smaller percentage of GDP by 2025 than at any point in more than 70 years. Federal revenues would also represent a larger percentage of GDP in the future than they have, on average, in the past few decades. Even so, spending would soon start to exceed revenues by increasing amounts relative to GDP, generating rising budget deficits. As a result, federal debt held by the public would grow faster than the economy, starting a few years from now. Because debt is already unusually high relative to GDP, further sustained increases could be especially harmful to economic growth.

To put the federal budget on a sustainable path for the long term, lawmakers would have to make major changes to tax policies, spending policies, or both—by reducing spending for large benefit programs below the projected amounts, letting revenues rise more than they would under current law, or adopting some combination of those approaches. The size of such changes would depend on the amount of federal debt that lawmakers considered appropriate.

For instance, if lawmakers set a goal for 2040 of reducing debt held by the public to the average percentage of GDP seen over the past 50 years (38 percent), one approach would be to increase revenues and cut noninterest spending, relative to current law, by a total of 2.6 percent of GDP in each year beginning in 2016. That would come to about $480 billion, or $1,450 per person, in 2016 (see Summary Figure 1).[5] Many combinations of policies could be adopted to meet that goal, including the following:

- At one end of the spectrum, lawmakers could choose to reduce deficits solely by increasing revenues. Such a policy would require boosting revenues by 14 percent in each year over the 2016–2040 period relative to the amounts that CBO projects in the extended baseline. For households in the middle fifth of the income distribution in 2016, a 14 percent increase in all types of revenues would raise federal tax payments for that year by about $1,700, on average.

- At the other end of the spectrum, lawmakers could choose to reduce deficits solely by cutting noninterest spending, in which case they would have to make such spending 13 percent lower than projected in the extended baseline in each of the next 25 years. For example, a 13 percent cut would lower initial Social Security benefits by an average of about $2,400 for people in the middle fifth of the lifetime earnings distribution who were born in the 1950s and who claimed benefits at age 65.

Another goal might be to reduce debt in 2040 to its current percentage of GDP—74 percent. Meeting that goal would require increases in revenues and cuts in noninterest spending, relative to current law, totaling 1.1 percent of GDP in each year beginning in 2016.[6] Of course, other goals and other patterns for the timing of savings are possible as well.

In deciding how quickly to carry out policies to put federal debt on a sustainable path—regardless of the chosen goal for debt—lawmakers would face difficult trade-offs:

5. The estimated size of those policy changes does not account for the macroeconomic effects either of the particular policies that might be changed or of the reduction in debt.

6. The estimated size of those policy changes does not account for the macroeconomic effects of the particular policies that might be changed.

Summary Figure 1.

The Size of Policy Changes Needed Over 25 Years to Make Federal Debt Meet Two Possible Goals in 2040

If Lawmakers Aimed for . . .

Debt in 2040 to Equal Its 50-Year Average of **38%** of GDP . . .	**Debt** in 2040 to Equal Its Current Level of **74%** of GDP . . .

How Much Would They Need to Increase Revenues or Reduce Noninterest Spending per Year?

2.6% of GDP, which is equal to a **14%** Increase in **Revenues** or **13%** Cut in **Spending**	**1.1%** of GDP, which is equal to a **6%** Increase in **Revenues** or **5½%** Cut in **Spending**

What Would That Increase in Revenues or Reduction in Noninterest Spending Amount to in 2016?

$480 billion, which is equal to **$1,450** per person	**$210 billion**, which is equal to **$650** per person

What If the Changes Were Increases (of Equal Percentage) in All Types of Revenues?

+$1,700

One effect in 2016 is that, on average, **taxes on households** would be higher than under current law.

+$750

Values are for households in the middle fifth of the income distribution. Those taxes are projected to be $12,300 under current law.

What If the Changes Were Cuts (of Equal Percentage) in All Types of Noninterest Spending?

-$2,400

One effect is that **initial Social Security benefits** would be lower than under current law.

-$1,050

Values are averages for people in the middle fifth of the lifetime earnings distribution who were born in the 1950s and who would claim benefits at age 65. Those benefits are projected to be $18,650 (in 2016 dollars) under current law.

Source: Congressional Budget Office.

Notes: The values shown in this figure are relative to CBO's extended baseline. The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period. The sizes of the policy changes do not account for the macroeconomic feedback of the policies that might be used to achieve the goals or, in the case of the goal to reduce debt to 38 percent of GDP, of the reduction in debt.

GDP = gross domestic product.

- The sooner significant deficit reduction was implemented, the smaller the government's accumulated debt would be; the smaller the policy changes would need to be to achieve the chosen goal; and the less uncertainty there would be about what policies might be adopted. However, precipitous spending cuts or tax increases would give people little time to plan and adjust to those policy changes, and the changes would weaken the economic expansion during the next two years or so—a period when the Federal Reserve would have little ability to lower short-term interest rates to boost the economy.

- Spending cuts or tax increases that were implemented several years from now would have a smaller negative effect on output and employment in the short term. However, waiting for some time before reducing spending or increasing taxes would result in a greater accumulation of debt, which would represent a greater drag on output and income in the long term and increase the size of the policy changes needed to reach the chosen target for debt.

CBO has estimated how much a delay in deficit reduction would increase the size of the policy changes needed to achieve a chosen goal for debt. If the goal was to reduce debt to its 50-year historical average by 2040, but lawmakers waited to implement new policies until 2021, the combination of increases in revenues and reductions in noninterest spending over the 2021–2040 period would need to equal 3.2 percent of GDP—0.6 percentage points more than if policy changes took effect in 2016. If lawmakers chose the same goal but postponed taking action until 2026, the necessary policy changes over the 2026–2040 period would amount to 4.2 percent of GDP.

Even if policy changes that shrank deficits in the long term were not implemented for several years, making decisions about them sooner rather than later could hold down longer-term interest rates, reduce uncertainty, and enhance businesses' and consumers' confidence. Such decisions could thereby make output and employment higher in the next few years than they would have been otherwise.

CHAPTER

1

The Long-Term Outlook for the Federal Budget

The Congressional Budget Office projects that the deficit will remain roughly stable as a share of the nation's output—its gross domestic product (GDP)—for the next several years if current laws remain generally unchanged. Federal debt held by the public also will be roughly stable relative to the size of the economy for several years, according to CBO's projections. However, the long-term budget outlook is projected to worsen.

The government's spending for major health care programs and for Social Security is a critical factor in that outlook. Such spending is expected to rise significantly from 2015 through 2040 because of a combination of three factors: the aging of the population; growth in per capita spending on health care; and, to a lesser extent, an increased number of recipients of exchange subsidies and Medicaid benefits attributable to the Affordable Care Act (ACA). That boost in spending is expected to exceed the decline in other noninterest spending relative to GDP over the same 25-year period. In addition, revenues are projected to increase, but more slowly than total noninterest spending. Higher interest payments and larger budget deficits would occur as a result, causing federal debt, which is already quite large relative to the size of the economy, to swell even more.

In this report, CBO presents its projections of federal outlays, revenues, deficits, and debt for the next few decades and discusses the possible consequences of the projected budgetary outcomes. The projections are consistent with CBO's current 10-year economic projections, which were released in January 2015, and the agency's March 2015 budget projections, with adjustments to incorporate the effects of recently enacted legislation.[1] CBO's long-term projections, which focus on the 25-year period ending in 2040, extend the baseline concept into later years; hence, they constitute what is called the *extended baseline*.

CBO's 10-year and extended baselines are meant to serve as benchmarks for assessing the budgetary effects of proposed changes in federal revenues or spending. They are not meant to be predictions of future budgetary outcomes; rather, they represent CBO's best assessment of future revenues, spending, and deficits if current law generally remained unchanged and the economy was generally stable in the long term. In that way, the baselines incorporate the assumption that some policy changes that lawmakers have routinely made in the past—such as extending certain expiring tax provisions—will not be made again.

The Budget Outlook for the Next 10 Years

The budget deficit is on track to fall in 2015 to its smallest percentage of economic output since 2007: CBO estimates that the deficit will be less than 3 percent of GDP, which is less than one-third of its peak of nearly 10 percent in 2009. That decline reflects the economy's gradual recovery from the 2007–2009 recession, the waning budgetary effects of policies enacted in response to the weak economy, and other changes to tax and spending policies. Debt held by the public will remain at about 74 percent

1. The most important adjustment to the March 2015 baseline was to incorporate the estimated effect of Public Law 114-10, the Medicare Access and CHIP [Children's Health Insurance Program] Reauthorization Act of 2015, which became law on April 16, 2015. See Congressional Budget Office, cost estimate for H.R. 2, the Medicare Access and CHIP Reauthorization Act of 2015 (March 25, 2015), www.cbo.gov/publication/50053. For information on the March baseline budget projections, see Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), www.cbo.gov/publication/49973. For information on the January 2015 economic projections, see Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), www.cbo.gov/publication/49892.

of GDP at the end of 2015—equal to its value in 2014, when it reached its highest level since 1950.

In those projections, a combination of the anticipated further strengthening of the economy and constraints on federal spending built into law keeps deficits close to their current percentage of GDP for the next several years. With deficits staying below 3 percent of GDP from 2015 through 2019, and then rising slowly thereafter, federal debt held by the public is projected to stay between 73 percent and 74 percent of GDP from 2015 through 2020.

Later in the 10-year baseline projection period, under current law, deficits would be notably larger, CBO anticipates. Interest rates are expected to rebound from their present unusually low levels, sharply increasing interest payments on the government's debt. Moreover, increased spending on the major health care programs and on Social Security is projected to cause mandatory spending to rise as a percentage of GDP.[2] In addition, revenues would grow relative to GDP for the next 10 years as an increase in individual income taxes was offset primarily by a decline in remittances from the Federal Reserve (all relative to the size of the economy). By 2025, under current law, the budget deficit would grow to nearly 4 percent of GDP; federal debt would equal 78 percent of GDP and would be on the rise relative to the size of the economy.

The Long-Term Budgetary Imbalance

The detailed long-term budget estimates that CBO presents in this and the following four chapters depend on projections of a host of demographic and economic conditions that the agency bases primarily on historical patterns. The estimates in these five chapters do not incorporate the long-term economic effects of changes in fiscal policies in the extended baseline; those effects are incorporated, however, in the estimates presented in Chapters 6 and 7. The demographic and economic projections that underlie the detailed long-term budget estimates are summarized later in this chapter and discussed in detail in Appendix A. (Appendix B offers a discussion of changes in CBO's projections since last year.)

CBO's extended baseline projections show a substantial imbalance in the federal budget over the long term, with revenues falling well short of spending. Two measures offer complementary perspectives on the size of that imbalance: Projections of federal debt illustrate how the shortfall in revenues relative to spending would accumulate over time under current law; and estimates of how much spending or revenues would need to be changed to achieve a chosen goal for federal debt illustrate the magnitude of the modifications in law that policymakers might consider.

In addition to its extended baseline, CBO has developed an *extended alternative fiscal scenario*, which incorporates the assumptions that certain policies that have been in place for a number of years will be continued, that some provisions of law that might be difficult to sustain for a long period will be modified, and that federal revenues and certain categories of federal spending will be maintained at or near their historical shares of GDP (see Chapter 6). Under that scenario, federal debt would grow even faster than it would under the extended baseline, so larger policy changes would be needed to reach any chosen fiscal target.

The Accumulation of Federal Debt

Debt held by the public represents the amount that the federal government has borrowed in financial markets, by issuing Treasury securities, to pay for its operations and activities.[3] If a given combination of federal spending and revenues is to be sustainable over time, debt held by the public eventually must grow no faster than the economy

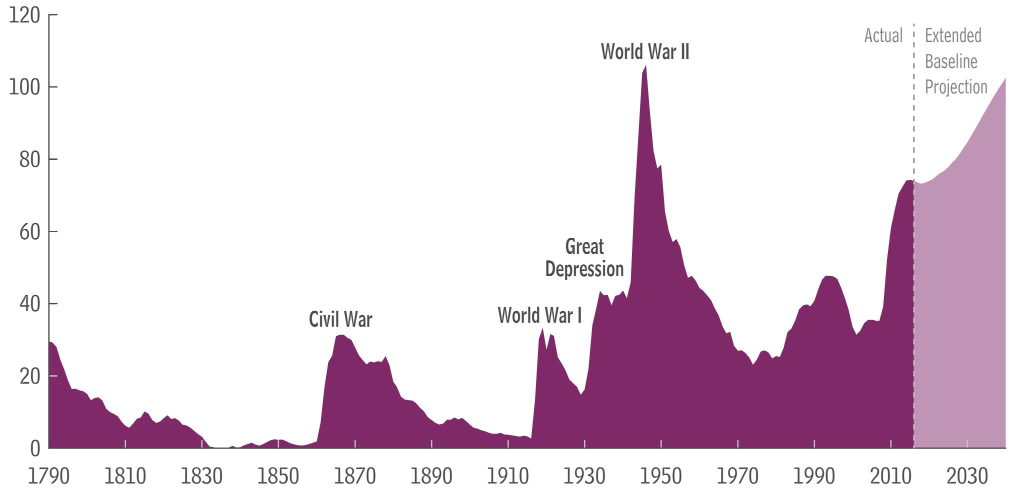
2. Lawmakers generally determine spending for mandatory programs by setting eligibility rules, benefit formulas, and other parameters rather than by appropriating specific amounts each year. In that way, mandatory spending differs from discretionary spending, which is controlled by annual appropriation acts.

3. When the federal government borrows in financial markets, it competes with other participants for financial resources and, in the long term, crowds out private investment, reducing economic output and income. In contrast, federal debt held by trust funds and other government accounts represents internal transactions of the government and has no direct effect on financial markets. (That debt and debt held by the public together make up gross federal debt.) For more discussion, see Congressional Budget Office, *Federal Debt and Interest Costs* (December 2010), www.cbo.gov/publication/21960. Several factors not directly included in the budget totals also affect the government's need to borrow from the public. They include increases or decreases in the government's cash balance as well as the cash flows reflected in the financing accounts used for federal credit programs.

Figure 1-1.

Federal Debt Held by the Public

Percentage of Gross Domestic Product



The historically high and rising amounts of federal debt that CBO projects would have significant negative consequences, including reducing the total amounts of national saving and income in the long term; increasing the government's interest payments, thereby putting more pressure on the rest of the budget; limiting lawmakers' flexibility to respond to unforeseen events; and increasing the likelihood of a fiscal crisis.

Source: Congressional Budget Office. For details about the sources of data used for past debt held by the public, see Congressional Budget Office, *Historical Data on Federal Debt Held by the Public* (July 2010), www.cbo.gov/publication/21728.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period. These projections do not reflect the macroeconomic feedback of the policies underlying the extended baseline. (For an analysis of those effects and their impact on debt, see Chapter 6.)

does. If debt continued to rise relative to GDP, at some point investors would begin to doubt the government's willingness or ability to repay its obligations. Such doubts would make it more expensive for the government to borrow money, thus necessitating cuts in spending, increases in taxes, or some combination of those two approaches. For that reason, the amount of federal debt held by the public relative to the nation's annual economic output is an important barometer of the government's financial position.

Measuring debt as a percentage of GDP is particularly useful when making comparisons between amounts of debt in different years. That measure accounts for changes in price levels, population, output, and income—all of which affect the scope of potential budgetary adjustments. Examining whether debt as a percentage of GDP is increasing over time from its current high level is therefore a simple and meaningful way to assess the sustainability of the budget.

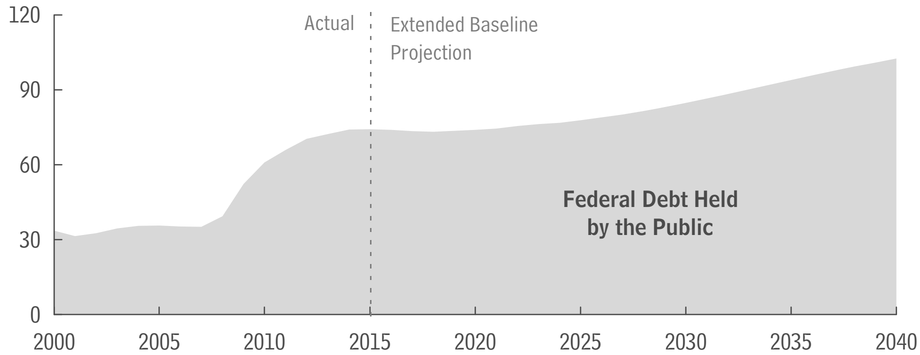
At the end of 2008, federal debt held by the public stood at 39 percent of GDP, which was close to its average of the preceding several decades. Since then, large deficits have caused debt held by the public to grow sharply—to 74 percent of GDP in 2014; debt is projected to stay at that level in 2015. Debt has exceeded 70 percent of GDP during only one other period in U.S. history: from 1944 through 1950; it peaked at 106 percent of GDP in 1946 because of the surge in federal spending that occurred during World War II (see Figure 1-1).

CBO projects that, as a share of GDP, debt held by the public will exceed its current level in 2021 and then keep rising if existing laws remain unchanged. By 2040, under the extended baseline, federal debt held by the public would reach 103 percent of GDP, even without accounting for the harmful economic effects of the growing debt (see Figure 1-2)—nearly the same percentage as that recorded in 1945 (104 percent) and in 1946 (106 percent) and more than two and a half times the average percentage during the past several decades. Incorporating the negative economic effects of higher debt pushes the projected debt up to 107 percent of GDP in 2040 (see Chapter 6). Moreover, the debt would be on an upward trajectory, which ultimately would be unsustainable.

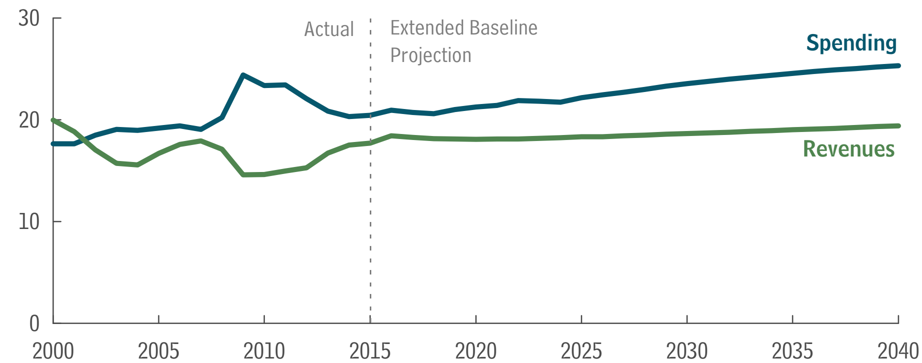
Figure 1-2.

Federal Debt, Spending, and Revenues

Percentage of Gross Domestic Product



Deficits and **debt held by the public** will remain roughly stable in the near term, reflecting the anticipated further strengthening of the economy and constraints on federal spending built into law. But the long-term outlook for the budget is projected to worsen . . .



. . . as growth in **total spending** would outpace growth in **total revenues**, resulting in larger budget deficits and debt if current laws remained generally unchanged.

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period. These projections do not reflect the macroeconomic feedback of the policies underlying the extended baseline. (For an analysis of those effects and their impact on debt, see Chapter 6.)

GDP = gross domestic product.

Continued

Projections so far into the future are highly uncertain, of course. Nevertheless, under a wide range of possible expectations about key factors affecting budgetary outcomes, CBO anticipates that if current laws generally stayed the same, federal debt in 2040 would be very high by the nation's historical standards (see Chapter 7).

The Magnitude and Timing of Policy Changes Needed to Meet Various Goals for Federal Debt

An alternative perspective on the long-term fiscal imbalance comes from assessing the changes in revenues or noninterest spending that would be needed to achieve a chosen goal for federal debt. One possible goal would be to try to ensure that federal debt remained the same percentage of GDP in some future year that it is today. Another would be to attempt to make federal debt the same percentage of GDP in some future year that it has been, on average, during the past several decades. Other goals are possible as well.

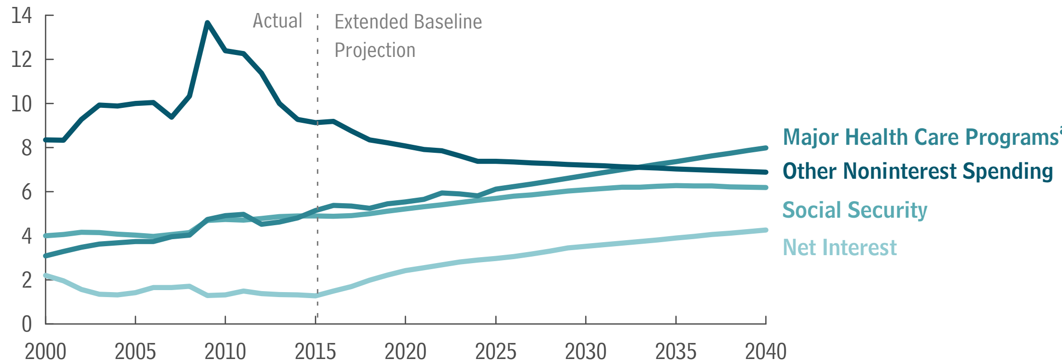
The changes in revenues or noninterest spending that are estimated to be necessary to achieve one of those goals are conceptually similar to the estimated actuarial imbalance—that is, a negative actuarial balance—that is commonly reported for the Social Security trust funds (see Table 3-1 on page 54). An estimated actuarial imbalance for a trust fund over a given period represents the changes in revenues or spending that would be needed to achieve the target balance for the trust funds if those changes were enacted immediately and maintained throughout the period. A similar calculation for the

Figure 1-2. **Continued**

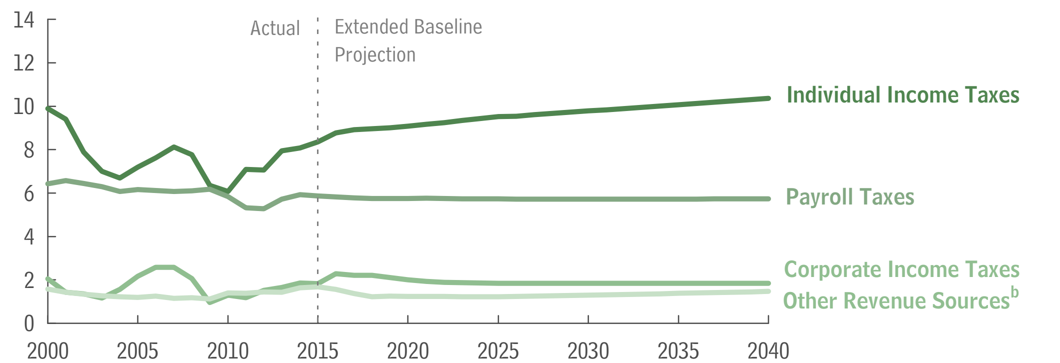
Federal Debt, Spending, and Revenues

Percentage of Gross Domestic Product

Growth in certain **components of spending**—the major health care programs and Social Security—is expected to exceed the decline in other noninterest spending relative to GDP. Net interest costs will also grow, as interest rates rebound . . .



. . . and as revenues grow only slightly more rapidly than GDP. A boost in one of the **sources of revenues**—individual income taxes—accounts for the rise in total revenues; receipts from all other sources, taken together, are projected to decline.



a. Consists of spending on Medicare (net of offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies offered through health insurance exchanges.

b. Consists of excise taxes, remittances to the Treasury from the Federal Reserve System, customs duties, estate and gift taxes, and miscellaneous fees and fines.

federal government as a whole is one way to summarize the projected fiscal imbalance over a specified period.

The magnitude of the policy changes that would be needed to achieve a chosen goal for federal debt would depend, in part, on how quickly that goal was expected to be reached. Determining the timing of policy changes involves various trade-offs, including the economic effects of those changes and the burdens borne by different generations.

The Magnitude of Policy Changes Needed to Meet Various Goals. The scale of the changes in noninterest spending or revenues that would be needed to ensure that federal debt equaled its current percentage of GDP at a specific date in the future is often referred to as the fiscal gap.[4] In CBO's extended baseline, the fiscal gap for the 2016–2040 period amounts to 1.1 percent of GDP (without accounting for the economic effects of the policy changes that might be used to close the gap). That is, relative to the extended baseline, a combination of cuts in noninterest spending and increases in revenues that equaled 1.1 percent of GDP in each year beginning in 2016—amounting to about $210 billion in that year or

4. The fiscal gap equals the present value of noninterest outlays and other means of financing minus the present value of revenues over the projected period with adjustments to make the ratio of federal debt to GDP at the end of the period equal to the current ratio. Specifically, current debt is added to the present value of outlays and other means of financing, and the present value of the target end-of-period debt (which equals GDP in the last year of the period multiplied by the ratio of debt to GDP at the end of 2015) is added to the present value of revenues. The present value of a flow of revenues or outlays over time is a single number that expresses that flow in terms of an equivalent sum received or paid at a specific time. The present value depends on a rate of interest (known as the discount rate) that is used to translate past and future cash flows into current dollars. Other means of financing include changes in the government's cash balances and the cash flows of federal credit programs (mostly programs that provide loans and loan guarantees).

$650 per person—would result in debt in 2040 that would equal 74 percent of GDP, or the same percentage of GDP in 25 years that it equals now. If those changes came entirely from revenues or entirely from spending, they would amount, roughly, to a 6 percent increase in revenues or a 5½ percent cut in noninterest spending relative to the amounts projected for the 2016–2040 period.

Increases in revenues or reductions in noninterest spending would need to be larger to reduce debt to the percentages of GDP that are more typical of those in recent decades. For debt as a share of GDP to return to its average percentage over the past 50 years—38 percent—by 2040, the government would need to pursue a combination of increases in revenues and cuts in noninterest spending (relative to current-law projections) that totaled 2.6 percent of GDP each year. (Those increases and cuts would not account for the economic effects of the reduction in debt and the policy changes that might be used to achieve the goal; in 2016, 2.6 percent of GDP would be about $480 billion or $1,450 per person.)[5] Many combinations of policies could be adopted to meet that goal, including the following:

- If those changes came from increases of equal percentage in all types of revenues, they would represent an increase of about 14 percent, under the extended baseline, for each year in the 2016–2040 period. For households in the middle fifth of the income distribution in 2016, for example, such an increase would raise annual federal tax payments by about $1,700, on average.
- If the changes came from cuts of equal percentage in all types of noninterest spending, they would represent a cut of about 13 percent for each of the next 25 years. For example, people in the middle fifth of the lifetime earnings distribution who were born in the 1950s and who claimed benefits at age 65 would have their initial annual Social Security benefits lowered by about $2,400, on average, by such a cut.

The Timing of Policy Changes Needed to Meet Various Goals. In deciding how quickly to implement policies to put federal debt on a sustainable path—regardless of the chosen goal for federal debt—lawmakers face trade-offs:

- The sooner significant deficit reduction was implemented, the smaller the government's accumulated debt would be, the smaller the policy changes would need to be to achieve a particular long-term outcome, and the less uncertainty there would be about what policies would be adopted. However, if lawmakers implemented spending cuts or tax increases quickly, people would have little time to plan and adjust to the policy changes, and those changes would weaken the economic expansion over the next two years or so.
- By contrast, reductions in federal spending or increases in taxes that were implemented several years from now would have a smaller effect on output and employment in the short term. However, if lawmakers waited for some time before reducing federal spending or increasing taxes, the result would be a greater accumulation of debt, which would represent a greater drag on output and income in the long term and would increase the size of the policy changes needed to reach any chosen target for debt.

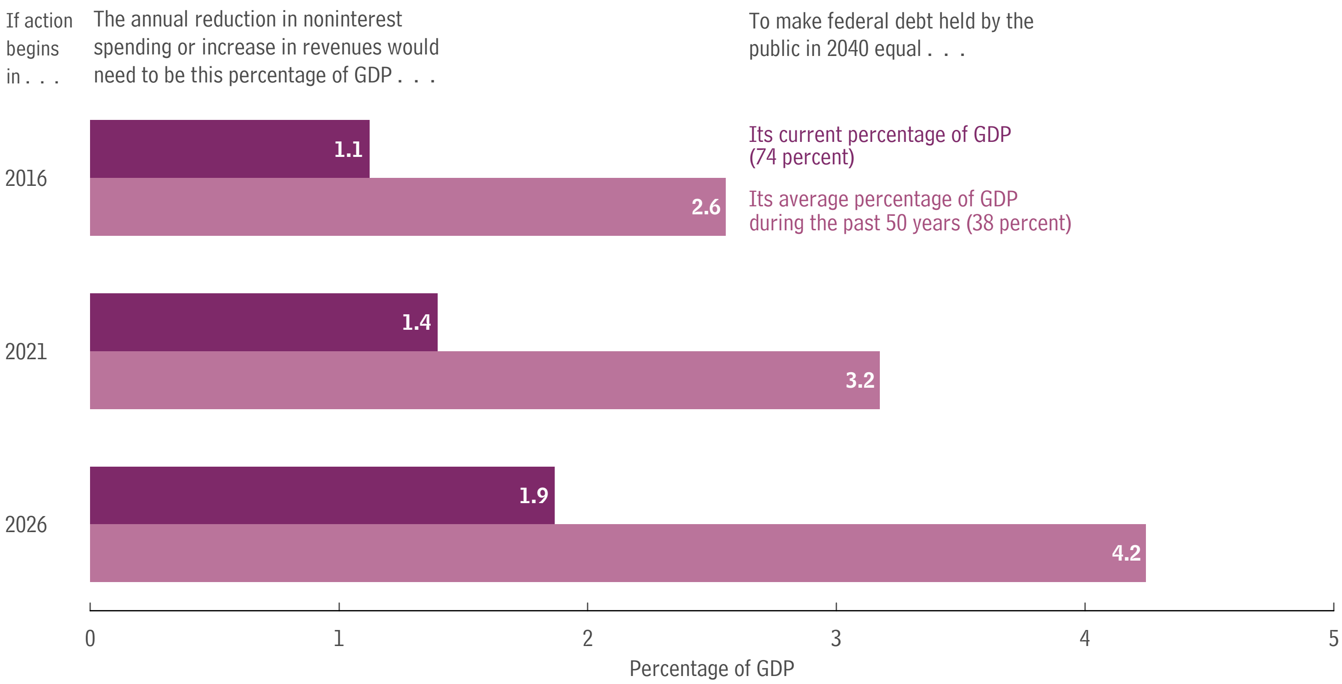
In addition, faster or slower implementation of policies to reduce budget deficits would tend to impose different burdens on different generations: Reducing deficits sooner would probably require more sacrifices by today's older workers and retirees for the benefit of today's younger workers and future generations. Reducing deficits later would require smaller sacrifices by older people and greater sacrifices by younger workers and future generations.

CBO has tried to illustrate that collection of trade-offs in three ways. First, the agency has estimated the macroeconomic consequences of several paths for federal debt in both the short term and the longer term. For example, it has analyzed the effects of phasing in deficit reduction so that, excluding interest payments, deficits would be $2 trillion lower through 2025 than under the baseline and, in subsequent years, would be reduced by the same percentage of GDP as in 2025. Under that scenario, CBO estimates, economic output would be slightly lower over the next few years but about 3 percent higher in

5. That figure is calculated in the same manner as the fiscal gap except that it uses a different target for end-of-period debt.

Figure 1-3.

The Magnitude and Timing of Policy Changes Needed to Make Federal Debt Meet Two Goals



Source: Congressional Budget Office.

Note: GDP = gross domestic product.

2040 than if current laws generally remained in effect. Those results and corresponding results for other scenarios are discussed in Chapter 6.

Second, CBO has estimated the amount by which delaying deficit reduction would increase the size of the policy adjustments needed to achieve any chosen goal for debt. For example, if the goal of lawmakers was for debt as a percentage of GDP to return to its historical average, but policy changes did not take effect until 2021, those changes would need to amount to 3.2 percent rather than 2.6 percent of GDP (see Figure 1-3). Waiting an additional five years would require even larger changes, amounting to 4.2 percent of GDP.

Third, CBO has studied how waiting to resolve the long-term fiscal imbalance would affect various generations of the U.S. population. In 2010, CBO compared economic outcomes under a policy that would stabilize the debt-to-GDP ratio starting in 2015 with outcomes under a policy that would delay stabilizing the ratio until 2025.[6] That analysis suggested that generations born after the earlier implementation date would be worse off if action to stabilize the debt-to-GDP ratio was postponed an additional 10 years. People born more than 25 years before that earlier implementation date, however, would be better off if action was delayed—largely because they would partly or entirely avoid the policy changes needed to stabilize the debt. Generations born between those two groups could either gain or lose from delayed action, depending on the details of the policy changes.[7]

Even if policy changes to reduce deficits in the long term were not implemented for several years, making decisions about them sooner rather than later would offer significant advantages. If decisions were reached sooner, people would have more time to plan and adjust their behavior to be prepared for the time when changes would be

6. See Congressional Budget Office, *Economic Impacts of Waiting to Resolve the Long-Term Budget Imbalance* (December 2010), www.cbo.gov/publication/21959. That analysis was based on a projection of slower growth in debt than CBO now projects, so the estimated effects of a similar policy today would be close, but not identical, to the effects estimated in that earlier analysis.

7. Those conclusions do not incorporate the possible negative effects of a fiscal crisis or effects that might arise from the government's reduced flexibility to respond to unexpected challenges.

implemented. In addition, decisions about policy changes that reduced future debt relative to amounts under current law would tend to increase output and employment in the next few years by holding down longer-term interest rates, reducing uncertainty, and enhancing businesses' and consumers' confidence.

Budgetary Imbalances Beyond the Next 25 Years

After 2040, the pressures of rising federal budget deficits and debt held by the public would increase further unless laws governing taxes and spending were changed. Although projections for the very long term are highly uncertain, CBO estimates that debt held by the public would be much larger relative to GDP after 75 years than it would be after 25 years. For information on CBO's projections for the very long term, see the supplemental material accompanying this report on the agency's website (www.cbo.gov/publication/50250).

Consequences of a Large and Growing Federal Debt

The high and rising amounts of federal debt held by the public that CBO projects for the coming decades under the extended baseline would have significant negative consequences for the economy in the long term and would impose significant constraints on future budget policy. In particular, the projected amounts of debt would reduce the total amounts of national saving and income in the long term; increase the government's interest payments, thereby putting more pressure on the rest of the budget; limit lawmakers' flexibility to respond to unforeseen events; and increase the likelihood of a fiscal crisis.

Less National Saving and Lower Income

Large federal budget deficits over the long term would reduce investment, resulting in lower national income and higher interest rates than would otherwise occur. Increased government borrowing would cause a larger share of the savings potentially available for investment to be used for purchasing government securities, such as Treasury bonds. Those purchases would crowd out investment in capital goods—factories and computers, for example—which would make workers less productive. Because wages are determined mainly by workers' productivity, the reduction in investment would reduce wages as well, lessening people's incentive to work. Both the government and private borrowers would face higher interest rates to compete for savings, and those rates would strengthen people's incentive to save. However, the rise in saving by households and businesses would be a good deal smaller than the increase in federal borrowing represented by the change in the deficit, so national saving—total saving by all sectors of the economy—would decline, as would private investment. (For a detailed analysis of those economic effects, see Chapter 6.)

In the short term, budget deficits would boost overall demand for goods and services, thus increasing output and employment relative to what they would be with smaller deficits or with no deficits at all. The impact of greater demand would be temporary, though, because stabilizing forces in the economy tend to push output back in the direction of its potential (or maximum sustainable) level. Those forces would include the response of prices and longer-term interest rates to greater demand and actions by the Federal Reserve.

Pressure for Larger Tax Increases or Spending Cuts

When the federal debt is large, the government ordinarily must make substantial interest payments to its lenders, and growth in the debt causes those interest payments to increase. (Net interest payments are currently fairly small relative to the size of the economy because interest rates are exceptionally low, but CBO anticipates that those payments will increase considerably as interest rates rise to their long-term levels.)

With rising debt and more normal interest rates, federal spending on interest payments would rise, thus requiring higher taxes, lower spending for benefits and services, or both to achieve any chosen targets for budget deficits and debt. If taxes were increased by raising marginal tax rates (the rates that apply to an additional dollar of income), those higher rates would discourage people from working and saving, thus further reducing output and income. Alternatively, lawmakers could choose to offset higher interest costs at least in part by reducing government benefits and services. Those reductions could be made in many ways, but to the extent that they came from cutting federal investments, future output and income also would be reduced. As another option, lawmakers could respond to higher interest payments by allowing deficits to increase for some period, but that approach would require greater deficit reduction later if lawmakers wanted to avoid a long-term increase in the debt-to-GDP ratio.

Reduced Ability to Respond to Domestic and International Problems

When the amount of outstanding debt is relatively small, a government can borrow money to address significant unexpected events—recessions, financial crises, or wars, for example. In contrast, when outstanding debt is large, a government has less flexibility to address financial and economic crises, which can be very costly for many countries.[8] A large amount of debt also can compromise a country's national security by constraining military spending in times of international crisis or by limiting the country's ability to prepare for such a crisis.

Several years ago, when federal debt was below 40 percent of GDP, the government had some flexibility to respond to the financial crisis and severe recession by increasing spending and cutting taxes to stimulate economic activity, providing public funding to stabilize the financial sector, and continuing to pay for other programs even as tax revenues dropped sharply because of the decline in output and income. As a result, federal debt almost doubled as a percentage of GDP. If federal debt stayed at its current percentage of GDP or increased further, the government would find it more difficult to undertake similar policies under similar conditions in the future. As a result, future recessions and financial crises could have larger negative effects on the economy and on people's well-being. Moreover, the reduced financial flexibility and increased dependence on foreign investors that accompany high and rising debt could weaken U.S. leadership in the international arena.

Greater Chance of a Fiscal Crisis

A large and continuously growing federal debt would have another significant negative consequence: It would increase the likelihood of a fiscal crisis in the United States.[9] Specifically, there would be a greater risk that investors would become unwilling to finance the government's borrowing needs unless they were compensated with very high interest rates; as a result, interest rates on federal debt would rise suddenly and sharply relative to rates of return on other assets. That increase in interest rates would reduce the market value of outstanding government bonds, causing losses for investors and perhaps precipitating a broader financial crisis by creating losses for mutual funds, pension funds, insurance companies, banks, and other holders of government debt—losses that might be large enough to cause some financial institutions to fail. A fiscal crisis can also make private-sector borrowing more expensive because uncertainty about the government's responses can reduce confidence in the viability of private-sector enterprises. Higher private-sector interest rates, when combined with reduced government spending and increased taxes, have tended to worsen economic conditions in the short term.

Unfortunately, predicting with any confidence whether or when such a fiscal crisis might occur in the United States is not possible. In particular, there is no identifiable tipping point in the debt-to-GDP ratio to indicate that a crisis is likely or imminent. All else being equal, however, the larger a government's debt, the greater the risk of a fiscal crisis.

The likelihood of such a crisis also depends on economic conditions. If investors expect continued economic growth, they are generally less concerned about the government's debt burden; conversely, substantial debt can reinforce more generalized concern about an economy. Thus, in many cases around the world, fiscal crises have begun during recessions—and, in turn, have exacerbated them. In some instances, a crisis has been triggered by news that a government would need to borrow an unexpectedly large amount of money. Then, as investors lost confidence and interest rates spiked, borrowing became more expensive for the government.

If a fiscal crisis were to occur in the United States, policymakers would have only limited—and unattractive—options for responding. In particular, the government would need to undertake some combination of three approaches: restructure the debt (that is, seek to modify the contractual terms of existing obligations), pursue an inflationary monetary policy, and adopt an austerity program of spending cuts and tax increases. Thus, such a crisis would confront policymakers with extremely difficult choices and probably have a significantly negative effect on the country.

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8. See, for example, Carmen M. Reinhart and Kenneth S. Rogoff, "The Aftermath of Financial Crises," *American Economic Review*, vol. 99, no. 2 (May 2009), pp. 466–472, http://tinyurl.com/ml9kchv; and Carmen M. Reinhart and Vincent R. Reinhart, "After the Fall," *Macroeconomic Challenges: The Decade Ahead* (Federal Reserve Bank of Kansas City, 2010), http://tinyurl.com/lntnp6j (PDF, 1.6 MB). Also see Luc Laeven and Fabian Valencia, *Systemic Banking Crises Database: An Update,* Working Paper 12-163 (International Monetary Fund, June 2012), http://tinyurl.com/p2clvmy.

9. For additional discussion, see Congressional Budget Office, *Federal Debt and the Risk of a Fiscal Crisis* (July 2010), www.cbo.gov/publication/21625.

CBO's Approach to Producing Long-Term Projections

Under the extended baseline, CBO's assumptions about policies governing federal spending and revenues generally reflect current law, incorporating the same assumptions underlying the agency's 10-year baseline through 2025 and then extending the baseline concept to later years. To formulate its extended baseline, CBO projects demographic and economic conditions for the decades ahead and develops assumptions about future policies for the major categories of federal spending and revenues. The set of projected demographic and economic conditions, which CBO refers to as its economic benchmark, is consistent with CBO's 10-year baseline projections, as adjusted for recently enacted legislation, and reflects CBO's assessment of long-term demographic and economic trends thereafter; instead of incorporating the changes in federal debt and tax rates under the extended baseline, the economic benchmark incorporates the assumption that federal debt as a share of GDP and marginal tax rates remain constant at their 2025 levels in subsequent years. (That approach produces a relatively stable economic benchmark, which is described more fully in Appendix A.) Because the long-term projections of federal spending, revenues, and debt presented in this and the next four chapters reflect the relatively stable economic conditions underlying the economic benchmark, those projections do not incorporate the economic effects of rising debt beyond 2025 or possible changes to fiscal policies; those considerations are addressed in Chapters 6 and 7.

Economic Projections

Economic growth will be slower in the future than it has been in the past, CBO projects, largely because of a slowdown in the growth of the labor force resulting from the retirement of members of the baby-boom generation, declining birthrates, and the leveling-off of increases in women's participation in the labor market. The labor force is projected to grow at an average annual rate of 0.5 percent over the next 25 years, compared with the 1.7 percent recorded during the 1965–2007 period.[10] CBO projects that future productivity growth will be close to its historical average. Accounting for those and other economic variables, CBO projects that real (inflation-adjusted) GDP will increase at an average annual rate of 2.2 percent over the next 25 years, compared with 3.3 percent during the 1965–2007 period.

In the economic benchmark—where debt as a percentage of GDP is assumed to remain constant at the 2025 level—CBO projects that interest rates will rise from the unusually low levels in effect today but still be lower in the future than they have been, on average, during the past few decades. According to CBO's most recent economic projection for the next decade, the real interest rate (specifically, the interest rate after adjusting for the rate of increase in the consumer price index) on 10-year Treasury notes is projected to rise to 2.2 percent for the 2020–2025 period. After 2025, it is projected to rise to 2.3 percent and remain at that level, below its average of 3.1 percent over both the 1965–2007 and 1990–2007 periods.[11]

The average interest rate on all federal debt held by the public tends to be a little lower than the rate on 10-year Treasury notes because interest rates are generally lower on shorter-term debt than on longer-term debt; and, since the 1950s, the average maturity of federal debt has been shorter than 10 years. CBO projects that the average real interest rate on all federal debt held by the public will be 2.0 percent after 2025.

For the 2015–2040 period, the real interest rate on 10-year Treasury notes is projected to average 2.2 percent, and the rate for all federal debt held by the public is projected to average 1.5 percent. The average interest rate on federal debt is projected to rise more slowly than rates on 10-year Treasury notes because only a portion of federal debt matures each year.

If those figures for real interest rates were adjusted instead to reflect the rate of increase in the GDP price index (or the price index for personal consumption expenditures), the real interest rate on all federal debt held by the public over the next 25 years would average 1.9 percent. Thus, during the next 25 years as a whole, the growth rate of GDP—at 2.2 percent—is projected to exceed the average real interest rate on federal debt. (Beyond 2025, the

10. In its assessment of historical experience, CBO has excluded the years that have elapsed since 2007 because of the effects of the recession.

11. For comparisons of historical real rates, past values of the consumer price index were based on the Consumer Price Index Research Series Using Current Methods from the Bureau of Labor Statistics; that series accounts for changes over time in how that index measures inflation.

average interest rate on federal debt is projected to be only slightly higher than the growth rate of GDP.) When the interest rate is about the same as the growth rate of GDP, the ratio of debt to GDP would remain steady over time if the federal budget, excluding interest payments, was in balance.

Policy Assumptions

Under CBO's extended baseline, projections for the 2016–2025 period are identical to those in the agency's 10-year baseline, as adjusted for recently enacted legislation. For later years, the extended baseline generally follows the baseline concept (see Table 1-1 for a summary of CBO's policy assumptions).

Major Health Care Programs. CBO projects federal spending for the government's major health care programs—Medicare, Medicaid, the Children's Health Insurance Program, and insurance subsidies provided through the exchanges created under the ACA—for 2015 through 2025 under the assumption that there will generally be no changes to laws currently governing those programs. (Unless otherwise specified, Medicare outlays are presented net of offsetting receipts, mostly premiums paid by enrollees, which reduce net outlays for that program.)

Beyond 2025, the considerable uncertainty that surrounds the evolution of the health care delivery and financing systems leads CBO to employ a formulaic approach in its projections of federal spending for health care programs. Specifically, CBO combines estimates of the number of people who will be receiving benefits from the government's health care programs with fairly mechanical estimates of the growth in spending per beneficiary. (See Chapter 2 for details about the long-term projections for the major health care programs; CBO assumes that Medicare will pay benefits as scheduled under current law regardless of the status of the program's trust funds—an assumption that is consistent with a statutory requirement that, in its 10-year baseline projections, CBO assume that funding for entitlement programs is adequate to make all payments required by law.)[12]

Social Security. CBO projects spending for Social Security under the assumption that there will be no changes to laws currently governing that program. The agency also assumes that Social Security will pay benefits as scheduled under current law regardless of the status of the program's trust funds.[13] (For more on Social Security, see Chapter 3.)

Other Mandatory Programs. For other mandatory programs—such as retirement programs for federal civilian and military employees, certain veterans' programs, the Supplemental Nutrition Assistance Program (SNAP), unemployment compensation, and refundable tax credits—the projections through 2025 are based on the assumption that current law will remain generally unchanged.[14] For years after 2025, CBO projects outlays for refundable tax credits as part of its revenue projections and projects spending for the remaining mandatory programs as a whole by assuming that such spending will decline as a share of GDP after 2025 at the same annual rate that it is projected to fall between 2020 and 2025. That is, CBO does not estimate outlays for each program separately after 2025 (see Chapter 4).

Discretionary Spending. Discretionary spending in the extended baseline matches that in the 10-year baseline through 2025. Under current law, most of the government's discretionary appropriations for the 2015–2021 period are constrained by the caps put in place by the Budget Control Act of 2011, as amended. For 2022 through 2025, those appropriations are assumed to grow from the 2021 amount at the rate of anticipated inflation. Funding for certain purposes, such as war-related activities, is not constrained by the caps; CBO assumes that such funding will increase each year through 2025 at the rate of inflation, starting from the amount appropriated for the current year. After 2025, discretionary spending is assumed to remain fixed at its percentage of GDP in 2025 (see Chapter 4).

Revenues. Revenue projections through 2025 follow the 10-year baseline, which generally incorporates the

12. Section 257(b)(1) of the Balanced Budget and Emergency Deficit Control Act of 1985, 2 U.S.C. §907(b)(1).

13. The balances of the trust funds represent the total amount that the government is legally authorized to spend for those purposes. For a discussion of the legal issues related to exhaustion of a trust fund, see Noah P. Meyerson, *Social Security: What Would Happen If the Trust Funds Ran Out?* Report for Congress RL33514 (Congressional Research Service, August 28, 2014).

14. The law governing CBO's baseline projections (section 257(b)(2) of the Deficit Control Act) makes exceptions for some programs, such as SNAP, that have expiring authorizations but that are assumed to continue as currently authorized.

Table 1-1.

Assumptions About Policies for Spending and Revenues Underlying CBO's Extended Baseline

	Assumptions About Policies for Spending
Social Security	As scheduled under current law[a]
Medicare	As scheduled under current law through 2025; thereafter, projected spending depends on the estimated number of beneficiaries and health care costs per beneficiary (for which growth is projected to move smoothly to the underlying path of excess cost growth rates over the succeeding 15 years and then follow that path)[a]
Medicaid	As scheduled under current law through 2025; thereafter, projected spending depends on the estimated number of beneficiaries and health care costs per beneficiary (for which growth is projected to move smoothly to the underlying path of excess cost growth rates over the succeeding 15 years and then follow that path)
Children's Health Insurance Program	As projected in CBO's baseline through 2025; remaining constant as a percentage of GDP thereafter
Exchange Subsidies	As scheduled under current law through 2025; thereafter, projected spending depends on the estimated number of beneficiaries, an additional indexing factor for subsidies, and health care costs per beneficiary (for which growth is projected to move smoothly to the underlying path of excess cost growth rates over the succeeding 15 years and then follow that path)
Other Mandatory Spending	As scheduled under current law through 2025; thereafter, refundable tax credits are estimated as part of revenue projections, and the rest of other mandatory spending is assumed to decline as a percentage of GDP at the same annual rate at which it is projected to decline between 2020 and 2025
Discretionary Spending	As projected in CBO's baseline through 2025; remaining constant as a percentage of GDP thereafter
	Assumptions About Policies for Revenues
Individual Income Taxes	As scheduled under current law
Payroll Taxes	As scheduled under current law
Corporate Income Taxes	As scheduled under current law through 2025; remaining constant as a percentage of GDP thereafter
Excise Taxes	As scheduled under current law[b]
Estate and Gift Taxes	As scheduled under current law
Other Sources of Revenues	As scheduled under current law through 2025; remaining constant as a percentage of GDP thereafter

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

For CBO's most recent 10-year baseline projections, see Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), www.cbo.gov/publication/49973.

GDP = gross domestic product.

a. Assumes the payment of full benefits as calculated under current law, regardless of the amounts available in the program's trust funds.

b. The sole exception to the current-law assumption applies to expiring excise taxes dedicated to trust funds. The Balanced Budget and Emergency Deficit Control Act of 1985 requires CBO's baseline to reflect the assumption that those taxes would be extended at their current rates. That law does not stipulate that the baseline include the extension of other expiring tax provisions, even if they have been routinely extended in the past.

assumption that various tax provisions will expire as scheduled even if they have routinely been extended in the past. After 2025, rules for individual income taxes, payroll taxes, excise taxes, and estate and gift taxes are assumed to evolve as scheduled under current law.[15] Because of the structure of current tax law, total federal revenues from those sources are estimated to grow faster than GDP over the long term. Revenues from corporate income taxes and other sources (such as receipts from the Federal Reserve) are assumed to remain constant as a percentage of GDP after 2025 (see Chapter 5).

Projected Spending Through 2040

Over the past 50 years, federal outlays other than those for the government's net interest costs have averaged 18 percent of GDP. However, in the past several years, noninterest spending has been well above that average, both because of underlying trends and because of temporary circumstances (namely, the financial crisis, the weak economy, and policies implemented in response to them). Noninterest spending spiked to 23 percent of GDP in 2009 but then declined, falling to about 19 percent this year. If current laws that affect spending were unchanged, noninterest outlays would remain at about 19 percent of GDP throughout the coming decade, CBO projects, as an increase in mandatory spending was offset by a decline in discretionary spending relative to the size of the economy. After the mid-2020s, however, under the assumptions of the extended baseline, noninterest spending would rise relative to the size of the economy, mostly because of increased spending for major health care programs, reaching 21 percent of GDP by 2040.

CBO projects that, under current law, net outlays for interest would jump from 1.3 percent of GDP this year to almost 3 percent 10 years from now. By 2040, interest costs would be 4.3 percent of GDP, bringing total federal spending to over 25 percent of GDP (see Figure 1-4). Federal spending has been larger relative to the size of the economy only during World War II, when it topped 40 percent of GDP for three years.

15. The sole exception to that current-law assumption applies to expiring excise taxes dedicated to trust funds. The Deficit Control Act requires CBO's baseline to reflect the assumption that those taxes would be extended at their current rates. That law does not stipulate that the baseline include the extension of other expiring tax provisions, even if they have been routinely extended in the past.

Spending for Major Health Care Programs and Social Security

Mandatory programs have accounted for a rising share of the federal government's noninterest spending over the past few decades, reaching more than 60 percent in recent years. Most of the growth in mandatory spending has involved the three largest programs—Medicare, Medicaid, and Social Security. Federal outlays for those programs together made up almost half of the government's noninterest spending, on average, during the past 10 years, compared with less than a sixth five decades ago.

Most of the anticipated growth in noninterest spending as a share of GDP over the long term is expected to come from the government's major health care programs: Medicare, Medicaid, the Children's Health Insurance Program, and the subsidies for health insurance purchased through the exchanges created under the ACA. CBO projects that, under current law, total outlays for those programs over the next 25 years, net of offsetting receipts, would grow much faster than the overall economy, increasing from 5.2 percent of GDP now to 8.0 percent in 2040 (see Chapter 2). Spending for Social Security also would increase relative to the size of the economy, but by much less—from 4.9 percent of GDP in 2015 to 6.2 percent in 2040 and beyond (see Chapter 3).

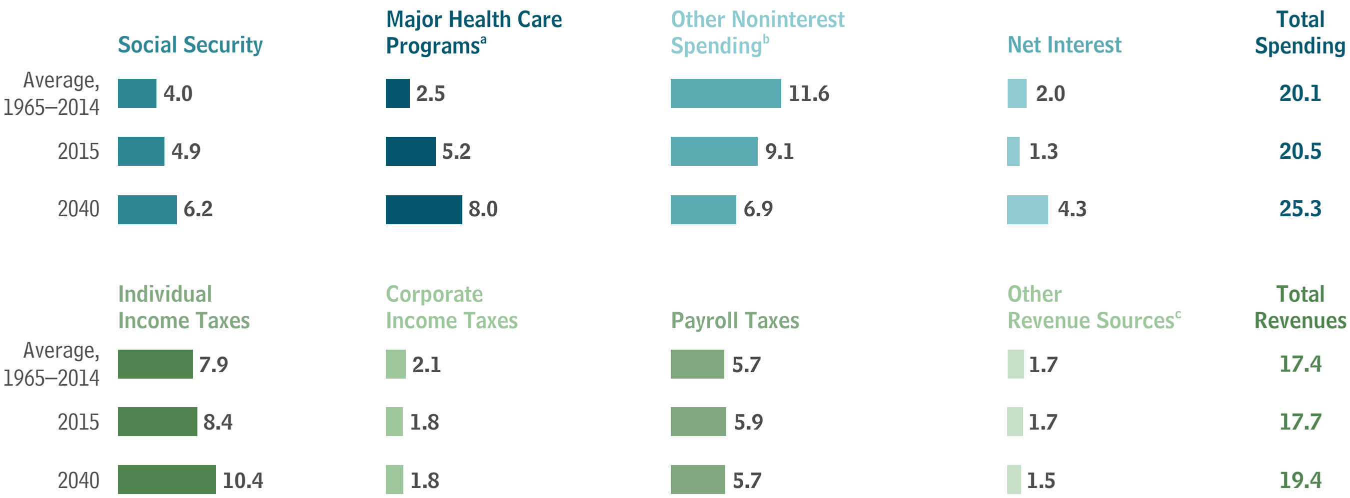
Those projected increases in spending for the government's major health care programs and Social Security between 2015 and 2040 are attributable primarily to three causes: the aging of the population; rising health care spending per beneficiary; and, to a lesser extent, an increased number of recipients of exchange subsidies and Medicaid benefits attributable to the ACA. (For estimates of the extent to which each cause contributes to the projected increases in spending, see Box 1-1 on page 24.)

The Aging of the Population. The retirement of members of the baby-boom generation portends a long-lasting shift in the age profile of the U.S. population—a change that will substantially alter the balance between working-age and retirement-age groups. During the next decade alone, the number of people age 65 or older is expected to rise by more than one-third, and the share of the population age 65 or older is projected to grow from the current 15 percent to 21 percent in 2040. By contrast, the share of the population between the ages of 20 and 64 is expected to drop from 59 percent to 54 percent.

Figure 1-4.

Spending and Revenues Under CBO's Extended Baseline, Compared With Past Averages

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

a. Consists of spending on Medicare (net of offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies offered through health insurance exchanges.

b. Consists of all federal spending other than that for the major health care programs, Social Security, and net interest.

c. Consists of excise taxes, remittances to the Treasury from the Federal Reserve System, customs duties, estate and gift taxes, and miscellaneous fees and fines.

The aging of the population is the main factor driving the projected growth of Social Security spending as a percentage of GDP. Initial Social Security benefits are based on a person's earnings history, but those earnings are indexed to the overall growth of wages in the economy, so average benefits increase at approximately the same rate as average earnings. As a result, economic growth does not significantly alter spending for Social Security as a share of GDP. Rather, that share depends primarily on the ratio of the number of people working in jobs covered by Social Security (covered workers) to the number of Social Security beneficiaries. CBO projects that the ratio of covered workers to beneficiaries will decline significantly over the next quarter century—from 3 to 1 now to almost 2 to 1 in 2040—and then continue to drift downward.

Rising Health Care Spending per Beneficiary. Although the growth of health care spending has been slower during the past several years than it had been historically, CBO projects that per-enrollee spending in federal health care programs will continue to increase at a faster pace than potential GDP per capita over the next 25 years. The growth rate of spending per beneficiary in Medicare and Medicaid is projected to remain very low over the next few years but is then projected to increase gradually through 2040 (although remaining below its average growth rate of the past few decades). Compared with Medicare and Medicaid, costs per enrollee in private insurance are expected to grow more rapidly over the coming decade, but CBO projects a gradual slowing in later years. Although costs per beneficiary in federal health care programs are projected to increase faster than potential GDP per capita over the 25-year projection period, the difference between those two growth rates will be smaller than its average of recent decades, CBO projects (see Chapter 2).

Increased Number of Recipients of Exchange Subsidies and Medicaid Benefits. Under the ACA, many people can purchase subsidized insurance through the health insurance exchanges (or marketplaces) that are operated by the federal or state governments. Those subsidies come in two forms: refundable tax credits that can be applied to premiums, and cost-sharing subsidies that reduce deductibles and copayments. CBO anticipates that the number of participants will increase over the next few years and that between 16 million and 17 million people will receive subsidized health insurance coverage through the exchanges in each year between 2019 and 2025, compared with 8 million now.[16] Also, several million others will obtain unsubsidized coverage through the exchanges.

In addition, as a result of the ACA and a subsequent Supreme Court ruling, each state has the option to expand eligibility for Medicaid to most nonelderly adults whose income is below 138 percent of the federal poverty guidelines (commonly known as the federal poverty level, or FPL).[17] By calendar year 2020, CBO anticipates, 80 percent of the people who meet the new eligibility criteria will live in states that will have expanded their programs.[18] Each year between 2020 and 2025, about 14 million more people, on net, are projected to have coverage through Medicaid than would have had such coverage in the absence of the ACA, compared with 10 million more now.

Other Noninterest Spending

In the extended baseline, total federal spending for everything other than the major health care programs, Social Security, and net interest declines to a smaller percentage of GDP than has been the case for more than 70 years. Such spending has amounted to more than 8 percent of GDP each year since the 1930s, reaching as much as 13 percent of GDP in 1965 and 12 percent in 1990; CBO estimates that it will be 9.1 percent of GDP in 2015. Under the assumptions used for this analysis, that spending is projected to fall below 8 percent of GDP in 2021 and then to decline further, dropping to 6.9 percent of GDP in 2040 (see Chapter 4).

Spending for discretionary programs is projected to decline significantly over the next 10 years relative to GDP—from 6.5 percent to 5.1 percent—because of the constraints on discretionary funding imposed by the Budget Control Act. For its long-term projections, CBO assumed that, in subsequent years, discretionary outlays would remain at the share of GDP projected for 2025.

Spending for mandatory programs other than the major health care programs and Social Security also is projected to decline relative to the size of the economy over the next 10 years. That spending accounts for 2.6 percent of GDP today and, under current law, is projected to fall to 2.3 percent of GDP in 2025. That decline would occur in part because the improving economy would reduce the number of people eligible for some programs in this category and in part because payments per beneficiary under some programs tend to rise with prices (which usually increase more slowly than people's income). Beyond 2025, CBO projects, other mandatory spending, excluding the portion stemming from refundable tax credits, would decline as a share of GDP at the same annual rate at which it is projected to fall between 2020 and 2025. As a result, other mandatory spending would fall to 1.8 percent of GDP by 2040—lower than at any point at least since 1962 (the first year for which comparable data are available).

Interest Payments

CBO expects interest rates to rebound in coming years from their current unusually low levels. As a result, the government's net interest costs are projected to more than double relative to the size of the economy over the next decade—from 1.3 percent of GDP in 2015 to 3.0 percent by 2025—even though, under current law, federal debt would be only slightly larger relative to GDP at the end of that decade than it is today.

Beyond 2025, interest rates in the economic benchmark are assumed to increase only slightly from their projected levels in 2025, so changes in net interest costs would roughly parallel changes in the amount of federal debt held by the public. By 2040, those costs would reach 4.3 percent of GDP under current law. Growth in net interest payments and growth in debt are mutually reinforcing: Rising interest payments push up deficits and debt, and rising debt pushes up interest payments.

16. See Congressional Budget Office, *Effects of the Affordable Care Act on Health Insurance Coverage—Baseline Projections* (March 2015), Table 3, www.cbo.gov/publication/43900.

17. The ACA expanded eligibility for Medicaid to include nonelderly residents with income of up to 133 percent of the FPL, but the law defines the income used to determine eligibility in a way that effectively increases that threshold to 138 percent of the FPL. The FPL is currently $24,250 for a family of four. See Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation, "2015 Poverty Guidelines" (January 2015), http://aspe.hhs.gov/poverty/15poverty.cfm. As a result of the Supreme Court's decision on June 28, 2012, in *National Federation of Independent Business v. Sebelius,* 132 S. Ct. 2566 (2012), some states may choose not to expand their programs.

18. See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), p. 69, www.cbo.gov/publication/49892.

Box 1-1.

Causes of Projected Growth in Federal Spending for the Major Health Care Programs and Social Security

Under its extended baseline, the Congressional Budget Office projects that the growth of federal noninterest spending as a share of gross domestic product (GDP) between 2015 and 2040 would result entirely from increases in spending for four large mandatory programs—Medicare, Medicaid, the subsidies provided through the health insurance exchanges established under the Affordable Care Act (ACA), and Social Security.[1] The health care programs currently account for about half of the overall spending for those four programs, and they would be responsible for more than two-thirds of the projected increase in such spending over the next 25 years. (By contrast, under the assumptions that govern the extended baseline, total federal spending on everything other than those four programs and net interest is projected to fall significantly as a percentage of GDP over the next 25 years.)

Three factors underlie the projected increase in federal spending for the health care programs and Social Security relative to the size of the economy:

- The aging of the U.S. population, which will increase the share of the population receiving benefits from those programs and also affect the average age, and thus the average health care costs, of beneficiaries;
- The effects of excess cost growth—that is, the extent to which health care costs per beneficiary, as adjusted for demographic changes, grow faster than potential GDP per capita;[2] and
- The increase, beyond that which has occurred through 2015, in enrollment in Medicaid under the ACA and in the number of people receiving subsidies for health insurance purchased through the exchanges.

1. The Children's Health Insurance Program, which is usually grouped with major federal health care programs in CBO's long-term projections, is not included in this analysis of the causes of projected growth.

CBO calculated how much of the projected growth in federal spending for the major health care programs and Social Security over the 2015–2040 period could be attributed to each of the three factors. (Of those factors, aging is the only one that affects CBO's projections for Social Security.) The agency compared the outlays projected for those programs under the extended baseline with the outlays that would occur under three alternative paths, each of which includes no increase in the number of recipients of exchange subsidies and Medicaid benefits attributable to the ACA: One included aging of the population but no excess cost growth; one included excess cost growth but no aging of the population; and one included both aging and excess cost growth.

The ways in which the aging of the population and excess cost growth interact accentuate those factors' individual effects. For example, as aging causes the number of Medicare beneficiaries to increase, rising health care spending per person has a greater impact on federal spending for health care. Likewise, when per-person health care costs rise, the increasing number of beneficiaries has greater budgetary consequences. The effect of that interaction can be identified separately—or, as in CBO's analysis, it can be allocated in proportion to the shares of projected growth that are attributable to the two factors: aging and excess cost growth.

2. Potential GDP is the economy's maximum sustainable output.

Continued

Projected Revenues Through 2040

Over the past 50 years, federal revenues as a share of GDP have averaged 17.4 percent—fluctuating between 14.6 percent and 20 percent of GDP—with no evident trend over time. After amounting to 17.9 percent of GDP in 2007, federal revenues fell sharply in 2009, to 14.6 percent of GDP, primarily because of the recession. With an improving economy and changes in certain tax rules that have resulted in higher tax rates, revenues will rebound to 17.7 percent of GDP in 2015, CBO estimates.

Box 1-1. Continued

Causes of Projected Growth in Federal Spending for the Major Health Care Programs and Social Security

Explaining Projected Growth in Federal Spending for the Major Health Care Programs and Social Security as a Share of GDP

	Percentage of Projected Growth Through	
	2025	2040
	Major Health Care Programs and Social Security	
Aging	62	56
Excess Cost Growth	17	35
Increased Number of Recipients of Exchange Subsidies and Medicaid Benefits Attributable to the ACA	21	10
	Major Health Care Programs	
Aging	42	43
Excess Cost Growth	26	45
Increased Number of Recipients of Exchange Subsidies and Medicaid Benefits Attributable to the ACA	32	12

Source: Congressional Budget Office.

Note: ACA = Affordable Care Act; GDP = gross domestic product.

The aging of the population and excess cost growth also affect the budgetary impact of the additional recipients of exchange subsidies and Medicaid benefits attributable to the ACA but in different directions: Excess cost growth increases the effect of the increased number of recipients on federal health care spending, but aging decreases the effect by reducing the share of the population that is under the age of 65 and, therefore, potentially eligible for the expanded federal benefits.

According to CBO's calculations, the aging of the population accounts for 56 percent of the projected growth in federal spending for the major health care programs and Social Security as a share of GDP through 2040 (see the table). Excess cost growth accounts for 35 percent, and the increased number of recipients of exchange subsidies and Medicaid benefits attributable to the ACA accounts for the remaining 10 percent. (For more information about CBO's projections of demographic changes over the 25-year period, see Figure 2-3 on page 45; for more information about excess cost growth and spending on federal health care programs, see Chapter 2.)

For the major health care programs alone, the relative impact of the population's aging is smaller, and the significance of factors related to health care is greater. Through 2040, aging accounts for 43 percent of projected growth in federal spending for those programs as a share of GDP, excess cost growth accounts for 45 percent, and the increased number of recipients of exchange subsidies and Medicaid benefits attributable to the ACA together account for 12 percent; most of that growth is projected to occur during the next few years. Total federal spending for those programs would increase from 5.2 percent of GDP in 2015 to 8.0 percent in 2040 under current law, CBO projects. Of that 2.8 percentage-point increase, aging would contribute 1.2 percentage points; excess cost growth, 1.3 percentage points; and the increased number of recipients of the exchange subsidies and Medicaid benefits attributable to the ACA, 0.3 percentage points.

Individual income taxes account for the bulk of federal revenues, almost half of all revenues in 2014; payroll taxes (also known as social insurance taxes) account for about one-third of all revenues; and corporate income taxes and excise taxes account for most of the remainder.[19]

CBO projects that, under current law, revenues would grow over the coming decade relative to GDP—to 18.3 percent of GDP in 2025. Individual income taxes would rise as a percentage of GDP largely because of structural features of the tax system, most significantly, real bracket creep—the pushing of a growing share of income into higher tax brackets because of a growth in real (inflation-adjusted) income and the interaction of the tax system with inflation. That increase would be

19. Most payroll tax revenues come from taxes designated for Social Security and Medicare; the rest come mainly from taxes for unemployment insurance.

partially offset by declines in other taxes relative to GDP, most notably receipts from the Federal Reserve.

Over the long term, revenues would keep growing slightly more rapidly than GDP under current law, as the effect of real bracket creep continues and certain tax increases enacted in the ACA generate a growing amount of revenues in relation to the size of the economy. By 2040, total revenues would be 19.4 percent of GDP, CBO projects. Increases in receipts from individual income taxes account for more than the 1.7 percentage-point rise in total revenues as a percentage of GDP over the next 25 years; receipts from all other sources, taken together, are projected to decline slightly as a percentage of GDP (see Chapter 5).

Even if no changes in tax law were enacted in the future, the effects of the tax system in 2040 would differ in significant ways from what those effects are today. Average taxpayers at all income levels would pay a greater share of income in taxes than similar taxpayers do now, primarily because a greater share of their income would be taxed in higher tax brackets. Moreover, the effective marginal tax rate on labor income (the percentage of an additional dollar of labor income paid in federal taxes) would be about 32 percent, compared with the current 29 percent. In contrast, the effective marginal tax rate on capital income (the percentage of an additional dollar of income from investments paid in federal taxes) would rise only slightly and remain close to 18 percent.

Changes From Last Year's Long-Term Budget Outlook

Each time it prepares long-term budget projections, CBO incorporates the effects of new legislation and updates the economic and technical aspects of its projections. The projections of federal revenues and overall noninterest outlays presented in this report are generally similar to those published in 2014, despite certain changes in law, revisions to some of the agency's assumptions and methods, and the availability of more recent data.[20] A downward revision to the projections for interest rates has lowered the projection for net interest costs and, as a result, CBO projects slightly lower debt in 2040 than the agency projected last year. That same downward revision to the projections for interest rates and some other changes have led CBO to estimate a smaller fiscal gap and a greater actuarial deficit for Social Security. (The key revisions to the projections since last year are discussed in Appendix B.)

Taken together, legislative, economic, and technical changes had the following effects on CBO's view of the federal budget in the long term:

- Under the extended baseline, CBO now projects that debt would reach 101 percent of GDP in 2039, compared with a projection last year of 106 percent. (Those figures do not incorporate feedback from the economic impact of those paths for federal debt; with such feedback considered, debt in 2039 is now projected to grow to 105 percent of GDP, compared with the 111 percent projected last year.)

- The estimated fiscal gap is smaller this year than last year. For the 2016–2040 period, CBO now estimates that cuts in noninterest spending or increases in revenues equal to 1.1 percent of GDP in each year through 2040 would be required to have debt in 2040 equal the same percentage of GDP that it constitutes today; last year, for the 2015–2039 period, CBO estimated that changes equal to 1.2 percent of GDP would be required. By itself, the reduction in projected interest rates on federal debt would have brought the gap down by 0.3 percent of GDP, but changes in projected GDP and the shift in the projection period offset most of that effect.

- The actuarial shortfall for the Social Security trust funds is estimated to be larger this year than was estimated last year. The estimated actuarial balance for Social Security is the sum of the present value of projected tax revenues and the trust funds' current balance minus the sum of the present value of projected outlays and a target balance at the end of the period; that difference is traditionally presented as a percentage of the present value of taxable payroll. CBO now estimates that the 75-year actuarial deficit for Social Security is 4.4 percent of taxable payroll, compared with the previous projection of 4.0 percent. That change reflects the reduction in projected interest rates, lower payroll tax revenues resulting from a lower projection of the taxable share of earnings, updated data, and other factors (see Chapter 3 and Appendix B).

20. For CBO's long-term projections for the 2014–2039 period, see Congressional Budget Office, *The 2014 Long-Term Budget Outlook* (July 2014), www.cbo.gov/publication/45471.

CHAPTER

2

The Long-Term Outlook for Major Federal Health Care Programs

Although spending for health care in the United States has grown more slowly in recent years than it did previously, high and rising amounts of such spending continue to pose a challenge not only for the federal government but also for state and local governments, businesses, and households. Total national spending on health care services and supplies—that is, by all people and entities in the United States, governmental and nongovernmental—increased from 4.6 percent of gross domestic product (GDP) in calendar year 1960 to 9.5 percent in 1985 and to 16.4 percent, about one-sixth of the economy, in 2013, the most recent year for which such data are available.[1] Federal spending for Medicare (net of certain receipts, termed offsetting receipts, which mostly consist of premiums paid by beneficiaries) and Medicaid rose from 2.0 percent of GDP in 1985 to 4.7 percent in 2014.[2]

Underlying those trends is the fact that health care spending per person has grown faster, on average, than the nation's economic output per capita during the past few decades. The Congressional Budget Office estimates that growth in health care spending per person outpaced growth in potential (or maximum sustainable) GDP per capita by an average of 1.4 percent per year between calendar years 1985 and 2013.[3] Key factors contributing to that faster growth were the emergence and increasing use of new medical technologies, rising personal income, and the declining share of health care costs that people paid out of pocket. Those factors were partly offset by other influences, including the spread of managed care plans in the 1990s, the 2007–2009 recession, and various legislated changes in Medicare's payment policies.

The future growth of health care spending by the federal government will depend on many factors, including demographic changes and the behavior of households, businesses, and state and local governments. (It will also depend on federal law, but CBO's extended baseline projections, which focus on the 25-year period ending in 2040, are generally based on the assumption that current law will not change.) CBO's extended baseline projections of federal health care spending match its 10-year baseline projections as adjusted to reflect recently enacted legislation for the next 10 years but employ a formulaic approach beyond that period, reflecting the considerable uncertainties about the evolution of the health care delivery and financing systems in the long run.[4] Specifically, CBO has projected federal spending after 2025 by

1. Centers for Medicare & Medicaid Services, National Health Expenditure Accounts, "NHE Tables" (accessed April 3, 2015), http://go.usa.gov/jmGY.

2. In this chapter, net federal spending for Medicare refers to gross spending for Medicare minus offsetting receipts, which are recorded in the budget as offsets to spending. When this chapter refers to net federal spending for *all* major federal health care programs, it means gross spending for all those programs minus offsetting receipts for Medicare.

3. As this chapter explains later, CBO derived that estimate after adjusting for demographic changes and giving greater weight to more recent years (in order to more closely reflect current trends in spending for health care).

4. The 10-year baseline referred to in this chapter is the one issued in March 2015, but adjusted to reflect legislation that was enacted after it was prepared. For the March baseline, see Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), www.cbo.gov/publication/49973. The most important adjustment to that baseline was the incorporation of the estimated effect of Public Law 114-10, the Medicare Access and CHIP Reauthorization Act of 2015, which became law on April 16, 2015. See Congressional Budget Office, cost estimate for H.R. 2, the Medicare Access and CHIP Reauthorization Act of 2015 (March 25, 2015), www.cbo.gov/publication/50053.

combining estimates of the number of people who will receive benefits from government health care programs with fairly mechanical estimates of the growth of spending per beneficiary:

- Under current law, the first of those factors—the number of people receiving benefits from government programs—is projected to increase during the next few decades. That increase can be attributed to two main causes. The first is the aging of the population—in particular, of the large baby-boom generation—which will increase the number of people receiving benefits from Medicare by about one-third over the next decade. The second is the projected increase over the next few years in the number of people who will enroll in Medicaid or receive federal subsidies for health insurance purchased through exchanges under the provisions of the Affordable Care Act (ACA).

- The second factor in CBO's projections of federal spending, the growth of spending per beneficiary in most of the major health care programs, is projected to move slowly from the average rate projected for the years 2023 through 2025 (with certain adjustments) to what CBO considers its underlying growth rate.[5] Each program's underlying growth rate is essentially its long-term growth rate, which begins with the rate of growth in health care spending in recent decades and is projected to decline gradually—as people try to limit their spending for health care in order to maintain their consumption of other goods and services, and as state governments, private insurers, and employers respond to the pressures of rising health care costs.

On the basis of that formula, CBO expects that federal spending on the government's major health care programs will continue to rise substantially relative to GDP. The major health care programs are Medicare, Medicaid, the Children's Health Insurance Program (CHIP), and the subsidies for health insurance purchased through the exchanges.[6] In CBO's extended baseline, net federal spending for those programs grows from an estimated 5.2 percent of GDP in 2015 to 8.0 percent in 2040—of which 5.1 percentage points would be devoted to net spending on Medicare and 2.9 percentage points to spending on Medicaid, CHIP, and the exchange subsidies.

Those estimates are subject to considerable uncertainty (as Chapter 7 explains). A particular challenge currently is assessing how much of the recent slowdown in the growth of health care spending can be attributed to temporary factors, such as the recession, and how much reflects more enduring developments. Studies have generally concluded that part of the slowdown cannot be linked directly to the weak economy, although they differ considerably in their assessment of other factors' importance. CBO's own analysis found no direct link between the recession and slower growth in Medicare spending.[7] Accordingly, over the past several years, CBO has substantially reduced its 10-year and long-term projections of spending per person for Medicare, for Medicaid, and for the country as a whole. However, the growth rates for spending per person are expected to rebound somewhat from their recent very low levels without returning all the way to the high levels seen in the past.

Overview of Major Government Health Care Programs

A combination of private and public sources finances health care in the United States, mostly through various forms of health insurance. Most nonelderly Americans—

5. CBO followed that procedure for three of the four major health care programs but a different one for the Children's Health Insurance Program.

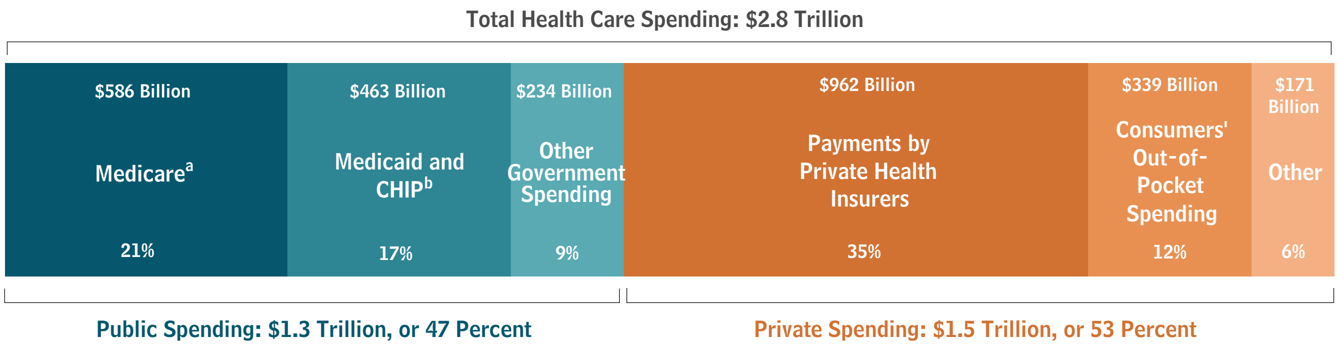
6. Federal spending on those programs is mandatory; that is, it results from budget authority provided in laws other than appropriation acts. Federal discretionary spending on health care—that is, spending that *is* subject to annual appropriations—is included not in the budget projections described here but rather in those for other noninterest spending (see Chapter 4 and Table 1-1 on page 20). Such discretionary spending includes spending for health research and for health care provided by the Veterans Health Administration. Some mandatory spending on health care (for example, spending for care for federal retirees) is also included in other noninterest spending; that mandatory spending represents a very small share of the federal budget. The spending for exchange subsidies that is analyzed in this chapter includes outlays for cost-sharing subsidies and for the refundable portion of subsidies for premiums; however, the reduction in taxes paid because of the premium subsidies—which is projected to be much smaller than the increase in outlays for the refundable portion of the subsidies—is included not here but in the revenue projections in Chapter 5.

7. Michael Levine and Melinda Buntin, *Why Has Growth in Spending for Fee-for-Service Medicare Slowed?* Working Paper 2013-06 (Congressional Budget Office, August 2013), www.cbo.gov/publication/44513.

Figure 2-1.

Distribution of Spending for Health Care, 2013

Total health care spending amounted to $2.8 trillion in calendar year 2013. That total does not include the cost to the federal government of the tax exclusion for employment-based health insurance, which amounted to roughly $250 billion in 2013.



Source: Congressional Budget Office based on data from the Centers for Medicare & Medicaid Services.

Note: CHIP = Children's Health Insurance Program.

a. Gross spending for Medicare refers to all of the program's spending not counting offsetting receipts (from premium payments made by beneficiaries to the government and amounts paid by states from savings on Medicaid's prescription drug costs) that are credited to the program.

b. Includes federal and state spending.

about 153 million of them in 2015, CBO and the staff of the Joint Committee on Taxation (JCT) estimate—have private health insurance obtained through an employer as their primary source of coverage. Many other people obtain insurance through government programs. In 2015, average monthly enrollment will be an estimated 55 million people in Medicare and an estimated 66 million in Medicaid.[8] In addition, CBO and JCT estimate that, over the course of this calendar year, an average of about 11 million nonelderly people will be covered by health insurance purchased through exchanges run by the federal government or state governments (though the total number enrolled at any particular time during the year might be higher), and most of those people will receive tax subsidies from the federal government to help pay for that insurance.[9] Another roughly 6 million people will be covered by a policy purchased directly from an insurer—that is, not through an exchange. At any given time during this calendar year, according to CBO and JCT's projections, about 35 million nonelderly people will be uninsured. Over the next few years, the number of people without insurance coverage is projected to decline.

In 2013, the most recent calendar year for which data are available, total spending for health care in the United States amounted to about $2.8 trillion (see Figure 2-1).[10] Of that amount, 53 percent was financed privately; specifically, 35 percent consisted of payments by private health insurers, 12 percent was consumers' out-of-pocket spending, and 6 percent came from other sources of

8. Congressional Budget Office, "Medicare—Baseline Projections" (March 2015), www.cbo.gov/publication/44205, and "Medicaid—Baseline Projections" (March 2015), www.cbo.gov/publication/44204. Both estimates given have been adjusted to reflect recently enacted legislation. Also, some people have coverage from more than one source at a time. Currently, about 8.3 million people with Medicaid coverage are also covered by Medicare, which is their primary source of coverage. For information about people eligible for benefits through both programs, see Congressional Budget Office, *Dual-Eligible Beneficiaries of Medicare and Medicaid: Characteristics, Health Care Spending, and Evolving Policies* (June 2013), www.cbo.gov/publication/44308.

9. Congressional Budget Office, "Effects of the Affordable Care Act on Health Insurance Coverage—Baseline Projections" (March 2015), www.cbo.gov/publication/43900. The estimates given have been adjusted to reflect recently enacted legislation.

10. This report defines total spending for health care as the health consumption expenditures in the national health expenditure accounts maintained by the Centers for Medicare & Medicaid Services. That definition excludes spending on medical research, structures, and equipment. Under a broader definition that includes those categories, total national spending for health care was 17.4 percent of GDP in calendar year 2013. For more information, see Micah Hartman and others, "National Health Spending in 2013: Growth Slows, Remains in Step With the Overall Economy," *Health Affairs*, vol. 34, no. 1 (January 2015), pp. 150–160, http://dx.doi.org/10.1377/hlthaff.2014.1107.

private funds, such as philanthropy.[11] The remaining 47 percent of total spending on health care was public: gross federal spending for Medicare, which made up 21 percent of the total; federal and state spending for Medicaid and CHIP, which accounted for 17 percent; and spending on various other programs (including those run by state and local governments' health departments, by the Department of Veterans Affairs, and by the Department of Defense), which accounted for 9 percent.

A significant share of private health care spending is subsidized through provisions in the tax code—primarily through the tax exclusion for employment-based health insurance, which is not reflected in the reported totals for health care spending. Under that provision, most payments that employers and employees make for health insurance coverage are exempt from payroll and income taxes. CBO estimates that in 2013, the federal cost, or tax expenditure, associated with that exclusion was roughly $250 billion, or 1.5 percent of GDP—a sum that was equal to nearly one-quarter of all spending on private health insurance and roughly equal to federal spending on Medicaid in that year.[12] It is projected to equal 1.6 percent of GDP over the 2016–2025 period.[13]

Medicare

In 2015, according to CBO's projections, Medicare will provide health insurance to about 55 million people who are elderly, are disabled, or have end-stage renal disease. The elderly make up about 85 percent of the enrollees; in general, people become eligible for Medicare when they reach 65, and disabled people become eligible 24 months after they qualify for benefits under Social Security's Disability Insurance program.[14]

The Medicare program provides a specified set of benefits. Hospital Insurance (HI), or Medicare Part A, covers inpatient services provided by hospitals, care in skilled nursing facilities, home health care, and hospice care. Part B mainly covers services provided by physicians, other practitioners, and hospitals' outpatient departments. Part D provides a prescription drug benefit. Most enrollees in Medicare are in the traditional fee-for-service program, in which the federal government pays for covered services directly; but about 30 percent have opted for Part C of the program, known as Medicare Advantage, in which they get coverage for Medicare benefits through a private health insurance plan. In 2014, gross spending for Medicare was $600 billion, and net spending (that is, gross spending minus offsetting receipts, which mostly consist of beneficiaries' payments of premiums) was $506 billion.

Parts A, B, and D of the program are financed in different ways. Outlays for Part A are financed by dedicated sources of income credited to a fund called the Hospital Insurance Trust Fund. Of those dedicated sources, the primary one is a payroll tax (amounting to 2.9 percent of all earnings), and the others are a 0.9 percent tax on earnings over $200,000 (or $250,000 for married couples) and a portion of the federal income taxes paid on Social Security benefits.[15] For Part B, premiums paid by beneficiaries cover just over one-quarter of outlays, and the government's general fund covers the rest. Enrollees' premiums under Part D are set to cover about one-quarter of the cost of the basic prescription drug benefit (although many low-income enrollees pay no premiums), and the general fund covers most of the rest. Federal payments to private insurance plans under Part C comprise a blend of funds drawn from Parts A, B, and D. Altogether, in calendar year 2013, about 43 percent of gross federal spending on Medicare was financed by the HI trust fund's

11. For the purposes of that analysis, out-of-pocket payments include payments made to satisfy cost-sharing requirements for services covered by insurance, as well as payments for services not covered by insurance. However, they do not include the premiums that people pay for health insurance—because premiums fund the payments that insurers provide, which have already been accounted for.

12. The estimated federal cost includes the effects on revenues from both payroll and income taxes. The income tax portion is based on Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012–2017*, JCS-1-13 (February 1, 2013), http://go.usa.gov/3PkZA. For more information about the tax exclusion, see Congressional Budget Office, *The Distribution of Major Tax Expenditures in the Individual Income Tax System* (May 2013), www.cbo.gov/publication/43768.

13. Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), p. 103, www.cbo.gov/publication/49892.

14. People with amyotrophic lateral sclerosis (also known as Lou Gehrig's disease) are an exception: They are eligible for Medicare in the month when their Disability Insurance benefits start.

15. The thresholds for the 0.9 percent tax are not indexed for inflation. Certain people are subject to an additional 3.8 percent tax on unearned income that is officially labeled a Medicare tax even though the revenues are credited to the government's general fund rather than to the HI trust fund.

dedicated income, about 13 percent came from beneficiaries' premiums, and about 41 percent came from the general fund; money from other sources financed the rest.[16]

In the fee-for-service portion of Medicare, beneficiaries' cost-sharing obligations (that is, what they are obliged to pay out of pocket) vary widely by type of service, and the program does not set an annual limit on the health care costs for which beneficiaries are responsible. However, the great majority of beneficiaries—about 90 percent of them in 2010, according to one recent study—have supplemental insurance that covers many or all of the program's cost-sharing requirements.[17] The most common sources of supplemental coverage are plans for retirees offered by former employers, Medicare Advantage plans, individually purchased policies (called medigap insurance), and Medicaid.

A number of provisions of law constrain Medicare's payments to providers of health care. Most recently, the Medicare Access and CHIP Reauthorization Act of 2015 set the schedule of increases in Medicare's payment rates for physicians' services. Those increases will vary depending on the year and certain other factors, but they will range between zero and 0.75 percent per year.[18] That legislation also modified updates to payment rates for certain other services in some years.

The ACA also contains numerous provisions that, on balance, limit the growth of Medicare spending. The provisions that will have the greatest effect impose permanent reductions on the annual updates to payment rates for many providers (other than physicians) in the fee-for-service portion of the program. Under those provisions, the updates equal the estimated percentage change in the average prices of providers' inputs, such as labor and equipment, minus the 10-year moving average of growth in productivity in the economy overall. As a result, the providers will face pressure to match other businesses in their ability to use fewer inputs to produce a given amount of output. Other provisions of the ACA subtract specified fractions of a percentage point from the updates to payment rates for various services through 2019.

In addition, the ACA established the Independent Payment Advisory Board (IPAB), which is required to submit a proposal to reduce Medicare spending in certain years if the rate of growth in spending per enrollee is projected to exceed specified targets.[19] The proposal—or an alternative proposal submitted by the Secretary of Health and Human Services if the board does not submit a qualifying proposal—must achieve a specified amount of savings in the year it is implemented while not increasing spending in the succeeding nine years by more than the amount of those first-year savings. The proposal would go into effect automatically unless blocked or replaced by subsequent legislation. In CBO's baseline projections, the rate of growth of Medicare spending per beneficiary is below the target rate for each year through 2024 but exceeds it in 2025. As a result, CBO projects that the IPAB mechanism will reduce spending in 2025 by about $1 billion.[20]

Finally, the Budget Control Act of 2011, as amended, specifies automatic procedures known as sequestration (that is, the cancellation of funding) that will reduce most Medicare payments through September 2024 still further. Sequestration will reduce payment rates for most services

16. Those calculations are based on data from Boards of Trustees, Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds, *2014 Annual Report of the Boards of Trustees of the Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds* (July 2014), Table II.B1, http://go.usa.gov/bUZm. The measures of benefits and premium receipts in that table treat Part D premiums for basic benefits that beneficiaries pay directly to plans as if those premiums were paid to Medicare and then disbursed to the plans.

17. Medicare Payment Advisory Commission, *A Data Book: Health Care Spending and the Medicare Program* (June 2014), p. 27, http://go.usa.gov/3D3DQ (PDF, 1.7 MB).

18. From October 1998 through March 2015, payment rates for services covered by the fee schedule for physicians were governed by the sustainable growth rate (SGR) mechanism. In practice, however, the Congress almost always overrode the SGR mechanism when it was about to reduce payment rates. In April 2015, legislation was enacted that replaced that mechanism. For more details, see Congressional Budget Office, cost estimate for H.R. 2, the Medicare Access and CHIP Reauthorization Act of 2015 (March 2015), www.cbo.gov/publication/50053.

19. From 2015 through 2019, the target growth rate is the average of inflation in the economy generally and inflation for medical services in particular; in subsequent years, the target growth rate is the percentage increase in per capita GDP plus 1 percentage point. The ACA prohibits the IPAB from proposing certain actions, such as modifying Medicare's eligibility rules or reducing benefits.

20. Congressional Budget Office, "Medicare—Baseline Projections" (March 2015), Note f, www.cbo.gov/publication/44205. The estimate has since been updated to reflect recently enacted legislation, but it still stands at about $1 billion in 2025.

by 2.0 percent through the first half of fiscal year 2023, by 2.9 percent for the second half of 2023, by 1.1 percent for the first half of 2024, and by 4.0 percent for the second half of 2024, according to CBO's estimates. All told, CBO projects that sequestration will cancel about $150 billion of Medicare payments to providers and health insurance plans over the 2016–2025 period.

Medicaid

A joint federal-state program, Medicaid pays for health care services, mostly for low-income people. About 83 million people will be enrolled in Medicaid at some point during 2015, CBO estimates, and the average monthly enrollment will be about 66 million.[21] Currently, almost half of Medicaid's enrollees are children in low-income families; almost one-third are adults under age 65 who are not disabled; and the remaining one-fifth or so are elderly or disabled adults. Expenses tend to be much higher for beneficiaries who are elderly or disabled, many of whom require long-term care, than for other beneficiaries. In 2014, about 30 percent of federal spending for benefits was for long-term services and supports, a category that includes institutional care provided in nursing homes and certain other facilities, as well as care provided in a person's home or in the community. In that year, the elderly or disabled accounted for more than half of federal spending for Medicaid benefits.[22]

States administer their Medicaid programs under federal guidelines that mandate a minimum set of services that must be provided to certain categories of low-income people. The required services include inpatient and outpatient hospital services, services provided by physicians and laboratories, comprehensive and preventive health care services for children, nursing home and home health care, and transportation. The required eligibility categories include families that would have met the financial requirements of the Aid to Families With Dependent Children program when it existed; elderly and disabled people who qualify for the Supplemental Security Income program; and children and pregnant women in families with income below 138 percent of the federal poverty guidelines (commonly referred to as the federal poverty level or FPL).[23]

Nevertheless, beyond the federal requirements, state governments have substantial flexibility to determine eligibility, benefits, and payments to providers under Medicaid. States may choose to make additional groups of people eligible (such as elderly adults who have income above the usual eligibility thresholds but who have high medical expenses relative to their income) or to provide additional benefits (such as coverage for prescription drugs and dental services). Moreover, many states seek and receive federal waivers that allow them to provide benefits and cover groups that would otherwise be excluded. Most recently, as a result of the ACA and a subsequent Supreme Court ruling, each state has the option to expand eligibility for Medicaid to most nonelderly adults with income below 138 percent of the FPL.[24] Currently, 29 states and the District of Columbia, which together contain about half of the people who meet the new eligibility criteria, have expanded their programs. CBO anticipates that more states will expand coverage during the next few years and that, by 2020, about 80 percent of the people who meet the new eligibility criteria will be in states that have expanded coverage.

The federal government's share of Medicaid's spending for benefits varies by state and has historically averaged about 57 percent. However, for enrollees newly eligible under the ACA's coverage expansion, the federal government will pay all costs through 2016, a slightly declining share of costs from 2017 to 2019, and 90 percent of costs in 2020 and beyond. According to CBO's estimates, those changes will raise the federal share of Medicaid

21. Those two estimates differ from each other for two reasons. First, many people are enrolled in Medicaid for less than 12 months. Second, for most enrollees, the typical 12-month eligibility period straddles two consecutive years. That is, some enrollees leave Medicaid partway through the year, after their eligibility period ends; other enrollees begin a new eligibility period after the start of the year. As a result, the total number of people enrolled in Medicaid at some point in the year is significantly higher than the average number of people enrolled in a given month.

22. Congressional Budget Office, "Medicaid—Baseline Projections" (March 2015), www.cbo.gov/publication/44204.

23. The FPL is currently $24,250 for a family of four. See Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation, "2015 Poverty Guidelines" (January 2015), http://aspe.hhs.gov/poverty/15poverty.cfm.

24. In fact, the ACA expanded eligibility for Medicaid to include nonelderly residents with income of up to 133 percent of the FPL, but the act defined income in a way that effectively raised that threshold to 138 percent of the FPL. As a result of the Supreme Court decision, which was issued on June 28, 2012 (*National Federation of Independent Business v. Sebelius*, 132 S. Ct. 2566 (2012)), some states chose not to expand their programs.

spending to between 62 percent and 64 percent in 2015 and later years.[25]

In 2014, federal spending for Medicaid amounted to $301 billion, of which $270 billion covered benefits for enrollees. (The rest included payments to hospitals that served a disproportionate share of Medicaid patients and low-income uninsured patients, costs for the Vaccines for Children program, and administrative expenses.) On the basis of data provided by the Centers for Medicare & Medicaid Services (CMS), CBO estimates that the states spent $195 billion on Medicaid in that year.[26]

Children's Health Insurance Program

CHIP, a much smaller joint federal-state program, provides health insurance coverage for children in families whose income, though modest, is too high for them to qualify for Medicaid.[27] States have discretion to determine income eligibility, but it usually falls in the range between 100 percent and 300 percent of the FPL. Like Medicaid, CHIP is administered by the states within broad federal guidelines. Unlike Medicaid, however, CHIP has a fixed nationwide limit on federal spending.[28]

In 2014, federal spending on CHIP was $9.3 billion, and about 8 million people (almost all of them children) were enrolled in the program at some point during the year.[29] The federal share of CHIP spending varies among the states but usually averages about 70 percent.[30]

25. Congressional Budget Office, "Medicaid—Baseline Projections" (March 2015), Note a, www.cbo.gov/publication/44204.

26. CBO's calculations rely on unpublished data from states' filings of the CMS-64 Quarterly Expense Report for fiscal year 2014. States use that form to report their spending for Medicaid-covered benefits and administrative activities.

27. Under certain conditions, pregnant women and parents of children enrolled in CHIP are also eligible for the program, but they constitute a very small percentage of the program's enrollment. See Congressional Budget Office, "Children's Health Insurance Program—Baseline Projections" (March 2015), www.cbo.gov/publication/44189.

28. CHIP also differs from Medicaid in that its funding expires after September 2017, under current law.

29. Congressional Budget Office, "Children's Health Insurance Program—Baseline Projections" (March 2015), www.cbo.gov/publication/44189.

Subsidies for Insurance Purchased Through Exchanges

Many people can buy subsidized insurance through exchanges (also called marketplaces) operated by the federal government, by state governments, or through a partnership between federal and state governments. There are two kinds of subsidy: refundable tax credits to help pay for premiums; and cost-sharing subsidies to reduce out-of-pocket expenses, such as deductibles and copayments. To qualify for the premium tax credits, a person generally must have household income between 100 percent and 400 percent of the FPL and must not have access to certain other sources of health insurance coverage. (The most common examples are coverage through an employer that meets the law's definition of being affordable and coverage from a government program, such as Medicare or Medicaid.) To qualify for the cost-sharing subsidies, a person must meet the requirements for the premium tax credits, enroll in what the ACA calls a silver plan (which covers about 70 percent of the cost of covered benefits), and have household income below 250 percent of the FPL.

The size of a person's premium tax credit is the difference between the cost of the second-lowest-cost silver plan available to that person and a specified percentage of his or her household income. For example, in calendar year 2014, the tax credit was set so that people with income between 100 percent and 133 percent of the FPL would pay about 2 percent of their income to enroll in the second-lowest-cost silver plan, while people with higher income would pay a larger share of their income, up to about 9.5 percent for those with income between 300 percent and 400 percent of the FPL. (Therefore, if a person's premium for such a plan would be less than the applicable percentage of income, that person would receive no tax credit.) The amounts that enrollees must pay are indexed so that the subsidies cover roughly the same shares of the premiums over time. After calendar year 2017, however, an additional indexing factor may apply; if so, the shares of the premiums that enrollees pay

30. The ACA provided for a 23 percentage-point increase in the federal share of each state's CHIP spending from 2016 through 2019. CBO estimates that the average federal share will consequently rise from 70 percent to 93 percent during those four years before reverting to 70 percent in 2020. See Centers for Medicare & Medicaid Services, "Children's Health Insurance Program Financing" (accessed April 6, 2015), http://tinyurl.com/kqjfj3s.

will increase, and the shares of the premiums that the subsidies cover will decline.[31]

CBO and JCT estimate that, over the course of calendar year 2015, an average of about 11 million people will be covered by insurance purchased through the exchanges, of whom about 8 million will receive subsidies and 3 million will not. Over time, coverage through the exchanges will increase substantially, CBO and JCT expect, as people respond to the subsidies and to rising penalties for failing to obtain coverage. According to CBO and JCT's projections, an average of about 21 million people will have such coverage in 2016, and between 22 million and 24 million will have it in each year between 2017 and 2025. Roughly three-quarters of those enrollees are expected to receive subsidies. In fiscal year 2015, outlays for those subsidies and related spending will be about $41 billion, CBO and JCT estimate.[32]

The Historical Growth of Health Care Spending

Total spending for health care in the United States—that is, private and public spending combined—has risen significantly as a share of GDP over the past several decades. Such spending has grown relative to GDP in most years, except for the periods between calendar years 1993 and 2000 and again between 2009 and 2013 (the most recent year for which data are available). During both of those periods, spending for health care remained roughly stable as a share of the economy.

Some analysts have attributed the lull in growth from 1993 to 2000 to a substantial rise in the number of people enrolled in managed care plans and to excess capacity among providers of some types, which increased the leverage that health plans had in negotiating payments to providers; also, economic growth was relatively rapid in that period, making it easier for rising spending to remain stable as a share of the economy.[33] In examining the more recent slowdown in health care spending—from 2009 to 2013—analysts have reached different conclusions about the relative contributions of the weak economy and of changes in the delivery and financing of health care. Some analysts believe that an expansion of high-deductible health plans, increasing efforts by states to control Medicaid spending, and a slackening in the diffusion of new technologies are the key factors in the most recent slowdown.[34] Others believe that the weakened economy has been the primary factor.[35] How long the slowdown may persist is highly uncertain. In fact, one recent study estimated that total spending for health care in the United States increased as a share of GDP in calendar year 2014 and would continue to do so through 2023 (the last year included in the analysis).[36]

Spending for Medicare and Medicaid has also grown quickly in the past few decades, partly because of rising enrollment and partly because of rising costs per enrollee. Between 1985 and 2014, net federal spending for Medicare rose from 1.5 percent of GDP to 2.9 percent, and federal spending for Medicaid rose from 0.5 percent of GDP to 1.7 percent. (*Total* spending for Medicaid, including spending by the states, rose from 0.9 percent of GDP to 2.9 percent.) During the last few years of that period, however, net federal spending for Medicare grew

31. The additional indexing factor will apply in any year after calendar year 2017 in which the total costs of the exchange subsidies exceed a specified percentage of GDP. CBO expects that the indexing factor will apply in some years, although the uncertainty of projections of both the exchange subsidies and GDP make the timing unclear. For an explanation of the indexing factor, see Congressional Budget Office, *Additional Information About CBO's Baseline Projections of Federal Subsidies for Health Insurance Provided Through Exchanges* (May 2011), www.cbo.gov/publication/41464.

32. Congressional Budget Office, "Effects of the Affordable Care Act on Health Insurance Coverage—Baseline Projections" (March 2015), Table 3, www.cbo.gov/publication/43900. Related spending includes grants to states and payments by the federal government to insurers under several provisions of the ACA.

33. See Katharine Levit and others, "National Health Expenditures in 1997: More Slow Growth," *Health Affairs,* vol. 17, no. 6 (November/December 1998), pp. 99–110, http://dx.doi.org/10.1377/hlthaff.17.6.99.

34. See, for example, Amitabh Chandra, Jonathan Holmes, and Jonathan Skinner, "Is This Time Different? The Slowdown in Health Care Spending," *Brookings Papers on Economic Activity* (Fall 2013), pp. 261–323, http://tinyurl.com/pyrjret (PDF, 752 KB).

35. See, for example, Larry Levitt and others, *Assessing the Effects of the Economy on the Recent Slowdown in Health Spending* (Kaiser Family Foundation, April 2013), http://tinyurl.com/m78guc9; and David Dranove and others, "Health Spending Slowdown Is Mostly Due to Economic Factors, Not Structural Change in the Health Care Sector," *Health Affairs*, vol. 33, no. 8 (August 2014), pp. 1399–1406, http://dx.doi.org/10.1377/hlthaff.2013.1416.

36. Andrea M. Sisko and others, "National Health Expenditure Projections, 2013–23: Faster Growth Expected With Expanded Coverage and Improving Economy," *Health Affairs*, vol. 33, no. 10 (October 2014), pp. 1841–1850, http://dx.doi.org/10.1377/hlthaff.2014.0560.

only about as quickly as the overall economy did. Federal spending for Medicaid also grew at about that rate in recent years—until 2014, when spending for Medicaid increased rapidly because of the expansion of Medicaid coverage under the ACA. Between 2013 and 2014, net Medicare spending grew by only 2.8 percent, whereas federal Medicaid spending grew by 13.6 percent.[37]

Factors Affecting the Growth of Health Care Spending

A crucial factor underlying the rise in per capita spending for health care during the past few decades has been the emergence, adoption, and widespread diffusion of new medical technologies and services.[38] Major advances in medical science allow providers to diagnose and treat illnesses in ways that previously were impossible. Many of those innovations rely on costly new drugs, equipment, and skills.[39] Other innovations are relatively inexpensive, but their costs add up quickly as growing numbers of providers and patients make use of them. Although technological advances can sometimes reduce costs, they have generally increased total health care spending.

Other factors that have contributed to the growth of per capita spending on health care in recent decades include increases in personal income and changes in insurance coverage—in particular, declines in the share of health care costs that people with coverage pay out of pocket. Demand for medical care tends to rise as real (that is, inflation-adjusted) family income increases. People also use more care if they pay a smaller portion of the cost—and between 1970 and 2000, the share of total health care spending paid out of pocket declined rapidly, from 37 percent to 16 percent.[40] (More recently, the rate of decline has slowed, leaving the share of health care spending paid out of pocket at about 12 percent in 2013; reasons for that slowing include an increase in the share of insured people who have an annual deductible and an increase in the share enrolled in high-deductible health plans.)

In general, disentangling the effects of technology, income, and insurance coverage on the growth of health care spending is difficult, because rising income and expanding insurance coverage have themselves increased the demand for new technologies. One study estimated that new medical technologies and rising income were the most important factors behind the growth of health care spending between 1960 and 2007, and that the two accounted for roughly equal shares of that growth—but also that the effect of increasing insurance coverage during that period was highly uncertain.[41] Another study concluded that after Medicare was introduced, the resulting expansion of insurance coverage increased health care spending not just for the elderly patients who gained coverage but for younger patients as well. Part of the reason, according to the study, was that the increased insurance coverage spurred a more rapid and widespread adoption of existing treatment methods, such as those provided by cardiac intensive care units, for the elderly and nonelderly alike—though the study concluded that questions remained about the magnitude of those effects.[42]

Spending on health care per person would also be expected to grow if people were developing more health problems or becoming more likely to contract diseases, but the evidence about the importance of those factors is mixed. In particular, researchers have reached different

37. Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), p. 11, www.cbo.gov/publication/49892.

38. Congressional Budget Office, *Technological Change and the Growth of Health Care Spending* (January 2008), www.cbo.gov/publication/41665.

39. See, for example, Jay H. Hoofnagle and Averell H. Sherker, "Therapy for Hepatitis C—The Costs of Success," *The New England Journal of Medicine*, vol. 370, no. 16 (April 17, 2014), pp. 1552–1553, http://tinyurl.com/p7z4tyu.

40. Centers for Medicare & Medicaid Services, National Health Expenditure Accounts, "NHE Tables" (accessed April 3, 2015), http://go.usa.gov/jmGY.

41. Sheila Smith, Joseph P. Newhouse, and Mark S. Freeland, "Income, Insurance, and Technology: Why Does Health Spending Outpace Economic Growth?" *Health Affairs*, vol. 28, no. 5 (September/October 2009), pp. 1276–1284, http://dx.doi.org/10.1377/hlthaff.28.5.1276.

42. Amy Finkelstein, "The Aggregate Effects of Health Insurance: Evidence From the Introduction of Medicare," *The Quarterly Journal of Economics*, vol. 122, no. 1 (February 2007), pp. 1–37, http://tinyurl.com/oqlrvjq. One factor that may have contributed to that study's findings was the relatively generous payment system that Medicare adopted. Following the common practice of private insurers at the time, Medicare initially paid hospitals on the basis of their incurred costs—an approach that gave hospitals little incentive to control those costs—rather than according to fee schedules, as it does today. The increase in hospital spending that resulted from Medicare's creation might have been smaller under a less generous payment system.

Table 2-1.

Average Annual Rate of Excess Cost Growth in Spending for Health Care

Percent

	Medicare	Medicaid	Other	Overall
1975 to 2013	1.9	1.5	1.8	1.8
1980 to 2013	1.6	1.2	1.7	1.6
1985 to 2013	1.4	0.9	1.5	1.4
1990 to 2013	1.2	0.3	1.3	1.1

Source: Congressional Budget Office.

Note: Excess cost growth refers to the extent to which the growth rate of nominal health care spending per capita—adjusted for demographic characteristics of the relevant populations—outpaces the annual growth rate of potential gross domestic product (GDP) per capita, on average. (Potential GDP is CBO's estimate of the maximum sustainable output of the economy.) The historical rates of excess cost growth are a weighted average of annual rates: Twice as much weight is placed on the latest year as on the earliest year.

conclusions about the extent to which spending growth is affected by changes in the prevalence of chronic diseases (such as cardiovascular disease, diabetes, and arthritis); in the share of the people with those diseases who receive treatment; and in the costs per case of treating those diseases.[43]

Studies that have analyzed the growth of health care spending have consistently found that the aging of the population has had only a small effect on it.[44] Although older adults have higher average medical expenses than younger adults do, the age composition of the population has not changed enough to account for much of the increase in per capita spending. Aging has had a larger effect on *federal* spending for health care, however, because nearly all U.S. residents become eligible for Medicare when they turn 65. From 1985 to 2015, the share of the population that was at least 65 years old grew by about one-quarter, from almost 12 percent to 15 percent.

Excess Cost Growth

As part of its analysis of health care spending, CBO calculates the growth in that spending per person relative to the growth of potential GDP per person after removing the effects of demographic changes on health care spending—in particular, changes in the age distribution of the population.[45] The resulting ratio is called excess cost growth. The phrase is not intended to imply that growth in per capita spending for health care is necessarily excessive or undesirable; excess cost growth simply measures the extent to which the growth in such spending (adjusted for demographic changes) outpaces the growth in potential output per capita.

According to CBO's calculations, average rates of excess cost growth have ranged between 0.3 percent and 1.9 percent for various parts of the health care system and during various periods in the past several decades (see Table 2-1).[46] Although such rates are quite variable from year to year, they have generally declined over the past few decades, probably because of two important shifts in how care is financed. First, private health insurance has moved away from indemnity policies—which generally

43. For additional discussion, see Congressional Budget Office, *Key Issues in Analyzing Major Health Insurance Proposals* (December 2008), p. 23, www.cbo.gov/publication/41746. See also Congressional Budget Office, *How Does Obesity in Adults Affect Spending on Health Care?* (September 2010), www.cbo.gov/publication/21772; Charles S. Roehrig and David M. Rousseau, "The Growth in Cost per Case Explains Far More of U.S. Health Spending Increases Than Rising Disease Prevalence," *Health Affairs*, vol. 30, no. 9 (September 2011), pp. 1657–1663, http://dx.doi.org/10.1377/hlthaff.2010.0644; and Kenneth E. Thorpe and others, "The Rising Prevalence of Treated Disease: Effects on Private Health Insurance Spending," *Health Affairs*, web exclusive (June 2005), http://dx.doi.org/10.1377/hlthaff.w5.317.

44. See, for example, Uwe E. Reinhardt, "Does the Aging of the Population Really Drive the Demand for Health Care?" *Health Affairs*, vol. 22, no. 6 (November 2003), pp. 27–39, http://dx.doi.org/10.1377/hlthaff.22.6.27.

45. Potential GDP is CBO's estimate of the maximum sustainable output of the economy; using potential GDP rather than actual GDP in the calculation of excess cost growth limits the effect of cyclical changes in the economy on that calculation.

46. The rates of excess cost growth are a weighted average of annual rates in which twice as much weight was placed on the latest year as on the earliest year. In calculating excess cost growth for Medicare, CBO adjusted for changes in the age distribution of beneficiaries. In calculating excess cost growth for Medicaid, CBO adjusted for changes in the program's case mix—that is, the proportions of beneficiaries who were children, elderly, disabled, and none of the above—rather than for changes in the age distribution of beneficiaries. The rates of excess cost growth adjusted for demographic changes reflect changes in spending per person rather than changes in the number or composition of beneficiaries. The introduction of Medicare's Part D drug benefit in 2006 resulted in a onetime shift in some spending from Medicaid to Medicare; to adjust for that shift, CBO assumed that excess cost growth in 2006 for both Medicare and Medicaid was equal to the average of excess cost growth in the two programs for that year.

reimburse enrollees for their incurred medical costs and which predominated before the 1990s—and toward greater management of care. Second, beginning in the 1980s, Medicare shifted from payments that were based on the costs that providers incurred or the charges that they submitted to fee schedules that constrained price increases.

Excess cost growth has been especially low, on average, during two periods—in most of the 1990s and during the past few years. In the mid- to late 1990s, managed care was spreading rapidly, and some of the low excess cost growth probably represented a series of onetime downward shifts in health care costs, spread out over several years, rather than a permanent change in the underlying growth rate of health care spending. During the past few years, some of the low excess cost growth has probably reflected the economic downturn and may be reversed once the economy recovers further. Even the part of the currently low excess cost growth that reflects structural changes in how care is delivered or how it is financed may largely represent another onetime downward shift in costs, rather than a permanent reduction in the growth rate of spending.

For those reasons, even though growth rates are currently below the historical average, CBO judges that the rate of excess cost growth in overall spending on health care since 1985 is the rate that best reflects features of the health care delivery and financing systems that are likely to endure for a number of years—which is important because the agency uses its estimate of historical excess cost growth to inform its projections of future spending. Within that period, the later years provide a more useful guide to the future than the earlier years do. Therefore, CBO calculated a weighted average of the annual excess cost growth rates between 1985 and 2013 (the latest year for which data are available), placing twice as much weight on the latest year as on the earliest year and setting the weights for intermediate years by following a linear progression between the two. After making that adjustment, CBO arrived at its estimate of the historical rate of excess cost growth to be used as a basis for its long-term projections: 1.4 percent per year.[47]

Long-Term Responses to Rising Health Care Costs

Health care spending cannot rise more quickly than GDP forever. When that spending increases as a share of GDP, it absorbs a growing share of people's income, restraining the consumption of other goods and services and building pressure to slow its growth, both in the private sector and in government programs. Those responses will occur even if, as CBO assumes in making its projections, current federal law does not change.

Responses in the Private Sector, Health Insurance Exchanges, and Medicaid

CBO expects that the private sector will respond to rising health care costs by pursuing various ways to restrain spending. Many employers will intensify their efforts to reduce the costs of the insurance plans that they offer—for example, by working with insurers and providers to make the delivery of health care more efficient, by limiting the amount of insurance coverage that they offer, or by offering a fixed contribution that employees can use to purchase health insurance. Some employees will move to plans with more tightly managed benefits, narrower networks of providers, or higher cost-sharing requirements—moves that would lower premiums by shifting costs to the employees, but that also could reduce total spending on health care. Such changes are already under way; for example, the share of covered workers with an annual deductible increased from 55 percent in 2006 to 80 percent in 2014.[48]

When it goes into effect in 2018, an excise tax on certain health insurance plans with high premiums will also encourage some employers and individuals to choose plans with lower premiums. In some cases, employers are already reducing the benefits that their insurance plans cover or increasing workers' deductibles and copayments to avoid having to pay the tax in the future.[49] Although the excise tax will not apply to health insurance plans offered through exchanges, people buying coverage through exchanges are also likely to seek ways to avoid

47. The same method applied to data through 2007 yields an estimate of 1.6 percent per year. That is, the slow growth of health care spending experienced during the past several years, all else being equal, has reduced the average rate of excess cost growth by about 0.2 percentage points.

48. Gary Claxton and others, *Employer Health Benefits: 2014 Annual Survey* (Kaiser Family Foundation and Health Research and Educational Trust, September 2014), p. 120, http://tinyurl.com/q7h4osw.

49. Julie Piotrowski, "Excise Tax on 'Cadillac' Plans," Health Policy Briefs, *Health Affairs* (September 12, 2013), http://tinyurl.com/my4kfd7.

higher premiums, which will tend to slow the growth of federal spending for the exchange subsidies.[50]

Many state governments will respond to growing costs for Medicaid by restraining payment rates to providers and managed care plans, limiting the services that they choose to cover, or tightening eligibility for the program so that it serves fewer beneficiaries than it would have otherwise. Because federal spending for Medicaid depends on state spending, such actions by the states will tend to slow the growth of federal spending for the program as well.

Over the long term, those responses by businesses, individuals, and state governments will sharply slow the growth of health care spending, resulting in a reduction of the rate of excess cost growth in the health care system, CBO projects. That slowdown could occur in different ways. Improvements in the efficiency of the health care sector, for example, could lower the rate of excess cost growth. Many experts believe that a substantial share of current health care spending is of low value, meaning that the services provided yield little health benefit relative to their costs. If the use of such services fell, the rate of excess cost growth could also decline for an extended period without imposing direct costs on patients. However, reducing the use of low-value care without affecting high-value care is very challenging, so the degree to which such a reduction might occur is highly uncertain.[51]

The responses to high and rising health care costs could have other effects as well. They could lead to significant changes in the amount that people paid directly for care, their access to care, or the quality of care—at least, relative to what would have occurred without a slowdown in spending. In the private sector, people might face increased cost-sharing requirements and narrower networks of providers; new and potentially useful health technologies might be introduced more slowly or used less frequently than they would have been otherwise; and more treatments and interventions might not be covered by insurance. Those outcomes might affect people with employment-based health insurance and people purchasing health insurance through the exchanges. In Medicaid, some beneficiaries might lose their eligibility or have to pay more out of pocket if states narrowed their eligibility criteria or dropped coverage of optional services. Medicaid beneficiaries might also end up with more tightly managed care. In addition, private insurers and Medicaid programs might constrain payments to providers in ways that limited access to care, the quality of care, or both.

Responses in Medicare

Many features of the Medicare program cannot be altered without changes in federal law. Still, a reduction in spending growth elsewhere in the health care sector would probably affect Medicare, which is integrated to a significant degree with the other parts of the health care system. In particular, spending on Medicare will slow to the extent that actions by businesses, individuals, and states result in lower-cost patterns of practice by physicians, slower development and diffusion of new medical technologies, and cost-limiting changes to the structure of the overall health care system.

In addition, current law includes a number of incentives and mechanisms that could reduce spending growth in Medicare. For one thing, the program's premiums and cost sharing will consume a growing share of beneficiaries' income—because the growth of health care spending in general is projected to outpace the growth of income—and that will constrain demand for some Medicare services. Changes being made in the structure of Medicare's payments to providers, such as financial incentives to reduce hospital-acquired infections and readmissions, may also help hold down federal spending.[52] Further, the Center for Medicare & Medicaid Innovation, an arm of CMS, is testing promising ways to modify rules and payment methods that could reduce costs without impairing

50. A recent analysis of insurance plans available through exchanges found that many consumers continued enrolling in cheaper plans with narrower networks of providers even though they reported low satisfaction with those plans. See McKinsey Center for U.S. Health System Reform, *Hospital Networks: Evolution of the Configurations on the 2015 Exchanges* (April 2015), http://tinyurl.com/pnyv563 (PDF, 881 KB).

51. See Katherine Baicker, Sendhil Mullainathan, and Joshua Schwartzstein, *Behavioral Hazard in Health Insurance*, Working Paper 18468 (National Bureau of Economic Research, October 2012), www.nber.org/papers/w18468.

52. Sarah L. Krein and others, "Preventing Hospital-Acquired Infections: A National Survey of Practices Reported by U.S. Hospitals in 2005 and 2009," *Journal of General Internal Medicine*, vol. 27, no. 7 (July 2012), pp. 773–779, www.ncbi.nlm.nih.gov/pmc/articles/PMC3378739/. For a description of the program to reduce hospital readmissions, see Centers for Medicare & Medicaid Services, "Readmissions Reduction Program" (accessed April 6, 2015), http://go.usa.gov/DxKC.

the quality of health care; the changes that prove effective may be expanded by the Secretary of Health and Human Services.[53] Several such demonstrations are currently under way, but which, if any, will prove successful in slowing spending growth for Medicare as a whole is uncertain.

Growth in Medicare spending will also be constrained by the rules governing the annual updates that are made to Medicare's payment rates for health care services. The scheduled updates will generally be smaller than the increases in the prices of inputs (namely, labor and supplies) used to deliver care. But it is unclear whether providers' responses to that constraint will lead to offsetting increases or to further reductions in spending for Medicare and other health care programs. The answer depends on whether or to what extent the providers can restrain the growth of their costs, either by increasing their productivity over time—that is, producing the same quantity and quality of output (treatments and procedures) with fewer or less costly inputs—or by other means.

There is considerable uncertainty, partly because of data limitations, about the degree of productivity growth in the health care sector and how it compares with productivity growth in the economy as a whole. Some evidence suggests that productivity growth in the hospital industry is substantial. For example, one recent study found such evidence for selected medical conditions, after adjusting for trends in the severity of illness and improvements in patients' outcomes.[54] Also, a recent analysis by CMS indicates that Medicare's payment updates for services by providers other than physicians were, on average, roughly in line with general price inflation (which reflects growth in productivity in the economy as a whole) over the 1991–2011 period.[55] Furthermore, an analysis by the American Hospital Association indicates that private-sector payment rates grew at about the same pace as Medicare's payment rates over that period, on average, and that aggregate profit margins for hospitals in 2012 were higher than those in the early 1990s.[56] Taken together, those findings suggest that, on average, hospitals have improved their productivity roughly in line with economywide productivity growth.[57] Earlier evidence, however, suggests that productivity growth in the hospital industry is very low.[58] Evidence about productivity growth for physicians is harder to interpret, partly because of the challenges involved in measuring the quality of the care that they provide.[59]

If providers cannot increase their productivity enough over time to keep the growth of their costs in line with the updates to Medicare's payment rates, they might respond in other ways, such as reducing the quality of care, reducing Medicare beneficiaries' access to care (which might reduce spending), or trying to increase revenues by other means (which might increase spending). Providers that are not able to adjust to the constraint imposed by the payment updates might merge with more profitable providers or close.

If access to providers under the traditional fee-for-service program declined, more enrollees might shift into Medicare Advantage plans, which are not bound by the updates to payment rates that apply to traditional Medicare. Medicare Advantage plans might be able to offer better access to care than the fee-for-service program if they increased the rates that they paid providers, but that would probably require enrollees in such plans to pay higher premiums. Because federal payments to those plans are based largely on costs in the fee-for-service

53. A list of the center's ongoing projects is available at Centers for Medicare & Medicaid Services, "Innovation Models" (accessed April 6, 2015), http://go.usa.gov/3Dc2Q.

54. John A. Romley, Dana P. Goldman, and Neeraj Sood, "U.S. Hospitals Experienced Substantial Productivity Growth During 2002–11," *Health Affairs*, vol. 34, no. 3 (March 2015), pp. 511–518, http://dx.doi.org/10.1377/hlthaff.2014.0587.

55. Centers for Medicare & Medicaid Services, *Review of Assumptions and Methods of the Medicare Trustees' Financial Projections* (December 2012), p. 60, http://go.usa.gov/Xn7Q.

56. American Hospital Association, "Trends in Hospital Financing," in *Trends Affecting Hospitals and Health Systems* (accessed April 6, 2015), http://tinyurl.com/m4by9zd.

57. Less information is readily available about the influence of changes in Medicare's payment rates and methods over the past two decades on the growth of costs for other providers.

58. Jonathan D. Cylus and Bridget A. Dickensheets, "Hospital Multifactor Productivity: A Presentation and Analysis of Two Methodologies," *Health Care Financing Review*, vol. 29, no. 2 (Winter 2007–2008), pp. 49–64, http://go.usa.gov/XrHC; and Michael J. Harper and others, "Nonmanufacturing Industry Contributions to Multifactor Productivity, 1987–2006," *Monthly Labor Review*, vol. 133, no. 6 (June 2010), pp. 16–31, www.bls.gov/opub/mlr/2010/06/art2full.pdf (1 MB).

59. See Joseph P. Newhouse and Anna D. Sinaiko, "Estimates of Physician Productivity: An Evaluation," *Health Care Financing Review*, vol. 29, no. 2 (Winter 2007–2008), pp. 33–39, www.ncbi.nlm.nih.gov/pmc/articles/PMC4195017/.

program, it is unclear whether such a shift—if it were to occur—would substantially alter the trajectory of Medicare spending.

Because of the uncertainty about the responses of Medicare providers to the payment updates, CBO has not adjusted its projections of spending in the long term to take such responses into account.

CBO's Method for Making Long-Term Projections of Federal Health Care Spending

CBO's extended baseline projections of federal spending on the major health care programs, like the rest of the agency's extended baseline projections, generally reflect the provisions of current law. The projections in the extended baseline for the next 10 years match the agency's 10-year baseline projections as adjusted to reflect recently enacted legislation, which are based on detailed analysis of the major health care programs. Beyond the coming decade, however, projecting federal health care spending becomes increasingly difficult because of the considerable uncertainties involved. A wide range of changes could occur—in people's health, in the sources and extent of their insurance coverage, and in the delivery of medical care—that are almost impossible to predict but that could have a significant effect on federal health care spending.

Therefore, for the projections beyond 2025, CBO has adopted a formulaic approach—one that combines estimates of the number of beneficiaries of government health care programs with fairly mechanical projections of spending growth per beneficiary. CBO has estimated spending growth per beneficiary by combining projected growth in potential GDP per capita and projected excess cost growth for the program in question (with adjustments for demographic changes in the beneficiaries of that program).

The long-term projections of excess cost growth depend on CBO's assessment of the *underlying* rates of excess cost growth. The underlying growth rates begin in 2014 with the historical average rate of excess cost growth described above—1.4 percent per year—and are projected to decline gradually, at different rates for different programs, in response to the pressures created by rising costs. Projected excess cost growth for each program depends on the rate of excess cost growth for that program implied by the baseline projections for the next decade; on CBO's assessment of the underlying rate of excess cost growth for the program a quarter century from now and beyond; and on a blend of those factors for the intervening period (the 11th through the 24th years of the projection).

Excess Cost Growth Over the Next Decade

For 2016 through 2025, the projected rates of excess cost growth used in CBO's extended baseline are derived from CBO's 10-year baseline:

- For Medicare, CBO's baseline projections imply an average annual rate of excess cost growth over that decade of about 0.4 percent; that is, spending per beneficiary for Medicare (adjusted for demographic changes) is projected to grow slightly faster than potential GDP per capita. That slow projected growth rate stems partly from slow projected growth in the use of Medicare services, which is consistent with recent experience. In addition, some of the limitations on payments under current law will be phased in. Consequently, excess cost growth in Medicare is projected to be negative during the next few years and then to rise to about 0.8 percent per year by the end of the decade.

- For federal Medicaid spending, CBO's baseline projections imply an average annual rate of excess cost growth of 0.5 percent (after the effects of the changing federal share of Medicaid spending are removed). The expansion of benefits in some states to people with income of up to 138 percent of the FPL will increase total Medicaid spending; it will also probably change the average cost per enrollee over the next several years, because average spending on the new enrollees (mostly adults who are not disabled) will tend to differ from average spending on previously eligible enrollees. However, excess cost growth incorporates an adjustment for demographic changes, so it is not significantly affected by the expansion.

- For the exchange subsidies, CBO's baseline projections of spending per enrollee depend on its projections of private health insurance premiums. The agency's baseline projections imply an average annual rate of excess cost growth of about 2 percent for those premiums. The agency's projections of spending per enrollee on the exchange subsidies also account for the likelihood that federal subsidies will cover a declining share of the premiums over time as a result of the additional indexing factor mentioned above.

Underlying Rates of Excess Cost Growth

CBO's projections of the underlying rates of excess cost growth are calculated as follows:

- For all parts of the health care system, the underlying rate of excess cost growth in 2014 equals the weighted average rate of excess cost growth observed in the overall health care system between 1985 and 2013, which is 1.4 percent.

- The underlying rates of excess cost growth gradually decline, over 75 years, to zero for Medicaid and private insurance premiums and to 1.0 percent for Medicare. CBO built in that difference because, in the absence of changes in federal law, state governments and the private sector have more flexibility to respond to the pressures of rising health care spending than the federal government does. Such a difference in growth rates could occur if, for instance, actions taken to reduce spending growth in the private sector weakened the incentives to develop and disseminate new medical technologies for nonelderly people but had a smaller effect on new technologies for diseases that principally affected the elderly.

- The underlying rate of excess cost growth in each sector declines in linear fashion—that is, by the same fraction of a percentage point each year. That linear decline, which CBO calls the underlying path of excess cost growth, reflects the agency's assessment that, over time, the steps needed to keep reducing growth rates will become increasingly onerous, but the pressure to take them will also intensify because of increasingly high health care spending.

Formulating Long-Term Projections

In CBO's extended baseline, projected federal spending for the major federal health care programs for the 2016–2025 period matches the projected spending in CBO's 10-year baseline. For 2026 and later years, the projection of federal spending is constructed as follows:

- For Medicare, excess cost growth in 2026 equals 0.9 percent, the average rate projected from 2023 through 2025 with certain adjustments.[60] It then increases by the same fraction of a percentage point each year for 14 years, so that in 2040 it matches the rate in the underlying path for that year, 1.3 percent. Altogether, by CBO's projections, excess cost growth for Medicare would average 0.8 percent per year during the 2016–2040 period. To generate estimates of total spending in the long term, CBO combined those projections of excess cost growth with estimates of the future number of Medicare beneficiaries. CBO estimates that the number of beneficiaries would grow with the size of the population age 65 and over and with the number of recipients of Social Security's Disability Insurance program.[61]

- For Medicaid, excess cost growth in 2026 equals 0.7 percent, the average rate projected from 2023 through 2025. It then increases by the same fraction of a percentage point each year for 14 years, so that in 2040 it matches the rate in the underlying path, 0.9 percent. According to the agency's projections, excess cost growth for the program would average 0.7 percent per year during the 2016–2040 period. To generate projections for Medicaid spending in the long term, CBO combined its projections of excess cost growth with estimates of the future number of Medicaid beneficiaries. States' future decisions about Medicaid eligibility and covered benefits are quite uncertain even over the next 10 years, and that uncertainty grows with time; accordingly, CBO adopted a formulaic approach to generating the number of Medicaid beneficiaries after the next decade. That approach takes into account population growth, increasing earnings, and prospective actions by states (see Appendix A).

- For private health insurance premiums, excess cost growth in 2026 is about 2 percent, the average rate projected from 2023 through 2025. It then decreases

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60. Spending amounts were adjusted for the fact that, because of the quirks of the calendar, Medicare is scheduled to make 11, rather than the normal 12, capitation payments in Parts C and D of the program in 2024. In addition, the effect of sequestration was removed because that cancellation of funding will not affect spending after 2024. After those adjustments were made, the average projected rate of excess cost growth rate from 2023 through 2025 came to 0.8 percent. Under current law, payment rates for physicians' services in Medicare will remain at the 2019 level from 2020 through 2025, and they will increase annually starting in 2026. Those changes in the scheduled payment updates boost the projected excess cost growth rate in 2026 from 0.8 percent to 0.9 percent.

61. For more information about how CBO projects the number of beneficiaries of Social Security's Disability Insurance program, see Congressional Budget Office, *CBO's Long-Term Model: An Overview* (June 2009), www.cbo.gov/publication/20807, and Appendix A of this report.

by the same fraction of a percentage point each year for 14 years, so that in 2040 it matches the rate in the underlying path for that year, 0.9 percent. CBO projected the amounts of the exchange subsidies on the basis of excess cost growth for private health insurance premiums, the effects of the additional indexing factor described above, and growth in income (which reduces the share of the population that is eligible for subsidies).

- Under current law, funding for CHIP expires after September 2017. Following statutory guidelines, CBO assumes in its baseline spending projections that annual funding for the program from 2018 through 2025 will amount to $5.7 billion.[62] For 2026 and beyond, CBO assumes that spending on the program will equal the same share of GDP as the share in 2025.

All long-term economic and demographic developments are uncertain, but excess cost growth in health care may be particularly so. Pharmaceuticals, medical procedures and technology, and the delivery of care all continue to evolve rapidly, potentially making spending for any of the federal health care programs much higher or lower than CBO projects. Compounding the uncertainty imposed by those factors are the uncertain responses of beneficiaries and providers. For example, enrollees may be willing to accept more restrictions on their use of new services in return for lower premiums and cost-sharing requirements in Medicare Advantage plans. And if some insurers encourage or discourage the use of certain new drugs and technologies, the result may be changes in providers' behavior that affect the services received by people covered by other insurers. The number of beneficiaries in Medicaid and the exchanges is also very uncertain, because changes in the distribution of income and the steps that states may take regarding eligibility are unclear. Chapter 7 shows how CBO's projections would differ if the growth of costs per beneficiary in Medicare and Medicaid proved significantly higher or lower than the agency projects in the extended baseline.

62. See Congressional Budget Office, cost estimate for H.R. 2, the Medicare Access and CHIP Reauthorization Act of 2015 (March 2015), www.cbo.gov/publication/50053.

Long-Term Projections of Spending for the Major Health Care Programs

In CBO's extended baseline projections, which generally reflect current law, federal spending on the major health care programs increases significantly as a percentage of the economy in the coming decades.

Projected Spending

In 2015, federal spending for Medicare (net of offsetting receipts), Medicaid, CHIP, and the exchange subsidies will amount to 5.2 percent of GDP, CBO expects; net Medicare spending will equal 3.0 percent and federal spending on Medicaid, CHIP, and the exchange subsidies will equal 2.2 percent. In CBO's extended baseline, federal spending for those programs rises to 8.0 percent of GDP in 2040; net Medicare spending accounts for 5.1 percent and spending on Medicaid, CHIP, and the exchange subsidies for 2.9 percent (see Figure 2-2).[63] Gross Medicare spending is projected to increase from 3.5 percent of GDP in 2015 to 6.3 percent in 2040.

The projected rise in federal spending for the major health care programs relative to GDP results from the continued aging of the population, the expectation that health care costs per beneficiary will continue to grow somewhat faster than potential GDP per capita, and the continued increase in spending for federal subsidies for health care through Medicaid and the insurance exchanges over the next few years. In CBO's extended baseline, aging accounts for 43 percent of the programs' spending growth relative to GDP over the next 25 years, excess cost growth accounts for 45 percent, and an increased number of recipients of exchange subsidies and Medicaid benefits attributable to the ACA accounts for 12 percent (see Box 1-1 on page 24).

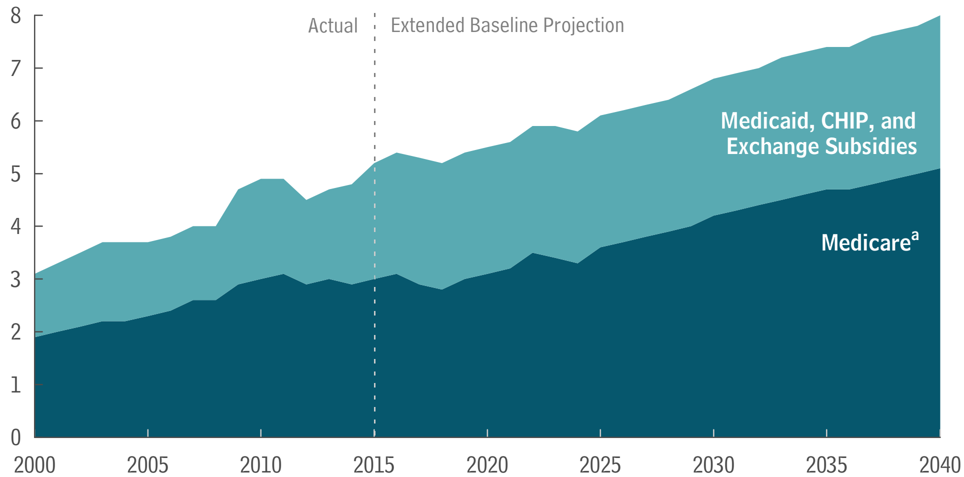
The factors that underlie the projected rise in total federal spending for the major health care programs also affect the amounts of spending that would subsidize care for different types of beneficiary. Although the ACA has

63. The projections in this chapter include the effects of the exchange subsidies on outlays; the smaller effects on revenues are included in the projections presented in Chapter 5. In all of the projections, the outlays for the exchange subsidies are presented in combination with outlays for Medicaid and CHIP; they all constitute federal subsidies for health insurance for low- and moderate-income households. Spending for the exchange subsidies includes related spending for risk adjustment.

Figure 2-2.

Federal Spending on the Major Health Care Programs, by Category

Percentage of Gross Domestic Product



The projected rise in federal spending for the major health care programs relative to GDP results from the continued aging of the population; the expectation that health care costs per person will continue to grow at a faster rate than potential GDP per capita; and, to a lesser extent, an increased number of recipients of exchange subsidies and Medicaid benefits attributable to the Affordable Care Act.

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

CHIP = Children's Health Insurance Program.

a. Net spending for Medicare refers to gross spending for Medicare net of offsetting receipts (from premium payments made by beneficiaries to the government and amounts paid by states from savings on Medicaid's prescription drug costs).

expanded federal support for health care regardless of people's health status, only about one-fifth of federal spending for the major health care programs in 2025 would finance care for able-bodied, nonelderly people, CBO projects in the extended baseline; about three-fifths would go toward care for people who are at least 65 years old, and about one-fifth toward care for blind and disabled people. After 2025, according to CBO's estimates in the extended baseline, the share of federal spending for the major health care programs that finances care for people who are at least 65 would rise slowly because of the continued aging of the population.

Among people who are at least 65, the fraction who will be significantly older than 65 will increase over the next 25 years (see Figure 2-3). That shift affects CBO's long-term projections because Medicare spending has traditionally been higher, on average, for the older people within the over-65 group. For example, in Parts A and B of the fee-for-service portion of Medicare in calendar year 2012, spending averaged about $5,000 for 66-year-olds, $8,500 for 75-year-olds, and $12,500 for 85-year-olds.[64] CBO expects that pattern to persist. One consequence of the pattern is that elderly beneficiaries over any given age receive a disproportionate share of the program's spending. For example, people who will be at least 75 years old in 2040 will represent about 56 percent of the elderly people enrolled in Medicare but will account for about 70 percent of the program's spending for elderly people, according to CBO's projections.

Although this chapter focuses on federal spending for health care, CBO also projected total national spending on health care (see Box 2-1). The agency combined its projections of federal spending on the major health care programs with rough projections of other health care spending. According to that analysis, which involves substantial uncertainty, national spending on health care as a share of GDP would continue to rise—from about

64. Calculating average spending for 65-year-old beneficiaries is not helpful for this comparison because most of them are enrolled in Medicare for only part of the calendar year in which they turn 65. The amounts reported here include spending under Parts A and B of Medicare averaged among all beneficiaries of each age enrolled in Part A, Part B, or both, within the traditional fee-for-service program. The fraction of beneficiaries enrolled in both Parts A and B increases as beneficiaries age.

Box 2-1.

National Spending on Health Care

National spending on health care increased from 9.5 percent of gross domestic product (GDP) in 1985 to 16.4 percent of GDP in 2013. In the Congressional Budget Office's extended baseline, which generally reflects current law, national spending for health care increases to about 25 percent of GDP by 2040.

CBO has only a limited ability to project national spending on health care, because the agency does not track all of the components of that spending as closely as it analyzes the components that are directly relevant to the federal budget. Therefore, to generate projections of national spending for health care, the agency combined its own projections for some categories of spending with projections for other categories developed by the Office of the Actuary in the Centers for Medicare & Medicaid Services (CMS).[1] The resulting projections were rough and involved substantial uncertainty—especially as they moved farther into the future—and therefore should be viewed with caution.

To project national spending for health care for the 2016–2025 period, CBO started with its projections of federal spending on the government's major health care programs. Other spending for health care includes payments by private health insurers, out-of-pocket payments by consumers, and other public spending. CBO estimated such spending by means of its own projections of payments by private health insurers and the Office of the Actuary's projections of out-of-pocket payments by consumers and of other public spending. Because the projections from CMS are available only through 2023, CBO used a historical rate of excess cost growth to extend them for the following two years.[2]

To project national spending for health care after 2025, CBO again started with its projections of federal spending on the government's major health care programs. It estimated other spending for health care by combining its projections of demographic and economic conditions with assumptions about excess cost growth for such spending. The starting point for projected excess cost growth in other health care spending was the weighted average rate of excess cost growth observed in the overall health care system between 1985 and 2013. CBO assumed that the rate of excess cost growth for other health care spending would slow from that historical rate—1.4 percent—in 2014 to zero over 75 years, in reaction to the pressures developing from rising health care spending. The slowdown was assumed to occur in linear fashion—that is, the rate of excess cost growth was assumed to decline by the same number of fractional percentage points each year.

1. This report defines total spending for health care as the health consumption expenditures in the national health expenditure accounts maintained by CMS. That definition excludes spending on medical research, structures, and equipment, and it includes out-of-pocket spending, payments made by public and private health insurance plans, spending on public health, and payments made by other third-party payers, such as workers' compensation.

2. Andrea M. Sisko and others, "National Health Expenditure Projections, 2013–23: Faster Growth Expected With Expanded Coverage and Improving Economy," *Health Affairs*, vol. 33, no. 10 (October 2014), pp. 1841–1850, http://dx.doi.org/10.1377/hlthaff.2014.0560.

17 percent of GDP now to about 25 percent by 2040—if current laws remained in place.

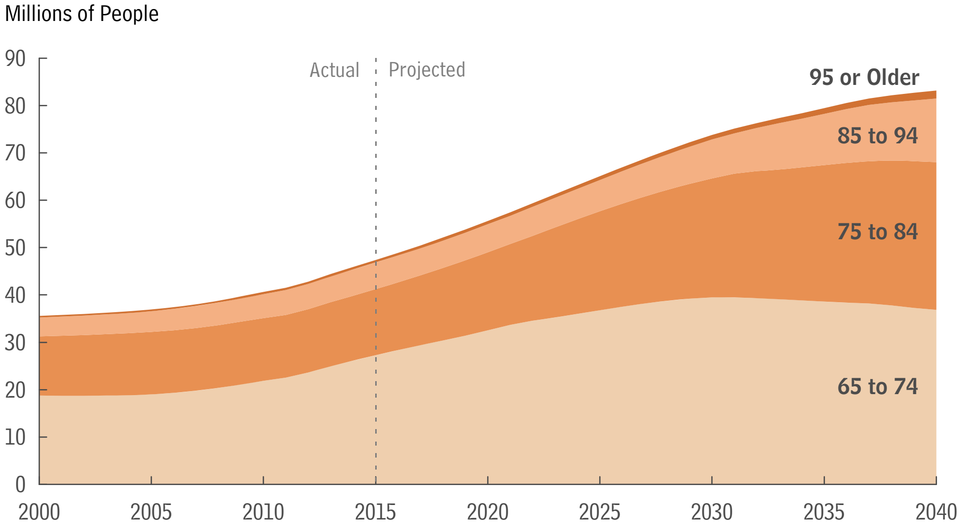
Projected Financing

Spending on the government's major health care programs is financed in various ways. For Medicaid and CHIP, states and the federal government share in the financing. The federal share of spending on those programs is funded entirely from the government's general fund, as are the outlays for subsidies provided through the health insurance exchanges.

In contrast, Medicare is funded mostly through a combination of dedicated taxes, beneficiaries' premiums, and

Figure 2-3.

Number of People Age 65 or Older, by Age Group



Per-person spending for Parts A and B of Medicare climbs with age: The program's average spending for an 85-year-old is more than twice that for a 66-year-old. Thus, average Medicare costs will rise as the number of people who are significantly older than 65 increases.

Source: Congressional Budget Office.

money from the government's general fund. The relative magnitudes of those sources of funding have changed significantly over time. Dedicated taxes have declined from 67 percent of gross federal spending for Medicare in 2000 to an estimated 40 percent in 2015 (see Figure 2-4). During the same period, the share of gross spending financed by offsetting receipts (mostly premiums paid by beneficiaries) has grown from 10 percent to an estimated 13 percent, and the share financed by the general fund and the remaining sources of funding for the program has increased from 23 percent to 47 percent. The increase in the share of spending covered by sources other than dedicated taxes is largely the result of an increase in the share of benefits provided by the parts of the program that are financed mainly by a combination of premiums and money from the general fund—Part B and, since 2006, Part D.[65] In CBO's extended baseline, receipts from dedicated Medicare taxes equal only 22 percent of gross federal spending for Medicare in 2040, and beneficiaries' premiums and other offsetting receipts account for 17 percent—leaving 61 percent financed by general funds and the remaining sources.

Benefits under Part A of Medicare are paid from the Hospital Insurance Trust Fund, which is credited with receipts largely from payroll taxes and from other revenues. A commonly used measure of the sustainability of Part A of Medicare is the timing of the projected exhaustion of the HI trust fund. According to CBO's baseline projections, under current law, the balance of the HI trust fund would increase from $202 billion at the end of fiscal year 2014 to $245 billion at the end of fiscal year 2020. Starting in 2021, CBO expects expenditures to outstrip income. By 2025, the fund's balance would be down to $156 billion.[66] CBO projects that the trust fund would be exhausted early in the 10-year period after 2025.[67]

Once the HI trust fund was exhausted, total payments to health plans and providers for services covered under Part A of Medicare would apparently be limited to the

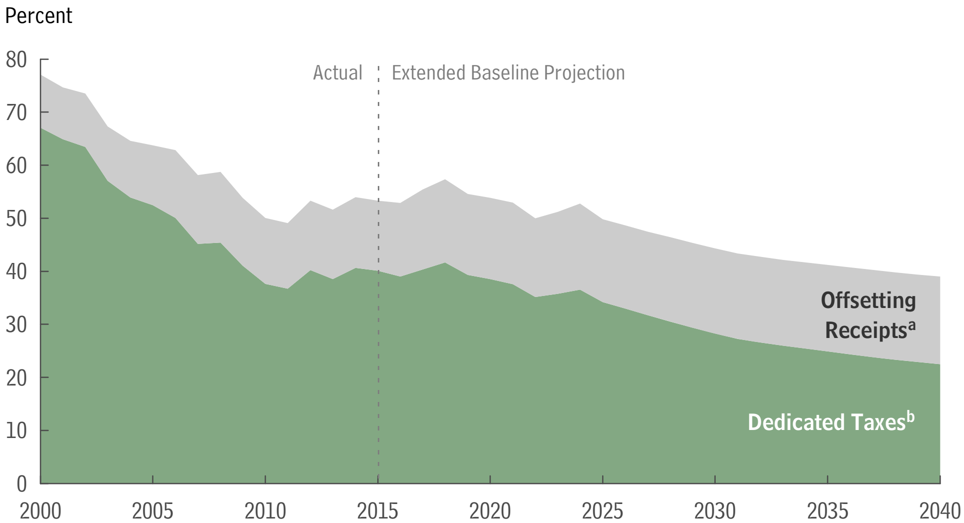
65. In 2000, Part B accounted for 41 percent of gross Medicare spending; in 2015, Parts B and D will account for 56 percent of gross Medicare spending, CBO estimates. In 2015, the percentage of benefits covered by premiums and other offsetting receipts would be higher than shown here if the two-thirds of Part D premiums paid directly by beneficiaries to Part D plans and the resulting benefit payments were included; however, they are not recorded in the federal budget.

66. Congressional Budget Office, "Medicare—Baseline Projections" (March 2015), www.cbo.gov/publication/44205. The estimate given is an updated one that reflects recently enacted legislation.

67. In contrast, the Supplementary Medical Insurance Trust Fund, which pays for benefits covered under Parts B and D of Medicare, cannot be exhausted, because it is financed mainly through premiums and money from the general fund. The amounts of contributions from those sources are set to cover the costs of those benefits.

Figure 2-4.

Medicare's Dedicated Taxes and Offsetting Receipts as a Share of Medicare Spending



Over the past several years, the share of Medicare spending funded by taxes and premiums has dropped. The share funded by the government's general fund has consequently grown.

Sources: Office of Management and Budget (actual shares up to 2014); Congressional Budget Office (projected shares).

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

a. Mostly premium payments made by beneficiaries to the government; also includes amounts paid by states from savings on Medicaid's prescription drug costs.

b. Payroll taxes and a portion of the federal income taxes paid on Social Security benefits.

amount of revenues subsequently credited to the trust fund. If that occurred, beneficiaries' access to health care services covered under Part A would almost certainly be reduced. However, for the purposes of these projections, CBO assumes that Medicare will pay benefits as scheduled under current law regardless of the status of the HI trust fund—an assumption that is consistent with a statutory requirement that CBO, in its 10-year baseline projections, assume that funding for an entitlement program is adequate to make all payments required by law for that program.[68]

Medicare Benefits and Payroll Taxes for People in Different Birth Cohorts

Over the course of their lifetimes, members of different generations will pay different amounts of Medicare payroll taxes and receive different amounts of Medicare benefits. Benefits will be a larger share of lifetime earnings for members of later generations, primarily because of the growth of health care spending per person but also because of increases in life expectancy, which will allow those people to receive benefits for longer periods, on average. Payroll taxes will be higher for later cohorts, because real earnings generally grow over time. Lifetime payroll taxes, however, will be about the same share of lifetime earnings, because payroll taxes are a fixed share of earnings.

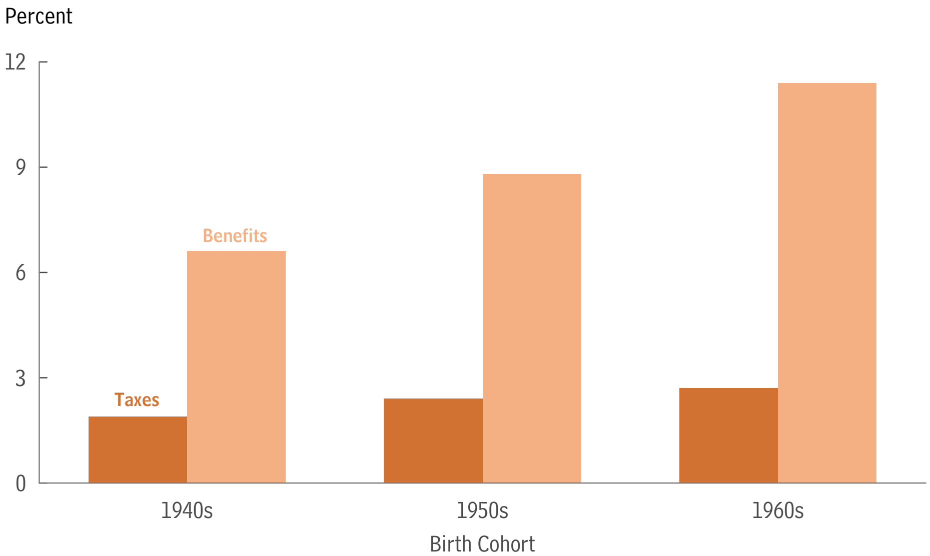
CBO estimated real lifetime benefits and payroll taxes for various birth cohorts as the present value, discounted to the year in which a beneficiary turns 65, of all benefits that a person receives from Medicare (net of premiums paid for those benefits) and all payroll taxes paid to the program (see Figure 2-5).[69] CBO estimates that, under the assumption that all scheduled benefits are paid, real

68. See section 257(b)(1) of the Balanced Budget and Emergency Deficit Control Act of 1985; 2 U.S.C. §907(b)(1).

69. For this analysis, benefits are those scheduled to be paid under current law, regardless of the balances projected for the HI trust fund. The present value of a flow of revenues or outlays over time is a single number that expresses that flow in terms of an equivalent sum received or paid at a specific time. The present value depends on a rate of interest (known as the discount rate) that is used to translate past and future cash flows into current dollars.

Figure 2-5.

Mean Lifetime Medicare Payroll Taxes and Benefits Relative to Lifetime Earnings, by Decade of Birth



Because of projected growth in health care spending per person and higher life expectancy, lifetime Medicare benefits will be a larger share of lifetime earnings for later generations.

Source: Congressional Budget Office.

Note: The amounts shown here are ratios of lifetime payroll taxes and benefits to lifetime earnings. Lifetime payroll taxes include all payroll taxes paid to the program. Payroll taxes consist of the employer's and employee's shares combined. Lifetime Medicare benefits include all benefits that a person is scheduled to receive from Medicare (net of premiums paid by beneficiaries to the government). To calculate present value, amounts are adjusted for inflation (to produce constant dollars) and discounted to age 65. The present value of a flow of revenues or outlays over time is a single number that expresses that flow in terms of an equivalent sum received or paid at a specific time. The present value depends on a rate of interest (known as the discount rate) that is used to translate past and future cash flows into current dollars. [Figure corrected on June 23, 2015]

average lifetime benefits (net of premiums paid) for each birth cohort as a percentage of lifetime earnings will generally be greater than those for the preceding cohort. For example, benefits received over a lifetime are projected to equal about 7 percent of lifetime earnings for people born in the 1940s, on average, but 11 percent for people born in the 1960s. By contrast, real average lifetime payroll taxes relative to lifetime earnings will rise from 2 percent for the 1940s cohort to almost 3 percent for the 1960s cohort.[70]

70. For people born in the 1940s and 1950s, lifetime payroll taxes as a share of lifetime earnings are lower than for later cohorts because those later cohorts face a higher statutory payroll tax rate for Hospital Insurance. That rate increased from 0.35 percent in 1966 to 2.9 percent in 1986, and it has stayed constant since.

[Text and footnote corrected on June 23, 2015]

CHAPTER

3

The Long-Term Outlook for Social Security

Social Security, which in 2015 marks its 80th anniversary, is currently the largest single program in the federal government's budget. The program consists of Old-Age and Survivors Insurance (OASI), which pays benefits to retired workers, to their dependents and survivors, and to some survivors of deceased workers; and Disability Insurance (DI), which makes payments to disabled workers and to their dependents until those workers reach the age of eligibility to receive full retirement benefits under OASI. Social Security currently has more than 59 million beneficiaries. The Congressional Budget Office estimates that mandatory outlays for Social Security will total $883 billion in fiscal year 2015, which will account for nearly one-quarter of all federal spending.[1]

During the program's first four decades, spending for Social Security increased sharply relative to the size of the economy—from less than 1 percent of gross domestic product (GDP) in the first few years to about 4 percent of GDP in the mid-1970s. That increase was caused largely by program expansions, including the creation in 1956 of the DI program. Spending rose to 4.8 percent of GDP in 1983, the year that marked the enactment of the last significant piece of legislation focused on Social Security. Between 1984 and 2007, Social Security spending fluctuated between 4.0 percent and 4.5 percent of GDP. During the 2007–2009 recession, GDP shrank, and the number of OASI and DI claimants rose unusually rapidly as the job market deteriorated. As a result, the program's outlays grew to 4.7 percent of GDP in 2009. CBO estimates that outlays for Social Security will be 4.9 percent of GDP in 2015.

In coming decades, more members of the baby-boom generation will reach retirement age and longer life spans will lead to longer retirements, so a much larger portion of the population will draw benefits. As a result, if the full benefits specified under current law are paid, CBO projects, Social Security spending would reach 6.2 percent of GDP in 2040 (see Figure 3-1).

How Social Security Works

Because 71 percent of its beneficiaries are retired workers or the spouses and children of those recipients, Social Security often is characterized as a retirement program.[2] In general, workers qualify for Social Security benefits if they are age 62 or older and have paid sufficient Social Security taxes for at least 10 years.

Social Security also provides other benefits, including payments to the survivors of deceased workers—about 10 percent of beneficiaries. In addition, workers who have not reached the full retirement age and who have had to limit employment because of a physical or mental disability can qualify for DI benefits—in many cases after a shorter period of employment than is required to collect retirement benefits. Disabled workers and their spouses and children account for 18 percent of beneficiaries.[3]

1. The $883 billion in mandatory outlays includes benefits paid ($878 billion), transfers to the Railroad Retirement Board ($5 billion), and payments to the U.S. Treasury for administrative costs (about $1 billion). CBO estimates that the Social Security Administration will spend an additional $6 billion, classified as discretionary outlays, on administration of the program. In this chapter, spending for Social Security generally refers to mandatory outlays.

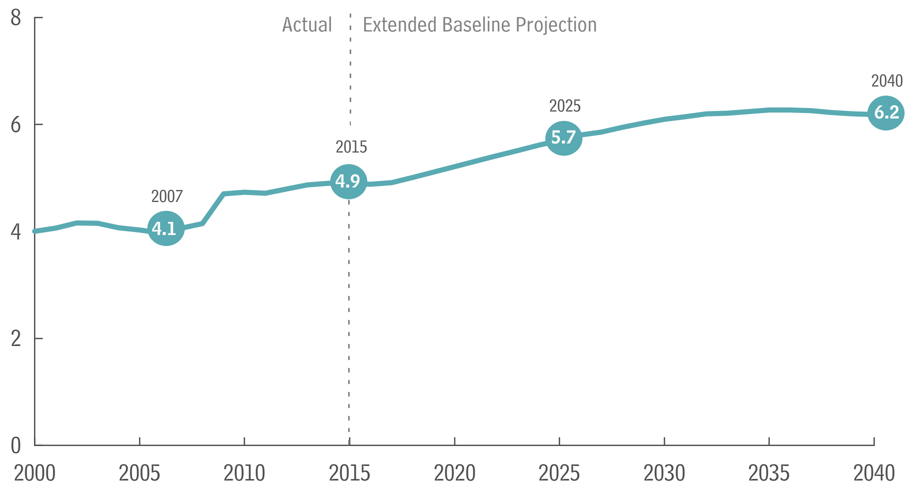
2. A more detailed description of the Social Security program is presented in Congressional Budget Office, *Social Security Policy Options 2015* (forthcoming).

3. See Congressional Budget Office, *Policy Options for the Social Security Disability Insurance Program* (July 2012), www.cbo.gov/publication/43421, and *Social Security Disability Insurance: Participation Trends and Their Fiscal Implications* (July 2010), www.cbo.gov/publication/21638.

Figure 3-1.

Spending for Social Security

Percentage of Gross Domestic Product



One effect of the 2007–2009 recession was a marked increase in spending for new Social Security recipients. The retirement of baby boomers is expected to increase spending over the rest of the projection period.

Source: Congressional Budget Office.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

In dollar terms, about 70 percent of Social Security benefits are paid to retired workers and their dependents, survivors receive 13 percent, and disabled workers and their spouses and children receive 16 percent.[4]

Benefits

The benefits that retired or disabled workers initially receive are based on individual earnings histories. Those earnings and the formula used to compute initial benefits are indexed to changes in average annual earnings for the U.S. workforce as a whole (including earnings that are not subject to taxation under Social Security). In subsequent years, a cost-of-living adjustment is applied to benefits to reflect annual growth in consumer prices.

The calendar year in which a worker was born determines the age at which that worker becomes eligible to receive full retirement benefits. Workers born before 1938 were eligible to receive full retirement benefits at the age of 65. Under a schedule put in place by the Social Security Amendments of 1983, the full retirement age is increasing gradually: It reached 66 for people born between 1943 and 1954; it will gradually rise again, beginning with people born in 1955, who will turn 62 in 2017, reaching 67 for people born after 1959, who will turn 62 in 2022 or later. The early eligibility age—at which a worker qualifies for reduced retirement benefits—remains unchanged at 62.

The Social Security Administration has estimated that the initial average annual benefit was about $19,800 for a worker who retired in calendar year 2014 at the full retirement age of 66 and whose earnings (averaged over his or her career) equaled the national average.[5] That amount would replace about 44 percent of that worker's career-average earnings indexed by national average wage growth to 2008, the year in which that worker turned 60. In coming decades, replacement rates will be lower for workers with average earnings who retire at age 66 because of the scheduled increase in the full retirement age. Nevertheless, because initial benefits are based on

4. The ways in which beneficiaries and benefits are categorized are not completely consistent—some beneficiaries receive benefits in more than one category. For instance, retired workers who also receive survivors' benefits are classified as retired for the purpose of calculating the number of beneficiaries in each category. For the purpose of calculating the distribution of benefits, however, their benefit payments are prorated to the categories of retired worker and survivor.

5. See Michael Clingman, Kyle Burkhalter, and Chris Chaplain, *Replacement Rates for Hypothetical Retired Workers*, Actuarial Note 2014.9 (Social Security Administration, July 2014), Table C, www.socialsecurity.gov/OACT/NOTES/ran9.

beneficiaries' previous earnings indexed to overall average wage growth and because wages are expected to grow faster than inflation over the long term, in CBO's estimation, the real (inflation-adjusted) value of those initial benefits will rise over time.

Taxes

The Social Security program is funded by dedicated tax revenues from two sources. Today, roughly 96 percent comes from a payroll tax—generally, 12.4 percent of earnings that are subject to the Social Security tax. Workers and their employers each pay half; self-employed people pay the entire amount. Earnings up to a maximum annual amount—$118,500 in calendar year 2015—are subject to the payroll tax. That taxable maximum generally increases annually at the same rate as average earnings in the United States, and it has remained a nearly constant proportion of the average wage since the early1980s. Because earnings have grown more for high earners than for others, the portion of earnings covered by Social Security on which payroll taxes are paid has fallen from 90 percent in 1983 to 81 percent in 2015. CBO expects this disparity in growth in earnings to continue for at least the next decade; the portion of earnings that is subject to the Social Security tax is projected to fall to about 79 percent by 2025 and to decline slightly thereafter.

The remaining share of tax revenues—4 percent—is collected from income taxes on Social Security benefits. Recipients who file as single people must pay taxes on their benefits if the sum of their non–Social Security income (adjusted gross income plus nontaxable interest income) and half of their benefits exceeds $25,000; the threshold for joint filers is $32,000. Under current law, those thresholds will remain the same over time—no adjustments are made to account for earnings growth or for inflation.

Trust Funds

Revenues from the payroll tax and the tax on benefits are credited to the two Social Security trust funds (the OASI Trust Fund and the DI Trust Fund). Social Security benefits account for 99 percent of total outlays from the trust funds; the remaining 1 percent covers administrative costs. Interest on the balances is credited to the trust funds, but because the interest transactions represent payments from one part of the government (the general fund of the U.S. Treasury) to another (the Social Security trust funds), they do not affect federal budget deficits or surpluses. The trust funds' balances ($2.8 trillion at the end of April 2015) have accumulated over many years; during that time, tax revenues and interest received by the trust funds have exceeded the benefits paid out.

The Outlook for Social Security Spending and Revenues

Analysts have long projected that the cost of the Social Security program will rise significantly over the coming decades. Average benefits per recipient are expected to continue to grow because the earnings on which those benefits are based also will increase, and, other things being equal, that relationship would tend to keep total benefits roughly stable as a percentage of GDP. Moreover, as a larger share of the baby-boom generation reaches retirement age and as longer life spans lead to longer retirements, a significantly larger portion of the population will draw benefits. Those forces will combine to cause the total amount of benefits scheduled to be paid under current law to grow faster than the economy. However, total revenues for the program are anticipated to decline slightly relative to the size of the economy because most of the revenues come from the payroll tax, which has a flat rate (up to the taxable maximum, indexed to average earnings), and the proportion of earnings subject to that tax is expected to shrink. That faster growth in total benefits than in total revenues will create a shortfall in the program's finances. The extent of the shortfall and the amounts of Social Security benefits received and taxes paid by people born in different years will depend on changes in life expectancy and other factors.

CBO's extended baseline, which encompasses the period from 2015 through 2040, generally reflects the provisions of current law. The projections for Social Security spending and revenues are based on a detailed microsimulation model, which starts with data about individuals from a representative sample of the population and projects demographic and economic outcomes for that sample through time. For each individual in the sample, the model simulates birth, death, immigration and emigration, marital status and changes to it, fertility, labor force participation, hours worked, earnings, and payroll taxes, along with Social Security retirement, disability, and dependent benefits.[6]

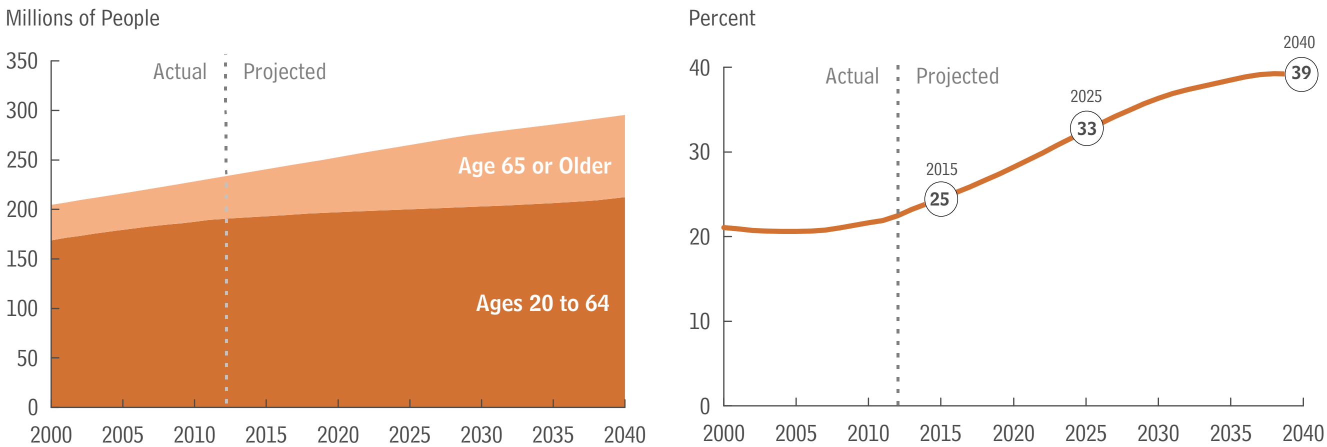
6. See Congressional Budget Office, *CBO's Long-Term Model: An Overview* (June 2009), www.cbo.gov/publication/20807.

Figure 3-2.

Changes in the Population, by Age Group

The number of people age 65 or older is expected to rise by 76 percent over the projection period, whereas the number between the ages of 20 and 64 will rise by just 10 percent.

Thus, by 2040, the proportion of the older to the younger group of people will have risen from the current 25 percent to nearly 40 percent.



Source: Congressional Budget Office.

Demographic Changes

According to CBO's projections, the number of people who are age 65 or older will increase by 37 percent between now and calendar year 2025 and by 76 percent between now and 2040. In comparison, CBO anticipates increases of just 4 percent and 10 percent in the population between the ages of 20 and 64 over those periods. Today, that older group is about one-quarter of the size of the younger group. The proportion is expected to increase to 33 percent by 2025 and to almost 40 percent by 2040 (see Figure 3-2). If current laws remained in place, more than 78 million people would collect benefits in 2025 and almost 100 million people would do so in 2040; currently, there are more than 59 million beneficiaries. (For more information on CBO's demographic projections, see Appendix A.)

After declining for several years, the average age of Social Security beneficiaries will begin to increase as the baby-boom generation continues to enter retirement. Currently, almost 12 percent of retired-worker beneficiaries over the age of 64 are at least 85 years old. As life expectancy increases, Social Security beneficiaries as a group will become older; by 2040, 19 percent of retired-worker beneficiaries over the age of 64 will be at least 85 years old.

CBO expects that future increases in life expectancy will be larger for people with higher lifetime earnings, which would be consistent with the pattern of past increases.[7] Today, a 65-year-old man whose household is in the highest quintile (the highest fifth) of lifetime earnings can be expected to live more than three years longer, CBO estimates, than a man of the same age whose household is in the lowest quintile of lifetime earnings; a 65-year-old woman in a household with high lifetime earnings can be expected to live more than a year longer than a woman of the same age in a household with low lifetime earnings. CBO projects that, on average by 2040, men in households with high lifetime earnings will live more than five years longer than men in households with low lifetime earnings, and women in households with high earnings will live almost three years longer than women in households with low earnings.

7. Life expectancy is the number of additional years a person is expected to live at a specified age. For more information on mortality differentials among groups with different earnings, see Congressional Budget Office, *Growing Disparities in Life Expectancy* (April 2008), www.cbo.gov/publication/41681; and Julian P. Cristia, *The Empirical Relationship Between Lifetime Earnings and Mortality,* Working Paper 2007-11 (Congressional Budget Office, August 2007), www.cbo.gov/publication/19096.

The projected changes in the life expectancy of people with high earnings relative to that of people with low earnings affect projections both of the total amount of Social Security benefits and of their distribution. Retirees with higher lifetime earnings receive larger benefits than retirees with lower earnings, so the greater increase in life expectancy of people in households with high lifetime earnings will raise total future benefits, all else being equal. Similarly, the greater increase in life expectancy of high earners will boost the ratio of lifetime Social Security benefits to lifetime Social Security taxes for high earners relative to that of low earners.[8]

Projected Spending and Revenues

If current laws remained in place, spending for Social Security would rise from 4.9 percent of GDP in 2015 to 6.2 percent by 2040, CBO estimates.[9] The share of Social Security spending on disability benefits would fall from 16 percent today to 13 percent in 2040. Most disabled beneficiaries are between age 50 and the full retirement age, and, as the baby-boom generation becomes older, the share of the population in that range will decline.

Between 2015 and 2040, Social Security revenues would grow more slowly than spending, according to projections in CBO's extended baseline. Because Social Security payroll tax receipts constitute a fixed share of taxable earnings, and taxable earnings are projected to decline as a share of GDP, payroll taxes also would decline as a share of GDP—from 4.2 percent in 2015 to 4.1 percent in 2040 (for further discussion, see Appendix A). However, both the number of Social Security recipients whose benefits are subject to taxation and their average income tax rates would increase, CBO projects. (For information about CBO's projections of total income taxes, see Chapter 5.) As a result, income taxes on Social Security benefits that are credited to the Social Security trust funds would grow from about 0.2 percent of GDP today to 0.3 percent of GDP in 2040. By that year, total Social Security tax revenues—payroll taxes plus taxes on benefits—would equal 4.4 percent of GDP, the same as the current amount.

In 2010, for the first time since the enactment of the Social Security Amendments of 1983, annual outlays for the program exceeded annual revenues excluding interest credited to the trust funds. A gap between those amounts has persisted since then, and in 2014 outlays exceeded noninterest income by about 9 percent. CBO now projects that, as more people in the baby-boom generation retire over the next 10 years, the gap will widen between amounts credited to the trust funds and payments to beneficiaries. According to CBO's extended baseline projections, if current laws remained unchanged, Social Security outlays would exceed the program's revenues by almost 30 percent in 2025 and by more than 40 percent in 2040.

Financing of Social Security

A common measure of the sustainability of a program that has a trust fund and a dedicated revenue source is its estimated actuarial balance over a given period—that is, the sum of the present value of projected tax revenues and the current trust fund balance minus the sum of the present value of projected outlays and a target balance at the end of the period.[10] For Social Security, that difference is traditionally presented as a percentage of the present value of taxable payroll. Over the next 75 years, if current laws remained in place, the program's actuarial

8. The ratio of lifetime benefits to taxes in Social Security depends on annual benefits and on the number of years for which benefits are collected. Beneficiaries with low lifetime earnings receive an annual benefit that replaces a larger portion of their average lifetime earnings than beneficiaries with high lifetime earnings, but they also tend to live for fewer years and therefore to collect benefits for a shorter period. All told, lifetime Social Security benefits as a share of lifetime earnings decrease as earnings rise, but estimates of that effect vary widely and depend on whether disabled and survivors' beneficiaries are included, how spousal benefits are accounted for, and how married couples are treated. For example, see Barry P. Bosworth and Kathleen Burke, *Differential Mortality and Retirement Benefits in the* Health and Retirement Study (April 2014), pp. 5–6, http://tinyurl.com/nqlhpyt.

9. CBO's projections incorporate the assumption that Social Security will pay benefits as scheduled under current law regardless of the status of the program's trust funds.

10. The present value of a flow of revenues or outlays over time is a single number that expresses that flow in terms of an equivalent sum received or paid at a specific time. The present value depends on a rate of interest (known as the discount rate) that is used to translate past and future cash flows into current dollars. To account for the difference between the trust fund's current balance and the balance desired for the end of the period, the balance at the beginning is added to the projected tax revenues and an additional year of costs at the end of the period is added to projected outlays.

Table 3-1.

Financial Measures for Social Security Under CBO's Extended Baseline

Projection Period (Calendar years)	Income Rate	Cost Rate	Actuarial Balance (Difference)
		As a Percentage of Taxable Payroll	
25 Years (2015 to 2039)	14.9	17.7	-2.8
50 Years (2015 to 2064)	14.2	17.9	-3.8
75 Years (2015 to 2089)	14.0	18.3	-4.4
		As a Percentage of Gross Domestic Product	
25 Years (2015 to 2039)	5.0	6.0	-0.9
50 Years (2015 to 2064)	4.7	6.0	-1.3
75 Years (2015 to 2089)	4.6	6.1	-1.4

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

Over the relevant periods, the income rate is the present value of annual tax revenues plus the initial trust fund balance, and the cost rate is the present value of annual outlays plus the present value of a year's worth of benefits as a reserve at the end of the period, each divided by the present value of gross domestic product or taxable payroll. The present value of a flow of revenues or outlays over time is a single number that expresses that flow in terms of an equivalent sum received or paid at a specific time. The present value depends on a rate of interest (known as the discount rate) that is used to translate past and future cash flows into current dollars. The actuarial balance is the difference between the income and cost rates.

To be consistent with the approach used by the Social Security trustees, the 25-, 50-, and 75-year projection periods for the financial measures reported here include 2015 and end in 2039, 2064, and 2089, respectively. See Social Security Administration, *The 2014 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds* (July 2014), www.socialsecurity.gov/OACT/TR/2014.

shortfall would be 4.4 percent of taxable payroll, or 1.4 percent of GDP, CBO estimates (see Table 3-1).[11] Thus, given CBO's projections, actuarial balance could be achieved for Social Security through calendar year 2089 if payroll taxes were increased immediately and permanently by 4.4 percent of taxable payroll, if scheduled benefits were reduced by an equivalent amount, or if some combination of tax increases and spending reductions of equal present value was adopted.

The estimates of the actuarial shortfall do not account for revenues and outlays after the 75-year projection period. A policy that increased revenues or reduced outlays by the same percentage of taxable payroll in each year so as to eliminate the 75-year shortfall would not necessarily place Social Security on a permanently stable financial path. Instead, such a policy would create surpluses during the next several decades but generate deficits in later years and leave the system in a state of financial imbalance after calendar year 2089. If such a policy was adopted, the 75-year measure used in this report and commonly used in other analyses of Social Security would show no shortfall now because the measure includes the taxes paid by workers each year until 2089 but does not include the benefits that would be paid to those workers after that year.

11. To be consistent with the 75-year actuarial balance reported by the Social Security trustees, the 75-year projection period used here begins in calendar year 2015 and ends in calendar year 2089. The Social Security trustees estimated in 2014 that the program's 75-year actuarial shortfall was 2.9 percent of taxable payroll, 1.5 percentage points less than CBO estimates. The larger shortfall projected by CBO stems largely from three differences in the projections: CBO anticipates that life expectancy will increase somewhat more rapidly, the incidence of disability will be a little higher, and in the long run interest rates will be 0.6 percentage points lower. Taken together, all of the other factors that affect the actuarial shortfall would lead CBO and the trustees to make roughly the same estimate. For more details on CBO's projections, see Appendix A. For more details on the trustees' projections, see Social Security Administration, *The 2014 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds* (July 2014), www.socialsecurity.gov/OACT/TR/2014.

The measure of actuarial balance used here is known as the 75-year open-group unfunded obligation because, with no change in law, the program would continue to be open to new participants. Those new participants would pay much more in taxes over the next 75 years than they would receive in benefits during that period.

An alternative measure—sometimes called the closed-group unfunded obligation—shows the shortfall in the system that would occur if the law was changed to close Social Security to anyone currently younger than age 15, thereby encompassing future taxes paid and benefits received only by people who are now age 15 or older. (Similar assessments are made of the financial outlook for private pension plans.) CBO estimates that, when measured as a percentage of the taxable payroll, the 75-year closed-group shortfall as of 2015 is about two-thirds larger than the 75-year open-group shortfall.

Another commonly used measure of Social Security's sustainability is the trust funds' date of exhaustion. Under CBO's extended baseline, the DI trust fund will be exhausted in fiscal year 2017 and the OASI trust fund will be exhausted in calendar year 2031. It is a common analytical convention, however, to consider the DI and OASI trust funds as combined, although legally they are separate. Therefore, this report focuses on the combined trust funds. In CBO's extended baseline, the combined OASDI trust funds are projected to be exhausted in calendar year 2029.

If a trust fund's balance declined to zero and current revenues were insufficient to cover benefits specified in law, the Social Security Administration would no longer have legal authority to pay full benefits when they were due. In the years after a trust fund's exhaustion, annual outlays therefore could not exceed annual revenues. Under those circumstances, all receipts to the trust fund would be used and the trust fund balance would remain essentially at zero.[12]

Social Security benefits can be projected in two different ways: as payable benefits, which conform to the limits imposed by a trust fund's balance, or as scheduled benefits, which reflect the benefit formulas specified in law, regardless of a trust fund's balance. This report uses the latter approach, which is consistent with a statutory requirement that CBO, in its 10-year baseline projections, assume that funding for entitlement programs is adequate to make all payments required by law.[13] In 2030, the year after the combined trust funds are expected to be exhausted, revenues are projected to equal 72 percent of scheduled outlays. Under those circumstances, payable benefits would be 28 percent less than scheduled benefits.

Social Security Benefits and Payroll Taxes for People in Different Birth Cohorts

People in different generations will, on average, end up paying different amounts of Social Security taxes and receiving different amounts of benefits over their lifetime.[14] Under current law, taxes and benefits alike would be higher for people born later because real earnings are projected to keep growing. Continuing increases in life expectancy also would contribute to growth in lifetime benefits because later cohorts would live to receive Social Security benefits for longer periods. To compare the effects of Social Security benefits and taxes on different generations, CBO calculated lifetime Social Security benefits and payroll taxes as the present value—discounted to the year in which the beneficiary turns 65—of all such benefits that workers would receive from the program or all payroll taxes they would pay to the program.[15] CBO measures the present value of benefits or taxes relative to the present value of lifetime earnings, with all values adjusted for inflation (see Figure 3-3). That analysis results in the following conclusions:

12. Noah P. Meyerson, *Social Security: What Would Happen If the Trust Funds Ran Out?* Report for Congress RL33514 (Congressional Research Service, August 2014). That report notes the entitlement created under the Social Security Act, cites other law that prohibits officials from making expenditures in excess of available funds, and acknowledges that the two create a potential conflict that must be resolved by the Congress or in the courts.

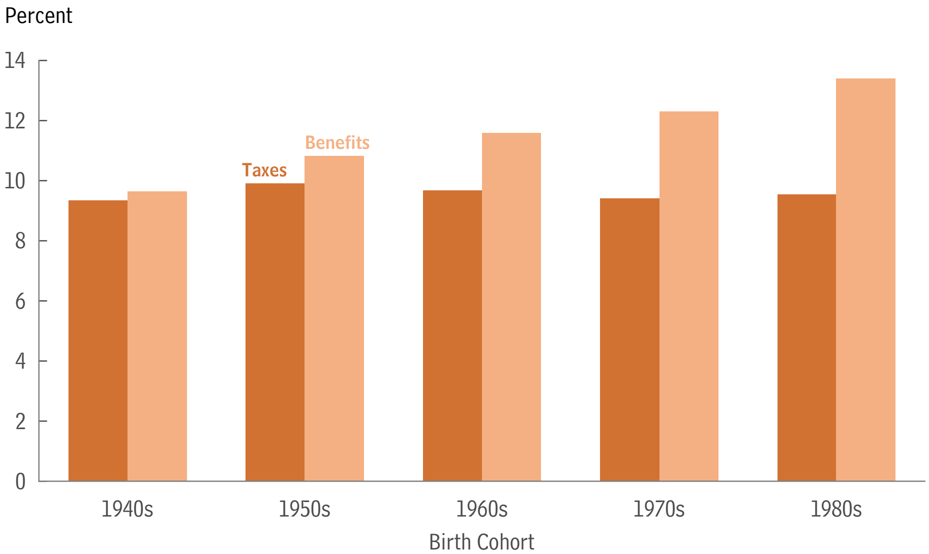
13. Section 257(b)(1) of the Balanced Budget and Emergency Deficit Control Act of 1985; 2 U.S.C. §907(b)(1).

14. For analysis of the distribution of Social Security benefits and taxes according to CBO's 2014 long-term projections, see Congressional Budget Office, *CBO's 2014 Long-Term Projections for Social Security: Additional Information* (December 2014), Exhibits 8–10, www.cbo.gov/publication/49795.

15. For this analysis, payroll taxes include the combined shares paid by employers and employees. Benefits are net of income taxes paid on benefits and credited to the Social Security trust funds. For discussion of the methods CBO used for these estimates, see Congressional Budget Office, *CBO's 2014 Long-Term Projections for Social Security: Additional Information* (December 2014), Appendix B, www.cbo.gov/publication/49795.

Figure 3-3.

Mean Lifetime Scheduled Social Security Taxes and Benefits Relative to Lifetime Earnings



An increase in life expectancy will mean that people born later will receive more in Social Security benefits (relative to their earnings) than those born earlier. Payroll taxes are not expected to keep pace, however, because they apply to a limited amount of earnings and that share of earnings subject to the tax is projected to decline for people born later.

Source: Congressional Budget Office.

Notes: The distribution of lifetime household earnings includes only people who live to at least age 45. Payroll taxes consist of the employer's and employee's shares combined. To calculate present value, amounts are adjusted for inflation (to produce constant dollars) and discounted to age 65. The present value of a flow of revenues or outlays over time is a single number that expresses that flow in terms of an equivalent sum received or paid at a specific time. The present value depends on a rate of interest (known as the discount rate) that is used to translate past and future cash flows into current dollars.

Lifetime Social Security benefits include all benefits paid to an individual except those received by young widows and children. Those benefits are excluded from this measure because there are insufficient data for years before 1984.

Scheduled benefits are benefits calculated under the Social Security Act, regardless of the balances in the program's trust funds.

- Real average lifetime scheduled benefits for each birth cohort as a percentage of lifetime earnings will generally be greater than those for the preceding cohort, and increases in life expectancy will cause that percentage to rise over time. For example, for people born in the 1950s, the mean amount of benefits received over a lifetime is projected to be about 11 percent of lifetime earnings. For people born in the 1980s, that amount will be 13 percent if they receive scheduled benefits.

- Real average lifetime payroll taxes for each birth cohort relative to lifetime earnings will generally be slightly less than those for the preceding cohort because of two factors: Under current law Social Security payroll taxes are a fixed share of earnings below the taxable maximum, and the portion of earnings that is subject to Social Security tax is projected to fall. For example, for people born in the 1950s, the mean amount of payroll taxes paid over a lifetime is projected to be about 10 percent of lifetime earnings. For people born in the 1980s, that amount will be 9.5 percent.

CHAPTER

4

The Long-Term Outlook for Other Federal Noninterest Spending

In 2015, almost half of the federal government's spending will go toward programs and activities other than the major health care programs (Medicare, Medicaid, the Children's Health Insurance Program, and the subsidies for health insurance purchased through exchanges), Social Security, and net interest. That spending—referred to in this report as other federal noninterest spending—includes outlays for discretionary programs, which are funded through the annual appropriation process, and outlays for mandatory programs other than the major health care programs and Social Security, which are usually funded according to laws that set eligibility and payment rules.[1] Mandatory spending in this category also includes the refundable portions of the earned income tax credit, the child tax credit, and the American Opportunity Tax Credit, which are recorded in the budget as outlays.

Under the broad assumptions used for this analysis, the Congressional Budget Office projects that other federal noninterest spending would drop from a total of 9.1 percent of gross domestic product (GDP) in 2015 to 7.4 percent in 2025 and then to 6.9 percent in 2040:

- Discretionary spending, which equals an estimated 6.5 percent of GDP in 2015, would fall to 5.1 percent of GDP by 2025; for its extended baseline, CBO assumed that discretionary spending would remain fixed at its percentage of GDP in 2025 (see Figure 4-1).
- Mandatory spending other than that for the major health care programs and Social Security would decrease from 2.6 percent of GDP this year to 2.3 percent in 2025. For its extended baseline, CBO assumed that such spending—other than the portion related to refundable tax credits—would continue to fall relative to GDP at the same rate that occurred over the 2020–2025 period. (Refundable tax credits are estimated as part of the revenue projections, which are described in Chapter 5.) Putting those pieces together, other mandatory spending is projected to equal 1.8 percent of GDP in 2040.

Other Federal Noninterest Spending Over the Past 50 Years

During the past 50 years, federal spending for everything other than the major health care programs, Social Security, and net interest has averaged 12 percent of GDP. Such spending equaled 13 percent of GDP in 1965, stayed between 12 percent and 15 percent from 1966 through 1987, and fell to around 8 percent in the late 1990s and early 2000s. By 2003, such spending had moved up to 10 percent of GDP, remaining close to that level through most of the first decade of the 2000s. It then spiked to 14 percent of GDP in 2009, before receding to 9 percent in 2014.

Discretionary Spending

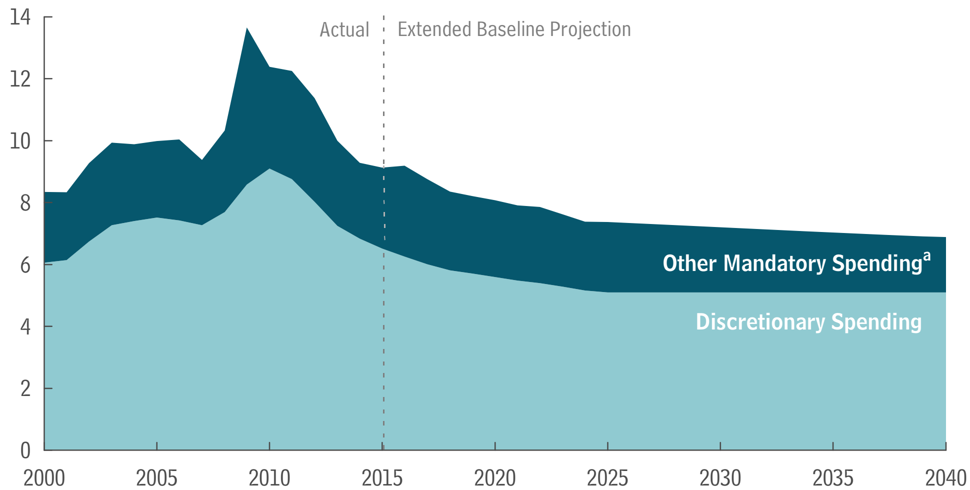
A distinct pattern in the federal budget since the 1970s has been the diminishing share of spending that occurs through the annual appropriation process. Between 1965 and 2014, discretionary spending declined from 66 percent of total federal spending to 34 percent. Relative to the size of the economy, that spending decreased from 10.9 percent of GDP to 6.8 percent.

1. For a description of the activities included in various categories of federal spending, see Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), Box 3-1, www.cbo.gov/publication/49892.

Figure 4-1.

Other Federal Noninterest Spending

Percentage of Gross Domestic Product



Other federal noninterest spending in CBO's extended baseline falls by 25 percent relative to gross domestic product between 2015 and 2040. Nearly two-thirds of that drop stems from the projected decline in discretionary spending over the next decade.

Source: Congressional Budget Office.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

a. Other mandatory spending is all mandatory spending other than that for the major health care programs, Social Security, and net interest. It includes the refundable portions of the earned income and child tax credits and of the American Opportunity Tax Credit.

About half of discretionary spending is devoted to national defense and is administered primarily by the Department of Defense (DoD). That department's spending falls mostly into three broad categories:

- Operation and maintenance, which supports the day-to-day activities of the military, the training of military units, the majority of costs for the military's health care system, and compensation for most of DoD's civilian employees;
- Military personnel, which covers compensation for uniformed service members, including pay, allowances for housing and food, and related activities, such as moving service members and their families to new duty stations; and
- Acquisition, which includes procurement, research, development, testing, and evaluation of weapon systems and other major pieces of equipment.

Fifty years ago, in 1965, defense discretionary spending equaled 7.2 percent of GDP. It dropped below 5.0 percent of GDP in the late 1970s but averaged 5.9 percent during the defense buildup from 1982 to 1986 (see Figure 4-2). After the end of the Cold War, outlays for defense fell again relative to GDP, reaching a low of 2.9 percent at the turn of the century. Such outlays climbed again in the 2000s, mainly as a result of spending on military operations in Iraq and Afghanistan. Defense spending averaged 4.6 percent of GDP from 2009 through 2011, before falling to 3.5 percent in 2014.

The rest of discretionary spending is for nondefense purposes. It covers a wide array of federal investment and other activities, including the following:

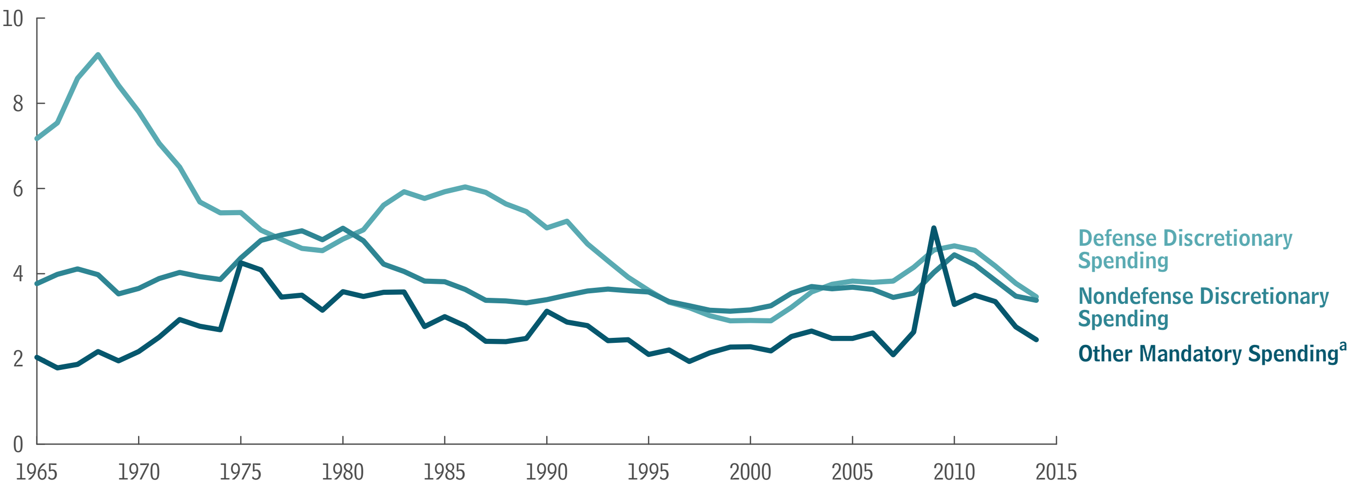
- Education (excluding student loans), training, employment, and social services;
- Transportation, including highway programs, transit programs, and airport security;
- Housing assistance;
- Veterans' health care;
- Health-related research and public health programs;
- Administration of justice, including federal law enforcement, criminal justice, and correctional activities;

Figure 4-2.

Other Federal Noninterest Spending, by Category, 1965 to 2014

Other federal noninterest spending is now about 30 percent lower as a percentage of gross domestic product (GDP) than it was in 1965. Lower defense discretionary spending—which is half the size it was, relative to GDP, in 1965—accounts for most of that reduction.

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

a. Other mandatory spending is all mandatory spending other than that for the major health care programs, Social Security, and net interest. It includes the refundable portions of the earned income and child tax credits and of the American Opportunity Tax Credit.

- International affairs, including international development, humanitarian assistance, peacekeeping, nuclear nonproliferation, and the operation of U.S. embassies and consulates; and
- Activities and programs in other areas, including natural resources and the environment, science, and community and regional development.

In 1965, nondefense discretionary spending amounted to 3.8 percent of GDP. Such spending remained close to 4 percent of GDP, on average, for the following decade but averaged almost 5 percent of GDP between 1976 and 1981. From 1984 to 2008, nondefense discretionary spending stayed between 3 percent and 4 percent of GDP. More recently, funding from the American Recovery and Reinvestment Act of 2009, as well as other funding associated with the federal government's response to the 2007–2009 recession, helped push nondefense discretionary spending above 4 percent of GDP from 2009 through 2011. Such spending dropped back to 3.4 percent of GDP in 2014.

Other Mandatory Spending

Mandatory spending other than that for the major health care programs and Social Security includes the following programs and activities:

- Civilian and military retirement, including benefits paid to retired federal civilian and military employees, and benefits paid to retired railroad workers;
- Earned income, child, and other refundable tax credits, for which payments are made to taxpayers for whom the credit exceeds their tax liability;
- Veterans' benefits, some of which are available to veterans only (such as housing, readjustment, disability compensation, and life insurance), and others of which are sometimes also available to dependents or survivors (such as educational assistance, pensions, dependency and indemnity compensation, and burial benefits);
- Food and nutrition programs, including the Supplemental Nutrition Assistance Program, (formerly known as the Food Stamp program), and child nutrition programs;

- Unemployment compensation;
- Supplemental Security Income; and
- Family support and foster care, including grants to states that help fund welfare programs, Temporary Assistance for Needy Families, foster care, and child support enforcement.

Other mandatory spending is net of various offsetting receipts, which are payments collected by government agencies from other government accounts or from the public in businesslike or market-oriented transactions and are recorded in the budget as negative outlays (that is, credits against mandatory spending). A significant share of offsetting receipts goes to the Medicare program (mostly in the form of premiums paid by beneficiaries) and is combined with Medicare outlays in this report (see Chapter 2 for more information). Other offsetting receipts come from the contributions that government agencies make to federal retirement programs, the proceeds from leases to drill for oil and natural gas on the Outer Continental Shelf, payments made to the U.S. Treasury by Fannie Mae and Freddie Mac, and other sources.

Other mandatory spending averaged about 2.5 percent of GDP from the mid-1960s through the mid-1970s. It then increased to about 3.5 percent of GDP, on average, from the mid-1970s through the early 1980s. It was generally lower from the mid-1980s to 2008, averaging about 2.5 percent of GDP. In 2009, however, other mandatory spending roughly doubled, to 5.1 percent of GDP, because of the financial crisis and recession and the federal government's response to them. As the economy has improved and the increases in spending related to the financial crisis and recession have waned, other mandatory spending has declined sharply relative to the size of the economy, falling to 2.5 percent of GDP in 2014.

Long-Term Projections of Other Federal Noninterest Spending

Under CBO's extended baseline, all federal spending apart from that for the major health care programs, Social Security, and net interest is projected to total 7.4 percent of GDP in 2025 and 6.9 percent in 2040. Those figures represent the lowest amounts relative to the size of the economy since the 1930s.

Discretionary Spending

Projections of discretionary spending for 2015 through 2025 come from CBO's most recent 10-year baseline budget projections, which were published in March.[2]

Through 2021, most discretionary appropriations are constrained by the caps put in place by the Budget Control Act of 2011 (as amended); for 2022 through 2025, CBO assumed that those appropriations would equal the 2021 amount, with increases for projected inflation. Funding for certain purposes, such as war-related activities, is not constrained by the Budget Control Act's caps; through 2025, CBO assumed, such funding would increase each year at the rate of inflation, starting from the current amount. Under those assumptions, outlays from discretionary appropriations are projected to decline from 6.5 percent of GDP this year—already well below the 50-year average of 8.8 percent—to 5.1 percent in 2025 (see Table 4-1). That 2025 amount would be the smallest share of discretionary spending relative to GDP in more than half a century (since at least 1962, the first year for which comparable data are available). Defense discretionary spending would equal 2.6 percent of GDP in 2025, and nondefense discretionary spending would equal 2.5 percent of GDP. Each of those amounts would also be the smallest as a share of the economy in at least five decades.

CBO's baseline and extended baseline are meant to be benchmarks for measuring the budgetary effects of legislation, so they mostly reflect the assumption that current laws remain unchanged. However, after 2021—when the caps established by the Budget Control Act are due to expire—total discretionary spending will not be constrained by current laws but instead will be determined by lawmakers' future actions. With no basis for predicting those actions, CBO based its long-term projections of discretionary spending on a combination of the baseline projections through 2025 and historical experience.

Specifically, after 2025, CBO's extended baseline incorporates the assumption that discretionary spending remains at the percentage of GDP projected for 2025—in other words, such spending grows at the same pace as the economy. In CBO's judgment, projecting a continued decline in discretionary spending as a share of GDP beyond 2025 would not provide the most useful benchmark for

2. See Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), www.cbo.gov/publication/49973.

Table 4-1.

Other Federal Noninterest Spending Projected Under CBO's Baseline

Percentage of Gross Domestic Product

	2015	2025
Discretionary Spending		
Defense	3.2	2.6
Nondefense	3.3	2.5
Total	**6.5**	**5.1**
Other Mandatory Spending		
Civilian and military retirement	0.9	0.8
Nutrition programs	0.5	0.4
Refundable tax credits[a]	0.5	0.3
Veterans' benefits	0.5	0.4
Unemployment compensation	0.2	0.2
Supplemental Security Income	0.3	0.3
Offsetting receipts	-0.9	-0.5
Other	0.6	0.5
Total	**2.6**	**2.3**
Total, Other Federal Spending	**9.1**	**7.4**

Source: Congressional Budget Office.

Note: Other federal spending is all spending other than that for the major health care programs, Social Security, and net interest.

a. The earned income and child tax credits and the American Opportunity Tax Credit.

considering potential changes to discretionary programs, for several related reasons: First, discretionary spending has been a larger share of economic output throughout the past 50 years than it is projected to be in 2025. Second, nondefense discretionary spending has been higher than 3.0 percent of GDP throughout the past five decades and has shown no sustained trend relative to GDP. Third, defense spending has equaled at least 2.9 percent of GDP throughout the past five decades and has shown no trend relative to GDP in the past two decades. Conversely, projecting an increase in discretionary spending as a percentage of GDP beyond 2025 would require CBO to select a specific percentage, which the agency does not have a clear basis for doing. As a result of those considerations, CBO assumed for the extended baseline that discretionary spending would remain the same as a share of GDP after 2025 as CBO projects for 2025 in the 10-year baseline.

Other Mandatory Spending

In constructing its baseline projections, CBO assumes that mandatory programs will operate as they do under current law, which includes the automatic spending cuts put in place by the Budget Control Act.

In CBO's most recent baseline projections, total mandatory spending other than that for the major health care programs and Social Security is estimated to be 2.6 percent of GDP this year and to rise to 2.9 percent of GDP in 2016, primarily because of lower offsetting receipts. Such spending then declines in subsequent years, to 2.3 percent of GDP by 2025.[3]

Most of the projected decline in other mandatory spending relative to GDP through 2025 occurs because the number of beneficiaries for some of the programs is expected to decline relative to the size of the population as the economy expands and because average payments per beneficiary are projected to decrease relative to average income. For example, income thresholds for eligibility for some large income support programs, such as Supplemental Security Income and the Supplemental Nutrition Assistance Program, generally rise with prices, whereas income usually rises more rapidly—especially with the strengthening of the economy that CBO anticipates during the next several years. As a result, CBO expects, the number of beneficiaries in some programs will rise more slowly than the population or even decrease over the next 10 years. Furthermore, average payments under some large programs are often indexed to inflation and therefore tend to grow more slowly than income.

A small part of the decline between 2015 and 2025 stems from a projected reduction in spending for the earned income tax credit, the child tax credit, and the American Opportunity Tax Credit. Outlays for the refundable portions of those credits are projected to decrease from 0.5 percent of GDP in 2015 to 0.3 percent in 2025. About one-third of the decrease stems from the scheduled expiration of the American Opportunity Tax Credit and temporary increases in the earned income and child tax credits at the end of calendar year 2017, and about two-thirds is because, as income grows, the amounts of various credits that people qualify for decrease.

3. See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), p. 16, www.cbo.gov/publication/49892.

For the years beyond 2025, CBO projected outlays for the refundable portions of the earned income and child tax credits as part of its long-term revenue projections (discussed in Chapter 5). The remainder of other mandatory spending was not projected in detail after 2025 because of the number of programs involved and the variety of factors that influence spending on them. Instead, CBO used an approximate method to project spending for those programs as a group, assuming that such spending would decline as a share of GDP after 2025 at the same rate at which it is projected to fall between 2020 and 2025. As benefits for some programs decline further relative to average income under current law, the benefits available to people many years in the future would differ markedly from what they are today.

Under the assumption that some benefits decline relative to average income, mandatory spending other than that for the major health care programs, Social Security, and refundable tax credits would decrease from 2.0 percent of GDP in 2025 to 1.6 percent by 2040. Including spending on those tax credits, other mandatory spending would equal 1.8 percent of GDP in 2040.

CHAPTER

5

The Long-Term Outlook for Federal Revenues

Federal revenues come from various sources, including individual and corporate income taxes, payroll (social insurance) taxes, excise taxes, estate and gift taxes, and other taxes and fees. Currently, proceeds from individual income taxes and payroll taxes account for about 80 percent of the federal government's revenues.

Projecting future revenue collections is difficult because revenues are sensitive to economic developments and because policymakers often make changes to tax law. For this report, the Congressional Budget Office projected the future path of revenues under an extended baseline. That approach follows the agency's baseline budget projections for the next decade and then extends the baseline concept beyond that 10-year window. The revenues projected for the 10-year window are the same as those in CBO's March 2015 baseline, as adjusted for recently enacted legislation.[1]

In general, the extended baseline reflects current law and embodies two assumptions about future federal tax policy:

- The rules governing individual income, payroll, excise, and estate and gift taxes will evolve as specified under current law (including the recent or scheduled expiration of temporary provisions lawmakers have routinely extended before); and
- Revenues from corporate income taxes and other sources (such as receipts from the Federal Reserve) will grow as projected under current law through 2025 and then remain constant as a share of gross domestic product (GDP) thereafter.[2]

Not intended to predict budgetary outcomes, the projections instead represent CBO's general assessment of future revenues if current laws remained unchanged. (Chapter 6 discusses the consequences of fiscal policies other than those that the extended baseline incorporates.)

Under the extended baseline, federal revenues as a share of GDP are projected to rise from 17.7 percent in 2015 to 18.3 percent in 2025. That growth largely reflects structural features of the tax system, most significantly because of real bracket creep—the pushing of a growing share of income into higher tax brackets because of growth in real (inflation-adjusted) income and the interaction of the tax system with inflation.

After 2025, in the extended baseline, revenues continue rising faster than GDP, largely for two reasons: The effect of real bracket creep continues, and certain tax increases enacted in the Affordable Care Act (ACA) generate a growing amount of revenues in relation to the size of the economy. As a result, federal revenues are projected to

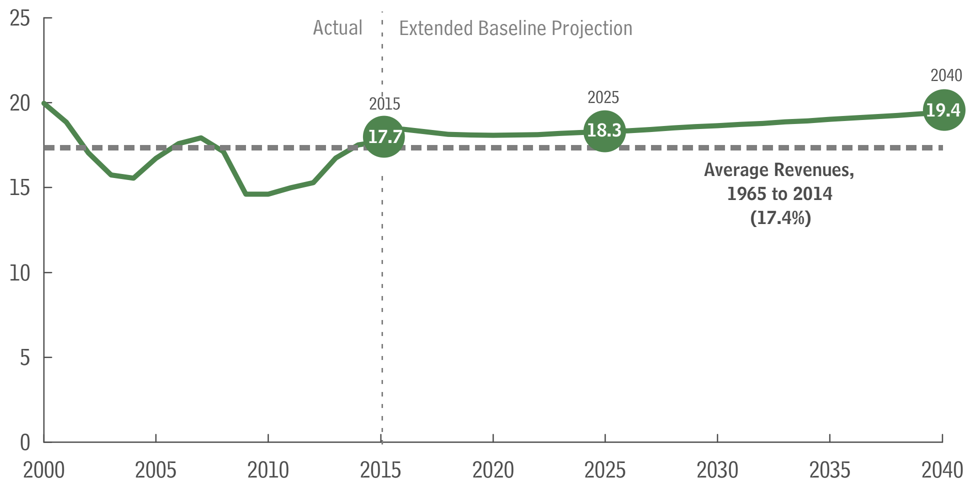
1. The baseline this chapter refers to is the baseline issued in March 2015, as adjusted to reflect legislation enacted after CBO prepared those projections. The only such legislation affecting revenues enacted before CBO made the current projections is Public Law 114-10, the Medicare Reauthorization and CHIP Extension Act of 2015, which became law on April 16, 2015. According to CBO's projections, that law will increase revenues by less than $1 billion in any given year between 2015 and 2025. For details of CBO's March baseline, see Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), www.cbo.gov/publication/49973. For details of Public Law 114-10, see Congressional Budget Office, cost estimate for H.R. 2, the Medicare Access and CHIP Reauthorization Act of 2015 (March 25, 2015), www.cbo.gov/publication/50053.

2. The sole exception to the current-law assumption during the 10-year baseline period applies to expiring excise taxes dedicated to trust funds. The Balanced Budget and Emergency Deficit Control Act of 1985 requires CBO's baseline to reflect the assumption that those taxes would be extended at their current rates. That law does not stipulate that the baseline include the extension of other expiring tax provisions, even if lawmakers have routinely extended them before.

Figure 5-1.

Total Revenues

Percentage of Gross Domestic Product



Under CBO's extended baseline, revenues as a share of GDP rise slowly after 2025 mainly because of real bracket creep and certain tax increases enacted in the Affordable Care Act.

Source: Congressional Budget Office.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

reach 19.4 percent of GDP by 2040 (see Figure 5-1).[3] By comparison, revenues over the past 50 years have averaged 17.4 percent of GDP. Without significant changes in tax law, the tax system's effects in 2040 would be quite different from what they are today. A larger share of each additional dollar of income that households earned would go to taxes, and households throughout the income distribution would pay more of their total income in taxes than households in similar places in that distribution pay today.

3. This chapter's revenue projections are based on CBO's benchmark projections of economic variables such as GDP, inflation, and interest rates. For the 2015–2025 period, the benchmark matches CBO's January 2015 economic forecast. For later years, the benchmark generally reflects the economic experience of the past few decades. The benchmark also incorporates two assumptions about fiscal policy—that debt held by the public is maintained at 78 percent of GDP, the level reached in 2025 in CBO's baseline budget projections, and that effective marginal tax rates on income from work and saving remain constant after that year. (Effective marginal tax rates on labor or capital income represent the percentage of an additional dollar of such income that is paid in federal taxes.) Thus, this chapter's economic benchmark and the revenue projections do not account for how the increase in marginal tax rates that would occur after 2025 under the extended baseline might affect people's behavior. Chapter 6 analyzes the economic impact of the debt levels and marginal tax rates that CBO projects under the extended baseline. For more about the economic benchmark, see Appendix A.

Revenues Over the Past 50 Years

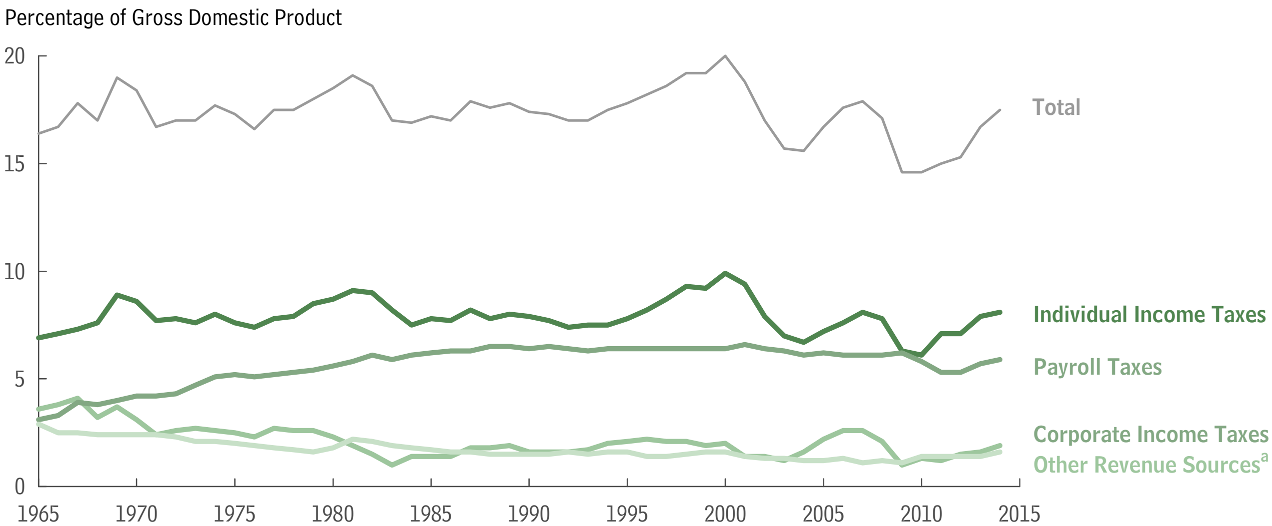
Over the past 50 years, total federal revenues have been as high as 20.0 percent of GDP (in 2000) and as low as 14.6 percent (in 2009 and 2010), with no evident trend (see Figure 5-2). The composition of total revenues during that period has varied as well. Individual income taxes, which account for about half of all revenues now, have ranged from slightly less than 10 percent of GDP (in 2000) to slightly more than 6 percent (in 2010). Payroll taxes, which generate about one-third of total revenues now, have varied from about 3 percent of GDP to more than 6 percent during the past 50 years. (Those taxes consist primarily of payroll taxes credited to the Social Security and Medicare Hospital Insurance trust funds.) Corporate income taxes have fluctuated between about 1 percent of GDP and 3 percent since the 1960s, as have combined revenues from other sources.

Some of the variation in the amounts of revenue that different taxes generated has stemmed from changes in economic conditions and from how those changes interact with the tax code. For example, without legislated tax reductions, real bracket creep tends to cause receipts from individual income taxes to grow in relation to GDP. Also, because some parameters of the tax system are not indexed to increase with inflation, rising prices alone subject a greater share of income to higher effective tax

Figure 5-2.

Revenues, by Source, 1965 to 2014

Over the past 50 years, total revenues averaged 17.4 percent of GDP; most of the variation around that average reflects variation in individual income tax receipts.



Source: Congressional Budget Office.

a. Consists of excise taxes, remittances to the U.S. Treasury from the Federal Reserve System, customs duties, estate and gift taxes, and miscellaneous fees and fines.

rates.[4] Cyclical developments in the economy also affect revenues. During economic downturns, for example, taxable corporate profits generally fall faster than the nation's output, shrinking corporate tax revenues in relation to GDP; losses in households' income also tend to push a greater share of total income into lower tax brackets, reducing individual income tax revenues in relation to GDP. Thus, total tax revenues as a share of GDP automatically decline when the economy is weak and rise when the economy is strong.

By contrast, revenues derived from excise taxes have declined over time in relation to GDP because many excise taxes are levied on the unit quantity of a good purchased (such as a gallon of gasoline) as opposed to a percentage of the price paid. Because those levies are not indexed for inflation, the revenues they generate have declined as a share of GDP as prices have risen.

Tax revenues as a share of GDP have also varied with legislative changes. In the past 50 years, at least a dozen changes in law have raised or lowered annual revenues by at least 0.5 percent of GDP.

Revenue Projections Under CBO's Extended Baseline

CBO's extended baseline follows the agency's March 2015 baseline budget projections, as adjusted for recently enacted legislation, for the next decade and then extends the baseline concept beyond that 10-year window.[5] The extended baseline reflects the assumptions that, after 2025, the rules governing the individual income, payroll, excise, and estate and gift taxes will evolve as specified under current law and that revenues from corporate income taxes and all other sources (such as receipts from the Federal Reserve) will remain constant as a share of GDP.

4. The parameters of the tax system include the amounts that define the various tax brackets; the amounts of the personal exemption, standard deductions, and credits; and tax rates. Although many of the parameters—including the personal exemption, standard deduction, and tax brackets—are indexed for inflation, some, such as the amount of the maximum child tax credit, are not. The effect of price increases on tax receipts was much more significant before 1984, when none of the parameters of the individual income tax were indexed for inflation.

5. See Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), www.cbo.gov/publication/49973.

Table 5-1.

Sources of Growth in Total Revenues as a Percentage of GDP Between 2015 and 2040 Under CBO's Extended Baseline

Source of Growth	Percentage of GDP
Structural Features of the Individual Income Tax System (Including real bracket creep)[a]	1.3
New and Expiring Tax Provisions	0.7
Aging and the Taxation of Retirement Income	0.3
Other Factors (Including remaining changes in individual income taxes and all changes in corporate, payroll, excise, and estate and gift taxes)[b]	-0.6
Growth in Total Revenues Over the 2015–2040 Period	**1.7**

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

GDP = gross domestic product.

a. Real bracket creep refers to the phenomenon in which rising real (inflation-adjusted) income causes an ever-larger proportion of income to be subject to higher tax rates.

b. Excludes the effects on all those revenue sources of new and expiring tax provisions, which are accounted for in a preceding line of the table.

During the next decade, under current law, some new provisions of tax law will go into effect and certain provisions will expire. Reflecting those scheduled changes, the extended baseline incorporates the following assumptions:

- A new tax on certain employment-based health insurance plans with high premiums, scheduled to go into effect in 2018 as a result of the ACA, will be implemented without modification.

- Certain tax provisions that recently expired will not be extended later, and provisions scheduled to expire over the next several years will do so, even if lawmakers have routinely extended them before. For example, tax credits for research and experimentation expired at the end of December 2014 and will not be extended, and certain individual income tax credits will expire or decline in value after 2017.

If current laws remained in place, tax revenues would rise from 17.7 percent of GDP in 2015 to 18.3 percent in 2025 and then to 19.4 percent in 2040, CBO estimates. Increases in receipts from individual income taxes more than account for the projected rise of 1.7 percentage points in total revenues as a percentage of GDP over the next 25 years; receipts from all the other sources, taken together, are projected to decline slightly as a share of GDP.

The projected increase in tax receipts reflects several factors, including structural features of the income tax system, new and expiring tax provisions (including scheduled future tax changes enacted in the ACA), demographic trends, and other factors (see Table 5-1).

Structural Features of the Individual Income Tax System

Real bracket creep is the most important structural feature of the tax system contributing to growth in revenue over time. It has two kinds of effects. Rising real income subjects an ever-larger proportion of income to higher tax rates, and it further increases taxes by reducing taxpayers' eligibility for various credits, such as the earned income tax credit and the child tax credit.

Also, some provisions of the tax code are not indexed for inflation, so cumulative inflation generates some increase in receipts in relation to GDP. For example, the ACA imposed an additional tax on the investment income of individuals with income exceeding $200,000 and of families with income exceeding $250,000. Those thresholds are not indexed for inflation, so the tax will affect an increasing share of investment income over time and will boost revenues by a small but growing share of GDP.[6]

6. The ACA also imposed an additional Medicare tax of 0.9 percent, paid entirely by the employee, on earnings (wages and salaries) exceeding $200,000 for individuals and $250,000 for families. Because those thresholds are not indexed for inflation, the tax will apply to an increasing share of earnings over time and thereby raise payroll tax revenues as a share of GDP by larger amounts over time. However, a decline in the share of earnings subject to the Social Security tax will more than offset that effect, CBO projects, because a further slight increase in earnings inequality will cause more earnings to be above the taxable maximum for Social Security.

Revenues from the individual income tax also depend on the distribution of income. CBO's projections reflect an expectation that earnings will grow faster for higher-income people than for others during the next decade—as they have over the past several decades—and that the incomes of all taxpayers will grow at similar rates thereafter. Altogether, if current laws remained in place, growth in people's income would increase income tax revenues as a portion of GDP by 1.3 percentage points between 2015 and 2040, CBO estimates.

New and Expiring Tax Provisions

Under the extended baseline, CBO assumes that tax provisions will take effect or expire as specified under current law. Two tax provisions enacted in the ACA will go into effect over the next several years. Those new provisions will begin to raise revenues as a share of GDP after 2015. Certain other provisions—mainly providing tax credits—are scheduled to expire, also boosting revenue.

The most significant new provision, an excise tax on employment-based health insurance whose value exceeds certain thresholds, is scheduled to go into effect in 2018. That tax is expected to increase revenues in two ways:

- First, in those cases in which the tax applied, it would generate additional excise tax revenues.

- Second, many individuals and employers will probably shift to lower-cost insurance plans to either reduce the excise tax paid or avoid paying it altogether. As a result, total payments of health insurance premiums for those individuals—and the associated tax-exempt contributions from their employers—will be less than they would have been without the tax. However, CBO expects that total compensation paid by employers (including wages and salaries, contributions to health insurance premiums, pensions, and other fringe benefits) will not be affected over the long term.[7] Thus, smaller expenditures for health insurance will mean higher taxable wages and salaries for employees and, as a result, higher payments of income and payroll taxes.[8]

Thus, whether policyholders decided to pay the excise tax or to avoid it by switching to lower-cost plans, total tax revenues would ultimately rise compared with what they would have been without the tax. Although the threshold for the tax on high-premium health insurance plans is indexed for changes in overall consumer prices, health care costs will grow faster than prices over the long term, CBO projects. Consequently, more people will be affected over time.[9] Under the extended baseline, the excise tax is projected to increase total revenues by 0.5 percent of GDP in 2040.

The other ACA provision that will increase revenues in relation to GDP after 2015 penalizes certain employers that do not offer their employees health insurance coverage meeting certain criteria. That provision will be phased in over the 2015–2016 period and will increase revenues starting in 2016, CBO estimates.

In addition, several tax provisions either recently expired or are slated to expire over the next several years. Recently expired provisions include tax credits for research and experimentation as well as a deferral of tax payments on certain types of foreign-earned income, both of which had been in effect for many years. And after 2017, several credits in the individual income tax system are scheduled to expire or to be scaled back.[10]

Together, under the extended baseline, the scheduled introduction of new tax provisions and the expiration of certain existing tax provisions would raise receipts by 0.7 percent of GDP between 2015 and 2040, CBO projects.

7. In the past, rising premiums have been an important cause of slow wage growth. See Paul Ginsburg, *Alternative Health Spending Scenarios: Implications for Employers and Working Households* (Brookings Institution, April 2014), http://tinyurl.com/ksh9p47.

8. Even if the excise tax caused employers to shift to lower-cost health insurance plans without a corresponding increase in wages, other taxes, such as those on corporate profits, would tend to rise. The resulting revenues would be similar to the amounts projected in CBO's extended baseline.

9. The thresholds will be indexed to general inflation plus 1 percentage point for 2019 and to general inflation for 2020 and later years.

10. A provision allowing businesses to immediately deduct 50 percent of new investments in equipment from their taxable income expired at the end of calendar year 2014. That expiration causes significant movements in receipts over the next few years but contributes little to the growth of revenues as a share of GDP over the 2015–2025 or 2015–2040 period. Projected receipts in 2016, the first fiscal year that fully reflects the less favorable depreciation rules in effect under current law for 2015 and later years, are higher because of the smaller initial deductions for new investments. Over time, however, that effect diminishes as taxpayers take deductions for investments made under the less favorable rules.

Aging and the Taxation of Retirement Income

During the next few decades, members of the baby-boom generation (people born between 1946 and 1964) will continue to retire. They will withdraw money from retirement accounts and receive pension benefits, boosting income tax revenues as a share of GDP. Depending on the specific characteristics of retirement plans—such as 401(k) plans and individual retirement accounts—some or all of the amounts withdrawn will be taxable. Likewise, compensation deferred under employer-sponsored defined benefit plans is taxed when benefits are paid.[11] Thus, the U.S. Treasury will receive significant tax revenues that have been deferred for years. As a result, under the extended baseline, revenues as a share of GDP are projected to climb by about 0.3 percentage points between 2015 and 2040. That upward trend is expected to end around 2040, when almost all baby boomers will have reached retirement.

Other Factors

Under the extended baseline, factors besides those already discussed would cause revenues to decline by a combined 0.6 percent of GDP between 2015 and 2040. (The estimate reflects current law but does not consider scheduled changes to law and the structural and demographic effects of individual income taxes, which are accounted for separately.) About two-thirds of that decline would occur by 2025. In particular, remittances to the Treasury from the Federal Reserve—which have been very large since 2010 because the central bank's portfolio has grown and changed in composition—are projected to decline to more typical levels.

CBO also projects that, excluding the excise tax on high-premium health insurance plans, excise taxes would decline as a share of GDP over time. Many excise taxes are assessed as a fixed dollar amount per unit quantity of a good purchased, not as a percentage of the price paid. Therefore, as overall prices rise over time, receipts from excise taxes as a share of GDP tend to fall. Moreover, payroll taxes for unemployment insurance are expected to decline to more typical levels over the next few years, further reducing receipts as a share of GDP. Partly offsetting the declines in receipts is a small projected rise in individual income taxes for reasons other than structural features, scheduled changes in law, or aging and the taxation of retirement income.

Long-Term Implications for Tax Rates and the Tax Burden

Even if legislators enacted no future changes in tax law, the effects of the tax system that would be in place in the future would differ significantly from those of today's tax system. Increases in real income over time would push more income into higher tax brackets in the individual income tax system, raising people's effective marginal tax rates and average tax rates. (The effective marginal tax rate is the percentage of an additional dollar of income from labor or capital that is paid in federal taxes. The average tax rate is total taxes paid divided by total income.) Moreover, fewer taxpayers would be eligible for certain tax credits, such as the earned income and child credits, because rising real income would push taxpayers above the income limits for eligibility. Inflation would also raise tax rates, although to a much lesser extent because most of the tax code's key parameters are indexed for inflation. Slightly more taxpayers would become subject to the alternative minimum tax (AMT) over time, although the American Taxpayer Relief Act of 2012 greatly limited the share of taxpayers who would pay that tax.[12] Thus, in the long run, people throughout the income distribution would pay a larger share of their income in taxes than people at the same points in the distribution pay today, and many taxpayers would face diminished incentives to work and save.

Marginal Tax Rates on Income From Labor and Capital

Under CBO's extended baseline, marginal tax rates on income from labor and capital would rise over time. The effective marginal federal tax rate on labor income would,

11. A defined benefit plan is an employment-based plan that promises employees a certain benefit upon retirement. Typically, the benefit is based on a formula that takes into account an employee's length of service and salary.

12. The AMT is a parallel income tax system with fewer exemptions, deductions, and rates than the regular income tax system. Households must calculate the amount they owe under both tax systems and pay whichever is larger. The American Taxpayer Relief Act raised the exemption amounts for the AMT for 2012 and, beginning in 2013, permanently indexed those exemption amounts for inflation. Also indexed for inflation were the income thresholds at which those exemptions phase out and the income threshold at which the second rate bracket for the AMT begins. Although rising real income will gradually subject more taxpayers to the AMT, many of those newly affected will owe only slightly more than their regular income tax liability.

Table 5-2.

Estimates of Effective Marginal Federal Tax Rates Under CBO's Extended Baseline

Percent

	2015	2025	2040
Marginal Tax Rate on Labor Income	28.8	31.1	32.2
Marginal Tax Rate on Capital Income	18.0	18.4	18.5

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The effective marginal federal tax rate on income from labor is the share of an additional dollar of such income that is paid in federal individual income taxes and payroll taxes, averaged across taxpayers by using weights proportional to their labor income. The effective marginal federal tax rate on income from capital is the share of the return on an additional dollar of investment made in a particular year that will be paid in taxes over the life of that investment. Rates are calculated for different types of assets and industries and then averaged over all types of assets and industries, using the share of asset values as weights.

CBO projects, increase from 28.8 percent in calendar year 2015 to 32.2 percent in 2040 (see Table 5-2). (The effective marginal tax rate on labor income reflects labor income averaged across taxpayers by using weights proportional to their labor income.) By contrast, the effective marginal federal tax rate on capital income (returns on investment) is projected to rise only from 18.0 percent to 18.5 percent over that period.

The projected increase in the effective marginal tax rate on labor income reflects four primary factors:

- *Real bracket creep under the regular income tax.* As households' inflation-adjusted income rose over time, they would be pushed into higher marginal tax brackets. (Because the thresholds for taxing income at different rates are indexed for inflation, increases in income that just kept pace with inflation would not generally raise households' marginal tax rates.) One consequence is that the share of ordinary income subject to the top rate of 39.6 percent would rise from 12 percent in 2015 to 16 percent by 2040, CBO estimates.[13]

- *The structure of premium subsidies in health insurance exchanges (or marketplaces).* Those subsidies are conveyed in the form of tax credits that phase out as income rises over a certain range, increasing marginal rates on income in that range. Under current law, the income range over which the subsidies are phased out would expand with inflation, but the subsidies would grow faster than inflation. As a result, over time, for each extra dollar of income someone earns, the subsidy would be reduced by a larger fraction of that dollar, thereby raising the effective marginal tax rate.

- *Rising health care costs.* Rising health care costs tend to reduce marginal tax rates by reducing the taxable share of compensation. However, CBO expects that the excise tax on certain high-premium health insurance plans would more than offset this effect over the next few decades. That tax would affect a growing share of compensation over time because health care costs are expected to rise faster than the threshold for the tax.

- *The additional 0.9 percent tax on earnings above an established threshold that was enacted in the ACA.* Over time, that tax would apply to a growing share of labor income because the $250,000 threshold is not indexed for inflation.

The effective marginal tax rate on capital income would rise only slightly over the next 25 years, CBO projects. CBO estimates that real bracket creep would not raise that rate very much because a large share of capital income is already being taxed at top rates in 2015. Moreover, the other key factors that would push up the effective marginal tax rate on labor income would not affect the tax rate on capital income.

The increase in the marginal tax rate on labor income would reduce people's incentive to work, and the increase in the marginal tax rate on capital income would reduce their incentive to save. However, the reduced earnings and savings because of the higher taxes would also encourage people to work and save more in order to maintain the same amount of after-tax income and savings. Evidence suggests that the former behavioral responses typically prevail and that, on balance, higher

13. Ordinary income is all income subject to the income tax except long-term capital gains and dividends.

marginal tax rates discourage economic activity.[14] (The overall effect of federal taxes on economic activity depends not only on marginal tax rates but also on the amount of revenues raised in relation to federal spending and thereby on the resulting federal deficits and debt.) This chapter's analysis does not reflect those macroeconomic effects, which are discussed in Chapter 6.

Average Tax Rates for Some Representative Households

Some parameters of the tax code are not indexed for inflation, and most are not indexed for real income growth. As a result, the personal exemption, the standard deduction, the amount of the child tax credit, and the thresholds for taxing income at different rates all would tend to decline in relation to income over time under current law. One consequence is that, under the extended baseline, average federal tax rates would increase over time.

The cumulative effect of rising prices would significantly reduce the value of some parameters of the tax system that are not indexed for inflation, CBO projects. For example, CBO estimates that the amount of mortgage debt eligible for the mortgage interest deduction, which is not indexed for inflation, would fall from $1 million today to about $600,000 in 2040 measured in today's dollars. As another example, the portion of Social Security benefits that is taxable would increase from about 35 percent now to over 50 percent by 2040, CBO estimates, because the thresholds for taxing benefits are not indexed for inflation.

Under the extended baseline, even tax parameters that are indexed for inflation would lose value over time in comparison with income. For example, according to CBO's projections, the current $4,000 personal exemption would rise by almost 80 percent by 2040 because it is indexed for inflation. But income per household will probably almost triple during that period, so the value of the exemption in relation to income would decline by almost 40 percent. If income grew at similar rates for higher-income and lower-income taxpayers, that decline would tend to boost the average tax rates of lower-income taxpayers more than the average tax rates of other taxpayers because, for lower-income taxpayers, the personal exemption is larger in relation to income. For another example, CBO projects that without legislative changes, the proportion of taxpayers claiming the earned income tax credit would fall from 16 percent this year to 11 percent in 2040 as growth in real income made more taxpayers ineligible for the credit.[15]

Those developments and others would cause individual income taxes as a share of income to grow by different amounts over time for households at different points in the income distribution. For example:

- According to CBO's analysis, a married couple with two children earning the median income of $105,600 (including both cash income and other compensation) in 2015 and filing a joint tax return will pay about 4 percent of their income in individual income taxes (see Table 5-3).[16] By 2040, under current law, a similar couple earning the median income would pay 8 percent of their income in individual income taxes.
- For a married couple with two children earning half the median income, the change in individual income taxes as a share of income would be much greater, CBO estimates: In 2015, such a family will typically receive a net payment from the federal government equal to 10 percent of its income in the form of refundable tax credits, but by 2040 it would become a net taxpayer, paying about 1 percent of its income in income taxes.
- By comparison, for a married couple with two children earning four times the median income, CBO projects that the share of income that they would pay in individual income taxes would be much higher in both 2015 and 2040 but rise much less—from 19 percent to 22 percent—between those years.

14. For additional discussion, see Congressional Budget Office, *How the Supply of Labor Responds to Changes in Fiscal Policy* (October 2012), www.cbo.gov/publication/43674, and *Taxing Capital Income: Effective Marginal Tax Rates Under 2014 Law and Selected Policy Options* (December 2014), www.cbo.gov/publication/49817.

15. In CBO's projections, future family structures are similar to those today. If marriage rates among families with earnings near the eligibility range for the credit were to decline, for instance, the proportion of the population receiving the earned income tax credit would probably be higher than it would be otherwise, and vice versa.

16. The examples incorporate the assumption that all income that taxpayers receive is from labor compensation. Furthermore, median income is assumed to grow with average income, so income at each multiple of the median grows at the same rate. For details about the calculations, see Table 5-3.

Table 5-3.

Individual Income and Payroll Taxes as a Share of Total Income Under CBO's Extended Baseline

	Income (2015 dollars)[a]		Taxes as a Share of Total Income (Percent)	
	Cash	Total	Income Taxes[b]	Income and Payroll Taxes[c]
		Taxpayer Filing a Single Return		
Half the Median Total Income				
2015	11,300	18,300	-1	9
2040	17,600	29,600	2	11
Median Total Income				
2015	28,300	36,500	6	18
2040	45,100	59,200	7	19
Twice the Median Total Income				
2015	62,200	73,100	10	23
2040	100,100	118,400	12	25
Four Times the Median Total Income				
2015	130,800	146,100	15	27
2040	212,100	236,700	16	29
		Married Couple (With Two Children) Filing a Joint Return[d]		
Half the Median Total Income				
2015	32,900	52,800	-10	0
2040	52,900	85,500	1	11
Median Total Income				
2015	81,900	105,600	4	16
2040	132,300	171,000	8	19
Twice the Median Total Income				
2015	180,000	211,200	11	24
2040	291,100	342,000	14	28
Four Times the Median Total Income				
2015	384,700	422,400	19	29
2040	624,500	683,900	22	32

Source: Congressional Budget Office based on data from the March 2014 Current Population Survey.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

Cash income includes compensation from wages. Total income includes cash income, the employer's costs for employment-based health insurance, and the employer's share of payroll taxes. For 2040, the premium on employment-based health insurance is assumed not to exceed the excise tax threshold in the Affordable Care Act.

Taxpayers are assumed to itemize if itemized deductions are greater than the standard deduction. State and local taxes are assumed to equal 8 percent of wages; other deductions are assumed to equal 15 percent of wages.

a. Income amounts have been rounded to the nearest $100. Inflation adjustments are made using the personal consumption expenditures price index.

b. Negative tax rates result when refundable tax credits, such as the earned income and child tax credits, exceed the tax owed by people in an income group. (Refundable tax credits are not limited to the amount of income tax owed before they are applied.)

c. Payroll taxes include the share paid by employers.

d. The examples for a married couple reflect the assumption that the spouses earn the same amount.

By contrast, under current law, payroll taxes as a share of income would differ only slightly in 2040 from what they are today. Those taxes are principally levied as a flat rate on earned income below a certain threshold, which is indexed for both inflation and overall growth in real earnings. Thus, the changes over the next 25 years in the sum of income and payroll taxes as a share of income would be quite similar to the changes in income taxes as a share of income.

Although rising real income would contribute to rising average tax rates under current law, that real income growth would also mean that future households would have higher after-tax income than similar households at the same point in the income distribution have today. For example, from 2015 to 2040, CBO projects that real after-tax income for a couple earning the median income would grow by over 50 percent under the extended baseline.

CHAPTER

6

The Macroeconomic and Budgetary Effects of Various Fiscal Policies

Federal tax and spending policies have significant effects on the economy, and those macroeconomic effects, in turn, affect the budget. Although the budget projections presented in the preceding chapters of this report incorporate the effects of fiscal policy on the economy over the next decade, they do not incorporate those effects beyond 2025, relying instead on “benchmark” projections of economic variables. Unlike the economic forecast constructed by the Congressional Budget Office for the traditional 10-year baseline period, which generally reflects current laws regarding taxes and spending, the economic benchmark that CBO uses for projections beyond the 10-year period reflects the assumption that marginal tax rates (the rates that apply to an additional dollar of income) and the ratio of debt to gross domestic product (GDP) will remain constant after 10 years.

This chapter expands on the analysis in the preceding chapters in two ways. First, it shows how the budgetary policies that would be in place under the extended baseline would affect the economy in the long run—that is, how the economy that resulted from those policies would differ from CBO’s economic benchmark—and how those macroeconomic effects would, in turn, feed back into the budget. Second, the chapter shows how the budget and the economy would evolve under three additional scenarios involving changes in fiscal policy. The first, the extended alternative fiscal scenario, incorporates changes to those policies assumed under the extended baseline that some analysts consider difficult to maintain; it would result in larger deficits and more debt than are projected in the extended baseline. The other two scenarios are illustrative. Through unspecified increases in tax revenue, cuts in spending, or some combination of the two, they would result in smaller deficits and lower debt than under the extended baseline.

Although changes in tax and spending policies can affect the economy in a variety of ways, CBO’s analysis in this chapter focuses on the following four changes and their macroeconomic effects:

- Higher debt draws money away from (that is, crowds out) investment in capital goods and thereby reduces output below what would otherwise occur.
- Higher marginal tax rates discourage working and saving, which reduces output.
- Larger transfer payments to working-age people discourage working, which reduces output.
- Increased federal investment in education, research and development (R&D), and infrastructure helps develop a skilled workforce, encourages innovation, and facilitates commerce, all of which increase output.

For each of those policy changes, the opposite change has the opposite effect; for example, lower marginal tax rates increase output above what would otherwise occur.

Because the magnitude of the macroeconomic effects of specified changes in fiscal policies is uncertain, CBO reports not only a central estimate for the outcome of each set of policies but also a range of likely outcomes.[1] When estimating output, CBO focused on effects on

1. For certain key variables in its long-term economic models, CBO has developed ranges of values based on the research literature on those variables; each range is intended to cover roughly the middle two-thirds of the likely values for the variable. To calculate the ranges of estimates for the effects of each set of fiscal policies, CBO used the ranges of values for each variable. To calculate the central estimates, it used values for the variables at the midpoints of those ranges.

gross national product (GNP), which—unlike the more commonly cited GDP—includes the income that U.S. residents earn abroad and excludes the income that foreigners earn in this country; it is therefore a better measure of the resources available to U.S. households.

CBO estimates that the fiscal policies in the extended baseline would result in output lower than what is projected in the economic benchmark, primarily because the ratio of debt to output and marginal tax rates on labor income would increase significantly over time; in addition, the increase in debt would lead to higher interest rates. According to CBO's central estimates, real (inflation-adjusted) GNP in 2040 would be roughly 2 percent lower than the amount projected in the benchmark, and interest rates would be about a quarter of a percentage point higher.[2] Those economic changes, in turn, would worsen the budgetary outlook, though not dramatically: Under the extended baseline with macroeconomic feedback, federal debt held by the public is projected to rise to 107 percent of GDP in 2040; under the extended baseline without macroeconomic feedback (described in Chapter 1), it is projected to be 103 percent.

For the three additional fiscal scenarios, CBO's analysis yields the following macroeconomic and budgetary outcomes (according to the agency's central estimates):

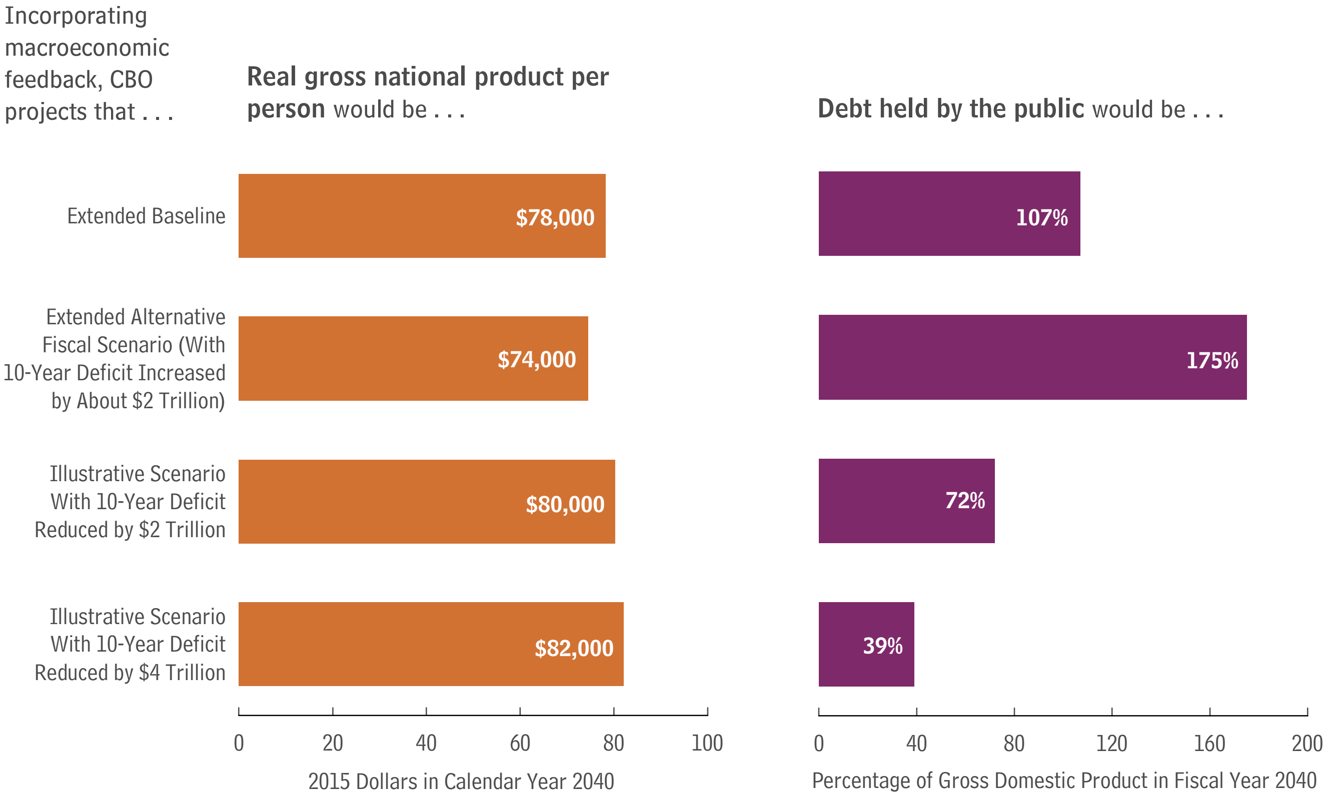
- In the first scenario—that is, the extended alternative fiscal scenario—revenues and certain categories of spending measured as shares of GDP remain close to their historical averages over the long run rather than change as they would under the extended baseline. Under that scenario, deficits excluding interest payments would be about $2 trillion larger over the first decade than those under the baseline; thereafter, such deficits would be larger than those under the extended baseline by rapidly increasing amounts, doubling as a percentage of GDP in less than 10 years. CBO projects that real GNP in 2040 would be about 5 percent lower under the extended alternative fiscal scenario than under the extended baseline with macroeconomic feedback and that interest rates would be about three-quarters of a percentage point higher. As a result of those economic developments, federal debt would rise to 175 percent of GDP in 2040 (see Figure 6-1).
- Under the second scenario, which is illustrative and does not reflect any specific fiscal policies, deficit reduction is phased in such that total deficits excluding interest payments through 2025 are $2 trillion lower than those projected under the baseline and, in each subsequent year, the reduction measured as a percentage of GDP equals the 2025 reduction. CBO projects that real GNP in 2040 would be about 3 percent higher and interest rates would be about a third of a percentage point lower under this scenario than under the extended baseline with macroeconomic feedback. After accounting for those economic developments, CBO projects that federal debt in 2040 would be about 72 percent of GDP—about the same ratio as it was in 2013.
- Under the third scenario, which is also illustrative, the amount of deficit reduction in the next 10 years is twice as large as in the second, with the reduction phased in such that total deficits excluding interest payments through 2025 are $4 trillion lower than those under the baseline. As in the second scenario, measured as a percentage of GDP, the reduction in the deficit in each subsequent year equals the 2025 reduction. CBO projects that real GNP in 2040 would be about 5 percent higher and interest rates would be about two-thirds of a percentage point lower under this scenario than under the extended baseline with macroeconomic feedback. With those economic effects accounted for, federal debt would fall to 39 percent of GDP in 2040, slightly above its level in 2007 (35 percent) and its average over the past 50 years (38 percent).

The three additional fiscal scenarios would have significant effects on the economy during the next few years as well as over the long term (which is the focus of this chapter). The scenarios that would raise output in the long term above what is projected in the extended baseline would lower it in the short term, and the scenario that would reduce output in the long term would raise it in the short term. CBO estimates that the decrease in tax revenues and increase in spending under the extended alternative fiscal scenario would cause real GDP in 2016 to be 0.6 percent higher than it would be under current law and would cause the number of full-time-equivalent employees in 2016 to be 0.7 million greater than is

2. For the results presented in this chapter, changes in interest rates refer to changes in both the average real return on private capital and the average real interest rate on federal debt.

Figure 6-1.

Effects in 2040 of the Fiscal Policies in CBO's Extended Baseline, Extended Alternative Fiscal Scenario, and Illustrative Scenarios With Smaller Deficits



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The extended alternative fiscal scenario incorporates these assumptions: Certain policies that have been in place for a number of years but that are scheduled to change will be continued, some provisions of law that might be difficult to sustain for a long period will be modified, and federal revenues and certain categories of federal spending measured as shares of gross domestic product will be maintained at or near their historical averages over the long term.

In the illustrative scenarios with the 10-year deficit reduced by $2 trillion and by $4 trillion relative to the baseline, those amounts are the cumulative reductions in deficits excluding interest payments between 2016 and 2025.

Real (inflation-adjusted) gross national product differs from gross domestic product, the more common measure of the output of the economy, by including the income that U.S. residents earn abroad and excluding the income that nonresidents earn in this country.

The results are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

projected under current law.[3] Under the first illustrative scenario, a drop in demand for goods and services would cause real GDP to be 0.2 percent lower and the number of full-time-equivalent employees to be 0.2 million smaller in 2016 than is projected under current law. Under the second illustrative scenario, which would bring about a larger decrease in demand, real GDP would be 0.3 percent lower and the number of full-time-equivalent employees would be 0.4 million smaller in 2016 than they would be under current law.

3. A year of full-time-equivalent employment is equal to 40 hours of employment per week for one year.

Long-Term Macroeconomic Effects of Federal Tax and Spending Policies

Federal tax and spending policies can affect the economy through many channels, including the amount of federal borrowing, marginal tax rates on labor and capital income, transfer payments to working-age people, and federal investment. To analyze medium-term to long-term effects of changes in federal tax and spending policies, CBO used an enhanced version of a model originally developed by Robert Solow in which people base their decisions about working and saving primarily on current economic conditions—especially wage levels, interest rates, and government policies. Their responses to changes in such conditions generally mirror their responses to economic and policy developments in the past; as a result, the responses reflect people's anticipation of future policies in a general way but not their expectations of particular future developments.[4]

How Increased Federal Borrowing Affects the Economy

Increased borrowing by the federal government generally crowds out private investment in productive capital in the long term. That is because the portion of the amount people save that is used to buy government securities is not available to finance private investment. The result is a smaller stock of capital and lower output in the long term than would otherwise be the case (all else held equal).

Two factors offset part of that crowding-out effect. One is that additional federal borrowing tends to boost private saving, which increases the total funds available to purchase federal securities and finance private investment. That response occurs for several reasons:

- Additional federal borrowing tends to raise interest rates, which boosts the return on saving;
- Some people anticipate that policymakers will raise taxes or cut spending in the future to cover the cost of paying interest on the additional accumulated debt, so those people increase their own saving to prepare for paying higher taxes or receiving less in benefits; and
- The policies that give rise to deficits (such as tax cuts or increases in government transfer payments) put more money in private hands, some of which is saved.

However, the rise in private saving is generally a good deal smaller than the increase in federal borrowing, so greater federal borrowing leads to less *national* saving.[5] CBO's central estimate, which is based on the research literature on this topic, is that private saving rises by 43 cents for every one-dollar increase in federal borrowing in the long run, leaving a net decline of 57 cents in national saving.

The second factor offsetting part of the crowding-out effect is that higher interest rates tend to increase net inflows of capital from other countries—by attracting more foreign capital to the United States and inducing U.S. savers to keep more of their money at home. Those additional net inflows prevent investment in this country from declining as much as national saving does in the face of more federal borrowing. CBO's central estimate, again drawn from the research literature on the topic, is that net inflows of private capital rise by 24 cents for every one-dollar increase in government borrowing in the long run.

However, an increase in inflows of capital from other countries also means that more profits and interest payments will flow overseas. Therefore, although flows of capital into the United States can help moderate a decline in domestic investment, part of the income resulting from that additional investment does not accrue to U.S. residents. The result is that greater net inflows of capital keep GDP from declining as much as it would otherwise, but they are less effective in restraining the decline in

4. For details of CBO's model, see Congressional Budget Office, *CBO's Method for Estimating Potential Output: An Update* (August 2001), www.cbo.gov/publication/13250. For a general explanation of how CBO analyzes the effects of fiscal policies, see Congressional Budget Office, *How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy* (November 2014), www.cbo.gov/publication/49494.

5. National saving comprises total saving by all sectors of the economy: personal saving; business saving, in the form of after-tax profits not paid out as dividends; and government saving or dissaving, in the form of surpluses or deficits of the federal government and state and local governments.

GNP.[6] Thus, other things being equal, increases in debt cause a greater reduction in GNP than in GDP, and reductions in debt lead to a greater increase in GNP than in GDP.

With those two offsets to the crowding-out effect taken together, when the deficit goes up by one dollar, national saving falls by 57 cents and foreign capital inflows rise by 24 cents, leaving a net decline of 33 cents in investment in the long run, according to CBO's central estimates. To reflect the wide range of estimates in the economics literature of how government borrowing affects national saving and domestic investment, CBO also uses a range of estimates for those effects: At the low end of that range, for each dollar that deficits rise, domestic investment falls by 15 cents; at the high end of that range, domestic investment falls by 50 cents.[7]

The effect of deficits on investment alters pretax wages and the return on capital, changing incentives to work and save:

- Less investment leads to a smaller capital stock, which makes workers less productive and thereby decreases pretax wages below what they would otherwise be. Those lower wages reduce people's incentive to work.

- Less investment also increases the productivity of existing capital because more workers make use of each unit of capital—each computer or piece of machinery, for example. That greater productivity raises the return on capital. A higher return on capital boosts the return on equity shares in the ownership of capital and boosts the return on other investments (such as interest rates on federal debt) that are competing for private saving. The resulting increase in the return on saving makes saving more attractive.

CBO's estimates of the effects of higher federal debt on private saving, net capital inflows, and interest rates are based on historical experience. However, history may not be a good guide to the effects of rising debt in the extended baseline because the extended baseline shows a large, persistent increase in the ratio of debt to GDP—an outcome that is unprecedented in the United States, where large increases in debt have been temporary, such as those that occurred during and immediately after wars or severe economic downturns. If participants in financial markets came to believe that policymakers intended to allow federal debt as a percentage of GDP to continue to rise, interest rates would probably increase by more than the historical relationship between federal debt and interest rates suggests. In addition, the increases in federal debt might not affect private saving and net capital inflows in the same way that they have in the past.

As Chapter 1 discusses in greater detail, increased federal debt would, in the long term, have several negative consequences in addition to the effects just described:

- Increased borrowing would increase the amount of interest that the government pays to its lenders, all else being equal. Those larger interest payments would make it more difficult to reduce future budget deficits, necessitating larger increases in taxes or reductions in noninterest spending.

- Increased borrowing would restrict policymakers' ability to use tax and spending policies to respond to unexpected challenges, such as economic downturns or financial crises. As a result, those challenges would tend to have larger negative effects on the economy and on people's well-being.

- Increased borrowing would increase the probability of a fiscal crisis in which investors lost so much confidence in the government's ability to manage its budget that the government was unable to borrow at affordable rates. Such a crisis would present policymakers with extremely difficult choices and would probably have a very significant negative impact on the country.

6. The difference in the effect of an increase in debt on GDP and GNP depends, in large part, on the amount of additional capital that foreigners invest in the United States and on the rate of return that they receive on their investments. The increase in the return on capital in this country and the increase in net holdings of U.S. assets by foreigners—both of which imply greater income earned by foreign investors—decrease GNP relative to GDP. In CBO's analyses of fiscal policy, the rate of return earned by foreign investors in the United States changes when the rate of return on capital in this country changes. However, to be consistent with U.S. experience in recent decades, that response is less than one-for-one.

7. For a review of evidence about the effect of deficits on investment, see Jonathan Huntley, *The Long-Run Effects of Federal Budget Deficits on National Saving and Private Domestic Investment*, Working Paper 2014-02 (Congressional Budget Office, February 2014), www.cbo.gov/publication/45140.

How Increases in Marginal Tax Rates Affect the Economy

Increases in marginal tax rates on labor and capital income reduce output and income below what they would be with lower rates (all else held equal). A higher marginal tax rate on capital income (income derived from wealth, such as stock dividends, realized capital gains, and owners' profits from businesses) decreases the after-tax rate of return on saving, weakening people's incentive to save. However, because that higher marginal tax rate also decreases the return that they receive on their existing savings, people will need to save more to have the same future standard of living, which tends to increase the amount of saving. CBO concludes, as do most analysts, that the former effect outweighs the latter, meaning that a higher marginal tax rate on capital income decreases saving. Specifically, CBO estimates that an increase in the marginal tax rate on capital income that decreased the after-tax return on saving by 1 percent would result in a decrease in private saving of 0.2 percent. (A decrease in the marginal tax rate on capital income would have the opposite effect.) Less saving results in less investment, a smaller capital stock, and lower output and income.

Similarly, a higher marginal tax rate on labor income (such as wages and salaries) decreases people's incentive to work: Reduced after-tax compensation for an additional hour of work makes work less valuable than other uses of a person's time. That phenomenon, known as the substitution effect, tends to reduce the labor supply. However, because that higher marginal tax rate also decreases the after-tax income that they earn from the work they are already doing, people will need to work more to maintain their standard of living. That phenomenon, known as the income effect, tends to increase the labor supply. CBO concludes, as do most analysts, that the former effect outweighs the latter, meaning that a higher marginal tax rate on labor income decreases the labor supply. (A lower marginal tax rate on labor income would have the opposite effect.) Fewer hours of work result in lower output and income.

To reflect the high degree of uncertainty about the size of the effect that changes in marginal tax rates have on the number of hours people choose to work, CBO uses a range of values in its analyses of fiscal policy.[8] The responsiveness of the labor supply to taxes is often expressed as the total wage elasticity (the change in total labor income caused by a 1 percent change in after-tax wages). The total wage elasticity equals the substitution elasticity (which measures the substitution effect) minus the income elasticity (which measures the income effect). In this analysis, CBO's central estimate for the change in the labor supply in response to an increase in marginal tax rates corresponds to a total wage elasticity of 0.19 (composed of a substitution elasticity of 0.24 and an income elasticity of 0.05). CBO's range of likely changes in the labor supply is bounded at the low end by a total wage elasticity of about 0.06 (with a substitution elasticity of 0.16 and an income elasticity of 0.10) and at the high end by a value of about 0.32 (with a substitution elasticity of 0.32 and an income elasticity of zero).[9]

How Increases in Transfer Payments to Working-Age People Affect the Economy

Increases in transfer payments to working-age people discourage work by increasing the amount of resources available to those people and by making work less attractive than other uses of their time. An increase in payments raises people's income, so they can work less and maintain the same standard of living. That income effect tends to reduce the labor supply. In addition, an increase in transfer payments tends to create an implicit tax on additional earnings because those earnings cause people to receive reduced benefits from some transfer programs, thereby encouraging them to substitute other activities for work. That substitution effect also tends to reduce the labor supply. (Thus, in contrast with changes in marginal tax rates, changes in transfer payments generate income and substitution effects that generally work in the same direction.) Those reductions in the labor supply take the form of some people's choosing to work fewer hours and other people's choosing to withdraw from the labor force altogether.

In this analysis, CBO incorporates the income effect of changes in transfer payments to working-age people by using the same income elasticity that it uses to analyze the response of the labor supply to changes in marginal tax rates. This analysis does not, however, incorporate the substitution effect of changes in transfer payments

8. CBO uses those same values to estimate the effect on the labor supply of changes in pretax hourly wages.

9. For details on CBO's estimates of the responsiveness of the supply of labor to changes in the after-tax wage rate, see Congressional Budget Office, *How the Supply of Labor Responds to Changes in Fiscal Policy* (October 2012), www.cbo.gov/publication/43674.

because CBO is still developing methods for estimating the complex array of implicit taxes arising from federal transfer policies.

How Increases in Federal Investment Affect the Economy

Increases in federal investment promote long-term economic growth by raising productivity.[10] Spending on education helps develop a skilled workforce, spending on R&D encourages innovation, and spending on infrastructure such as roads and airports facilitates commerce. If not for receiving a public education (funded in part by federal spending), many workers would have lower wages than they do; the development of the Internet, initially funded through government R&D, led to the creation of whole segments of today's economy; and without public highways, the trucking industry would face much higher costs. The result of that greater productivity is higher private-sector output. By contrast, decreases in federal investment could reduce productivity and long-term growth.

CBO's central estimate is that federal investment yields, on average, one-half of the return of a comparable investment by the private sector.[11] However, the size of the return on federal investment is subject to considerable uncertainty, so CBO also uses a range of likely returns. At the low end, CBO uses a rate of return of zero on federal investment—which would mean that such investment has no effect on future private-sector output. At the high end, CBO uses a rate of return on federal investment equal to the average return on a comparable investment by the private sector. The actual rate of return for a particular federal investment could lie outside that range; a project might have a negative return or, alternatively, yield a greater return than a comparable private-sector investment.

Because of the nature of federal investment, CBO estimates that its returns accrue more slowly than do returns to private investment.[12] The agency expects that, on average, the full effect of federal investment on output is realized within eight years after the outlays are made. In particular, the agency expects that 10 percent of federal investment becomes productive within one year of investment, 20 percent in each of the next two years, and 10 percent in each of the fourth through eighth years following the investment.

Long-Term Effects of the Extended Baseline

The extended baseline generally incorporates the fiscal policies specified in current law. Those policies would cause deficits and debt as percentages of GDP to rise and marginal tax rates to increase over time. Those policies would also increase transfers to working-age families (primarily for health care) and reduce federal investment as a percentage of GDP. Together, those changes would make output lower and interest rates higher than projected in the economic benchmark. Those macroeconomic effects, in turn, would result in worse budgetary outcomes than those based on the economic benchmark.

Fiscal Policies in the Extended Baseline

Under the extended baseline, federal debt would be larger and marginal tax rates would be higher than the values CBO assumed for its economic benchmark after 2025. Furthermore, that benchmark does not reflect the increase in transfer payments and decline in federal investment as a share of GDP that are projected under the extended baseline.

Under the policies in the extended baseline, federal debt held by the public, which is currently 74 percent of GDP, would rise to 78 percent in 2025 and to 107 percent in 2040 (with macroeconomic feedback), CBO projects

10. For further discussion, see Congressional Budget Office, *Federal Investment* (December 2013), www.cbo.gov/publication/44974. This analysis focuses on federal investment for nondefense purposes. Defense investment contributes to the production of weapon systems and other defense goods, but much of it is sufficiently separate from domestic economic activity that it does not typically contribute to future private-sector output; the exception is the small portion of defense investment that goes to basic and applied research.

11. For a discussion of the macroeconomic effects of federal investment, see Congressional Budget Office, *The Macroeconomic and Budgetary Effects of Federal Investment* (forthcoming).

12. From 1988 to 2008, for example, 33 percent of nondefense federal investment was for education and 23 percent was for R&D; such investments, in CBO's assessment, take considerably longer to boost private-sector output than does the investment in physical capital that accounts for most private-sector investment.

(see Table 6-1).[13] Those percentages are larger than the ones underlying the economic benchmark, which incorporates the assumption that federal debt will rise to 78 percent of GDP by 2025 and then remain at that level thereafter.

In addition, marginal tax rates on labor and capital income would increase over time, as rising real incomes pushed more income into higher tax brackets. The effective marginal tax rate on labor income in 2040 would be about 32 percent and the rate on capital income would be about 19 percent; those rates are currently about 29 percent and 18 percent, respectively (see Chapter 5 for details). By contrast, the economic benchmark reflects the assumption that effective marginal tax rates on income from labor and capital will rise through 2025 in line with CBO's estimates under current law and remain at their 2025 levels (namely, 31 percent and 18 percent) thereafter.

Transfer payments to working-age people measured as a share of GDP would increase under the extended baseline, CBO projects. The macroeconomic effects of the increase in those payments over the coming decade are incorporated in CBO's baseline economic forecast for the 2015–2025 period and thus are incorporated in the economic benchmark. However, the further increase in those payments beyond 2025—which is expected to occur as rising federal spending for certain health care programs more than offsets declining federal spending (relative to the size of the economy) for some other transfer programs—is not included in the economic benchmark.

Given the assumptions underlying CBO's baseline, discretionary spending for nondefense purposes measured as a share of GDP is projected to decline significantly during the next decade and then to remain level thereafter (see Chapter 4 for details). Over the past two decades, about half of nondefense discretionary spending has been for investments in education, infrastructure, and R&D. If the share of such spending that goes to investment was the same as it has been in the past, then federal investment measured as a share of GDP would also fall markedly over the next decade and then remain at its 2025 level thereafter. The macroeconomic effects of such a reduction in investment are incorporated in CBO's baseline economic forecast and economic benchmark for the 2015–2025 period. The benchmark does not, however, include the effects of such a reduction beyond 2025.

Output and Interest Rates Under the Extended Baseline

In CBO's assessment, larger federal debt and higher marginal tax rates on labor income are the developments projected under the extended baseline that would have the largest effects on the economy. The projected rise in transfer payments and decline in federal investment as a share of GDP would also affect the economy, but to a lesser extent. That macroeconomic feedback would cause output and interest rates to differ from the amounts projected under CBO's economic benchmark, which does not account for such feedback.

Under the extended baseline, real GNP in 2040 would be about 2 percent below what is projected in the economic benchmark, CBO estimates.[14] As a result, real GNP per person in 2040 would be about $78,000 (in 2015 dollars), whereas it would be about $80,000 under the benchmark (which does not incorporate macroeconomic feedback); those amounts would be considerably greater than the estimated GNP per person in 2015 (about $57,000), primarily because of anticipated growth in productivity (see Figure 6-2). Interest rates in 2040 would be about a quarter of a percentage point higher than those projected in the benchmark, CBO estimates.

Those outcomes are CBO's central estimates. On the basis of the agency's ranges of likely outcomes for key variables, CBO estimates that under the extended baseline, real GNP in 2040 would probably be between about 1 percent and about 4 percent lower than in the benchmark. The estimated increase in interest rates in 2040 would probably range from one-tenth to one-half of a

13. Some combination of increases in revenues or reductions in noninterest spending that resulted in deficits that were 1.1 percent of GDP lower than those projected in the extended baseline would be necessary in each year over the 2015–2040 period to return debt as a percentage of GDP to its current level in 2040. To return debt to its average percentage of GDP over the past 50 years (38 percent), the annual deficits would have to be 2.6 percent of GDP lower than under the extended baseline. For a discussion of how CBO constructs those measures, see Chapter 1. The estimates here, like those in Chapter 1, are calculated without macroeconomic feedback.

14. Projected real GNP in 2025 under the extended baseline equals that in the economic benchmark because during the 10-year budget window, the benchmark matches CBO's economic forecast, which is consistent with the baseline tax and spending policies, and includes macroeconomic feedback.

Table 6-1.

Long-Run Effects on the Federal Budget of the Fiscal Policies in Various Budget Scenarios

Percentage of Gross Domestic Product

	2025	2040
	Revenues	
Without Macroeconomic Feedback		
Extended baseline	18.3	19
With Macroeconomic Feedback		
Extended baseline	18.3	19
Extended alternative fiscal scenario (with 10-year deficit increased by about $2 trillion)	18.0	18
Illustrative scenario with 10-year deficit reduced by $2 trillion	n.a.	n.a.
Illustrative scenario with 10-year deficit reduced by $4 trillion	n.a.	n.a.
	Spending Excluding Interest Payments	
Without Macroeconomic Feedback		
Extended baseline	19.2	21
With Macroeconomic Feedback		
Extended baseline	19.2	21
Extended alternative fiscal scenario (with 10-year deficit increased by about $2 trillion)	19.7	25
Illustrative scenario with 10-year deficit reduced by $2 trillion	n.a.	n.a.
Illustrative scenario with 10-year deficit reduced by $4 trillion	n.a.	n.a.
	Deficit (-) or Surplus Excluding Interest Payments	
Without Macroeconomic Feedback		
Extended baseline	-0.9	-2
With Macroeconomic Feedback		
Extended baseline	-0.9	-2
Extended alternative fiscal scenario (with 10-year deficit increased by about $2 trillion)	-1.6	-7
Illustrative scenario with 10-year deficit reduced by $2 trillion	0.5	*
Illustrative scenario with 10-year deficit reduced by $4 trillion	1.9	1
	Total Deficit (-) or Surplus	
Without Macroeconomic Feedback		
Extended baseline	-3.8	-6
With Macroeconomic Feedback		
Extended baseline	-3.8	-7
Extended alternative fiscal scenario (with 10-year deficit increased by about $2 trillion)	-5.0	-15
Illustrative scenario with 10-year deficit reduced by $2 trillion	-2.1	-3
Illustrative scenario with 10-year deficit reduced by $4 trillion	-0.4	*
	Federal Debt Held by the Public	
Without Macroeconomic Feedback		
Extended baseline	78	103
With Macroeconomic Feedback		
Extended baseline	78	107
Extended alternative fiscal scenario (with 10-year deficit increased by about $2 trillion)	87	175
Illustrative scenario with 10-year deficit reduced by $2 trillion	68	72
Illustrative scenario with 10-year deficit reduced by $4 trillion	59	39

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections, which include macroeconomic feedback, through 2025 and then extending the baseline concept for the rest of the long-term projection period. The extended baseline without macroeconomic feedback does not include any additional feedback after 2025.

The extended alternative fiscal scenario incorporates these assumptions: Certain policies that have been in place for a number of years but that are scheduled to change will be continued, some provisions of law that might be difficult to sustain for a long period will be modified, and federal revenues and certain categories of federal spending measured as shares of gross domestic product will be maintained at or near their historical averages over the long term.

In the illustrative scenarios with the 10-year deficit reduced by $2 trillion and by $4 trillion relative to the baseline, those amounts are the cumulative reductions in deficits excluding interest payments between 2016 and 2025.

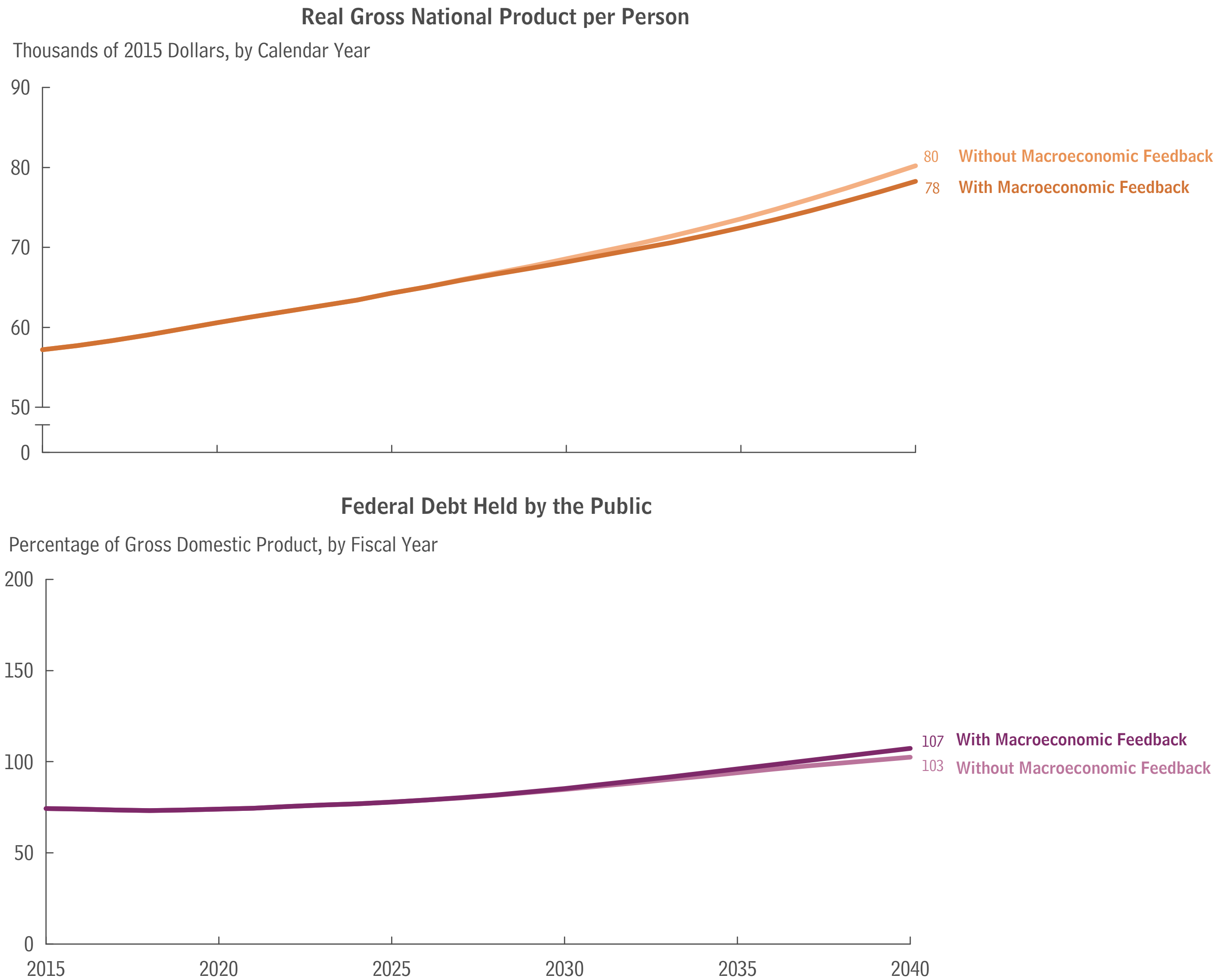
The results with macroeconomic feedback include the macroeconomic effects of the budget policies in the long run and the effects of that macroeconomic feedback on the budget. Those results are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

n.a. = not applicable; * = between -0.5 percent and zero.

Figure 6-2.

Effects of the Fiscal Policies in CBO's Extended Baseline

The fiscal policies in the extended baseline would further raise federal debt because they would reduce output and increase interest rates relative to the values for those factors without macroeconomic feedback—that is, in the economic benchmark that is intended to reflect stable economic conditions.



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections, which include macroeconomic feedback, through 2025 and then extending the baseline concept for the rest of the long-term projection period. The extended baseline without macroeconomic feedback does not include any additional feedback after 2025.

Real (inflation-adjusted) gross national product differs from gross domestic product, the more common measure of the output of the economy, by including the income that U.S. residents earn abroad and excluding the income that nonresidents earn in this country.

The results with macroeconomic feedback include the macroeconomic effects of the budget policies and the effects of that macroeconomic feedback on the budget. Those results are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

percentage point. Outcomes could fall outside those ranges, which reflect only a few sources of uncertainty regarding the effects of fiscal policies on the economy. Significant uncertainty surrounds CBO's projections for other reasons as well. (That uncertainty is explored in Chapter 7.)

Budgetary Outcomes Under the Extended Baseline

The reduction in economic output and increase in interest rates (relative to the benchmark) caused by the fiscal policies in the extended baseline would make budgetary outcomes worse. Lower output implies less income and thus less tax revenue; it also implies that for any given amount of federal debt, the ratio of debt to GDP would be higher. Moreover, higher interest rates would mean larger interest payments on federal debt. In the other direction, lower output implies lower federal spending on health care and retirement programs.[15]

After incorporating those additional budgetary effects, CBO projects that debt held by the public in 2040 would be 107 percent of GDP; it is projected to be 103 percent under the extended baseline without macroeconomic feedback after 2025 (see Table 6-1 and Figure 6-2). In addition to the effects on output, income, and interest rates reported here, the high and rising federal debt projected under the extended baseline would impose significant constraints on policymakers and would raise the risk of a fiscal crisis.

Long-Term Effects of an Alternative Fiscal Scenario

Under the extended alternative fiscal scenario, certain policies now in place that are scheduled to change under current law are assumed to continue, some provisions of law that might be difficult to sustain for a long period are assumed to be modified, and federal revenues and certain categories of federal spending measured as shares of GDP are assumed to be maintained at or near historical averages. Thus, the scenario incorporates changes to those current policies that are reflected in the extended baseline but that some analysts consider difficult to maintain.

Under the extended alternative fiscal scenario, deficits would be substantially larger than they are projected to be in the extended baseline, and marginal tax rates on labor income and capital income would be lower. In addition, transfers to working-age people would be larger, and federal investment would be higher. Taken together, those differences would cause output to be lower and interest rates to be higher in the long run than under the extended baseline. Those macroeconomic effects, in turn, would further increase the gap between deficits and debt in this scenario and those in the extended baseline.

Fiscal Policies in the Extended Alternative Fiscal Scenario

Under the extended alternative fiscal scenario, deficits excluding interest payments would be larger than they are projected to be in the extended baseline by about $2 trillion through 2025 and by increasing amounts in subsequent years.[16] Deficits would be larger under this scenario than under the extended baseline because noninterest spending would be higher and revenues lower (see Table 6-1).

Noninterest spending under this scenario would be 0.5 percent of GDP higher in 2025 and roughly 4 percent of GDP higher in 2040 than in the extended baseline. Those differences stem from two assumptions about the policies underlying the scenario that differ from those underlying the extended baseline:

- The automatic reductions in spending in 2016 and later that are required by the Budget Control Act of 2011 as amended would not occur—although the original caps on discretionary appropriations in the 2011 law would remain in place; and

15. In this analysis (as well as the analysis in Chapter 7), decreases in GDP stemming from macroeconomic feedback are estimated to reduce revenues (given current tax law), spending for Social Security (because lower earnings result in smaller benefits), and federal spending for health care programs (according to CBO's standard approach to projecting long-term cost growth, which is described in Chapter 2). However, CBO projects that other federal noninterest spending would remain at the amounts projected in the extended baseline even if GDP deviated from that baseline.

16. For additional detail on the policies underlying the alternative fiscal scenario, see Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), www.cbo.gov/publication/49892. In contrast to the estimates of the budgetary effects of those policies that CBO published in that earlier report, the estimates shown in Table 6-1 in this report incorporate macroeconomic feedback.

- Federal noninterest spending—apart from that for Social Security, the major health care programs (net of offsetting receipts), and certain refundable tax credits—as a percentage of GDP would rise after 2025 to its average during the past two decades rather than fall significantly below that level, as it does in the extended baseline.

Eliminating the Budget Control Act's automatic spending reductions and raising projected spending for a broad set of programs after 2025 would increase transfers to working-age people. Those policy changes would also increase discretionary spending and, consequently, federal investment, CBO projects.

Revenues under the extended alternative fiscal scenario would be 0.3 percent of GDP lower in 2025 and roughly 1 percent of GDP lower in 2040 than they are projected to be under the extended baseline. Overall, revenues as a share of GDP under the extended alternative fiscal scenario would remain flat after 2025 rather than rise as they do in the extended baseline. In the latter, revenues are projected to grow over time as a percentage of GDP largely for two reasons: Rising real income would push a greater share of income into higher tax brackets, and certain tax increases enacted in the Affordable Care Act would, to a lesser extent, generate increasing amounts of revenue relative to the size of the economy. Historically, however, federal revenues as a percentage of GDP have not trended upward; they have fluctuated with no evident trend during the past few decades.

The path of revenues in the extended alternative fiscal scenario shows what would happen if policymakers extended expiring tax provisions over the next decade and then made other changes to the law to keep revenues measured as a percentage of GDP close to their historical average. In particular, CBO incorporated the following two assumptions in the extended alternative fiscal scenario that differ from those underlying the extended baseline:

- About 70 expiring tax provisions, including one that allows businesses to deduct 50 percent of new investments in equipment immediately, will be extended through 2025; and

- After 2025, revenues will equal 18 percent of GDP, which is the level projected for 2025 given that assumption about expiring tax provisions and which is slightly higher than the average of 17.4 percent over the past 50 years.

Output and Interest Rates Under the Extended Alternative Fiscal Scenario

The substantially larger debt under the extended alternative fiscal scenario than under the extended baseline would reduce output and income below the projections in that baseline because of the additional crowding out of capital investment. In addition, the larger transfers to working-age people would reduce the supply of labor. However, the lower marginal tax rates on labor and capital income and the additional federal investment would boost output above the level projected for the extended baseline.

On balance, in CBO's assessment, output would be lower and interest rates would be higher under the extended alternative fiscal scenario than they would be under the extended baseline with macroeconomic feedback. In its central estimates, CBO projects that real GNP would be 0.6 percent lower in 2025 and about 5 percent lower in 2040; according to CBO's ranges of likely values for key variables, the reduction in real GNP would range from 0.3 percent to 1 percent in 2025 and from about 2 percent to about 8 percent in 2040 (see Table 6-2). However, even with the negative impact of the fiscal policies that are assumed under the alternative scenario, CBO projects that real GNP per person would be considerably higher in 2040 than in 2015 because of continued growth in productivity. Interest rates in 2040 would be about three-quarters of a percentage point higher under the alternative scenario than under the extended baseline, according to CBO's central estimate.

Budgetary Outcomes Under the Extended Alternative Fiscal Scenario

Budgetary outcomes under the extended alternative fiscal scenario would be worsened by the economic changes that resulted from the fiscal policies included in it. With the effects of lower output and higher interest rates incorporated, federal debt held by the public under the extended alternative fiscal scenario would reach 175 percent of GDP in 2040, according to CBO's central estimate; it is projected to be 107 percent of GDP under the extended baseline with macroeconomic feedback (see Figure 6-3). Thus, debt would be much higher and would rise much more rapidly than under the extended baseline.

In addition to having the effects on output, income, and interest rates reported here, the alternative fiscal scenario would also bring about many of the other consequences associated with high and rising federal debt that are

Table 6-2.

Long-Run Effects on Real GNP of the Fiscal Policies in Various Budget Scenarios

Percentage Difference From Level in the Extended Baseline With Macroeconomic Feedback

	2025	2040
Extended Alternative Fiscal Scenario (With 10-Year Deficit Increased by About $2 Trillion)		
Central estimate	-0.6	-5
Range	-1.0 to -0.3	-8 to -2
Illustrative Scenario With 10-Year Deficit Reduced by $2 Trillion		
Central estimate	0.6	3
Range	0.3 to 1.0	1 to 4
Illustrative Scenario With 10-Year Deficit Reduced by $4 Trillion		
Central estimate	1.2	5
Range	0.6 to 1.9	2 to 8

Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The extended alternative fiscal scenario incorporates these assumptions: Certain policies that have been in place for a number of years but that are scheduled to change will be continued, some provisions of law that might be difficult to sustain for a long period will be modified, and federal revenues and certain categories of federal spending measured as shares of gross domestic product will be maintained at or near their historical averages over the long term.

In the illustrative scenarios with the 10-year deficit reduced by $2 trillion and by $4 trillion relative to the baseline, those amounts are the cumulative reductions in deficits excluding interest payments between 2016 and 2025.

Real (inflation-adjusted) gross national product (GNP) differs from gross domestic product, the more common measure of the output of the economy, by including the income that U.S. residents earn abroad and excluding the income that nonresidents earn in this country.

The central estimates and ranges reflect alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

discussed above, and they would be especially acute under this scenario because the debt would be so high and would rise so rapidly. Such a path for debt would impose considerable constraints on policymakers and would significantly raise the risk of a fiscal crisis—and it would ultimately be unsustainable.

Long-Term Effects of Two Illustrative Scenarios With Smaller Deficits

CBO also projected economic developments during the coming decade under two illustrative budgetary paths that would gradually decrease deficits through unspecified increases in tax revenue, cuts in spending, or some combination of the two.[17] In the long run, the reduced federal deficits and debt under those scenarios would cause output and income to be higher and the ratio of federal debt to GDP to be lower than they would be under the extended baseline.

Fiscal Policies in the Two Illustrative Scenarios

In the two illustrative scenarios, CBO assumed that total deficits excluding interest payments between 2015 and 2025 would be $2 trillion or $4 trillion lower than what they are projected to be under current law. The reduction in the deficit relative to the extended baseline would be comparatively small in 2016 but would increase steadily through 2025; at that point, the reduction in the deficit excluding interest payments would be $360 billion, or nearly 1½ percent of GDP, under the first scenario and $720 billion, or over 2½ percent of GDP, under the second. In each subsequent year, the reduction, measured as a percentage of GDP, would equal the 2025 reduction.

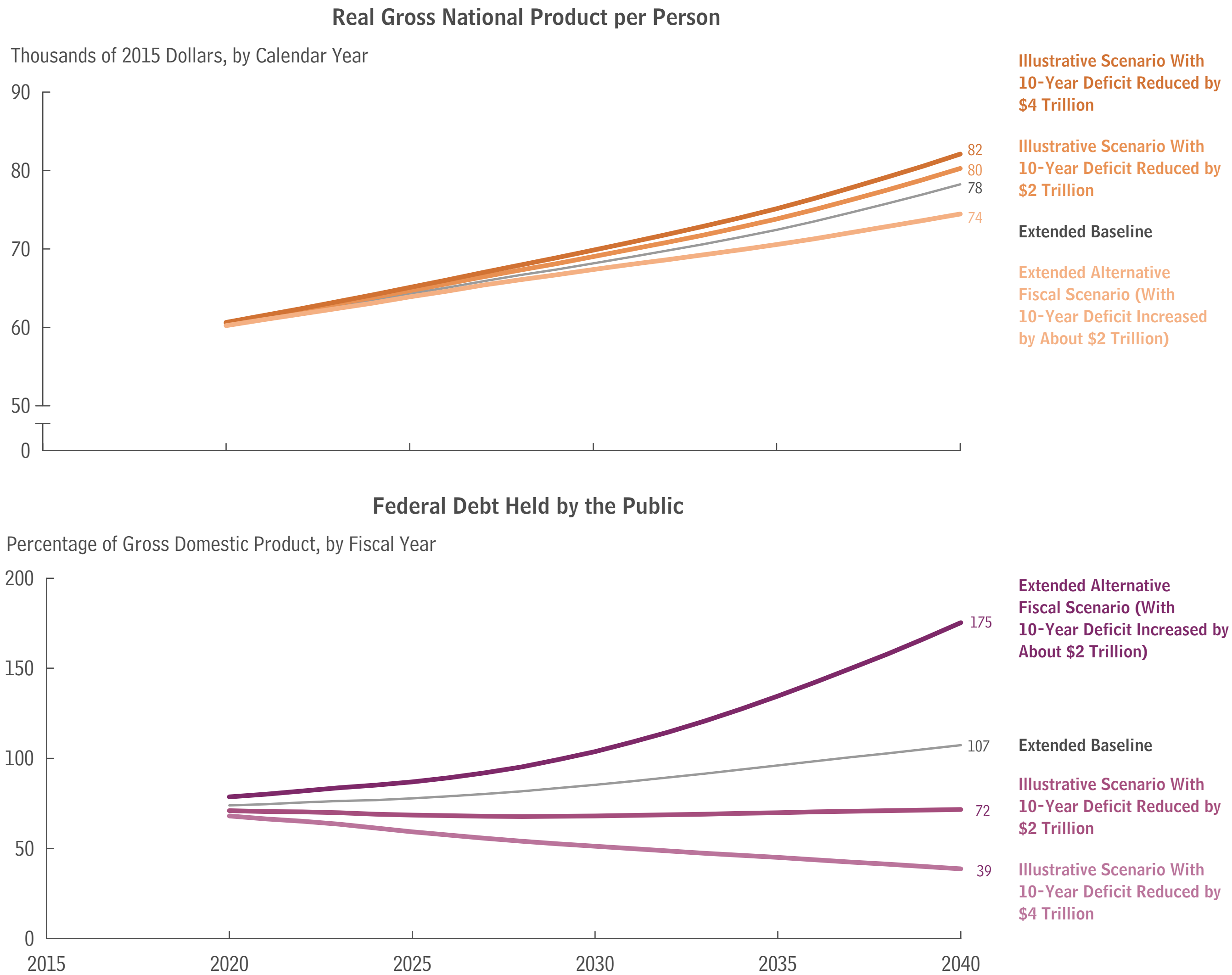
For the sake of simplicity and to avoid any presumption about which policies might be chosen to reduce the deficit, CBO analyzed those illustrative scenarios without

17. Congressional Budget Office, *Budgetary and Economic Outcomes Under Paths for Federal Revenues and Noninterest Spending Specified by Chairman Price* (March 2015), www.cbo.gov/publication/49977.

Figure 6-3.

Long-Run Effects of the Fiscal Policies in CBO's Extended Baseline, Extended Alternative Fiscal Scenario, and Illustrative Scenarios With Smaller Deficits

The effects of lower economic output and higher interest rates under the extended alternative fiscal scenario would raise federal debt held by the public by increasing amounts over time. The two illustrative scenarios involving deficit reductions would have the opposite effects.



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The extended alternative fiscal scenario incorporates these assumptions: Certain policies that have been in place for a number of years but that are scheduled to change will be continued, some provisions of law that might be difficult to sustain for a long period will be modified, and federal revenues and certain categories of federal spending measured as shares of gross domestic product will be maintained at or near their historical averages over the long term.

In the illustrative scenarios with the 10-year deficit reduced by $2 trillion and by $4 trillion relative to the baseline, those amounts are the cumulative reductions in deficits excluding interest payments between 2016 and 2025.

The results shown here do not include the macroeconomic effects of the scenarios from 2015 to 2019. Short-run macroeconomic effects are discussed later in this chapter.

Real (inflation-adjusted) gross national product differs from gross domestic product, the more common measure of the output of the economy, by including the income that U.S. residents earn abroad and excluding the income that nonresidents earn in this country.

The results are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

specifying the tax and spending policies underlying them. As a result, the projected outcomes under the scenarios do not reflect any direct changes to incentives to work and save; in particular, marginal tax rates and transfers to working-age people are assumed to be the same as those under current law. Also, the contributions that government investment makes to future productivity and output are assumed to reflect their historical averages.

The estimated macroeconomic effects presented here therefore arise solely from the differences in deficits and debt. However, reducing budget deficits significantly below what they would be under current law without altering government investment or incentives to work and save would be very difficult. The overall economic impact of policies that lowered deficits would depend not only on the way they changed federal borrowing but also on the way they affected government investment and incentives to work and save.

Output and Interest Rates Under the Two Illustrative Scenarios

Under the scenario involving a $2 trillion reduction in deficits in the first decade, real GNP would be higher than it would be under the extended baseline with macroeconomic feedback by 0.6 percent in 2025 and by about 3 percent in 2040, according to CBO's central estimates (see Table 6-2). According to CBO's ranges of likely values for key variables, the increase in real GNP would probably be between 0.3 percent and 1 percent in 2025 and between about 1 percent and about 4 percent in 2040. Interest rates in 2040 would be about one-third of a percentage point lower under that scenario than under the extended baseline, according to CBO's central estimate.

Under the scenario involving a $4 trillion reduction in deficits in the first decade, real GNP would be higher than it would be under the extended baseline with macroeconomic feedback by 1.2 percent in 2025 and by about 5 percent in 2040, by CBO's central estimates. According to CBO's ranges of likely values for key variables, the increase in real GNP would probably be between 0.6 percent and 1.9 percent in 2025 and between about 2 percent and about 8 percent in 2040. Interest rates in 2040 would be about two-thirds of a percentage point lower under that scenario than under the extended baseline, according to CBO's central estimate.

CBO projects that under either illustrative scenario, real GNP per person would be substantially higher in 2040 than in 2015.

Budgetary Outcomes Under the Two Illustrative Scenarios

The higher output and lower interest rates under the illustrative scenarios would improve budgetary outcomes in the long run. For the scenario with $2 trillion of deficit reduction in the first decade, federal debt held by the public in 2040 would stand at 72 percent of GDP, according to CBO's central estimates, slightly less than the 74 percent of GDP that debt amounted to at the end of 2014 and 35 percentage points lower than it is projected to be under the extended baseline with macroeconomic feedback (see Table 6-1 on page 81 and Figure 6-3). For the scenario with $4 trillion of deficit reduction in the first decade, federal debt held by the public would fall to 39 percent of GDP in 2040, 68 percentage points lower than it is projected to be under the extended baseline with macroeconomic feedback; such debt was 35 percent of GDP in 2007 and averaged 38 percent over the past 50 years.

The scenario with the $2 trillion deficit reduction would also limit the other consequences of high and rising federal debt that were discussed above. Because debt as a percentage of GDP would be fairly steady—albeit high by historical standards—the constraints on policymakers and the risk of a fiscal crisis would be smaller than they would be under the extended baseline scenario, in which the debt-to-GDP ratio is projected to increase substantially. The scenario with the $4 trillion deficit reduction would reduce the other consequences of high debt much more sharply. With debt returning to about the percentage of GDP that it averaged over the past 50 years, the constraints on policymakers and the risk of a fiscal crisis would be greatly diminished compared with what they would be under the extended baseline.

Short-Term Macroeconomic Effects of the Three Additional Fiscal Scenarios

The various fiscal policies whose long-term macroeconomic effects have been analyzed in this chapter would have short-term effects as well. In the short term, policies that increased federal spending or cut taxes (and thus boosted budget deficits) would generally increase the demand for goods and services, thereby raising output and employment above what they would be in the absence of those policies. Similarly, policies that decreased federal

Table 6-3.

Short-Run Effects of the Fiscal Policies in Various Budget Scenarios

	Inflation-Adjusted Gross Domesic Product (Percentage difference)		Full-Time-Equivalent Employment (Difference in millions)	
	2016	2017	2016	2017
Alternative Fiscal Scenario				
Central estimate	0.6	0.3	0.7	0.5
Range	0.1 to 1.0	0 to 0.6	0.2 to 1.3	0.1 to 0.9
Illustrative Scenario With 10-Year Deficit Reduced by $2 Trillion				
Central estimate	-0.2	-0.2	-0.2	-0.2
Range	-0.3 to -0.1	-0.3 to 0	-0.3 to -0.1	-0.4 to -0.1
Illustrative Scenario With 10-Year Deficit Reduced by $4 Trillion				
Central estimate	-0.3	-0.3	-0.4	-0.5
Range	-0.6 to -0.1	-0.6 to -0.1	-0.7 to -0.1	-0.9 to -0.1

Source: Congressional Budget Office.

Notes: Figures reflect the differences in the levels between outcomes under a scenario and outcomes under CBO's baseline, which incorporates an assumption that current laws generally remain unchanged.

The alternative fiscal scenario incorporates these assumptions: Certain policies that have been in place for a number of years but that are scheduled to change will be continued, some provisions of law that might be difficult to sustain for a long period will be modified, and federal revenues and certain categories of federal spending measured as shares of gross domestic product will be maintained at or near their historical averages over the long term.

In the illustrative scenarios with the 10-year deficit reduced by $2 trillion and by $4 trillion relative to the baseline, those amounts are the cumulative reductions in deficits excluding interest payments between 2016 and 2025.

The central estimates and ranges reflect alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

spending or raised taxes (and thus decreased budget deficits) would generally reduce demand, thereby lowering output and employment below what they would be otherwise. Those effects are stronger when short-term interest rates are near zero and output is below its potential (maximum sustainable) level, in part because under those conditions the Federal Reserve is unlikely to adjust short-term interest rates to try to offset the effects of changes in federal spending and taxes.

Effects of the Extended Alternative Fiscal Scenario

The increase in deficits under the extended alternative fiscal scenario would cause real GDP to be higher in the next few years than it would be under current law, CBO estimates. The policies incorporated in that scenario would raise the demand for goods and services in the short run, increasing real GDP above what is projected under current law by 0.6 percent in 2016 and 0.3 percent in 2017, according to CBO's central estimates (see Table 6-3).[18] The policies would probably also increase real GDP for a few years after 2017, but CBO has not estimated the effects for those years. According to CBO's ranges of likely outcomes for key variables, in 2016, real GDP would probably be between 0.1 percent and 1 percent higher, and in 2017, it would probably be equal to or be as much as 0.6 percent higher, than what is projected under current law.[19]

18. CBO's estimates of the short-term effects of the extended alternative fiscal scenario and the two illustrative scenarios on real GDP are very similar to the agency's estimates of the effects on real GNP. This analysis focuses on GDP to be consistent with CBO's other analyses of the short-term impact of fiscal policies. The estimates reported here refer to averages during the calendar years referenced; some of CBO's other analyses of the short-term impact of fiscal policies have focused on effects during particular quarters of the year.

19. For a discussion of CBO's analytical approach to estimating the short-term economic effects of fiscal policy, see Felix Reichling and Charles Whalen, *Assessing the Short-Term Effects on Output of Changes in Federal Fiscal Policies*, Working Paper 2012-08 (Congressional Budget Office, May 2012), www.cbo.gov/publication/43278; and Congressional Budget Office, *How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy* (November 2014), www.cbo.gov/publication/49494.

To produce that additional output, businesses would hire more workers. According to CBO's central estimates, the policies in the alternative fiscal scenario would increase the number of full-time-equivalent employees above the number projected under current law by 0.7 million in 2016 and by 0.5 million in 2017.

Effects of the Two Scenarios With Smaller Deficits

Under the two illustrative scenarios that reduce deficits, real GDP would be lower in the next several years than projected under current law, CBO estimates. Because the agency did not specify the fiscal policies underlying those two scenarios, the estimated macroeconomic effects arise solely from the differences in overall deficits.

In the $2 trillion scenario, the reductions in the deficit excluding interest costs amount to $40 billion in 2016 and $76 billion in 2017. In the $4 trillion scenario, those reductions amount to $80 billion in 2016 and $151 billion in 2017. Under the first scenario, real GDP in 2016 would be 0.2 percent lower than it is projected to be under current law (or between 0.1 percent and 0.3 percent lower, according to CBO's ranges of likely outcomes for key variables); in 2017, real GDP would again be 0.2 percent lower (or, according to CBO's ranges of likely outcomes, it would be equal to or be as much as 0.3 percent lower than what it is projected to be under current law).[20] Under the second scenario, real GDP would be 0.3 percent lower than it is projected to be under current law (or between 0.1 percent and 0.6 percent lower, according to CBO's ranges of likely outcomes for key variables) in both 2016 and 2017. By CBO's estimates, the policies would continue to reduce real GDP below what it would be under current law for a few years after 2017, but CBO has not estimated the effects for those years.

Because businesses would produce less, they would hire fewer workers. According to CBO's central estimates, the number of full-time-equivalent employees under the first scenario would be 0.2 million smaller both in 2016 and 2017 than under current law; under the second scenario, there would be 0.4 million fewer full-time-equivalent employees in 2016 and 0.5 million fewer in 2017 than under current law.

20. CBO's central estimates here reflect the agency's assumption that in the two illustrative scenarios, each one-dollar change in budget deficits excluding interest payments relative to those under current law would, in the short term and under current economic conditions, change output cumulatively by one dollar over several quarters. That dollar-for-dollar response lies within the ranges of estimated effects on GDP of many policies that CBO examined in analyzing the macroeconomic effects of the American Recovery and Reinvestment Act of 2009. CBO's range of likely outcomes implies that each one-dollar change in deficits excluding interest payments would, in the short term and under current economic conditions, change output cumulatively by between $0.33 and $1.67. For a similar approach, see Congressional Budget Office, *Budgetary and Economic Outcomes Under Paths for Federal Revenues and Noninterest Spending Specified by Chairman Price, March 2015* (March 2015), www.cbo.gov/publication/49977.

CHAPTER

7

The Uncertainty of Long-Term Budget Projections

Budget projections are inherently uncertain. The projections in this report generally reflect current law and estimates of future economic conditions and demographic trends. If future spending and tax policies differ from what is prescribed in current law, budgetary outcomes will differ from those in the Congressional Budget Office's extended baseline, as the preceding chapter shows. But even if policies do not change, the economy, demographics, and other factors will undoubtedly differ from what CBO projects, and those differences will in turn cause budgetary outcomes to deviate from the projections in this report. Those variations could be within the ranges of experience observed in the relevant historical data—which, for the factors that CBO analyzes, cover roughly the past 50 to 70 years—or they might deviate from historical experience. Moreover, there could be significant budgetary effects from channels that CBO does not currently take into account in its estimates.

To illustrate some of the uncertainty about long-term budgetary outcomes, CBO constructed alternative projections showing what would happen to the budget if various underlying factors differed from the values that are used in most of this report. The agency focused on four factors that are among the most fundamental and yet most uncertain inputs into the agency's long-term economic and budget projections. Specifically, CBO quantified the consequences of alternative paths for the following variables:

- The decline in mortality rates;
- The growth rate of total factor productivity (that is, the efficiency with which labor and capital are used to produce goods and services; it is often referred to in this chapter simply as productivity);
- Interest rates on federal debt held by the public; and
- The growth rate of federal spending per beneficiary for Medicare and Medicaid.

Different paths for those four factors would affect the budget in various ways. For example, lower-than-projected mortality rates would mean longer average life spans, which would increase the number of people who received benefits from such programs as Social Security, Medicare, and Medicaid; lower mortality rates would also boost the size of the labor force and thereby add to tax revenues (but by less than the increase in benefit costs). Faster growth in spending per beneficiary for Medicare and Medicaid would boost outlays for those two programs. Either of those changes would increase deficits and debt—which would lead to lower output and higher interest rates, macroeconomic feedback that would further worsen the budget outlook.[1] By contrast, faster growth in productivity or lower interest rates on federal debt held by the public would reduce deficits and debt—the former, by raising output and increasing revenues, and the latter, by lowering the government's interest payments.

The projected budgetary outcomes under the alternative paths differ widely. The simulated variations in productivity, interest rates, and Medicare and Medicaid spending have large effects on the budget within 25 years, whereas the simulated variation in mortality rates does not. When only one of the factors is changed, CBO's projections of federal debt held by the public in 2040 range from

1. In cases in which projected budget deficits are larger than those in the extended baseline, output would be lower, leading to lower revenues (under current tax law), less spending on Social Security (because lower earnings result in smaller benefits), and less federal spending on Medicare and Medicaid (according to CBO's standard approach to projecting long-term cost growth, which is described in Chapter 2). However, CBO assumes that other federal noninterest spending would remain at the amounts in the extended baseline even if output deviated from the amounts underlying that baseline.

89 percent of gross domestic product (GDP) to 130 percent, whereas it is projected to be 107 percent under the extended baseline with macroeconomic feedback.[2] When all four factors are changed at once, projections of federal debt in 2040 range from 76 percent to 144 percent of GDP. Those projected levels of debt are all high by historical standards, and a number of them exceed the peak of 106 percent of GDP that the United States reached in 1946.

The four factors listed above are not the only ones that could differ from CBO's expectations and, in turn, affect the agency's budget projections. For example, an increase in the birth rate or in labor force participation could boost the growth of the labor force and thus raise tax revenues. Similarly, decisions by states about how much they spend on Medicaid could increase or decrease federal spending relative to CBO's projections.

Large disruptions in the economy could have significant effects on the budget that are not quantified in this analysis. The analytic approach that CBO used for this long-term analysis focuses on projecting average outcomes. An economic depression, unexpectedly large losses on federal financial obligations, a large-scale military conflict, the development of a previously underused natural resource, or a major catastrophe—to give just a few examples—could create conditions in the next 25 years that are substantially better or worse than those that produced the historical data on which the analysis is based.

Policymakers could address the uncertainty associated with long-term budget projections in various ways. For instance, they might design policies that partly insulated the federal budget from some unanticipated events; however, such policies could have unwanted consequences, such as shifting risk to individuals. Another possibility is that policymakers might aim for a smaller amount of federal debt to provide a buffer against the budgetary impact of adverse surprises and allow for more flexibility in responding to unexpected crises in the future.

2. As Chapter 6 explains, that version of the extended baseline incorporates the macroeconomic effects of the fiscal policies in the extended baseline and, in turn, the feedback of those effects to the federal budget. As a result, the economic and budget projections in the extended baseline with macroeconomic feedback differ somewhat from those presented in the first five chapters of this report.

Long-Term Budgetary Effects of Changes in Mortality, Productivity, Interest Rates on Federal Debt, and Federal Spending on Medicare and Medicaid

Budgetary outcomes could differ from CBO's projections if mortality rates, the growth rate of productivity, interest rates on government debt, or the growth of federal spending on Medicare and Medicaid diverged from the paths that underlie the extended baseline projections in this report. Unexpected changes in mortality rates would gradually lead to changes in spending for Social Security, Medicare, and Medicaid. Changes in productivity would lead to changes in economic output, which would affect both revenues and spending. Changes in the interest rates on federal debt would affect the amount of interest paid by the government. And changes in the growth rate of federal health care spending, one of the largest components of the budget, would have significant implications for overall federal spending.

For CBO's alternative projections, the ranges of variation for those four factors were based on the historical variation in their 25-year averages as well as on consideration of possible future developments, which together offer a guide (though admittedly an imperfect one) to the amount of uncertainty that surrounds projections of those factors over the next 25 years. To better capture overall uncertainty, CBO also constructed two projections in which all four factors simultaneously varied from their values under the extended baseline. In one of those cases, all of the factors varied in ways that increased the amount of federal debt; in the other, they varied in ways that reduced the amount of the debt.[3]

Under the projections of those four factors that are used in CBO's extended baseline, federal debt held by the

3. Another approach to quantifying the uncertainty of budget projections would be to create a distribution of outcomes from a large number of simulations in which such factors as productivity growth, interest rates, and the rate of increase of health care costs varied. CBO generally uses that approach in its reports on the financial outlook for the Social Security trust funds. See Congressional Budget Office, *CBO's 2014 Long-Term Projections for Social Security: Additional Information* (December 2014), www.cbo.gov/publication/49795, and *Quantifying Uncertainty in the Analysis of Long-Term Social Security Projections* (November 2005), www.cbo.gov/publication/17472. However, determining the appropriate variation in those factors and estimating the distribution of outcomes for the federal budget as a whole requires additional modeling tools that CBO has not yet developed.

public would equal 107 percent of GDP in 2040 (including macroeconomic feedback). Alternative projections of the factors would lead to the following outcomes:

- If mortality rates declined 0.5 percentage points per year more slowly or more quickly than they do in CBO's extended baseline, federal debt held by the public in 2040 would be 106 percent of GDP or 109 percent of GDP, respectively.
- If productivity grew 0.5 percentage points per year more quickly or more slowly than it does in CBO's extended baseline, federal debt held by the public in 2040 would be 91 percent of GDP or 125 percent of GDP, respectively.
- If the average interest rate on government debt was 0.75 percentage points lower or higher than that in CBO's extended baseline, federal debt held by the public in 2040 would be 89 percent of GDP or 130 percent of GDP, respectively.
- If spending per beneficiary for Medicare and Medicaid grew 0.75 percentage points per year more slowly or more quickly than it does in CBO's extended baseline, federal debt held by the public in 2040 would be 89 percent of GDP or 129 percent of GDP, respectively.
- If all four factors deviated from their baseline values in ways that reduced deficits but did so by only 60 percent as much as in the cases specified above, federal debt held by the public in 2040 would be 76 percent of GDP; if all four factors deviated in ways that increased deficits but did so by only 60 percent as much as in the cases specified above, federal debt held by the public would be 144 percent of GDP.[4]

Mortality

Mortality rates measure the number of deaths in a given year per thousand people in a population. Faster improvement in age-specific mortality rates would mean people of all ages would be expected to live longer, which would increase the number of people who received benefits from—and thus outlays for—Social Security, Medicare, Medicaid, and certain other mandatory spending programs.[5] Changes in mortality rates would also affect the budget by changing the size of the labor force and thereby changing tax revenues; specifically, CBO projects that the average person would work three more months for each additional year of life expectancy, slightly increasing overall labor force participation (see Appendix A).

Mortality rates have declined steadily over the past half century, and CBO expects that decline to continue. Just how steep that future decline will be, however, is quite uncertain. CBO therefore constructed projections covering a 1 percentage-point range (see Figure 7-1). The agency arrived at that range by comparing the average annual change in mortality rates for the 45 25-year periods that began each year from 1942 (the 1942–1966 period) to 1986 (the 1986–2010 period). The average annual change varied by about the same amount—roughly 1 percentage point—for men and for women.[6] Applying that 1 percentage-point range around the 1.2 percent rate used in CBO's extended baseline resulted in rates of decline ranging from 0.7 percent per year to 1.7 percent per year. If the rate of decline was within that range, life expectancy for 65-year-olds would be between 85.8 years and 87.9 years in 2040, whereas under the extended baseline, it would be 86.8 years in 2040; it is 84.5 years today.

Those alternative projections for the decline in mortality rates would lead to the following alternative budget projections:

4. According to CBO's analysis of the historical data, joint variation to that extent yields outcomes for federal debt that are about as likely as the outcomes when an individual factor changes to the full extent of its range.

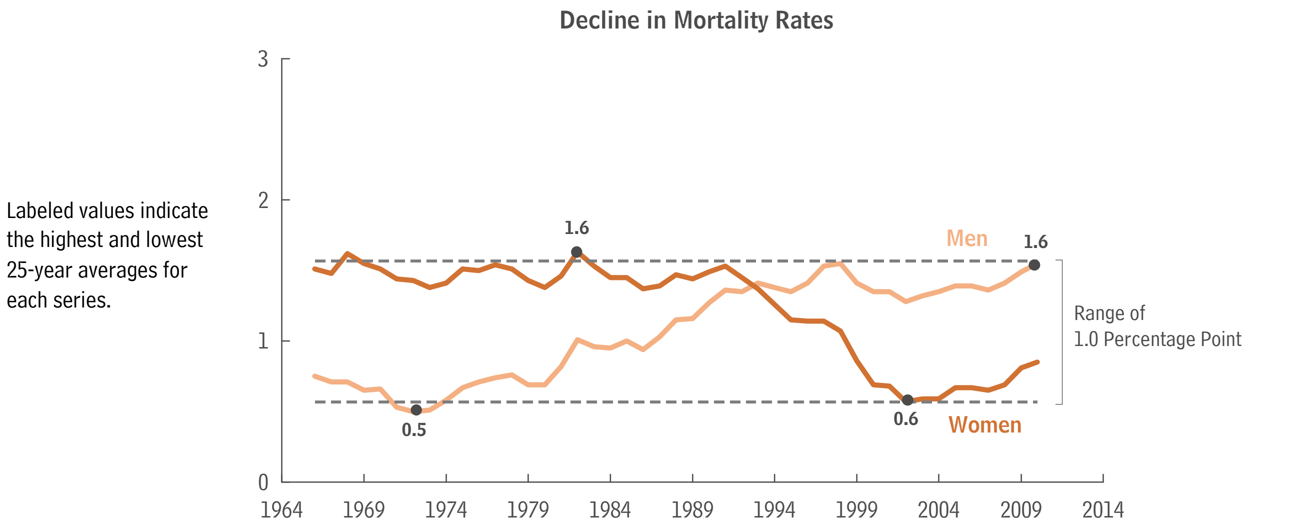
5. If an increase in life expectancy was accompanied by a gain in the average number of years that elderly people spend in good health, Medicare and Medicaid spending for elderly beneficiaries would not necessarily increase with the growth in the elderly population.

6. The rate of decline in *aggregate* mortality—that is, the rate for men and women combined—exhibited substantially less variation than the decline in mortality rates for men and women separately. From 1950 through 1980, the mortality rate for women declined faster than the mortality rate for men; after 1980, the mortality rate for men declined faster than the mortality rate for women. (That difference resulted in part from changes in smoking rates over time for men and for women.) In CBO's assessment, the variations in the declines of the mortality rates of men and women considered separately are more representative of the uncertainty in mortality rates over the next 25 years.

Figure 7-1.

The 25-Year Averages and Ranges CBO Used for Four Factors Affecting Budgetary Outcomes

Percentage Points



Sources: Congressional Budget Office; Social Security Administration; Federal Reserve.

Notes: The 25-year average for a given year is the average of the data value for that year and the values for the preceding 24 years. For example, the 25-year average for productivity growth in 1974 is the average of the growth of productivity from 1949 through 1974.

The decline in the mortality rate is the decline in the number of deaths per thousand people in a population in a given year.

Productivity growth is the growth in total factor productivity, which is the efficiency with which labor and capital are used to produce goods and services.

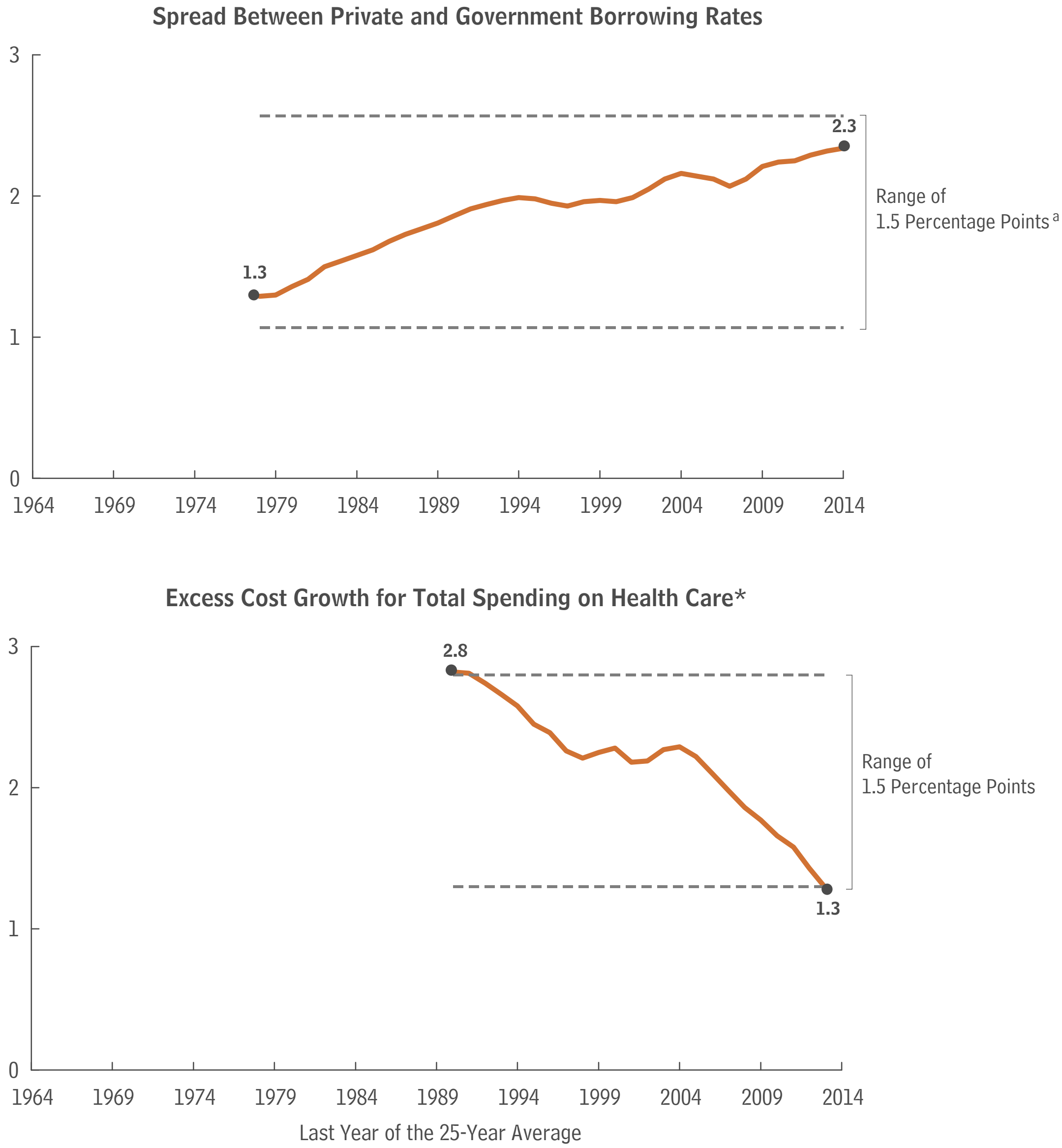
The spread between private and government borrowing rates is the difference between the interest rate on Baa-rated corporate bonds and on 10-year Treasury notes.

Continued

Figure 7-1. **Continued**

The 25-Year Averages and Ranges CBO Used for Four Factors Affecting Budgetary Outcomes

Percentage Points



Excess cost growth refers to the extent to which the annual growth rate of nominal health care spending per capita—adjusted for demographic characteristics of the relevant populations—outpaces the annual growth rate of potential (maximum sustainable) output per capita. The historical rates of excess cost growth are a weighted average of annual rates: Twice as much weight is placed on the latest year as on the earliest year.

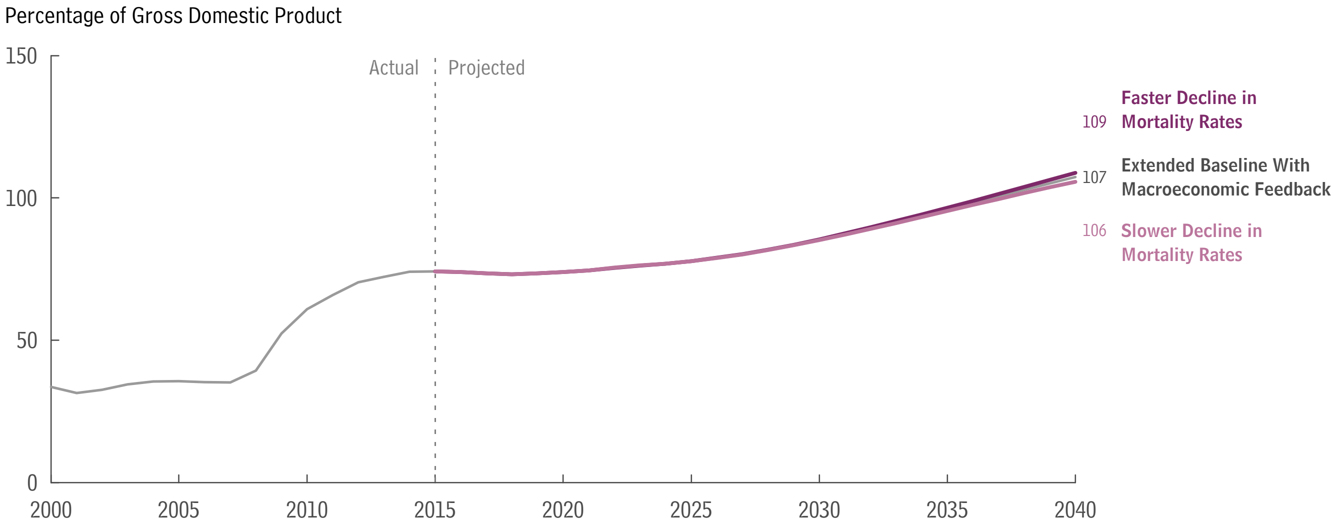
Time periods reflect data availability.

a. To account for various sources of uncertainty as well as for other factors that may not be fully represented by the particular measure of the spread used and the historical time period analyzed, CBO expanded the range of uncertainty used for this analysis from the 1.0 percentage point suggested by the historical data to 1.5 percentage points.

[* Panel heading corrected on July 1, 2015]

Figure 7-2.

Federal Debt Given Different Rates of Mortality Decline



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The faster decline in the mortality rates is 0.5 percentage points higher—and the slower decline in the mortality rates is 0.5 percentage points lower—than the annual decline of 1.2 percent used in the extended baseline with macroeconomic feedback.

Federal debt refers to debt held by the public. Estimates for the extended baseline with macroeconomic feedback are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

- If mortality rates declined by 0.7 percent a year—that is, 0.5 percentage points more slowly than the rate used in the extended baseline—outlays for Social Security, Medicare, and Medicaid would be lower. That would lead to less federal debt held by the public—specifically, debt would equal 106 percent of GDP in 2040 rather than the 107 percent that CBO projects under the extended baseline with macroeconomic feedback (see Figure 7-2). In addition, the estimated changes in spending or revenues needed to keep federal debt held by the public at its current level of 74 percent of GDP over the 25-year period—the fiscal gap—would be slightly smaller than CBO projects under the extended baseline, but they would round to the same 1.1 percent of GDP.[7] Although those differences are relatively small in 2040, they would grow substantially over time as the effect on mortality rates compounded and average life spans fell increasingly below those incorporated in the baseline.

- In contrast, if mortality rates declined by 1.7 percent a year, or 0.5 percentage points more quickly than in the extended baseline, outlays for the same three programs would be higher, resulting in federal debt held by the public that reached 109 percent of GDP in 2040. The 25-year fiscal gap would rise to 1.2 percent of GDP.

Productivity

Total factor productivity is an important determinant of economic output. Its growth stems from the introduction and spread of new technological approaches, from increases in workers' education and skill levels, and from

7. For a discussion of how CBO measures the fiscal gap, see Chapter 1. The estimates of the fiscal gap presented in this chapter, like those in Chapter 1, are calculated without macroeconomic feedback. It would not be informative to include the negative economic effects of rising debt (and their feedback to the budget) in the fiscal gap calculation because the fiscal gap shows the budgetary changes required to keep debt from rising in the first place; if those budgetary changes were made, the negative economic effects (and their feedback to the budget) would not occur.

the use of new processes that improve the efficiency of organizations.[8] CBO estimates that the growth of total factor productivity, which has averaged 1.4 percent per year since 1950, has accounted for over 40 percent of the increase in real (inflation-adjusted) nonfarm business output over that time. CBO's extended baseline incorporates the projection that such productivity will increase, on average, by 1.3 percent per year in the coming decades.

However, the growth rate of total factor productivity has often varied for extended periods. Periods of rapid growth have generally resulted from major technological innovations. For example, innovations in four critical areas—electricity generation, internal combustion engines, chemicals, and telecommunications—triggered a surge in productivity in the 1920s and 1930s. Another surge occurred in the 1950s and 1960s, spurred by the electrification of homes and workplaces, suburbanization, completion of the nation's highway system, and production of consumer appliances. The latest surge in productivity—a more modest one—began in the 1990s and is attributed to innovations involving computers and other types of information technology.[9] Productivity growth has been relatively weak since the 2007–2009 recession, largely because of the cyclical weakness in the economy that is expected to continue to dissipate over the next few years.

The future growth rate of productivity is quite uncertain. The nation could experience faster growth in productivity than is reflected in CBO's extended baseline, either steadily (from ongoing gains from, for example, integrating information technology into the economy) or in a burst (from a technological breakthrough, such as the development of a new source of energy). Conversely, the growth of productivity could be slower than in CBO's extended baseline if the rate of increase in workers' education levels declined or if technological innovation or the dispersion of previous technological innovations throughout the economy diminished. For example, although CBO projects that productivity growth will improve once the economy fully recovers, the 2007–2009 recession and slow recovery have weakened productivity for an extended period. If the continued weakness indicates that the effects of the recession will last longer than CBO projected, productivity growth over the longer term could be weaker than is reflected in the extended baseline.

A different growth rate for productivity would affect the federal budget by changing output and income and also, in CBO's assessment, by changing the interest rates paid by the federal government. Higher total factor productivity means that capital is more productive, which implies a higher rate of return from private capital investment, all else being equal. According to widely used economic models, if productivity grows faster, that rate of return remains higher over time. Because the federal government competes with private borrowers for investors' money, higher returns from private investment should push up interest rates paid by the federal government. Although empirical estimates of the relationship between productivity growth and interest rates vary, the theoretical relationship is clear enough for CBO to incorporate an effect on interest rates into this analysis.[10]

Average productivity growth during the 41 25-year periods beginning with the 1950–1974 period and ending with the 1990–2014 period varied by about 1 percentage point (see Figure 7-1 on page 94). CBO therefore projected economic and budgetary outcomes if total factor productivity grew by either 0.8 percent or 1.8 percent per year over the next 25 years—that is, 0.5 percentage points more slowly or more quickly than the 1.3 percent per year incorporated in the extended baseline.[11]

8. Total factor productivity is different from labor productivity, which measures the amount of goods and services that can be produced per hour of labor.

9. For further discussion, see Robert Shackleton, *Total Factor Productivity Growth in Historical Perspective*, Working Paper 2013-01 (Congressional Budget Office, March 2013), www.cbo.gov/publication/44002.

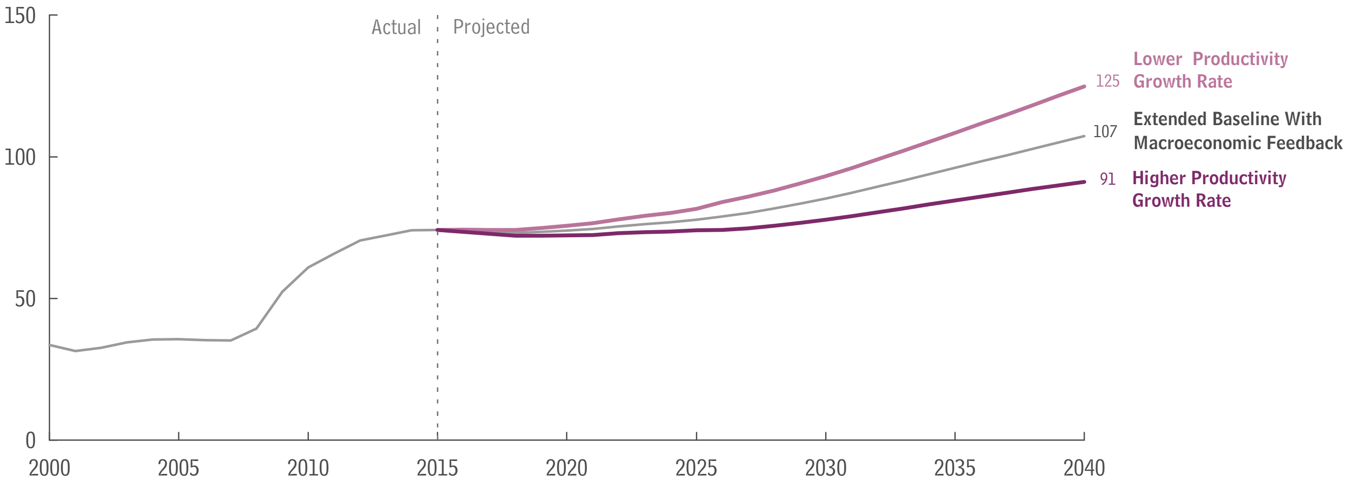
10. For example, in the Solow-type growth model that CBO used for this analysis, if productivity grew 0.5 percentage points more quickly than in the extended baseline with macroeconomic feedback, the average interest rate on federal debt held by the public in 2040 would be about 1 percentage point higher than the baseline value. For details of that model, see Congressional Budget Office, *CBO's Method for Estimating Potential Output: An Update* (August 2001), www.cbo.gov/publication/13250.

11. For another approach to measuring uncertainty in long-run projections of productivity growth, see Ulrich K. Müller and Mark W. Watson, *Measuring Uncertainty About Long-Run Predictions* (draft, Princeton University, September 2014), http://tinyurl.com/nl9bzws (PDF, 3 MB). Müller and Watson's approach yields a range of uncertainty around productivity growth that is similar in size to the range that CBO calculated.

Figure 7-3.

Federal Debt Given Different Rates of Productivity Growth

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The lower productivity growth rate is 0.5 percentage points lower—and the higher productivity growth rate is 0.5 percentage points higher—than the annual rate of 1.3 percent used in the extended baseline with macroeconomic feedback.

Federal debt refers to debt held by the public. Estimates for the extended baseline with macroeconomic feedback are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

Those alternative projections for total factor productivity growth would lead to the following alternative budget projections:

- If total factor productivity grew by 1.8 percent annually, 0.5 percentage points more quickly than in the baseline, then the greater GDP would result in more revenue, smaller budget deficits, and less federal debt. Federal debt held by the public would be 91 percent of GDP in 2040 rather than the 107 percent that CBO projects under the extended baseline with macroeconomic feedback (see Figure 7-3). The 25-year fiscal gap would be 0.8 percent of GDP rather than the 1.1 percent that CBO projects under the extended baseline.

- If productivity grew by 0.8 percent annually, 0.5 percentage points more slowly than in the baseline, the slower economic growth would result in less revenue, bigger budget deficits, and more debt. That debt would be 125 percent of GDP in 2040. The 25-year fiscal gap would rise to 1.5 percent of GDP.

Faster or slower productivity growth could also affect the budget in ways that are not accounted for in this analysis—for example, by changing the shares of the nation's income received by workers (as wages and salaries, for instance) and by the owners of capital (as corporate profits, for instance). In recent years, technological change appears to have affected productivity in ways that put downward pressure on labor's share (for example, by expanding options for using capital in place of labor), a trend that some economists believe will be long-lasting.[12] In addition, some types of ongoing technological change appear to be intensifying wage inequality.[13] Such shifts in

12. For further discussion, see Congressional Budget Office, *How CBO Projects Income* (July 2013), www.cbo.gov/publication/44433.

13. For further discussion, see Congressional Budget Office, *The Distribution of Household Income and Federal Taxes, 2011* (November 2014), www.cbo.gov/publication/49440.

the distribution of income could significantly affect tax revenues and spending for some programs (such as Social Security); whether they would have a large net effect on the federal budget overall is unclear.

Interest Rates on Federal Debt

Interest rates affect the budget by changing the interest payments that the federal government makes on debt held by the public. Interest rates are currently at historic lows, but CBO projects that they will rise over the next few years and return to levels closer to their long-run averages. As a result, interest payments on federal debt held by the public, which are currently a little over 1 percent of GDP, are projected to grow to about 3 percent of GDP by 2025, even though federal debt as a percentage of GDP is projected to be only slightly larger in that year than it is currently.

However, given how much interest rates on government debt have varied in the past, projections of those rates involve a great deal of uncertainty. CBO estimates that the real interest rate on 10-year Treasury notes (that is, the rate adjusted to exclude the effects of inflation) averaged about 3 percent during the 1960s, about 1 percent during the 1970s, about 5 percent during the 1980s, about 4 percent during the 1990s, about 2 percent between 2000 and 2007, and about 1 percent during the past seven years.[14]

CBO's long-term projection of interest rates takes into account economic and financial factors such as the amount of federal debt, the rate of growth of the labor force, the rate of growth of productivity, private saving, and the amount of inflows of capital from foreign investors (see Appendix A). Different projections of those factors would imply different projections of interest rates. For example, as explained above, faster productivity growth implies higher interest rates, all else being equal. But many of the economic and financial factors that affect interest rates also affect the budget in other ways—for instance, faster productivity growth leads to faster income growth and higher revenues—and those additional effects complicate the relationship between interest rates and the budget.[15]

To isolate the budgetary effect of changes to the interest rate that the federal government pays on debt held by the public, CBO analyzed uncertainty in its projection of the difference (called the spread) between the federal government's borrowing rates and private borrowing rates. For any given level of private borrowing rates, changes to that spread affect the rate at which the federal government borrows but do not usually have significant direct effects on economic conditions or on the federal budget apart from interest payments.

The conditions that have historically determined the spread between the government's borrowing rates and private borrowing rates include portfolio preferences among U.S. and foreign investors, the perception of the underlying risk of private securities relative to federal debt, the response of financial institutions to regulations that require the holding of low-risk assets, and the liquidity of federal debt relative to that of private securities. For example, the difference between the rates of interest on 10-year Treasury notes and on highly rated corporate bonds rose from the 1990s to the 2000s as investors became more averse to risk in the wake of the sharp stock market drop of the early 2000s; even after the economy recovered, the difference remained larger than it had been before the drop.

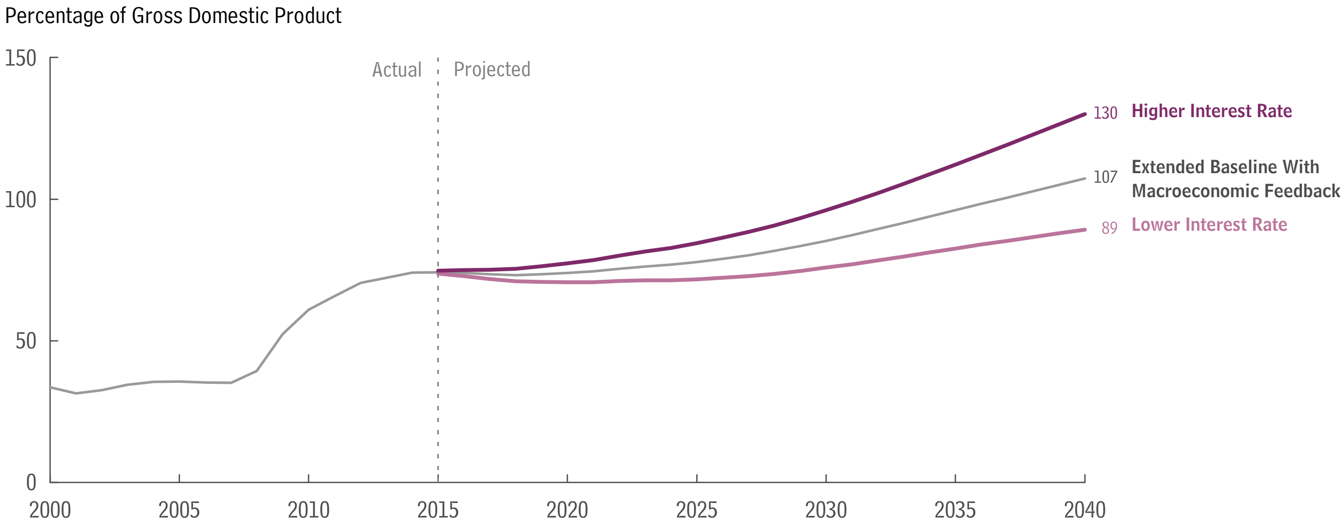
To find a guide to the uncertainty surrounding the spread between government borrowing rates and private borrowing rates, CBO examined the average spread between the interest rate on 10-year Treasury notes and the interest rate on a large class of corporate debt (specifically, an index of corporate debt with a credit rating of Baa) during the 25-year periods beginning with the 1954–1978 period and ending with the 1990–2014 period. That spread varied over those periods by about 1 percentage point (see Figure 7-1 on page 94). However, the historical averages do not reflect certain sources of uncertainty about spreads in the future. For one thing, estimates of the risk premium—the additional return that investors require to hold assets that are riskier than Treasury securities—have been quite volatile in recent years, so more distant history may be a poor guide to the future premium. For another, although private and foreign investors alike have been eager to invest in risk-free U.S. assets in recent

14. To calculate historical real interest rates, the actual rates were adjusted using changes in the consumer price index. Past values of the consumer price index were adjusted to account for changes over time in how that index measures inflation.

15. In addition, many economic and financial factors that affect the government's borrowing rate also affect interest rates in the private sector, which in turn affect private capital investment and thus income and output.

Figure 7-4.

Federal Debt Given Different Interest Rates



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The higher interest rate is 0.75 percentage points higher—and the lower interest rate is 0.75 percentage points lower—than the rate used for each year in the extended baseline with macroeconomic feedback.

Federal debt refers to debt held by the public. Estimates for the extended baseline with macroeconomic feedback are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

years, those investors may change their preferences as financial markets in emerging economies continue to develop and become more attractive. Furthermore, the effect that the regulatory changes that were enacted in response to the 2007–2009 financial crisis will have on investors' demand for corporate and federal debt remains very uncertain. To account for those sources of uncertainty as well as for other factors that may not be fully represented by the particular measure of the spread used and the historical period analyzed, CBO expanded the range of uncertainty used for this analysis from the 1.0 percentage point suggested by the historical data to 1.5 percentage points.[16]

16. For the extended baseline with macroeconomic feedback, CBO projects that the federal government's nominal borrowing rate wil average 3.9 percent between 2015 and 2040. If the spread between government and private borrowing rates was within the 1.5 percentage-point range of uncertainty, then after accounting for macroeconomic feedback, the government's nominal borrowing rate would be expected to be between 3.1 percent and 4.8 percent, on average, over that period.

Those alternative projections for the interest rate on federal debt held by the public would lead to the following alternative budget projections:

- If the spread between the government and private borrowing rates was 0.75 percentage points larger than the average incorporated in the baseline—resulting in a lower government borrowing rate—but the economy was otherwise the same, then net interest would equal 3.2 percent of GDP by 2040 instead of the 4.7 percent projected in the extended baseline with macroeconomic feedback.[17] Federal debt held by the public would be 89 percent of GDP in 2040 rather than the 107 percent that CBO projected in that baseline (see Figure 7-4). The 25-year fiscal gap

17. The estimated effects on budget projections of changes in the government's borrowing rates do not incorporate any changes in remittances by the Federal Reserve or in the relative amounts of different types of taxable income (for example, profits and interest income). Such changes would have additional budgetary implications.

would be 0.6 percent of GDP rather than the 1.1 percent that CBO projects under the extended baseline.[18]

- If the spread between the government and private borrowing rates was 0.75 percentage points smaller than the average incorporated in the baseline but the economy was otherwise the same, then net interest would equal 6.9 percent of GDP in 2040, and federal debt held by the public would be projected to reach 130 percent of GDP. The 25-year fiscal gap would rise to 1.6 percent of GDP.

Federal Spending on Medicare and Medicaid

The federal government pays for health care through Medicare, Medicaid, subsidies for insurance purchased through the exchanges established under the Affordable Care Act, and other programs as well as through tax preferences, especially the exclusion for employment-based health insurance.[19] In CBO's extended baseline, federal spending on health care per beneficiary increases more slowly in the future than it has, on average, in recent decades, though it still substantially outpaces the growth of potential (that is, maximum sustainable) output per capita. But the future growth of health care costs is quite uncertain, and it is consequently a significant source of budgetary uncertainty. CBO assesses the effects of uncertainty in the future growth of health care costs on the federal budget by varying the growth rate of costs in the two largest components of federal spending on health care, Medicare and Medicaid.

Many factors will affect Medicare and Medicaid spending per beneficiary in the long term (for further discussion, see Chapter 2). One of them is the extent to which advances in health care technology raise or lower costs. New medical procedures or treatments may prove more effective in helping patients, which could lower costs. However, such procedures and treatments are often very expensive; even services that are relatively inexpensive could make spending rise quickly if ever-growing numbers of patients used them.[20] Other factors that could affect health care costs are changes in the structure of payment systems and innovations in the delivery of health care.

In addition, Medicare and Medicaid spending will be affected by the health of the population. Outlays for Medicare and Medicaid depend in part on the prevalence of certain medical conditions—cardiovascular and pulmonary diseases, diabetes, arthritis, and depression, for example—among beneficiaries. The prevalence of such conditions could evolve in unexpected ways for various reasons, including changes in behavior (for example, in smoking rates, levels of physical activity, or dietary patterns), new treatments for various illnesses, new medical interventions that reduced the occurrence or severity of certain conditions or diseases, and the emergence of epidemics.

The measure that CBO examined for this analysis of uncertainty was excess cost growth—that is, the difference between the growth rate of health care spending per capita and the growth rate of potential output per capita.[21] In the 25-year periods starting with the 1966–1990 period and ending with the 1989–2013 period, excess cost growth for the health care system as a whole varied by about 1.5 percentage points (see Figure 7-1 on page 94). CBO used a 1.5 percentage-point range of variation and analyzed the effects of rates of excess cost growth for Medicare and Medicaid that were 0.75 percentage points above and below the rate of growth for each year in the extended baseline.[22] (CBO focused on Medicare and Medicaid because the projected

18. In estimating the fiscal gap under the alternative projections for interest rates, CBO altered the rate used to discount future taxes, noninterest spending, and debt by the same amount as other interest rates. For example, in calculating the fiscal gap under the projection with lower interest rates, future primary deficits (that is, deficits excluding interest payments) and the end-of-period debt are given a greater weight than they are under projections with higher interest rates.

19. Under that provision of the tax code, most payments that employers and employees make for health insurance coverage are exempt from income and payroll taxes.

20. See Congressional Budget Office, *Technological Change and the Growth of Health Care Spending* (January 2008), www.cbo.gov/publication/41665.

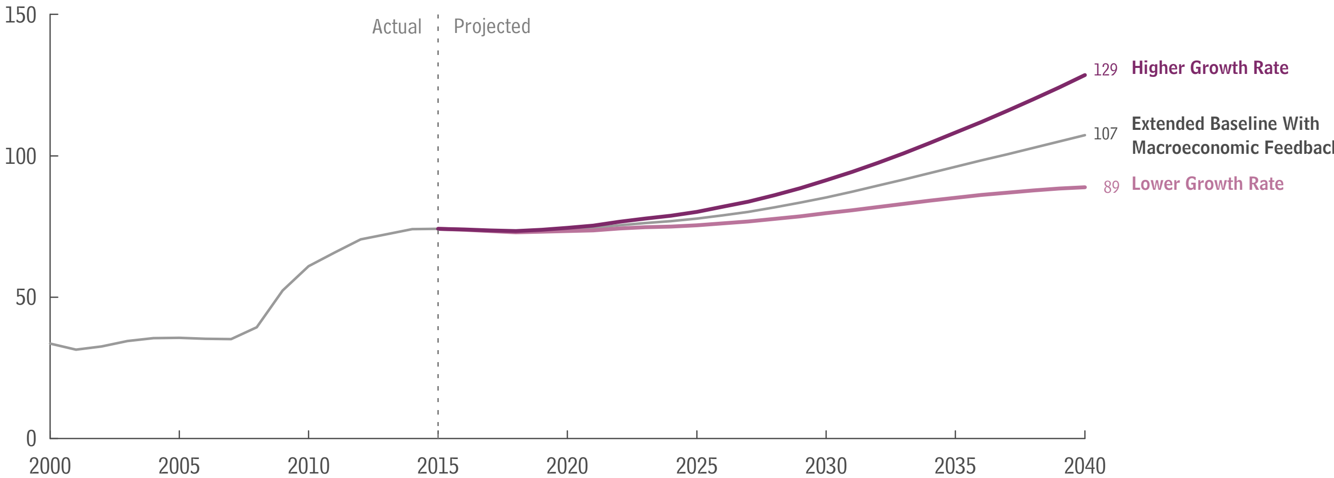
21. The definition and calculation of excess cost growth are discussed in more detail in Chapter 2.

22. In the extended baseline, CBO projects that the rate of excess cost growth in Medicare and Medicaid for each year will match the rate in the agency's baseline projections for the next 10 years and then move in the succeeding 15 years toward the projected underlying path. The estimated underlying rate starts at the rate of excess cost growth experienced in the health care system in recent decades and declines gradually as people respond to the pressures of rising costs.

Figure 7-5.

Federal Debt Given Different Rates of Growth of Federal Health Care Spending

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

The higher growth rate of per-beneficiary federal spending on Medicare and Medicaid is 0.75 percentage points higher—and the lower growth rate is 0.75 percentage points lower—than the growth rate used for each year in the extended baseline with macroeconomic feedback.

Federal debt refers to debt held by the public. Estimates for the extended baseline with macroeconomic feedback are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

size of those programs means that variations in their rates of growth would have particularly large effects on the federal budget.)

Those alternative projections for the growth of health care spending would lead to the following alternative budget projections:

- If Medicare and Medicaid spending per beneficiary rose 0.75 percentage points per year more slowly than in the extended baseline, federal debt held by the public would be 89 percent of GDP in 2040 rather than the 107 percent that CBO projects under the extended baseline with macroeconomic feedback (see Figure 7-5). The 25-year fiscal gap would be 0.5 percent of GDP rather than the 1.1 percent that CBO projects under the extended baseline.

- If Medicare and Medicaid spending per beneficiary rose 0.75 percentage points per year more quickly than in the extended baseline, federal debt held by the public would be 129 percent of GDP in 2040. The 25-year fiscal gap would rise to 1.8 percent of GDP.

Multiple Factors

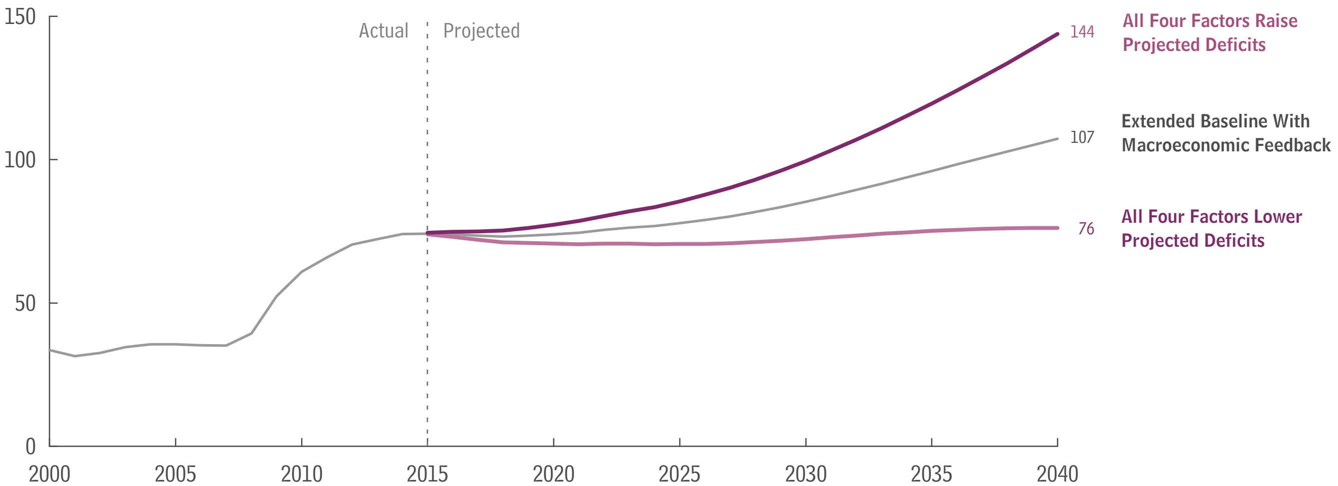
The previous cases illustrated what would happen to the federal budget if a single factor differed from the projections that CBO used in the extended baseline. Undoubtedly, however, multiple factors will differ from CBO's projections. In addition, estimating the budgetary consequences of such a circumstance is more complicated than simply adding together the outcomes of the individual cases. For example, higher-than-projected health care costs would have a larger effect on the budget if interest rates on federal debt were also higher than CBO projects—because the government would have to pay more interest on debt that resulted from the additional health care spending.

To account for the interactions among the key variables and the fact that having just one individual factor reach the end of its range is much more likely than having all

Figure 7-6.

Federal Debt Given Different Rates of Mortality Decline, Productivity Growth, Interest, and Growth of Federal Health Care Spending

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

Notes: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period.

For this figure, CBO used ranges for the four factors that are 60 percent as large as the ranges used for the individual cases (shown in Figures 7-2 to 7-5).

Federal debt refers to debt held by the public. Estimates for the extended baseline with macroeconomic feedback are CBO's central estimates from ranges determined by alternative assessments about how much deficits crowd out investment in capital goods such as factories and computers (because a larger portion of private saving is being used to purchase government securities) and about how much people respond to changes in after-tax wages by adjusting the number of hours they work.

four do so simultaneously, CBO used smaller ranges for each of the four factors when they are assumed to change together than it used for them individually. It analyzed illustrative cases in which all four factors varied from the baseline by 60 percent of their individual ranges. According to CBO's analysis of the historical data, joint variation to that extent yields outcomes for federal debt that are about as likely as the outcomes when an individual factor changes to the full extent of its range. For example, in the cases discussed above, the range for the rate of productivity growth was 1 percentage point, yielding growth rates that were 0.5 percentage points higher and lower than the values in the extended baseline; but for the combined projections, the range for the rate of productivity growth is 0.6 percentage points, yielding growth rates that span the baseline values by 0.3 percentage points.

Varying the four factors together in that way would lead to the following budget projections:

- If mortality rates declined 0.3 percentage points per year more slowly, productivity grew 0.3 percentage points per year more quickly, the difference between the average interest rate on government debt and private interest rates was about 0.45 percentage points greater, and federal costs per beneficiary for Medicare and Medicaid grew by about 0.45 percentage points per year more slowly than under the extended baseline, federal debt held by the public would be 76 percent of GDP in 2040—about what it is now—rather than the 107 percent that CBO projects under the extended baseline with macroeconomic feedback (see Figure 7-6). The 25-year fiscal gap would be 0.6 percent of GDP rather than the 1.1 percent that CBO projects under the extended baseline.

- If mortality rates declined 0.3 percentage points per year more quickly, productivity grew 0.3 percentage points per year more slowly, the difference between the average interest rate on government debt and private interest rates was about 0.45 percentage points smaller, and federal costs per beneficiary for Medicare and Medicaid grew by about 0.45 percentage points per year more quickly than under the extended baseline, federal debt held by the public would be 144 percent of GDP in 2040. The 25-year fiscal gap would be 1.7 percent of GDP.

Other Sources of Uncertainty Related to Demographic, Economic, and Other Trends

CBO's long-term budget estimates depend on projections of numerous variables in addition to those analyzed above. (Many of those variables are discussed in detail in Appendix A.) Although the factors discussed in the previous section are four of the more important ones, they are intended to provide illustrative examples, not to be exhaustive. Every variable has some uncertainty associated with it. For instance, demographics, labor force growth, and decisions by states about Medicaid are also important, but CBO has not yet quantified the potential effects on the budget of uncertainty involving those factors.

Changes in Demographics and Labor Force Growth

Demographic factors have significant effects on economic and budgetary outcomes. For instance, GDP depends to a large degree on the size of the labor force, which is related to the number of adults between the ages of 20 and 64, and federal outlays for Medicare, Medicaid, and Social Security are closely linked to the number of people who are at least 65 years old. Higher rates of fertility or greater immigration flows would generally cause federal spending to decrease relative to GDP because they would increase the ratio of adults ages 20 to 64 to elderly adults. (Mortality, another demographic factor that affects the economy and the budget, was addressed separately above.)

The growth of the labor force could also change for reasons other than demographic ones. Projections of the labor force are based on estimates of the size of the population and estimates of the rates of participation in the labor force by people in different demographic groups. Those participation rates in turn depend on a number of factors, including economic conditions, cultural shifts, and public policies (especially those that involve taxes on labor or that directly affect people's incentive to work in some other way).[23] The overall rate of participation in the labor force has varied considerably over time. For example, it averaged 59 percent in the 1950s and 1960s, increased to more than 67 percent by 2000, and has declined since then, averaging a little more than 62.8 percent in the first four months of 2015. The large increase from the 1960s to 2000 was mostly the result of an increasing number of women in the labor force. If the next 25 years saw some kind of cultural shift that had a similarly large effect on the overall rate of participation in the labor force, labor force growth could be significantly different from what CBO expects.

Faster or slower labor force growth would produce better or worse budgetary outcomes, all else being equal. If the labor force grew more quickly than projected for the extended baseline, the faster economic growth would result in higher revenues, smaller budget deficits, and a smaller ratio of federal debt to GDP. In contrast, if the labor force grew more slowly than projected in the extended baseline, the slower economic growth would result in lower revenues, larger budget deficits, and a greater ratio of debt to GDP.

Decisions by States About Medicaid

State governments have flexibility in administering their Medicaid programs, and the decisions that they make about eligibility, benefits, and payments to providers affect the federal budget because the federal government pays a large share of Medicaid's costs. One source of uncertainty is whether states will maintain or increase Medicaid spending—by obtaining program waivers to expand eligibility to new population groups, enhancing outreach efforts to increase enrollment of eligible people, or expanding covered benefits—as rising earnings reduce the number of children and nondisabled adults who are eligible for the program over time. Decisions by states could significantly decrease or increase federal expenditures for Medicaid relative to the amounts in CBO's projections.

Potential Developments in the Economy and Their Effects on the Budget

The range of outcomes presented above conveys only part of the uncertainty associated with long-term budget projections. They do not account for other plausible

23. The rate of participation in the labor force has changed over time within demographic groups; see Congressional Budget Office, *CBO's Labor Force Projections Through 2021* (March 2011), www.cbo.gov/publication/22011.

but unpredictable developments that could increase or decrease federal debt relative to CBO's projections. Such possible developments could include an economic depression like the one that occurred in the United States in the 1930s; unexpectedly large losses on federal financial obligations, such as mortgage guarantees; and unpredictable catastrophes, such as a major natural disaster or world war, the effects of changes in climate, or the discovery of valuable natural resources.

A Severe Economic Downturn

In general, when economic output rises or falls, the federal budget is automatically affected. For example, economic downturns can reduce revenues significantly and raise outlays for safety-net programs, such as unemployment insurance and nutrition assistance.[24] In addition, such downturns have historically prompted policymakers to enact legislation that further reduces revenues and increases federal spending—to help people suffering from the weak economy, to bolster the financial condition of state and local governments, and to stimulate additional economic activity and employment. The budgetary effects of the recent recession were particularly large: Federal debt increased from 35 percent of GDP at the end of 2007 to 70 percent at the end of 2012, in large part because of the recession and weak recovery and the policy responses enacted to counter those developments.

The long-term projections of output and unemployment in this report reflect economic trends from the end of World War II to the present, a period that included several economic downturns that were not fully offset by upturns of similar magnitude.[25] But the projections do not account for the possibility of a severe economic downturn like the Great Depression of the 1930s. Such events are rare; for that reason and others, their magnitude and timing cannot readily be predicted. If such an event occurred in the next 25 years, federal debt would probably be substantially greater than projected in CBO's extended baseline.

Changes in Losses on Federal Insurance or Credit Programs

The federal government supports a variety of private activities through federal insurance and credit programs that provide loans and loan guarantees.[26] CBO includes the expected losses from those credit and insurance programs in its baseline projections. Significantly greater losses could result from certain unexpected events, such as a major disruption in the financial system or a deep slump in the economy. Alternatively, long periods of financial and economic stability could lead to smaller losses.

Federal insurance and credit programs generate losses when the support provided by the federal government exceeds the money taken in by the programs through fees, loan repayments, interest payments, asset sales, wage garnishment, and other means. For example, in the wake of the recent housing crisis, widespread defaults on guaranteed mortgages led to substantial outlays by the federal government. Widespread defaults on student loans or the bankruptcy of numerous companies with underfunded pension plans could lead to analogous costs for the federal government in the future.[27] Conversely, long periods of particularly strong economic growth could allow federal insurance and credit programs to collect higher-than-projected repayments and cover lower-than-projected expenses.

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24. See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), Appendix D, www.cbo.gov/publication/49892.

25. Since the end of World War II, the unemployment rate has been about one-quarter of one percentage point higher, on average, than CBO's estimate of the natural rate of unemployment (the rate arising from all sources except fluctuations in aggregate demand). That difference implies that periods of significant economic weakness (such as the 2007–2009 recession and its aftermath) have pushed the unemployment rate above CBO's estimate of the natural rate more than periods of significant economic strength have pushed it below that estimate. Consistent with that finding is CBO's projection that the unemployment rate in the long term will be 5.3 percent, which is about one-quarter of one percentage point higher than CBO's estimate of the natural rate of unemployment in the long term. For further discussion, see Appendix A.

26. Federal insurance programs provide coverage for deposits at financial institutions (through the Federal Deposit Insurance Corporation), for workers' pensions (through the Pension Benefit Guaranty Corporation), and for property against damage by floods (through the National Flood Insurance Program), among other things. The largest federal credit programs provide mortgage loan guarantees (through the Federal Housing Administration, Fannie Mae, and Freddie Mac); student loans; and federally backed loans to businesses (through the Small Business Administration, for example). There are a number of smaller programs, including the loan guarantees provided by the Department of Energy and the terrorism risk insurance program administered by the Treasury Department.

27. For more discussion, see James D. Hamilton, *Off-Balance-Sheet Federal Liabilities*, Working Paper 19253 (National Bureau of Economic Research, July 2013), www.nber.org/papers/w19253.

Moreover, the federal government may have significant implicit liabilities apart from the liabilities created by formal government programs. In the event of a financial crisis, for example, federal policymakers might decide to provide monetary support to the financial system, as they did during the recent financial crisis. Such support could increase federal outlays above the amounts in the extended baseline.

Catastrophes

The federal government also faces implicit obligations in the case of catastrophes. Small-scale natural and man-made disasters occur fairly often in the United States; they may seriously damage local communities and economies, but they have rarely had significant, lasting impacts on the national economy. By contrast, a catastrophe could affect budgetary outcomes by reducing economic growth over a number of years, leading to substantial increases in federal spending. For example, the nation could experience a massive earthquake, a pandemic, an asteroid strike, a geomagnetic storm from a large solar flare, or a nuclear meltdown or attack that rendered a significant part of the country uninhabitable. Participation in a major war could also have significant economic and budgetary impacts: The ratio of federal debt held by the public to GDP rose by 60 percentage points during World War II, for instance. Because catastrophic events are extremely rare, it is very difficult to estimate the probability of their future occurrence and their possible effects on the budget.

Climate Change

CBO's extended baseline does not explicitly incorporate the effects of climate change. It implicitly includes some small effects by reflecting historical spending on such programs as federal crop insurance, federal flood insurance, and the Federal Emergency Management Agency's disaster relief program.[28] Aside from those implicit changes in federal outlays, the extended baseline does not incorporate any budgetary effect that climate change might have; it does not, for example, account for the effect on federal tax revenues that climate change could have if it affected the nation's economic output.

Substantial uncertainty surrounds any projection that attempts to account for the impact that climate change might have on the economy or on the budget. That uncertainty arises from several sources, including the unpredictability of global economic activity and technology development—both of which affect the amount of emissions in the future—as well as limitations in current data and the imperfect understanding of physical processes and of many aspects of the interacting components (land, air, water and ice, and life) that make up the Earth's climate system. In addition to the unpredictability of climate change itself, the impact that any such change would have on the economy and the budget is also quite uncertain.

CBO has not undertaken a full analysis of the budgetary costs stemming from climate change, but it is currently analyzing the potential costs of future hurricanes.[29] That analysis suggests that the costs of future hurricane damage will rise at a faster rate than GDP; however, the amount of additional hurricane damage is likely to remain small enough, on average, that the resulting federal expenditures would not significantly affect the general budget categories in which hurricane-related spending falls.

Three factors that influence the rate of growth of future hurricane damage are sea levels, the frequency of severe hurricanes, and the amount of development in coastal areas (because the damage caused by hurricanes will depend, in part, on the amount of people and property in harm's way):

- Hurricane damage is expected to increase over time because climate change is projected to lead to rising sea levels, which will tend to increase damage from storm surges when hurricanes occur.

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28. Some of the programs most affected by weather-related disasters—such as federal crop insurance and flood insurance—fall into the "other mandatory spending" category in CBO's long-term projections; in CBO's extended baseline, other mandatory spending (apart from outlays for refundable tax credits) is projected to continue to decline as a share of GDP after the 10-year period that CBO's baseline projections span at the same rate as it is projected to decline during the last five years of that initial period. Other programs affected by weather-related disasters—such as the Federal Emergency Management Agency's disaster relief program—are discretionary; spending for those programs is projected to remain constant as a share of GDP after the 10-year baseline projection period.

29. Terry Dinan, Senior Adviser, Congressional Budget Office, "Hurricane Damage: Effects of Climate Change and Coastal Development" (presentation to the Summer Conference of the Association of Environmental and Resource Economists, San Diego, Calif., June 5, 2015), www.cbo.gov/publication/50230.

- Climate change may increase the occurrence of the most intense (Category 4 and 5) storms in the North Atlantic Basin, leading to more damage in the United States.

- The growth in hurricane damage attributable solely to increases in coastal development is projected to be slower than the growth of the economy overall. That slower rate stems from the expectation that new development will tend to be denser (reducing wind damage per structure if buildings are closer together and storm surge damage per structure if buildings are taller), more expensive construction and therefore less vulnerable to storm damage.

All told, CBO projects that the amount of damage attributable to climate change and coastal development will probably be around 0.05 percent of GDP in the 2030s and less than 0.1 percent of GDP in the 2070s.

Many estimates suggest that the effect of climate change on the nation's economic output, and hence federal tax revenues, will probably be small over the period that is covered by CBO's long-term projections and larger, but still modest, in later years.[30] Even under scenarios in which significant warming is assumed, the projected long-term effects of climate change on GDP in the United States tend to be modest relative to underlying economic growth for two primary reasons. First, only a small share of the U.S. economy is directly affected by changes in climate; the largest effects will probably occur in the agricultural sector, which currently represents about 1 percent of total U.S. output. (The direct economic effects of climate change may be larger in other countries, particularly those for which agricultural output is a larger share of the total.) Second, some activities within the agricultural sector—crop production in the north, for example—could experience gains because of climate change. In any event, some of the effects of climate change (such as the loss of biodiversity), neither directly relate to measured economic output nor affect tax revenues. CBO continues to monitor research on the effects of climate change on the U.S economy, to consider how those effects might alter the federal budget outlook, and to evaluate federal policies that may lead to lower emissions or mitigate damage from changes in the climate.

In addition to uncertainty about the magnitude of disasters caused by climate change, there is uncertainty about how lawmakers would respond to them. In the future, lawmakers could increase funding above the amounts in CBO's projections if the effect of climate change on the frequency and magnitude of weather-related disasters became significantly larger. For example, increased damage from storm surges might lead the Congress to pass additional emergency supplemental appropriations for disaster relief or to approve legislation providing funding to protect infrastructure that is vulnerable to rising sea levels. Or lawmakers could amend existing laws to reduce federal spending on weather-related disasters. For instance, the Congress might decide to alter flood insurance or crop insurance programs in a way that provides insured parties with greater incentive to avoid potential damage. But CBO's baseline projections, which are built on current law, cannot capture such possible changes.

Natural Resources

The future discovery and development of productive natural resources may cause federal receipts to increase. For example, recent advances in combining two drilling techniques, hydraulic fracturing and horizontal drilling, have allowed access to large deposits of shale resources—that is, crude oil and natural gas trapped in shale and certain other dense rock formations. Virtually nonexistent a decade ago, the development of shale resources has boomed in the United States in recent years, affecting two kinds of federal receipts—federal tax revenues and payments to the government by private developers of federally owned resources. By boosting GDP, shale development increases tax receipts. Because some of the shale resources being developed are federally owned, developers must make payments to the federal government; however, most of the nation's shale resources are not federally owned, so those payments do not increase federal receipts by a significant amount.[31] Advances in the development of other resources may also contribute to federal receipts and make federally owned resources more valuable.

30. Congressional Budget Office, *Potential Impacts of Climate Change in the United States* (May 2009), www.cbo.gov/publication/41180.

31. Congressional Budget Office, *The Economic and Budgetary Effects of Producing Oil and Natural Gas From Shale* (December 2014), www.cbo.gov/publication/49815.

Implications of Uncertainty for the Design of Fiscal Policy

Policymakers could take uncertainty into account in various ways when making fiscal policy choices.[32] For example, they might decide to design policies that reduced the budgetary implications of certain unexpected events. Policymakers might also decide to provide a buffer against events with negative budgetary implications by aiming for lower debt than they would otherwise.

Reducing the Budgetary Implications of Unexpected Events

Fiscal policy cannot eliminate the risk factors that create uncertainty about budgetary outcomes, but it can reduce the budgetary implications of those factors. However, reducing budgetary uncertainty for the federal government could have unwanted consequences, such as shifting risk to individuals. Under current law, for example, growth in Medicare and Medicaid outlays per beneficiary depends on the growth of per capita health care costs. Some policymakers have proposed that growth in federal outlays per beneficiary of those programs be linked instead to measures of overall economic growth.[33] Such a change could affect national spending for health care, the federal budget, individuals' costs, and the budgets of state and local governments. It might greatly reduce uncertainty about future federal outlays for Medicare and Medicaid, but it might also greatly increase uncertainty about the future costs borne by the programs' beneficiaries and by state and local governments.[34]

Similarly, policymakers could reduce the budgetary implications of uncertainty about future life expectancy by indexing the eligibility age for programs such as Social Security or Medicare to average life spans. Under current law, if longevity increased more than expected, outlays for federal health care and retirement programs would exceed projections. If policies were changed so that the age of eligibility for those programs rose automatically with increases in longevity, the budgetary effects of such increases would be dampened. However, people would face greater uncertainty about the timing and size of the benefits that they would receive, and the effects would vary among subgroups of the population.

In addition, policymakers could reduce the budgetary implications of unexpected rises in interest rates by increasing the share of government borrowing that is done through longer-term securities. Using that approach, the Treasury could lock in interest rates for a considerable period. However, interest rates on longer-term debt are typically higher than rates on shorter-term debt, so that approach would probably raise the interest that the federal government paid. Moreover, if interest rates were locked in for a long period, the federal government would benefit less from unexpected *declines* in interest rates.

Whether or not the federal budget directly bears the risk of uncertain outcomes, all risk is ultimately distributed among individuals—as taxpayers, as beneficiaries of federal programs, or as both. If federal spending for certain programs turned out to be higher than projected, the additional imbalance could be offset only through higher revenues or lower outlays for other programs or activities at some point in the future. If the additional imbalance was not offset, then deficits would be larger, resulting in lower future income. Conversely, if budgetary imbalances were smaller than expected, then an opportunity would exist to lower taxes or boost spending; it would also be possible to reduce future deficits, resulting in higher income. Which income groups or generations benefited the most—or bore the largest burden—from unexpected budgetary imbalances would depend on the policies that lawmakers enacted to deal with such imbalances.

Reducing Federal Debt

As an alternative or complementary approach, policymakers could improve the federal government's ability to withstand the effects of events that would significantly worsen the budgetary outlook. In particular, reducing the amount of federal debt held by the public would give future policymakers more flexibility in responding to extraordinary events. For example, a financial crisis in the future might have significant negative economic and budgetary implications—just as the 2007–2009 financial

32. See Alan J. Auerbach and Kevin Hassett, "Uncertainty and the Design of Long-Run Fiscal Policy," in Auerbach and Ronald D. Lee, eds., *Demographic Change and Fiscal Policy* (Cambridge University Press, 2001), pp. 73–92, http://tinyurl.com/p93enfp.

33. For examples of these proposals, see Congressional Budget Office, *Preliminary Analysis of the Rivlin-Ryan Health Care Proposal* (attachment to a letter to the Honorable Paul D. Ryan, November 17, 2010), www.cbo.gov/publication/21928.

34. Most proposed policy changes of that sort would affect both the expected amounts of federal outlays and the uncertainty about those outlays, but those two effects are conceptually distinct.

crisis did: The ratio of federal debt held by the public to GDP increased by 35 percentage points between 2007 and 2012. If another financial crisis prompted a similar increase when the ratio of federal debt to GDP was already at a high level (such as its current level of 74 percent), policymakers might be reluctant to accept the initial cost of a desired intervention in the financial system or the economy, even if they expected to recoup at least part of that cost over time.

In addition, a high ratio of debt to GDP increases the risk of a fiscal crisis in which investors lose confidence in the government's ability to manage its budget and the government in turn loses its ability to borrow at affordable rates.[35] There is no way to predict the amount of debt that might precipitate such a crisis, but starting from a position of relatively low debt would reduce the risk.

35. That sort of crisis might be triggered by an adverse event that quickly drove up the ratio of debt to GDP, such as a depression or a war. For further discussion, see Congressional Budget Office, *Federal Debt and the Risk of a Fiscal Crisis* (July 2010), www.cbo.gov/publication/21625.

APPENDIX

A

CBO's Projections of Demographic, Economic, and Other Trends

The long-term budget estimates in this report depend on projections by the Congressional Budget Office for a host of demographic, economic, and other variables. CBO refers to that collection of projections as its economic benchmark, a measure that is consistent with the agency's baseline economic and budgetary projections for the ensuing 10 years. Beyond 2025, the economic benchmark generally reflects historical trends; it does not incorporate the extent to which economic output and interest rates would change if federal debt as a percentage of gross domestic product (GDP) or marginal tax rates changed after 2025, as is projected to occur under current law. (For average values from 2015 through 2040, see Table A-1. Projected annual values for the major demographic and economic variables for the next 75 years are included in the supplemental data for this report, available online at www.cbo.gov/publication/50250.)

Demographic Variables

The size and composition of the U.S. population in coming decades will affect federal tax revenues and spending as well as the overall performance of the economy. Among other effects, demographic changes will influence the size of the labor force and the number of beneficiaries of such federal programs as Medicare and Social Security. Population projections include estimates of rates of fertility, immigration, and mortality. (CBO uses projections published by the Social Security trustees for fertility rates but makes its own projections of immigration and mortality rates.) CBO anticipates that the total U.S. population will increase from 325 million at the beginning of 2015 to 394 million in 2040.

Fertility

CBO has adopted the intermediate (midrange) estimates of fertility rates published by the Social Security Administration in 2014.[1] Those values imply an average fertility rate of 2.0 children per woman between 2015 and 2040. (The Social Security trustees' report defines the fertility rate as the average number of children that a woman would have in her lifetime if, at each age of her life, she experienced the birth rate observed or assumed for that year and if she survived her entire childbearing period.)

Immigration

For its economic benchmark, CBO projects that after 2025, net annual immigration (the net result of people leaving and entering the United States) will equal 3.2 immigrants for every 1,000 members of the U.S. population, a ratio that is consistent with the data for most of the past two centuries.[2] On that basis, CBO projects, net annual immigration to the United States will amount to 1.2 million people in 2026 and 1.3 million in

1. See Social Security Administration, *The 2014 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds* (July 2014), Table V.A1, www.ssa.gov/oact/tr/2014.

2. The ratio equals the estimated average net flow of immigrants between 1821 and 2002; see 2003 Technical Panel on Assumptions and Methods, *Report to the Social Security Advisory Board* (October 2003), p. 28, http://go.usa.gov/38pbH (PDF, 450 KB). That ratio also was published in 2011 Technical Panel on Assumptions and Methods, *Report to the Social Security Advisory Board* (September 2011), p. 64, http://go.usa.gov/38pE3 (PDF, 6.3 MB). For more details about U.S. immigration, see Congressional Budget Office, *A Description of the Immigrant Population—2013 Update* (May 2013), www.cbo.gov/publication/44134.

Table A-1.

Values for Demographic and Economic Variables Underlying CBO's Long-Term Budget Projections

	Average Annual Values		
	2015–2025	2015–2040	2031–2040
Demographic Variables			
Fertility rate (Children per woman)	2.0	2.0	2.0
Immigration rate (Per 1,000 people in the U.S. population)	4.0	3.6	3.2
Rate of mortality decline (Percent, adjusted for age and sex)	1.2	1.2	1.2
Economic Variables (Percent)			
Growth of the labor force	0.6	0.5	0.4
Growth of average hours worked	-0.1	-0.1	*
Unemployment			
Unemployment rate	5.4	5.4	5.3
Natural rate of unemployment	5.3	5.1	5.0
Earnings as a share of compensation	81	81	80
Inflation			
Growth of the CPI-U	2.3	2.3	2.4
Growth of the GDP deflator	1.9	2.0	2.0
Interest rates			
Real rates			
On 10-year Treasury notes and the OASDI trust funds	2.0	2.2	2.3
On all federal debt held by the public	0.9	1.5	2.0
Nominal rates			
On 10-year Treasury notes and the OASDI trust funds	4.2	4.5	4.7
On all federal debt held by the public	3.2	3.9	4.4
Growth of productivity			
Total factor productivity	1.4	1.3	1.3
Labor productivity	1.8	1.8	1.8
Growth of real earnings per worker	1.6	1.4	1.4
Growth of GDP			
Real GDP	2.3	2.2	2.2
Nominal GDP	4.3	4.3	4.2

Source: Congressional Budget Office.

Note: CPI-U = consumer price index for all urban consumers; GDP = gross domestic product; OASDI = Old-Age, Survivors, and Disability Insurance (Social Security); * = between -0.05 percent and zero.

2040. Estimates of authorized and unauthorized immigration over the long term are subject to a great deal of uncertainty, however, and the number of immigrants could be higher or lower than CBO projects. Over the past 50 years, net annual immigration (averaged over five-year periods) has varied from almost 7 to fewer than 2 immigrants per 1,000 members of the U.S. population.[3]

3. 2011 Technical Panel on Assumptions and Methods, *Report to the Social Security Advisory Board* (September 2011), p. 70, http://go.usa.gov/38pE3 (PDF, 6.3 MB).

Mortality

Demographers have concluded that mortality rates have declined steadily in the United States for at least the past half century. (Mortality rates measure the number of deaths per thousand people in a population. Historically, declines in mortality rates have varied among age groups, but for simplicity, CBO projects the same rate of decline for all ages.) In the absence of compelling reasons to expect that trends will differ in the future, CBO projects that mortality rates will continue to fall at the same pace exhibited over the 60 years from 1950 to 2010; that is, at an average rate of 1.2 percent per year.[4] That extrapolation of past trends suggests that the average life expectancy for someone born in 2040 will be 82.6 years*; in contrast, CBO estimates an average life expectancy of 79.2 years for someone born in 2015. Similarly, CBO projects that someone who turns 65 in 2040 can be expected to live another 21.8 years, on average, or 2.4 years longer than someone turning 65 in 2015 is expected to live. Those figures represent averages for all people of a given age and sex in those years.

CBO's projections also incorporate differences in mortality on the basis of age, sex, marital status, education, and lifetime household earnings. (For people under 30, the mortality projections reflect only age and sex.) CBO expects that future increases in life expectancy will be larger for people with higher lifetime earnings than for those with lower earnings—an assessment that is consistent with patterns of past increases.[5] Today, on average, a 65-year-old man whose household is in the highest one-fifth (quintile) of the distribution of lifetime earnings will live more than three years longer, CBO projects, than a man of the same age whose household is in the lowest quintile of lifetime earnings; for women, that difference in life span is more than a year. CBO projects that by 2040, men in households with high lifetime earnings will live more than five years longer than men in households with low lifetime earnings; the corresponding difference for women will be almost three years.

4. That projection is greater than the 0.8 percent average annual decline projected in the Social Security trustees' 2014 report but less than the 1.3 percent average annual decline that is consistent with methods recommended by the Social Security Advisory Board's 2011 Technical Panel on Assumptions and Methods. The panel's recommendation reflects a belief that the decrease in mortality rates will be larger in the future than in the past because of a decline in tobacco use. However, because of uncertainty about the possible effects of many other factors in the future, such as obesity rates and advancements in medical technology, CBO has based its mortality projections on a simple extrapolation of past trends. For additional discussion, see Joyce Manchester, "Why CBO Changed Its Approach to Projecting Mortality," *CBO Blog* (September 24, 2013), www.cbo.gov/publication/44598. For further discussion of mortality patterns in the past and methods for projecting mortality, see 2011 Technical Panel on Assumptions and Methods, *Report to the Social Security Advisory Board* (September 2011), pp. 55–64, http://go.usa.gov/38pE3 (PDF, 6.3 MB). For additional background, see Hilary Waldron, "Literature Review of Long-Term Mortality Projections," *Social Security Bulletin*, vol. 66, no. 1 (September 2005), pp. 16–30, http://go.usa.gov/XKGk; and John R. Wilmoth, *Overview and Discussion of the Social Security Mortality Projections*, Working Paper (Social Security Advisory Board, 2003 Technical Panel on Assumptions and Methods, May 2005), http://go.usa.gov/38dce (PDF, 480 KB).

5. For more information about mortality differences among groups with different earnings, see Congressional Budget Office, *Growing Disparities in Life Expectancy* (April 2008), www.cbo.gov/publication/41681; and Julian P. Cristia, *The Empirical Relationship Between Lifetime Earnings and Mortality*, Working Paper 2007-11 (Congressional Budget Office, August 2007), www.cbo.gov/publication/19096.

[*Value corrected on June 23, 2015]

Economic Variables

For the 2015–2025 period, CBO's benchmark projections of economic variables—such as the size of the labor force, inflation, interest rates, and earnings per worker—match the values in the agency's January 2015 economic forecast (which underlies the agency's most recent 10-year budget projections).[6] Beyond 2025, the economic benchmark generally reflects the experience of the past few decades, adjusted to account for projected demographic developments and an assumption that the ratio of debt to GDP and effective marginal tax rates will remain stable.[7] Thus, it does not incorporate the extent to which economic output and interest rates would change if federal debt as a percentage of GDP or if marginal tax rates changed after 2025, as is projected to occur under current law. Rather, the benchmark is governed by the assumption that federal debt held by the public will be kept at 78 percent of GDP (the percentage at the end of 2025, according to CBO's baseline budget projections) and that effective marginal tax rates on income from labor and capital will remain constant at their 2025 levels. (Chapter 6 presents some estimates of the economic effects of projected deficits and marginal tax rates under CBO's extended baseline and some alternative policies.)

The Labor Market

Benchmark projections for the labor market include estimates of the growth of the labor force, the average number of hours that people work, the rate of unemployment, the share of total compensation that people receive in the form of earnings, and the share of those earnings that is subject to Social Security payroll taxes. Those factors affect the amount of tax revenues that the government

6. See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), Chapter 2, www.cbo.gov/publication/49892.

7. Those budgetary assumptions allow for relatively stable long-term economic projections.

collects and the amount of federal spending on Social Security and certain other federal programs.

Growth of the Labor Force. The number of workers is expected to increase more slowly in coming decades than in past years. Although the labor force expanded at an average rate of 1.7 percent annually between 1970 and 2007 (the most recent peak in the business cycle), CBO projects slower average growth—about 0.5 percent a year—for the 2015–2040 period.

That slowdown is expected to result both from more workers' exiting the labor force and from fewer workers' entering it. The number projected to leave the labor force is anticipated to increase compared with past decades as the older members of the baby-boom generation have begun reaching retirement age (although the average age at which people leave the labor force to retire has increased slightly in recent decades). At the same time, fewer workers are projected to enter the labor force than in past decades for two main reasons: First, birth rates have declined (the average fertility rate was more than three children per woman in the 1950s and 1960s, compared with fewer than two children today), and second, the increased participation of women in the labor force has leveled off over the past several years.

Despite those trends, however, increases in longevity will cause participation in the labor force to be slightly greater than it would be otherwise, CBO anticipates. CBO expects that the average person will work three months longer for each additional year of life expectancy in the coming decades. Thus, if life expectancy is four years longer for one cohort of workers than for an earlier group, the longer-lived cohort would work an average of one extra year (everything else being equal). CBO's projections also reflect the view that older people with more education will stay in the labor force longer than those with less education because people with more education are both more likely to be in the labor force when they enter their 60s and less likely to claim Social Security benefits at an early age.

Over the 1970–2007 period, the population of people ages 20 to 64 grew by an average of 1.3 percent per year, but the labor force grew by 1.7 percent per year, mainly because of large increases in the participation rate of women (a factor that was only partly offset by a decline in the participation rate of men). Over the next decade, the gap between those growth rates will narrow, CBO projects, with the population between the ages of 20 and 64 increasing by about 0.4 percent a year and the labor force growing by about 0.6 percent a year, on average. That narrowing reflects partially offsetting effects: The increased propensity of people who are age 65 or older to continue to work and the positive effects of the strengthening labor market on participation more than offset the negative effects on participation from the reduction in people's incentive to work that results from the Affordable Care Act and the structure of the tax code. From 2015 to 2040, the labor force is projected to increase at a rate of about 0.5 percent a year, on average, which is slightly faster than the average annual growth of about 0.4 percent that is projected for the population between the ages of 20 and 64 because of increased labor force participation at older ages.

Average Hours Worked. Different subgroups of the labor force work different numbers of hours, on average. For instance, men tend to work more hours than women do, and people between the ages of 30 and 40 tend to work more hours than do people between the ages of 50 and 60. CBO's projections are based on the assumption that those differences among groups will remain stable. However, CBO also expects that over the long term, the composition of the labor force will shift toward certain groups (such as older workers) that tend to work less, slightly reducing the average number of hours worked by the labor force as a whole. CBO estimates that by 2040, the average number of hours per worker will be about 2 percent less than it is today.

The Unemployment Rate. In January 2015, CBO projected that the unemployment rate would decline from 5.7 percent at the end of 2014 to 5.3 percent at the end of 2017. That projected improvement through 2017 reflects CBO's expectation that the economic expansion will strengthen in the next few years and that the effects of certain structural factors that have contributed to higher unemployment—such as the stigma attached to long-term unemployment and the possible erosion of unemployed workers' job skills—will diminish.[8] The projections for 2018 and 2019 are largely based on the transition to a period when the relationship between the unemployment rate and the natural rate of unemployment is expected to match its historical average. (The natural rate of

8. See Congressional Budget Office, *The Slow Recovery of the Labor Market* (February 2014), www.cbo.gov/publication/45011.

unemployment is the rate that results from all sources other than fluctuations in overall demand related to the business cycle.) As a result, the unemployment rate is projected to increase to 5.5 percent by 2020, when the natural rate of unemployment is expected to be 5.3 percent.[9]

CBO projects that in 2020 and later, the average unemployment rate will be about one-quarter of a percentage point higher than the natural rate of unemployment. That projection is based not on a forecast of specific cyclical movements in the economy but rather on CBO's estimate that the unemployment rate has been roughly that much higher than the natural rate since the end of World War II, on average, and has been higher than the natural rate in each of the past five business cycles.

After 2025, the average unemployment rate is projected to decline as the natural rate of unemployment slowly moves downward, continuing its previous trend as structural factors continue to fade. The natural and actual rates of unemployment are projected to decrease to 5.0 percent and 5.3 percent, respectively, by 2028 and then to remain at those levels.

Earnings as a Share of Compensation. Workers' total compensation consists of taxable earnings and nontaxable benefits, such as paid leave and employers' contributions to health insurance and pensions. Over the years, the share of total compensation paid in the form of earnings has slipped—from about 90 percent in 1960 to about 80 percent in 2014—mainly because the cost of health insurance has grown more quickly than has total compensation.[10]

Looking ahead, CBO expects that health care costs will continue to rise more rapidly than earnings, a trend that by itself would further decrease the proportion of compensation that workers receive as earnings. However, the Affordable Care Act imposed an excise tax on some employment-based health insurance plans that have premiums above a specific threshold. Some employers and workers will respond to that tax—which is scheduled to take effect in 2018—by shifting to less expensive plans, thereby reducing the share of compensation composed of health insurance premiums and increasing the share composed of earnings. CBO projects that the effects of the excise tax on the mix of compensation will roughly offset the effects of rising costs for health care for a few decades; after that, the effects of rising health care costs will outweigh the effects of the excise tax.[11] As a result, in CBO's benchmark, the share of compensation that workers receive as earnings is projected to remain near 80 percent through 2040. (For more about the projected effects of the excise tax, see Chapter 5; for a discussion of projected changes in the costs of health care, see Chapter 2.)

Share of Earnings Below the Taxable Maximum. Most workers are in jobs that are covered by Social Security—their earnings are subject to Social Security payroll taxes. (A small segment of the workforce, mostly people who work for some state and local governments and members of the clergy, have jobs that are excluded from such coverage.) Covered earnings are expected to be about 85 percent of all earnings in 2015. Social Security payroll taxes are levied only on covered earnings up to a maximum annual amount ($118,500 in 2015). Earnings below that amount are taxed at a combined rate of 12.4 percent, split between the employer and employee (self-employed workers pay the full amount), and no tax is paid on earnings above the cap. The taxable maximum has remained a nearly constant proportion of the average wage since the mid-1980s, but because earnings have grown more for higher earners than for others, the portion of covered earnings on which Social Security taxes are paid has fallen from 90 percent in 1983 to 81 percent now. CBO expects that unequal growth in earnings to continue at least for the next decade, and therefore the portion of earnings subject to Social Security tax is projected to fall to about 79 percent by 2025 and to decline slightly thereafter.

Inflation

CBO's economic benchmark includes projections of the rate of inflation in the prices of various categories of goods and services, as measured by the annual rate of

9. See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), pp. 30 and 50, www.cbo.gov/publication/49892.

10. For more details, see Congressional Budget Office, *How CBO Projects Income* (July 2013), www.cbo.gov/publication/44433.

11. CBO anticipates that the effects of the excise tax on the taxable share of compensation will diminish over time, both because it expects that most people will continue to want a significant amount of health insurance and because the Affordable Care Act set minimum amounts of coverage for health insurance plans. Therefore, the number of additional people moving to less expensive insurance plans will eventually dwindle.

change in the consumer price index for urban wage earners and clerical workers (CPI-W) and in the consumer price index for all urban consumers (CPI-U). CBO projects that inflation will average 2.3 percent over the 2015–2040 period. The projected long-term rate is similar to the average rate of inflation since 1990, a period in which growth in the CPI-U averaged 2.6 percent a year.

The annual inflation rate for all final goods and services produced in the economy, as measured by the rate of increase in the GDP deflator, is projected to average 0.4 percentage points less than the annual increase in the consumer price indexes over the long term.[12] The GDP deflator grows more slowly than the consumer price indexes because of the different methods used to calculate them and also because it is based on the prices of a different set of goods and services.

Interest Rates

CBO's economic benchmark includes projections of various interest rates that the federal government pays to borrow money, such as the rate on 10-year Treasury notes, the average rate on federal debt held by the public, and the average rate on holdings of the Social Security trust funds.

After considering several factors, including slower growth of the labor force, CBO expects real (inflation-adjusted) interest rates on federal borrowing to be lower in the future than they have been, on average, in the past few decades. For example, the real interest rate on 10-year Treasury notes (calculated by subtracting the rate of increase in the CPI-U from the nominal yield on those notes) averaged roughly 3.1 percent between 1990 and 2007.[13] From 2015 to 2040, that rate is projected to average 2.2 percent. But in the later years of the projection period, it is projected to be 2.3 percent.

Factors Affecting Interest Rates. Using past trends as a starting point for projecting interest rates over the long term requires analysts to make judgments about which periods to consider. Real interest rates were very low in the 1970s because of an unexpected surge in inflation, and those rates were quite high in the 1980s as inflation declined unexpectedly rapidly.[14] Interest rates also fell sharply during the financial crisis and recession that began in 2007. To avoid using those possibly less representative periods, CBO examined average interest rates and their determinants between 1990 and 2007 and then considered how different those determinants might be over the long term.

In CBO's assessment, the following factors will probably reduce interest rates on government securities relative to their 1990–2007 average:

- The labor force is projected to grow much more slowly in the future than it has for the past few decades. If everything else remains equal, slower growth in the labor force will raise the amount of capital per worker in the long term, reducing the return on capital and therefore also reducing the return on alternative investments, such as government bonds.[15]
- The share of total income received by high-income households is expected to remain larger in the future than it has been during the past few decades. Higher-income households tend to save a greater proportion of income, so that the difference in the distribution of income will increase the total amount of savings available for investment (other things being equal), also increasing the amount of capital per worker.
- Total factor productivity—real output per unit of combined labor and capital services—will grow slightly more slowly in the future than it has in recent decades, CBO projects. For a given rate of investment, lower productivity growth reduces both the return on capital and interest rates (all else being equal).

12. Final goods and services include goods and services bought by consumers, those purchased for investment, and those purchased by governments, as well as net exports.

13. Farther back, the real interest rate on 10-year Treasury notes averaged 3.2 percent between 1970 and 2007 and 2.9 percent between 1953 and 2007. For comparisons of historical real rates, past rates are calculated using the CPI Research Series Using Current Methods.

14. Although real interest rates are calculated by subtracting inflation rates from nominal interest rates, inflation can still affect them. If lenders set nominal interest rates assuming that inflation will be a certain percentage and it ends up being much higher, real interest rates will be lower than lenders intended. If inflation ends up being lower than expected, the opposite will occur.

15. For more information about the relationship between the growth of the labor force and interest rates, see Congressional Budget Office, *How Slower Growth in the Labor Force Could Affect the Return on Capital* (October 2009), www.cbo.gov/publication/41325.

- The risk premium—the additional return that investors require to hold assets that are riskier than Treasury securities—will probably remain higher in the future than it was, on average, in the 1990–2007 period. Financial markets were already showing less appetite for risk in the early 2000s, so the risk premium was higher toward the end of that 18-year period than the average over the whole 1990–2007 period. In addition, CBO expects, the demand for low-risk assets will be stronger in the wake of the financial crisis, in part because of the ways in which financial institutions have responded to oversight from regulators.

At the same time, in CBO's assessment, the following factors will tend to increase interest rates on government securities relative to their 1990–2007 average:

- If current laws do not change, federal debt will be much larger as a percentage of GDP than it was before 2007. CBO's economic benchmark is built on the assumption that the ratio of debt to GDP after 2025 will remain at its 2025 value—78 percent—which is almost twice as high as the 40 percent average seen over the 1990–2007 period.[16] Higher federal debt tends to crowd out private investment in the long term, reducing the amount of capital per worker and increasing both the return on capital and interest rates.

- Net inflows of capital from other countries will be smaller as a percentage of GDP in the future than they have been, on average, in recent decades, CBO projects. In the 1990s and early to mid-2000s, rapid economic growth and high rates of saving in various nations with emerging market economies led to large flows of capital from those countries to the United States. As those nations' economies continue to grow, however, their consumption will probably increase relative to their saving—because markets for those countries' debt will develop and because average citizens will tend to receive more of the gains from economic growth—and their demand for domestic investment will rise. That combination of changes will reduce capital flows to the United States, decreasing domestic investment and the amount of capital per worker and increasing rates of return. (Those developments are consistent with CBO's projection that the United States' trade deficit, the gap between its imports and its exports, will be narrower in the future as a percentage of GDP than it has been for the past few decades.)

- The capital share of income—the percentage of total income that is paid to owners of capital—which has been on an upward trend for the past few decades, will remain higher than its average of recent decades, CBO projects. Although it is expected to decline somewhat over the next decade from its current, historically high level, the factors that appear to have contributed to its rise (such as technological change and globalization) are likely to persist, keeping it above the historical average. A larger share of income accruing to owners of capital will directly boost the return on capital and thus interest rates, in CBO's estimation.

- The retirement of the baby-boom generation and slower growth of the labor force will reduce the number of workers in their prime saving years relative to the number of older people drawing down their savings. The result will be a decrease in the total amount of savings available for investment (all else being equal), which will tend to reduce the amount of capital per worker and thereby push up interest rates. (CBO estimates that this effect will only partially offset the effect on savings of increased income inequality, leaving a net increase in savings available for investment.)

Other factors not listed here will have smaller—and largely offsetting—effects on interest rates on federal borrowing over the long term, CBO estimates.

CBO also relies on information from financial markets in projecting interest rates over the long term. For example, the current interest rate on 30-year Treasury bonds implies a forecast of interest rates on shorter-term securities 30 years into the future. Incorporating that information tends to reduce interest rates that CBO projects compared with rates implied by the analysis of factors described above.

Projections of Interest Rates. Although some of the factors mentioned above have received considerable attention from researchers, others have not. The effects on interest rates of the growth of the labor force and the amount of federal debt, for example, can be quantified

16. See Chapter 6 for a discussion of the ways that the budgetary policies that would be in place under the extended baseline would affect the economy in the long term.

using available data, theoretical models, and estimates from the research literature. But the extent to which other factors will affect interest rates is more difficult to quantify. For example, changes such as shifting preferences for high-risk rather than low-risk assets are not directly observable. And factors such as the distribution of income are observable, but models and empirical estimates offer little guidance for quantifying their effects on interest rates. Moreover, prices in financial markets do not definitively indicate investors' expectations about interest rates over the long term, in part because most of the government's outstanding debt securities have maturities that are much shorter than the 25-year period that is the focus of CBO's long-term projections.

With those considerable sources of uncertainty, CBO relied on its own economic models, the economics research literature, and other information to guide assessments of the influence of different factors on interest rates in the future. Nevertheless, its projections ultimately reflect CBO's judgment.

The estimates and assumptions that underlie the economic benchmark suggest that the inflation-adjusted interest rate on 10-year Treasury notes will be about 1 percentage point lower in the coming decades than its average of 3.1 percent for the 1990–2007 period. Therefore, CBO projects, the real interest rate on 10-year Treasury notes (adjusted for the rate of increase in the CPI-U) will rise in the next few years from its current, extraordinarily low level of 1.7 percent to average 2.2 percent over the 2015–2040 period.

The average interest rate on all federal debt held by the public tends to be a little lower than the rate on 10-year Treasury notes because interest rates are generally lower on shorter-term debt than on longer-term debt, and the average maturity of federal debt is expected to remain at less than 10 years. Thus, CBO projects, the average real interest rate on all federal debt held by the public (adjusted for the rate of increase in the CPI-U) will be 1.5 percent over the 2015–2040 period. (The average interest rate on all federal debt is projected to rise more slowly than the 10-year rate because only a portion of federal debt matures each year.) CBO generally uses the average interest rate on all federal debt as a discount rate when it calculates the present value of future streams of total federal revenues and outlays in its long-term projections, as it does in estimating the fiscal gap described in Chapter 1.[17]

The Social Security trust funds hold special-issue bonds that generally earn interest rates that are higher than the average interest rate on federal debt. Therefore, in projecting the balances in the trust funds and calculating the present value of future streams of revenues and outlays for those funds, CBO uses an interest rate that averages 2.2 percent from 2015 to 2040 and 2.3 percent in the later years of the projection.

Combining CBO's projections of average real interest rates with its projection of inflation as measured by the growth of the CPI-U produces estimates of average nominal interest rates. Over the 2015–2040 period, nominal rates are projected to average 4.5 percent on 10-year Treasury notes and 3.9 percent on all federal debt held by the public.

Output

In its economic benchmark, CBO projects that real GDP will grow fairly quickly over the next few years, reflecting a recovery in aggregate demand. Thereafter, real GDP is projected to grow at a pace that reflects increases in the capital stock, productivity, and the supply of labor.

Capital Stock. Over the next decade, growth in the nation's stock of capital will be driven by economic output, national saving, and international capital flows, CBO estimates. For simplicity, CBO projects that after 2025, the capital stock will expand at a pace that is sufficient to maintain a constant rate of return on capital. That projection is consistent with CBO's projection that the average real interest rate on all federal debt held by the public will be 2.0 percent in the long term (after 2029).

Productivity. Total factor productivity is projected to increase at an average annual rate of 1.3 percent from 2015 to 2040—a growth rate that is slightly slower than the average rate of 1.4 percent seen over the period since 1950. CBO expects productivity to grow more slowly in coming decades partly because increases in average educational attainment, which contribute to

17. The present value of a flow of revenues or outlays over time is a single number that expresses that flow in terms of an equivalent sum received or paid at a specific time. The present value depends on a rate of interest (known as the discount rate) that is used to translate past and future cash flows into current dollars. The lower the discount rate, the higher the present value of the future flows.

workers' skills, have slowed since 1980.[18] That effect will be partly offset, however, by the aging of the labor force over the next few decades, as better health and longer life spans cause people to stay in the workforce longer than previous cohorts did. An older workforce will be composed of more highly educated workers, because workers with higher educational attainment tend to remain in the labor force longer.

Another factor that is projected to slow the growth of total factor productivity is a lower projected amount of federal investment. Under the assumptions used for these projections, the government's nondefense discretionary spending is projected to decline over the next decade to a much smaller percentage of GDP than it has averaged in the past. Since the 1980s, about half of such spending has consisted of federal investment in physical capital (such as roads), education and training, and research and development.[19] Those forms of investment contribute to total factor productivity, CBO estimates, so as the economy adjusts to smaller amounts of federal investment (consistent with less nondefense discretionary spending as a percentage of GDP), the growth rate of total factor productivity is projected to be dampened slightly.

18. CBO calculates total factor productivity as the portion of growth in output that is not accounted for by growth in hours worked and in capital services. Therefore, when an increase in workers' skills makes each hour of work more productive, CBO measures that effect as an increase in total factor productivity. Various researchers have examined trends in workers' skills and the effect of those trends on future economic growth; that research has not reached a consensus about the size of the effect. For example, see David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel, *Is the Information Technology Revolution Over?* Finance and Economics Discussion Series Paper 2013-36 (Board of Governors of the Federal Reserve System, March 2013), http://go.usa.gov/XXNR; John Fernald, *Productivity and Potential Output Before, During, and After the Great Recession*, Working Paper 2012-18 (Federal Reserve Bank of San Francisco, September 2012), http://tinyurl.com/pk8b666 (PDF, 480 MB); Robert J. Gordon, *Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds*, Policy Insight 63 (Center for Economic Policy Research, September 2012), http://tinyurl.com/p57pzt5; and Claudia Goldin and Lawrence F. Katz, *The Race Between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005*, Working Paper 12984 (National Bureau of Economic Research, March 2007), www.nber.org/papers/w12984.

19. See Congressional Budget Office, *Federal Investment* (December 2013), www.cbo.gov/publication/44974.

Supply of Labor. Total hours worked will increase at an average annual rate of 0.4 percent between 2015 and 2040, CBO estimates, on the basis of the projections of the size of the labor force, average hours worked, and unemployment.

The growth rates projected for the labor supply, the capital stock, and total factor productivity are consistent with CBO's projection of the average growth of labor productivity (real output per hour worked): 1.8 percent annually over the 2015–2040 period. Trends in prices, in the growth of nonwage compensation (such as employment-based health insurance), and in average hours worked imply that real earnings per worker will grow more slowly than labor productivity—by an average of 1.6 percent a year over the 2015–2025 period and by 1.4 percent a year over the 2015–2040 period.[20]

Real GDP. CBO's projection of the growth rate of real GDP—an annual average of 2.2 percent over the 2015–2040 period—is much slower than the rate of economic growth seen in the past few decades (3.1 percent), primarily because of the slowdown that CBO anticipates in the growth of the labor force. Moreover, as the fraction of the population that is of working age shrinks, per capita real GDP is expected to increase more slowly than in the past—at an average annual rate of 1.5 percent over the 2015–2040 period, compared with 2.1 percent during the 40 years before the start of the 2007–2009 recession.

Just as the unemployment rate is projected to be about one-quarter of a percentage point higher than the natural rate of unemployment in the long term, total GDP is projected to be one-half of a percent lower than its potential (maximum sustainable) amount. That projection is based on CBO's estimate that actual GDP has been roughly that much lower than potential GDP, on average, since the end of World War II and has been lower than potential GDP, on average, in each of the past five business cycles. Those outcomes reflect the fact that actual output has fallen short of CBO's estimate of potential output during and after economic downturns to

20. Trends in prices are important in projecting those measures because real earnings per worker are calculated here using the CPI-U, and real output per hour is calculated using the GDP deflator. CBO projects that the CPI-U will grow 0.4 percentage points faster per year than will the GDP deflator over the long term.

a larger extent and for longer periods than actual output has exceeded potential output during economic booms.

If the real interest rates were adjusted to reflect the rate of increase in the GDP price index instead of the CPI-U, the real interest rate on all federal debt held by the public over the next 25 years would average 1.9 percent. Thus, during the next 25 years as a whole, the growth rate of GDP—at 2.2 percent—is projected to exceed the average real interest rate on federal debt. (Beyond 2025, the average interest rate on federal debt is projected to be only slightly higher than the growth rate of GDP.) When the interest rate is about the same as the growth rate of GDP, the ratio of debt to GDP would remain steady over time if the federal budget, excluding interest payments, was in balance.

Other Trends

In addition to projecting the demographic and economic trends that underlie the economic benchmark, CBO also projects other trends as it develops its long-term budget projections. CBO has produced its own projection of the rate at which people will qualify for Social Security's Disability Insurance program in coming decades as well as projections of enrollment in Medicaid.

Disability

One variable that affects the federal budget is the rate of disability incidence, defined here as the rate at which people will become eligible for Social Security's Disability Insurance program. CBO projects that an average of 5.6 per thousand people who have worked long enough to qualify for disability benefits, but who are not yet receiving them, will qualify for the program each year after 2025. (That projection accounts for changes in the age and sex makeup of the population, relative to its composition in 2000.) CBO's estimate is based on analysis of past trends and on recommendations by the Social Security Technical Panel on Assumptions and Methods.[21]

21. See Congressional Budget Office, *The 2013 Long-Term Budget Outlook* (September 2013), p. 17, www.cbo.gov/publication/44521.

Medicaid Enrollment

To implement the formulaic approach it used to project Medicaid enrollment over the long term, CBO adopted the assumption that the number of elderly and disabled Medicaid beneficiaries would grow with the overall population, with adjustments for changes in the age distribution of the population. The agency also projected that the number of beneficiaries who are children and nondisabled adults would increase more slowly than the population overall, reflecting the assumption that growth in earnings will reduce the number of people whose income is below the most common threshold for eligibility for those groups—in many states that threshold is 138 percent of the federal poverty guidelines. Because earnings are projected to grow faster than prices, on average, and because poverty guidelines are indexed to prices, over time fewer people are projected to have income below the eligibility threshold in their state.

In the past, many states have used Medicaid's flexible program rules to increase or decrease spending in various ways. Under current law, for example, states with income eligibility criteria below 138 percent of the federal poverty guidelines for nonelderly adults can expand coverage for that group. They also can increase enrollment in the program by adopting administrative policies and procedures that simplify the enrollment process and expand program benefits by covering more optional services. (Such mechanisms also may be used to shrink program spending when states are facing fiscal constraints.) More generally, states can apply for waivers of Medicaid program requirements to enable them to change program eligibility criteria and covered benefits in other ways. (The Secretary of Health and Human Services has the authority to waive some Medicaid program requirements through certain research and demonstration projects or through consolidated State Innovation Waivers that include Medicaid-related components.) For these projections, therefore, CBO assumed that, over time, states would make changes in their Medicaid programs that offset roughly half of the effect of earnings growth on eligibility. As a result, the total number of people enrolled in Medicaid is projected to be roughly constant after 2035.

APPENDIX

B

Changes in CBO's Long-Term Projections Since July 2014

The long-term projections of federal revenues and outlays presented in this report are generally similar to the ones that the Congressional Budget Office published in 2014 despite certain changes in law, revisions to some of the agency's assumptions and methods, and the availability of more recent data.[1] Without macroeconomic feedback taken into account, debt is projected to rise from about 74 percent of gross domestic product (GDP) this year to 101 percent in 2039 under the extended baseline, whereas last year, CBO projected that debt would rise to 106 percent of GDP in 2039 (see Figure B-1). The difference stems primarily from a change in CBO's projection of the interest rates on federal debt. Under the extended alternative fiscal scenario with macroeconomic feedback, debt is projected to rise to 166 percent of GDP in 2039; last year, that figure was 183 percent.

Changes in Methods Underlying the Extended Baseline

Since last year, CBO has changed its projections of economic output and interest rates in the long term, has modified its expectations about the share of payroll that will be subject to Social Security's payroll tax, and has revised its projections of enrollment in Medicaid. Those changes, taken together, result in a projected path for debt that is slightly lower than the one last year.

Lower GDP

CBO's current projection of nominal GDP in 2039 is about 3 percent smaller than its estimate last year. Mostly, that change occurred because CBO lowered its projection of real (inflation-adjusted) GDP in the 10-year economic projections that it published in January 2015.[2] That revision derived mostly from a reduced estimate of total factor productivity (that is, the efficiency with which labor and capital are used to produce goods and services) in the first 10 years of the projection period. Because the projected growth rate of real GDP after 2025 is about the same this year as it was last year, that difference persists. CBO also reduced its projection of the rate of inflation by 0.1 percentage point.

Lower Interest Rates

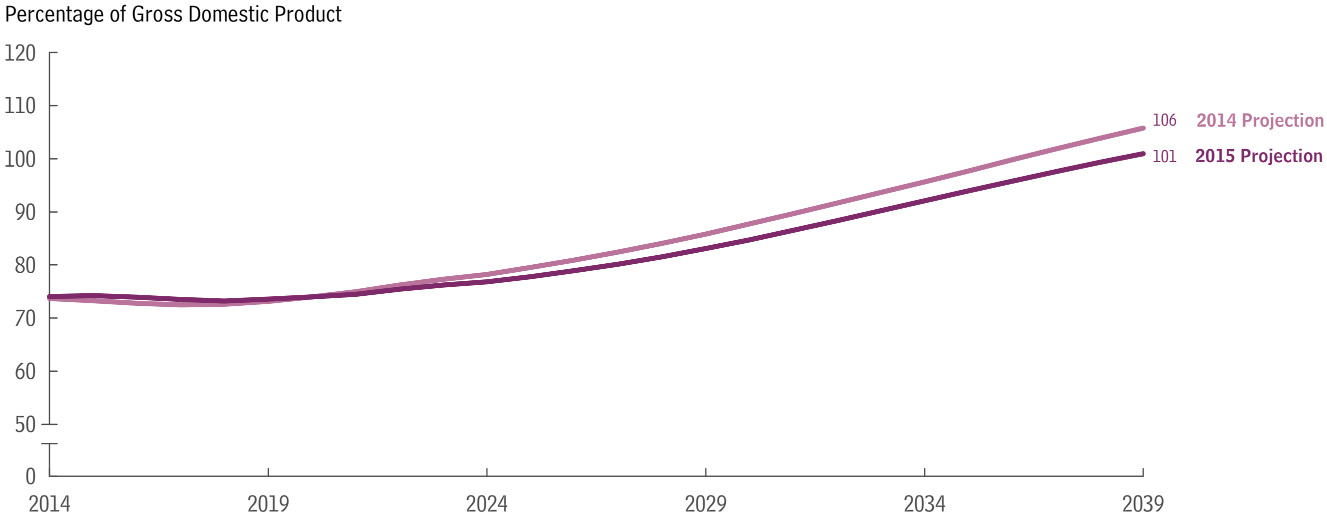
In last year's long-term analysis, the real interest rate on 10-year Treasury notes—calculated by subtracting the rate of increase in the consumer price index from the nominal yield on such notes—was projected to be 2.5 percent in the long term. CBO now projects that rate to be 2.3 percent. Similarly, last year, the projected average real interest rate on government debt was 2.2 percent, but the agency now expects it to be 2.0 percent (thus lower by the same amount). Primarily, CBO's revision to projected interest rates results from incorporating financial market participants' expectations for low interest rates well into the future. Gleaning market participants' predicted path of interest rates over the long term from prices of financial instruments is subject to enormous uncertainty because current interest rates are also influenced by transitory liquidity and risk factors that are difficult to disentangle from expectations about future interest rates. Nonetheless, a review of the results from the available models and evidence linking current rates to future rates suggests that participants in financial markets expect low interest rates well into the future, and the paths that they anticipate have fallen notably over the past year.

1. See Congressional Budget Office, *The 2014 Long-Term Budget Outlook* (July 2014), www.cbo.gov/publication/45471.

2. For further discussion, see Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), pp. 52–55, www.cbo.gov/publication/49892.

Figure B-1.

Comparison of CBO's 2014 and 2015 Projections of Federal Debt Held by the Public Under the Extended Baseline



Source: Congressional Budget Office.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period. These projections do not reflect the macroeconomic effects of the policies underlying the extended baseline. (For an analysis of those effects and their impact on debt, see Chapter 6.)

A Lower Share of Earnings That Are Subject to the Social Security Payroll Tax

Since last year, a methodological improvement has led CBO to lower its projection of the share of earnings that are subject to the Social Security payroll tax, from an average of 82 percent to an average of 78 percent for the 2025–2039 period. Specifically, the agency has better aligned its methods for projecting revenues and its methods for projecting the earnings of workers covered by Social Security. This year, the estimated share of earnings below the taxable maximum (reported in Appendix A) for years beyond the next decade incorporates the increase in earnings inequality that underlies CBO's baseline projection of revenues over the next decade.

Lower Enrollment in Medicaid

This year, CBO has revised an assumption that affects the projected enrollment in Medicaid. Specifically, CBO now anticipates that states will take fewer actions that would maintain Medicaid spending over the long term (through such means as obtaining program waivers to expand eligibility to new population groups, enhanced outreach efforts to increase enrollment of eligible people, and expansion of covered benefits) as rising earnings over time reduce the number of people who would be eligible for the program as it is currently implemented. Last year, CBO assumed that states' actions would offset all of the effect of earnings growth on eligibility; this year, CBO assumes that those actions will offset only half of that effect. The change reduces the agency's projection of the number of Medicaid beneficiaries by an increasing amount over time and by a total of 4 percent after 25 years.

Changes in Spending and Revenues Under the Extended Baseline

In CBO's extended baseline, noninterest spending exceeds revenues throughout the next quarter century; the shortfall is similar to that projected in 2014 (see the bottom panel of Figure B-2). Interest costs on the debt are lower than last year because of lower interest rates.

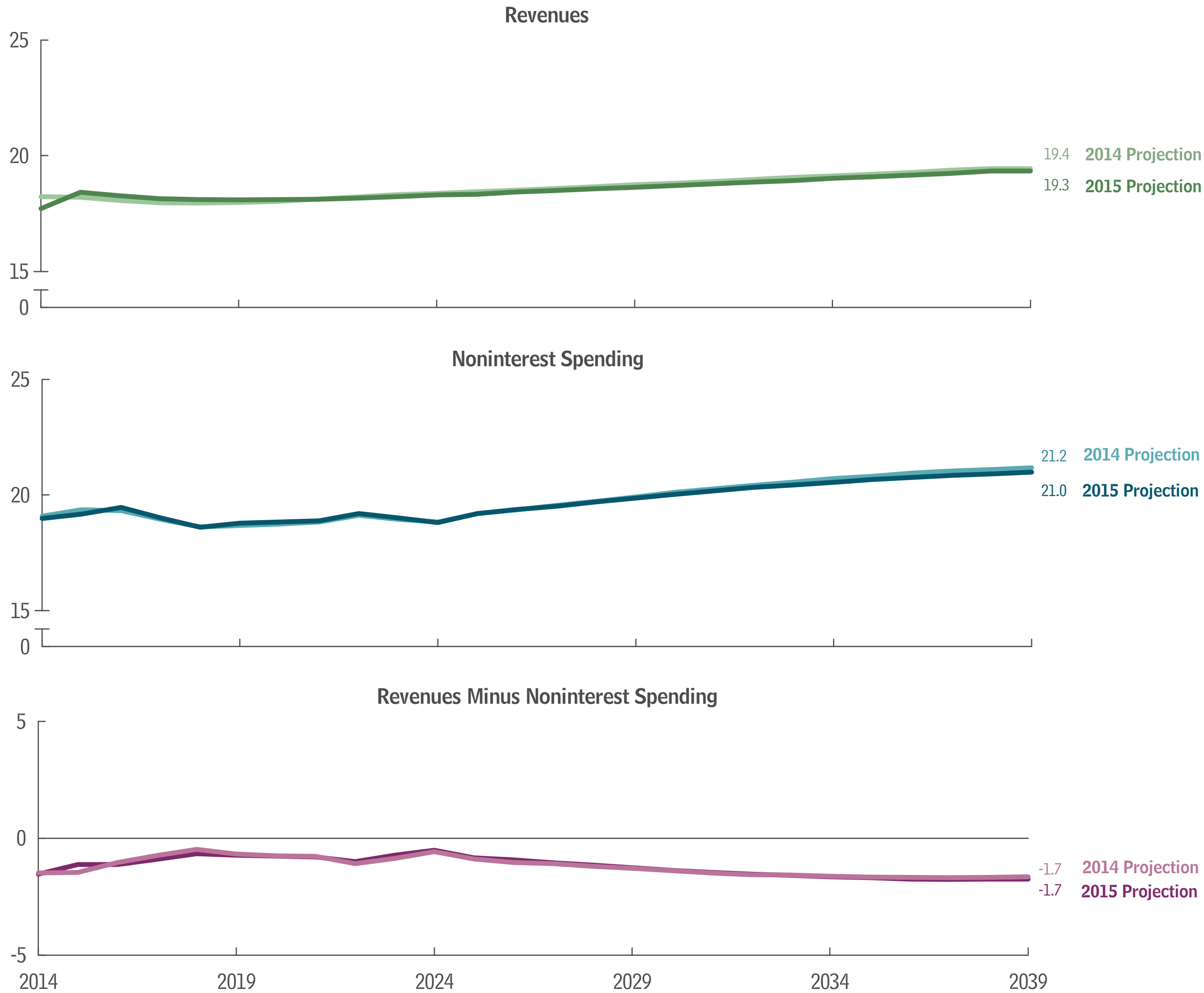
Revenues

Federal revenues are projected to be slightly lower relative to GDP in coming decades than the amounts CBO projected in 2014 (see the top panel of Figure B-2). By 2025, revenues are projected to be 18.3 percent of GDP, whereas last year, the estimate was 18.4 percent. That difference is estimated to persist in subsequent years,

Figure B-2.

Comparison of CBO's 2014 and 2015 Budget Projections Under the Extended Baseline

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2025 and then extending the baseline concept for the rest of the long-term projection period. These projections do not reflect the macroeconomic effects of the policies underlying the extended baseline. (For an analysis of those effects and their impact on debt, see Chapter 6.)

reflecting slightly slower growth in realizations of capital gains that are taxable and other factors. By 2039, revenues are now projected to equal 19.3 percent of GDP, or 0.1 percentage point lower than the 19.4 percent estimate last year.

Noninterest Spending

Noninterest spending is projected to be about the same relative to GDP as what CBO projected in 2014 (see the middle panel of Figure B-2). In particular, noninterest spending is projected to be slightly higher than last year's estimates for about the first decade of the projection period and then to fall below last year's estimates beginning in 2027. In 2039, it is projected to be 21.0 percent of GDP, or 0.2 percentage points lower than last year's estimate. Federal health care spending is projected to be about the same, Social Security spending lower, and other noninterest spending about the same relative to GDP compared with the amounts CBO projected last year.

Federal Health Care Spending. CBO's current long-term projection of federal spending on major health care programs is largely the same as last year's—though the growth rate of Medicare spending is faster than that projected last year, and the growth rate of the spending for Medicaid and exchange subsidies is much slower. Spending for Medicare net of offsetting receipts is now estimated to amount to 5.0 percent of GDP in 2039, or about 0.4 percentage points higher than what CBO estimated last year. That difference reflects higher projected spending for the program in the first 10 years and slightly higher estimates of the rate of excess cost growth (or growth in spending per beneficiary beyond the growth in potential output per capita) through the end of the projection period. In total, federal spending for Medicaid, the Children's Health Insurance Program, and the exchange subsidies is projected to amount to 2.8 percent of GDP in 2039, or 0.5 percentage points lower than the sum projected last year; that difference reflects less spending for Medicaid and exchange subsidies in the first 10 years, lower average excess cost growth, and lower enrollment in Medicaid after 2025.

Social Security Spending. The current 25-year projection of Social Security spending is lower as a percentage of GDP than last year's, largely because CBO projects that a smaller portion of earnings would be subject to the Social Security tax. The program's benefits are based on taxable earnings, so that a reduction in the share of taxable earnings, which would yield lower tax revenues, would also result in smaller benefits in the future. The 75-year actuarial deficit currently projected for Social Security, 4.4 percent of taxable payroll, is greater than the 4.0 percent estimated last year (see Table 3-1 on page 54). Revised projections of economic factors, primarily lower projected interest rates, account for about half of the 0.4 percentage-point increase, and revised projections of taxable payroll account for the other half. Smaller changes—arising from updated data, the effects of the one-year shift in the projection period, and estimating changes—largely offset one another.

Other Noninterest Spending. This year, total federal spending as a share of GDP on everything other than the major health care programs, Social Security, and net interest is projected to be similar throughout the next 25 years to the share CBO projected last year.

Interest Costs

Although CBO's current projection of debt held by the public expressed as a share of GDP is only slightly lower than the agency's estimate last year, interest outlays are significantly lower in this year's analysis because of lower projected interest rates and a lower projected cumulative deficit (see Figure B-1 on page 122). In this year's report, interest spending in 2039 is projected to equal 4.2 percent of GDP, whereas last year, that figure was 4.7 percent.

The Fiscal Gap

The magnitude of the changes in noninterest spending or revenues that would be needed to make federal debt equal its current percentage of GDP at a specific date in the future is often called the fiscal gap.[3] The estimated fiscal gap is slightly smaller this year than last year, largely because CBO projects lower interest rates. All else held equal, a lower interest rate leads to a smaller fiscal gap. For the 2016–2040 period, CBO estimates that cuts in noninterest spending or increases in revenues equal to 1.1 percent of GDP in each year through 2040 would be required to have debt that year equal the same percentage of GDP that it constitutes today; last year, for the 2015–2039 period, CBO estimated that changes equal to 1.2 percent of GDP would be required. By itself, the reduction in projected interest rates on federal debt would have brought the gap down by 0.3 percent of GDP, but changes in projected GDP and the shift in the projection period offset most of that effect.

Changes in Assumptions Incorporated in the Extended Alternative Fiscal Scenario

Under its extended alternative fiscal scenario last year, CBO assumed that Medicare's payment rates for services provided by physicians would be held constant at the 2014 level rather than being cut by about a quarter early in 2015, as was scheduled under current law and therefore reflected in the extended baseline. The Medicare

3. The fiscal gap equals the present value of noninterest outlays and other means of financing minus the present value of revenues over the projected period with adjustments to make the ratio of federal debt to GDP at the end of the period equal to the current ratio. Specifically, current debt is added to the present value of outlays and other means of financing, and the present value of projected debt at the end of the period (which equals GDP in the last year of the period multiplied by the ratio of debt to GDP at the end of 2015) is added to the present value of revenues.

Access and CHIP Reauthorization Act of 2015 set new rules for updating those payment rates starting in April 2015. So for that element, the extended alternative fiscal scenario and the extended baseline are now the same.

Changes in Estimated Economic Effects of Various Fiscal Policies

In this year's long-term analysis, the estimated effects on gross national product of fiscal policies that would increase or decrease future debt relative to that in the extended baseline are smaller than those in last year's analysis. Those reductions stem primarily from two factors. First, CBO reduced its projection of interest rates, so a given change in the deficit in one year cumulates to a smaller change in debt in future years and therefore has less effect on output. Second, under the extended alternative fiscal scenario, deficits excluding interest payments differ from those under the extended baseline by slightly less than they did in last year's analysis and, again, affect output less.

Changes in Methods for Analyzing Uncertainty

CBO changed its approach to analyzing the long-term budgetary effects of simultaneous changes in multiple economic factors—namely, mortality rates, growth of total factor productivity, interest rates on federal debt, and the growth rate of federal spending per beneficiary for Medicare and Medicaid (as discussed in Chapter 7). An occasion when one of those factors is at the end of the range used in the analysis of uncertainty is more likely than having all four of the factors at the end of their ranges simultaneously; so last year, adopting a rough approximation for the latter occasions, CBO narrowed those ranges by half. This year, CBO undertook more detailed analysis of the simultaneous movement in the four factors since 1967 and concluded that slightly wider ranges (60 percent as wide as the ranges applicable to individual factors in isolation) more accurately reflect the historical data.

Changes in the Presentation of Projections Beyond 25 Years

In the past, CBO included projections for years 25 years in the future in an appendix to the report, but after reassessing the considerable uncertainty surrounding projections of deficits and debt that far into the future, the agency decided to post them only as supplemental data on its website (www.cbo.gov/publication/50250).

Changes in the Presentation of Summarized Financial Measures for the Hospital Insurance Trust Fund

CBO is no longer reporting summarized financial measures, such as actuarial balances over 75 years, for Medicare's Hospital Insurance (Part A) trust fund. After reassessing those measures, the agency concluded that they do not provide meaningful information given the formulaic methodology CBO uses to project Medicare spending over the long term. Changes over time in the nature of health care and in the system for delivering health care might affect Part A and the other portions of Medicare differently, but the summarized financial measures for the Hospital Insurance trust fund that CBO previously provided did not take that possibility into account. Because CBO has yet to develop the analytic capability to project such developments, it concluded that projections for just Part A of the Medicare program were not useful.

List of Tables and Figures

Tables

Figures

Figures (Continued)

About This Document

This volume is one of a series of reports on the state of the budget and the economy that the Congressional Budget Office issues each year. In accordance with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Prepared with guidance from Linda Bilheimer, Wendy Edelberg, Benjamin Page, Julie Topoleski, and David Weiner, the report represents the work of many analysts at CBO. Julie Topoleski wrote the summary. Michael Simpson wrote Chapter 1. Geena Kim, Lyle Nelson, and Xiaotong Niu wrote Chapter 2. Charles Pineles-Mark wrote Chapter 3. Geena Kim wrote Chapter 4. Joshua Shakin wrote Chapter 5. Devrim Demirel wrote Chapter 6. Jonathan Huntley wrote Chapter 7. Geena Kim wrote Appendix A. Xiaotong Niu and Michael Simpson wrote Appendix B. Leigh Angres, Christina Hawley Anthony, Jessica Banthin, Elizabeth Bass, Tom Bradley, Chad Chirico, Kent Christensen, Sheila Dacey, Terry Dinan, Philip Ellis, Kathleen FitzGerald, Matthew Goldberg, Holly Harvey, Jeffrey Holland, Kim Kowalewski, Sarah Masi, Eamon Molloy, Damien Moore, Andrea Noda, Sam Papenfuss, Allison Percy, Kevin Perese, Emily Stern, Robert Stewart, and Dwayne Wright made valuable contributions.

Michael Simpson developed the long-term budget simulations, with assistance from Geena Kim, Xiaotong Niu, and Charles Pineles-Mark. Devrim Demirel, Jonathan Huntley, Leah Loversky, and Frank Russek prepared the macroeconomic simulations. David Weiner coordinated the revenue simulations, which were prepared by Paul Burnham, Ed Harris, Shannon Mok, Kurt Seibert, Joshua Shakin, Logan Timmerhoff, and Marvin Ward. Stephanie Hugie Barello, Leah Loversky, Kyle Redfield, Logan Timmerhoff, Zoe Williams, and Shiqi Zheng fact-checked the report. Also, the report builds on the 10-year projections of the economy and budget that CBO released earlier this year and that reflected the contributions of more than 100 people at the agency.

Jeffrey Kling and Robert Sunshine reviewed the report. Christine Bogusz, Kate Kelly, Loretta Lettner, Bo Peery, Benjamin Plotinsky, John Skeen, and Gabe Waggoner edited the report, and Maureen Costantino and Jeanine Rees prepared it for publication. Geena Kim, Xiaotong Niu, Charles Pineles-Mark, and Michael Simpson prepared the supplemental data, with assistance from Jeanine Rees.

The report is available on CBO's website (www.cbo.gov/publication/50250).

Keith Hall
Director

June 2015

	2012	2013	2014	2015	2016	2017

Report Annual Energy Outlook 2015
Scenario ref2015 Reference case
Datekey d021915a
Release Date April 2015

20. Macroeconomic Indicators

(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	2012	2013	2014	2015	2016	2017
Real Gross Domestic Product	**15369**	**15710**	**16055**	**16553**	**16970**	**17369**
Components of Real Gross Domestic Product						
Real Consumption	10450	10700	10941	11270	11611	11919
Real Investment	2436	2556	2688	2851	3017	3127
Real Government Spending	2954	2894	2889	2894	2908	2927
Real Exports	1960	2020	2085	2174	2250	2340
Real Imports	2413	2440	2523	2611	2790	2918
Energy Intensity						
(thousand Btu per 2009 dollar of GDP)						
Delivered Energy	4.47	4.53	4.50	4.33	4.27	4.19
Total Energy	6.14	6.18	6.14	5.91	5.82	5.70
Price Indices						
GDP Chain-type Price Index (2009=1.000)	1.052	1.067	1.084	1.105	1.126	1.146
Consumer Price Index (1982-84=1.00)						
All-urban	2.30	2.33	2.37	2.37	2.43	2.48
Energy Commodities and Services	2.46	2.44	2.44	2.05	2.25	2.33
Wholesale Price Index (1982=1.00)						
All Commodities	2.02	2.03	2.06	2.01	2.07	2.11
Fuel and Power	2.12	2.12	2.10	1.76	1.92	1.99
Metals and Metal Products	2.20	2.14	2.16	2.21	2.25	2.28
Industrial Commodities excluding Energy	1.94	1.96	1.98	2.02	2.06	2.10
Interest Rates (percent, nominal)						
Federal Funds Rate	0.14	0.11	0.09	0.16	1.76	3.35
10-Year Treasury Note	1.80	2.35	2.57	2.86	3.75	4.21
AA Utility Bond Rate	3.83	4.24	4.20	4.30	5.78	6.54

Value of Shipments (billion 2009 dollars)						
Non-Industrial and Service Sectors	23989	24398	24943	25646	26202	26679
Total Industrial	6822	7004	7233	7598	7785	7965
Agriculture, Mining, and Construction	1813	1858	1905	2020	2106	2197
Manufacturing	5009	5146	5328	5577	5679	5768
Energy-Intensive	1675	1685	1716	1760	1791	1833
Non-Energy-Intensive	3334	3461	3612	3817	3888	3936
Total Shipments	**30810**	**31402**	**32176**	**33244**	**33986**	**34644**
Population and Employment (millions)						
Population, with Armed Forces Overseas	314.5	316.7	319.0	321.5	324.0	326.5
Population, aged 16 and over	249.2	251.5	253.7	255.9	258.2	260.4
Population, aged 65 and over	43.4	44.9	46.4	48.0	49.5	51.1
Employment, Nonfarm	133.9	136.2	138.6	141.6	143.8	145.3
Employment, Manufacturing	11.8	11.9	12.0	12.0	12.1	12.1
Key Labor Indicators						
Labor Force (millions)	155.0	155.4	155.9	157.6	159.7	161.7
Nonfarm Labor Productivity (2009=1.00)	1.05	1.05	1.06	1.08	1.10	1.12
Unemployment Rate (percent)	8.08	7.35	6.19	5.70	5.51	5.42
Key Indicators for Energy Demand						
Real Disposable Personal Income	11676	11651	11970	12361	12707	13198
Housing Starts (millions)	0.84	0.99	1.06	1.30	1.41	1.55
Commercial Floorspace (billion square feet)	82.3	82.8	83.4	84.1	84.9	85.9
Unit Sales of Light-Duty Vehicles (millions)	14.43	15.52	16.37	17.01	17.16	17.10

GDP = Gross domestic product.

Btu = British thermal unit.

- - = Not applicable.

Sources: 2012 and 2013: IHS Economics, Industry and Employment models, November 2014.

Projections: U.S. Energy Information Administration, AEO2015 National Energy Modeling System run ref2015.d021915a.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
17835	**18296**	**18801**	**19259**	**19721**	**20221**	**20753**	**21295**	**21818**	**22344**	**22864**
12217	12520	12832	13133	13432	13762	14116	14484	14842	15202	15570
3290	3399	3531	3620	3704	3812	3915	4025	4125	4221	4298
2940	2959	2985	3005	3026	3047	3068	3098	3135	3173	3209
2484	2644	2813	2989	3179	3375	3593	3807	4009	4206	4406
3070	3201	3334	3460	3591	3743	3905	4079	4250	4410	4566
4.11	4.02	3.93	3.84	3.75	3.67	3.58	3.49	3.41	3.33	3.26
5.59	5.49	5.36	5.24	5.13	5.02	4.91	4.79	4.68	4.58	4.48
1.168	1.190	1.211	1.231	1.252	1.272	1.293	1.314	1.336	1.359	1.382
2.53	2.58	2.63	2.68	2.73	2.78	2.84	2.89	2.94	3.00	3.06
2.39	2.46	2.55	2.65	2.73	2.81	2.89	2.98	3.07	3.16	3.24
2.15	2.20	2.25	2.30	2.34	2.39	2.43	2.47	2.52	2.57	2.61
2.06	2.16	2.26	2.36	2.43	2.51	2.58	2.67	2.76	2.84	2.91
2.34	2.39	2.43	2.47	2.51	2.54	2.58	2.62	2.66	2.71	2.76
2.14	2.18	2.22	2.26	2.29	2.33	2.36	2.40	2.44	2.48	2.52
3.41	3.39	3.40	3.44	3.40	3.44	3.48	3.56	3.65	3.68	3.69
4.11	4.12	4.12	4.17	4.11	4.12	4.12	4.14	4.16	4.18	4.21
6.21	6.17	6.15	6.21	6.13	6.11	6.06	6.06	6.11	6.16	6.21

27190	27795	28468	29117	29768	30497	31290	32023	32680	33288	33866
8151	8307	8467	8585	8722	8875	9044	9212	9351	9492	9614
2260	2303	2344	2359	2373	2392	2415	2441	2467	2490	2503
5891	6004	6123	6226	6350	6483	6629	6771	6884	7001	7112
1877	1915	1946	1973	2003	2033	2060	2084	2103	2122	2141
4014	4090	4177	4253	4347	4451	4569	4687	4781	4879	4971
35342	**36101**	**36935**	**37702**	**38490**	**39373**	**40334**	**41235**	**42030**	**42780**	**43481**

329.0	331.5	334.0	336.5	339.1	341.6	344.1	346.5	349.0	351.4	353.8
262.5	264.6	266.8	268.9	271.0	273.2	275.3	277.3	279.3	281.3	283.4
52.7	54.5	56.3	58.1	59.9	61.7	63.5	65.4	67.1	68.7	70.2
146.2	147.3	148.7	149.7	150.6	151.6	152.8	153.9	154.8	155.7	156.7
11.9	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.1	11.0	10.9

163.3	164.7	165.6	166.5	167.5	168.4	169.2	169.9	170.6	171.3	172.1
1.15	1.17	1.20	1.22	1.25	1.28	1.31	1.34	1.37	1.40	1.43
5.51	5.52	5.40	5.32	5.31	5.25	5.09	4.96	4.96	4.95	4.96

13603	14008	14411	14742	15095	15489	15889	16318	16750	17205	17653
1.63	1.67	1.69	1.64	1.64	1.65	1.67	1.70	1.70	1.68	1.64
86.9	88.0	89.0	90.1	91.2	92.2	93.1	94.1	95.0	95.8	96.7
17.09	16.95	17.02	16.87	16.80	16.86	16.98	17.21	17.36	17.51	17.59

2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039

2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
23374	**23894**	**24405**	**24921**	**25480**	**26062**	**26659**	**27278**	**27908**	**28554**	**29212**
15929	16275	16620	16980	17360	17762	18179	18613	19058	19514	19988
4377	4474	4572	4649	4752	4864	4984	5112	5238	5365	5494
3245	3286	3319	3354	3389	3427	3469	3512	3556	3599	3642
4607	4815	5037	5271	5517	5765	6010	6263	6520	6786	7058
4724	4888	5066	5245	5439	5644	5859	6084	6311	6540	6782
3.20	3.13	3.07	3.01	2.95	2.89	2.83	2.77	2.72	2.67	2.62
4.39	4.31	4.22	4.14	4.05	3.97	3.90	3.82	3.75	3.68	3.61
1.406	1.431	1.458	1.485	1.513	1.540	1.569	1.598	1.629	1.661	1.695
3.12	3.18	3.25	3.32	3.39	3.46	3.54	3.61	3.69	3.77	3.86
3.33	3.42	3.53	3.65	3.78	3.90	4.03	4.17	4.32	4.49	4.67
2.66	2.71	2.77	2.83	2.89	2.96	3.02	3.08	3.15	3.22	3.31
2.99	3.08	3.19	3.31	3.44	3.56	3.69	3.83	3.97	4.15	4.35
2.80	2.85	2.91	2.96	3.02	3.08	3.13	3.19	3.25	3.30	3.36
2.57	2.61	2.66	2.71	2.76	2.81	2.85	2.90	2.95	3.01	3.06
3.68	3.69	3.67	3.67	3.69	3.73	3.76	3.79	3.85	3.92	3.99
4.23	4.28	4.31	4.33	4.37	4.40	4.41	4.42	4.46	4.52	4.58
6.26	6.33	6.38	6.42	6.44	6.47	6.47	6.47	6.52	6.58	6.65

34409	34968	35488	36007	36566	37162	37767	38387	38991	39595	40205
9731	9870	10001	10110	10255	10428	10614	10791	10957	11139	11299
2515	2540	2550	2544	2554	2576	2601	2622	2643	2667	2684
7216	7330	7451	7567	7701	7852	8012	8169	8314	8471	8615
2155	2168	2181	2193	2207	2221	2237	2252	2271	2290	2304
5060	5162	5270	5373	5494	5631	5776	5917	6043	6181	6310
44140	**44838**	**45489**	**46118**	**46820**	**47590**	**48380**	**49178**	**49948**	**50733**	**51503**

356.2	358.6	360.9	363.1	365.4	367.6	369.7	371.8	373.9	376.0	378.0
285.6	287.7	289.8	291.9	294.0	296.0	298.0	299.9	301.8	303.7	305.5
71.7	73.0	74.0	74.9	75.7	76.6	77.5	78.3	78.9	79.2	79.5
157.6	158.6	159.4	160.2	161.2	162.2	163.2	164.2	165.3	166.3	167.4
10.8	10.7	10.6	10.5	10.4	10.4	10.3	10.2	10.1	10.0	9.9

173.0	174.0	175.0	175.9	176.9	177.9	178.9	179.9	181.1	182.3	183.5
1.45	1.48	1.51	1.53	1.56	1.59	1.62	1.65	1.68	1.72	1.75
4.99	5.03	5.09	5.13	5.12	5.08	5.02	4.96	4.91	4.88	4.87

18078	18487	18881	19289	19721	20161	20610	21061	21516	21986	22462
1.64	1.66	1.65	1.60	1.60	1.61	1.62	1.62	1.63	1.63	1.61
97.5	98.4	99.2	100.1	101.1	102.1	103.2	104.4	105.6	106.8	107.9
17.60	17.54	17.45	17.43	17.47	17.56	17.68	17.80	17.91	18.02	18.10

2040

2040	2013-2040
29898	**2.4%**
20476	2.4%
5634	3.0%
3691	0.9%
7338	4.9%
7037	4.0%
2.56	-2.1%
3.54	-2.0%
1.730	1.8%
3.95	2.0%
4.85	2.6%
3.39	1.9%
4.56	2.9%
3.42	1.8%
3.12	1.7%
4.04	- -
4.63	- -
6.71	- -

40814	1.9%
11463	1.8%
2712	1.4%
8751	2.0%
2317	1.2%
6433	2.3%
52277	**1.9%**

380.0	0.7%
307.3	0.7%
79.8	2.2%
168.5	0.8%
9.7	-0.7%

184.7	0.6%
1.78	2.0%
4.85	- -

22957	2.5%
1.62	1.8%
109.1	1.0%
18.18	0.6%

ref2015.d021915a	2012	2013	2014	2015	2016	2017

Report Annual Energy Outlook 2015
Scenario ref2015 Reference case
Datekey d021915a
Release Date April 2015

20. Macroeconomic Indicators

(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	2012	2013	2014	2015	2016	2017
Real Gross Domestic Product	**15369**	**15710**	**16055**	**16553**	**16970**	**17369**
Components of Real Gross Domestic Product						
Real Consumption	10450	10700	10941	11270	11611	11919
Real Investment	2436	2556	2688	2851	3017	3127
Real Government Spending	2954	2894	2889	2894	2908	2927
Real Exports	1960	2020	2085	2174	2250	2340
Real Imports	2413	2440	2523	2611	2790	2918
Energy Intensity						
(thousand Btu per 2009 dollar of GDP)						
Delivered Energy	4.47	4.53	4.50	4.33	4.27	4.19
Total Energy	6.14	6.18	6.14	5.91	5.82	5.70
Price Indices						
GDP Chain-type Price Index (2009=1.000)	1.052	1.067	1.084	1.105	1.126	1.146
Consumer Price Index (1982-84=1.00)						
All-urban	2.30	2.33	2.37	2.37	2.43	2.48
Energy Commodities and Services	2.46	2.44	2.44	2.05	2.25	2.33
Wholesale Price Index (1982=1.00)						
All Commodities	2.02	2.03	2.06	2.01	2.07	2.11
Fuel and Power	2.12	2.12	2.10	1.76	1.92	1.99
Metals and Metal Products	2.20	2.14	2.16	2.21	2.25	2.28
Industrial Commodities excluding Energy	1.94	1.96	1.98	2.02	2.06	2.10
Interest Rates (percent, nominal)						
Federal Funds Rate	0.14	0.11	0.09	0.16	1.76	3.35
10-Year Treasury Note	1.80	2.35	2.57	2.86	3.75	4.21
AA Utility Bond Rate	3.83	4.24	4.20	4.30	5.78	6.54

Value of Shipments (billion 2009 dollars)						
Non-Industrial and Service Sectors	23989	24398	24943	25646	26202	26679
Total Industrial	6822	7004	7233	7598	7785	7965
Agriculture, Mining, and Construction	1813	1858	1905	2020	2106	2197
Manufacturing	5009	5146	5328	5577	5679	5768
Energy-Intensive	1675	1685	1716	1760	1791	1833
Non-Energy-Intensive	3334	3461	3612	3817	3888	3936
Total Shipments	**30810**	**31402**	**32176**	**33244**	**33986**	**34644**
Population and Employment (millions)						
Population, with Armed Forces Overseas	314.5	316.7	319.0	321.5	324.0	326.5
Population, aged 16 and over	249.2	251.5	253.7	255.9	258.2	260.4
Population, aged 65 and over	43.4	44.9	46.4	48.0	49.5	51.1
Employment, Nonfarm	133.9	136.2	138.6	141.6	143.8	145.3
Employment, Manufacturing	11.8	11.9	12.0	12.0	12.1	12.1
Key Labor Indicators						
Labor Force (millions)	155.0	155.4	155.9	157.6	159.7	161.7
Nonfarm Labor Productivity (2009=1.00)	1.05	1.05	1.06	1.08	1.10	1.12
Unemployment Rate (percent)	8.08	7.35	6.19	5.70	5.51	5.42
Key Indicators for Energy Demand						
Real Disposable Personal Income	11676	11651	11970	12361	12707	13198
Housing Starts (millions)	0.84	0.99	1.06	1.30	1.41	1.55
Commercial Floorspace (billion square feet)	82.3	82.8	83.4	84.1	84.9	85.9
Unit Sales of Light-Duty Vehicles (millions)	14.43	15.52	16.37	17.01	17.16	17.10

GDP = Gross domestic product.

Btu = British thermal unit.

- - = Not applicable.

Sources: 2012 and 2013: IHS Economics, Industry and Employment models, November 2014.

Projections: U.S. Energy Information Administration, AEO2015 National Energy Modeling System run ref2015.d021915a.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
17835	**18296**	**18801**	**19259**	**19721**	**20221**	**20753**	**21295**	**21818**	**22344**	**22864**	**23374**
12217	12520	12832	13133	13432	13762	14116	14484	14842	15202	15570	15929
3290	3399	3531	3620	3704	3812	3915	4025	4125	4221	4298	4377
2940	2959	2985	3005	3026	3047	3068	3098	3135	3173	3209	3245
2484	2644	2813	2989	3179	3375	3593	3807	4009	4206	4406	4607
3070	3201	3334	3460	3591	3743	3905	4079	4250	4410	4566	4724
4.11	4.02	3.93	3.84	3.75	3.67	3.58	3.49	3.41	3.33	3.26	3.20
5.59	5.49	5.36	5.24	5.13	5.02	4.91	4.79	4.68	4.58	4.48	4.39
1.168	1.190	1.211	1.231	1.252	1.272	1.293	1.314	1.336	1.359	1.382	1.406
2.53	2.58	2.63	2.68	2.73	2.78	2.84	2.89	2.94	3.00	3.06	3.12
2.39	2.46	2.55	2.65	2.73	2.81	2.89	2.98	3.07	3.16	3.24	3.33
2.15	2.20	2.25	2.30	2.34	2.39	2.43	2.47	2.52	2.57	2.61	2.66
2.06	2.16	2.26	2.36	2.43	2.51	2.58	2.67	2.76	2.84	2.91	2.99
2.34	2.39	2.43	2.47	2.51	2.54	2.58	2.62	2.66	2.71	2.76	2.80
2.14	2.18	2.22	2.26	2.29	2.33	2.36	2.40	2.44	2.48	2.52	2.57
3.41	3.39	3.40	3.44	3.40	3.44	3.48	3.56	3.65	3.68	3.69	3.68
4.11	4.12	4.12	4.17	4.11	4.12	4.12	4.14	4.16	4.18	4.21	4.23
6.21	6.17	6.15	6.21	6.13	6.11	6.06	6.06	6.11	6.16	6.21	6.26

27190	27795	28468	29117	29768	30497	31290	32023	32680	33288	33866	34409
8151	8307	8467	8585	8722	8875	9044	9212	9351	9492	9614	9731
2260	2303	2344	2359	2373	2392	2415	2441	2467	2490	2503	2515
5891	6004	6123	6226	6350	6483	6629	6771	6884	7001	7112	7216
1877	1915	1946	1973	2003	2033	2060	2084	2103	2122	2141	2155
4014	4090	4177	4253	4347	4451	4569	4687	4781	4879	4971	5060
35342	**36101**	**36935**	**37702**	**38490**	**39373**	**40334**	**41235**	**42030**	**42780**	**43481**	**44140**

329.0	331.5	334.0	336.5	339.1	341.6	344.1	346.5	349.0	351.4	353.8	356.2
262.5	264.6	266.8	268.9	271.0	273.2	275.3	277.3	279.3	281.3	283.4	285.6
52.7	54.5	56.3	58.1	59.9	61.7	63.5	65.4	67.1	68.7	70.2	71.7
146.2	147.3	148.7	149.7	150.6	151.6	152.8	153.9	154.8	155.7	156.7	157.6
11.9	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.1	11.0	10.9	10.8

163.3	164.7	165.6	166.5	167.5	168.4	169.2	169.9	170.6	171.3	172.1	173.0
1.15	1.17	1.20	1.22	1.25	1.28	1.31	1.34	1.37	1.40	1.43	1.45
5.51	5.52	5.40	5.32	5.31	5.25	5.09	4.96	4.96	4.95	4.96	4.99

13603	14008	14411	14742	15095	15489	15889	16318	16750	17205	17653	18078
1.63	1.67	1.69	1.64	1.64	1.65	1.67	1.70	1.70	1.68	1.64	1.64
86.9	88.0	89.0	90.1	91.2	92.2	93.1	94.1	95.0	95.8	96.7	97.5
17.09	16.95	17.02	16.87	16.80	16.86	16.98	17.21	17.36	17.51	17.59	17.60

2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040

2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2013-2040
23894	**24405**	**24921**	**25480**	**26062**	**26659**	**27278**	**27908**	**28554**	**29212**	**29898**	**2.4%**
16275	16620	16980	17360	17762	18179	18613	19058	19514	19988	20476	2.4%
4474	4572	4649	4752	4864	4984	5112	5238	5365	5494	5634	3.0%
3286	3319	3354	3389	3427	3469	3512	3556	3599	3642	3691	0.9%
4815	5037	5271	5517	5765	6010	6263	6520	6786	7058	7338	4.9%
4888	5066	5245	5439	5644	5859	6084	6311	6540	6782	7037	4.0%
3.13	3.07	3.01	2.95	2.89	2.83	2.77	2.72	2.67	2.62	2.56	-2.1%
4.31	4.22	4.14	4.05	3.97	3.90	3.82	3.75	3.68	3.61	3.54	-2.0%
1.431	1.458	1.485	1.513	1.540	1.569	1.598	1.629	1.661	1.695	1.730	1.8%
3.18	3.25	3.32	3.39	3.46	3.54	3.61	3.69	3.77	3.86	3.95	2.0%
3.42	3.53	3.65	3.78	3.90	4.03	4.17	4.32	4.49	4.67	4.85	2.6%
2.71	2.77	2.83	2.89	2.96	3.02	3.08	3.15	3.22	3.31	3.39	1.9%
3.08	3.19	3.31	3.44	3.56	3.69	3.83	3.97	4.15	4.35	4.56	2.9%
2.85	2.91	2.96	3.02	3.08	3.13	3.19	3.25	3.30	3.36	3.42	1.8%
2.61	2.66	2.71	2.76	2.81	2.85	2.90	2.95	3.01	3.06	3.12	1.7%
3.69	3.67	3.67	3.69	3.73	3.76	3.79	3.85	3.92	3.99	4.04	- -
4.28	4.31	4.33	4.37	4.40	4.41	4.42	4.46	4.52	4.58	4.63	- -
6.33	6.38	6.42	6.44	6.47	6.47	6.47	6.52	6.58	6.65	6.71	- -

34968	35488	36007	36566	37162	37767	38387	38991	39595	40205	40814	1.9%
9870	10001	10110	10255	10428	10614	10791	10957	11139	11299	11463	1.8%
2540	2550	2544	2554	2576	2601	2622	2643	2667	2684	2712	1.4%
7330	7451	7567	7701	7852	8012	8169	8314	8471	8615	8751	2.0%
2168	2181	2193	2207	2221	2237	2252	2271	2290	2304	2317	1.2%
5162	5270	5373	5494	5631	5776	5917	6043	6181	6310	6433	2.3%
44838	**45489**	**46118**	**46820**	**47590**	**48380**	**49178**	**49948**	**50733**	**51503**	**52277**	**1.9%**

358.6	360.9	363.1	365.4	367.6	369.7	371.8	373.9	376.0	378.0	380.0	0.7%
287.7	289.8	291.9	294.0	296.0	298.0	299.9	301.8	303.7	305.5	307.3	0.7%
73.0	74.0	74.9	75.7	76.6	77.5	78.3	78.9	79.2	79.5	79.8	2.2%
158.6	159.4	160.2	161.2	162.2	163.2	164.2	165.3	166.3	167.4	168.5	0.8%
10.7	10.6	10.5	10.4	10.4	10.3	10.2	10.1	10.0	9.9	9.7	-0.7%

174.0	175.0	175.9	176.9	177.9	178.9	179.9	181.1	182.3	183.5	184.7	0.6%
1.48	1.51	1.53	1.56	1.59	1.62	1.65	1.68	1.72	1.75	1.78	2.0%
5.03	5.09	5.13	5.12	5.08	5.02	4.96	4.91	4.88	4.87	4.85	- -

18487	18881	19289	19721	20161	20610	21061	21516	21986	22462	22957	2.5%
1.66	1.65	1.60	1.60	1.61	1.62	1.62	1.63	1.63	1.61	1.62	1.8%
98.4	99.2	100.1	101.1	102.1	103.2	104.4	105.6	106.8	107.9	109.1	1.0%
17.54	17.45	17.43	17.47	17.56	17.68	17.80	17.91	18.02	18.10	18.18	0.6%

Table A20. Macroeconomic indicators
(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Real gross domestic product	**15,369**	**15,710**	**18,801**	**21,295**	**23,894**	**26,659**	**29,898**	**2.4%**
Components of real gross domestic product								
Real consumption	10,450	10,700	12,832	14,484	16,275	18,179	20,476	2.4%
Real investment	2,436	2,556	3,531	4,025	4,474	4,984	5,634	3.0%
Real government spending	2,954	2,894	2,985	3,098	3,286	3,469	3,691	0.9%
Real exports	1,960	2,020	2,813	3,807	4,815	6,010	7,338	4.9%
Real imports	2,413	2,440	3,334	4,079	4,888	5,859	7,037	4.0%
Energy intensity								
(thousand Btu per 2009 dollar of GDP)								
Delivered energy	4.47	4.53	3.93	3.49	3.13	2.83	2.56	-2.1%
Total energy	6.14	6.18	5.36	4.79	4.31	3.90	3.54	-2.0%
Price indices								
GDP chain-type price index (2009=1.000)	1.05	1.07	1.21	1.31	1.43	1.57	1.73	1.8%
Consumer price index (1982-4=1.00)								
All-urban	2.30	2.33	2.63	2.89	3.18	3.54	3.95	2.0%
Energy commodities and services	2.46	2.44	2.55	2.98	3.42	4.03	4.85	2.6%
Wholesale price index (1982=1.00)								
All commodities	2.02	2.03	2.25	2.47	2.71	3.02	3.39	1.9%
Fuel and power	2.12	2.12	2.26	2.67	3.08	3.69	4.56	2.9%
Metals and metal products	2.20	2.14	2.43	2.62	2.85	3.13	3.42	1.8%
Industrial commodities excluding energy	1.94	1.96	2.22	2.40	2.61	2.85	3.12	1.7%
Interest rates (percent, nominal)								
Federal funds rate	0.14	0.11	3.40	3.56	3.69	3.76	4.04	- -
10-year treasury note	1.80	2.35	4.12	4.14	4.28	4.41	4.63	- -
AA utility bond rate	3.83	4.24	6.15	6.06	6.33	6.47	6.71	- -
Value of shipments (billion 2009 dollars)								
Non-industrial and service sectors	23,989	24,398	28,468	32,023	34,968	37,767	40,814	1.9%
Total industrial	6,822	7,004	8,467	9,212	9,870	10,614	11,463	1.8%
Agriculture, mining, and construction	1,813	1,858	2,344	2,441	2,540	2,601	2,712	1.4%
Manufacturing	5,009	5,146	6,123	6,771	7,330	8,012	8,751	2.0%
Energy-intensive	1,675	1,685	1,946	2,084	2,168	2,237	2,317	1.2%
Non-energy-intensive	3,334	3,461	4,177	4,687	5,162	5,776	6,433	2.3%
Total shipments	**30,810**	**31,402**	**36,935**	**41,235**	**44,838**	**48,380**	**52,277**	**1.9%**
Population and employment (millions)								
Population, with armed forces overseas	315	317	334	347	359	370	380	0.7%
Population, aged 16 and over	249	251	267	277	288	298	307	0.7%
Population, aged 65 and over	43	45	56	65	73	78	80	2.2%
Employment, nonfarm	134	136	149	154	159	163	169	0.8%
Employment, manufacturing	11.8	11.9	11.8	11.3	10.7	10.3	9.7	-0.7%
Key labor indicators								
Labor force (millions)	155	155	166	170	174	179	185	0.6%
Nonfarm labor productivity (2009=1.00)	1.05	1.05	1.20	1.34	1.48	1.62	1.78	2.0%
Unemployment rate (percent)	8.08	7.35	5.40	4.96	5.03	5.02	4.85	- -
Key indicators for energy demand								
Real disposable personal income	11,676	11,651	14,411	16,318	18,487	20,610	22,957	2.5%
Housing starts (millions)	0.84	0.99	1.69	1.70	1.66	1.62	1.62	1.8%
Commercial floorspace (billion square feet)	82.3	82.8	89.0	94.1	98.4	103.2	109.1	1.0%
Unit sales of light-duty vehicles (millions)	14.4	15.5	17.0	17.2	17.5	17.7	18.2	0.6%

GDP = Gross domestic product.
Btu = British thermal unit.
- - = Not applicable.
Sources: 2012 and 2013: IHS Economics, Industry and Employment models, November 2014. **Projections:** U.S. Energy Information Administration, AEO2015 National Energy Modeling System run REF2015.D021915A.

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Annual Energy Outlook 2015

with projections to 2040

Independent Statistics & Analysis
U.S. Energy Information Administration

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AEO2015 is available on the EIA website at www.eia.gov/forecasts/aeo. Assumptions underlying the projections, tables of regional results, and other detailed results are available at www.eia.gov/forecasts/aeo/assumptions.

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Annual Energy Outlook 2015

With Projections to 2040

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Preface

The *Annual Energy Outlook 2015* (AEO2015), prepared by the U.S. Energy Information Administration (EIA), presents long-term annual projections of energy supply, demand, and prices through 2040. The projections, focused on U.S. energy markets, are based on results from EIA's National Energy Modeling System (NEMS). NEMS enables EIA to make projections under alternative, internally-consistent sets of assumptions, the results of which are presented as cases. The analysis in AEO2015 focuses on six cases: Reference case, Low and High Economic Growth cases, Low and High Oil Price cases, and High Oil and Gas Resource case.

For the first time, the Annual Energy Outlook (AEO) is presented as a shorter edition under a newly adopted two-year release cycle. With this approach, full editions and shorter editions of the AEO will be produced in alternating years. This approach will allow EIA to focus more resources on rapidly changing energy markets both in the United States and internationally and how they might evolve over the next few years. The shorter edition of the AEO includes a more limited number of model updates, predominantly to reflect historical data updates and changes in legislation and regulation. The AEO shorter editions will include this publication, which discusses the Reference case and five alternative cases, and an accompanying *Assumptions Report*.[1] Other documentation—including documentation for each of the NEMS models and a *Retrospective Review*—will be completed only in years when the full edition of the AEO is published.

This AEO2015 report includes the following major sections:

- **Executive summary**, highlighting key results of the projections
- **Economic growth**, discussing the economic outlooks completed for each of the AEO2015 cases
- **Energy prices**, discussing trends in the markets and prices for crude oil, petroleum and other liquids,[2] natural gas, coal, and electricity for each of the AEO2015 cases
- **Delivered energy consumption by sector**, discussing energy consumption trends in the transportation, industrial, residential, and commercial sectors
- **Energy consumption by primary fuel**, discussing trends in energy consumption by fuel, including natural gas, renewables, coal, nuclear, liquid biofuels, and oil and other liquids
- **Energy intensity**, examining trends in energy use per capita, energy use per 2009 dollar of gross domestic product (GDP), and carbon dioxide (CO_2) emissions per 2009 dollar of GDP
- **Energy production, imports, and exports**, examining production, import, and export trends for petroleum and other liquids, natural gas, and coal
- **Electricity generation,** discussing trends in electricity generation by fuel and prime mover for each of the AEO2015 cases
- **Energy-related CO_2 emissions,** examining trends in CO_2 emissions by sector and AEO2015 case.

Summary tables for the six cases are provided in Appendixes A through D. Complete tables are available in a table browser on EIA's website, at http://www.eia.gov/oiaf/aeo/tablebrowser. Appendix E provides a short discussion of the major changes adopted in AEO2015 and a brief comparison of the AEO2015 and Annual Energy Outlook 2014 results. Appendix F provides a summary of the regional formats, and Appendix G provides a summary of the energy conversion factors used in AEO2015.

The AEO2015 projections are based generally on federal, state, and local laws and regulations in effect as of the end of October 2014. The potential impacts of pending or proposed legislation, regulations, and standards (and sections of existing legislation that require implementing regulations or funds that have not been appropriated) are not reflected in the projections (for example, the proposed Clean Power Plan[3]). In certain situations, however, where it is clear that a law or a regulation will take effect shortly after AEO2015 is completed, it may be considered in the projection.

AEO2015 is published in accordance with Section 205c of the U.S. Department of Energy (DOE) Organization Act of 1977 (Public Law 95-91), which requires the EIA Administrator to prepare annual reports on trends and projections for energy use and supply.

[1]U.S. Energy Information Administration, *Assumptions to the Annual Energy Outlook 2015*, DOE/EIA-0554(2015) (Washington, DC, to be published), http://www.eia.gov/forecasts/aeo/assumptions.

[2]Liquid fuels (or petroleum and other liquids) include crude oil and products of petroleum refining, natural gas liquids, biofuels, and liquids derived from other hydrocarbon sources (including coal-to-liquids and gas-to-liquids).

[3]U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," *Federal Register*, pp. 34829-34958 (Washington, DC: June 18, 2014), https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.

Projections by EIA are not statements of what will happen but of what might happen, given the assumptions and methodologies used for any particular case. The AEO2015 Reference case projection is a business-as-usual trend estimate, given known technology and technological and demographic trends. EIA explores the impacts of alternative assumptions in other cases with different macroeconomic growth rates, world oil prices, and resource assumptions. The main cases in AEO2015 generally assume that current laws and regulations are maintained throughout the projections. Thus, the projections provide policy-neutral baselines that can be used to analyze policy initiatives.

While energy markets are complex, energy models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. Behavioral characteristics are indicative of real-world tendencies rather than representations of specific outcomes.

Energy market projections are subject to much uncertainty. Many of the events that shape energy markets are random and cannot be anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Some key uncertainties in the AEO2015 projections are addressed through alternative cases.

EIA has endeavored to make these projections as objective, reliable, and useful as possible; however, they should serve as an adjunct to, not a substitute for, a complete and focused analysis of public policy initiatives.

Contents

Appendixes

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Executive summary

Projections in the *Annual Energy Outlook 2015* (AEO2015) focus on the factors expected to shape U.S. energy markets through 2040. The projections provide a basis for examination and discussion of energy market trends and serve as a starting point for analysis of potential changes in U.S. energy policies, rules, and regulations, as well as the potential role of advanced technologies.

Key results from the AEO2015 Reference and alternative cases include the following:

- The future path of crude oil and natural gas prices can vary substantially, depending on assumptions about the size of global and domestic resources, demand for petroleum products and natural gas (particularly in non-Organization for Economic Cooperation and Development (non-OECD) countries), levels of production, and supplies of other fuels. AEO2015 considers these factors in examining alternative price and resource availability cases.
- Growth in U.S. energy production—led by crude oil and natural gas—and only modest growth in demand reduces U.S. reliance on imported energy supplies. Energy imports and exports come into balance in the United States starting in 2028 in the AEO2015 Reference case and in 2019 in the High Oil Price and High Oil and Gas Resource cases. Natural gas is the dominant U.S. energy export, while liquid fuels[4] continue to be imported.
- Through 2020, strong growth in domestic crude oil production from tight formations leads to a decline in net petroleum imports[5] and growth in net petroleum product exports in all AEO2015 cases. In the High Oil and Gas Resource case, increased crude production before 2020 results in increased processed condensate[6] exports. Slowing growth in domestic production after 2020 is offset by increased vehicle fuel economy standards that limit growth in domestic demand. The net import share of crude oil and petroleum products supplied falls from 33% of total supply in 2013 to 17% of total supply in 2040 in the Reference case. The United States becomes a net exporter of petroleum and other liquids after 2020 in the High Oil Price and High Oil and Gas Resource cases because of greater U.S. crude oil production.
- The United States transitions from being a modest net importer of natural gas to a net exporter by 2017. U.S. export growth continues after 2017, with net exports in 2040 ranging from 3.0 trillion cubic feet (Tcf) in the Low Oil Price case to 13.1 Tcf in the High Oil and Gas Resource case.
- Growth in crude oil and dry natural gas production varies significantly across oil and natural gas supply regions and cases, forcing shifts in crude oil and natural gas flows between U.S. regions, and requiring investment in or realignment of pipelines and other midstream infrastructure.
- U.S. energy consumption grows at a modest rate over the AEO2015 projection period, averaging 0.3%/year from 2013 through 2040 in the Reference case. A marginal decrease in transportation sector energy consumption contrasts with growth in most other sectors. Declines in energy consumption tend to result from the adoption of more energy-efficient technologies and existing policies that promote increased energy efficiency.
- Growth in production of dry natural gas and natural gas plant liquids (NGPL) contributes to the expansion of several manufacturing industries (such as bulk chemicals and primary metals) and the increased use of NGPL feedstocks in place of petroleum-based naphtha[7] feedstocks.
- Rising long-term natural gas prices, the high capital costs of new coal and nuclear generation capacity, state-level policies, and cost reductions for renewable generation in a market characterized by relatively slow electricity demand growth favor increased use of renewables.
- Rising costs for electric power generation, transmission, and distribution, coupled with relatively slow growth of electricity demand, produce an 18% increase in the average retail price of electricity over the period from 2013 to 2040 in the AEO2015 Reference case. The AEO2015 cases do not include the proposed Clean Power Plan.[8]
- Improved efficiency in the end-use sectors and a shift away from more carbon-intensive fuels help to stabilize U.S. energy-related carbon dioxide (CO2) emissions, which remain below the 2005 level through 2040.

The future path of crude oil prices can vary substantially, depending on assumptions about the size of the resource and growth in demand, particularly in non-OECD countries

AEO2015 considers a number of factors related to the uncertainty of future crude oil prices, including changes in worldwide demand for petroleum products, crude oil production, and supplies of other liquid fuels. In all the AEO2015 cases, the North Sea

[4]Liquid fuels (or petroleum and other liquids) includes crude oil and products of petroleum refining, natural gas liquids, biofuels, and liquids derived from other hydrocarbon sources (including coal-to-liquids and gas-to-liquids).
[5]*Net product imports* includes trade in crude oil and petroleum products.
[6]The U.S. Department of Commerce, Bureau of Industry and Security has determined that condensate which has been processed through a distillate tower can be exported without licensing.
[7]Naphtha is a refined or semi-refined petroleum fraction used in chemical feedstocks and many other petroleum products. For a complete definition, see www.eia.gov/tools/glossary/index.cfm?id=naphtha.
[8]U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," *Federal Register*, pp. 34829-34958 (Washington, DC: June 18, 2014) https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.

Brent crude oil price reflects the world market price for light sweet crude, and all the cases account for market conditions in 2014, including the 10% decline in the average Brent spot price to $97/barrel (bbl) in 2013 dollars.

In the AEO2015 Reference case, continued growth in U.S. crude oil production contributes to a 43% decrease in the Brent crude oil price, to $56/bbl in 2015 (Figure ES1). Prices rise steadily after 2015 in response to growth in demand from countries outside the OECD; however, downward price pressure from continued increases in U.S. crude oil production keeps the Brent price below $80/bbl through 2020. U.S. crude oil production starts to decline after 2020, but increased production from non-OECD countries and from countries in the Organization of the Petroleum Exporting Countries (OPEC) contributes to the Brent price remaining below $100/bbl through 2028 and limits the Brent price increase through 2040, when it reaches $141/bbl.

There is significant price variation in the alternative cases using different assumptions. In the Low Oil Price case, the Brent price drops to $52/bbl in 2015, 7% lower than in the Reference case, and reaches $76/bbl in 2040, 47% lower than in the Reference case, largely as a result of lower non-OECD demand and higher upstream investment by OPEC. In the High Oil Price case, the Brent price increases to $122/bbl in 2015 and to $252/bbl in 2040, largely in response to significantly lower OPEC production and higher non-OECD demand. In the High Oil and Gas Resource case, assumptions about overseas demand and supply decisions do not vary from those in the Reference case, but U.S. crude oil production growth is significantly greater, resulting in lower U.S. net imports of crude oil, and causing the Brent spot price to average $129/bbl in 2040, which is 8% lower than in the Reference case.

Future natural gas prices will be influenced by a number of factors, including oil prices, resource availability, and demand for natural gas

Projections of natural gas prices are influenced by assumptions about oil prices, resource availability, and natural gas demand. In the Reference case, the Henry Hub natural gas spot price (in 2013 dollars) rises from $3.69/million British thermal units (Btu) in 2015 to $4.88/million Btu in 2020 and to $7.85/million Btu in 2040 (Figure ES2), as increased demand in domestic and international markets leads to the production of increasingly expensive resources.

In the AEO2015 alternative cases, the Henry Hub natural gas spot price is lowest in the High Oil and Gas Resource case, which assumes greater estimated ultimate recovery per well, closer well spacing, and greater gains in technological development. In the High Oil and Gas Resource case, the Henry Hub natural gas spot price falls from $3.14/million Btu in 2015 to $3.12/million Btu in 2020 (36% below the Reference case price) before rising to $4.38/million Btu in 2040 (44% below the Reference case price). Cumulative U.S. domestic dry natural gas production from 2015 to 2040 is 26% higher in the High Oil and Gas Resource case than in the Reference case and is sufficient to meet rising domestic consumption and exports—both pipeline gas and liquefied natural gas (LNG)—even as prices remain low.

Henry Hub natural gas spot prices are highest in the High Oil Price case, which assumes the same level of resource availability as the AEO2015 Reference case, but different Brent crude oil prices. The higher Brent crude oil prices in the High Oil Price case affect the level of overseas demand for U.S. LNG exports, because international LNG contracts are often linked to crude oil prices—although the linkage is expected to weaken with changing market conditions. When the Brent spot price rises in the High Oil Price case, world LNG contracts that are linked to oil prices become relatively more competitive, making LNG exports from the United States more desirable.

In the High Oil Price case, the Henry Hub natural gas spot price remains close to the Reference case price through 2020; however, higher overseas demand for U.S. LNG exports raises the average Henry Hub price to $10.63/million Btu in 2040, which is 35%

Figure ES1. North Sea Brent crude oil spot prices in four cases, 2005-40 (2013 dollars per barrel)

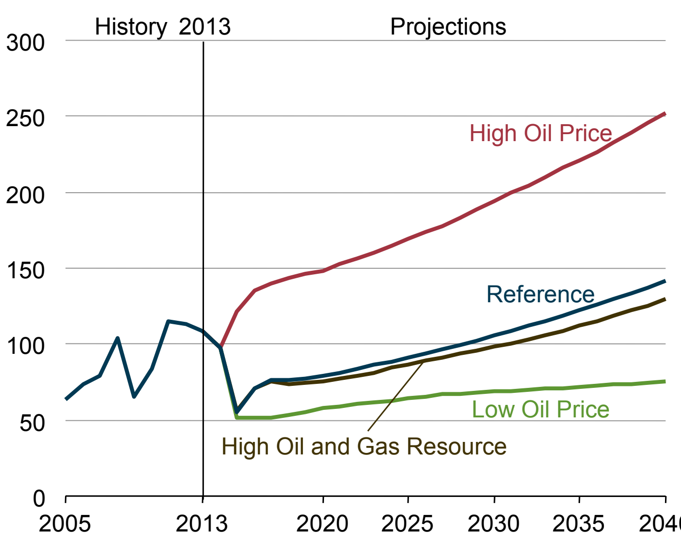
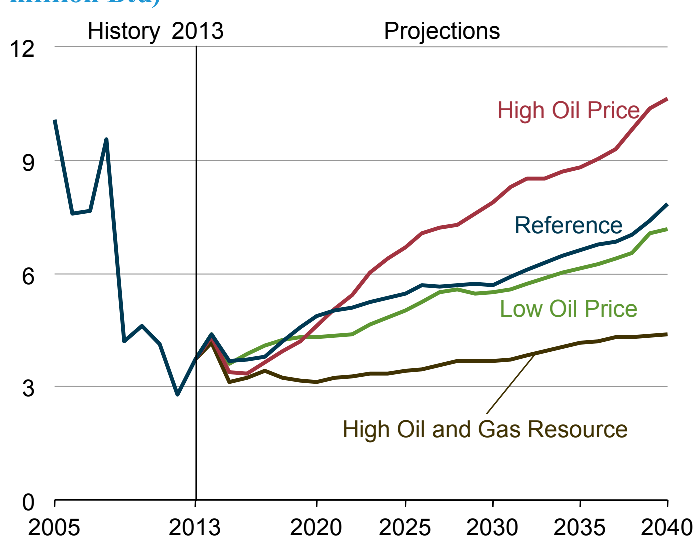


Figure ES2. Average Henry Hub spot prices for natural gas in four cases, 2005-40 (2013 dollars per million Btu)



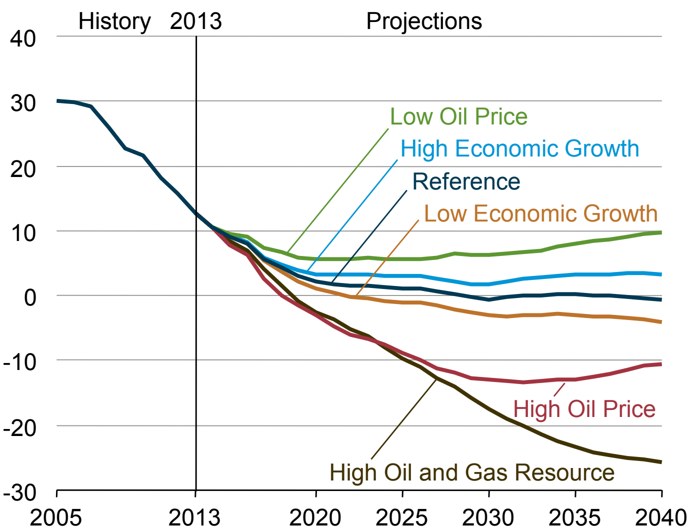
above the Reference case price. Cumulative U.S. exports of LNG from 2015 to 2040 in the High Oil Price case are more than twice those in the Reference case. The opposite occurs in the Low Oil Price case: low Brent crude oil prices cause oil-linked LNG contracts to become relatively less competitive and make U.S. LNG exports less desirable. Lower overseas demand for U.S. LNG exports causes the average Henry Hub price to reach only $7.15/million Btu in 2040, 9% lower than in the Reference case.

Global growth and trade weaken beyond 2025, creating headwinds for U.S. export-oriented industries

In the AEO2015 projections, growth in U.S. net exports contributes more to GDP growth than it has over the past 30 years (partially due to a reduction in net energy imports); however, its impact diminishes in the later years of the projection, reflecting slowing GDP growth in nations that are U.S. trading partners, along with the impacts of exchange rates and prices on trade. As economic growth in the rest of the world slows (as shown in Table ES1), so does U.S. export growth, with commensurate impacts on growth in manufacturing output, particularly in the paper, chemicals, primary metals, and other energy-intensive industries. The impact varies across industries.

Recent model revisions to the underlying industrial supply and demand relationships[9] have emphasized the importance of trade to manufacturing industries, so that the composition of trade determines the level of industrial output. Consumer goods and industrial supplies show higher levels of net export growth than other categories throughout the projection. The diminishing net export growth in all categories in the later years of the projection explains much of the leveling off of growth that occurs in some trade-sensitive industries.

Figure ES3. U.S. net energy imports in six cases, 2005-40 (quadrillion Btu)



U.S. net energy imports decline and ultimately end, largely in response to increased oil and dry natural gas production

Energy imports and exports come into balance in the United States in the AEO2015 Reference case, starting in 2028. In the High Oil Price and High Oil and Gas Resource cases, with higher U.S. crude oil and dry natural gas production and lower imports, the United States becomes a net exporter of energy in 2019. In contrast, in the Low Oil Price case, the United States remains a net energy importer through 2040 (Figure ES3).

Economic growth assumptions also affect the U.S. energy trade balance. In the Low Economic Growth case, U.S. energy imports are lower than in the Reference case, and the United States becomes a net energy exporter in 2022. In the High Economic Growth case, the United States remains a net energy importer through 2040.

The share of total U.S. energy production from crude oil and lease condensate rises from 19% in 2013 to 25% in 2040 in the High Oil and Gas Resource case, as compared with no

Table ES1. Growth of trade-related factors in the Reference case, 1983-2040 (average annual percent change)

Measure	History: 1983-2013	2013-20	2020-25	2025-30	2030-35	2035-40
U.S. GDP	2.8%	2.6%	2.5%	2.3%	2.2%	2.3%
U.S. GDP per capita	1.8%	1.8%	1.8%	1.6%	1.6%	1.8%
U.S. exports	6.1%	4.8%	6.2%	4.8%	4.5%	4.1%
U.S. imports	6.0%	4.6%	4.1%	3.7%	3.7%	3.7%
U.S. net export growth	0.1%	0.3%	2.1%	1.1%	0.8%	0.3%
Real GDP of OECD trading partners	2.4%	2.1%	1.9%	1.8%	1.7%	1.7%
Real GDP of other trading partners	4.7%	4.3%	4.2%	3.7%	3.4%	3.2%

Note: Major U.S. trading partners include Australia, Canada, Switzerland, United Kingdom, Japan, Sweden, and the Eurozone. Other U.S. trading partners include Argentina, Brazil, Chile, Columbia, Mexico, Hong Kong, Indonesia, India, Israel, South Korea, Malaysia, Philippines, Russia, Saudi Arabia, Singapore, Thailand, Taiwan, and Venezuela.

[9]AEO2015 incorporates the U.S. Bureau of Economic Analysis (BEA) updated 2007 input-output table, released at the end of December 2013. See U.S. Department of Commerce, Bureau of Economic Analysis, "Industry Economic Accounts Information Guide (Washington, DC: December 18, 2014), http://www.bea.gov/industry/iedguide.htm#aia.

change in the Reference case. Dry natural gas production remains the largest contributor to total U.S. energy production through 2040 in all the AEO2015 cases, with a higher share in the High Oil and Gas Resource case (38%) than in the Reference case (34%) and all other cases. In 2013, dry natural gas accounted for 30% of total U.S. energy production.

Coal's share of total U.S. energy production in the High Oil and Gas Resource case falls from 26% in 2013 to 15% in 2040. In the Reference case and most of the other AEO2015 cases, the coal share remains slightly above 20% of total U.S. energy production through 2040; in the Low Oil Price case, with lower oil and gas production levels, it remains essentially flat at 23% through 2040.

Continued strong growth in domestic production of crude oil from tight formations leads to a decline in net imports of crude oil and petroleum products

U.S. crude oil production from tight formations leads the growth in total U.S. crude oil production in all the AEO2015 cases. In the Reference case, lower levels of domestic consumption of liquid fuels and higher levels of domestic production of crude oil push the net import share of crude oil and petroleum products supplied down from 33% in 2013 to 17% in 2040 (Figure ES4).

In the High Oil Price and High Oil and Gas Resource cases, growth in tight oil production results in significantly higher levels of total U.S. crude oil production than in the Reference case. Crude oil production in the High Oil and Gas Resource case increases to 16.6 million barrels per day (bbl/d) in 2040, compared with a peak of 10.6 million bbl/d in 2020 in the Reference case. In the High Oil Price case, production reaches a high of 13.0 million bbl/d in 2026, then declines to 9.9 million bbl/d in 2040 as a result of earlier resource development. In the Low Oil Price case, U.S. crude oil production totals 7.1 million bbl/d in 2040. The United States becomes a net petroleum exporter in 2021 in both the High Oil Price and High Oil and Gas Resource cases. With lower levels of domestic production and higher domestic consumption in the Low Oil Price case, the net import share of total liquid fuels supply increases to 36% of total domestic supply in 2040.

Net natural gas trade, including LNG exports, depends largely on the effects of resource levels and oil prices

In all the AEO2015 cases, the United States transitions from a net importer of 1.3 Tcf of natural gas in 2013 (5.5% of the 23.7 Tcf delivered to consumers) to a net exporter in 2017. Net exports continue to grow after 2017, to a 2040 range between 3.0 Tcf in the Low Oil Price case and 13.1 Tcf in the High Oil and Gas Resource case (Figure ES5).

In the Reference case, LNG exports reach 3.4 Tcf in 2030 and remain at that level through 2040, when they account for 46% of total U.S. natural gas exports. The growth in U.S. LNG exports is supported by differences between international and domestic natural gas prices. LNG supplied to international markets is primarily priced on the basis of world oil prices, among other factors. This results in significantly higher prices for global LNG than for domestic natural gas supply, particularly in the near term. However, the relationship between the price of international natural gas supplies and world oil prices is assumed to weaken later in the projection period, in part as a result of growth in U.S. LNG export capacity. U.S. natural gas prices are determined primarily by the availability and cost of domestic natural gas resources.

In the High Oil Price case, with higher world oil prices resulting in higher international natural gas prices, U.S. LNG exports climb to 8.1 Tcf in 2033 and account for 73% of total U.S. natural gas exports in 2040. In the High Oil and Gas Resource case, abundant U.S. dry natural gas production keeps domestic natural gas prices lower than international prices, supporting the growth of U.S. LNG exports, which total 10.3 Tcf in 2037 and account for 66% of total U.S. natural gas exports in 2040. In the Low Oil Price case,

Figure ES4. Net crude oil and petroleum product imports as a percentage of U.S. product supplied in four cases, 2005-40 (percent)

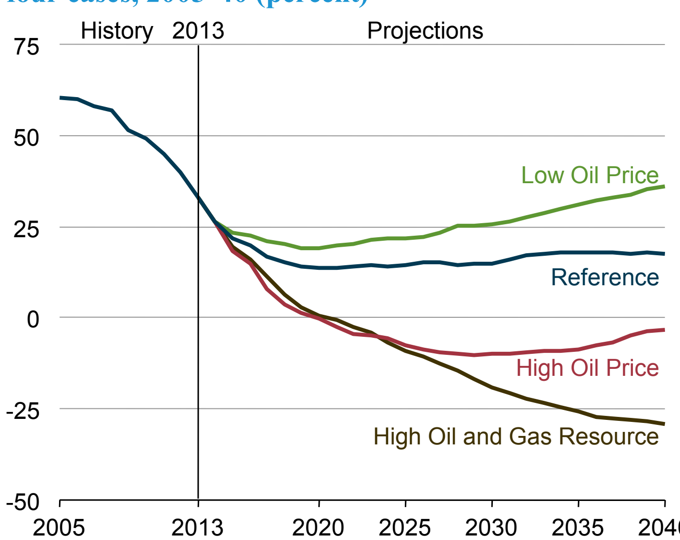
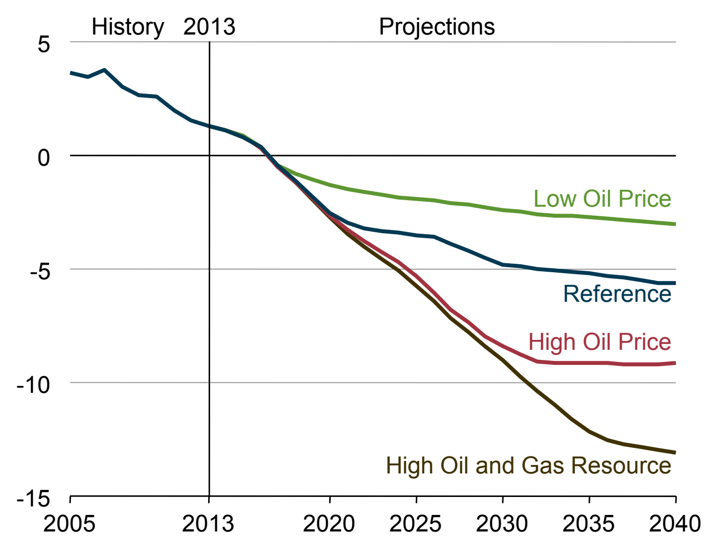


Figure ES5. U.S. total net natural gas imports in four cases, 2005-40 (trillion cubic feet)



with lower world oil prices, U.S. LNG exports are less competitive and grow more slowly, to a peak of 0.8 Tcf in 2018, and account for 13% of total U.S. natural gas exports in 2040.

Additional growth in net natural gas exports comes from growing natural gas pipeline exports to Mexico, which reach a high of 4.7 Tcf in 2040 in the High Oil and Gas Resource case (compared with 0.7 Tcf in 2013). In the High Oil Price case, U.S. natural gas pipeline exports to Mexico peak at 2.2 Tcf in 2040, as higher domestic natural gas prices resulting from increased world demand for LNG reduce the incentive to export natural gas via pipeline. Natural gas pipeline net imports from Canada remain below 2013 levels through 2040 in all the AEO2015 cases, but these imports do increase in response to higher natural gas prices in the latter part of the projection period.

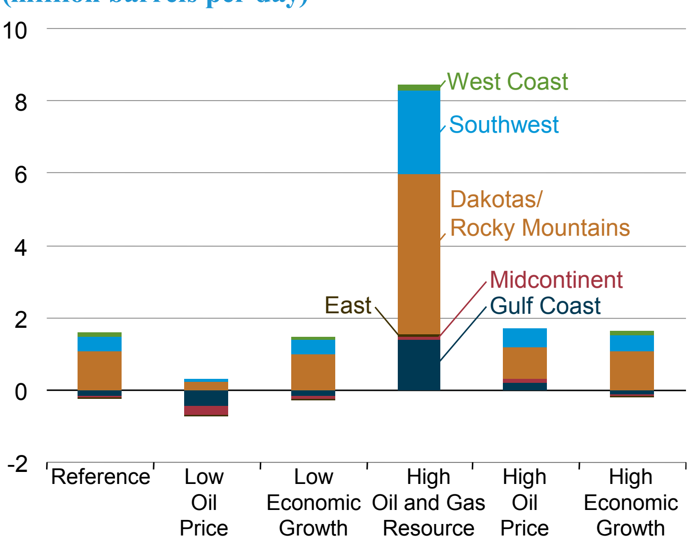
Regional variations in domestic crude oil and dry natural gas production can force significant shifts in crude oil and natural gas flows between U.S. regions, requiring investment in or realignment of pipelines and other midstream infrastructure

U.S. crude oil and dry natural gas production levels have increased rapidly in recent years. From 2008 to 2013, crude oil production grew from 5.0 million bbl/d to 7.4 million bbl/d, and annual dry natural gas production grew from 20.2 Tcf to 24.3 Tcf. All the AEO2015 cases project continued growth in U.S. dry natural gas production, whereas crude oil production continues to increase but eventually declines in all cases except the High Oil and Gas Resource case. In most of the cases, Lower 48 onshore crude oil production shows the strongest growth in the Dakotas/Rocky Mountains region (which includes the Bakken formation), followed by the Southwest region (which includes the Permian Basin) (Figure ES6). The strongest growth of dry natural gas production in the Lower 48 onshore in most of the AEO2015 cases occurs in the East region (which includes the Marcellus Shale and Utica Shale), followed by the Gulf Coast onshore region and the Dakotas/Rocky Mountains region. Interregional flows to serve downstream markets vary significantly among the different cases.

In the High Oil Price case, higher prices for crude oil and increased demand for LNG support higher levels of Lower 48 onshore crude oil and dry natural gas production than in the Reference case. Production in the High Oil Price case is exceeded only in the High Oil and Gas Resource case, where greater availability of oil and natural gas resources leads to more rapid production growth. The higher production levels in the High Oil Price and High Oil and Gas Resource cases are sustained through the entire projection period. Onshore Lower 48 crude oil production in 2040 drops below its 2013 level only in the Low Oil Price case, which also shows the lowest growth of dry natural gas production.

Crude oil imports into the East Coast and Midwest Petroleum Administration for Defense Districts (PADDs) 1 and 2 grow from 2013 to 2040 in all cases except the High Oil and Gas Resource case. All cases, including the High Oil and Gas Resource case, maintain significant crude oil imports into the Gulf Coast (PADD 3) and West Coast (PADD 5) through 2040. The Dakotas/Rocky Mountains (PADD 4) has significant crude oil imports only through 2040 in the High Oil Price case. The high levels of crude oil imports in all cases except the High Oil and Gas Resource case support growing levels of gasoline, diesel, and jet fuel exports as U.S. refineries continue to have a competitive advantage over refineries in the rest of the world. The High Oil and Gas Resource case is the only case with significant crude oil exports, which occur as a result of additional crude oil exports to Canada. The High Oil and Gas Resource case also shows significantly higher amounts of natural gas flowing out of the Mid-Atlantic and Dakotas/Rocky Mountains regions than most other cases, and higher LNG exports out of the Gulf Coast than any other case.

Figure ES6. Change in U.S. Lower 48 onshore crude oil production by region in six cases, 2013-40 (million barrels per day)



U.S. energy consumption grows at a modest rate over the projection with reductions in energy intensity resulting from improved technologies and from policies in place

U.S. energy consumption grows at a relatively modest rate over the AEO2015 projection period, averaging 0.3%/year from 2013 through 2040 in the Reference case. The transportation and residential sector's decreases in energy consumption (less than 2% over the entire projection period) contrast with growth in other sectors. The strongest energy consumption growth is projected for the industrial sector, at 0.7%/year. Declines in energy consumption tend to result from the adoption of more energy-efficient technologies and policies that promote energy efficiency. Increases tend to result from other factors, such as economic growth and the relatively low energy prices that result from an abundance of supplies.

Near-zero growth in energy consumption is a relatively recent phenomenon, and substantial uncertainty is associated with specific aspects of U.S. energy consumption in the AEO2015 projections. This uncertainty is especially relevant as the United States continues to recover from the latest economic recession and resumes more normal economic growth. Although demand for energy often grew with economic recoveries during the second half of the 20th century, technology and policy factors currently are acting in combination to dampen growth in energy consumption.

The AEO2015 alternative cases demonstrate these dynamics. The High and Low Economic Growth cases project higher and lower levels of travel demand, respectively, and of energy consumption growth, while holding policy and technology assumptions constant. In the High Economic Growth case and the High Oil and Gas Resource case, energy consumption growth (0.6%/year and 0.5%/year, respectively) is higher than in the Reference case. Energy consumption growth in the Low Economic Growth case is lower than in the Reference case (nearly flat). In the High Oil Price case, it is higher than in the Reference case, at 0.5%/year, mainly as a result of increased domestic energy production and more consumption of diesel fuel for freight transportation and trucking.

In the AEO2015 Reference case, as a result of increasingly stringent fuel economy standards, gasoline consumption in the transportation sector in 2040 is 21% lower than in 2013. In contrast, diesel fuel consumption, largely for freight transportation and trucking, grows at an average rate of 0.8%/year from 2013 to 2040, as economic growth results in more shipments of goods. Because the United States consumes more gasoline than diesel fuel, the pattern of gasoline consumption strongly influences the overall trend of energy consumption in the transportation sector (Figure ES7).

Industrial energy use rises with growth of shale gas supply

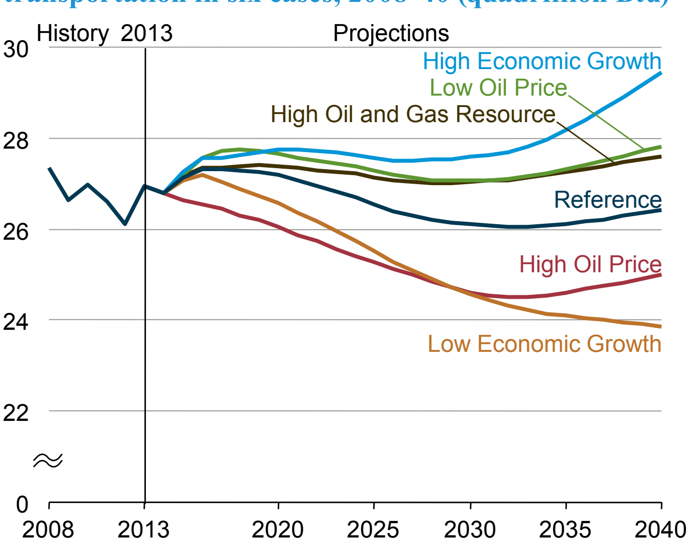
Production of dry natural gas and natural gas plant liquids (NGPL) in the United States has increased markedly over the past few years, and the upward production trend continues in the AEO2015 Reference, High Oil Price, and High Oil and Gas Resource cases, with the High Oil and Gas Resource case showing the strongest growth in production of both dry natural gas and NGPL. Sustained high levels of dry natural gas and NGPL production at prices that are attractive to industry in all three cases contribute to the growth of industrial energy consumption over the 2013-40 projection period and expand the range of fuel and feedstock choices.

Increased supply of natural gas from shale resources and the associated liquids contributes to lower prices for natural gas and hydrocarbon gas liquids (HGL), which support higher levels of industrial output. The energy-intensive bulk chemicals industry benefits from lower prices for fuel (primarily natural gas) and feedstocks (natural gas and HGL), as consumption of natural gas and HGL feedstocks increases by more than 50% from 2013 to 2040 in the Reference case, mostly as a result of growth in the total capacity of U.S. methanol, ammonia (mostly for nitrogenous fertilizers), and ethylene catalytic crackers. Increased availability of HGL leads to much slower growth in the use of heavy petroleum-based naphtha feedstocks compared to the lighter HGL feedstocks (ethane, propane, and butane). With sustained low HGL prices, the feedstock slate continues to favor HGL at unprecedented levels.

Other energy-intensive industries, such as primary metals and pulp and paper, also benefit from the availability and pricing of dry natural gas production from shale resources. However, factors other than lower natural gas and HGL prices, such as changes in nonenergy costs and export demand, also play significant roles in increasing manufacturing output.[10]

Manufacturing gross output in the High Oil and Gas Resource case is only slightly higher than in the Reference case, and most of the difference in industrial natural gas use between the two cases is attributable to the mining industry—specifically, oil and gas extraction. With increased extraction activity in the High Oil and Gas Resource case, natural gas consumption for lease and plant use in 2040 is 1.6 quadrillion Btu (68%) higher than in the Reference case.

Figure ES7. Delivered energy consumption for transportation in six cases, 2008-40 (quadrillion Btu)



Increased production of dry natural gas from shale resources (e.g., as seen in the High Oil and Gas Resource case relative to the Reference case) leads to a lower natural gas price, which leads to more natural gas use for combined heat and power (CHP) generation in the industrial sector. In 2040, natural gas use for CHP generation is 12% higher in the High Oil and Gas Resource case than in the Reference case, reflecting the higher levels of dry natural gas production. Finally, the increased supply of dry natural gas from shale resources leads to the increased use of natural gas to meet heat and power needs in the industrial sector.

Renewables meet much of the growth in electricity demand

Renewable electricity generation in the AEO2015 Reference case increases by 72% from 2013 to 2040, accounting for more than one-third of new generation capacity. The renewable share of total generation grows from 13% in 2013

[10] E. Sendich, "The Importance of Natural Gas in the Industrial Sector With a Focus on Energy-Intensive Industries," EIA Working Paper (February 28, 2014), http://www.eia.gov/workingpapers/pdf/natgas_indussector.pdf.

to 18% in 2040. Federal tax credits and state renewable portfolio standards that do not expire (sunset) continue to drive the relatively robust near-term growth of nonhydropower renewable sources, with total renewable generation increasing by 25% from 2013 to 2018. However, from 2018 through about 2030, the growth of renewable capacity moderates, as relatively slow growth of electricity demand reduces the need for new generation capacity. In addition, the combination of relatively low natural gas prices and the expiration of several key federal and state policies results in a challenging economic environment for renewables. After 2030, renewable capacity growth again accelerates, as natural gas prices increase over time and renewables become increasingly cost-competitive in some regions.

Wind and solar generation account for nearly two-thirds of the increase in total renewable generation in the AEO2015 Reference case. Solar photovoltaic (PV) technology is the fastest-growing energy source for renewable generation, at an annual average rate of 6.8%. Wind energy accounts for the largest absolute increase in renewable generation and for 40.0% of the growth in renewable generation from 2013 to 2038, displacing hydropower and becoming the largest source of renewable generation by 2040. PV capacity accounts for nearly all the growth in solar generation, split between the electric power sector and the end-use sectors (e.g., distributed or customer-sited generation). Geothermal generation grows at an average annual rate of about 5.5% over the projection period, but because geothermal resources are concentrated geographically, the growth is limited to the western United States. Biomass generation increases by an average of 3.1%/year, led by cofiring at existing coal plants through about 2030. After 2030, new dedicated biomass plants account for most of the growth in generation from biomass energy sources.

In the High Economic Growth and High Oil Price cases, renewable generation growth exceeds the levels in the Reference case—more than doubling from 2013 to 2040 in both cases (Figure ES8), primarily as a result of increased demand for new generation capacity in the High Economic Growth case and relatively more expensive competing fuel prices in the High Oil Price case. In the Low Economic Growth and Low Oil Price cases, with slower load growth and lower natural gas prices, the overall increase in renewable generation from 2013 to 2040 is somewhat smaller than in the Reference case but still grows by 49% and 61%, respectively, from 2013 to 2040. Wind and solar PV generation in the electric power sector, the sector most affected by renewable electric generation, account for most of the variation across the alternative cases in the later years of the projections.

Electricity prices increase with rising fuel costs and expenditures on electric transmission and distribution infrastructure

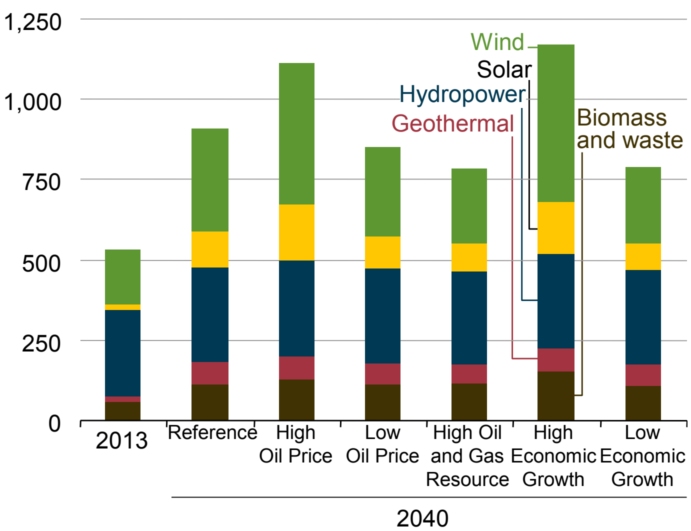
In the AEO2015 Reference case, increasing costs of electric power generation and transmission and distribution, coupled with relatively slow growth of electricity sales (averaging 0.7%/year), result in an 18% increase in the average retail price of electricity (in real 2013 dollars) over the projection period. In the Reference case, prices increase from 10.1 cents/kilowatthour (kWh) in 2013 to 11.8 cents/kWh in 2040. In comparison, over the same period, the largest increase in retail electricity prices (28%) is in the High Oil Price case (to 12.9 cents/kWh in 2040), and the smallest increase (2%) is in the High Oil and Gas Resource case (to 10.3 cents/kWh in 2040). Electricity prices are determined by economic conditions, efficiency of energy use, competitiveness of electricity supply, investment in new generation capacity, investment in transmission and distribution infrastructure, and the costs of operating and maintaining plants in service. Those factors vary in the alternative cases.

Fuel costs (mostly for coal and natural gas) account for the largest portion of generation costs in consumer electricity bills. In 2013, coal accounted for 44% and natural gas accounted for 42% of the total fuel costs for electricity generation. In the AEO2015 Reference case, coal accounts for 35% and natural gas for 55% of total fuel costs in 2040. Coal prices rise on average by 0.8% per year and natural gas prices by 2.4%/year in the Reference case, compared with 1.3%/year and 3.1%/year, respectively, in the High Oil Price case and 0.5%/year and 0.2%/year, respectively, in the High Oil and Gas Resource case.

There has been a fivefold increase in investment in new electricity transmission capacity in the United States since 1997, as well as large increases in spending for distribution capacity. Although investments in new transmission and distribution capacity do not continue at the same rates in AEO2015, spending continues on additional transmission and distribution capacity to connect to new renewable energy sources; improvements in the reliability and resiliency of the grid; enhancements to community aesthetics (underground lines); and smart grid construction.

The average annual rate of growth in U.S. electricity use (including sales and direct use) has slowed from 9.8% in the 1950s to 0.5% over the past decade. Factors contributing to the lower rate of growth include slower population growth, market saturation of electricity-intensive appliances, improvements in the efficiency of household appliances, and

Figure ES8. Total U.S. renewable generation in all sectors by fuel in six cases, 2013 and 2040 (billion kilowatthours)



a shift in the economy toward a larger share of consumption in less energy-intensive industries. In the AEO2015 Reference case, U.S. electricity use grows by an average of 0.8%/year from 2013 to 2040.

Energy-related CO2 emissions stabilize with improvements in the energy intensity and carbon intensity of electricity generation

U.S. energy-related CO2 emissions in 2013 totaled 5,405 million metric tons (mt).[11] In the AEO2015 Reference case, CO2 emissions increase by 144 million mt (2.7%) from 2013 to 2040, to 5,549 million mt—still 444 million mt below the 2005 level of 5,993 million mt. Among the AEO2015 alternative cases, total emissions in 2040 range from a high of 5,979 million mt in the High Economic Growth case to a low of 5,160 million mt in the Low Economic Growth case.

In the Reference case:

- CO2 emissions from the electric power sector increase by an average of 0.2%/year from 2013 to 2040, as a result of relatively slow growth in electricity sales (averaging 0.7%/year) and increasing substitution of lower-carbon fuels, such as natural gas and renewable energy sources, for coal in electricity generation.
- CO2 emissions from the transportation sector decline by an average of 0.2%/year, with overall improvements in vehicle energy efficiency offsetting increased travel demand, growth in diesel consumption in freight trucks, and consumer's preference for larger, less-efficient vehicles as a result of the lower fuel prices that accompany strong growth of domestic oil and dry natural gas production.
- CO2 emissions from the industrial sector increase by an average of 0.5%/year, reflecting a resurgence of industrial activity fueled by low energy prices, particularly for natural gas and HGL feedstocks in the bulk chemical sector.
- CO2 emissions from the residential sector decline by an average of 0.2%/year, with improvements in appliance and building shell efficiencies more than offsetting growth in housing units.
- CO2 emissions from the commercial sector increase by an average of 0.3%/year even with improvements in equipment and building shell efficiency, as a result of increased electricity consumption resulting from the growing proliferation of data centers and electric devices, such as networking equipment and video displays, as well as greater use of natural gas-fueled combined heat and power distributed generation.

[11] Based on EIA, Monthly Energy Review (November 2014), and reported here for consistency with data and other calculations in the AEO2015 tables. The 2013 total was subsequently updated to 5,363 million metric tons in EIA's February 2015 Monthly Energy Review, DOE/EIA-0035(2015/02), http://www.eia.gov/totalenergy/data/monthly/archive/00351502.pdf.

Introduction

In preparing the *Annual Energy Outlook 2015* (AEO2015)—a shorter edition; see text box on page 2—the U.S. Energy Information Administration (EIA) evaluated a range of trends and issues that could have major implications for U.S. energy markets. This report presents the AEO2015 Reference case and compares it with five alternative cases (Low and High Oil Price, Low and High Economic Growth, and High Oil and Gas Resource) that were completed as part of AEO2015 (see Appendixes A, B, C, and D).

Because of the uncertainties inherent in any energy market projection, the Reference case results should not be viewed in isolation. Readers are encouraged to review the alternative cases to gain perspective on how variations in key assumptions can lead to different outlooks for energy markets. In addition to the alternative cases prepared for AEO2015, EIA has examined many proposed policies affecting energy markets over the past few years. Reports describing the results of those analyses are available on EIA's website.[12]

Table 1 provides a summary of the six cases produced as part of AEO2015. For each case, the table gives the name used in AEO2015 and a brief description of the major assumptions underlying the projections. Regional results and other details of the projections are available at http://www.eia.gov/forecasts/aeo/tables_ref.cfm#supplement.

Table 1. Summary of AEO2015 cases

Case name	Description
Reference	Real gross domestic product (GDP) grows at an average annual rate of 2.4% from 2013 to 2040, under the assumption that current laws and regulations remain generally unchanged throughout the projection period. North Sea Brent crude oil prices rise to $141/barrel (bbl) (2013 dollars) in 2040. Complete projection tables are provided in Appendix A.
Low Economic Growth	Real GDP grows at an average annual rate of 1.8% from 2013 to 2040. Other energy market assumptions are the same as in the Reference case. Partial projection tables are provided in Appendix B.
High Economic Growth	Real GDP grows at an average annual rate of 2.9% from 2013 to 2040. Other energy market assumptions are the same as in the Reference case. Partial projection tables are provided in Appendix B.
Low Oil Price	Low oil prices result from a combination of low demand for petroleum and other liquids in nations outside the Organization for Economic Cooperation and Development (non-OECD nations) and higher global supply. On the supply side, the Organization of Petroleum Exporting Countries (OPEC) increases its liquids market share from 40% in 2013 to 51% in 2040, and the costs of other liquids production technologies are lower than in the Reference case. Light, sweet (Brent) crude oil prices remain around $52/bbl (2013 dollars) through 2017, and then rise slowly to $76/bbl in 2040. Other energy market assumptions are the same as in the Reference case. Partial projection tables are provided in Appendix C.
High Oil Price	High oil prices result from a combination of higher demand for liquid fuels in non-OECD nations and lower global crude oil supply. OPEC's liquids market share averages 32% throughout the projection. Non-OPEC crude oil production expands more slowly in short- to mid-term relative to the Reference case. Brent crude oil prices rise to $252/bbl (2013 dollars) in 2040. Other energy market assumptions are the same as in the Reference case. Partial projection tables are provided in Appendix C.
High Oil and Gas Resource	Estimated ultimate recovery (EUR) per shale gas, tight gas, and tight oil well is 50% higher and well spacing is 50% closer (i.e., the number of wells drilled is 100% higher) than in the Reference case. In addition, tight oil resources are added to reflect new plays or the expansion of known tight oil plays, and the EUR for tight and shale wells increases by 1%/year more than the annual increase in the Reference case to reflect additional technology improvements. This case also includes kerogen development; undiscovered resources in the offshore Lower 48 states and Alaska; and coalbed methane and shale gas resources in Canada that are 50% higher than in the Reference case. Other energy market assumptions are the same as in the Reference case. Partial projection tables are provided in Appendix D.

[12]See "Congressional and other requests," http://www.eia.gov/analysis/reports.cfm?t=138.

Changes in release cycle for EIA's *Annual Energy Outlook*

To focus more resources on rapidly changing energy markets and the ways in which they might evolve over the next few years, the U.S. Energy Information Administration (EIA) is revising the schedule and approach for production of the *Annual Energy Outlook* (AEO). Starting with this *Annual Energy Outlook 2015* (AEO2015), EIA is adopting a two-year release cycle for the AEO, with full and shorter editions of the AEO produced in alternating years. AEO2015 is a shorter edition of the AEO.

The shorter AEO includes a limited number of model updates, which are selected predominantly to reflect historical data updates and changes in legislation and regulations. A complete listing of the changes made for AEO2015 is shown in Appendix E. The shorter edition includes a Reference case and five alternative cases: Low Oil Price, High Oil Price, Low Economic Growth, High Economic Growth, and High Oil and Gas Resource.

The shorter AEO will include this publication, which discusses the Reference case and alternative cases, as well as the report, *Assumptions to the Annual Energy Outlook 2015.*[13] Other documentation—including model documentation for each of the National Energy Modeling System (NEMS) models and the *Retrospective Review*—will be completed only for the years when a full edition of the AEO is produced.

To provide a basis against which alternative cases and policies can be compared, the AEO Reference case generally assumes that current laws and regulations affecting the energy sector remain unchanged throughout the projection (including the assumption that laws that include sunset dates do, in fact, expire at the time of those sunset dates). This assumption enables policy analysis with less uncertainty regarding unstated legal or regulatory assumptions.

Economic growth

The AEO economic forecasts are trend projections, with no major shocks assumed and with potential growth determined by the economy's supply capability. Growth in aggregate supply depends on increases in the labor force, growth of capital stocks, and improvements in productivity. Long-term demand growth depends on labor force growth, income growth, and population growth. The AEO2015 Reference case uses the U.S. Census Bureau's December 2012 middle population projection: U.S. population grows at an average annual rate of 0.7%, real GDP at 2.4%, labor force at 0.6%, and nonfarm labor productivity at 2.0% from 2013 to 2040.

Table 2. Growth in key economic factors in historical data and in the Reference case

	AEO2015 (2013-40)	Previous 30 Years
Real 2009 dollars (annual average percent change)		
GDP	2.4	2.8
GDP per capita	1.7	1.8
Disposable income	2.5	2.9
Consumer spending	2.4	3.1
Private investment	3.0	3.5
Exports	4.9	6.1
Imports	*4.0*	*6.0*
Government expenditures	*0.9*	*1.7*
GDP: Major trading countries	*1.9*	*2.4*
GDP: Other trading countries	*3.8*	*4.7*
Average annual rate		
Federal funds rate	*3.2*	*4.5*
Unemployment rate	*5.3*	*6.3*
Nonfarm business output per hour	*2.0*	*2.0*

Source: AEO2015 Reference case D021915a, based on IHS Global Insight T301114.wf1.

Table 2 compares key long-run economic growth projections in AEO2015 with actual growth rates over the past 30 years. In the AEO2015 Reference case, U.S. real GDP grows at an average annual rate of 2.4% from 2013 to 2040—a rate that is 0.4 percentage points slower than the average over the past 30 years. GDP expands in the Reference case by 3.1% in 2015, 2.5% in 2016, 2.6% from 2015 to 2025, and 2.4% from 2015 to 2040. As a share of GDP, consumption expenditures account for more than two-thirds of total GDP. In terms of growth, it is exports and business fixed investment that contribute the most to GDP. Growth in these is relatively strong during the first 10 years of the projection and then moderates for the remaining years. The growth rates for both exports and business fixed investment are above the rate of GDP growth with exports dominating throughout the projection (Figure 1).

In the AEO2015 Reference case, nominal interest rates over the 2013-40 period are generally lower than those observed for the preceding 30 years, based on an expectation of lower inflation rates in the projection period. At present, the term structure of interest rates is still at the lowest level seen over the past 40 years. In 2012, the federal funds rate averaged 0.1%. Longer-term nominal interest rates are projected to average around 6.0%, which is lower than the previous 30-year average of 7.8%. After 2015, interest rates in ensuing

[13]U.S. Energy Information Administration, Assumptions to the Annual Energy Outlook 2015, DOE/EIA-0554(2015) (Washington, DC, to be published), http://www.eia.gov/forecasts/aeo/assumptions.

five-year periods through 2040 are expected to stabilize at a slightly higher level than the five-year averages through 2013, 2014, and 2015, as the result of a modest inflation rate.

Appreciation in the U.S. dollar exchange rate dampens export growth during the first five years of the projections; however, the dollar is expected to depreciate relative to the currencies of major U.S. trading partners after 2020, which combined with modest growth in unit labor costs stimulates U.S. export growth toward the end of the projection, eventually improving the U.S. current account balance. Real exports of goods and services grow at an average annual rate of 4.9%—and real imports of goods and services grow at an average annual rate of 4.0%—from 2013 to 2040 in the Reference case. The inflation rate, as measured by growth in the Consumer Price Index (CPI), averages 2.0% from 2013 to 2040 in the Reference case, compared with the average annual CPI inflation rate of 2.9% from 1983 to 2013.

Annual growth in total gross output of all goods and services, which includes both final and intermediate products, averages 1.9%/year from 2013 to 2040, with growth in the service sector (1.9%/year) just below manufacturing growth (2.0%/year) over the long term. In 2040, the manufacturing share of total gross output (17%) rises slightly above the 2013 level (16%) in the AEO2015 Reference case.

Total industrial production (which includes manufacturing, construction, agriculture, and mining) grows by 1.8%/year from 2013 to 2040 in the AEO2015 Reference case, with slower growth in key manufacturing industries, such as paper, primary metals, and aspects of chemicals excluding the plastic resin and pharmaceutical industries. Except for trade of industrial supplies, which mostly affect energy-intensive industries, net exports show weak growth until 2020. After 2020, export growth recovers as the dollar begins to depreciate and the economic growth of trading partners continues. Net export growth is strongest from the late 2020s through 2034 and declines from 2035 to 2040.

Updated information on how industries supply other industries and meet the demand of different types of GDP expenditures has influenced certain industrial projections.[14] For example, as a result of a better understanding of how the pulp and paper industry supplies other industries, trade of consumer goods and industrial supplies has a greater effect on production in the pulp and paper industry. Nonenergy-intensive manufacturing industries show higher growth than total industrial production, primarily as a result of growth in metal-based durables (Figure 2).

In the AEO2015 Reference case, manufacturing output goes through two distinct growth periods, with the clearest difference between periods seen in the energy-intensive industries. Stronger growth in U.S. manufacturing through 2025 results in part from increased shale gas production, which affects U.S. competitiveness and also results in higher GDP growth early in the projection period. In the Reference case, manufacturing output grows at an average annual rate of 2.3% from 2013 to 2025. After 2025, growth slows to 1.7% as a result of increased foreign competition and rising energy prices, with energy-intensive, trade-exposed industries showing the largest drop in growth. The energy-intensive industries grow at average rates of 1.8%/year from 2013 to 2025 and 0.7%/year from 2025 to 2040. Growth rates in the sector are uneven, with pulp and paper output decreasing at an average annual rate of 0.1% and the cement industry growing at an average annual rate of 3.1% from 2013 to 2040.

Figure 1. Annual changes in U.S. gross domestic product, business investment, and exports in the Reference case, 2015-40 (percent)

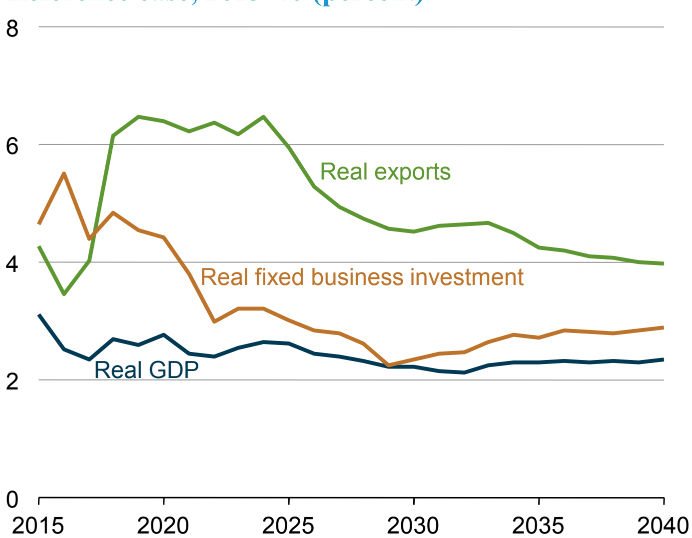
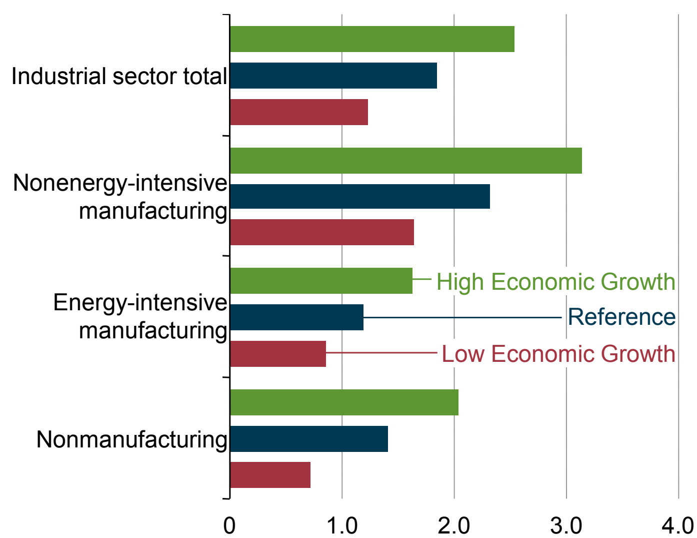


Figure 2. Annual growth rates for industrial output in three cases, 2013-40 (percent per year)



[14] The Industrial Output Model of the NEMS Macroeconomic Activity Module now uses the Bureau of Economic Analysis detailed input-output (IO) matrices for 2007 rather than 2002 (http://bea.gov/industry/io_annual.htm) and also now incorporates information from the aggregate IO matrices (http://bea.gov/industry/gdpbyind_data.htm).

AEO2015 presents three economic growth cases: Reference, High, and Low. The High Economic Growth case assumes higher growth and lower inflation, compared with the Reference case, and the Low Economic Growth case assumes lower growth and higher inflation. Differences among the Reference, High Economic Growth, and Low Economic Growth cases reflect different expectations for growth in population (specifically, net immigration), labor force, capital stock, and productivity, which are above trend in the High Economic Growth case and below trend in the Low Economic Growth case. The average annual growth rate for real GDP from 2013 to 2040 in the Reference case is 2.4%, compared with 2.9% in the High Economic Growth case and 1.8% in the Low Economic Growth case.

In the High Economic Growth case, with greater productivity gains and a larger labor force, the U.S. economy expands by 4.1% in 2015, 3.6% in 2016, 3.2% from 2015 to 2025, and 2.9% from 2015 to 2040. In the Low Economic Growth case, the current economic recovery (which is now more than five years old) stalls in the near term, and productivity and labor force growth are weak in the long term. As a result, economic growth averages 2.4% in 2015, 1.6% in 2016, 1.7% from 2015 to 2025, and 1.8% from 2015 to 2040 in the Low Economic Growth case (Table 3).

Energy prices

Crude oil

AEO2015 considers a number of factors related to the uncertainty of future world crude oil prices, including changes in worldwide demand for petroleum products, crude oil production, and supplies of other liquid fuels.[15] In the Reference, High Oil Price, and Low Oil Price cases, the North Sea Brent (Brent) crude oil price reflects the market price for light sweet crude oil free on board (FOB) at the Sullen Voe oil terminal in Scotland.

The Reference case reflects global oil market events through the end of 2014. Over the past two years, growth in U.S. crude oil production, along with the late-2014 drop in global crude oil prices, has altered the economics of the oil market. These new market conditions are assumed to continue in the Reference case, with the average Brent price dropping from $109/barrel (bbl) in 2013 to $56/bbl in 2015, before increasing to $76/bbl in 2018. After 2018, growth in demand from non-OECD countries—countries outside the Organization for Economic Cooperation and Development (OECD)—pushes the Brent price to $141/bbl in 2040 (in 2013 dollars). The increase in oil prices supports growth in domestic crude oil production.

The High Oil Price case assumes higher world demand for petroleum products, less upstream investment by the Organization of the Petroleum Exporting Countries (OPEC), and higher non-OPEC exploration and development costs. These factors all contribute to a rise in the average spot market price for Brent crude oil to $252/bbl in 2040, 78% above the Reference case. The reverse is true in the Low Oil Price case: lower non-OECD demand, higher OPEC upstream investment, and lower non-OPEC exploration

Table 3. Average annual growth of labor productivity, employment, income, and consumption in three cases (percent per year)

	2015	2016	2015-25	2015-40
Productivity				
High Economic Growth	2.3	2.3	2.4	2.3
Reference	1.9	1.6	2.1	2.0
Low Economic Growth	1.3	0.9	1.7	1.6
Non-farm employment				
High Economic Growth	2.9	1.9	1.2	0.9
Reference	2.2	1.6	0.8	0.7
Low Economic Growth	1.6	1.1	0.6	0.5
Real personal income				
High Economic Growth	3.6	3.3	3.4	2.8
Reference	3.3	2.8	2.8	2.5
Low Economic Growth	2.7	2.4	2.4	2.3
Real personal consumption				
High Economic Growth	3.6	3.5	3.2	2.9
Reference	3.0	3.0	2.5	2.4
Low Economic Growth	2.5	2.6	1.7	1.7

Source: AEO2015 Reference case D021915a, based on IHS Global Insight T301114.wf1.

[15] Liquid fuels, or petroleum and other liquids, includes crude oil and products of petroleum refining, natural gas liquids, biofuels, and liquids derived from other hydrocarbon sources (including coal-to-liquids and gas-to-liquids).

and development costs cause the Brent spot price to increase slowly to $76/bbl, or 47% below the price in the Reference case, in 2040 (Figure 3).

World liquid fuels consumption varies in the three cases as a result of different assumptions about future trends in oil prices, world oil supply, and the rate of non-OECD demand growth. Uncertainty about world crude oil production is also captured in the three cases. In the Reference case, world production is 99.1 million bbl/d in 2040. In comparison to the Reference case, total liquid fuel supplies and OPEC's market share are higher in the Low Oil Price case and lower in the High Oil Price case. For OPEC countries in the Middle East, Africa, and South America, combined production grows from less than 32.6 million bbl/d in 2013 to 58.3 million bbl/d in 2040 in the Low Oil Price case, compared with 43.5 million bbl/d in 2040 in the Reference case and 35.0 million bbl/d in 2040 in the High Oil Price case.

As increased OPEC production depresses world oil prices in the Low Oil Price case, development of some non-OPEC resources that are viable in the Reference case become uneconomical. As a result, non-OPEC production increases only slightly in the Low Oil Price case, from 45.3 million bbl/d in 2013 to 46.8 million bbl/d in 2040. In the High Oil Price case, non-OPEC production totals 63.8 million bbl/d in 2040. Unlike the High Oil and Gas Resource case, which assumes higher estimated ultimate recovery of crude oil and natural gas per well, closer well spacing, and greater advancement in production technology than the Reference case, the High Oil Price and Low Oil Price cases assume no changes in those factors from the Reference case.

Petroleum and other liquids products

The prices charged for petroleum products and other liquid products in the United States reflect the price that refiners pay for crude oil inputs, as well as operation, transportation, and distribution costs, and the margins that refiners receive. Changes in gasoline and distillate fuel oil prices generally move in the same direction as changes in the world crude oil price, but the changes in price are also influenced by demand factors. A 30% rise in the North Sea Brent crude oil spot price from 2013 to 2040 in the Reference case results in the weighted average U.S. petroleum product price rising by 15%, from $3.16/gallon to $3.62/gallon (in 2013 dollars). However, the effect of rising crude oil prices on distillate fuel use in the United States is less than for motor gasoline, because of a greater increase in distillate fuel demand as freight requirements continue to grow and the mix of light-duty vehicle fuels shifts from gasoline to diesel fuel. U.S. distillate fuel prices rise by 23% through 2040 in the Reference case, compared to an 11% increase for motor gasoline (Figure 4 and Figure 5). However, distillate fuel consumption rises by 15%, compared to a 20% decrease in motor gasoline consumption.

In the High Oil Price case, higher demand for crude oil in non-OECD countries and lower supply of OPEC crude oil push world crude oil prices up. As a result, the weighted average

Figure 3. North Sea Brent crude oil prices in three cases, 2005-40 (2013 dollars per barrel)

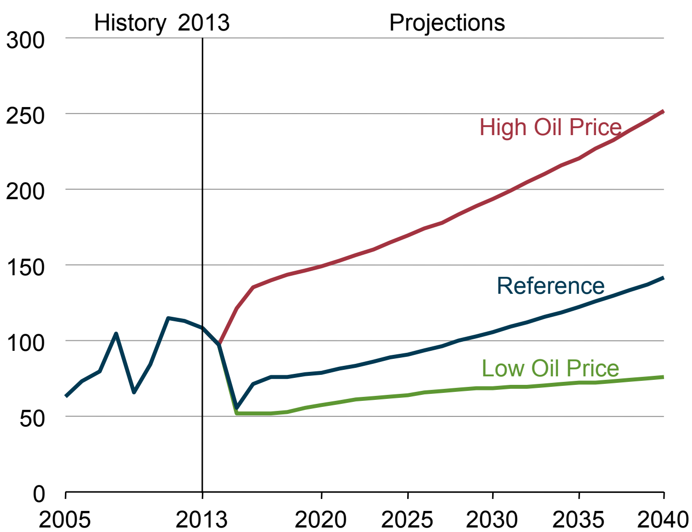


Figure 4. Motor gasoline prices in three cases, 2005-40 (2013 dollars per gallon)

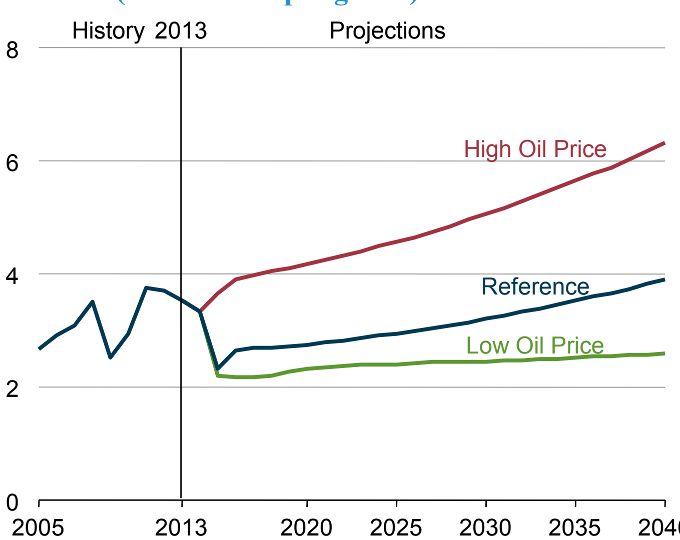
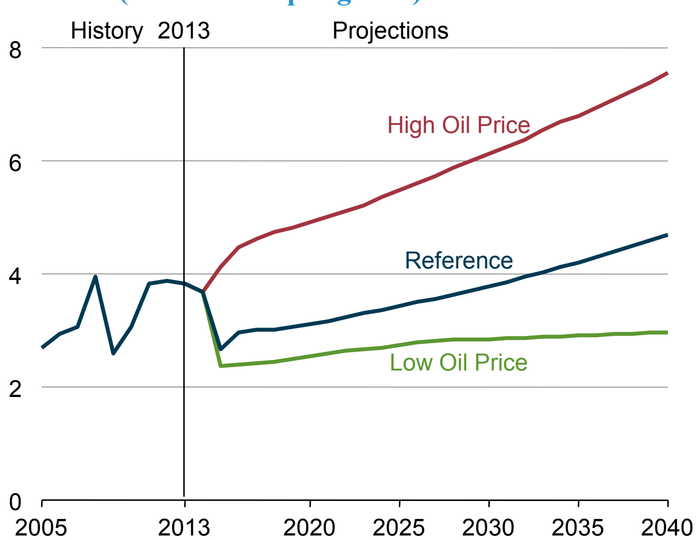


Figure 5. Distillate fuel oil prices in three cases, 2005-40 (2013 dollars per gallon)



price for U.S. petroleum products increases by 84%, from $3.16/gallon in 2013 to $5.81/gallon in 2040. In the Low Oil Price case, with lower non-OECD demand and higher OPEC supply pushing world oil prices down, the weighted average price for U.S. petroleum products drops by 26%, from $3.16/gallon in 2013 to $2.32/gallon in 2040.

In all the AEO2015 cases, U.S. laws and regulations shape demand and, consequently, the price of petroleum products in the United States. The Corporate Average Fuel Economy (CAFE) standards for new light-duty vehicles (LDVs), which typically use gasoline, rise from 30 miles per gallon (mpg) in 2013 to 54 mpg in 2040 under the fleet composition assumptions used in the final rule issued by the U.S. Environmental Protection Agency (EPA) and National Highway Transportation Safety Administration.[16] The rise in vehicle miles traveled (VMT) for LDVs does not fully offset the increase in fuel efficiency, and motor gasoline consumption declines through 2040 in all the AEO2015 cases. However, the effect of the standards varies by case because of the use of different assumptions about prices and economic growth. The 32% decrease in motor gasoline consumption in the High Oil Price case is larger than the decrease in the Reference case because higher gasoline prices reduce VMT, reducing consumption. In the Low Oil Price case, the decrease in gasoline consumption (11%) is smaller than in the Reference case because lower gasoline prices stimulate enough increased VMT to offset a part of the impact of fuel efficiency improvements resulting from regulation.

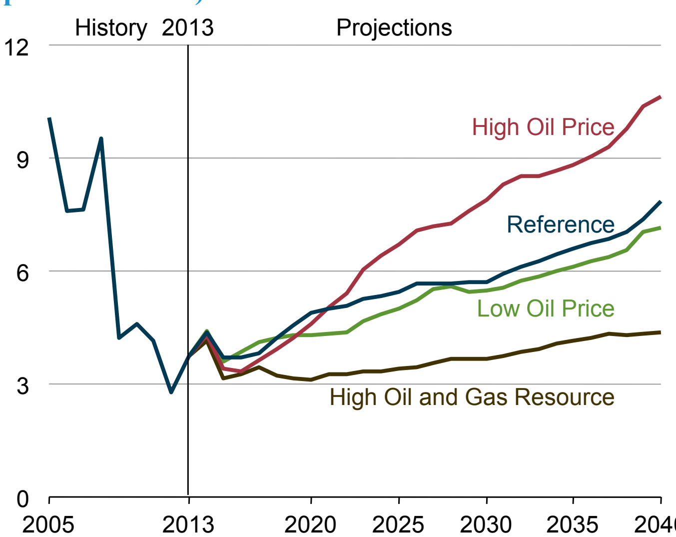
The efficiency and greenhouse gas (GHG) standard for heavy-duty vehicles, which typically consume distillate fuel, rises by about 16% through 2040, remaining below 8 mpg in all AEO2015 cases. Unlike the case for LDVs, the higher VMT in the Low Oil Price case more than offsets the increase in vehicle fuel efficiency, and distillate fuel consumption increases by 21% from 2013 to 2040. The increase in fuel consumption in the Low Oil Price case is greater than in the Reference case as a result of a 22% decrease in distillate fuel prices, to $2.97/gallon in 2040. In the High Oil Price case, the price of distillate fuel oil increases to $7.55/gallon in 2040—61% higher than in the Reference case—resulting in a 2% decline in distillate fuel consumption.

Natural gas

Henry Hub natural gas spot prices vary according to assumptions about the availability of domestically produced natural gas resources, overseas demand for U.S. liquefied natural gas (LNG), and trends in domestic consumption. In all cases, prices are lower in 2015 than the $3.73/million British thermal units (Btu) average Henry Hub spot price in 2013, and in most cases they are above that level by 2020 (Figure 6). In the AEO2015 Reference case, the Henry Hub spot price is $4.88/million Btu (2013 dollars) in 2020 and $7.85/million Btu in 2040, as increased demand in domestic and international markets requires an increased number of well completions to achieve higher levels of production. In addition, lower cost resources generally are expected to be produced earlier, with more expensive production occurring later in the projection period.

In the High Oil and Gas Resource case, U.S. domestic production from tight oil and natural gas formations is higher than in the Reference case as a result of assumed greater estimated ultimate recovery (EUR) per well, closer well spacing, and greater gains in technological development. Consequently, even with low natural gas prices, total U.S. domestic dry natural gas production grows sufficiently to satisfy higher levels of domestic consumption, as well as higher pipeline and LNG exports. With the abundance of natural gas produced domestically, the Henry Hub spot price (in 2013 dollars) falls from $3.14/million Btu in 2015 to $3.12/million Btu in 2020 (36% below the Reference case price) before rising to $4.38/million Btu in 2040 (44% below the Reference case price).

Figure 6. Average Henry Hub spot prices for natural gas in four cases, 2005-40 (2013 dollars per million Btu)



The Low and High Oil Price cases assume the same level of resource availability as the Reference case but different world oil prices, which affect the level of overseas demand for U.S. LNG exports. International LNG contracts are often linked to crude oil prices, even though their relationship may be weakening. Global demand for LNG is also directly influenced by oil prices, as LNG competes directly with petroleum products in many applications. When the North Sea Brent spot price, which is the principal benchmark price for crude oil on world markets, rises in the High Oil Price case, world LNG contracts linked to oil prices become more expensive, making LNG exports from the United States more desirable.

In the High Oil Price case, the Henry Hub natural gas spot price remains close to the Reference case price through 2020. However, higher overseas demand for U.S. LNG exports raises the average Henry Hub spot price to $10.63/million Btu in 2040, which is 35% above the Reference case price.

[16] U.S. Environmental Protection Agency and National Highway Transportation Safety Administration, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule," *Federal Register*, Vol. 77, No. 199 (Washington, DC, October 15, 2012), https://www.federalregister.gov/articles/2012/10/15/2012-21972/2017-and-later-model-year-light-duty-vehicle-greenhouse-gas-emissions-and-corporate-average-fuel.

In the Low Oil Price case, with lower demand for U.S. LNG exports, the Henry Hub spot price is only $7.15/million Btu in 2040—which is 9% lower than in the Reference case but 63% higher than in the High Oil and Gas Resource case.

Changes in the Henry Hub natural gas spot price generally translate to changes in the price of natural gas delivered to end users. The delivered price of natural gas to the electric power sector is highest in the High Oil Price case, where it rises from $4.40/million Btu in 2013 to $10.08/million Btu in 2040, compared with $8.28/million Btu in the Reference case. Higher delivered natural gas prices result in a decline in natural gas consumption in the electric power sector in the High Oil Price case, from 8.2 Tcf in 2013 to 6.8 Tcf in 2040, compared with an increase in natural gas consumption in the electric power sector to 9.4 Tcf in 2040 in the Reference case. In the Low Oil Price and High Oil and Gas Resource cases, smaller increases in delivered natural gas prices result in more consumption for power generation than in the Reference case or High Oil Price case in 2040.

As in the electric power sector, natural gas consumption in the U.S. industrial sector also changes in response to delivered natural gas prices. However, industrial natural gas consumption also changes in response to shifts in the mix of industrial output, as well as changes in refinery output and utilization. Consumption also varies with the relative economics of using natural gas for electricity generation in industrial combined heat and power (CHP) facilities. The largest increase in the price of natural gas delivered to the industrial sector, from $4.56/million Btu in 2013 to $11.03/million Btu in 2040, is seen in the High Oil Price case, followed by the Reference case ($8.78/million Btu in 2040), Low Oil Price case ($8.25/million Btu in 2040), and High Oil and Gas Resource case ($5.22/million Btu in 2040). Of those four cases, the largest increase in industrial natural gas consumption occurs in the High Oil and Gas Resource case, in which lower prices contribute to higher consumption. The next largest increase occurs in the High Oil Price case, where higher prices spur a significant increase in U.S. crude oil production and, accordingly, natural gas consumption at U.S. oil refineries.[17]

The price of natural gas delivered to the residential and commercial sectors increases from 2013 to 2040 in all the AEO2015 cases. The largest increase in delivered natural gas prices to both sectors through 2040 is in the High Oil Price case, followed by the Reference, Low Oil Price, and High Oil and Gas Resource cases. In the commercial sector, natural gas consumption increases in all cases, mainly as a result of increased commercial CHP use and growth in aggregate commercial square footage. Conversely, consumption in the residential sector decreases in all cases despite economic growth, as overall demand is reduced by population shifts to warmer areas, improvements in appliance efficiency, and increased use of electricity for home heating.

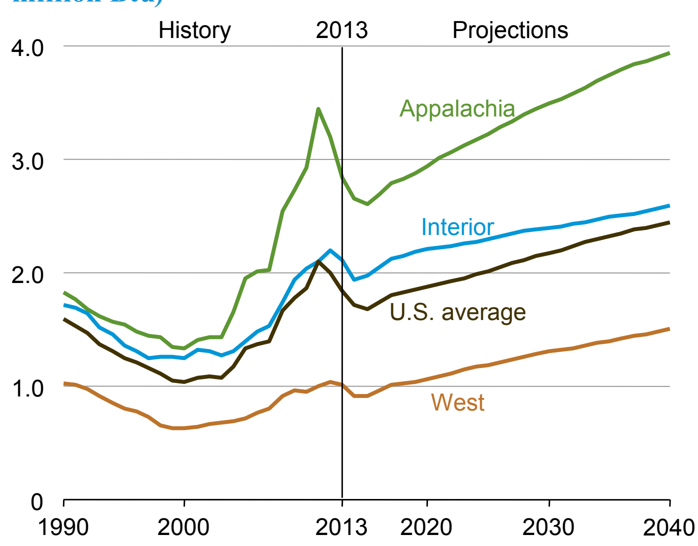
Coal

The average minemouth coal price increases by 1.0%/year in the AEO2015 Reference case, from $1.84/million Btu in 2013 to $2.44/million Btu in 2040. Higher prices result primarily from declines in coal mining productivity in several key supply regions, including Central Appalachia and Wyoming's Powder River Basin.

Across the AEO2015 alternative cases, the most significant changes in the average minemouth coal price compared with the Reference case occur in the Low and High Oil Price cases. In 2040, the average minemouth price is 6% lower in the Low Oil Price case and 7% higher in the High Oil Price case than in the Reference case. These variations from the Reference case are primarily the result of differences in the projections for diesel fuel and electricity prices in the Low and High Oil Price cases, because diesel fuel and electricity are key inputs to the coal mining process. The AEO2015 cases do not include the EPA's proposed Clean Power Plan,[18] which if implemented would likely have a substantial impact on coal use for power generation and coal markets more generally.

Increases in minemouth coal prices (in dollars/million Btu) occur in all coal-producing regions (Figure 7). In Appalachia and in the West, increases of 1.2%/year and 1.5%/year between 2013 and 2040, respectively, are primarily the result of continuing declines in coal mining productivity. In the Interior region, a more optimistic outlook for coal mining productivity, combined with substantially higher production quantities, results in slower average price growth of 0.8%/year from 2013 to 2040. Increased output from large, highly productive longwall mines in the Interior region support labor productivity gains averaging 0.3%/year over the same period.

Figure 7. Average minemouth coal prices by region in the Reference case, 1990-2040 (2013 dollars per million Btu)



[17]While not discussed in this section, the High Economic Growth case has higher levels of industrial natural gas consumption through 2040 than any of the four cases mentioned, in response to higher demand that results from significantly higher levels of industrial output.

[18]U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," *Federal Register*, pp. 34829-34958 (Washington, DC: June 18, 2014) https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.

The average delivered price of coal (the sum of minemouth and coal transportation costs) increases at a similar, but slightly slower pace of 0.8%/year than minemouth prices, with prices rising from $2.50/million Btu in 2013 to $3.09/million Btu in 2040 in the AEO2015 Reference case (Figure 8). A relatively flat outlook for coal transportation rates results in a slightly lower growth rate for the average delivered price of coal.

Electricity

The average retail price of electricity in real 2013 dollars increases in the AEO2015 Reference case by 18% from 2013 to 2040 as a result of rising costs for power generation and delivery, coupled with relatively slow growth in electricity demand (0.7%/year on average). Electricity prices are determined by a complex set of factors that include economic conditions; energy use and efficiency; the competitiveness of electricity supply; investment in new generation, transmission, and distribution capacity; and the fuel, operation, and maintenance costs of plants in service. Figure 9 illustrates effects on retail electricity prices in the AEO2015 Reference and alternative cases resulting from different assumptions about the factors determining prices.

In the AEO2015 Reference case, average retail electricity prices (2013 dollars) increase by an average of 0.6%/year, from 10.1 cents/kilowatthour (kWh) in 2013 to 11.8 cents/kWh in 2040, an overall increase of 18%. The High Oil Price case shows the largest overall average price increase, at 28%, to 12.9 cents/kWh in 2040. The High Oil and Gas Resource case shows the smallest average increase, at 2%, to 10.3 cents/kWh in 2040. With more fuel resources available to meet demand from power producers in the High Oil and Gas Resource case, lower fuel prices lead to lower generation costs and lower retail electricity prices for consumers. In the High Economic Growth case, stronger economic growth increases demand for electricity, putting price pressure on the fuel costs and the construction cost of new generating plants. In the Low Economic Growth case, weaker growth results in lower electricity demand and associated costs.

The average annual growth in electricity use (including sales and direct use) in the United States has slowed from 9.8%/year in the 1950s to 0.5%/year over the past decade. Contributing factors include slowing population growth, market saturation of major electricity-using appliances, efficiency improvements in appliances, and a shift in the economy toward a larger share of consumption in less energy-intensive industries. In the AEO2015 Reference case, U.S. electricity use grows by 0.8%/year on average from 2013 to 2040.

Combined electricity demand in the residential and commercial sectors made up over 70% of total electricity demand in 2013, with each sector using roughly the same amount of electricity. From 2013 to 2040, residential and commercial electricity prices increase by 19% and 16%, respectively, in the Reference case; by 30% and 27% in the High Oil Price case; and by 5% and 0% in the High Oil and Gas Resource case. These variations largely reflect the importance of natural gas prices to electricity prices.

Industrial electricity prices grow by 22% in the Reference case, from 6.9 cents/kWh in 2013 to 8.4 cents/kWh in 2040. Among the alternative cases, growth in industrial electricity prices ranges from 35% (9.3 cents/kWh in 2040) in the High Oil Price case to 2% (7.1 cents/KWh in 2040) in the High Oil and Gas Resource case. In the industrial sector, electricity use increases in most industries but falls throughout the projection period for the energy-intensive refining and paper industries and, after 2024, in the aluminum, bulk chemical, and mining industries.

Retail electricity prices include generation, transmission, and distribution components. In the AEO2015 cases, about two-thirds of the retail price of electricity (between 59% and 67%) is attributable to the price of generation, which includes generation costs and retail taxes, with the remaining portion attributable to transmission and distribution costs. The generation price increases by 0.5% annually in the Reference case, from 6.6 cents/kWh in 2013 to 7.6 cents/kWh in 2040. In the High Oil Price Case, the price

Figure 8. Average delivered coal prices in six cases, 1990-2040 (2013 dollars per million Btu)

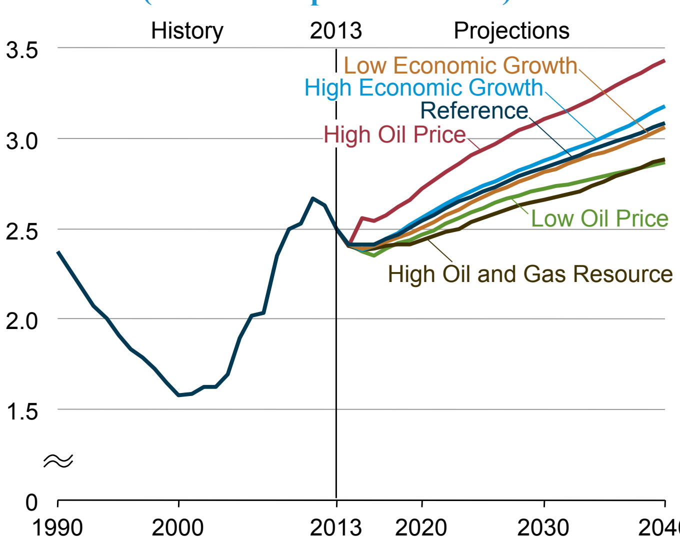
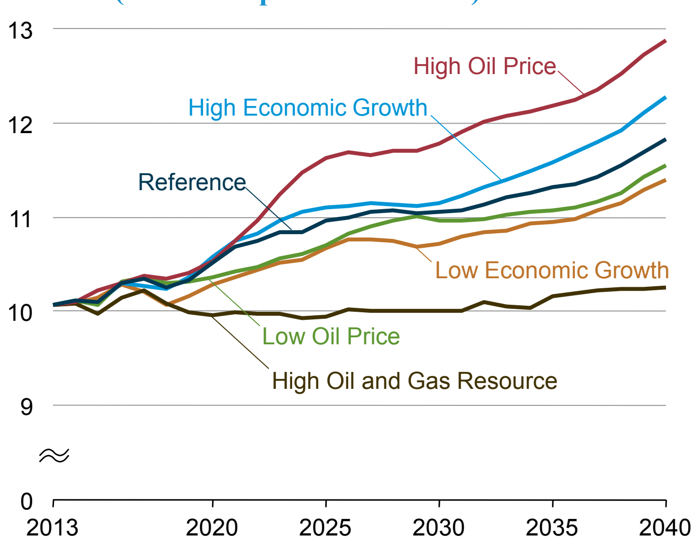


Figure 9. Average retail electricity prices in six cases, 2013-40 (2013 cents per kilowatthour)



of generation increases by 1%/year to 8.6 cents/kWh in 2040; and in the High Oil and Gas Resource Case, it falls by 0.3%/year to 6.1 cents/kWh in 2040.

Generation prices are determined differently in states with regulated and competitive electricity supplies. The AEO2015 Reference case assumes that 67% of electricity sales are subject to regulated average-cost pricing and 33% are priced competitively, based on the marginal cost of energy. In fully regulated regions, the price of generation is determined by both fixed costs (such as the costs of paying off electricity plant construction and fixed operation and maintenance costs) and variable costs (fuel and variable operation and maintenance costs).

In the Reference case, new generation capacity added through the projection period includes 144 GW of natural gas capacity, 77 GW of renewable capacity (45% is wind and 44% solar), 9 GW of nuclear capacity, and 1 GW of coal-fired capacity. Significant variation in the mix of generation capacity types added in the different AEO2015 cases also affects generation prices. Natural gas capacity additions vary substantially, with only 117 GW added in the Low Economic Growth case and 236 GW added in the High Economic Growth case. In the High Economic Growth case, a more vibrant economy leads to more industrial and commercial activity, more consumer demand for electric devices and appliances, and consequently greater demand for electricity.

Renewable generation capacity additions vary the most, with 66 GW added in the High Oil and Gas Resource case, but 194 GW added in the High Economic Growth case. Only 6 GW of new nuclear capacity is built in the Low Economic Growth and High Oil and Gas Resource cases, but 22 GW of new nuclear capacity is added in the High Oil Price case where natural gas prices are significantly above those in the Reference case. Across all the AEO2015 cases, very little new coal-fired capacity—and no new oil-fired capacity—is built through 2040.

Most generating fuel costs are attributed to coal and natural gas. In 2013, coal made up 44% of total generation fuel costs, and natural gas made up 42%. In 2040, coal makes up only 35% of total fuel costs in the Reference case, compared with 55% for natural gas. Oil, which is the most expensive fuel for generation, accounted for 6% of the total generating fuel costs in 2013 and from 2019 through 2040 accounts for only 3% of the total. Nuclear fuel accounts for 6% to 8% of electricity generation fuel costs throughout the projection period.

In regions with competitive wholesale electricity markets, the generation price generally follows the natural gas price. The price of electricity in wholesale markets is determined by the marginal cost of energy—the cost of serving the next increment of demand for a determined time period. Natural gas fuels the marginal generators during most peak and some off-peak periods in many regions.

There has been a fivefold increase in investment in new electricity transmission capacity since 1997, as well as large increases in spending for distribution capacity. Since 1997, roughly $107 billion has been spent on new transmission infrastructure and $318 billion on new distribution infrastructure, both in 2013 dollars. Those investments are paid off gradually over the projection period.

Although investment in new transmission and distribution capacity does not continue in the AEO2015 Reference case at the pace seen in recent years, spending still occurs at a rate greater than that needed to keep up with demand driven by requirements for additional transmission and distribution capacity to interconnect with new renewable energy sources, grid reliability and resiliency improvements, community aesthetics (including burying lines), and smart grid construction. In the AEO2015 Reference case, the transmission portion of the price of electricity increases by 1.2%/year, from 0.9 cents/kWh in 2013 to 1.3 cents/kWh in 2040. The distribution portion of the electricity price increases by 0.6%/year over the projection period, from 2.6 cents/kWh in 2013 to 3.0 cents/kWh in 2040. The investments in distribution capacity are undertaken mainly to serve residential and commercial customers. As a result, residential and commercial customers typically pay significantly higher distribution charges per kilowatthour than those paid by industrial customers.

Delivered energy consumption by sector

Transportation

Energy consumption in the transportation sector declines in the AEO2015 Reference case from 27.0 quadrillion Btu (13.8 million bbl/d) in 2013 to 26.4 quadrillion Btu (13.5 million bbl/d) in 2040. Energy consumption falls most rapidly through 2030, primarily as a result of improvement in light-duty vehicle (LDV) fuel economy with the implementation of corporate average fuel economy (CAFE) standards and greenhouse gas emissions (GHG) standards (Figure 10). This projection is a significant departure from the historical trend. Transportation energy consumption grew by an average of 1.3%/year from 1973 to 2007—when it peaked at 28.7 quadrillion Btu—as a result of increases in demand for personal travel and movement of goods that outstripped gains in fuel efficiency.

Transportation sector energy consumption varies across the alternative cases (Figure 11). Compared with the Reference case, energy consumption levels in 2040 are higher in the High Economic Growth case (by 3.0 quadrillion Btu), Low Oil Price case (by 1.4 quadrillion Btu), and High Oil and Gas Resource case (by 1.2 quadrillion Btu) and lower in the High Oil Price case (by 1.4 quadrillion Btu) and Low Economic Growth case (by 2.6 quadrillion Btu).

In the Reference case, energy consumption by LDVs—including passenger cars, light-duty trucks, and commercial light-duty trucks—falls from 15.7 quadrillion Btu in 2013 to 12.6 quadrillion Btu in 2040, as increases in fuel economy more than offset increases in LDV travel. Total vehicle miles traveled (VMT) for LDVs increase by 36% from 2013 (2,711 billion miles) to 2040 (3,675 billion miles), and the average VMT per licensed driver increase from about 12,200 miles in 2013 to 13,300 miles in 2040. The fuel economy of new vehicles increases from 32.8 mpg in 2013 to 48.1 mpg in 2040, as more stringent CAFE and GHG emissions standards take effect. As a result, the average fuel economy of the LDV stock increases by 69%, from 21.9 mpg in 2013 to 37.0 mpg in 2040.

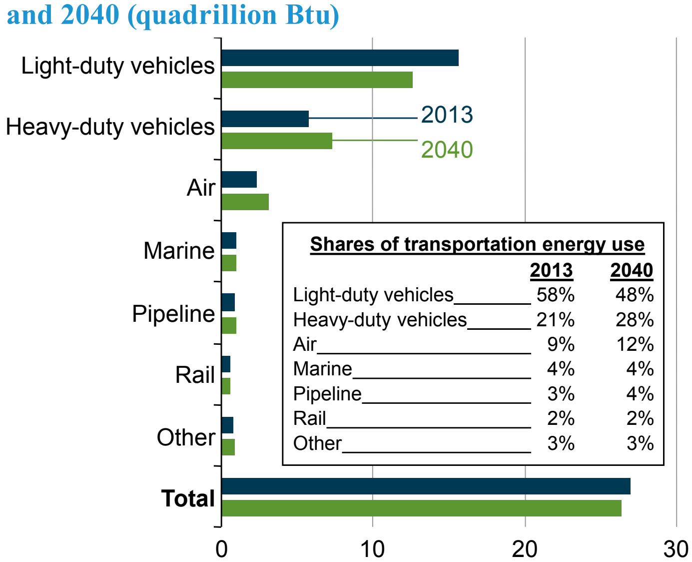
Passenger vehicles fueled exclusively by motor gasoline for all motive and accessory power, excluding any hybridization and flex-fuel capabilities, accounted for 83% of new sales in 2013. In the AEO2015 Reference case, gasoline-only vehicles, excluding hybridization or flex-fuel capabilities, still represent the largest share of new sales in 2040, at 46% of the total (see the first box below for comparison of relative economics of various technologies). However, alternative fuel vehicles and vehicles with hybrid technologies gain significant market shares, including gasoline vehicles equipped with micro hybrid systems (33%), E85 flex-fuel vehicles (10%), full hybrid electric vehicles (5%), diesel vehicles (4%), and plug-in hybrid vehicles and electric vehicles (2%). (EIA considers several types of hybrid electric vehicles—micro, mild, full, and plug-in—as described in the box on page 11.)

In comparison with the Reference case, LDV energy consumption in 2040 is higher in the Low Oil Price case (14.3 quadrillion Btu), High Economic Growth case (13.2 quadrillion Btu), and High Oil and Gas Resource case (12.9 quadrillion Btu), as a result of projected higher VMT in all three cases and lower fuel economy in the Low Oil Price and High Oil and Gas Resource cases. Conversely, LDV energy consumption in 2040 in the High Oil Price case (10.6 quadrillion Btu) and the Low Economic Growth case (11.3 quadrillion Btu) is lower than projected in the Reference case, as a result of lower VMT in both cases and higher fuel economy in the High Oil Price case.

Energy use by all heavy-duty vehicles (HDVs)—including tractor trailers, buses, vocational vehicles,[19] and heavy-duty pickups and vans—increases from 5.8 quadrillion Btu (2.8 million bbl/d) in 2013 to 7.3 quadrillion Btu (3.5 million bbl/d) in 2040, with higher VMT only partially offset by improved fuel economy. HDV travel grows by 48% in the Reference case—as a result of increases in industrial output—from 268 billion miles in 2013 to 397 billion miles in 2040, while average HDV fuel economy increases from 6.7 mpg in 2013 to 7.8 mpg in 2040 as a result of HDV fuel efficiency standards and GHG emissions standards. Diesel remains the most widely used HDV fuel. The share of diesel falls from 92% of total HDV energy use in 2013—with the remainder 7% motor gasoline and 1% gaseous (propane, natural gas, liquefied natural gas)—to 87% diesel in 2040, with natural gas, either compressed or liquefied, accounting for 7% of HDV energy use in 2040 as the economics of natural gas fuels improve and the refueling infrastructure expands.

The largest differences from the Reference case level of HDV energy consumption in 2040 are in the High and Low Economic Growth cases (9.4 quadrillion Btu and 6.3 quadrillion Btu, respectively), as a result of their higher and lower projections for travel demand, respectively. Notably, the use of natural gas is significantly higher in the High Oil Price case than in the Reference case, at nearly 30% of total HDV energy use in 2040.

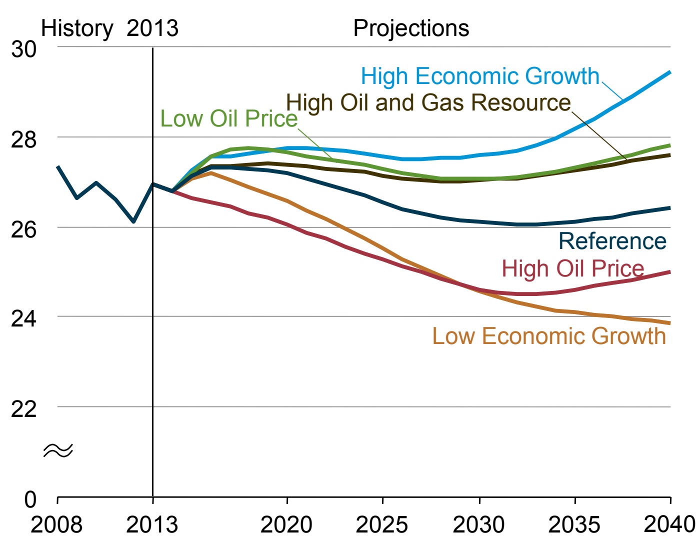
Figure 10. Delivered energy consumption for transportation by mode in the Reference case, 2013 and 2040 (quadrillion Btu)



	2013	2040
Light-duty vehicles	58%	48%
Heavy-duty vehicles	21%	28%
Air	9%	12%
Marine	4%	4%
Pipeline	3%	4%
Rail	2%	2%
Other	3%	3%

Note: The sum of the shares may not equal 100% due to independent rounding.

Figure 11. Delivered energy consumption for transportation in six cases, 2008-40 (quadrillion Btu)

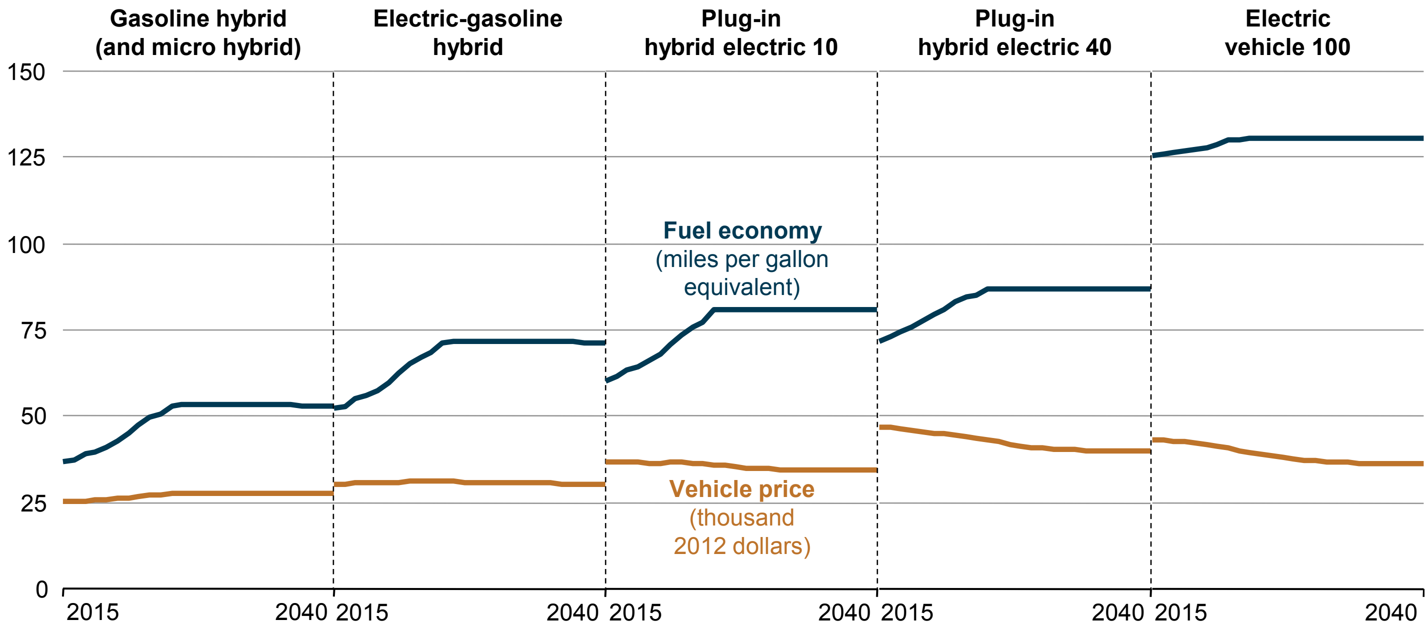


[19]Vocational vehicles include a diverse group of heavy-duty trucks, such as box/delivery trucks, refuse haulers, dump trucks, etc.

Future gasoline vehicles are strong competitors when compared with other vehicle technology types on the basis of fuel economics

Several fuel-efficient technologies are currently, or are expected to be, available for all vehicle fuel types. Those technologies will enable manufacturers to meet upcoming CAFE and GHG emissions standards at a relatively modest cost, predominately with vehicles powered by gasoline only or with gasoline-powered vehicles employing micro hybrid systems. Because of diminishing returns from improved fuel economy, future gasoline vehicles, including those with micro hybrid systems, are strong competitors when compared with other, more expensive vehicle technology types on the basis of fuel economics. Even though the price of vehicles that use some electric drive for motive power is projected to decline, in some cases significantly, their relative cost-effectiveness does not improve over the projection period, due to advances in gasoline-only and gasoline micro hybrid vehicles. While the reasons for consumer vehicle purchases vary and are not always on a strictly economic basis, wider market acceptance would require more favorable fuel economics—as seen in the High Oil Price case, where sales of plug-in hybrid and electric vehicle sales more than double.

Midsize passenger car fuel economy and vehicle price by technology type in the Reference case, 2015-2040



In 2040, compared with gasoline vehicles, fuel cost savings would be $227/year for an electric-gasoline hybrid, with a "payback period" of approximately 13 years for recovery of the difference in vehicle purchase price compared with a conventional gasoline vehicle; $247/year for a PHEV10, with a 27-year payback period; $271/year for a PHEV40, with a 46-year payback period; and $469/year for a 100% electric drive vehicle, with a 19-year payback period. These results are based on the following assumptions for each vehicle type: 12,000 miles traveled per year; average motor gasoline price of $3.90 per gallon; average electricity price of $0.12 per kilowatthour; and 0% discount rate. For plug-in hybrids it is assumed that a hybrid electric 10 (PHEV10) will use electric drive power for 21% of total miles traveled, and a hybrid electric 40 (PHEV40) for 58% of total miles traveled. The assumed vehicle purchase prices do not reflect national or local tax incentives.

The *Annual Energy Outlook 2015* includes several types of light-duty vehicle hybrid technology

Micro hybrids, also known as start/stop technology, are those vehicles with an electrically powered auxiliary system that allow the internal combustion engine to be turned off when the vehicle is coasting or idle and then quickly restarted. These systems do not provide power to the wheels for traction and can use regenerative braking to recharge the batteries.

Mild hybrids are those vehicles that, in addition to start/stop capability, provide some power assist to the wheels but no electric-only motive power.

Full hybrid electric vehicles can, in addition to start/stop and mild capabilities, operate at slow speeds for limited distances on the electric motor and assists the drivetrain throughout its drive cycle. Full hybrid electric vehicle systems are configured in parallel, series, or power split systems, depending on how power is delivered to the drivetrain.

Plug-in hybrid electric vehicles have larger batteries to provide power to drive the vehicle for some distance in charge-depleting mode, until a minimum level of battery power is reached (a "minimum state of charge"), at which point they operate on a mixture of battery and internal combustion engine power ("charge-sustaining mode"). PHEVs also can be engineered to run in a "blended mode," using an onboard computer to determine the most efficient use of battery and engine power. The battery can be recharged either from the grid (plugging a power cord into an electrical outlet) or by the engine.

Aircraft energy consumption increases from 2.3 quadrillion Btu in 2013 to 3.1 quadrillion Btu in 2040, with growth in personal air travel partially offset by gains in aircraft fuel efficiency. Energy consumption by marine vessels (including international marine, recreational boating, and domestic marine) remains flat, as increases in demand for international marine and recreational boating are offset by declines in fuel use for domestic marine vessels. The decline in domestic marine energy use is the result of improved efficiency and the continuation of the historical decline in travel demand. In the near term, distillate fuel provides a larger share of the fuel used by marine vessels, the result of stricter fuel and emissions standards. Pipeline energy use increases slowly, with growing volumes of natural gas produced from tight formations that are relatively close to end-use markets. Energy consumption for rail travel (freight and passenger) also remains flat, as improvement in locomotive fuel efficiency offsets growth in travel demand. In 2040, natural gas provides about a third of the fuel used for freight rail.

Industrial

Delivered energy consumption in the industrial sector totaled 24.5 quadrillion Btu in 2013, representing approximately 34% of total U.S. delivered energy consumption. In the AEO2015 Reference case, industrial delivered energy consumption grows at an annual rate of 0.7% from 2013 to 2040. The annual growth rate is much higher from 2013 to 2025 (1.3%) than from 2025 to 2040 (0.2%), as increased international competition slows industrial production growth and energy efficiency continues to improve in the industrial sector over the long term. Among the alternative cases, delivered industrial energy consumption grows most rapidly in the High Economic Growth case at 1.2%/year, almost twice the rate in the Reference case. The slowest growth in industrial energy consumption is projected in the Low Economic Growth case, at 0.4%/year from 2013 to 2040 (Figure 12).

Total industrial natural gas consumption in the AEO2015 Reference case increases from 9.1 quadrillion Btu in 2013 to 11.2 quadrillion Btu in 2040. Natural gas is used in the industrial sector for heat and power, bulk chemical feedstocks, natural gas-to-liquids (GTL) heat and power, and lease and plant fuel. The 6.7 quadrillion Btu of natural gas used for heat and power in 2013 was 74% of total industrial natural gas consumption for the year. From 2013 to 2040, natural gas use for heat and power grows by an average of 0.4%/year in the Reference case, with 41% of the total growth occurring between 2013 and 2020. In the High Oil and Gas Resource case, natural gas use for heat and power grows by 0.7%/year from 2013 to 2040, largely as a result of oil and gas extraction activity (Figure 13).

Natural gas use for GTL is responsible for the rapid post-2025 consumption growth in the High Oil Price compared with the other two cases shown in Figure 13. In the High Oil Price case, natural gas use for heat and power increases by 1.0%/year from 2013 to 2040, including significant use for GTL production, which grows to about 1 quadrillion Btu in 2040 in the High Oil Price case. Natural gas use for GTL occurs only in the High Oil Price case. Market conditions (primarily liquid fuel prices) do not support GTL investments in the other cases.

Purchased electricity (excluding electricity generated and used onsite) used by industrial customers in the AEO2015 Reference case grows from 3.3 quadrillion Btu in 2013 to 4.1 quadrillion Btu in 2040. Most of the growth occurs between 2013 and 2025, when it averages 1.7%/year. After 2025, there is little growth in purchased electricity consumption in the Reference case. In the High Economic Growth case, purchased electricity consumption grows by 1.5%/year from 2013 to 2040, which is almost twice the rate in the Reference case. Consumption increases significantly from 2025 to 2040 in the High Economic Growth case, as shipments of industrial products increase relatively more than in the Reference case and do not slow down nearly as much after 2025.

Figure 12. Industrial sector total delivered energy consumption in three cases, 2010-40 (quadrillion Btu)

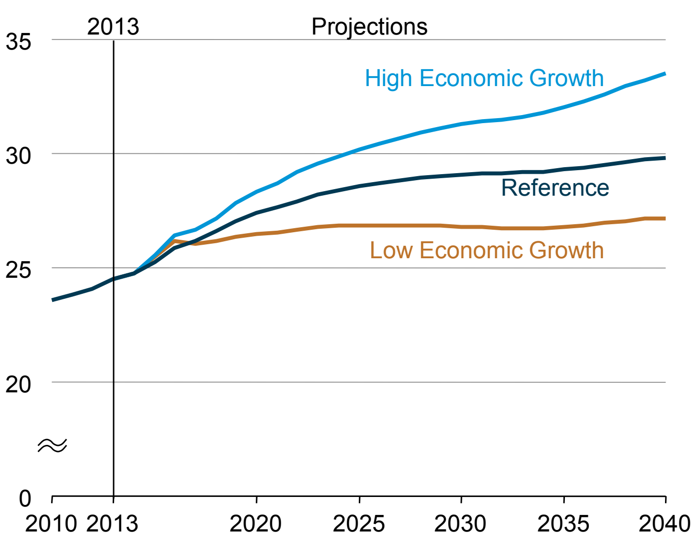
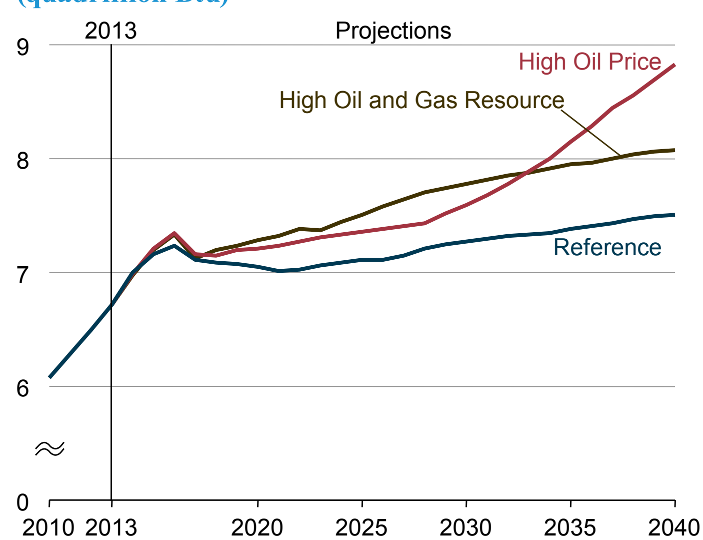


Figure 13. Industrial sector natural gas consumption for heat and power in three cases, 2010-40 (quadrillion Btu)



Purchased electricity consumption in the five metal-based durables industries,[20] which accounted for nearly 25% of the industrial sector total in 2013, grows at a slightly higher rate than in other industries in the Reference case. Although metal-based durable industries are not energy-intensive, they are relatively electricity-intensive, and they are by far the largest industry subgroup as measured by shipments in 2013. In the High Economic Growth case, shipments of metal-based durables grow more rapidly than shipments from many of the other industry segments. As a result, purchased electricity consumption in the metal-based durables industries grows by 2.0% per year from 2013 to 2040 in the High Economic Growth case, which is higher than the rate of growth for the industry in the Reference case.

Combined heat and power (CHP) generation in the industrial sector—almost all of which occurs in the bulk chemicals, food, iron and steel, paper, and refining industries—grows by 50% from 147 billion kWh in 2013 to 221 billion kWh in 2040 in the AEO2015 Reference case. Most of the CHP generation uses natural gas, although the paper industry also has a significant amount of renewables-based generation. All of the CHP-intensive industries are also energy intensive. Growth in CHP generation is slightly higher than growth in purchased electricity consumption, despite a shift toward lower energy intensity in the manufacturing and service sectors in the United States.

Bulk chemicals are the most energy-intensive segment of the industrial sector. In the AEO2015 Reference case, energy consumption in the U.S. bulk chemicals industry, which totaled 5.6 quadrillion Btu in 2013, grows by an average of 2.3%/year from 2013 to 2025. After 2025, energy consumption growth in bulk chemicals is negligible, as U.S. shipments of bulk chemicals begin to decrease because of increased international competition.

Approximately 60% of energy use in the bulk chemicals industry over the projection period is for feedstocks. Hydrocarbon gas liquids (HGL)[21] and petroleum products (such as naphtha)[22] are used as feedstocks for organic chemicals, inorganic chemicals, and resins. Growth in natural gas production from shale formations has contributed to an increase in the supply of HGL. Some chemicals can use either HGL or petroleum as feedstock; for those chemicals, the feedstock used depends on the relative prices of natural gas and petroleum. Although HGL or petroleum is used as a feedstock for most chemicals, natural gas feedstocks are used to manufacture methanol and agricultural chemicals. Natural gas feedstock consumption, which constituted roughly 13% of total bulk chemical feedstock consumption in 2013, grows rapidly from 2014 to 2018, reflecting increased capacity in the U.S. agricultural chemicals industry.

Residential and commercial

Delivered energy consumption decreases at an average rate of 0.3%/year in the residential sector and grows by 0.6%/year in the commercial sector from 2013 through 2040 in the AEO2015 Reference case (Figure 14 and Figure 15). Over the same period, the total number of households grows by 0.8%/year, and commercial floorspace increases by 1.0%/year (Table 4). The AEO2015 alternative cases illustrate the effects of different assumptions on residential and commercial energy consumption. Higher or lower economic growth, fuel prices, and fuel resources yield a range of residential and commercial energy demand. Different

Figure 14. Residential sector delivered energy consumption by fuel in the Reference case, 2010-40 (quadrillion Btu)

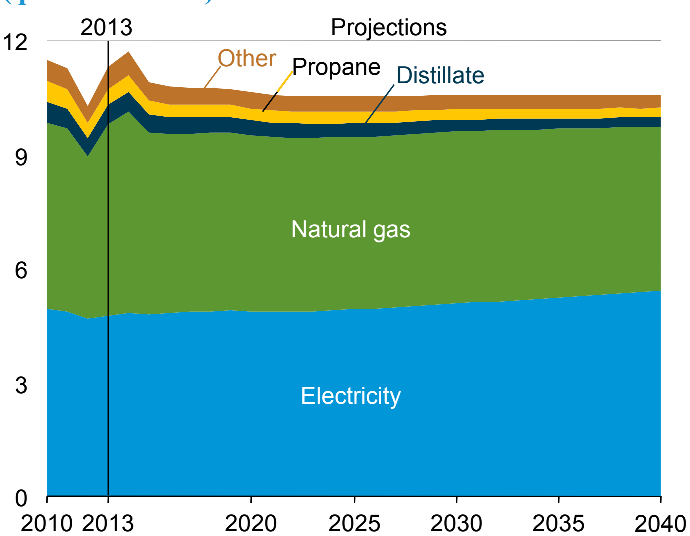
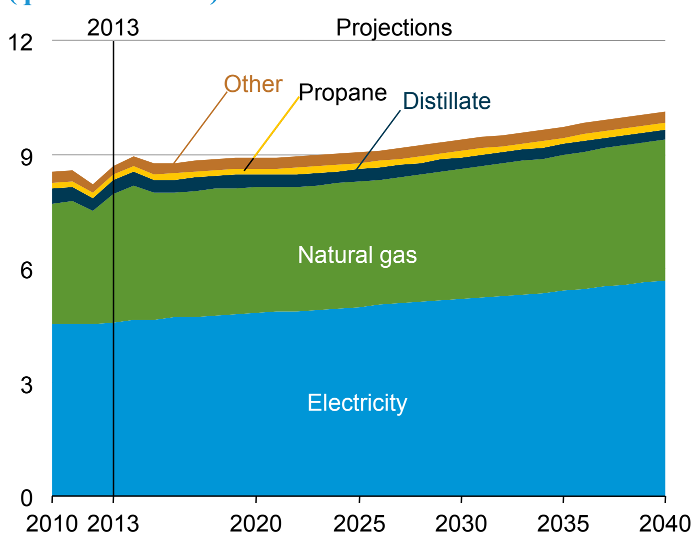


Figure 15. Commercial sector delivered energy consumption by fuel in the Reference case, 2010-40 (quadrillion Btu)



[20]The five metal-based durables industries are fabricated metal products (NAICS 332), machinery (NAICS 333), computers (NAICS 335), transportation equipment (NAICS 336), and electrical equipment (NAICS 335).

[21]Hydrocarbon gas liquids are natural gas liquids (NGL) and olefins. NGL include ethane, propane, normal butane, isobutane, and natural gasoline. Olefins include ethylene, propylene, butylene, and isobutylene. See http://www.eia.gov/tools/glossary/index.cfm?id=Hydrocarbon%20gas%20liquids.

[22]Naphtha is a refined or semi-refined petroleum fraction used in chemical feedstocks and many other petroleum products, see www.eia.gov/tools/glossary/index.cfm?id=naphtha.

levels of economic growth affect the number of households more than the amount of commercial floorspace, leading to greater differences in residential energy demand across the cases.

In the Reference case, electricity consumption in the residential and commercial sectors increases by 0.5%/year and 0.8%/year from 2013 through 2040, respectively, with the growth in residential electricity use ranging from 0.2%/year to 0.9%/year and the growth in commercial electricity use ranging from 0.7% to 0.9%/year in the alternative cases. In all cases, demand shifts from space heating to space cooling as a growing share of the population moves to warmer regions of the country. Miscellaneous electric loads (MELs)—from a variety of devices and appliances that range from microwave ovens to medical imaging equipment—continue to grow in the residential and commercial sectors, showing both increased market penetration (the share of the potential market that uses the device) and saturation (the number of devices per building).

In the commercial sector, the use of computer servers continues to grow to meet increasing needs for data storage, data processing, and other cloud-based services; however, only a small number of servers are installed in large, dedicated data center buildings. Most of the electricity used by servers can be attributed to equipment located in server rooms at the building site in offices, education buildings, and healthcare facilities.

Residential natural gas use declines in the Reference case with improvements in equipment and building shell efficiencies, price increases over time, and reduced heating needs as populations shift. Natural gas consumption in the commercial sector would be relatively flat as a result of efficiency improvements that offset floorspace growth, but increases in natural gas-fueled CHP capacity keep sector consumption trending upward throughout the projection. In the residential and commercial sectors, natural gas prices increase 2.5 and 3.0 times faster, respectively, than electricity prices through 2040 in the Reference case. In the High Oil and Gas Resources case, with lower natural gas prices, commercial delivered natural gas consumption grows by 0.7%/year, or more than twice the rate in the Reference case.

In the residential sector, distillate consumption and propane consumption, primarily for space heating, decline by 2.7%/year and 2.0%/year, respectively, in the Reference case from 2013 to 2040. The declines are even larger in the High Oil Price case, at 3.1%/year and 2.3%/year for distillate and propane, respectively, over the same period.

End-use energy intensity, as measured by consumption per residential household or square foot of commercial floorspace, decreases in the Reference case as a result of increases in the efficiency of equipment for many end uses (Figure 16 and Figure 17). Federal standards and voluntary market transformation programs (e.g., Energy Star) target uses such as space heating and cooling, water heating, lighting, and refrigeration, as well as devices that are rapidly proliferating, such as set-top boxes and external power supplies.

As a result of collaboration among industry, efficiency advocates, and government, a voluntary agreement for set-top boxes has been issued in lieu of federal standards.[23] Commercial refrigeration standards that will affect walk-in and reach-in coolers and freezers are under discussion among stakeholders.[24] As more states adopt new building codes, shell efficiencies of newly constructed buildings are improving, which will reduce future energy use for heating and cooling in the residential and commercial sectors.

In the AEO2015 Reference case, residential and commercial energy intensities for miscellaneous electric loads (MEL) and nonelectric miscellaneous uses in 2040 are roughly 18% and 23% higher, respectively, than they were in 2013. These devices and appliances vary greatly in their energy use characteristics, and their total energy consumption is closely tied to their levels of

Table 4. Residential households and commercial indicators in three AEO2015 cases, 2013 and 2040

Indicator	2013	2040	Average annual growth rate, 2013-40 (percent per year)
Residential households (millions)			
High Economic Growth	114.3	158.5	1.2
Reference	114.3	141.0	0.8
Low Economic Growth	114.3	127.9	0.4
Commercial floorspace (billion square feet)			
High Economic Growth	82.8	112.4	1.1
Reference	82.8	109.1	1.0
Low Economic Growth	82.8	106.0	0.9

[23]Following a consensus agreement among manufacturers and industry representatives that is expected to achieve significant energy savings, the U.S. Department of Energy (DOE) has withdrawn its proposed rulemaking for set-top boxes. See https://www.federalregister.gov/articles/text/raw_text/201/331/264.txt.

[24]Walk-in coolers and walk-in freezer panels, doors, and refrigeration systems are currently scheduled to comply with the updated standard beginning in August 2017 (see http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/26), and DOE has denied a petition from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) to reconsider its final rulemaking (see http://www.energy.gov/sites/prod/files/2014/09/f18/petition_denial.pdf).

penetration and saturation in the buildings sectors. As a result, MEL and nonelectric miscellaneous uses are difficult targets for federal efficiency standards.[25]

Penetration of grid-connected distributed generation continues to grow as both equipment and non-equipment costs decline, slowing delivered electricity demand growth in both residential and commercial buildings. In the AEO2015 Reference case, solar photovoltaic (PV) capacity in the residential sector grows by an average of about 30%/year from 2013 through 2016, compared with 9%/year for commercial sector PV, driven by the recent popularity of third-party leasing and other innovative financing options and tax credits. Following expiration of the 30% federal investment tax credit at the end of 2016, the average annual growth of PV capacity in residential and commercial buildings slows to about 6% in both sectors through 2040.

Natural gas CHP capacity in the commercial sector grows by an average of 9%/year from 2013 to 2040 in the Reference case and shows little variation across the alternative cases. Although natural gas prices are lower in the High Oil and Gas Resource case than in the Reference case, lower electricity prices limit the attractiveness of commercial CHP relative to purchased electricity.

Figure 16. Residential sector delivered energy intensity for selected end uses in the Reference case, 2013 and 2040 (million Btu per household per year)

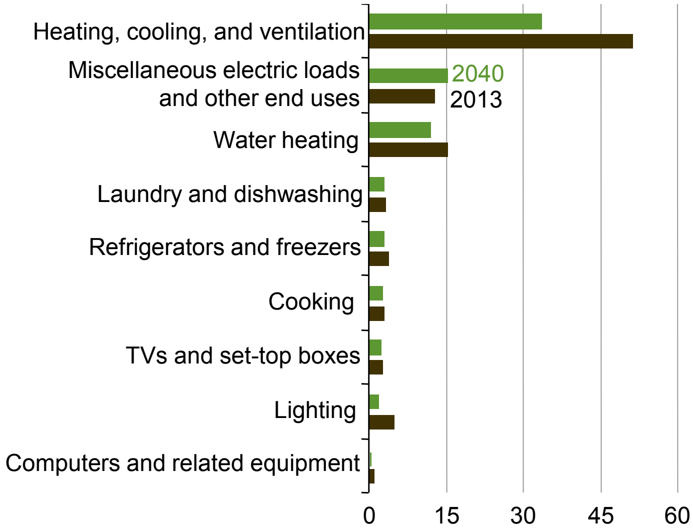
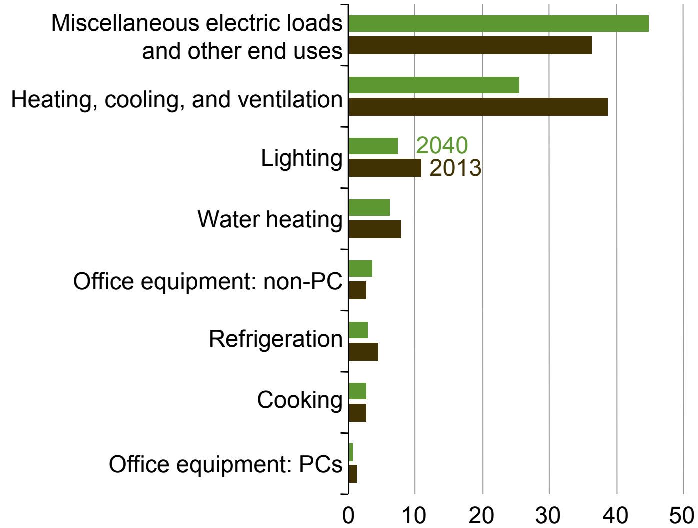


Figure 17. Commercial sector delivered energy intensity for selected end uses in the Reference case, 2013 and 2040 (thousand Btu per square foot per year)

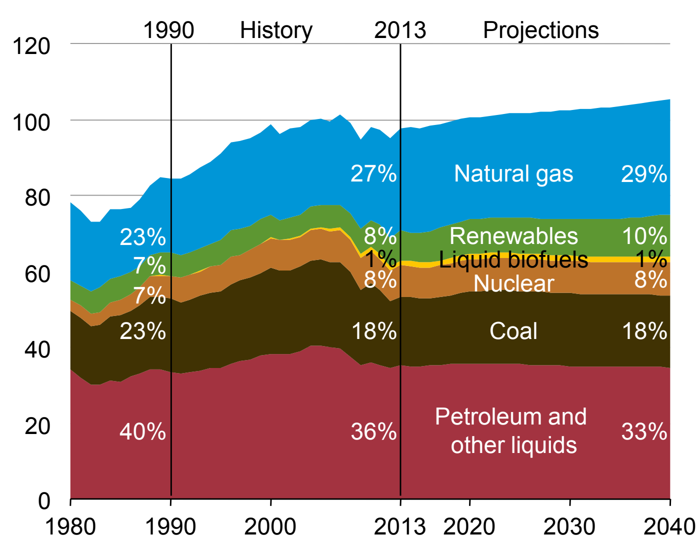


Energy consumption by primary fuel

Total primary energy consumption grows in the AEO2015 Reference case by 8.6 quadrillion Btu (8.9%), from 97.1 quadrillion Btu in 2013 to 105.7 quadrillion Btu in 2040 (Figure 18). Most of the growth is in consumption of natural gas and renewable energy. Consumption of petroleum products across all sectors in 2040 is unchanged from 2013 levels, as motor gasoline consumption in the transportation sector declines as a result of a 70% increase in the average efficiency of on-road light-duty vehicles (LDVs), to 37 mpg in 2040, which more than offsets projected growth in vehicle miles traveled (VMT). Total motor gasoline consumption in the transportation sector is about 3.4 quadrillion Btu (1.8 million barrels per day (bbl/d)) lower in 2040 than in 2013, and total petroleum consumption in the transportation sector is about 1.6 quadrillion Btu (0.9 million bbl/d) lower in 2040 than in 2013.

U.S. consumption of petroleum and other liquids, which totaled 35.9 quadrillion Btu (19.0 million bbl/d) in 2013, increases to 37.1 quadrillion Btu (19.6 million bbl/d) in 2020, then declines to 36.2 quadrillion Btu (19.3 million bbl/d) in

Figure 18. Primary energy consumption by fuel in the Reference case, 1980-2040 (quadrillion Btu)



[25]Navigant Consulting Inc. and Leidos—formerly SAIC, *Analysis and Representation of Miscellaneous Electric Loads in NEMS*, prepared for the U.S. Energy Information Administration (Washington, DC: May 2013), http://www.eia.gov/analysis/studies/demand/miscelectric/.

2040. In the transportation sector, which continues to dominate demand for petroleum and other liquids, there is a shift from motor gasoline to distillate. The gasoline share of total demand for transportation petroleum and other liquids declines by 10.6 percentage points, while distillate consumption increases by 7.2 percentage points. Increased use of compressed natural gas and LNG in vehicles also replaces about 3% of petroleum and other liquids consumption in the transportation sector in 2040. Consumption of ethane and propane (the latter including propylene), which are used in chemical production, shows the largest increase of all petroleum products in the AEO2015 Reference case from 2013 to 2040. Industrial consumption of ethane and propane, extracted from wet gas in natural gas processing plants, grows by almost 1 quadrillion Btu (790 thousand bbl/d) as dry natural gas production increases.

Natural gas consumption in the AEO2015 Reference case increases from 26.9 quadrillion Btu (26.2 Tcf) in 2013 to 30.5 quadrillion Btu (29.7 Tcf) in 2040. The largest share of the growth is for electricity generation in the electric power sector, where demand for natural gas grows from 8.4 quadrillion Btu (8.2 Tcf) in 2013 to 9.6 quadrillion Btu (9.4 Tcf) in 2040, in part as a result of the retirement of 40.1 GW of coal-fired capacity by 2025. Natural gas consumption in the industrial sector also increases, rapidly through 2016 and then more slowly through 2040, benefiting from the increase in shale gas production that is accompanied by slower growth of natural gas prices. Industries such as bulk chemicals, which use natural gas as a feedstock, are more strongly affected than others. Natural gas use as a feedstock in the chemical industry increases by about 0.4 quadrillion Btu from 2013 to 2040. In the residential sector, natural gas consumption declines from 2018 to 2040 and it increases slightly in the commercial sector over the same period.

Coal use in the Reference case grows from 18.0 quadrillion Btu (925 million short tons) in 2013 to 19.0 quadrillion Btu (988 million short tons) in 2040. As previously noted, the Reference case and other AEO2015 cases do not include EPA's proposed Clean Power Plan, which if it is implemented is likely to have a significant effect on coal use. Coal use in the industrial sector falls off slightly over the projection period, as steel production becomes more energy efficient. On the other hand, if oil prices were significantly higher than projected in the Reference case, coal could be used to make liquids via the Fischer-Tropsch process. In the High Oil Price case—the only AEO2015 case in which coal-to-liquids (CTL) technology becomes economically viable—liquids production from CTL plants totals about 710,000 bbl/d in 2040, representing about 3.3 quadrillion Btu (including liquids value), or about 180 million short tons, of coal consumption.

Consumption of marketed renewable energy increases by about 3.6 quadrillion Btu in the Reference case, from 9.0 quadrillion Btu in 2013 to 12.5 quadrillion Btu in 2040, with most of the growth in the electric power sector. Hydropower, the largest category of renewable electricity generation in 2013, contributes little to the increase in renewable fuel consumption. Wind-powered generation, the second-largest category of renewable electricity generation in 2013, becomes the largest contributor in 2038 (including wind generation by utilities and end-users onsite). However, solar photovoltaics (6.8%/year), geothermal (5.5%/year), and biomass (3.1%/year) all increase at faster average annual rates than wind (2.4%/year), including all sectors. Modest penetration of E85 and a small increase in liquids blended into diesel fuel result in a slight increase in consumption of renewable liquid fuels for transportation, despite a smaller pool for ethanol blending as a result of a projected overall decrease in motor gasoline consumption in the AEO2015 Reference case.

In the High Oil Price case, total primary energy use in 2040 is 109.7 quadrillion Btu, 3.9 quadrillion Btu higher than in the Reference case, even though total liquids consumption in 2040 is 3.3 quadrillion Btu lower, despite an 0.3 quadrillion Btu increase in renewable liquids. The decrease in petroleum and other liquids consumption is more than offset by increased consumption of natural gas (31.8 quadrillion Btu in 2040, 1.3 quadrillion Btu more than in the Reference case), coal (21.6 quadrillion Btu in 2040, 2.6 quadrillion Btu more, not including the Fischer-Tropsch coal consumed as liquids), nuclear (9.8 quadrillion Btu in 2040, 1.1 quadrillion Btu more), and many renewables (13.2 quadrillion Btu in 2040, 2.3 quadrillion Btu more, not including consumption of liquids from renewable fuels). The increases in coal and natural gas consumption are explained by the attractiveness of turning them into liquid fuels, made profitable by higher oil prices despite lower demand for motor gasoline and diesel fuels.

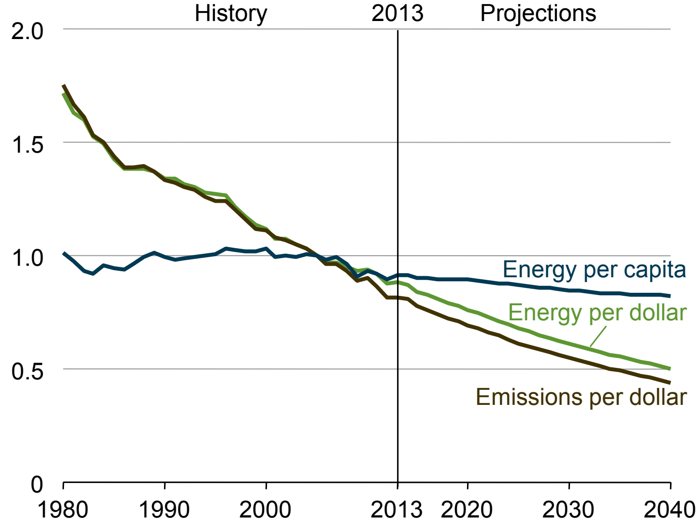
Uncertainty about economic growth results in the widest variation in the projections for total primary energy consumption in 2040, ranging from 98.0 quadrillion Btu in the Low Economic Growth case (1.8% average annual growth in real GDP measured in 2009 dollars) to 116.2 quadrillion Btu in the High Economic Growth case (2.9% average annual growth in real GDP). Changes in the assumed rate of economic growth lead to variations in the growth of energy consumption across all fuels, whereas changes in crude oil prices or in the size of the oil and natural gas resource base result in shifts among the fuel types consumed, with some fuels gaining share and others losing share. In the Low Oil Price case, the petroleum and other liquids share of total energy consumption is about 36.4% in 2040; in the High Oil Price case, it is 30.0% in the same year. With cheaper natural gas in the High Oil and Gas Resource case, less electricity is generated from coal and renewable fuels.

Energy intensity

Energy intensity (measured both by energy use per capita and by energy use per dollar of GDP) declines in the AEO2015 Reference case over the projection period (Figure 19). While a portion of the decline results from a small shift from energy-intensive to nonenergy-intensive manufacturing, most of it results from changes in other sectors.

Increasing energy efficiency reduces the energy intensity of many residential end uses between 2013 and 2040. Total energy consumption for space heating is 4.2 quadrillion Btu in 2040, 1.7 quadrillion Btu (57%) lower than it was in 2013, despite a 23% increase in the number of households and an 11% increase in the average size (square feet) of a household. Energy use for lighting is 0.8 quadrillion Btu in 2040, 1.0 quadrillion Btu lower than it was in 2013 reflecting a 57% decline in energy use despite an increase in lighting services. Energy use for computers and related equipment is 0.1 quadrillion Btu, 0.2 quadrillion Btu lower than it was in 2013. Improved efficiency also reduces delivered energy use in the transportation sector from 27.0 quadrillion Btu in 2013 to 26.5 quadrillion Btu in 2040, by 0.5 quadrillion Btu, as motor gasoline consumption declines by 3.4 quadrillion Btu. The result is an average annual reduction in energy use per capita of 0.4%/year from 2013 through 2040 and an average annual decline in energy use per 2009 dollar of GDP of 2.0%/year. As renewable fuels and natural gas account for larger shares of total energy consumption, carbon intensity (CO2 emissions per unit of GDP) declines by 2.3%/year from 2013 to 2040.

Figure 19. Energy use per capita and per 2009 dollar of gross domestic product, and carbon dioxide emissions per 2009 dollar of gross domestic product, in the Reference case, 1980-2040 (index, 2005 = 1.0)

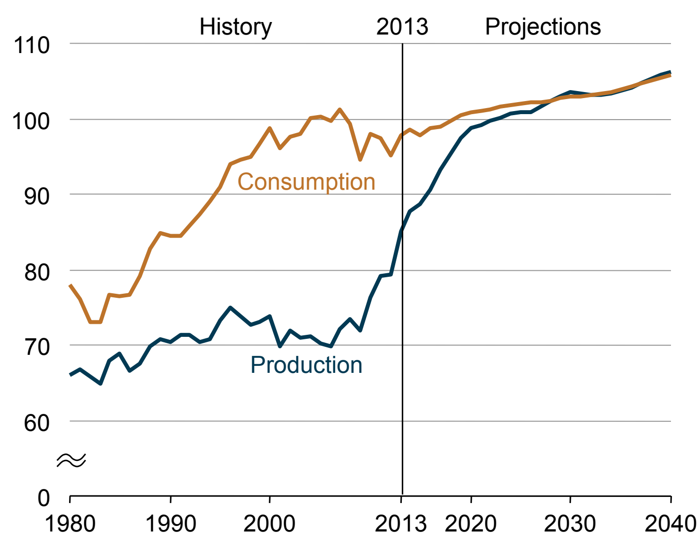


Macroeconomic growth has the largest impact on energy intensity among the AEO2015 alternative cases. Real GDP grows by an average of 1.8%/year from 2013 to 2040 in the Low Economic Growth case, and population grows by an average of 0.6%/year over the same period. Even though energy use increases only slightly (growing by 0.9 quadrillion Btu from 2013 to 2040) because GDP growth is lower than in the other cases, energy intensity as measured in relationship to GDP declines the least—an average rate of 1.8% per year from 2013 to 2040. However, the same case shows the largest decline in energy use per person, averaging 0.5%/year from 2013 to 2040. In the High Economic Growth case, real GDP increases at an average annual rate of 2.9%/year, population grows at an average annual rate of 0.8%/year, and energy use increases at an average annual rate of 0.7%/year from 2013 to 2040. As a result, the energy intensity of GDP declines at a slightly higher rate than in the Reference case, while the decline in energy use per person is slower than in the Reference case.

Energy production, imports, and exports

Net U.S. imports of energy declined from 30% of total energy consumption in 2005 to 13% in 2013, as a result of strong growth in domestic oil and dry natural gas production from tight formations and slow growth of total energy consumption. The decline in net energy imports is projected to continue at a slower rate in the AEO2015 Reference case, with energy imports and exports coming into balance around 2028 (although liquid fuel imports continue, at a reduced level, throughout the Reference case). From 2035 to 2040, energy exports account for about 23% of total annual U.S. energy production in the Reference case (Figure 20). Economic growth has a major influence on U.S. energy consumption, imports, and exports. In the High Economic Growth case, the United States remains a net energy importer through 2040, with net imports equal to about 3% of consumption in 2040. In the Low Economic Growth case, the United States becomes a net exporter of energy in 2022, with energy exports equal to 4% of total domestic energy production in 2040.

Figure 20. Total energy production and consumption in the Reference case, 1980-2040 (quadrillion Btu)



Changes in the world oil price affect both consumption and production, but in opposite directions from the effects of changes in U.S. economic growth. Higher world oil prices place downward pressure on consumption while making domestic production more profitable. In the Low Oil Price case, with lower domestic production and higher U.S. energy consumption, the United States remains a net energy importer, with imports increasing every year from 2033 to 2040 and net imports equal to 9% of total domestic energy consumption in 2040. In the High Oil Price case, with stronger growth in production and more incentives for energy efficiency, the United States becomes and remains a net energy exporter starting in 2019, and net exports increase to 9% of total energy production in 2040 after peaking at 11% in 2032. In the High Oil and Gas Resource case, with faster growth in domestic natural gas and crude oil production, U.S. net energy exports, mostly in the form of petroleum and natural gas, grow to almost 19% of total domestic energy production in 2040.

Petroleum and other liquids

Production from tight formations leads the growth in U.S. crude oil production across all AEO2015 cases. The path of projected crude oil production varies significantly across the cases, with total U.S. crude oil production reaching high points of 10.6 million barrels per day (bbl/d) in the Reference case (in 2020), 13.0 million bbl/d in the High Oil Price case (in 2026), 16.6 million bbl/d in the High Oil and Gas Resource case (in 2039), and 10.0 million bbl/d in the Low Oil Price case (in 2020).

In the Reference case, the existing U.S. competitive advantage in oil refining compared to the rest of the world continues over the projection period. This advantage results in growing gasoline and diesel exports through 2040 in the Reference case. The production of motor gasoline blending components, which totaled 7.9 million bbl/d in 2013, begins declining in 2015 and falls to 7.2 million bbl/d by the end of the projection period, while diesel fuel production rises from 4.2 million bbl/d in 2013 to 5.3 million bbl/d in 2040. As a result of declining consumption of liquid fuels and increasing production of domestic crude oil, net imports of crude oil and petroleum products fall from 6.2 million bbl/d in 2013 (33% of total domestic consumption) to 3.3 million bbl/d in 2040 (17% of domestic consumption) in the Reference case. Growth in gross exports of refined petroleum products, particularly of motor gasoline and diesel fuel, results in a significant increase in net petroleum product exports between 2013 and 2040.

In both the High Oil and Gas Resource and High Oil Price cases, total U.S. crude oil production is higher than in the Reference case mainly as a result of growth in tight oil production, which rises at a substantially faster rate in the near term in both cases than in the Reference case. In the High Oil and Gas Resource case, tight oil production grows in response to assumed higher estimated ultimate recovery (EUR) and technology improvements, closer well spacing, and development of new tight oil formations or additional layers within known tight oil formations. Total crude oil production reaches 16.6 million bbl/d in 2037 in the High Oil and Gas Resource case. In the High Oil Price case, higher oil prices improve the economics of production from new wells in tight formations as well as from other domestic production sources, leading to a more rapid increase in production volumes than in the Reference case. Tight oil production increases through 2022, when it totals 7.4 million bbl/d. After 2022, tight oil production declines, as drilling moves into less productive areas. Total U.S. crude oil production reaches 13.0 million bbl/d by 2025 in the High Oil Price case before declining to 9.9 million bbl/d in 2040 (Figure 21 and Figure 22).

Recent declines in West Texas Intermediate[26] oil prices (falling by 59% from June 2014 to January 2015) have triggered interest in the effect of lower prices on U.S. oil production. In the Low Oil Price case, domestic crude oil production is 9.8 million bbl/d in 2022, 0.7 million bbl/d lower than the 10.4 million bbl/d in the Reference case. In 2040, U.S. crude oil production is 7.1 million bbl/d, 2.3 million bbl/d lower than the 9.4 million bbl/d in the Reference case. Most of the difference in total crude oil production levels between the Reference and Low Oil Price cases reflects changes in production from tight oil formations. However, all sources of U.S. oil production are adversely affected by low oil prices. As crude oil prices fall and remain at or below $76/ barrel (Brent) in the Low Oil Price case after 2014, poor investment returns lead to fewer wells being drilled in noncore areas of

Figure 21. U.S. tight oil production in four cases, 2005-40 (million barrels per day)

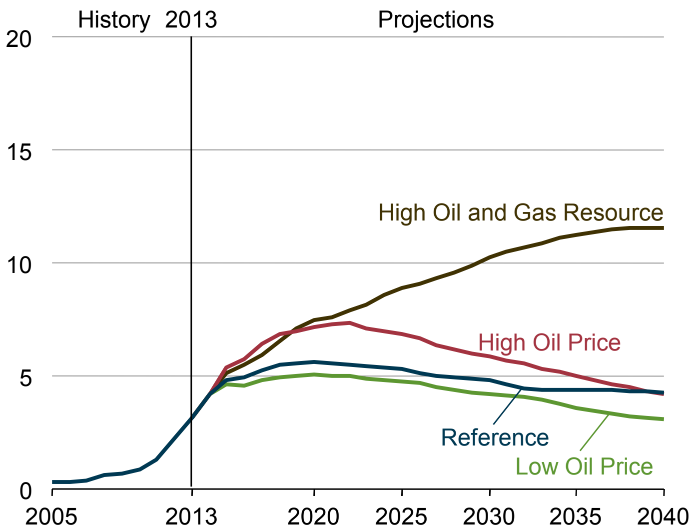
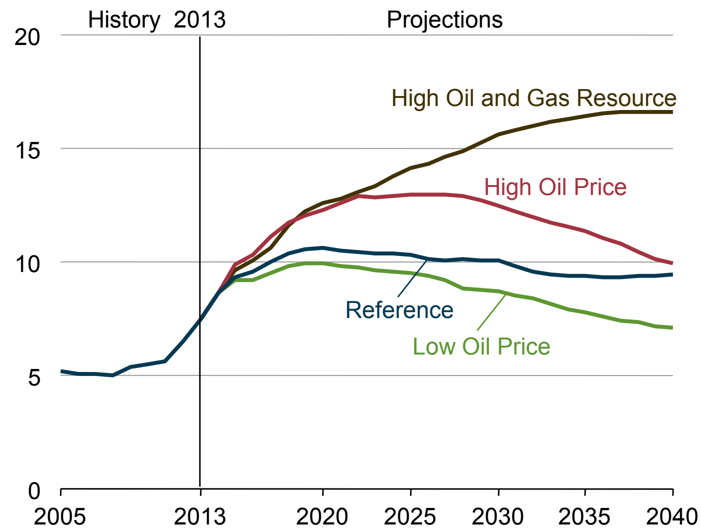


Figure 22. U.S. total crude oil production in four cases, 2005-40 (million barrels per day)



[26]West Texas Intermediate is a crude stream produced in Texas and southern Oklahoma that serves as a reference, or marker, for pricing a number of other crude streams and is traded in the domestic spot market at Cushing, Oklahoma.

formations, which have smaller estimated ultimate recoveries (EURs) than wells drilled in core areas. As a result, they have a more limited impact on total production growth in the near term.

In both the High Oil and Gas Resource and High Oil Price cases, growing production of 27°–35° American Petroleum Institute (API) medium sour crude oil from the offshore Gulf of Mexico (GOM) helps balance the crude slate when combined with the increasing production of light, sweet crude from tight oil formations. In all cases, GOM crude oil production increases through 2019, as offshore deepwater projects have relatively long development cycles that have already begun. GOM production declines through at least 2025 in all cases and fluctuates thereafter as a result of the timing of large, discrete discoveries that are brought into production. Overall GOM production through 2040 is highest in the High Oil and Gas Resource case, followed closely by the High Oil Price case and finally by the Reference case and Low Oil Price case.

In the High Oil Price case, producers take greater advantage of CO2-enhanced oil recovery (CO2-EOR) technologies. CO2-EOR production increases at a steady pace over the projection period in the Reference case and increases more dramatically in the High Oil Price case, where higher prices make additional CO2-EOR projects economically viable. In the High Oil and Gas Resource and Low Oil Price cases, with lower crude oil prices, fewer CO2-EOR projects are economical than in the Reference case.

Production of natural gas plant liquids (NGPL), including ethane, propane, butane, isobutane, and natural gasoline, increases from 2013 to 2023 in all the AEO2015 cases. After 2023, only the High Oil and Gas Resource case shows increasing NGPL production through the entire projection period. However, the High Oil Price case also shows significant NGPL production growth through 2026. Most of the early growth in NGPL production is associated with the continued development of liquids-rich areas in the Marcellus, Utica, and Eagle Ford formations.

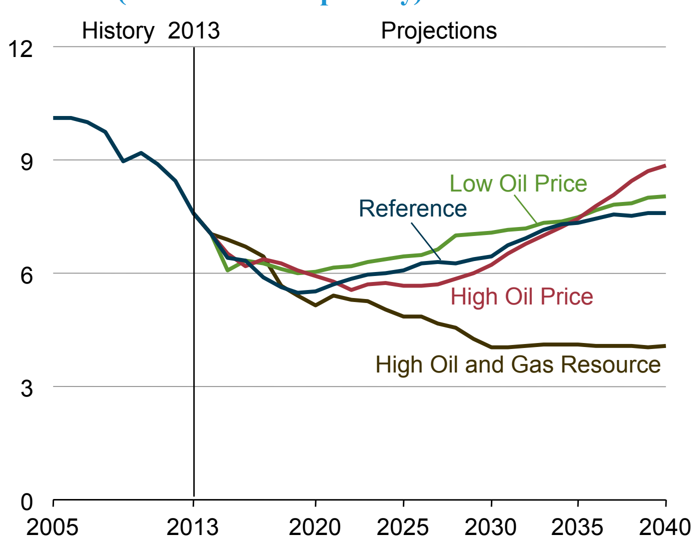
Production of petroleum products at U.S. refineries depends largely on the cost of crude oil, domestic demand, and the absorption of petroleum product exports in foreign markets. U.S. refinery production of gasoline blending components declines in the Reference and Low Oil Price cases but increases in the High Oil Price and High Oil and Gas Resource cases. The steepest decline in production of motor gasoline blending components is projected in the Reference case, with production of blending components declining from 7.9 million bbl/d in 2013 to 7.2 million bbl/d in 2040, in response to a drop in U.S. crude oil production, higher crude oil prices, and lower demand. In the High Oil and Gas Resource case, production of blending components increases to 9.1 million bbl/d in 2040, because abundant domestic supply of lighter crude oil results in lower feedstock costs for refiners, lower gasoline prices, increased exports, and relatively higher levels of gasoline consumption (including exports) and production.

Diesel fuel output from U.S. refineries rises in the High Oil and Gas Resource case from 4.2 million bbl/d in 2013 to 6.6 million bbl/d in 2037, as a result of lower costs for refinery feedstocks. In the Low Oil Price case, lower domestic diesel fuel prices result in higher levels of domestic consumption, leading to a 4.7 million bbl/d increase in diesel fuel production in 2040. In the High Oil Price case, higher oil prices (which are assumed to occur worldwide) make diesel fuel from U.S. refineries more competitive. Total U.S. diesel fuel output increases to 6.1 million bbl/d in 2040. In the Reference case, U.S. diesel fuel output increases to 5.3 million bbl/d in 2040.

As in the Reference case, the United States remains a net importer of liquid fuels through 2040 in the Low Oil Price case. In the High Oil and Gas Resource case, as a result of higher levels of both domestic crude oil production and petroleum product exports, the United States becomes a net exporter of liquid fuels by 2021. Refiners and oil producers gain a competitive advantage from abundant domestic supply of light crude oil and higher GOM production of lower API crude oil streams, along with lower refinery fuel costs as a result of abundant domestic natural gas supply. In the High Oil Price case, the United States becomes a net exporter of liquid fuels in 2020, as higher oil prices reduce U.S. consumption of petroleum products and spur additional U.S. crude oil production. U.S. net crude oil imports—which fall to 5.5 million bbl/d in 2022 as domestic crude oil production grows—rise to 8.9 million bbl/d in 2040 as domestic production flattens and begins to decline.

By 2040, the level of net liquid fuels exports is significantly larger in the High Oil and Gas Resource case than in the High Oil Price case. In the High Oil Price case, higher world crude oil prices make overseas refineries less competitive compared to U.S. refineries. As a result, net U.S. exports of petroleum products increase by more in the High Oil Price case than in the High Oil and Gas Resource case. However, the availability of more domestic crude oil resources in the High Oil and Gas Resource case results in a significantly greater drop in net crude oil imports and a larger overall swing in liquid fuels trade than in any of the other AEO2015 cases (Figure 23 and Figure 24).

Figure 23. U.S. net crude oil imports in four cases, 2005-40 (million barrels per day)



In the High Oil and Gas Resource case, the United States swings from net liquid fuels imports equal to 33% of total domestic product supplied in 2013 to net liquid fuels exports equal to 29% of total domestic product supplied in 2040 (compared with net exports equal to 3% of total domestic product supplied in 2040 in the High Oil Price case). In the Reference case, net imports fall to 14% of total domestic product supplied in 2020, before rising to nearly 18% of product supplied in 2033 and remaining around that level through 2040. Net imports of liquid fuels fall to 19% of total product supplied in 2020 in the Low Oil Price case before rising to 36% of total product supplied in 2040.

Cheaper light crude oil production from inland basins and increased production of heavier GOM crude oil leads to a 35% decline in gross crude oil imports in the High Oil and Gas Resource case—from 7.7 million bbl/d in 2013 to 5.0 million bbl/d in 2040. This compares with a 6% increase in the Reference case (to 8.2 million bbl/d in 2040) and a 12% increase in the Low Oil Price case (to 8.7 million bbl/d in 2040).

Net petroleum product exports increase as U.S. refineries become more competitive in all cases except for the Low Oil Price case. Net petroleum product exports increase most in the High Oil Price and High Oil and Gas Resource cases (from 1.4 million bbl/d in 2013 to 9.5 million bbl/d and 9.9 million bbl/d, respectively, in 2040). In the Reference case, net petroleum product exports increase to 4.3 million bbl/d in 2040, and in the Low Oil Price case they increase to 2.2 million bbl/d in 2020 and then decline to 0.7 million bbl/d in 2040.

In the High Oil and Gas Resource case, gross crude oil exports allowed under current laws and regulations, including exports to Canada and exports of processed condensate, rise significantly in response to increased production. It is assumed that condensate which has been processed through a distillation tower can be exported in accordance with a clarification from the U.S. Department of Commerce, Bureau of Industry and Security.[27] Gross crude exports increase from 0.1 million bbl/d in 2013 to a high of 1.3 million bbl/d in 2027 in the High Oil and Gas Resource case, before declining to 0.9 million bbl/d in 2040—compared with 0.6 million bbl/d in 2040 in the Reference, High Oil Price, and Low Oil Price cases. With U.S. refinery access to increased amounts of low-cost domestic crude supplies, gross petroleum product exports increase from 3.4 million bbl/d in 2013 to 12.0 million bbl/d in the High Oil and Gas Resource case and to 11.5 million bbl/d in 2040 in the High Oil Price case, compared with 6.4 million bbl/d in the Reference case and 3.5 million bbl/d in the Low Oil Price case.

Natural gas

Production

Total dry natural gas production in the United States increased by 35% from 2005 to 2013, with the natural gas share of total U.S. energy consumption rising from 23% to 28%. Production growth resulted largely from the development of shale gas resources in the Lower 48 states (including natural gas from tight oil formations), which more than offset declines in other Lower 48 onshore production. In the AEO2015 Reference case, more than half of the total increase in shale gas production over the projection period comes from the Haynesville and Marcellus formations. Lower 48 shale gas production (including natural gas from tight oil formations) increases by 73% in the Reference case, from 11.3 Tcf in 2013 to 19.6 Tcf in 2040, leading to a 45% increase in total U.S. dry natural gas production, from 24.4 Tcf in 2013 to 35.5 Tcf in 2040. Growth in tight gas, federal offshore, and onshore Alaska production also contributes to overall production growth over the projection period (Figure 25 and Figure 26).

Figure 24. U.S. net petroleum product imports in four cases, 2005-40 (million barrels per day)

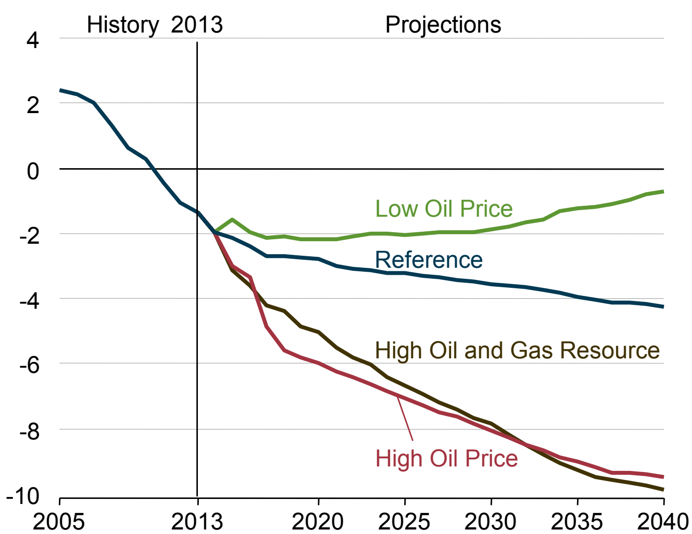
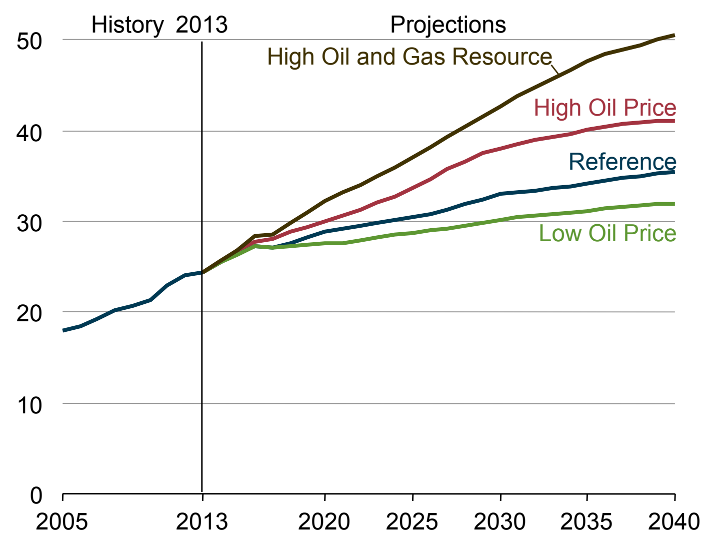


Figure 25. U.S. total dry natural gas production in four cases, 2005-40 (trillion cubic feet)



[27] U.S. Department of Commerce, Bureau of Industry and Security, "FAQs–Crude Oil and Petroleum Products December 30, 2014" (see question no. 3, "Is lease condensate considered crude oil?") (Washington, DC: December 30, 2014), http://www.bis.doc.gov/index.php/policy-guidance/faqs.

Future dry natural gas production depends primarily on the size and cost of tight and shale gas resources, technology improvements, domestic natural gas demand, and the relative price of oil. Projections in the High Oil and Gas Resource case assume closer well spacing; higher EURs per shale gas well, tight gas well, and tight oil well; development of new tight oil formations either from new discoveries or additional layers within known tight oil formations; and additional long-term technology improvements that further increase the EUR per tight gas and shale gas well over the projection period above those in the Reference case. Even with lower prices, total U.S. dry natural gas production increases in the High Oil and Gas Resource case to 50.6 Tcf in 2040, 43% above the Reference case level, with Lower 48 shale gas production of 34.6 Tcf in 2040, or 77% above the Reference case level.

The High and Low Oil Price cases use the same natural gas resource assumptions as the Reference case, but production levels vary in response to natural gas demand, primarily from the transportation sector and global demand for U.S.-origin LNG. In the High Oil Price case, increased demand for natural gas as a fuel for motor vehicles, as LNG for export, and as plant fuel for natural gas liquefaction facilities accounts for the increase in total domestic dry natural gas production to 41.1 Tcf in 2040 (16% above the Reference case). U.S. shale gas production in the High Oil Price case totals 23.6 Tcf in 2040, 21% above the Reference case total. In the Low Oil Price case, with lower demand for natural gas and LNG exports, U.S. dry natural gas production totals 31.9 Tcf in 2040 (10% below the Reference case total), and U.S. shale gas production totals 18.1 Tcf in 2040 (8% below the Reference case).

Tight gas accounts for a smaller, but still significant, portion of the increase in U.S. dry natural gas production compared to shale gas. Tight gas production responds largely to crude oil prices and the same levels of technological progress experienced with shale gas production. Tight gas production increases from 4.4 Tcf in 2013 to 7.0 Tcf in 2040 in the Reference case, compared with 8.1 Tcf in 2040 in the High Oil and Gas Resource case, 8.4 Tcf in the High Oil Price case, and 6.6 Tcf in the Low Oil Price case. Most of the tight gas production growth occurs in the Gulf Coast and Dakotas/Rocky Mountains regions. Tight gas production in the Midcontinent region—which declines in the Reference case—increases by 24% from 2013 to 2040 in the High Oil and Gas Resource case.

Undiscovered crude oil and natural gas resources in the federal offshore and Alaska regions are assumed to be 50% higher in the High Oil and Gas Resource case than in the Reference case. Lower 48 offshore natural gas production increases from 1.5 Tcf in 2013 to 3.0 Tcf in 2040 in the High Oil and Gas Resource case, and to 2.8 Tcf in 2040 in both the High Oil Price and Reference cases. Cumulative federal offshore natural gas production is highest in the High Oil Price case, with federal offshore natural gas production increasing more than in any of the other AEO2015 cases through 2036, before declining. Alaska dry natural gas production begins increasing in 2026 in the High Oil Price case, and in 2027 in the Reference case. Alaska dry natural gas production reaches 1.2 Tcf in 2029 and remains at that level through 2040 in the High Oil Price case. Alaskan production reaches 1.1 Tcf in 2040 in the Reference case, following the projected completion of a new LNG export facility in Alaska. In the Low Oil Price and High Oil and Gas Resource cases, lower international natural gas prices make LNG exports from Alaska uneconomical, and Alaska dry natural gas production falls through 2040 as declines in oil production result in decreased use of natural gas for drilling operations.

Imports and exports

In all the AEO2015 cases, net natural gas imports continue to decline through 2040, as they have since 2007. Gross exports of natural gas increase over the period, and gross imports decline. The rate of decline in net imports varies across the cases—depending on assumptions about changes in world oil prices and U.S. natural gas resources—and slows in the later years of the projections (Figure 27). In all the cases, the United States becomes a net exporter of natural gas in 2017, driven by LNG exports (Figure 28), increased pipeline exports to Mexico, and reduced imports from Canada.

Figure 26. U.S. shale gas production in four cases, 2005-40 (trillion cubic feet)

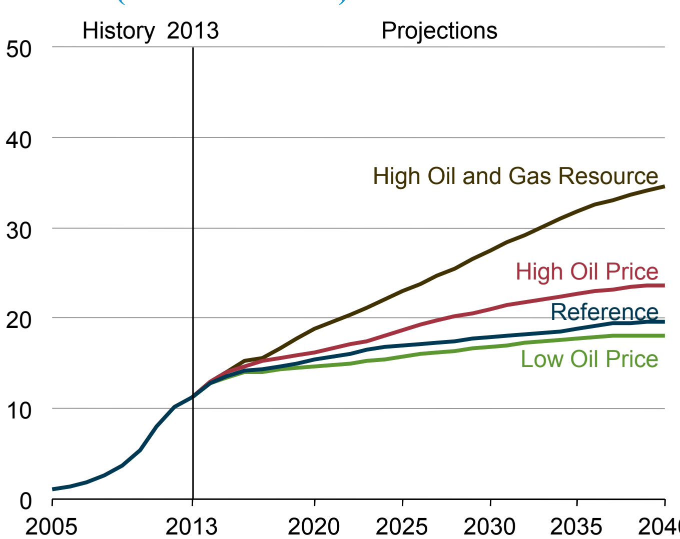
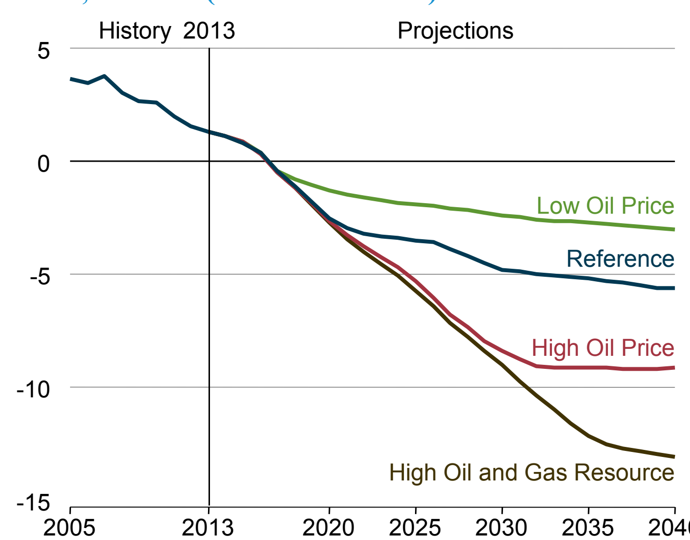


Figure 27. U.S. total natural gas net imports in four cases, 2005-40 (trillion cubic feet)



In the Reference case, net exports of natural gas from the United States total 5.6 Tcf in 2040. Most of the growth in U.S. net natural gas exports occurs before 2030, when gross liquefied natural gas (LNG) exports reach their highest level of 3.4 Tcf, where they remain through 2040. In all the cases, the United States remains a net pipeline importer of natural gas from Canada through 2040, but at lower levels than in recent history, while net pipeline exports of natural gas to Mexico grow from 0.7 Tcf in 2013 to 3.0 Tcf in 2040 in the Reference case.

The price of LNG supplied to international markets, which in part reflects world oil prices, is significantly higher than the price of U.S. domestic natural gas supply, particularly in the near term. The growth in U.S. LNG exports is driven by this price difference, which also discourages U.S. LNG imports. LNG export growth after 2020 is highest in the High Oil and Gas Resource case, where higher production capability lowers the price of U.S. natural gas supply to the world market, leading to net LNG exports of 10.3 Tcf in 2040 (212% more than in the Reference case) and total net natural gas exports of 13.1 Tcf in 2040 (133% more than in the Reference case).

Most of the variations in projected net exports of U.S. natural gas among the AEO2015 cases result from differences in levels of LNG exports. In the High Oil Price and Low Oil Price cases, projected LNG exports vary in response to differences between international and domestic natural gas prices, after accounting for the costs associated with processing and transporting the gas. Over the projection, the relationship between international LNG prices and world oil prices is assumed to weaken, particularly as U.S. LNG exports increase. Low world oil prices limit the competitiveness of domestic natural gas relative to oil itself and also to LNG volumes sold through contracts linked to oil prices, which are less likely to be renegotiated in a low oil price environment.

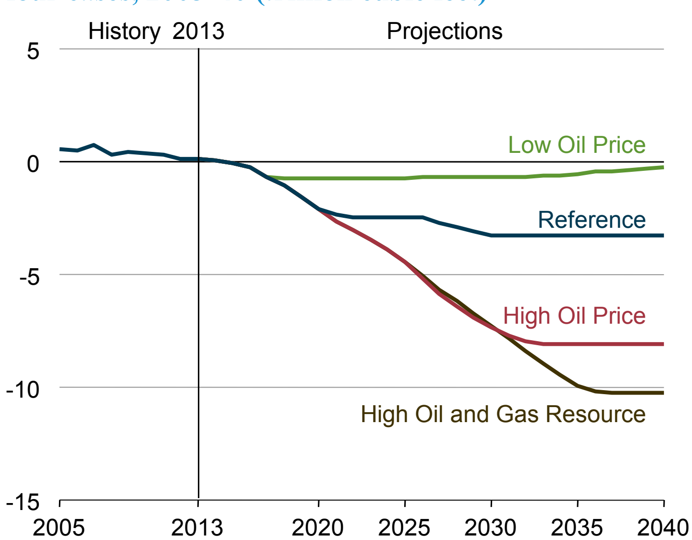
In the High Oil Price case, U.S. LNG exports total 8.1 Tcf in 2040, or 142% more than in the Reference case. As a result, U.S. net natural gas exports total 9.1 Tcf in 2040 in the High Oil Price case, or 63% more than in the Reference case. In the Low World Oil Price case, LNG net exports never surpass 0.8 Tcf, and U.S. net exports of natural gas total 3.0 Tcf in 2040, or 46% below the Reference case level.

Canada, which accounted for 97% of total U.S. pipeline imports of natural gas in 2013, continues as the source of nearly all U.S. pipeline imports through 2040. Most natural gas imported into the United States comes from western Canada and is delivered mainly to the West Coast and the Midwest.

In the AEO2015 alternative cases, gross pipeline imports from Canada generally are higher than in the Reference case when prices in the United States are higher, and vice versa. However, gross pipeline imports from Canada in 2040 are highest in the High Oil and Gas Resource case, with growth after 2030 resulting from an assumed increase in Canada's shale and coalbed resources. Gross exports of U.S. natural gas to Canada, largely into the eastern provinces, generally increase when prices are low in the United States, and vice versa.

U.S. pipeline exports of natural gas—most flowing south to Mexico—have grown substantially since 2010 and are projected to continue increasing in all the AEO2015 cases because increases in Mexico's production are not expected to keep pace with the country's growing demand for natural gas, primarily for electric power generation. In the High Oil and Gas Resource case, with the lowest projected U.S. natural gas prices, pipeline exports to Mexico in 2040 total 4.7 Tcf, as compared with 3.3 Tcf in the Low Oil Price case and 2.2 Tcf by 2040 in the High Oil Price case.

Figure 28. U.S. liquefied natural gas net imports in four cases, 2005-40 (trillion cubic feet)



Coal

Between 2008 and 2013, U.S. coal production fell by 187 million short tons (16%), as declining natural gas prices made coal less competitive as a fuel for generating electricity (Figure 29). In the AEO2015 Reference case, U.S. coal production increases at an average rate of 0.7%/year from 2013 to 2030, from 985 million short tons (19.9 quadrillion Btu) to 1,118 million short tons (22.4 quadrillion Btu). Over the same period, rising natural gas prices, particularly after 2017, contribute to increases in electricity generation from existing coal-fired power plants as coal prices increase more slowly. After 2030, coal consumption for electricity generation levels off through 2040. The cases presented in AEO2015 do not include EPA's proposed Clean Power Plan, which would have a material impact on projected levels of coal-fired generation. A separate EIA analysis of the Clean Power Plan is forthcoming.

Compliance with the Mercury and Air Toxics Standards (MATS),[28] coupled with low natural gas prices and

[28]U.S. Environmental Protection Agency, "Mercury and Air Toxics Standards," http://www.epa.gov/mats (Washington, DC: March 27, 2012).

competition from renewables, leads to the projected retirement of 31 gigawatts (GW) of coal-fired generating capacity and the conversion of 4 GW of coal-fired generating capacity to natural gas between 2014 and 2016. However, coal consumption in the U.S. electric power sector is supported by an increase in output from the remaining coal-fired power plants, with the projected capacity factor for the U.S. coal fleet increasing from 60% in 2013 to 67% in 2016. In the absence of any significant additions of coal-fired electricity generating capacity, coal production after 2030 levels off as many existing coal-fired generating units reach maximum capacity factors and coal exports grow slowly. Total U.S. coal production in the AEO2015 Reference case remains below its 2008 level through 2040.

Across the AEO2015 alternative cases, the largest changes in U.S. coal production relative to the Reference case occur in the High Oil and Gas Resource and High Oil Price cases. In the High Oil and Gas Resource case, lower natural gas prices lead to a significant shift away from the use of coal in the electric power sector, resulting in coal production levels that are 13% lower in 2020 and 11% lower in 2040 than in the Reference case. In the High Oil Price case, higher oil prices spur investments in coal-based synthetic fuels, which result in increasing demand for domestically produced coal, primarily from mines in the Western supply region. In the High Oil Price case, coal consumption at coal-to-liquids (CTL) plants rises from 11 million short tons in 2025 to 181 million short tons in 2040, and total coal production in 2040 is 13% higher than in the Reference case.

In the other AEO2015 cases, variations in the quantities of coal produced relative to the Reference case are more modest, ranging from 4% (49 million short tons) lower in the Low Economic Growth case to 4% (40 million short tons) higher in the High Economic Growth case in 2040. Factors that limit the variation in U.S. coal production across cases include the high capital costs associated with building new coal-fired generating capacity, which limit potential growth in coal use; the relatively low operating costs of existing coal-fired units, which tend to limit the decline in coal use; and limited potential to increase coal use at existing generating units, which already are at maximum utilization rates in some regions.

Changes in assumptions about the rate of economic growth also affect the outlook for coal demand in the U.S. industrial sector (coke and other industrial plants) and, consequently, coal production. In the Low Economic Growth case, lower levels of industrial coal consumption in 2040 account for 17% of the reduction in total coal consumption relative to the Reference case. In the High Economic Growth case, higher levels of coal consumption in the industrial sector in 2040 account for 44% of the increase in total coal consumption relative to the Reference case.

Regionally, strong production growth in the Interior region contrasts with declining production in the Appalachian region in the AEO2015 Reference case. In the Interior region, coal production becomes increasingly competitive as a result of a combination of improving labor productivity and the installation of scrubbers at existing coal-fired power plants, which allows those plants to burn the region's higher-sulfur coals at a lower delivered cost compared with coal from other regions. Appalachian coal production declines in the Reference case, as coal produced from the extensively mined, higher-cost reserves of Central Appalachia is replaced by lower-cost coals from other regions. Western coal production in the Reference case increases from 2017 to 2024, in line with the increase in U.S. consumption, but falls slightly thereafter as a result of competition from producers in the Interior region and limited growth in coal use at existing coal-fired power plants after 2025.

U.S. coal exports decline from 118 million short tons in 2013 to 97 million short tons in 2014 and to 82 million short tons in 2015 in the AEO2015 Reference case, then increase gradually to 141 million short tons in 2040 (Figure 30). Much of the growth in exports after 2015 is attributable to increased exports of steam coal from mines in the Interior and Western regions. Between 2015 and 2040, U.S. steam coal exports increase by 42 million short tons, and coking coal exports increase by 17 million short tons.

Figure 29. U.S. coal production in six cases, 1990-2040 (million short tons)

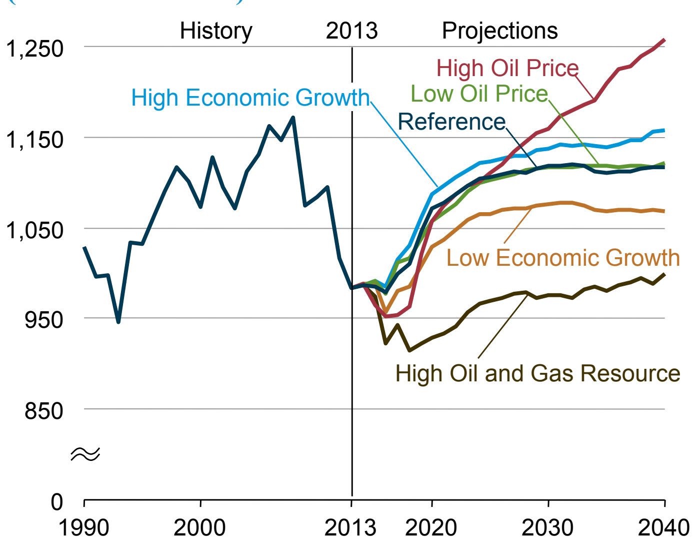
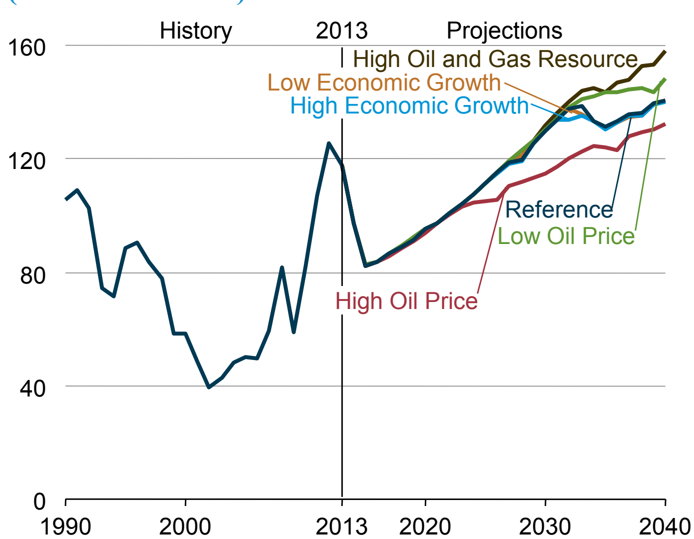


Figure 30. U.S. coal exports in six cases, 1990-2040 (million short tons)



Across the AEO2015 alternative cases, U.S. coal exports in 2040 vary from a low of 132 million short tons in the High Oil Price case (6% lower than in the Reference case) to a high of 158 million short tons in the High Oil and Gas Resource case (12% higher than in the Reference case). Coal exports are also higher in the Low Oil Price case than in the Reference case, increasing to 149 million short tons in 2040. In the Low and High Oil Price cases, variations in the prices of diesel fuel and electricity, which are two important inputs to coal mining and transportation, are key factors affecting U.S. coal exports. The projections of lower and higher fuel prices for coal mining and transportation affect the relative competiveness of U.S. coal in international coal markets. In the High Oil and Gas Resource case, the combination of lower prices for diesel fuel and electricity and lower domestic demand for coal contribute to higher export projections relative to the Reference case.

Electricity generation

Total electricity use in the AEO2015 Reference case, including both purchases from electric power producers and on-site generation, grows by an average of 0.8%/year, from 3,836 billion kilowatthours (kWh) in 2013 to 4,797 billion kWh in 2040. The relatively slow rate of growth in demand, combined with rising natural gas prices, environmental regulations, and continuing growth in renewable generation, leads to tradeoffs between the fuels used for electricity generation. From 2000 to 2012, electricity generation from natural gas-fired plants more than doubled as natural gas prices fell to relatively low levels. In the AEO2015 Reference case, natural gas-fired generation remains below 2012 levels until after 2025, while generation from existing coal-fired plants and new nuclear and renewable plants increases (Figure 31). In the longer term, natural gas fuels more than 60% of the new generation needed from 2025 to 2040, and growth in generation from renewable energy supplies most of the remainder. Generation from coal and nuclear energy remains fairly flat, as high utilization rates at existing units and high capital costs and long lead times for new units mitigate growth in nuclear and coal-fired generation. Considerable variation in the fuel mix results when fuel prices or economic conditions differ from those in the Reference case.

AEO2015 assumes the implementation of the Mercury and Air Toxics Standards (MATS) in 2016, which regulates mercury emissions and other hazardous air pollutants from electric power plants. Because the equipment choices to control these emissions often reduce sulfur dioxide emissions as well, by 2016 sulfur dioxide emissions in the Reference case are well below the levels required by both the Clean Air Interstate Rule (CAIR)[29] and the Cross-State Air Pollution Rule (CSAPR).[30,31]

Total electricity generation increases by 24% from 2013 to 2040 in the Reference case but varies significantly with different economic assumptions, ranging from a 15% increase in the Low Economic Growth case to a 37% increase in the High Economic Growth case. Coal-fired generation is similar across most of the cases in 2040, except the High Oil and Gas Resource case, which is the only one that shows a significant decline from the Reference case, and the High Oil Price case, which is the only one showing a large increase (Figure 32). The coal share of total electricity generation drops from 39% in 2013 to 34% in 2040 in the Reference

Figure 31. Electricity generation by fuel in the Reference case, 2000-2040 (trillion kilowatthours)

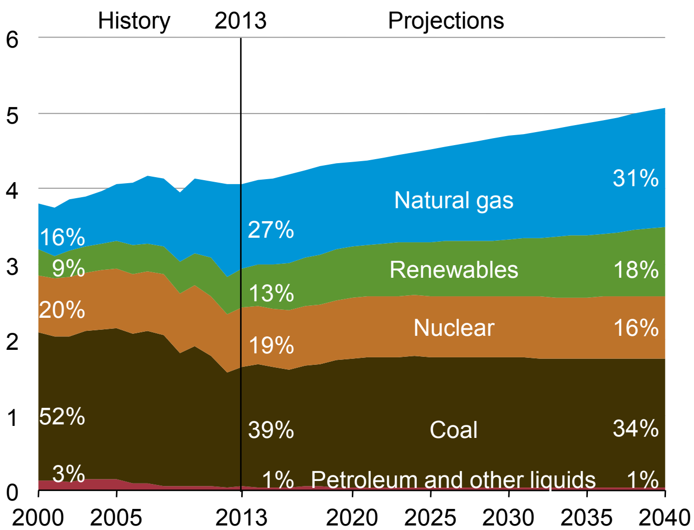
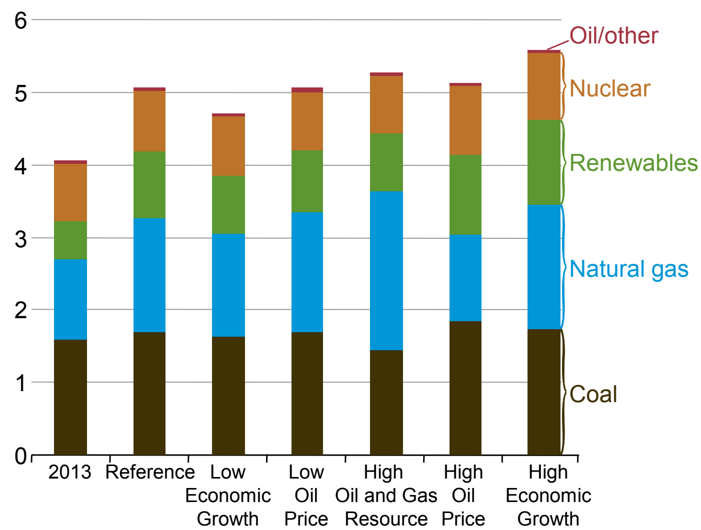


Figure 32. Electricity generation by fuel in six cases, 2013 and 2040 (trillion kilowatthours)



[29]U.S. Environmental Protection Agency, "Clean Air Interstate Rule (CAIR)" (Washington, DC: February 5, 2015), http://www.epa.gov/airmarkets/programs/cair/.

[30]U.S. Environmental Protection Agency, "Cross-State Air Pollution Rule (CSAPR)" (Washington, DC: October 23, 2014), http://www.epa.gov/airtransport/CSAPR.

[31]The AEO2015 Reference case assumes implementation of the Clean Air Interstate Rule (CAIR), which has been replaced by the Cross-State Air Pollution Rule (CSAPR) following a recent D.C. Circuit Court of Appeals decision to lift a stay on CSAPR. Although CAIR and CSAPR are broadly similar, future AEOs will incorporate CSAPR, absent further court action to stay its implementation.

case but still accounts for the largest share of total generation. When natural gas prices are lower than those in the Reference case, as in the High Oil and Gas Resource case, the coal share of total electricity generation drops below the natural gas share by 2020. When total electricity generation is reduced in the Low Economic Growth case, and as a result there is less need for new generation capacity, coal-fired generation maintains a larger share of the total.

Total natural gas-fired generation grows by 40% from 2013 to 2040 in the AEO2015 Reference case—and the natural gas share of total generation grows from 27% to 31%—with most of the growth occurring in the second half of the projection period. The natural gas share of total generation varies by AEO2015 case, depending on fuel prices; however, its growth is also supported by limited potential to increase coal use at existing coal-fired generating units, which in some regions are already at maximum utilization rates. In the High Oil Price case, the natural gas share of total electricity generation in 2040 drops to 23%. In the High Oil and Gas Resource case, with delivered natural gas prices 44% below those in the Reference case, the natural gas share of total generation in 2040 is 42%. Lower natural gas prices in the High Oil and Gas Resource case result in the addition of new natural gas-fired capacity, as well as increased operation of combined-cycle plants, which displace some coal-fired generation. The average capacity factor of natural gas combined-cycle plants is more than 60% in the High Oil and Gas Resource case, compared with an average capacity factor of around 50% in the Reference case (Figure 33), while the average capacity factor of coal-fired plants is lower in the High Oil and Gas Resource case than in the Reference case.

Electricity generation from nuclear units across the cases reflects the impacts of planned and unplanned builds and retirements. Nuclear power plants provided 19% of total electricity generation in 2013. From 2013 to 2040, the nuclear share of total generation declines in all cases, to 15% in the High Oil and Gas Resource case and to 18% in the High Oil Price case, where higher natural gas prices lead to additional growth in nuclear capacity.

Renewable generation grows substantially from 2013 to 2040 in all the AEO2015 cases, with increases ranging from less than 50% in the High Oil and Gas Resource and Low Economic Growth cases to 121% in the High Economic Growth case. State and national policy requirements play an important role in the continuing growth of renewable generation. In the Reference case, the largest growth is seen for wind and solar generation (Figure 34). In 2013, as a result of increases in wind and solar generation, total nonhydropower renewable generation was almost equal to hydroelectric generation for the first time. In 2040, nonhydropower renewable energy sources account for more than two-thirds of the total renewable generation in the Reference case. The total renewable share of all electricity generation increases from 13% in 2013 to 18% in 2040 in the Reference case and to as much as 22% in 2040 in the High Oil Price case. With lower natural gas prices in the High Oil and Gas Resource case, the renewable generation share of total electricity generation grows more slowly but still increases to 15% of total generation in 2040.

Total electricity generation capacity, including capacity in the end-use sectors, increases from 1,065 GW in 2013 to 1,261 GW in 2040 in the AEO2015 Reference case. Over the first 10 years of the projection, capacity additions are roughly equal to retirements, and the level of total capacity remains relatively flat as existing capacity is sufficient to meet expected demand. Capacity additions between 2013 and 2040 total 287 GW, and retirements total 90 GW. From 2018 to 2024, capacity additions average less than 4 GW/year, as earlier planned additions are sufficient to meet most demand growth. From 2025 to 2040, average annual capacity additions—primarily natural gas-fired and renewable technologies—average 12 GW/year. The mix of capacity types added varies across the cases, depending on natural gas prices (Figure 35).

Figure 33. Coal and natural gas combined-cycle generation capacity factors in two cases, 2010-40 (percent)

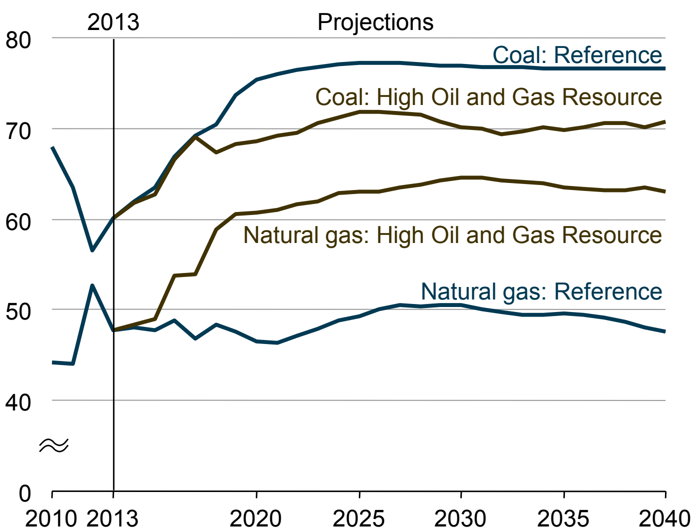


Figure 34. Renewable electricity generation by fuel type in the Reference case, 2000-2040 (billion kilowatthours)

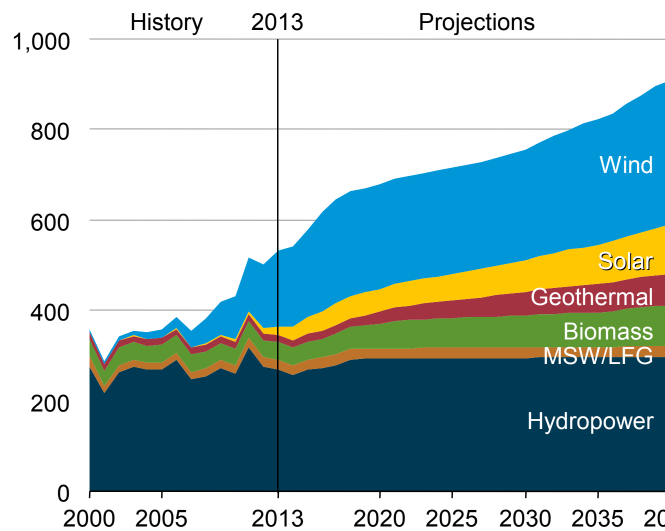
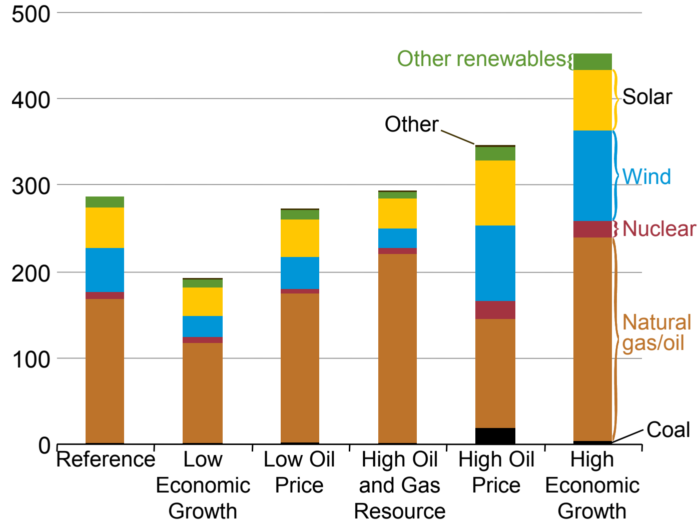


Figure 35. Cumulative additions to electricity generation capacity by fuel in six cases, 2013-40 (gigawatts)



In recent years, natural gas-fired capacity has grown considerably. In particular, combined-cycle plants are relatively inexpensive to build in comparison with new coal, nuclear, or renewable technologies, and they are more efficient to operate than existing natural gas-, oil- or coal-fired steam plants. Natural gas turbines are the most economical way to meet growth for peak demand. In most of the AEO2015 cases, the growth in natural gas capacity continues. Natural gas-fired plants account for 58% of total capacity additions from 2013 to 2040 in the Reference case, and they represent more than 50% of additions in all cases, except for the High Oil Price case, where higher fuel prices for natural gas-fired plants reduce their competitiveness, and only 36% of new builds are gas-fired. With lower fuel prices in the High Oil and Gas Resource case, natural gas-fired capacity makes up three-quarters of total capacity additions.

Coal-fired capacity declines from 304 GW in 2013 to 260 GW in 2040 in the Reference case, as a result of retirements and very few new additions. A total of 40 GW of coal capacity is retired from 2013 to 2040 in the Reference case, representing both announced retirements and those projected on the basis of relative economics, including the costs of meeting environmental regulations and competition with natural gas-fired generation in the near term. As a result of the uncertainty surrounding future greenhouse gas legislation and regulations and given its high capital costs, very little unplanned coal-fired capacity is added across all the AEO2015 cases. About 19 GW of new coal-fired capacity is added in the High Oil Price case, but much of that is associated with CTL plants built in the refinery sector in response to higher oil prices.

Renewables account for more than half the capacity added through 2022, largely to take advantage of the current production tax credit and to help meet state renewable targets. Renewable capacity additions are significant in most of the cases, and in the Reference case they represent 38% of the capacity added from 2013 to 2040. The 109 GW of renewable capacity additions in the Reference case are primarily wind (49 GW) and solar (48 GW) technologies, including 31 GW of solar PV installations in the end-use sectors. The renewable share of total additions ranges from 22% in the High Oil and Gas Resource case to 51% in the High Oil Price case, reflecting the relative economics of natural gas-fired power plants, which are the primary choice for new generating capacity.

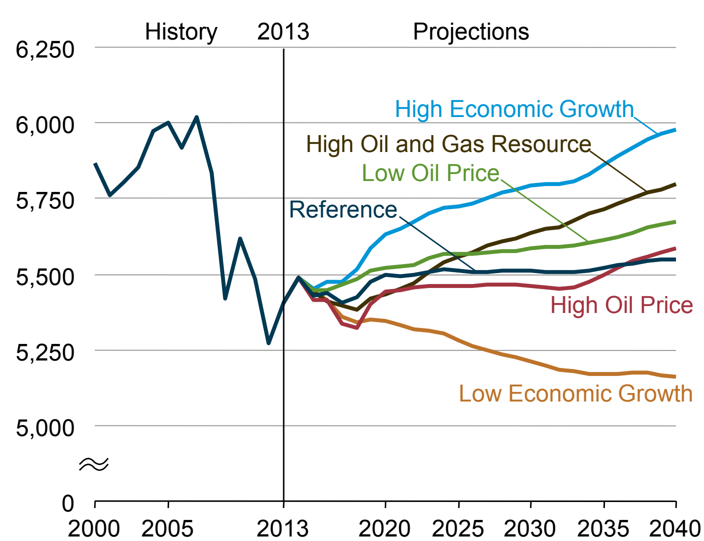
High construction costs for nuclear plants limit their competitiveness to meet new demand in the Reference case. In the near term, 5.5 GW of planned additions are put into place by 2020, offset by 3.2 GW of retirements over the same period. After 2025, 3.5 GW of additional nuclear capacity is built, based on relative economics. In the High Economic Growth and High Oil Price cases, an additional 10 GW to 13 GW of nuclear capacity above the Reference case is added by 2040 to meet demand growth, as a result of higher costs for the alternative technologies and/or higher capacity requirements.

Energy-related carbon dioxide emissions

In the AEO2015 Reference case projection, U.S. energy-related CO2 emissions are 5,549 million metric tons (mt) in 2040. Among the alternative cases, emissions totals show the greatest sensitivity to levels of economic growth (Figure 36), with 2040 totals varying from 5,979 million mt in the High Economic Growth case to 5,160 million mt in the Low Economic Growth case. In all the AEO2015 cases, emissions remain below the 2005 level of 5,993 million mt. As noted above, the AEO2015 cases do not assume implementation of EPA's proposed Clean Power Plan or other actions beyond current policies to limit or reduce CO2 emissions.

Emissions per dollar of GDP fall from the 2013 level in all the AEO2015 cases. In the Reference case, most of the decline is

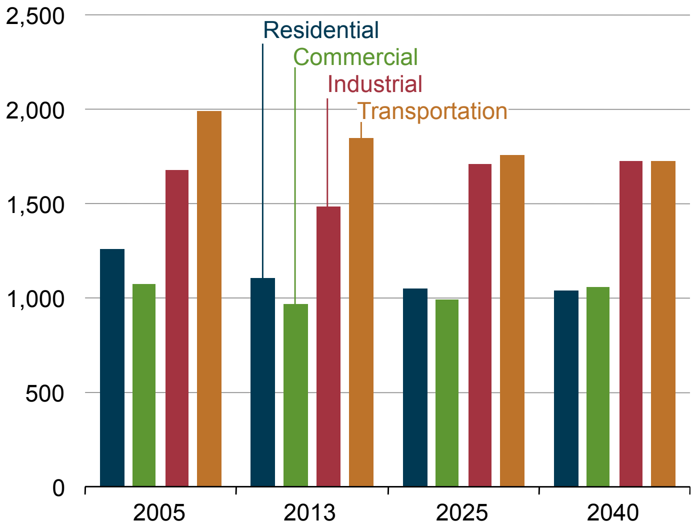
Figure 36. Energy-related carbon dioxide emissions in six cases. 2000-2040 (million metric tons)



attributable to a 2.0%/year decrease in energy intensity. In addition, the carbon intensity of the energy supply declines by 0.2%/year over the projection period.

The main factors influencing CO2 emissions include substitution of natural gas for coal in electricity generation, increases in the use of renewable energy, improvements in vehicle fuel economy, and increases in the efficiencies of appliances and industrial processes. In the Reference case, CO2 emissions growth varies across the end-use sectors (Figure 37). The highest annual growth rate (0.5%) is projected for the industrial sector, reflecting a resurgence of industrial production fueled mainly by natural gas. CO2 emissions in the commercial sector grow by 0.3%/year in the Reference case, while emissions in both the residential and transportation sectors decline on average by 0.2%/year.

Figure 37. Energy-related carbon dioxide emissions by sector in the Reference case, 2005, 2013, 2025, and 2040 (million metric tons)



In the alternative cases, various factors play roles in the emissions picture. In the High Economic Growth case, GDP increases annually by 2.9% and overshadows the decrease in energy intensity of 2.2%, leading to the largest annual rate of increase in CO2 emissions (0.4%/year). In the Low Economic Growth case, GDP grows by only 1.8%/year, and that growth is offset by a similar annual average decline in energy intensity. With the additional decline in the carbon intensity of the energy supply, CO2 emissions decline by 0.2%/year in the Low Economic Growth case.

Emissions levels also vary across the other alternative cases. The High Oil and Gas Resource case has the second-highest rate of emissions in 2040 (after the High Economic Growth case) at 5,800 million mt. In the Low Oil Price case, CO2 emissions total 5,671 million mt in 2040. In the High Oil Price case, emissions levels remain lower than projected in the Reference case throughout most of the period from 2013 to 2040, but energy-related CO2 emissions exceed the Reference case level by 35 million mt in 2040, at 5,584 million mt.

List of acronyms

AEO	Annual Energy Outlook	GW	Gigawatt(s)
AEO2015	Annual Energy Outlook 2015	HDV	Heavy-duty vehicle
API	American Petroleum Institute	HGL	Hydrocarbon gas liquids
bbl	Barrels	kWh	Kilowatthour(s)
bbl/d	Barrels per day	LDV	Light-duty vehicle
Brent	North Sea Brent	LNG	Liquefied natural gas
Btu	British thermal unit(s)	MARPOL	Marine pollution
CAFE	Corporate average fuel economy	MATS	Mercury and Air Toxics Standards
CAIR	Clean Air Interstate Rule	Mcf	Thousand cubic feet
CHP	Combined heat and power	MELs	Miscellaneous electric loads
CO2	Carbon dioxide	mpg	Miles per gallon
CPI	Consumer price index	mt	Metric ton(s)
CSAPR	Cross-State Air Pollution Rule	NGPL	Natural gas plant liquids
CTL	Coal-to-liquids	OECD	Organization for Economic Cooperation and Development
E85	Motor fuel containing up to 85% ethanol	OPEC	Organization of the Petroleum Exporting Countries
EIA	U.S. Energy Information Administration	PADD	Petroleum Administration for Defense District
EOR	Enhanced oil recovery	PV	Photovoltaic
EPA	U.S. Environmental Protection Agency	RFS	Renewable fuel standard
EUR	Estimated ultimate recovery	Tcf	Trillion cubic feet
GDP	Gross domestic product	U.S.	United States
GTL	Gas-to-liquids	VMT	Vehicle miles traveled

Figure and table sources

Links current as of April 2015

Figure ES1. North Sea Brent crude oil spot prices in four cases, 2005-40: History: U.S. Energy Information Administration, Petroleum & Other Liquids, Europe Bent Spot Price FOB, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=D. **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure ES2. Average Henry Hub spot prices for natural gas in four cases, 2005-40: History: U.S. Energy Information Administration, *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure ES3. U.S. net energy imports in six cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Table ES1. Growth of trade-related factors in the Reference case, 1983-2040: AEO2015 National Energy Modeling System, runs REF2015.D021915A.

Figure ES4. Net crude oil and petroleum product imports as a percentage of U.S. product supplied in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure ES5. U.S. total net natural gas imports in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure ES6. Change in U.S. Lower 48 onshore crude oil production by region in six cases, 2013-40: Projections: AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure ES7. Delivered energy consumption for transportation in six cases, 2008-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure ES8. Total U.S. renewable generation in all sectors by fuel in six cases, 2013 and 2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Table 1. Summary of AEO2015 cases: U.S. Energy Information Administration.

Table 2. Growth in key economic factors in historical data and in the Reference case: AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 1. Annual changes in U.S. gross domestic product, business investment, and exports in the Reference case, 2015-40: Projections: AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 2. Annual growth rates for industrial output in three cases, 2013-40: Projections: AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWMACRO.D021915A, and HIGHMACRO.D021915A.

Table 3. Average annual growth of labor productivity, employment, income, and consumption in three cases: Projections: AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWMACRO.D021915A, and HIGHMACRO.D021915A.

Figure 3. North Sea Brent crude oil spot prices in four cases, 2005-40: History: U.S. Energy Information Administration, Petroleum & Other Liquids, Europe Bent Spot Price FOB, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=D. **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, and HIGHPRICE.D021915A.

Figure 4. Motor gasoline prices in three cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, and HIGHPRICE.D021915A.

Figure 5. Distillate fuel oil prices in three cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, and HIGHPRICE.D021915A.

Figure 6. Average Henry Hub spot prices for natural gas in four cases, 2005-40: History: U.S. Energy Information Administration, *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 7. Average minemouth coal prices by region in the Reference case, 1990-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 8. Average delivered coal prices in six cases, 1990-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 9. Average retail electricity prices in six cases, 2013-40: AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 10. Delivered energy consumption for transportation by mode in the Reference case, 2013 and 2040: History: U.S. Energy Information Administration, Natural Gas Annual 2013, DOE/EIA-0131(2013) (Washington, DC, October 2014). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 11. Delivered energy consumption for transportation in six cases, 2008-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 12. Industrial sector total delivered energy consumption in three cases, 2010-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWMACRO.D021915A, and HIGHMACRO.D021915A.

Figure 13. Industrial sector natural gas consumption for heat and power in three cases, 2010-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 14. Residential sector delivered energy consumption by fuel in the Reference case, 2010-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 15. Commercial sector delivered energy consumption by fuel in the Reference case, 2010-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Table 4. Residential households and commercial indicators in three AEO2015 cases, 2013 and 2040: AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWMACRO.D021915A, and HIGHMACRO.D021915A.

Figure 16. Residential sector delivered energy intensity for selected end uses in the Reference case, 2013 and 2040: AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 17. Commercial sector delivered energy intensity for selected end uses in the Reference case, 2013 and 2040: AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 18. Primary energy consumption by fuel in the Reference case, 1980-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 19. Energy use per capita and per 2009 dollar of gross domestic product, and carbon dioxide emissions per 2009 dollar of gross domestic product, in the Reference case, 1980-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 20. Total energy production and consumption in the Reference case, 1980-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 21. U.S. tight oil production in four cases, 2005-40: AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 22. U.S. total crude oil production in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 23. U.S. net crude oil imports in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 24. U.S. net petroleum product imports in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 25. U.S. total dry natural gas production in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 26. U.S. shale gas production in four cases, 2005-40: AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 27. U.S. total natural gas net imports in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 28. U.S. liquefied natural gas net imports in four cases, 2005-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, and HIGHRESOURCE.D021915B.

Figure 29. U.S. coal production in six cases, 1990-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 30. U.S. coal exports in six cases, 1990-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 31. Electricity generation by fuel in the Reference case, 2000-2040: History: U.S. Energy Information Administration, Monthly Energy Review, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 32. Electricity generation by fuel in six cases, 2013 and 2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 33. Coal and natural gas combined-cycle generation capacity factors in two cases, 2010-40: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Figure 34. Renewable electricity generation by fuel type in the Reference case, 2000-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

Figure 35. Cumulative additions to electricity generation capacity by fuel in six cases, 2013-40: AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 36. Energy-related carbon dioxide emissions in six cases, 2000-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, runs REF2015.D021915A, LOWPRICE.D021915A, HIGHPRICE.D021915A, LOWMACRO.D021915A, HIGHMACRO.D021915A, and HIGHRESOURCE.D021915B.

Figure 37. Energy-related carbon dioxide emissions by sector in the Reference cases, 2005, 2013, 2025, and 2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A.

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Table A1. Total energy supply, disposition, and price summary
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Production								
Crude oil and lease condensate	13.7	15.6	22.2	21.5	21.1	19.8	19.9	0.9%
Natural gas plant liquids	3.3	3.6	5.5	5.7	5.7	5.6	5.5	1.7%
Dry natural gas	24.6	25.1	29.6	31.3	33.9	35.1	36.4	1.4%
Coal[1]	20.7	20.0	21.7	22.2	22.5	22.5	22.6	0.5%
Nuclear / uranium[2]	8.1	8.3	8.4	8.5	8.5	8.5	8.7	0.2%
Conventional hydroelectric power	2.6	2.5	2.8	2.8	2.8	2.8	2.8	0.4%
Biomass[3]	4.0	4.2	4.4	4.6	4.6	4.7	5.0	0.7%
Other renewable energy[4]	1.9	2.3	3.2	3.4	3.6	4.1	4.6	2.7%
Other[5]	0.8	1.3	0.9	0.9	0.9	0.9	1.0	-1.0%
Total	**79.6**	**82.7**	**98.7**	**100.9**	**103.7**	**103.9**	**106.6**	**0.9%**
Imports								
Crude oil	18.7	17.0	13.6	14.9	15.7	17.7	18.2	0.3%
Petroleum and other liquids[6]	4.2	4.3	4.6	4.5	4.4	4.3	4.1	-0.2%
Natural gas[7]	3.2	2.9	1.9	1.7	1.6	1.5	1.7	-1.9%
Other imports[8]	0.3	0.3	0.1	0.1	0.1	0.1	0.1	-5.2%
Total	**26.4**	**24.5**	**20.2**	**21.3**	**21.7**	**23.6**	**24.1**	**-0.1%**
Exports								
Petroleum and other liquids[9]	6.5	7.3	11.2	12.0	12.6	13.3	13.7	2.4%
Natural gas[10]	1.6	1.6	4.5	5.2	6.4	6.8	7.4	5.9%
Coal	3.1	2.9	2.5	2.9	3.3	3.4	3.5	0.8%
Total	**11.2**	**11.7**	**18.1**	**20.1**	**22.4**	**23.4**	**24.6**	**2.8%**
Discrepancy[11]	**0.4**	**-1.6**	**-0.1**	**0.0**	**0.2**	**0.3**	**0.3**	**- -**
Consumption								
Petroleum and other liquids[12]	35.2	35.9	37.1	36.9	36.5	36.3	36.2	0.0%
Natural gas	26.1	26.9	26.8	27.6	28.8	29.6	30.5	0.5%
Coal[13]	17.3	18.0	19.2	19.3	19.2	19.0	19.0	0.2%
Nuclear / uranium[2]	8.1	8.3	8.4	8.5	8.5	8.5	8.7	0.2%
Conventional hydroelectric power	2.6	2.5	2.8	2.8	2.8	2.8	2.8	0.4%
Biomass[14]	2.8	2.9	3.0	3.2	3.2	3.2	3.5	0.7%
Other renewable energy[4]	1.9	2.3	3.2	3.4	3.6	4.1	4.6	2.7%
Other[15]	0.4	0.4	0.3	0.3	0.3	0.3	0.3	-0.7%
Total	**94.4**	**97.1**	**100.8**	**102.0**	**102.9**	**103.8**	**105.7**	**0.3%**
Prices (2013 dollars per unit)								
Crude oil spot prices (dollars per barrel)								
Brent	113	109	79	91	106	122	141	1.0%
West Texas Intermediate	96	98	73	85	99	116	136	1.2%
Natural gas at Henry Hub (dollars per million Btu)	2.79	3.73	4.88	5.46	5.69	6.60	7.85	2.8%
Coal (dollars per ton)								
at the minemouth[16]	40.5	37.2	37.9	40.3	43.7	46.7	49.2	1.0%
Coal (dollars per million Btu)								
at the minemouth[16]	2.01	1.84	1.88	2.02	2.18	2.32	2.44	1.0%
Average end-use[17]	2.63	2.50	2.54	2.71	2.84	2.96	3.09	0.8%
Average electricity (cents per kilowatthour)	10.0	10.1	10.5	11.0	11.1	11.3	11.8	0.6%

Table A1. Total energy supply, disposition, and price summary (continued)
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Prices (nominal dollars per unit)								
Crude oil spot prices (dollars per barrel)								
Brent	112	109	90	112	142	180	229	2.8%
West Texas Intermediate	94	98	83	105	133	171	220	3.0%
Natural gas at Henry Hub (dollars per million Btu)	2.75	3.73	5.54	6.72	7.63	9.70	12.73	4.7%
Coal (dollars per ton)								
at the minemouth[16]	40.0	37.2	43.0	49.7	58.6	68.6	79.8	2.9%
Coal (dollars per million Btu)								
at the minemouth[16]	1.98	1.84	2.14	2.48	2.92	3.41	3.96	2.9%
Average end-use[17]	2.59	2.50	2.88	3.33	3.81	4.35	5.00	2.6%
Average electricity (cents per kilowatthour)	9.8	10.1	11.9	13.5	14.8	16.6	19.2	2.4%

[1]Includes waste coal.
[2]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[3]Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table A17 for details.
[4]Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table A17 for selected nonmarketed residential and commercial renewable energy data.
[5]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.
[6]Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.
[7]Includes imports of liquefied natural gas that are later re-exported.
[8]Includes coal, coal coke (net), and electricity (net). Excludes imports of fuel used in nuclear power plants.
[9]Includes crude oil, petroleum products, ethanol, and biodiesel.
[10]Includes re-exported liquefied natural gas.
[11]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[12]Estimated consumption. Includes petroleum-derived fuels and non-petroleum derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel. Refer to Table A17 for detailed renewable liquid fuels consumption.
[13]Excludes coal converted to coal-based synthetic liquids and natural gas.
[14]Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.
[15]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[16]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[17]Prices weighted by consumption; weighted average excludes export free-alongside-ship (f.a.s.) prices.
Btu = British thermal unit.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 natural gas supply values: U.S. Energy Information Administration (EIA), *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014). 2013 natural gas supply values: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2012 and 2013 coal minemouth and delivered coal prices: EIA, *Annual Coal Report 2013*, DOE/EIA-0584(2013) (Washington, DC, January 2015). 2013 petroleum supply values and 2012 crude oil and lease condensate production: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). Other 2012 petroleum supply values: EIA, *Petroleum Supply Annual 2012*, DOE/EIA-0340(2012)/1 (Washington, DC, September 2013). 2012 and 2013 crude oil spot prices and natural gas spot price at Henry Hub: Thomson Reuters. Other 2012 and 2013 coal values: *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014). Other 2012 and 2013 values: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A2. Energy consumption by sector and source
(quadrillion Btu per year, unless otherwise noted)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Energy consumption								
Residential								
Propane	0.40	0.43	0.32	0.30	0.28	0.26	0.25	-2.0%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-3.0%
Distillate fuel oil	0.49	0.50	0.40	0.35	0.31	0.27	0.24	-2.7%
Petroleum and other liquids subtotal	0.90	0.93	0.73	0.66	0.59	0.54	0.49	-2.4%
Natural gas	4.25	5.05	4.63	4.54	4.52	4.43	4.31	-0.6%
Renewable energy[1]	0.44	0.58	0.41	0.39	0.38	0.36	0.35	-1.8%
Electricity	4.69	4.75	4.86	4.92	5.08	5.23	5.42	0.5%
Delivered energy	**10.28**	**11.32**	**10.63**	**10.51**	**10.57**	**10.56**	**10.57**	**-0.3%**
Electricity related losses	9.57	9.79	9.75	9.74	9.91	10.10	10.33	0.2%
Total	**19.85**	**21.10**	**20.38**	**20.25**	**20.48**	**20.66**	**20.91**	**0.0%**
Commercial								
Propane	0.14	0.15	0.16	0.17	0.17	0.17	0.18	0.7%
Motor gasoline[2]	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.8%
Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.4%
Distillate fuel oil	0.36	0.37	0.34	0.32	0.30	0.29	0.27	-1.1%
Residual fuel oil	0.03	0.03	0.07	0.07	0.07	0.07	0.06	3.3%
Petroleum and other liquids subtotal	0.57	0.59	0.62	0.61	0.60	0.59	0.58	-0.1%
Natural gas	2.97	3.37	3.30	3.29	3.43	3.57	3.71	0.4%
Coal	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.5%
Renewable energy[3]	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.0%
Electricity	4.53	4.57	4.82	4.99	5.19	5.40	5.66	0.8%
Delivered energy	**8.22**	**8.69**	**8.90**	**9.06**	**9.38**	**9.73**	**10.12**	**0.6%**
Electricity related losses	9.24	9.42	9.68	9.88	10.13	10.43	10.80	0.5%
Total	**17.46**	**18.10**	**18.58**	**18.94**	**19.52**	**20.16**	**20.92**	**0.5%**
Industrial[4]								
Liquefied petroleum gases and other[5]	2.42	2.51	3.20	3.56	3.72	3.69	3.67	1.4%
Motor gasoline[2]	0.24	0.25	0.26	0.26	0.25	0.25	0.25	0.0%
Distillate fuel oil	1.28	1.31	1.42	1.38	1.36	1.34	1.35	0.1%
Residual fuel oil	0.07	0.06	0.10	0.14	0.13	0.13	0.13	2.9%
Petrochemical feedstocks	0.74	0.74	0.95	1.10	1.14	1.17	1.20	1.8%
Other petroleum[6]	3.33	3.52	3.67	3.80	3.83	3.89	3.99	0.5%
Petroleum and other liquids subtotal	8.08	8.40	9.61	10.24	10.44	10.47	10.59	0.9%
Natural gas	7.39	7.62	8.33	8.47	8.65	8.76	8.90	0.6%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[7]	1.43	1.52	1.87	1.98	2.10	2.18	2.29	1.5%
Natural gas subtotal	8.82	9.14	10.20	10.44	10.75	10.94	11.19	0.8%
Metallurgical coal	0.59	0.62	0.61	0.59	0.56	0.53	0.51	-0.7%
Other industrial coal	0.87	0.88	0.93	0.95	0.96	0.97	0.99	0.4%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Net coal coke imports	0.00	-0.02	0.00	-0.01	-0.03	-0.05	-0.06	4.5%
Coal subtotal	1.47	1.48	1.54	1.53	1.48	1.44	1.44	-0.1%
Biofuels heat and coproducts	0.73	0.72	0.80	0.80	0.80	0.81	0.86	0.6%
Renewable energy[8]	1.51	1.48	1.53	1.60	1.59	1.58	1.63	0.4%
Electricity	3.36	3.26	3.74	3.98	4.04	4.05	4.12	0.9%
Delivered energy	**23.97**	**24.48**	**27.42**	**28.58**	**29.10**	**29.29**	**29.82**	**0.7%**
Electricity related losses	6.87	6.72	7.51	7.88	7.88	7.83	7.85	0.6%
Total	**30.84**	**31.20**	**34.93**	**36.46**	**36.98**	**37.12**	**37.68**	**0.7%**

Table A2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Transportation								
Propane	0.05	0.05	0.04	0.05	0.05	0.06	0.07	1.3%
Motor gasoline[2]	15.82	15.94	15.35	14.22	13.30	12.82	12.55	-0.9%
of which: E85[9]	0.01	0.02	0.03	0.12	0.20	0.24	0.28	10.0%
Jet fuel[10]	2.86	2.80	3.01	3.20	3.40	3.54	3.64	1.0%
Distillate fuel oil[11]	5.80	6.50	7.35	7.59	7.76	7.94	7.97	0.8%
Residual fuel oil	0.67	0.57	0.35	0.36	0.36	0.36	0.36	-1.6%
Other petroleum[12]	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.2%
Petroleum and other liquids subtotal	25.35	26.00	26.27	25.57	25.03	24.88	24.76	-0.2%
Pipeline fuel natural gas	0.75	0.88	0.85	0.90	0.94	0.94	0.96	0.3%
Compressed / liquefied natural gas	0.04	0.05	0.07	0.10	0.17	0.31	0.71	10.3%
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Electricity	0.02	0.02	0.03	0.04	0.04	0.05	0.06	3.4%
Delivered energy	**26.16**	**26.96**	**27.22**	**26.60**	**26.18**	**26.19**	**26.49**	**-0.1%**
Electricity related losses	0.05	0.05	0.06	0.07	0.08	0.10	0.12	3.1%
Total	**26.20**	**27.01**	**27.29**	**26.67**	**26.27**	**26.29**	**26.61**	**-0.1%**
Unspecified sector[13]	**0.04**	**-0.27**	**-0.34**	**-0.36**	**-0.37**	**-0.38**	**-0.38**	**- -**
Delivered energy consumption for all sectors								
Liquefied petroleum gases and other[5]	3.01	3.14	3.73	4.08	4.23	4.19	4.17	1.1%
Motor gasoline[2]	16.10	16.36	15.79	14.65	13.72	13.23	12.96	-0.9%
of which: E85[9]	0.01	0.02	0.03	0.12	0.20	0.24	0.28	10.0%
Jet fuel[10]	2.90	2.97	3.20	3.39	3.61	3.76	3.86	1.0%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-1.0%
Distillate fuel oil	7.92	8.10	8.86	8.97	9.05	9.14	9.13	0.4%
Residual fuel oil	0.77	0.65	0.53	0.56	0.56	0.55	0.56	-0.6%
Petrochemical feedstocks	0.74	0.74	0.95	1.10	1.14	1.17	1.20	1.8%
Other petroleum[14]	3.47	3.67	3.82	3.96	3.98	4.05	4.15	0.5%
Petroleum and other liquids subtotal	34.93	35.65	36.89	36.72	36.30	36.09	36.03	0.0%
Natural gas	14.65	16.10	16.32	16.40	16.76	17.07	17.64	0.3%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[7]	1.43	1.52	1.87	1.98	2.10	2.18	2.29	1.5%
Pipeline fuel natural gas	0.75	0.88	0.85	0.90	0.94	0.94	0.96	0.3%
Natural gas subtotal	16.82	18.50	19.05	19.28	19.80	20.19	20.88	0.4%
Metallurgical coal	0.59	0.62	0.61	0.59	0.56	0.53	0.51	-0.7%
Other coal	0.91	0.92	0.98	1.00	1.00	1.01	1.04	0.4%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Net coal coke imports	0.00	-0.02	0.00	-0.01	-0.03	-0.05	-0.06	4.5%
Coal subtotal	1.51	1.52	1.59	1.58	1.53	1.49	1.49	-0.1%
Biofuels heat and coproducts	0.73	0.72	0.80	0.80	0.80	0.81	0.86	0.6%
Renewable energy[15]	2.06	2.18	2.06	2.11	2.09	2.06	2.10	-0.1%
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Electricity	12.61	12.60	13.45	13.91	14.35	14.74	15.25	0.7%
Delivered energy	**68.66**	**71.17**	**73.84**	**74.39**	**74.87**	**75.39**	**76.62**	**0.3%**
Electricity related losses	25.73	25.97	27.00	27.58	28.01	28.46	29.10	0.4%
Total	**94.40**	**97.14**	**100.84**	**101.97**	**102.87**	**103.85**	**105.73**	**0.3%**
Electric power[16]								
Distillate fuel oil	0.05	0.05	0.09	0.09	0.08	0.08	0.08	1.6%
Residual fuel oil	0.17	0.21	0.08	0.09	0.09	0.09	0.09	-3.0%
Petroleum and other liquids subtotal	0.22	0.26	0.17	0.17	0.17	0.17	0.18	-1.5%
Natural gas	9.31	8.36	7.80	8.33	9.03	9.40	9.61	0.5%
Steam coal	15.82	16.49	17.59	17.75	17.63	17.54	17.52	0.2%
Nuclear / uranium[17]	8.06	8.27	8.42	8.46	8.47	8.51	8.73	0.2%
Renewable energy[18]	4.53	4.78	6.13	6.43	6.72	7.26	7.99	1.9%
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.0%
Electricity imports	0.16	0.18	0.11	0.12	0.10	0.09	0.11	-1.8%
Total	**38.34**	**38.57**	**40.45**	**41.49**	**42.35**	**43.19**	**44.36**	**0.5%**

Table A2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	Reference case 2012	2013	2020	2025	2030	2035	2040	Annual growth 2013-2040 (percent)
Total energy consumption								
Liquefied petroleum gases and other[5]	3.01	3.14	3.73	4.08	4.23	4.19	4.17	1.1%
Motor gasoline[2]	16.10	16.36	15.79	14.65	13.72	13.23	12.96	-0.9%
of which: E85[9]	0.01	0.02	0.03	0.12	0.20	0.24	0.28	10.0%
Jet fuel[10]	2.90	2.97	3.20	3.39	3.61	3.76	3.86	1.0%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-1.0%
Distillate fuel oil	7.98	8.15	8.95	9.06	9.13	9.22	9.21	0.5%
Residual fuel oil	0.94	0.87	0.61	0.65	0.64	0.64	0.65	-1.1%
Petrochemical feedstocks	0.74	0.74	0.95	1.10	1.14	1.17	1.20	1.8%
Other petroleum[14]	3.47	3.67	3.82	3.96	3.98	4.05	4.15	0.5%
Petroleum and other liquids subtotal	35.16	35.91	37.06	36.89	36.47	36.26	36.21	0.0%
Natural gas	23.96	24.46	24.12	24.73	25.79	26.47	27.25	0.4%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[7]	1.43	1.52	1.87	1.98	2.10	2.18	2.29	1.5%
Pipeline fuel natural gas	0.75	0.88	0.85	0.90	0.94	0.94	0.96	0.3%
Natural gas subtotal	26.14	26.86	26.85	27.60	28.83	29.59	30.50	0.5%
Metallurgical coal	0.59	0.62	0.61	0.59	0.56	0.53	0.51	-0.7%
Other coal	16.73	17.41	18.57	18.75	18.63	18.55	18.56	0.2%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Net coal coke imports	0.00	-0.02	0.00	-0.01	-0.03	-0.05	-0.06	4.5%
Coal subtotal	17.33	18.01	19.18	19.33	19.16	19.03	19.01	0.2%
Nuclear / uranium[17]	8.06	8.27	8.42	8.46	8.47	8.51	8.73	0.2%
Biofuels heat and coproducts	0.73	0.72	0.80	0.80	0.80	0.81	0.86	0.6%
Renewable energy[19]	6.59	6.96	8.19	8.54	8.81	9.32	10.09	1.4%
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.0%
Electricity imports	0.16	0.18	0.11	0.12	0.10	0.09	0.11	-1.8%
Total	**94.40**	**97.14**	**100.84**	**101.97**	**102.87**	**103.85**	**105.73**	**0.3%**
Energy use and related statistics								
Delivered energy use	68.66	71.17	73.84	74.39	74.87	75.39	76.62	0.3%
Total energy use	94.40	97.14	100.84	101.97	102.87	103.85	105.73	0.3%
Ethanol consumed in motor gasoline and E85	1.09	1.12	1.12	1.12	1.12	1.16	1.27	0.5%
Population (millions)	315	317	334	347	359	370	380	0.7%
Gross domestic product (billion 2009 dollars)	15,369	15,710	18,801	21,295	23,894	26,659	29,898	2.4%
Carbon dioxide emissions (million metric tons)	5,272	5,405	5,499	5,511	5,514	5,521	5,549	0.1%

[1]Includes wood used for residential heating. See Table A4 and/or Table A17 for estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal water heating, and electricity generation from wind and solar photovoltaic sources.
[2]Includes ethanol and ethers blended into gasoline.
[3]Excludes ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. See Table A5 and/or Table A17 for estimates of nonmarketed renewable energy consumption for solar thermal water heating and electricity generation from wind and solar photovoltaic sources.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[5]Includes ethane, natural gasoline, and refinery olefins.
[6]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Represents natural gas used in well, field, and lease operations, in natural gas processing plant machinery, and for liquefaction in export facilities.
[8]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[9]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[10]Includes only kerosene type.
[11]Diesel fuel for on- and off- road use.
[12]Includes aviation gasoline and lubricants.
[13]Represents consumption unattributed to the sectors above.
[14]Includes aviation gasoline, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[15]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[16]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[17]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[18]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[19]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
Btu = British thermal unit.
- - = Not applicable.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 population and gross domestic product: IHS Economics, Industry and Employment models, November 2014. 2012 and 2013 carbon dioxide emissions and emission factors: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014).
Projections: EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A3. Energy prices by sector and source
(2013 dollars per million Btu, unless otherwise noted)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Residential								
Propane	24.3	23.3	23.0	23.7	24.4	25.5	26.6	0.5%
Distillate fuel oil	27.3	27.2	21.5	23.7	26.3	29.4	32.9	0.7%
Natural gas	10.6	10.0	11.6	12.7	12.8	13.7	15.5	1.6%
Electricity	35.3	35.6	37.8	39.6	40.0	40.8	42.4	0.6%
Commercial								
Propane	21.0	20.0	19.4	20.2	21.1	22.5	23.9	0.7%
Distillate fuel oil	26.8	26.7	21.0	23.2	25.8	28.9	32.5	0.7%
Residual fuel oil	22.9	22.1	14.2	16.0	18.1	20.6	24.3	0.4%
Natural gas	8.2	8.1	9.6	10.5	10.4	11.1	12.6	1.6%
Electricity	30.0	29.7	31.1	32.5	32.6	33.1	34.5	0.6%
Industrial[1]								
Propane	21.3	20.3	19.6	20.5	21.5	22.9	24.5	0.7%
Distillate fuel oil	27.4	27.3	21.2	23.5	26.1	29.2	32.7	0.7%
Residual fuel oil	20.6	20.0	13.3	15.1	17.2	19.7	23.5	0.6%
Natural gas[2]	3.8	4.6	6.2	6.9	6.8	7.5	8.8	2.5%
Metallurgical coal	7.3	5.5	5.8	6.2	6.7	6.9	7.2	1.0%
Other industrial coal	3.3	3.2	3.3	3.5	3.6	3.7	3.9	0.7%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	19.8	20.2	21.3	22.4	22.6	23.3	24.7	0.7%
Transportation								
Propane	25.3	24.6	24.0	24.7	25.5	26.5	27.6	0.4%
E85[3]	35.7	33.1	30.4	29.0	31.2	33.2	35.4	0.3%
Motor gasoline[4]	30.7	29.3	22.5	24.3	26.4	29.1	32.3	0.4%
Jet fuel[5]	23.0	21.8	16.1	18.3	21.3	24.5	28.3	1.0%
Diesel fuel (distillate fuel oil)[6]	28.8	28.2	23.1	25.5	28.0	31.1	34.7	0.8%
Residual fuel oil	20.0	19.3	11.7	13.3	15.4	17.6	20.3	0.2%
Natural gas[7]	20.4	17.6	17.8	16.8	15.7	17.1	19.6	0.4%
Electricity	27.8	28.5	30.2	32.3	32.9	33.9	36.0	0.9%
Electric power[8]								
Distillate fuel oil	24.1	24.0	18.8	20.9	23.6	26.7	30.2	0.9%
Residual fuel oil	20.8	18.9	11.5	13.3	15.4	17.8	21.6	0.5%
Natural gas	3.5	4.4	5.4	6.3	6.2	7.0	8.3	2.4%
Steam coal	2.4	2.3	2.4	2.5	2.7	2.8	2.9	0.8%
Average price to all users[9]								
Propane	22.9	21.9	21.1	21.8	22.6	23.8	25.2	0.5%
E85[3]	35.7	33.1	30.4	29.0	31.2	33.2	35.4	0.3%
Motor gasoline[4]	30.4	29.0	22.5	24.3	26.4	29.1	32.3	0.4%
Jet fuel[5]	23.0	21.8	16.1	18.3	21.3	24.5	28.3	1.0%
Distillate fuel oil	28.3	27.9	22.6	25.0	27.6	30.7	34.2	0.8%
Residual fuel oil	20.3	19.4	12.2	14.0	16.0	18.4	21.5	0.4%
Natural gas	5.5	6.1	7.5	8.3	8.2	9.0	10.5	2.0%
Metallurgical coal	7.3	5.5	5.8	6.2	6.7	6.9	7.2	1.0%
Other coal	2.5	2.4	2.4	2.6	2.7	2.8	3.0	0.8%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	29.3	29.5	30.8	32.1	32.4	33.2	34.7	0.6%
Non-renewable energy expenditures by sector (billion 2013 dollars)								
Residential	234	243	254	268	276	289	311	0.9%
Commercial	174	177	194	210	219	234	259	1.4%
Industrial[1]	218	224	264	302	323	349	389	2.1%
Transportation	738	719	565	596	638	706	791	0.4%
Total non-renewable expenditures	1,364	1,364	1,276	1,376	1,456	1,579	1,751	0.9%
Transportation renewable expenditures	0	1	1	4	6	8	10	10.2%
Total expenditures	**1,365**	**1,364**	**1,277**	**1,379**	**1,462**	**1,587**	**1,761**	**0.9%**

Table A3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Residential								
Propane	23.9	23.3	26.1	29.1	32.8	37.5	43.1	2.3%
Distillate fuel oil	26.9	27.2	24.4	29.1	35.3	43.2	53.3	2.5%
Natural gas	10.4	10.0	13.2	15.7	17.1	20.2	25.1	3.5%
Electricity	34.8	35.6	42.9	48.8	53.6	60.0	68.8	2.5%
Commercial								
Propane	20.7	20.0	22.0	24.9	28.3	33.0	38.8	2.5%
Distillate fuel oil	26.4	26.7	23.8	28.6	34.6	42.5	52.6	2.5%
Residual fuel oil	22.6	22.1	16.1	19.7	24.3	30.3	39.4	2.2%
Natural gas	8.0	8.1	10.8	13.0	13.9	16.4	20.5	3.5%
Electricity	29.6	29.7	35.3	40.0	43.7	48.7	56.0	2.4%
Industrial[1]								
Propane	21.0	20.3	22.3	25.2	28.8	33.7	39.7	2.5%
Distillate fuel oil	27.0	27.3	24.1	29.0	35.0	42.9	53.0	2.5%
Residual fuel oil	20.3	20.0	15.1	18.6	23.1	29.0	38.0	2.4%
Natural gas[2]	3.8	4.6	7.0	8.5	9.1	11.1	14.2	4.3%
Metallurgical coal	7.2	5.5	6.6	7.7	8.9	10.2	11.6	2.8%
Other industrial coal	3.3	3.2	3.8	4.3	4.8	5.5	6.3	2.5%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	19.5	20.2	24.2	27.5	30.3	34.2	40.0	2.6%
Transportation								
Propane	24.9	24.6	27.2	30.4	34.1	38.9	44.8	2.2%
E85[3]	35.2	33.1	34.4	35.8	41.9	48.8	57.4	2.1%
Motor gasoline[4]	30.2	29.3	25.5	29.9	35.3	42.8	52.4	2.2%
Jet fuel[5]	22.6	21.8	18.3	22.6	28.6	36.0	45.8	2.8%
Diesel fuel (distillate fuel oil)[6]	28.4	28.2	26.2	31.4	37.6	45.7	56.2	2.6%
Residual fuel oil	19.7	19.3	13.2	16.4	20.6	25.9	32.9	2.0%
Natural gas[7]	20.1	17.6	20.2	20.6	21.0	25.2	31.8	2.2%
Electricity	27.4	28.5	34.3	39.8	44.1	49.9	58.4	2.7%
Electric power[8]								
Distillate fuel oil	23.8	24.0	21.3	25.8	31.7	39.3	49.0	2.7%
Residual fuel oil	20.5	18.9	13.0	16.3	20.6	26.2	35.0	2.3%
Natural gas	3.5	4.4	6.1	7.7	8.3	10.3	13.4	4.2%
Steam coal	2.4	2.3	2.7	3.1	3.6	4.1	4.7	2.6%

Table A3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Average price to all users[9]								
Propane	22.6	21.9	23.9	26.8	30.3	35.0	40.9	2.3%
E85[3]	35.2	33.1	34.4	35.8	41.9	48.8	57.4	2.1%
Motor gasoline[4]	30.0	29.0	25.5	29.9	35.3	42.8	52.4	2.2%
Jet fuel[5]	22.6	21.8	18.3	22.6	28.6	36.0	45.8	2.8%
Distillate fuel oil	27.9	27.9	25.7	30.8	36.9	45.1	55.5	2.6%
Residual fuel oil	20.0	19.4	13.8	17.2	21.5	27.0	34.8	2.2%
Natural gas	5.4	6.1	8.5	10.2	11.0	13.2	17.0	3.8%
Metallurgical coal	7.2	5.5	6.6	7.7	8.9	10.2	11.6	2.8%
Other coal	2.4	2.4	2.8	3.2	3.7	4.2	4.8	2.6%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	28.8	29.5	34.9	39.5	43.4	48.7	56.2	2.4%
Non-renewable energy expenditures by sector (billion nominal dollars)								
Residential	231	243	288	330	370	425	504	2.7%
Commercial	172	177	220	259	294	344	420	3.2%
Industrial[1]	215	224	299	372	433	513	631	3.9%
Transportation	727	719	641	734	855	1,038	1,283	2.2%
Total non-renewable expenditures	1,344	1,364	1,448	1,694	1,952	2,320	2,839	2.8%
Transportation renewable expenditures	0	1	1	4	8	12	16	12.2%
Total expenditures	**1,345**	**1,364**	**1,449**	**1,698**	**1,960**	**2,332**	**2,855**	**2.8%**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Excludes use for lease and plant fuel.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Kerosene-type jet fuel. Includes Federal and State taxes while excluding county and local taxes.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Natural gas used as fuel in motor vehicles, trains, and ships. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[8]Includes electricity-only and combined heat and power plants that have a regulatory status.
[9]Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
- - = Not applicable.
Note: Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 prices for motor gasoline, distillate fuel oil, and jet fuel are based on prices in the U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2012 residential, commercial, and industrial natural gas delivered prices: EIA, *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014). 2013 residential, commercial, and industrial natural gas delivered prices: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2012 transportation sector natural gas delivered prices are based on: EIA, *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014), EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014) and estimated State and Federal motor fuel taxes and dispensing costs or charges. 2013 transportation sector natural gas delivered prices are model results. 2012 and 2013 electric power sector distillate and residual fuel oil prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 electric power sector natural gas prices: EIA, *Electric Power Monthly*, DOE/EIA-0226, April 2013 and April 2014, Table 4.2, and EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014). 2012 and 2013 coal prices based on: EIA, *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014) and EIA, AEO2015 National Energy Modeling System run REF2015.D021915A. 2012 and 2013 electricity prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 E85 prices derived from monthly prices in the Clean Cities Alternative Fuel Price Report. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A4. Residential sector key indicators and consumption
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Key indicators								
Households (millions)								
Single-family	79.3	79.7	84.5	88.4	92.1	95.4	98.6	0.8%
Multifamily	28.2	28.4	30.4	32.1	33.9	35.7	37.5	1.0%
Mobile homes	6.4	6.3	5.5	5.3	5.1	4.9	4.8	-1.0%
Total	**113.9**	**114.3**	**120.5**	**125.8**	**131.1**	**136.0**	**141.0**	**0.8%**
Average house square footage	**1,670**	**1,678**	**1,733**	**1,768**	**1,800**	**1,829**	**1,855**	**0.4%**
Energy intensity								
(million Btu per household)								
Delivered energy consumption	90.2	99.0	88.2	83.5	80.6	77.6	75.0	-1.0%
Total energy consumption	174.3	184.6	169.1	161.0	156.2	151.9	148.3	-0.8%
(thousand Btu per square foot)								
Delivered energy consumption	54.0	59.0	50.9	47.3	44.8	42.5	40.4	-1.4%
Total energy consumption	104.3	110.0	97.6	91.1	86.8	83.1	79.9	-1.2%
Delivered energy consumption by fuel								
Purchased electricity								
Space heating	0.29	0.40	0.35	0.34	0.33	0.32	0.31	-1.0%
Space cooling	0.83	0.66	0.79	0.82	0.88	0.94	1.00	1.5%
Water heating	0.44	0.44	0.46	0.47	0.48	0.48	0.48	0.2%
Refrigeration	0.37	0.36	0.34	0.33	0.33	0.35	0.36	0.0%
Cooking	0.11	0.11	0.11	0.12	0.13	0.14	0.14	1.1%
Clothes dryers	0.20	0.20	0.21	0.22	0.23	0.24	0.25	0.7%
Freezers	0.08	0.08	0.07	0.07	0.07	0.06	0.06	-0.7%
Lighting	0.64	0.59	0.43	0.38	0.34	0.29	0.27	-2.9%
Clothes washers[1]	0.03	0.03	0.02	0.02	0.02	0.02	0.02	-2.0%
Dishwashers[1]	0.10	0.09	0.10	0.10	0.11	0.12	0.12	1.0%
Televisions and related equipment[2]	0.33	0.33	0.32	0.32	0.34	0.36	0.37	0.5%
Computers and related equipment[3]	0.12	0.12	0.10	0.08	0.07	0.06	0.05	-3.1%
Furnace fans and boiler circulation pumps	0.09	0.13	0.11	0.11	0.10	0.10	0.09	-1.3%
Other uses[4]	1.06	1.19	1.44	1.53	1.65	1.77	1.89	1.7%
Delivered energy	**4.69**	**4.75**	**4.86**	**4.92**	**5.08**	**5.23**	**5.42**	**0.5%**
Natural gas								
Space heating	2.52	3.32	2.90	2.80	2.76	2.69	2.61	-0.9%
Space cooling	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.2%
Water heating	1.20	1.20	1.21	1.22	1.24	1.23	1.19	0.0%
Cooking	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.3%
Clothes dryers	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.5%
Other uses[5]	0.25	0.25	0.24	0.23	0.23	0.22	0.21	-0.6%
Delivered energy	**4.25**	**5.05**	**4.63**	**4.54**	**4.52**	**4.43**	**4.31**	**-0.6%**
Distillate fuel oil								
Space heating	0.43	0.44	0.36	0.32	0.28	0.25	0.22	-2.5%
Water heating	0.05	0.05	0.03	0.03	0.02	0.02	0.01	-4.7%
Other uses[6]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.5%
Delivered energy	**0.49**	**0.50**	**0.40**	**0.35**	**0.31**	**0.27**	**0.24**	**-2.7%**
Propane								
Space heating	0.26	0.30	0.20	0.18	0.17	0.15	0.14	-2.8%
Water heating	0.07	0.06	0.05	0.04	0.04	0.03	0.03	-3.0%
Cooking	0.03	0.03	0.03	0.03	0.02	0.02	0.02	-0.9%
Other uses[6]	0.04	0.04	0.05	0.05	0.05	0.06	0.06	1.5%
Delivered energy	**0.40**	**0.43**	**0.32**	**0.30**	**0.28**	**0.26**	**0.25**	**-2.0%**
Marketed renewables (wood)[7]	0.44	0.58	0.41	0.39	0.38	0.36	0.35	-1.8%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-3.0%

Table A4. Residential sector key indicators and consumption (continued)
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Delivered energy consumption by end use								
Space heating	3.95	5.05	4.23	4.04	3.92	3.78	3.63	-1.2%
Space cooling	0.86	0.68	0.81	0.84	0.90	0.96	1.02	1.5%
Water heating	1.76	1.76	1.75	1.76	1.78	1.75	1.71	-0.1%
Refrigeration	0.37	0.36	0.34	0.33	0.33	0.35	0.36	0.0%
Cooking	0.35	0.34	0.35	0.36	0.37	0.38	0.39	0.4%
Clothes dryers	0.25	0.25	0.26	0.27	0.28	0.29	0.30	0.7%
Freezers	0.08	0.08	0.07	0.07	0.07	0.06	0.06	-0.7%
Lighting	0.64	0.59	0.43	0.38	0.34	0.29	0.27	-2.9%
Clothes washers[1]	0.03	0.03	0.02	0.02	0.02	0.02	0.02	-2.0%
Dishwashers[1]	0.10	0.09	0.10	0.10	0.11	0.12	0.12	1.0%
Televisions and related equipment[2]	0.33	0.33	0.32	0.32	0.34	0.36	0.37	0.5%
Computers and related equipment[3]	0.12	0.12	0.10	0.08	0.07	0.06	0.05	-3.1%
Furnace fans and boiler circulation pumps	0.09	0.13	0.11	0.11	0.10	0.10	0.09	-1.3%
Other uses[8]	1.36	1.49	1.73	1.82	1.94	2.05	2.17	1.4%
Delivered energy	**10.28**	**11.32**	**10.63**	**10.51**	**10.57**	**10.56**	**10.57**	**-0.3%**
Electricity related losses	**9.57**	**9.79**	**9.75**	**9.74**	**9.91**	**10.10**	**10.33**	**0.2%**
Total energy consumption by end use								
Space heating	4.53	5.88	4.93	4.71	4.56	4.39	4.21	-1.2%
Space cooling	2.56	2.05	2.38	2.47	2.62	2.79	2.93	1.3%
Water heating	2.66	2.68	2.69	2.70	2.72	2.68	2.62	-0.1%
Refrigeration	1.12	1.12	1.02	0.99	0.99	1.01	1.06	-0.2%
Cooking	0.56	0.56	0.58	0.60	0.62	0.64	0.66	0.6%
Clothes dryers	0.66	0.67	0.69	0.70	0.73	0.75	0.78	0.5%
Freezers	0.24	0.24	0.22	0.20	0.19	0.19	0.19	-0.9%
Lighting	1.94	1.80	1.29	1.13	1.00	0.85	0.77	-3.1%
Clothes washers[1]	0.09	0.09	0.07	0.05	0.05	0.05	0.05	-2.2%
Dishwashers[1]	0.29	0.29	0.29	0.30	0.32	0.34	0.36	0.8%
Televisions and related equipment[2]	1.01	1.01	0.97	0.96	1.00	1.05	1.09	0.3%
Computers and related equipment[3]	0.38	0.37	0.29	0.24	0.20	0.18	0.15	-3.3%
Furnace fans and boiler circulation pumps	0.28	0.40	0.34	0.33	0.31	0.28	0.27	-1.5%
Other uses[8]	3.52	3.95	4.62	4.86	5.17	5.46	5.78	1.4%
Total	**19.85**	**21.10**	**20.38**	**20.25**	**20.48**	**20.66**	**20.91**	**0.0%**
Nonmarketed renewables[9]								
Geothermal heat pumps	0.01	0.01	0.02	0.02	0.03	0.03	0.03	4.1%
Solar hot water heating	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.8%
Solar photovoltaic	0.02	0.04	0.09	0.13	0.18	0.24	0.29	8.0%
Wind	0.00	0.00	0.01	0.01	0.01	0.01	0.01	6.9%
Total	**0.04**	**0.06**	**0.13**	**0.17**	**0.23**	**0.28**	**0.35**	**7.0%**
Heating degree days[10]	**3,772**	**4,469**	**4,119**	**4,042**	**3,966**	**3,893**	**3,820**	**-0.6%**
Cooling degree days[10]	**1,494**	**1,307**	**1,467**	**1,517**	**1,568**	**1,618**	**1,670**	**0.9%**

[1]Does not include water heating portion of load.
[2]Includes televisions, set-top boxes, home theater systems, DVD players, and video game consoles.
[3]Includes desktop and laptop computers, monitors, and networking equipment.
[4]Includes small electric devices, heating elements, and motors not listed above. Electric vehicles are included in the transportation sector.
[5]Includes such appliances as outdoor grills, exterior lights, pool heaters, spa heaters, and backup electricity generators.
[6]Includes such appliances as pool heaters, spa heaters, and backup electricity generators.
[7]Includes wood used for primary and secondary heating in wood stoves or fireplaces as reported in the *Residential Energy Consumption Survey 2009*.
[8]Includes small electric devices, heating elements, outdoor grills, exterior lights, pool heaters, spa heaters, backup electricity generators, and motors not listed above. Electric vehicles are included in the transportation sector.
[9]Consumption determined by using the fossil fuel equivalent of 9,516 Btu per kilowatthour.
[10]See Table A5 for regional detail.
Btu = British thermal unit.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 degree days based on state-level data from the National Oceanic and Atmospheric Administration's Climatic Data Center and Climate Prediction Center. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A5. Commercial sector key indicators and consumption
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Key indicators								
Total floorspace (billion square feet)								
Surviving	80.8	81.4	86.9	92.0	96.4	100.9	106.6	1.0%
New additions	1.6	1.5	2.1	2.0	2.0	2.3	2.4	1.9%
Total	**82.3**	**82.8**	**89.0**	**94.1**	**98.4**	**103.2**	**109.1**	**1.0%**
Energy consumption intensity (thousand Btu per square foot)								
Delivered energy consumption	99.8	104.9	100.0	96.3	95.4	94.2	92.8	-0.5%
Electricity related losses	112.3	113.7	108.7	105.1	103.0	101.1	99.0	-0.5%
Total energy consumption	212.1	218.6	208.7	201.4	198.4	195.3	191.8	-0.5%
Delivered energy consumption by fuel								
Purchased electricity								
Space heating[1]	0.14	0.16	0.14	0.13	0.12	0.11	0.11	-1.5%
Space cooling[1]	0.57	0.49	0.53	0.53	0.54	0.55	0.56	0.5%
Water heating[1]	0.09	0.09	0.09	0.09	0.08	0.08	0.08	-0.6%
Ventilation	0.51	0.52	0.54	0.55	0.56	0.57	0.58	0.4%
Cooking	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.3%
Lighting	0.92	0.91	0.87	0.85	0.84	0.81	0.80	-0.5%
Refrigeration	0.38	0.37	0.33	0.31	0.30	0.31	0.31	-0.7%
Office equipment (PC)	0.12	0.11	0.07	0.05	0.04	0.03	0.02	-5.5%
Office equipment (non-PC)	0.22	0.22	0.24	0.27	0.31	0.34	0.38	2.1%
Other uses[2]	1.56	1.68	1.99	2.19	2.38	2.58	2.80	1.9%
Delivered energy	**4.53**	**4.57**	**4.82**	**4.99**	**5.19**	**5.40**	**5.66**	**0.8%**
Natural gas								
Space heating[1]	1.51	1.86	1.69	1.62	1.58	1.51	1.41	-1.0%
Space cooling[1]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.1%
Water heating[1]	0.53	0.54	0.54	0.55	0.57	0.57	0.57	0.2%
Cooking	0.20	0.20	0.21	0.22	0.23	0.24	0.25	0.8%
Other uses[3]	0.69	0.74	0.81	0.87	1.01	1.21	1.44	2.5%
Delivered energy	**2.97**	**3.37**	**3.30**	**3.29**	**3.43**	**3.57**	**3.71**	**0.4%**
Distillate fuel oil								
Space heating[1]	0.13	0.15	0.14	0.13	0.12	0.11	0.10	-1.7%
Water heating[1]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.1%
Other uses[4]	0.21	0.20	0.18	0.17	0.17	0.16	0.16	-0.8%
Delivered energy	**0.36**	**0.37**	**0.34**	**0.32**	**0.30**	**0.29**	**0.27**	**-1.1%**
Marketed renewables (biomass)	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.0%
Other fuels[5]	0.26	0.26	0.33	0.34	0.34	0.35	0.35	1.1%
Delivered energy consumption by end use								
Space heating[1]	1.78	2.17	1.97	1.87	1.82	1.73	1.61	-1.1%
Space cooling[1]	0.62	0.53	0.57	0.57	0.57	0.58	0.59	0.4%
Water heating[1]	0.64	0.65	0.65	0.65	0.67	0.67	0.67	0.1%
Ventilation	0.51	0.52	0.54	0.55	0.56	0.57	0.58	0.4%
Cooking	0.22	0.22	0.24	0.24	0.25	0.26	0.27	0.7%
Lighting	0.92	0.91	0.87	0.85	0.84	0.81	0.80	-0.5%
Refrigeration	0.38	0.37	0.33	0.31	0.30	0.31	0.31	-0.7%
Office equipment (PC)	0.12	0.11	0.07	0.05	0.04	0.03	0.02	-5.5%
Office equipment (non-PC)	0.22	0.22	0.24	0.27	0.31	0.34	0.38	2.1%
Other uses[6]	2.82	3.00	3.43	3.69	4.02	4.42	4.87	1.8%
Delivered energy	**8.22**	**8.69**	**8.90**	**9.06**	**9.38**	**9.73**	**10.12**	**0.6%**

Table A5. Commercial sector key indicators and consumption (continued)
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Electricity related losses	**9.24**	**9.42**	**9.68**	**9.88**	**10.13**	**10.43**	**10.80**	**0.5%**
Total energy consumption by end use								
Space heating[1]	2.05	2.50	2.25	2.13	2.05	1.95	1.82	-1.2%
Space cooling[1]	1.78	1.54	1.63	1.62	1.62	1.64	1.66	0.3%
Water heating[1]	0.83	0.84	0.83	0.82	0.83	0.83	0.82	-0.1%
Ventilation	1.55	1.58	1.63	1.64	1.66	1.67	1.68	0.2%
Cooking	0.27	0.27	0.28	0.28	0.30	0.31	0.31	0.5%
Lighting	2.81	2.78	2.62	2.53	2.47	2.38	2.34	-0.6%
Refrigeration	1.15	1.14	0.99	0.93	0.90	0.90	0.91	-0.8%
Office equipment (PC)	0.35	0.33	0.20	0.15	0.11	0.09	0.07	-5.7%
Office equipment (non-PC)	0.66	0.66	0.72	0.81	0.91	1.01	1.10	1.9%
Other uses[6]	6.01	6.47	7.43	8.02	8.67	9.40	10.21	1.7%
Total	**17.46**	**18.10**	**18.58**	**18.94**	**19.52**	**20.16**	**20.92**	**0.5%**
Nonmarketed renewable fuels[7]								
Solar thermal	0.08	0.08	0.09	0.09	0.10	0.10	0.11	1.1%
Solar photovoltaic	0.04	0.05	0.08	0.11	0.15	0.20	0.27	6.1%
Wind	0.00	0.00	0.00	0.00	0.00	0.01	0.01	9.0%
Total	**0.13**	**0.14**	**0.17**	**0.20**	**0.25**	**0.32**	**0.39**	**3.9%**
Heating degree days								
New England	5,561	6,424	6,030	5,924	5,818	5,711	5,603	-0.5%
Middle Atlantic	4,970	5,836	5,427	5,333	5,239	5,146	5,054	-0.5%
East North Central	5,356	6,622	6,016	5,953	5,890	5,827	5,764	-0.5%
West North Central	5,515	7,134	6,367	6,322	6,275	6,229	6,181	-0.5%
South Atlantic	2,307	2,732	2,595	2,552	2,508	2,466	2,425	-0.4%
East South Central	2,876	3,649	3,349	3,325	3,301	3,276	3,251	-0.4%
West South Central	1,650	2,328	1,975	1,928	1,882	1,836	1,790	-1.0%
Mountain	4,574	5,271	4,874	4,809	4,741	4,669	4,595	-0.5%
Pacific	3,412	3,377	3,477	3,463	3,450	3,438	3,426	0.1%
United States	**3,772**	**4,469**	**4,119**	**4,042**	**3,966**	**3,893**	**3,820**	**-0.6%**
Cooling degree days								
New England	564	541	573	603	634	664	695	0.9%
Middle Atlantic	815	688	803	840	877	913	950	1.2%
East North Central	974	690	821	841	860	880	900	1.0%
West North Central	1,221	893	1,012	1,031	1,051	1,070	1,090	0.7%
South Atlantic	2,161	2,002	2,191	2,235	2,280	2,325	2,369	0.6%
East South Central	1,762	1,441	1,725	1,756	1,787	1,818	1,849	0.9%
West South Central	2,915	2,535	2,848	2,920	2,993	3,065	3,138	0.8%
Mountain	1,572	1,464	1,556	1,607	1,660	1,715	1,772	0.7%
Pacific	917	889	891	915	940	963	987	0.4%
United States	**1,494**	**1,307**	**1,467**	**1,517**	**1,568**	**1,618**	**1,670**	**0.9%**

[1]Includes fuel consumption for district services.
[2]Includes (but is not limited to) miscellaneous uses such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, and water services.
[3]Includes miscellaneous uses, such as pumps, emergency generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings.
[4]Includes miscellaneous uses, such as cooking, emergency generators, and combined heat and power in commercial buildings.
[5]Includes residual fuel oil, propane, coal, motor gasoline, and kerosene.
[6]Includes (but is not limited to) miscellaneous uses such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, water services, pumps, emergency generators, combined heat and power in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, propane, coal, motor gasoline, kerosene, and marketed renewable fuels (biomass).
[7]Consumption determined by using the fossil fuel equivalent of 9,516 Btu per kilowatthour.
Btu = British thermal unit.
PC = Personal computer.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 degree days based on state-level data from the National Oceanic and Atmospheric Administration's Climatic Data Center and Climate Prediction Center. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A6. Industrial sector key indicators and consumption

Shipments, prices, and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Key indicators								
Value of shipments (billion 2009 dollars)								
Manufacturing	5,009	5,146	6,123	6,771	7,330	8,012	8,751	2.0%
Agriculture, mining, and construction	1,813	1,858	2,344	2,441	2,540	2,601	2,712	1.4%
Total	**6,822**	**7,004**	**8,467**	**9,212**	**9,870**	**10,614**	**11,463**	**1.8%**
Energy prices								
(2013 dollars per million Btu)								
Propane	21.3	20.3	19.6	20.5	21.5	22.9	24.5	0.7%
Motor gasoline	17.5	17.5	22.5	24.2	26.3	29.1	32.3	2.3%
Distillate fuel oil	27.4	27.3	21.2	23.5	26.1	29.2	32.7	0.7%
Residual fuel oil	20.6	20.0	13.3	15.1	17.2	19.7	23.5	0.6%
Asphalt and road oil	10.1	9.8	8.9	10.3	11.9	13.5	15.7	1.8%
Natural gas heat and power	3.5	4.3	6.0	6.7	6.6	7.4	8.6	2.6%
Natural gas feedstocks	4.2	4.8	6.3	7.0	6.9	7.7	8.9	2.3%
Metallurgical coal	7.3	5.5	5.8	6.2	6.7	6.9	7.2	1.0%
Other industrial coal	3.3	3.2	3.3	3.5	3.6	3.7	3.9	0.7%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	19.8	20.2	21.3	22.4	22.6	23.3	24.7	0.7%
(nominal dollars per million Btu)								
Propane	21.0	20.3	22.3	25.2	28.8	33.7	39.7	2.5%
Motor gasoline	17.3	17.5	25.5	29.9	35.3	42.7	52.3	4.1%
Distillate fuel oil	27.0	27.3	24.1	29.0	35.0	42.9	53.0	2.5%
Residual fuel oil	20.3	20.0	15.1	18.6	23.1	29.0	38.0	2.4%
Asphalt and road oil	10.0	9.8	10.0	12.7	15.9	19.9	25.5	3.6%
Natural gas heat and power	3.5	4.3	6.8	8.2	8.9	10.8	13.9	4.4%
Natural gas feedstocks	4.1	4.8	7.2	8.6	9.3	11.3	14.5	4.2%
Metallurgical coal	7.2	5.5	6.6	7.7	8.9	10.2	11.6	2.8%
Other industrial coal	3.3	3.2	3.8	4.3	4.8	5.5	6.3	2.5%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	19.5	20.2	24.2	27.5	30.3	34.2	40.0	2.6%
Energy consumption (quadrillion Btu)[1]								
Industrial consumption excluding refining								
Propane heat and power	0.25	0.28	0.32	0.36	0.38	0.38	0.38	1.1%
Liquefied petroleum gas and other feedstocks[2]	2.16	2.22	2.89	3.21	3.35	3.31	3.30	1.5%
Motor gasoline	0.24	0.25	0.26	0.26	0.25	0.25	0.25	0.0%
Distillate fuel oil	1.28	1.31	1.42	1.38	1.36	1.34	1.35	0.1%
Residual fuel oil	0.07	0.06	0.10	0.14	0.13	0.13	0.13	3.1%
Petrochemical feedstocks	0.74	0.74	0.95	1.10	1.14	1.17	1.20	1.8%
Petroleum coke	0.17	0.11	0.20	0.23	0.22	0.21	0.22	2.5%
Asphalt and road oil	0.83	0.78	1.01	1.09	1.15	1.19	1.25	1.8%
Miscellaneous petroleum[3]	0.37	0.61	0.42	0.42	0.44	0.46	0.47	-1.0%
Petroleum and other liquids subtotal	6.11	6.37	7.57	8.18	8.42	8.43	8.55	1.1%
Natural gas heat and power	5.26	5.42	5.86	5.93	6.07	6.13	6.20	0.5%
Natural gas feedstocks	0.58	0.59	0.97	1.05	1.05	1.04	1.03	2.1%
Lease and plant fuel[4]	1.43	1.52	1.87	1.98	2.10	2.18	2.29	1.5%
Natural gas subtotal	7.27	7.54	8.70	8.96	9.22	9.35	9.53	0.9%
Metallurgical coal and coke[5]	0.60	0.60	0.61	0.58	0.53	0.48	0.45	-1.0%
Other industrial coal	0.87	0.88	0.93	0.95	0.96	0.97	0.99	0.4%
Coal subtotal	1.47	1.48	1.54	1.53	1.48	1.44	1.44	-0.1%
Renewables[6]	1.51	1.48	1.53	1.60	1.59	1.58	1.63	0.4%
Purchased electricity	3.16	3.05	3.58	3.83	3.89	3.90	3.95	1.0%
Delivered energy	**19.52**	**19.92**	**22.92**	**24.10**	**24.60**	**24.70**	**25.10**	**0.9%**
Electricity related losses	6.46	6.29	7.19	7.59	7.59	7.52	7.54	0.7%
Total	**25.98**	**26.22**	**30.11**	**31.69**	**32.19**	**32.22**	**32.64**	**0.8%**

Table A6. Industrial sector key indicators and consumption (continued)

Shipments, prices, and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Refining consumption								
Liquefied petroleum gas heat and power[2]	0.01	0.00	0.00	0.00	0.00	0.00	0.00	- -
Distillate fuel oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Residual fuel oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Petroleum coke	0.54	0.53	0.39	0.42	0.41	0.42	0.43	-0.8%
Still gas	1.41	1.47	1.61	1.63	1.59	1.61	1.60	0.3%
Miscellaneous petroleum[3]	0.01	0.01	0.03	0.01	0.02	0.01	0.02	2.1%
Petroleum and other liquids subtotal	1.97	2.03	2.04	2.06	2.02	2.03	2.04	0.0%
Natural gas heat and power	1.23	1.30	1.19	1.17	1.20	1.25	1.31	0.0%
Natural gas feedstocks	0.32	0.31	0.31	0.31	0.32	0.34	0.35	0.5%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Natural gas subtotal	1.55	1.60	1.50	1.48	1.52	1.59	1.66	0.1%
Other industrial coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Coal subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Biofuels heat and coproducts	0.73	0.72	0.80	0.80	0.80	0.81	0.86	0.6%
Purchased electricity	0.20	0.21	0.16	0.15	0.15	0.16	0.16	-0.8%
Delivered energy	**4.45**	**4.56**	**4.50**	**4.48**	**4.49**	**4.59**	**4.73**	**0.1%**
Electricity related losses	0.41	0.42	0.31	0.29	0.29	0.30	0.31	-1.1%
Total	**4.86**	**4.98**	**4.81**	**4.78**	**4.78**	**4.90**	**5.04**	**0.0%**
Total industrial sector consumption								
Liquefied petroleum gas heat and power[2]	0.26	0.29	0.32	0.36	0.38	0.38	0.38	1.0%
Liquefied petroleum gas and other feedstocks[2]	2.16	2.22	2.89	3.21	3.35	3.31	3.30	1.5%
Motor gasoline	0.24	0.25	0.26	0.26	0.25	0.25	0.25	0.0%
Distillate fuel oil	1.28	1.31	1.42	1.38	1.36	1.34	1.35	0.1%
Residual fuel oil	0.07	0.06	0.10	0.14	0.13	0.13	0.13	2.9%
Petrochemical feedstocks	0.74	0.74	0.95	1.10	1.14	1.17	1.20	1.8%
Petroleum coke	0.70	0.65	0.59	0.65	0.63	0.63	0.65	0.0%
Asphalt and road oil	0.83	0.78	1.01	1.09	1.15	1.19	1.25	1.8%
Still gas	1.41	1.47	1.61	1.63	1.59	1.61	1.60	0.3%
Miscellaneous petroleum[3]	0.38	0.63	0.46	0.43	0.46	0.47	0.49	-0.9%
Petroleum and other liquids subtotal	8.08	8.40	9.61	10.24	10.44	10.47	10.59	0.9%
Natural gas heat and power	6.50	6.72	7.05	7.11	7.27	7.38	7.51	0.4%
Natural gas feedstocks	0.89	0.90	1.28	1.36	1.37	1.38	1.39	1.6%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[4]	1.43	1.52	1.87	1.98	2.10	2.18	2.29	1.5%
Natural gas subtotal	8.82	9.14	10.20	10.44	10.75	10.94	11.19	0.8%
Metallurgical coal and coke[5]	0.60	0.60	0.61	0.58	0.53	0.48	0.45	-1.0%
Other industrial coal	0.87	0.88	0.93	0.95	0.96	0.97	0.99	0.4%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Coal subtotal	1.47	1.48	1.54	1.53	1.48	1.44	1.44	-0.1%
Biofuels heat and coproducts	0.73	0.72	0.80	0.80	0.80	0.81	0.86	0.6%
Renewables[6]	1.51	1.48	1.53	1.60	1.59	1.58	1.63	0.4%
Purchased electricity	3.36	3.26	3.74	3.98	4.04	4.05	4.12	0.9%
Delivered energy	**23.97**	**24.48**	**27.42**	**28.58**	**29.10**	**29.29**	**29.82**	**0.7%**
Electricity related losses	6.87	6.72	7.51	7.88	7.88	7.83	7.85	0.6%
Total	**30.84**	**31.20**	**34.93**	**36.46**	**36.98**	**37.12**	**37.68**	**0.7%**

Table A6. Industrial sector key indicators and consumption (continued)

Key indicators and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Energy consumption per dollar of shipments (thousand Btu per 2009 dollar)								
Petroleum and other liquids	1.18	1.20	1.13	1.11	1.06	0.99	0.92	-1.0%
Natural gas	1.29	1.31	1.21	1.13	1.09	1.03	0.98	-1.1%
Coal	0.21	0.21	0.18	0.17	0.15	0.14	0.13	-1.9%
Renewable fuels[5]	0.33	0.31	0.28	0.26	0.24	0.23	0.22	-1.4%
Purchased electricity	0.49	0.47	0.44	0.43	0.41	0.38	0.36	-1.0%
Delivered energy	**3.51**	**3.50**	**3.24**	**3.10**	**2.95**	**2.76**	**2.60**	**-1.1%**
Industrial combined heat and power[1]								
Capacity (gigawatts)	26.9	27.6	30.6	32.8	35.8	38.9	40.7	1.5%
Generation (billion kilowatthours)	144	147	170	181	195	211	221	1.5%

[1]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Includes ethane, natural gasoline, and refinery olefins.
[3]Includes lubricants and miscellaneous petroleum products.
[4]Represents natural gas used in well, field, and lease operations, in natural gas processing plant machinery, and for liquefaction in export facilities.
[5]Includes net coal coke imports.
[6]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources.
Btu = British thermal unit.
- - = Not applicable.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 prices for motor gasoline and distillate fuel oil are based on: U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2012 and 2013 petrochemical feedstock and asphalt and road oil prices are based on: EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014). 2012 and 2013 coal prices are based on: EIA, *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014) and EIA, AEO2015 National Energy Modeling System run REF2015.D021915A. 2012 and 2013 electricity prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 natural gas prices: EIA, *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014). 2013 natural gas prices: *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2012 refining consumption values are based on: *Petroleum Supply Annual 2012*, DOE/EIA-0340(2012)/1 (Washington, DC, September 2013). 2013 refining consumption based on: *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). Other 2012 and 2013 consumption values are based on: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 shipments: IHS Economics, Industry model, November 2014. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A7. Transportation sector key indicators and delivered energy consumption

Key indicators and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Key indicators								
Travel indicators								
(billion vehicle miles traveled)								
Light-duty vehicles less than 8,501 pounds	2,578	2,644	2,917	3,090	3,287	3,458	3,570	1.1%
Commercial light trucks[1]	62	67	79	85	92	98	105	1.7%
Freight trucks greater than 10,000 pounds	242	268	314	337	355	374	397	1.5%
(billion seat miles available)								
Air	1,033	1,047	1,174	1,279	1,391	1,481	1,557	1.5%
(billion ton miles traveled)								
Rail	1,729	1,758	1,828	1,960	1,999	2,013	2,066	0.6%
Domestic shipping	475	480	467	444	424	416	420	-0.5%
Energy efficiency indicators								
(miles per gallon)								
New light-duty vehicle CAFE standard[2]	29.4	30.0	36.3	46.0	46.3	46.5	46.8	1.7%
New car[2]	33.4	34.1	43.7	54.3	54.3	54.3	54.4	1.7%
New light truck[2]	25.7	26.3	30.9	39.5	39.5	39.5	39.5	1.5%
Compliance new light-duty vehicle[3]	32.7	32.8	37.9	46.7	47.4	47.9	48.1	1.4%
New car[3]	37.0	37.2	44.2	54.6	55.3	55.5	55.5	1.5%
New light truck[3]	28.6	28.8	33.1	40.3	40.7	40.9	40.9	1.3%
Tested new light-duty vehicle[4]	31.7	31.7	37.9	46.6	47.4	47.8	48.1	1.6%
New car[4]	36.3	36.5	44.1	54.6	55.3	55.4	55.5	1.6%
New light truck[4]	27.4	27.6	33.1	40.3	40.7	40.9	40.8	1.5%
On-road new light-duty vehicle[5]	25.6	25.6	30.6	37.7	38.3	38.7	38.9	1.6%
New car[5]	29.6	29.8	36.1	44.6	45.1	45.3	45.3	1.6%
New light truck[5]	22.0	22.1	26.5	32.3	32.6	32.7	32.7	1.5%
Light-duty stock[6]	21.5	21.9	25.0	28.5	32.3	35.1	37.0	2.0%
New commercial light truck[1]	18.1	18.1	20.6	24.2	24.4	24.6	24.6	1.1%
Stock commercial light truck[1]	15.2	15.5	18.0	20.3	22.4	23.8	24.4	1.7%
Freight truck	6.7	6.7	7.2	7.5	7.7	7.8	7.8	0.6%
(seat miles per gallon)								
Aircraft	64.2	65.9	67.4	68.7	70.2	72.0	74.1	0.4%
(ton miles per thousand Btu)								
Rail	3.4	3.5	3.6	3.8	3.9	4.1	4.2	0.7%
Domestic shipping	4.7	4.7	5.0	5.2	5.4	5.6	5.8	0.8%
Energy use by mode (quadrillion Btu)								
Light-duty vehicles	15.00	15.13	14.62	13.57	12.74	12.31	12.08	-0.8%
Commercial light trucks[1]	0.51	0.54	0.55	0.53	0.51	0.52	0.54	0.0%
Bus transportation	0.24	0.26	0.27	0.28	0.29	0.30	0.31	0.6%
Freight trucks	4.98	5.51	6.03	6.19	6.34	6.60	6.98	0.9%
Rail, passenger	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.9%
Rail, freight	0.44	0.51	0.50	0.52	0.51	0.50	0.49	-0.1%
Shipping, domestic	0.10	0.10	0.10	0.09	0.08	0.08	0.07	-1.3%
Shipping, international	0.66	0.62	0.63	0.63	0.64	0.64	0.64	0.1%
Recreational boats	0.23	0.24	0.26	0.28	0.29	0.29	0.30	0.8%
Air	2.33	2.30	2.54	2.73	2.91	3.02	3.08	1.1%
Military use	0.71	0.67	0.63	0.64	0.68	0.72	0.77	0.5%
Lubricants	0.12	0.13	0.14	0.14	0.14	0.14	0.14	0.3%
Pipeline fuel	0.75	0.88	0.85	0.90	0.94	0.94	0.96	0.3%
Total	**26.11**	**26.96**	**27.18**	**26.54**	**26.12**	**26.11**	**26.41**	**-0.1%**

Table A7. Transportation sector key indicators and delivered energy consumption (continued)

Key indicators and consumption	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Energy use by mode								
(million barrels per day oil equivalent)								
Light-duty vehicles	8.06	8.13	7.85	7.31	6.88	6.67	6.57	-0.8%
Commercial light trucks[1]	0.26	0.28	0.28	0.27	0.26	0.26	0.27	0.0%
Bus transportation	0.11	0.12	0.13	0.14	0.14	0.14	0.15	0.6%
Freight trucks	2.40	2.65	2.90	2.98	3.05	3.18	3.36	0.9%
Rail, passenger	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.9%
Rail, freight	0.21	0.24	0.24	0.25	0.24	0.24	0.23	-0.1%
Shipping, domestic	0.04	0.05	0.05	0.04	0.04	0.04	0.03	-1.3%
Shipping, international	0.29	0.27	0.29	0.29	0.29	0.29	0.29	0.2%
Recreational boats	0.12	0.13	0.14	0.15	0.15	0.16	0.16	0.8%
Air	1.13	1.11	1.23	1.32	1.40	1.46	1.49	1.1%
Military use	0.34	0.32	0.30	0.31	0.33	0.35	0.37	0.5%
Lubricants	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.3%
Pipeline fuel	0.35	0.42	0.40	0.42	0.44	0.44	0.45	0.3%
Total	**13.41**	**13.82**	**13.90**	**13.56**	**13.32**	**13.32**	**13.48**	**-0.1%**

[1]Commercial trucks 8,501 to 10,000 pounds gross vehicle weight rating.
[2]CAFE standard based on projected new vehicle sales.
[3]Includes CAFE credits for alternative fueled vehicle sales and credit banking.
[4]Environmental Protection Agency rated miles per gallon.
[5]Tested new vehicle efficiency revised for on-road performance.
[6]Combined"on-the-road" estimate for all cars and light trucks.
CAFE = Corporate average fuel economy.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014); EIA, Alternatives to Traditional Transportation Fuels 2009 (Part II - User and Fuel Data), April 2011; Federal Highway Administration, *Highway Statistics 2012* (Washington, DC, January 2014); Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 33* (Oak Ridge, TN, July 2014); National Highway Traffic and Safety Administration, *Summary of Fuel Economy Performance* (Washington, DC, June 2014); U.S. Department of Commerce, Bureau of the Census, "Vehicle Inventory and Use Survey," EC02TV (Washington, DC, December 2004); EIA, U.S. Department of Transportation, Research and Special Programs Administration, *Air Carrier Statistics Monthly, December 2010/2009* (Washington, DC, December 2010); and United States Department of Defense, Defense Fuel Supply Center, Factbook (January, 2010). **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A8. Electricity supply, disposition, prices, and emissions
(billion kilowatthours, unless otherwise noted)

Supply, disposition, prices, and emissions	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Net generation by fuel type								
Electric power sector[1]								
Power only[2]								
Coal	1,478	1,550	1,670	1,685	1,674	1,665	1,663	0.3%
Petroleum	18	22	14	15	14	14	15	-1.6%
Natural gas[3]	1,000	894	867	954	1,073	1,143	1,198	1.1%
Nuclear power	769	789	804	808	808	812	833	0.2%
Pumped storage/other[4]	2	3	3	3	3	3	3	-0.1%
Renewable sources[5]	458	483	620	648	679	733	805	1.9%
Distributed generation (natural gas)	0	0	1	1	1	2	2	- -
Total	**3,726**	**3,741**	**3,978**	**4,113**	**4,252**	**4,372**	**4,518**	**0.7%**
Combined heat and power[6]								
Coal	22	22	26	26	26	26	26	0.5%
Petroleum	2	2	1	1	1	1	1	-4.0%
Natural gas	132	126	133	133	134	134	133	0.2%
Renewable sources	5	5	6	7	7	7	8	1.7%
Total	**164**	**158**	**166**	**167**	**168**	**168**	**167**	**0.2%**
Total net electric power sector generation	**3,890**	**3,899**	**4,144**	**4,280**	**4,420**	**4,540**	**4,686**	**0.7%**
Less direct use	13	13	14	14	14	14	14	0.2%
Net available to the grid	**3,877**	**3,886**	**4,131**	**4,267**	**4,406**	**4,527**	**4,672**	**0.7%**
End-use sector[7]								
Coal	13	13	13	13	13	13	13	0.0%
Petroleum	3	3	3	3	3	3	3	-0.4%
Natural gas	95	98	116	134	163	199	235	3.3%
Other gaseous fuels[8]	11	11	19	19	19	19	19	2.1%
Renewable sources[9]	39	42	53	60	70	82	97	3.1%
Other[10]	3	3	3	3	3	3	3	0.0%
Total end-use sector net generation	**164**	**171**	**207**	**233**	**271**	**320**	**370**	**2.9%**
Less direct use	126	132	167	190	225	269	313	3.3%
Total sales to the grid	**38**	**39**	**40**	**43**	**46**	**51**	**56**	**1.4%**
Total net electricity generation by fuel								
Coal	1,514	1,586	1,709	1,724	1,713	1,704	1,702	0.3%
Petroleum	23	27	18	18	18	18	18	-1.6%
Natural gas	1,228	1,118	1,117	1,223	1,371	1,478	1,569	1.3%
Nuclear power	769	789	804	808	808	812	833	0.2%
Renewable sources[5,9]	501	530	679	716	756	823	909	2.0%
Other[11]	19	20	25	25	25	25	25	0.8%
Total net electricity generation	**4,055**	**4,070**	**4,351**	**4,513**	**4,691**	**4,860**	**5,056**	**0.8%**
Net generation to the grid	**3,916**	**3,925**	**4,171**	**4,309**	**4,453**	**4,578**	**4,729**	**0.7%**
Net imports	**47**	**52**	**33**	**35**	**30**	**26**	**32**	**-1.8%**
Electricity sales by sector								
Residential	1,375	1,391	1,423	1,441	1,488	1,533	1,587	0.5%
Commercial	1,327	1,338	1,413	1,461	1,522	1,583	1,659	0.8%
Industrial	986	955	1,096	1,166	1,183	1,188	1,206	0.9%
Transportation	7	7	9	10	12	15	18	3.4%
Total	**3,695**	**3,691**	**3,941**	**4,078**	**4,205**	**4,319**	**4,470**	**0.7%**
Direct use	139	145	180	204	239	283	327	3.1%
Total electricity use	**3,834**	**3,836**	**4,121**	**4,282**	**4,444**	**4,602**	**4,797**	**0.8%**

Table A8. Electricity supply, disposition, prices, and emissions (continued)
(billion kilowatthours, unless otherwise noted)

Supply, disposition, prices, and emissions	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
End-use prices								
(2013 cents per kilowatthour)								
Residential	12.1	12.2	12.9	13.5	13.6	13.9	14.5	0.6%
Commercial	10.2	10.1	10.6	11.1	11.1	11.3	11.8	0.6%
Industrial	6.8	6.9	7.3	7.6	7.7	7.9	8.4	0.7%
Transportation	9.5	9.7	10.3	11.0	11.2	11.6	12.3	0.9%
All sectors average	**10.0**	**10.1**	**10.5**	**11.0**	**11.1**	**11.3**	**11.8**	**0.6%**
(nominal cents per kilowatthour)								
Residential	11.9	12.2	14.6	16.6	18.3	20.5	23.5	2.5%
Commercial	10.1	10.1	12.0	13.6	14.9	16.6	19.1	2.4%
Industrial	6.7	6.9	8.2	9.4	10.3	11.7	13.6	2.6%
Transportation	9.3	9.7	11.7	13.6	15.0	17.0	19.9	2.7%
All sectors average	**9.8**	**10.1**	**11.9**	**13.5**	**14.8**	**16.6**	**19.2**	**2.4%**
Prices by service category								
(2013 cents per kilowatthour)								
Generation	6.5	6.6	6.6	7.0	7.0	7.1	7.6	0.5%
Transmission	0.9	0.9	1.1	1.2	1.2	1.2	1.3	1.2%
Distribution	2.5	2.6	2.8	2.9	2.9	3.0	3.0	0.6%
(nominal cents per kilowatthour)								
Generation	6.4	6.6	7.5	8.6	9.3	10.5	12.3	2.3%
Transmission	0.9	0.9	1.2	1.4	1.6	1.8	2.1	3.0%
Distribution	2.5	2.6	3.2	3.6	3.9	4.4	4.9	2.4%
Electric power sector emissions[1]								
Sulfur dioxide (million short tons)	3.43	3.27	1.42	1.44	1.44	1.47	1.53	-2.8%
Nitrogen oxide (million short tons)	1.68	1.69	1.57	1.57	1.56	1.57	1.57	-0.3%
Mercury (short tons)	26.69	27.94	6.58	6.53	6.43	6.40	6.41	-5.3%

[1]Includes electricity-only and combined heat and power plants that have a regulatory status.
[2]Includes plants that only produce electricity and that have a regulatory status.
[3]Includes electricity generation from fuel cells.
[4]Includes non-biogenic municipal waste. The U.S. Energy Information Administration estimates that in 2013 approximately 7 billion kilowatthours of electricity were generated from a municipal waste stream containing petroleum-derived plastics and other non-renewable sources. See U.S. Energy Information Administration, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy*, (Washington, DC, May 2007).
[5]Includes conventional hydroelectric, geothermal, wood, wood waste, biogenic municipal waste, landfill gas, other biomass, solar, and wind power.
[6]Includes combined heat and power plants whose primary business is to sell electricity and heat to the public (i.e., those that report North American Industry Classification System code 22 or that have a regulatory status).
[7]Includes combined heat and power plants and electricity-only plants in the commercial and industrial sectors that have a non-regulatory status; and small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
[8]Includes refinery gas and still gas.
[9]Includes conventional hydroelectric, geothermal, wood, wood waste, all municipal waste, landfill gas, other biomass, solar, and wind power.
[10]Includes batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.
[11]Includes pumped storage, non-biogenic municipal waste, refinery gas, still gas, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 electric power sector generation; sales to the grid; net imports; electricity sales; and electricity end-use prices: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014), and supporting databases. 2012 and 2013 emissions: U.S. Environmental Protection Agency, Clean Air Markets Database. 2012 and 2013 electricity prices by service category: EIA, AEO2015 National Energy Modeling System run REF2015.D021915A. **Projections**: EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A9. Electricity generating capacity
(gigawatts)

Net summer capacity[1]	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Electric power sector[2]								
Power only[3]								
Coal[4]	300.2	296.1	255.4	252.8	252.8	252.8	252.9	-0.6%
Oil and natural gas steam[4,5]	99.2	94.6	87.5	78.3	73.2	69.2	68.2	-1.2%
Combined cycle	185.3	188.3	203.2	211.9	233.6	255.1	281.3	1.5%
Combustion turbine/diesel	136.4	139.6	140.1	144.2	151.8	160.7	172.6	0.8%
Nuclear power[6]	102.1	98.9	101.4	101.4	101.6	102.1	104.9	0.2%
Pumped storage	22.4	22.4	22.4	22.4	22.4	22.4	22.4	0.0%
Fuel cells	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0%
Renewable sources[7]	148.1	153.3	187.1	190.2	196.6	209.7	229.2	1.5%
Distributed generation (natural gas)[8]	0.0	0.0	0.7	1.1	1.7	2.4	3.1	- -
Total	**993.7**	**993.2**	**997.9**	**1,002.4**	**1,033.7**	**1,074.4**	**1,134.6**	**0.5%**
Combined heat and power[9]								
Coal	4.5	4.3	4.1	4.1	4.1	4.1	4.1	-0.2%
Oil and natural gas steam[5]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0%
Combined cycle	25.7	25.7	26.0	26.0	26.0	26.0	26.0	0.0%
Combustion turbine/diesel	3.1	3.1	3.1	3.1	3.1	3.1	3.1	0.0%
Renewable sources[7]	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0.1%
Total	**35.6**	**35.4**	**35.6**	**35.6**	**35.6**	**35.6**	**35.6**	**0.0%**
Cumulative planned additions[10]								
Coal	- -	- -	0.7	0.7	0.7	0.7	0.7	- -
Oil and natural gas steam[5]	- -	- -	0.4	0.4	0.4	0.4	0.4	- -
Combined cycle	- -	- -	14.2	14.2	14.2	14.2	14.2	- -
Combustion turbine/diesel	- -	- -	1.6	1.6	1.6	1.6	1.6	- -
Nuclear power	- -	- -	5.5	5.5	5.5	5.5	5.5	- -
Pumped storage	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Fuel cells	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Renewable sources[7]	- -	- -	30.5	30.5	30.5	30.5	30.5	- -
Distributed generation[8]	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Total	**- -**	**- -**	**52.8**	**52.8**	**52.8**	**52.8**	**52.8**	**- -**
Cumulative unplanned additions[10]								
Coal	- -	- -	0.3	0.3	0.3	0.3	0.4	- -
Oil and natural gas steam[5]	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Combined cycle	- -	- -	7.7	17.3	39.0	60.5	86.9	- -
Combustion turbine/diesel	- -	- -	3.8	8.5	16.8	26.1	37.9	- -
Nuclear power	- -	- -	0.0	0.0	0.1	0.6	3.5	- -
Pumped storage	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Fuel cells	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Renewable sources[7]	- -	- -	4.0	7.1	13.4	26.6	46.1	- -
Distributed generation[8]	- -	- -	0.7	1.1	1.7	2.4	3.1	- -
Total	**- -**	**- -**	**16.5**	**34.3**	**71.4**	**116.5**	**177.9**	**- -**
Cumulative electric power sector additions[10]	**- -**	**- -**	**69.3**	**87.1**	**124.2**	**169.4**	**230.7**	**- -**
Cumulative retirements[11]								
Coal	- -	- -	37.4	40.1	40.1	40.1	40.1	- -
Oil and natural gas steam[5]	- -	- -	11.8	21.0	26.1	30.1	31.0	- -
Combined cycle	- -	- -	7.1	8.0	8.0	8.0	8.3	- -
Combustion turbine/diesel	- -	- -	4.9	5.5	6.1	6.5	6.5	- -
Nuclear power	- -	- -	3.2	3.2	3.2	3.2	3.2	- -
Pumped storage	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Fuel cells	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Renewable sources[7]	- -	- -	0.6	0.6	0.6	0.6	0.6	- -
Total	**- -**	**- -**	**65.0**	**78.3**	**84.1**	**88.5**	**89.7**	**- -**
Total electric power sector capacity	**1,029**	**1,029**	**1,033**	**1,038**	**1,069**	**1,110**	**1,170**	**0.5%**

Table A9. Electricity generating capacity (continued)
(gigawatts)

Net summer capacity[1]	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
End-use generators[12]								
Coal	3.4	3.4	3.4	3.4	3.4	3.4	3.4	0.0%
Petroleum	0.9	0.9	0.9	0.9	0.9	0.9	0.9	-0.4%
Natural gas	16.3	16.9	19.5	22.7	27.6	33.6	38.9	3.1%
Other gaseous fuels[13]	2.1	2.1	2.8	2.8	2.8	2.8	2.8	1.0%
Renewable sources[7]	10.4	12.1	18.2	22.4	28.6	36.0	44.6	4.9%
Other[14]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0%
Total	**33.6**	**36.0**	**45.3**	**52.8**	**63.8**	**77.2**	**91.1**	**3.5%**
Cumulative capacity additions[10]	**- -**	**- -**	**10.5**	**18.0**	**29.1**	**42.6**	**56.5**	**- -**

[1]Net summer capacity is the steady hourly output that generating equipment is expected to supply to system load (exclusive of auxiliary power), as demonstrated by tests during summer peak demand.
[2]Includes electricity-only and combined heat and power plants that have a regulatory status.
[3]Includes plants that only produce electricity and that have a regulatory status. Includes capacity increases (uprates) at existing units.
[4]Coal and oil and natural gas steam capacity reflect the impact of 4.1 GW of existing coal capacity converting to gas steam capacity.
[5]Includes oil-, gas-, and dual-fired capacity.
[6]Nuclear capacity includes 0.2 gigawatts of uprates.
[7]Includes conventional hydroelectric, geothermal, wood, wood waste, all municipal waste, landfill gas, other biomass, solar, and wind power. Facilities co-firing biomass and coal are classified as coal.
[8]Primarily peak load capacity fueled by natural gas.
[9]Includes combined heat and power plants whose primary business is to sell electricity and heat to the public (i.e., those that report North American Industry Classification System code 22 or that have a regulatory status).
[10]Cumulative additions after December 31, 2013.
[11]Cumulative retirements after December 31, 2013.
[12]Includes combined heat and power plants and electricity-only plants in the commercial and industrial sectors that have a non-regulatory status; and small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
[13]Includes refinery gas and still gas.
[14]Includes batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 capacity and projected planned additions: U.S. Energy Information Administration (EIA), Form EIA-860, "Annual Electric Generator Report" (preliminary). **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A10. Electricity trade
(billion kilowatthours, unless otherwise noted)

Electricity trade	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Interregional electricity trade								
Gross domestic sales								
Firm power	156	157	122	63	28	28	28	-6.2%
Economy	184	115	195	214	207	232	268	3.2%
Total	**340**	**272**	**318**	**277**	**235**	**260**	**296**	**0.3%**
Gross domestic sales (million 2013 dollars)								
Firm power	9,711	9,802	7,622	3,952	1,722	1,722	1,722	-6.2%
Economy	6,217	4,772	9,376	11,934	11,963	14,056	18,159	5.1%
Total	**15,929**	**14,574**	**16,998**	**15,886**	**13,685**	**15,778**	**19,881**	**1.2%**
International electricity trade								
Imports from Canada and Mexico								
Firm power	15.9	15.8	20.4	16.4	14.0	14.0	14.0	-0.5%
Economy	43.1	47.9	28.0	34.4	30.6	26.2	32.1	-1.5%
Total	**59.0**	**63.7**	**48.4**	**50.7**	**44.6**	**40.2**	**46.1**	**-1.2%**
Exports to Canada and Mexico								
Firm power	2.7	2.3	1.5	0.5	0.0	0.0	0.0	- -
Economy	8.8	9.1	14.0	14.7	14.7	14.4	14.4	1.7%
Total	**11.5**	**11.4**	**15.4**	**15.2**	**14.7**	**14.4**	**14.4**	**0.9%**

- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports. Firm power sales are capacity sales, meaning the delivery of the power is scheduled as part of the normal operating conditions of the affected electric systems. Economy sales are subject to curtailment or cessation of delivery by the supplier in accordance with prior agreements or under specified conditions.
Sources: 2012 and 2013 interregional firm electricity trade data: 2013 seasonal reliability assessments from North American Electric Reliability Council regional entities and Independent System Operators. 2012 and 2013 interregional economy electricity trade are model results. 2012 and 2013 Mexican electricity trade data: U.S. Energy Information Administration (EIA), *Electric Power Annual 2012*, DOE/EIA-0348(2012) (Washington, DC, December 2013). 2012 Canadian international electricity trade data: National Energy Board, *Electricity Exports and Imports Statistics, 2012*. 2013 Canadian international electricity trade data: National Energy Board, *Electricity Exports and Imports Statistics, 2013*. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A11. Petroleum and other liquids supply and disposition
(million barrels per day, unless otherwise noted)

Supply and disposition	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Crude oil								
Domestic crude production[1]	6.50	7.44	10.60	10.28	10.04	9.38	9.43	0.9%
Alaska	0.53	0.52	0.42	0.32	0.24	0.18	0.34	-1.6%
Lower 48 states	5.98	6.92	10.18	9.96	9.80	9.20	9.09	1.0%
Net imports	8.46	7.60	5.51	6.09	6.44	7.35	7.58	0.0%
Gross imports	8.53	7.73	6.14	6.72	7.07	7.98	8.21	0.2%
Exports	0.07	0.13	0.63	0.63	0.63	0.63	0.63	5.9%
Other crude supply[2]	0.04	0.27	0.00	0.00	0.00	0.00	0.00	- -
Total crude supply	**15.00**	**15.30**	**16.11**	**16.37**	**16.48**	**16.73**	**17.01**	**0.4%**
Net product imports	-1.05	-1.37	-2.80	-3.24	-3.56	-3.94	-4.26	- -
Gross refined product imports[3]	0.82	0.82	1.21	1.28	1.31	1.31	1.26	1.6%
Unfinished oil imports	0.60	0.66	0.60	0.56	0.52	0.49	0.45	-1.4%
Blending component imports	0.62	0.60	0.59	0.55	0.49	0.45	0.40	-1.5%
Exports	3.08	3.43	5.20	5.63	5.89	6.18	6.36	2.3%
Refinery processing gain[4]	1.06	1.09	0.98	1.00	0.97	0.99	0.98	-0.4%
Product stock withdrawal	-0.07	0.11	0.00	0.00	0.00	0.00	0.00	- -
Natural gas plant liquids	2.41	2.61	4.04	4.16	4.19	4.13	4.07	1.7%
Supply from renewable sources	0.88	0.93	1.01	1.01	1.01	1.04	1.12	0.7%
Ethanol	0.82	0.83	0.84	0.84	0.84	0.87	0.95	0.5%
Domestic production	0.84	0.85	0.86	0.86	0.86	0.87	0.93	0.4%
Net imports	-0.02	-0.02	-0.02	-0.02	-0.02	0.00	0.02	- -
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Biodiesel	0.06	0.10	0.14	0.11	0.11	0.11	0.11	0.4%
Domestic production	0.06	0.09	0.13	0.10	0.10	0.10	0.10	0.3%
Net imports	-0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.9%
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Other biomass-derived liquids[5]	0.00	0.00	0.03	0.06	0.06	0.06	0.06	31.9%
Domestic production	0.00	0.00	0.03	0.06	0.06	0.06	0.06	31.9%
Net imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Liquids from gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Liquids from coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Other[6]	0.19	0.21	0.28	0.29	0.30	0.31	0.32	1.6%
Total primary supply[7]	**18.43**	**18.87**	**19.62**	**19.59**	**19.38**	**19.26**	**19.24**	**0.1%**
Product supplied								
by fuel								
Liquefied petroleum gases and other[8]	2.30	2.50	2.91	3.19	3.30	3.27	3.25	1.0%
Motor gasoline[9]	8.69	8.85	8.49	7.89	7.41	7.16	7.05	-0.8%
of which: E85[10]	0.01	0.01	0.02	0.08	0.13	0.16	0.19	9.9%
Jet fuel[11]	1.40	1.43	1.55	1.64	1.75	1.82	1.87	1.0%
Distillate fuel oil[12]	3.74	3.83	4.26	4.31	4.34	4.38	4.38	0.5%
of which: Diesel	3.46	3.56	3.94	4.02	4.09	4.15	4.17	0.6%
Residual fuel oil	0.37	0.32	0.27	0.28	0.28	0.28	0.28	-0.4%
Other[13]	1.97	2.04	2.18	2.30	2.33	2.37	2.43	0.7%
by sector								
Residential and commercial	0.82	0.86	0.76	0.71	0.67	0.64	0.61	-1.3%
Industrial[14]	4.49	4.69	5.50	5.90	6.04	6.04	6.09	1.0%
Transportation	13.04	13.36	13.46	13.08	12.79	12.71	12.66	-0.2%
Electric power[15]	0.10	0.12	0.08	0.08	0.08	0.08	0.08	-1.4%
Unspecified sector[16]	0.02	-0.12	-0.15	-0.16	-0.17	-0.17	-0.17	- -
Total product supplied	**18.47**	**18.96**	**19.65**	**19.61**	**19.41**	**19.29**	**19.27**	**0.1%**
Discrepancy[17]	-0.03	-0.10	-0.03	-0.02	-0.03	-0.03	-0.03	- -

Table A11. Petroleum and other liquids supply and disposition (continued)
(million barrels per day, unless otherwise noted)

Supply and disposition	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Domestic refinery distillation capacity[18]	17.4	17.8	18.8	18.8	18.8	18.8	18.8	0.2%
Capacity utilization rate (percent)[19]	88.7	88.3	87.8	89.0	89.4	90.7	92.0	0.2%
Net import share of product supplied (percent)	40.1	33.0	13.7	14.5	14.8	17.7	17.4	-2.3%
Net expenditures for imported crude oil and petroleum products (billion 2013 dollars)	345	308	167	211	259	339	405	1.0%

[1]Includes lease condensate.
[2]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude oil stock withdrawals.
[3]Includes other hydrocarbons and alcohols.
[4]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[5]Includes pyrolysis oils, biomass-derived Fischer-Tropsch liquids, biobutanol, and renewable feedstocks used for the on-site production of diesel and gasoline.
[6]Includes domestic sources of other blending components, other hydrocarbons, and ethers.
[7]Total crude supply, net product imports, refinery processing gain, product stock withdrawal, natural gas plant liquids, supply from renewable sources, liquids from gas, liquids from coal, and other supply.
[8]Includes ethane, natural gasoline, and refinery olefins.
[9]Includes ethanol and ethers blended into gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Includes distillate fuel oil from petroleum and biomass feedstocks.
[13]Includes kerosene, aviation gasoline, petrochemical feedstocks, lubricants, waxes, asphalt, road oil, still gas, special naphthas, petroleum coke, crude oil product supplied, methanol, and miscellaneous petroleum products.
[14]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[15]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[16]Represents consumption unattributed to the sectors above.
[17]Balancing item. Includes unaccounted for supply, losses, and gains.
[18]End-of-year operable capacity.
[19]Rate is calculated by dividing the gross annual input to atmospheric crude oil distillation units by their operable refining capacity in barrels per calendar day.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 product supplied based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). Other 2012 data: EIA, *Petroleum Supply Annual 2012*, DOE/EIA-0340(2012)/1 (Washington, DC, September 2013). Other 2013 data: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A12. Petroleum and other liquids prices
(2013 dollars per gallon, unless otherwise noted)

Sector and fuel	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Crude oil prices (2013 dollars per barrel)								
Brent spot	113	109	79	91	106	122	141	1.0%
West Texas Intermediate spot	96	98	73	85	99	116	136	1.2%
Average imported refiners acquisition cost[1]	103	98	71	82	96	112	131	1.1%
Brent / West Texas Intermediate spread	17.8	10.7	6.2	6.1	6.2	6.0	5.6	-2.4%
Delivered sector product prices								
Residential								
Propane	2.22	2.13	2.10	2.16	2.23	2.33	2.43	0.5%
Distillate fuel oil	3.79	3.78	2.99	3.28	3.65	4.08	4.56	0.7%
Commercial								
Distillate fuel oil	3.69	3.68	2.89	3.20	3.56	3.99	4.47	0.7%
Residual fuel oil	3.43	3.31	2.12	2.39	2.71	3.08	3.64	0.4%
Residual fuel oil (2013 dollars per barrel)	144	139	89	101	114	129	153	0.4%
Industrial[2]								
Propane	1.95	1.85	1.79	1.87	1.96	2.09	2.24	0.7%
Distillate fuel oil	3.76	3.75	2.91	3.23	3.58	4.00	4.49	0.7%
Residual fuel oil	3.09	3.00	2.00	2.27	2.58	2.95	3.51	0.6%
Residual fuel oil (2013 dollars per barrel)	130	126	84	95	108	124	147	0.6%
Transportation								
Propane	2.31	2.24	2.19	2.25	2.32	2.42	2.52	0.4%
E85[3]	3.39	3.14	2.90	2.77	2.98	3.16	3.38	0.3%
Ethanol wholesale price	2.58	2.37	2.49	2.47	2.35	2.49	2.64	0.4%
Motor gasoline[4]	3.72	3.55	2.74	2.95	3.20	3.53	3.90	0.3%
Jet fuel[5]	3.10	2.94	2.17	2.47	2.88	3.31	3.81	1.0%
Diesel fuel (distillate fuel oil)[6]	3.94	3.86	3.17	3.49	3.84	4.26	4.75	0.8%
Residual fuel oil	3.00	2.89	1.74	2.00	2.30	2.64	3.03	0.2%
Residual fuel oil (2013 dollars per barrel)	126	122	73	84	97	111	127	0.2%
Electric power[7]								
Distillate fuel oil	3.34	3.33	2.60	2.90	3.28	3.70	4.19	0.9%
Residual fuel oil	3.12	2.83	1.71	1.99	2.30	2.67	3.23	0.5%
Residual fuel oil (2013 dollars per barrel)	131	119	72	83	97	112	136	0.5%
Average prices, all sectors[8]								
Propane	2.09	2.00	1.93	1.99	2.06	2.18	2.30	0.5%
Motor gasoline[4]	3.70	3.53	2.74	2.95	3.20	3.53	3.90	0.4%
Jet fuel[5]	3.10	2.94	2.17	2.47	2.88	3.31	3.81	1.0%
Distillate fuel oil	3.89	3.83	3.11	3.43	3.78	4.20	4.69	0.8%
Residual fuel oil	3.04	2.90	1.83	2.10	2.40	2.75	3.22	0.4%
Residual fuel oil (2013 dollars per barrel)	128	122	77	88	101	116	135	0.4%
Average	**3.29**	**3.16**	**2.46**	**2.65**	**2.89**	**3.23**	**3.62**	**0.5%**

Table A12. Petroleum and other liquids prices (continued)
(nominal dollars per gallon, unless otherwise noted)

Sector and fuel	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Crude oil prices (nominal dollars per barrel)								
Brent spot	112	109	90	112	142	180	229	2.8%
West Texas Intermediate spot	94	98	83	105	133	171	220	3.0%
Average imported refiners acquisition cost[1]	101	98	80	102	129	165	212	2.9%
Delivered sector product prices								
Residential								
Propane	2.19	2.13	2.38	2.66	2.99	3.42	3.94	2.3%
Distillate fuel oil	3.73	3.78	3.39	4.04	4.90	5.99	7.40	2.5%
Commercial								
Distillate fuel oil	3.63	3.68	3.28	3.94	4.78	5.86	7.25	2.5%
Residual fuel oil	3.38	3.31	2.41	2.95	3.63	4.53	5.90	2.2%
Residual fuel oil (nominal dollars per barrel)	142	139	101	124	153	190	248	2.2%
Industrial[2]								
Propane	1.92	1.85	2.04	2.30	2.63	3.08	3.62	2.5%
Distillate fuel oil	3.71	3.75	3.30	3.98	4.80	5.89	7.28	2.5%
Residual fuel oil	3.05	3.00	2.26	2.79	3.46	4.34	5.69	2.4%
Residual fuel oil (nominal dollars per barrel)	128	126	95	117	145	182	239	2.4%
Transportation								
Propane	2.28	2.24	2.49	2.78	3.12	3.56	4.09	2.2%
E85[3]	3.34	3.14	3.29	3.41	3.99	4.65	5.48	2.1%
Ethanol wholesale price	2.55	2.37	2.83	3.04	3.15	3.67	4.27	2.2%
Motor gasoline[4]	3.67	3.55	3.10	3.63	4.29	5.18	6.32	2.2%
Jet fuel[5]	3.06	2.94	2.47	3.05	3.86	4.87	6.18	2.8%
Diesel fuel (distillate fuel oil)[6]	3.89	3.86	3.60	4.30	5.15	6.26	7.70	2.6%
Residual fuel oil	2.95	2.89	1.98	2.46	3.08	3.88	4.92	2.0%
Residual fuel oil (nominal dollars per barrel)	124	122	83	103	129	163	207	2.0%
Electric power[7]								
Distillate fuel oil	3.29	3.33	2.95	3.57	4.39	5.45	6.79	2.7%
Residual fuel oil	3.07	2.83	1.94	2.45	3.09	3.93	5.24	2.3%
Residual fuel oil (nominal dollars per barrel)	129	119	82	103	130	165	220	2.3%
Average prices, all sectors[8]								
Propane	2.06	2.00	2.19	2.45	2.77	3.20	3.73	2.3%
Motor gasoline[4]	3.64	3.53	3.10	3.63	4.29	5.18	6.32	2.2%
Jet fuel[5]	3.06	2.94	2.47	3.05	3.86	4.87	6.18	2.8%
Distillate fuel oil	3.83	3.83	3.52	4.22	5.07	6.18	7.61	2.6%
Residual fuel oil	2.99	2.90	2.07	2.58	3.22	4.04	5.21	2.2%
Residual fuel oil (nominal dollars per barrel)	126	122	87	108	135	170	219	2.2%
Average	**3.24**	**3.16**	**2.79**	**3.26**	**3.88**	**4.75**	**5.86**	**2.3%**

[1]Weighted average price delivered to U.S. refiners.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Includes only kerosene type.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Includes electricity-only and combined heat and power plants that have a regulatory status.
[8]Weighted averages of end-use fuel prices are derived from the prices in each sector and the corresponding sectoral consumption.
Note: Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. 2012 and 2013 average imported crude oil price: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 prices for motor gasoline, distillate fuel oil, and jet fuel are based on: EIA, *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2012 and 2013 residential, commercial, industrial, and transportation sector petroleum product prices are derived from: EIA, Form EIA-782A, "Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales Report." 2012 and 2013 electric power prices based on: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 E85 prices derived from monthly prices in the Clean Cities Alternative Fuel Price Report. 2012 and 2013 wholesale ethanol prices derived from Bloomberg U.S. average rack price. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A13. Natural gas supply, disposition, and prices
(trillion cubic feet per year, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Supply								
Dry gas production[1]	24.06	24.40	28.82	30.51	33.01	34.14	35.45	1.4%
Supplemental natural gas[2]	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.6%
Net imports	1.52	1.29	-2.55	-3.50	-4.81	-5.19	-5.62	- -
Pipeline[3]	1.37	1.20	-0.48	-1.01	-1.52	-1.90	-2.33	- -
Liquefied natural gas	0.15	0.09	-2.08	-2.49	-3.29	-3.29	-3.29	- -
Total supply	**25.64**	**25.75**	**26.33**	**27.07**	**28.27**	**29.01**	**29.90**	**0.6%**
Consumption by sector								
Residential	4.15	4.92	4.50	4.42	4.40	4.31	4.20	-0.6%
Commercial	2.90	3.28	3.21	3.20	3.33	3.47	3.61	0.4%
Industrial[4]	7.21	7.41	8.10	8.24	8.41	8.52	8.66	0.6%
Natural-gas-to-liquids heat and power[5]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Natural gas to liquids production[6]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Electric power[7]	9.11	8.16	7.61	8.13	8.81	9.17	9.38	0.5%
Transportation[8]	0.04	0.05	0.07	0.10	0.17	0.31	0.70	10.3%
Pipeline fuel	0.73	0.86	0.83	0.87	0.91	0.92	0.93	0.3%
Lease and plant fuel[9]	1.40	1.48	1.82	1.92	2.05	2.12	2.23	1.5%
Total consumption	**25.53**	**26.16**	**26.14**	**26.88**	**28.08**	**28.82**	**29.70**	**0.5%**
Discrepancy[10]	**0.11**	**-0.41**	**0.19**	**0.19**	**0.19**	**0.19**	**0.19**	**- -**
Natural gas spot price at Henry Hub								
(2013 dollars per million Btu)	2.79	3.73	4.88	5.46	5.69	6.60	7.85	2.8%
(nominal dollars per million Btu)	2.75	3.73	5.54	6.72	7.63	9.70	12.73	4.7%
Delivered prices								
(2013 dollars per thousand cubic feet)								
Residential	10.86	10.29	11.92	13.07	13.15	14.13	15.90	1.6%
Commercial	8.36	8.35	9.82	10.83	10.69	11.44	12.97	1.6%
Industrial[4]	3.94	4.68	6.35	7.07	6.99	7.75	9.03	2.5%
Electric power[7]	3.59	4.51	5.52	6.43	6.38	7.15	8.49	2.4%
Transportation[11]	20.93	18.13	18.27	17.23	16.13	17.60	20.18	0.4%
Average[12]	**5.61**	**6.32**	**7.66**	**8.50**	**8.40**	**9.22**	**10.76**	**2.0%**
(nominal dollars per thousand cubic feet)								
Residential	10.70	10.29	13.52	16.09	17.62	20.77	25.77	3.5%
Commercial	8.24	8.35	11.14	13.34	14.33	16.81	21.03	3.5%
Industrial[4]	3.88	4.68	7.20	8.71	9.37	11.39	14.64	4.3%
Electric power[7]	3.54	4.51	6.26	7.92	8.55	10.51	13.76	4.2%
Transportation[11]	20.62	18.13	20.73	21.21	21.62	25.87	32.72	2.2%
Average[12]	**5.53**	**6.32**	**8.68**	**10.46**	**11.27**	**13.55**	**17.44**	**3.8%**

[1]Marketed production (wet) minus extraction losses.
[2]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
[3]Includes any natural gas regasified in the Bahamas and transported via pipeline to Florida, as well as gas from Canada and Mexico.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems. Excludes use for lease and plant fuel.
[5]Includes any natural gas used in the process of converting natural gas to liquid fuel that is not actually converted.
[6]Includes any natural gas converted into liquid fuel.
[7]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[8]Natural gas used as fuel in motor vehicles, trains, and ships.
[9]Represents natural gas used in well, field, and lease operations, in natural gas processing plant machinery, and for liquefaction in export facilities.
[10]Balancing item. Natural gas lost as a result of converting flow data measured at varying temperatures and pressures to a standard temperature and pressure and the merger of different data reporting systems which vary in scope, format, definition, and respondent type. In addition, 2012 and 2013 values include net storage injections.
[11]Natural gas used as fuel in motor vehicles, trains, and ships. Price includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[12]Weighted average prices. Weights used are the sectoral consumption values excluding lease, plant, and pipeline fuel.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 supply values; lease, plant, and pipeline fuel consumption; and residential, commercial, and industrial delivered prices: U.S. Energy Information Administration (EIA), *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014). 2013 supply values; lease, plant, and pipeline fuel consumption; and residential, commercial, and industrial delivered prices: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). Other 2012 and 2013 consumption based on: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 natural gas spot price at Henry Hub: Thomson Reuters. 2012 and 2013 electric power prices: EIA, *Electric Power Monthly*, DOE/EIA-0226, April 2013 and April 2014, Table 4.2, and EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014). 2012 transportation sector delivered prices are based on: EIA, *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014), EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014), and estimated State and Federal motor fuel taxes and dispensing costs or charges. 2013 transportation sector delivered prices are model results. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A14. Oil and gas supply

Production and supply	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Crude oil								
Lower 48 average wellhead price[1]								
(2013 dollars per barrel)	**96**	**97**	**75**	**87**	**101**	**117**	**136**	**1.3%**
Production (million barrels per day)[2]								
United States total	6.50	7.44	10.60	10.28	10.04	9.38	9.43	0.9%
Lower 48 onshore	4.60	5.57	8.03	8.01	7.60	7.07	6.92	0.8%
Tight oil[3]	2.19	3.15	5.60	5.31	4.83	4.40	4.29	1.1%
Carbon dioxide enhanced oil recovery	0.28	0.28	0.35	0.47	0.58	0.69	0.83	4.1%
Other	2.12	2.14	2.08	2.23	2.19	1.98	1.80	-0.6%
Lower 48 offshore	1.38	1.36	2.15	1.95	2.21	2.14	2.17	1.7%
State	0.07	0.07	0.05	0.04	0.03	0.03	0.02	-3.8%
Federal	1.31	1.29	2.10	1.92	2.18	2.11	2.14	1.9%
Alaska	0.53	0.52	0.42	0.32	0.24	0.18	0.34	-1.6%
Onshore	0.47	0.45	0.30	0.23	0.18	0.14	0.12	-4.9%
State offshore	0.06	0.06	0.12	0.09	0.06	0.04	0.02	-3.6%
Federal offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.20	15.9%
Lower 48 end of year reserves[2]								
(billion barrels)	**30.1**	**29.4**	**37.4**	**39.4**	**42.6**	**43.4**	**44.8**	**1.6%**
Natural gas plant liquids production								
(million barrels per day)								
United States total	2.41	2.61	4.04	4.16	4.20	4.13	4.07	1.7%
Lower 48 onshore	2.18	2.39	3.82	3.94	3.92	3.87	3.79	1.7%
Lower 48 offshore	0.20	0.18	0.19	0.20	0.26	0.25	0.26	1.3%
Alaska	0.03	0.03	0.02	0.02	0.01	0.01	0.02	-1.4%
Natural gas								
Natural gas spot price at Henry Hub								
(2013 dollars per million Btu)	2.79	3.73	4.88	5.46	5.69	6.60	7.85	2.8%
Dry production (trillion cubic feet)[4]								
United States total	24.06	24.40	28.82	30.51	33.01	34.14	35.45	1.4%
Lower 48 onshore	22.16	22.63	26.52	28.10	29.05	30.26	31.49	1.2%
Tight gas	4.78	4.38	5.21	5.55	5.99	6.40	6.97	1.7%
Shale gas and tight oil plays[3]	10.16	11.34	15.44	17.03	17.85	18.85	19.58	2.0%
Coalbed methane	1.64	1.29	1.45	1.32	1.24	1.24	1.25	-0.1%
Other	5.58	5.61	4.42	4.19	3.97	3.77	3.69	-1.5%
Lower 48 offshore	1.57	1.46	2.03	2.16	2.79	2.73	2.81	2.5%
State	0.14	0.11	0.06	0.04	0.03	0.02	0.02	-5.9%
Federal	1.42	1.35	1.98	2.13	2.76	2.70	2.79	2.7%
Alaska	0.33	0.32	0.27	0.25	1.18	1.16	1.15	4.9%
Onshore	0.33	0.32	0.27	0.25	1.18	1.16	1.15	4.9%
State offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Federal offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lower 48 end of year dry reserves[4]								
(trillion cubic feet)	**298**	**293**	**309**	**316**	**329**	**338**	**345**	**0.6%**
Supplemental gas supplies (trillion cubic feet)[5]	**0.06**	**0.05**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.6%**
Total lower 48 wells drilled (thousands)	**44.7**	**44.5**	**43.4**	**47.4**	**52.1**	**54.0**	**56.7**	**0.9%**

[1]Represents lower 48 onshore and offshore supplies.
[2]Includes lease condensate.
[3]Tight oil represents resources in low-permeability reservoirs, including shale and chalk formations. The specific plays included in the tight oil category are Bakken/Three Forks/Sanish, Eagle Ford, Woodford, Austin Chalk, Spraberry, Niobrara, Avalon/Bone Springs, and Monterey.
[4]Marketed production (wet) minus extraction losses.
[5]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 crude oil lower 48 average wellhead price: U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2012 and 2013 lower 48 onshore, lower 48 offshore, and Alaska crude oil production: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). 2012 U.S. crude oil and natural gas reserves: EIA, *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves*, DOE/EIA-0216(2012) (Washington, DC, April 2014). 2012 Alaska and total natural gas production, and supplemental gas supplies: EIA, *Natural Gas Annual 2013*, DOE/EIA-0131(2013) (Washington, DC, October 2014). 2012 and 2013 natural gas spot price at Henry Hub: Thomson Reuters. 2013 Alaska and total natural gas production, and supplemental gas supplies: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). Other 2012 and 2013 values: EIA, Office of Energy Analysis. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A15. Coal supply, disposition, and prices
(million short tons per year, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Production[1]								
Appalachia	293	272	260	248	243	235	228	-0.6%
Interior	180	183	219	235	258	278	300	1.8%
West	543	530	592	622	617	597	589	0.4%
East of the Mississippi	423	407	428	426	442	453	467	0.5%
West of the Mississippi	593	578	643	679	676	658	650	0.4%
Total	**1,016**	**985**	**1,071**	**1,105**	**1,118**	**1,111**	**1,117**	**0.5%**
Waste coal supplied[2]	**11**	**10**	**11**	**10**	**10**	**10**	**10**	**0.0%**
Net imports								
Imports[3]	8	7	1	1	1	1	1	-6.8%
Exports	126	118	95	112	130	131	141	0.7%
Total	**-118**	**-110**	**-94**	**-110**	**-129**	**-130**	**-140**	**0.9%**
Total supply[4]	**909**	**885**	**987**	**1,005**	**999**	**990**	**988**	**0.4%**
Consumption by sector								
Commercial and institutional	2	2	2	2	2	2	2	0.5%
Coke plants	21	21	21	21	20	19	18	-0.7%
Other industrial[5]	43	43	47	47	48	48	49	0.5%
Coal-to-liquids heat and power	0	0	0	0	0	0	0	- -
Coal to liquids production	0	0	0	0	0	0	0	- -
Electric power[6]	824	858	917	935	930	921	919	0.3%
Total	**889**	**925**	**987**	**1,005**	**999**	**990**	**988**	**0.2%**
Discrepancy and stock change[7]	**20**	**-40**	**0**	**0**	**0**	**0**	**0**	**- -**
Average minemouth price[8]								
(2013 dollars per short ton)	40.5	37.2	37.9	40.3	43.7	46.7	49.2	1.0%
(2013 dollars per million Btu)	2.01	1.84	1.88	2.02	2.18	2.32	2.44	1.0%
Delivered prices[9]								
(2013 dollars per short ton)								
Commercial and institutional	92.1	90.5	86.4	89.2	92.0	95.0	99.2	0.3%
Coke plants	193.4	157.0	165.8	177.7	189.5	197.3	204.4	1.0%
Other industrial[5]	71.4	69.3	70.3	73.6	76.5	79.1	82.5	0.6%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electric power[6]								
(2013 dollars per short ton)	46.5	45.2	45.7	48.2	50.6	53.1	55.6	0.8%
(2013 dollars per million Btu)	2.41	2.34	2.38	2.54	2.67	2.79	2.92	0.8%
Average	**51.5**	**49.1**	**49.5**	**52.2**	**54.7**	**57.1**	**59.7**	**0.7%**
Exports[10]	120.2	95.1	100.9	107.2	112.7	118.9	120.7	0.9%

Table A15. Coal supply, disposition, and prices (continued)
(million short tons per year, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Average minemouth price[8]								
(nominal dollars per short ton)	40.0	37.2	43.0	49.7	58.6	68.6	79.8	2.9%
(nominal dollars per million Btu)	1.98	1.84	2.14	2.48	2.92	3.41	3.96	2.9%
Delivered prices[9]								
(nominal dollars per short ton)								
Commercial and institutional	90.8	90.5	98.0	109.9	123.4	139.7	160.8	2.2%
Coke plants	190.6	157.0	188.0	218.7	254.0	289.9	331.3	2.8%
Other industrial[5]	70.3	69.3	79.7	90.7	102.5	116.3	133.8	2.5%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electric power[6]								
(nominal dollars per short ton)	45.8	45.2	51.8	59.4	67.9	78.0	90.1	2.6%
(nominal dollars per million Btu)	2.37	2.34	2.70	3.13	3.58	4.10	4.73	2.6%
Average	**50.7**	**49.1**	**56.2**	**64.3**	**73.3**	**84.0**	**96.8**	**2.6%**
Exports[10]	118.4	95.1	114.4	131.9	151.1	174.7	195.6	2.7%

[1]Includes anthracite, bituminous coal, subbituminous coal, and lignite.
[2]Includes waste coal consumed by the electric power and industrial sectors. Waste coal supplied is counted as a supply-side item to balance the same amount of waste coal included in the consumption data.
[3]Excludes imports to Puerto Rico and the U.S. Virgin Islands.
[4]Production plus waste coal supplied plus net imports.
[5]Includes consumption for combined heat and power plants that have a non-regulatory status, and small on-site generating systems. Excludes all coal use in the coal-to-liquids process.
[6]Includes all electricity-only and combined heat and power plants that have a regulatory status.
[7]Balancing item: the sum of production, net imports, and waste coal supplied minus total consumption.
[8]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[9]Prices weighted by consumption; weighted average excludes commercial and institutional prices, and export free-alongside-ship prices.
[10]Free-alongside-ship price at U.S. port of exit.
- - = Not applicable.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 data based on: U.S. Energy Information Administration (EIA), *Annual Coal Report 2013*, DOE/EIA-0584(2013) (Washington, DC, January 2015); EIA, *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014); and EIA, AEO2015 National Energy Modeling System run REF2015.D021915A. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A16. Renewable energy generating capacity and generation
(gigawatts, unless otherwise noted)

Net summer capacity and generation	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Electric power sector[1]								
Net summer capacity								
Conventional hydroelectric power	78.1	78.3	79.2	79.6	79.7	79.8	80.1	0.1%
Geothermal[2]	2.6	2.6	3.8	5.3	7.0	8.2	9.1	4.7%
Municipal waste[3]	3.6	3.7	3.8	3.8	3.8	3.8	3.8	0.1%
Wood and other biomass[4]	2.9	3.3	3.5	3.5	3.6	4.2	5.5	1.8%
Solar thermal	0.5	1.3	1.8	1.8	1.8	1.8	1.8	1.2%
Solar photovoltaic[5]	2.6	5.2	14.4	14.7	15.7	17.9	22.2	5.5%
Wind	59.2	60.3	82.0	83.0	86.3	95.6	108.2	2.2%
Offshore wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	- -
Total electric power sector capacity	**149.4**	**154.7**	**188.6**	**191.6**	**198.0**	**211.2**	**230.6**	**1.5%**
Generation (billion kilowatthours)								
Conventional hydroelectric power	273.9	265.7	291.0	292.8	293.4	293.8	295.6	0.4%
Geothermal[2]	15.6	16.5	26.8	38.5	52.4	62.3	69.6	5.5%
Biogenic municipal waste[6]	16.9	16.5	20.0	20.3	20.1	20.0	20.2	0.8%
Wood and other biomass	11.1	12.2	24.7	36.2	40.4	47.1	58.8	6.0%
Dedicated plants	9.9	11.1	13.4	15.1	16.7	20.4	30.3	3.8%
Cofiring	1.2	1.1	11.3	21.1	23.7	26.7	28.5	12.7%
Solar thermal	0.9	0.9	3.6	3.6	3.6	3.6	3.6	5.1%
Solar photovoltaic[5]	3.3	8.0	29.7	30.3	32.6	37.6	47.1	6.8%
Wind	140.7	167.6	230.6	233.8	243.3	276.1	317.1	2.4%
Offshore wind	0.0	0.0	0.1	0.1	0.1	0.1	0.1	- -
Total electric power sector generation	**462.3**	**487.4**	**626.4**	**655.6**	**685.9**	**740.7**	**812.1**	**1.9%**
End-use sectors[7]								
Net summer capacity								
Conventional hydroelectric power	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0%
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	- -
Municipal waste[8]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0%
Biomass	4.9	5.0	5.4	5.4	5.4	5.5	5.6	0.4%
Solar photovoltaic[5]	4.6	6.2	11.4	15.5	21.5	28.7	36.7	6.8%
Wind	0.2	0.2	0.7	0.7	0.9	1.1	1.5	7.7%
Total end-use sector capacity	**10.4**	**12.1**	**18.2**	**22.4**	**28.6**	**36.0**	**44.6**	**4.9%**
Generation (billion kilowatthours)								
Conventional hydroelectric power	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0.0%
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	- -
Municipal waste[8]	3.6	3.6	3.6	3.6	3.6	3.6	3.6	0.0%
Biomass	26.5	27.2	29.1	29.3	29.4	29.4	30.5	0.4%
Solar photovoltaic[5]	7.1	9.6	17.9	24.8	34.7	46.3	59.3	7.0%
Wind	0.2	0.3	0.9	1.0	1.2	1.5	2.1	8.0%
Total end-use sector generation	**38.8**	**42.1**	**52.9**	**60.1**	**70.2**	**82.3**	**96.9**	**3.1%**

Table A16. Renewable energy generating capacity and generation (continued)
(gigawatts, unless otherwise noted)

Net summer capacity and generation	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Total, all sectors								
Net summer capacity								
Conventional hydroelectric power	78.4	78.5	79.5	79.9	80.0	80.1	80.4	0.1%
Geothermal	2.6	2.6	3.8	5.3	7.0	8.2	9.1	4.7%
Municipal waste	4.1	4.1	4.3	4.3	4.3	4.3	4.3	0.1%
Wood and other biomass[4]	7.8	8.3	8.9	8.9	9.1	9.6	11.1	1.1%
Solar[5]	7.6	12.7	27.6	31.9	39.0	48.3	60.6	6.0%
Wind	59.4	60.5	82.7	83.8	87.3	96.7	109.7	2.2%
Total capacity, all sectors	**159.8**	**166.8**	**206.8**	**214.1**	**226.6**	**247.2**	**275.2**	**1.9%**
Generation (billion kilowatthours)								
Conventional hydroelectric power	275.2	267.1	292.3	294.2	294.7	295.2	297.0	0.4%
Geothermal	15.6	16.5	26.8	38.5	52.4	62.3	69.6	5.5%
Municipal waste	20.6	20.1	23.7	23.9	23.7	23.7	23.8	0.6%
Wood and other biomass	37.6	39.4	53.8	65.5	69.8	76.5	89.3	3.1%
Solar[5]	11.2	18.5	51.3	58.7	70.9	87.5	110.1	6.8%
Wind	141.0	167.8	231.5	234.9	244.6	277.8	319.3	2.4%
Total generation, all sectors	**501.2**	**529.5**	**679.4**	**715.6**	**756.2**	**823.0**	**909.1**	**2.0%**

[1]Includes electricity-only and combined heat and power plants that have a regulatory status.
[2]Includes both hydrothermal resources (hot water and steam) and near-field enhanced geothermal systems (EGS). Near-field EGS potential occurs on known hydrothermal sites, however this potential requires the addition of external fluids for electricity generation and is only available after 2025.
[3]Includes municipal waste, landfill gas, and municipal sewage sludge. Incremental growth is assumed to be for landfill gas facilities. All municipal waste is included, although a portion of the municipal waste stream contains petroleum-derived plastics and other non-renewable sources.
[4]Facilities co-firing biomass and coal are classified as coal.
[5]Does not include off-grid photovoltaics (PV). Based on annual PV shipments from 1989 through 2013, EIA estimates that as much as 274 megawatts of remote electricity generation PV applications (i.e., off-grid power systems) were in service in 2013, plus an additional 573 megawatts in communications, transportation, and assorted other non-grid-connected, specialized applications. See U.S. Energy Information Administration, *Annual Energy Review 2011*, DOE/EIA-0384(2011) (Washington, DC, September 2012), Table 10.9 (annual PV shipments, 1989-2010), and Table 12 (U.S. photovoltaic module shipments by end use, sector, and type) in U.S. Energy Information Administration, *Solar Photovoltaic Cell/Module Shipments Report, 2011* (Washington, DC, September 2012) and U.S. Energy Information Administration, *Solar Photovoltaic Cell/Module Shipments Report, 2012* (Washington, DC, December 2013). The approach used to develop the estimate, based on shipment data, provides an upper estimate of the size of the PV stock, including both grid-based and off-grid PV. It will overestimate the size of the stock, because shipments include a substantial number of units that are exported, and each year some of the PV units installed earlier will be retired from service or abandoned.
[6]Includes biogenic municipal waste, landfill gas, and municipal sewage sludge. Incremental growth is assumed to be for landfill gas facilities. Only biogenic municipal waste is included. The U.S. Energy Information Administration estimates that in 2013 approximately 7 billion kilowatthours of electricity were generated from a municipal waste stream containing petroleum-derived plastics and other non-renewable sources. See U.S. Energy Information Administration, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy* (Washington, DC, May 2007).
[7]Includes combined heat and power plants and electricity-only plants in the commercial and industrial sectors that have a non-regulatory status; and small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
[8]Includes municipal waste, landfill gas, and municipal sewage sludge. All municipal waste is included, although a portion of the municipal waste stream contains petroleum-derived plastics and other non-renewable sources.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 capacity: U.S. Energy Information Administration (EIA), Form EIA-860, "Annual Electric Generator Report" (preliminary). 2012 and 2013 generation: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A17. Renewable energy consumption by sector and source
(quadrillion Btu per year)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Marketed renewable energy[1]								
Residential (wood)	**0.44**	**0.58**	**0.41**	**0.39**	**0.38**	**0.36**	**0.35**	**-1.8%**
Commercial (biomass)	**0.11**	**0.12**	**0.12**	**0.12**	**0.12**	**0.12**	**0.12**	**0.0%**
Industrial[2]	**2.24**	**2.20**	**2.33**	**2.39**	**2.39**	**2.39**	**2.49**	**0.5%**
Conventional hydroelectric power	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0%
Municipal waste[3]	0.17	0.19	0.19	0.19	0.19	0.19	0.19	0.2%
Biomass	1.32	1.28	1.33	1.39	1.39	1.38	1.42	0.4%
Biofuels heat and coproducts	0.73	0.72	0.80	0.80	0.80	0.81	0.86	0.6%
Transportation	**1.18**	**1.26**	**1.43**	**1.42**	**1.42**	**1.46**	**1.57**	**0.8%**
Ethanol used in E85[4]	0.01	0.01	0.02	0.08	0.13	0.16	0.19	9.9%
Ethanol used in gasoline blending	1.05	1.06	1.07	1.00	0.95	0.96	1.05	0.0%
Biodiesel used in distillate blending	0.11	0.19	0.27	0.21	0.21	0.21	0.21	0.4%
Biobutanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Liquids from biomass	0.00	0.00	0.01	0.02	0.02	0.02	0.02	22.0%
Renewable diesel and gasoline[5]	0.00	0.00	0.06	0.11	0.11	0.11	0.11	- -
Electric power[6]	**4.53**	**4.78**	**6.13**	**6.43**	**6.72**	**7.26**	**7.99**	**1.9%**
Conventional hydroelectric power	2.61	2.53	2.77	2.79	2.79	2.80	2.81	0.4%
Geothermal	0.15	0.16	0.26	0.37	0.50	0.60	0.67	5.5%
Biogenic municipal waste[7]	0.23	0.23	0.27	0.27	0.27	0.27	0.27	0.6%
Biomass	0.17	0.18	0.32	0.45	0.50	0.58	0.74	5.3%
Dedicated plants	0.10	0.12	0.14	0.16	0.18	0.21	0.32	3.8%
Cofiring	0.07	0.07	0.18	0.29	0.33	0.37	0.42	7.0%
Solar thermal	0.01	0.01	0.03	0.03	0.03	0.03	0.03	5.1%
Solar photovoltaic	0.03	0.08	0.28	0.29	0.31	0.36	0.45	6.8%
Wind	1.34	1.59	2.19	2.23	2.32	2.63	3.02	2.4%
Total marketed renewable energy	**8.50**	**8.95**	**10.42**	**10.76**	**11.04**	**11.60**	**12.52**	**1.3%**
Sources of ethanol								
from corn and other starch	1.08	1.09	1.10	1.09	1.10	1.11	1.19	0.3%
from cellulose	0.00	0.00	0.01	0.01	0.01	0.01	0.01	- -
Net imports	-0.02	-0.02	-0.03	-0.02	-0.03	-0.01	0.02	- -
Total	**1.06**	**1.07**	**1.09**	**1.08**	**1.08**	**1.12**	**1.23**	**0.5%**

Table A17. Renewable energy consumption by sector and source (continued)
(quadrillion Btu per year)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Nonmarketed renewable energy[8]								
Selected consumption								
Residential	**0.04**	**0.06**	**0.13**	**0.17**	**0.23**	**0.28**	**0.35**	**7.0%**
Solar hot water heating	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.8%
Geothermal heat pumps	0.01	0.01	0.02	0.02	0.03	0.03	0.03	4.1%
Solar photovoltaic	0.02	0.04	0.09	0.13	0.18	0.24	0.29	8.0%
Wind	0.00	0.00	0.01	0.01	0.01	0.01	0.01	6.9%
Commercial	**0.13**	**0.14**	**0.17**	**0.20**	**0.25**	**0.32**	**0.39**	**3.9%**
Solar thermal	0.08	0.08	0.09	0.09	0.10	0.10	0.11	1.1%
Solar photovoltaic	0.04	0.05	0.08	0.11	0.15	0.20	0.27	6.1%
Wind	0.00	0.00	0.00	0.00	0.00	0.01	0.01	9.0%

[1]Includes nonelectric renewable energy groups for which the energy source is bought and sold in the marketplace, although all transactions may not necessarily be marketed, and marketed renewable energy inputs for electricity entering the marketplace on the electric power grid. Excludes electricity imports; see Table A2. Actual heat rates used to determine fuel consumption for all renewable fuels except hydroelectric, geothermal, solar, and wind. Consumption at hydroelectric, geothermal, solar, and wind facilities is determined by using the fossil fuel equivalent of 9,516 Btu per kilowatthour.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]Includes municipal waste, landfill gas, and municipal sewage sludge. All municipal waste is included, although a portion of the municipal waste stream contains petroleum-derived plastics and other non-renewable sources.
[4]Excludes motor gasoline component of E85.
[5]Renewable feedstocks for the on-site production of diesel and gasoline.
[6]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[7]Includes biogenic municipal waste, landfill gas, and municipal sewage sludge. Incremental growth is assumed to be for landfill gas facilities. Only biogenic municipal waste is included. The U.S. Energy Information Administration estimates that in 2013 approximately 0.3 quadrillion Btus were consumed from a municipal waste stream containing petroleum-derived plastics and other non-renewable sources. See U.S. Energy Information Administration, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy* (Washington, DC, May 2007).
[8]Includes selected renewable energy consumption data for which the energy is not bought or sold, either directly or indirectly as an input to marketed energy. The U.S. Energy Information Administration does not estimate or project total consumption of nonmarketed renewable energy.
- - = Not applicable.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 ethanol: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2012 and 2013 electric power sector: EIA, Form EIA-860, "Annual Electric Generator Report" (preliminary). Other 2012 and 2013 values: EIA, Office of Energy Analysis. **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A18. Energy-related carbon dioxide emissions by sector and source
(million metric tons, unless otherwise noted)

Sector and source	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Residential								
Petroleum	61	64	50	45	41	37	33	-2.4%
Natural gas	225	267	246	241	240	235	229	-0.6%
Electricity[1]	757	773	761	761	770	776	779	0.0%
Total residential	**1,044**	**1,105**	**1,057**	**1,047**	**1,051**	**1,048**	**1,042**	**-0.2%**
Commercial								
Petroleum	40	41	44	43	42	41	41	-0.1%
Natural gas	157	178	175	175	182	189	197	0.4%
Coal	4	4	5	5	5	5	4	0.5%
Electricity[1]	731	744	755	772	788	801	814	0.3%
Total commercial	**933**	**968**	**979**	**994**	**1,016**	**1,037**	**1,057**	**0.3%**
Industrial[2]								
Petroleum	345	350	410	425	424	424	429	0.8%
Natural gas[3]	447	462	512	523	539	549	563	0.7%
Coal	142	143	150	148	144	139	139	-0.1%
Electricity[1]	543	531	586	615	613	601	592	0.4%
Total industrial	**1,476**	**1,486**	**1,658**	**1,711**	**1,719**	**1,714**	**1,723**	**0.5%**
Transportation								
Petroleum[4]	1,774	1,792	1,752	1,701	1,662	1,647	1,631	-0.3%
Natural gas[5]	41	49	49	53	59	67	89	2.2%
Electricity[1]	4	4	5	5	6	8	9	2.9%
Total transportation	**1,819**	**1,845**	**1,806**	**1,759**	**1,727**	**1,722**	**1,728**	**-0.2%**
Electric power[6]								
Petroleum	19	23	13	13	13	13	13	-2.1%
Natural gas	493	442	412	441	478	497	509	0.5%
Coal	1,511	1,575	1,670	1,687	1,674	1,664	1,661	0.2%
Other[7]	12	12	12	12	12	12	12	0.0%
Total electric power	**2,035**	**2,053**	**2,107**	**2,153**	**2,177**	**2,186**	**2,195**	**0.2%**
Total by fuel								
Petroleum[4]	2,240	2,272	2,269	2,227	2,182	2,163	2,147	-0.2%
Natural gas	1,363	1,399	1,394	1,432	1,497	1,538	1,586	0.5%
Coal	1,657	1,722	1,824	1,840	1,822	1,808	1,804	0.2%
Other[7]	12	12	12	12	12	12	12	0.0%
Total	**5,272**	**5,405**	**5,499**	**5,511**	**5,514**	**5,521**	**5,549**	**0.1%**
Carbon dioxide emissions (tons per person)	**16.8**	**17.1**	**16.5**	**15.9**	**15.4**	**14.9**	**14.6**	**-0.6%**

[1]Emissions from the electric power sector are distributed to the end-use sectors.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]Includes lease and plant fuel.
[4]This includes carbon dioxide from international bunker fuels, both civilian and military, which are excluded from the accounting of carbon dioxide emissions under the United Nations convention. From 1990 through 2013, international bunker fuels accounted for 90 to 126 million metric tons annually.
[5]Includes pipeline fuel natural gas and natural gas used as fuel in motor vehicles, trains, and ships.
[6]Includes electricity-only and combined heat and power plants that have a regulatory status.
[7]Includes emissions from geothermal power and nonbiogenic emissions from municipal waste.
Note: By convention, the direct emissions from biogenic energy sources are excluded from energy-related carbon dioxide emissions. The release of carbon from these sources is assumed to be balanced by the uptake of carbon when the feedstock is grown, resulting in zero net emissions over some period of time. If, however, increased use of biomass energy results in a decline in terrestrial carbon stocks, a net positive release of carbon may occur. See Table A19, "Energy-Related Carbon Dioxide Emissions by End Use", for the emissions from biogenic energy sources as an indication of the potential net release of carbon dioxide in the absence of offsetting sequestration. Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 emissions and emission factors: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A19. Energy-related carbon dioxide emissions by end use
(million metric tons)

Sector and end use	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Residential								
Space heating	228	293	248	236	228	218	207	-1.3%
Space cooling	136	109	124	128	135	141	145	1.1%
Water heating	143	144	142	142	143	139	134	-0.3%
Refrigeration	60	59	53	51	51	51	52	-0.5%
Cooking	30	30	31	32	32	33	34	0.4%
Clothes dryers	35	36	36	37	37	38	39	0.3%
Freezers	13	13	11	11	10	10	9	-1.1%
Lighting	103	96	67	59	52	43	38	-3.3%
Clothes washers[1]	5	5	4	3	3	2	2	-2.4%
Dishwashers[1]	16	15	15	15	17	17	18	0.5%
Televisions and related equipment[2]	54	54	50	50	51	53	54	0.0%
Computers and related equipment[3]	20	20	15	12	11	9	7	-3.6%
Furnace fans and boiler circulation pumps	15	21	18	17	16	14	13	-1.8%
Other uses[4]	188	211	242	253	267	278	288	1.2%
Discrepancy[5]	0	0	0	0	0	0	0	- -
Total residential	**1,044**	**1,105**	**1,057**	**1,047**	**1,051**	**1,048**	**1,042**	**-0.2%**
Commercial								
Space heating[6]	112	136	122	115	111	105	97	-1.2%
Space cooling[6]	95	82	85	84	84	83	82	0.0%
Water heating[6]	44	45	44	44	44	44	43	-0.2%
Ventilation	82	84	85	85	85	84	83	0.0%
Cooking	14	14	15	15	16	16	16	0.4%
Lighting	149	148	137	131	127	120	116	-0.9%
Refrigeration	61	61	52	48	46	45	45	-1.1%
Office equipment (PC)	19	17	11	8	6	4	3	-5.9%
Office equipment (non-PC)	35	35	38	42	47	51	55	1.6%
Other uses[7]	321	346	392	422	452	484	516	1.5%
Total commercial	**933**	**968**	**979**	**994**	**1,016**	**1,037**	**1,057**	**0.3%**
Industrial[8]								
Manufacturing								
Refining	261	268	252	251	250	255	260	-0.1%
Food products	96	96	104	109	113	116	119	0.8%
Paper products	69	69	63	59	54	50	49	-1.2%
Bulk chemicals	247	247	293	311	309	298	291	0.6%
Glass	15	15	16	16	17	16	16	0.1%
Cement and lime	29	30	41	42	45	48	52	2.1%
Iron and steel	125	123	135	141	135	129	122	0.0%
Aluminum	45	46	54	55	51	43	38	-0.7%
Fabricated metal products	38	39	42	43	42	43	43	0.3%
Machinery	22	22	24	25	27	28	29	1.1%
Computers and electronics	47	48	48	49	51	53	52	0.3%
Transportation equipment	44	47	50	52	53	58	63	1.1%
Electrical equipment	8	8	9	10	10	11	12	1.4%
Wood products	15	17	20	20	20	19	18	0.3%
Plastics	39	40	44	46	48	49	49	0.8%
Balance of manufacturing	154	156	161	164	165	166	169	0.3%
Total manufacturing	**1,254**	**1,270**	**1,355**	**1,392**	**1,389**	**1,383**	**1,383**	**0.3%**
Nonmanufacturing								
Agriculture	66	66	65	64	62	60	58	-0.4%
Construction	62	64	77	80	83	85	87	1.1%
Mining	101	102	117	115	113	108	108	0.2%
Total nonmanufacturing	**230**	**232**	**259**	**259**	**257**	**253**	**253**	**0.3%**
Discrepancy[5]	-8	-16	44	61	73	79	86	- -
Total industrial	**1,476**	**1,486**	**1,658**	**1,711**	**1,719**	**1,714**	**1,723**	**0.5%**

Table A19. Energy-related carbon dioxide emissions by end use (continued)
(million metric tons)

Sector and end use	Reference case 2012	2013	2020	2025	2030	2035	2040	Annual growth 2013-2040 (percent)
Transportation								
Light-duty vehicles	1,035	1,044	967	892	834	801	777	-1.1%
Commercial light trucks[9]	36	38	37	36	35	35	36	-0.2%
Bus transportation	16	18	18	18	19	19	19	0.2%
Freight trucks	356	389	417	429	440	456	477	0.8%
Rail, passenger	5	6	6	6	6	6	7	0.6%
Rail, freight	31	36	35	36	34	32	31	-0.5%
Shipping, domestic	7	7	7	6	6	5	5	-1.4%
Shipping, international	52	48	47	47	47	48	48	0.0%
Recreational boats	16	17	18	18	19	20	20	0.6%
Air	165	163	180	193	206	214	219	1.1%
Military use	50	48	45	45	48	51	54	0.5%
Lubricants	5	5	5	5	5	5	5	0.3%
Pipeline fuel	40	47	45	48	50	50	51	0.3%
Discrepancy[5]	5	-21	-21	-21	-21	-21	-20	- -
Total transportation	**1,819**	**1,845**	**1,806**	**1,759**	**1,727**	**1,722**	**1,728**	**-0.2%**
Biogenic energy combustion[10]								
Biomass	192	203	205	221	224	229	247	0.7%
Electric power sector	16	17	30	42	47	55	69	5.3%
Other sectors	176	186	175	179	177	174	178	-0.2%
Biogenic waste	21	21	24	25	24	24	24	0.6%
Biofuels heat and coproducts	69	68	75	75	75	76	81	0.6%
Ethanol	73	73	74	74	74	77	84	0.5%
Biodiesel	8	14	20	16	16	16	16	0.4%
Liquids from biomass	0	0	1	1	1	1	1	22.0%
Renewable diesel and gasoline	0	0	4	8	8	8	8	- -
Total	**362**	**379**	**403**	**419**	**422**	**431**	**461**	**0.7%**

[1]Does not include water heating portion of load.
[2]Includes televisions, set-top boxes, home theater systems, DVD players, and video game consoles.
[3]Includes desktop and laptop computers, monitors, and networking equipment.
[4]Includes small electric devices, heating elements, outdoor grills, exterior lights, pool heaters, spa heaters, backup electricity generators, and motors not listed above. Electric vehicles are included in the transportation sector.
[5]Represents differences between total emissions by end-use and total emissions by fuel as reported in Table A18. Emissions by fuel may reflect benchmarking and other modeling adjustments to energy use and the associated emissions that are not assigned to specific end uses.
[6]Includes emissions related to fuel consumption for district services.
[7]Includes emissions related to (but not limited to) miscellaneous uses such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, water services, pumps, emergency generators, combined heat and power in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, propane, coal, motor gasoline, kerosene, and marketed renewable fuels (biomass).
[8]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[9]Commercial trucks 8,501 to 10,000 pounds gross vehicle weight rating.
[10]By convention, the direct emissions from biogenic energy sources are excluded from energy-related carbon dioxide emissions. The release of carbon from these sources is assumed to be balanced by the uptake of carbon when the feedstock is grown, resulting in zero net emissions over some period of time. If, however, increased use of biomass energy results in a decline in terrestrial carbon stocks, a net positive release of carbon may occur. Accordingly, the emissions from biogenic energy sources are reported here as an indication of the potential net release of carbon dioxide in the absence of offsetting sequestration.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 emissions and emission factors: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A20. Macroeconomic indicators
(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Real gross domestic product	**15,369**	**15,710**	**18,801**	**21,295**	**23,894**	**26,659**	**29,898**	**2.4%**
Components of real gross domestic product								
Real consumption	10,450	10,700	12,832	14,484	16,275	18,179	20,476	2.4%
Real investment	2,436	2,556	3,531	4,025	4,474	4,984	5,634	3.0%
Real government spending	2,954	2,894	2,985	3,098	3,286	3,469	3,691	0.9%
Real exports	1,960	2,020	2,813	3,807	4,815	6,010	7,338	4.9%
Real imports	2,413	2,440	3,334	4,079	4,888	5,859	7,037	4.0%
Energy intensity								
(thousand Btu per 2009 dollar of GDP)								
Delivered energy	4.47	4.53	3.93	3.49	3.13	2.83	2.56	-2.1%
Total energy	6.14	6.18	5.36	4.79	4.31	3.90	3.54	-2.0%
Price indices								
GDP chain-type price index (2009=1.000)	1.05	1.07	1.21	1.31	1.43	1.57	1.73	1.8%
Consumer price index (1982-4=1.00)								
All-urban	2.30	2.33	2.63	2.89	3.18	3.54	3.95	2.0%
Energy commodities and services	2.46	2.44	2.55	2.98	3.42	4.03	4.85	2.6%
Wholesale price index (1982=1.00)								
All commodities	2.02	2.03	2.25	2.47	2.71	3.02	3.39	1.9%
Fuel and power	2.12	2.12	2.26	2.67	3.08	3.69	4.56	2.9%
Metals and metal products	2.20	2.14	2.43	2.62	2.85	3.13	3.42	1.8%
Industrial commodities excluding energy	1.94	1.96	2.22	2.40	2.61	2.85	3.12	1.7%
Interest rates (percent, nominal)								
Federal funds rate	0.14	0.11	3.40	3.56	3.69	3.76	4.04	- -
10-year treasury note	1.80	2.35	4.12	4.14	4.28	4.41	4.63	- -
AA utility bond rate	3.83	4.24	6.15	6.06	6.33	6.47	6.71	- -
Value of shipments (billion 2009 dollars)								
Non-industrial and service sectors	23,989	24,398	28,468	32,023	34,968	37,767	40,814	1.9%
Total industrial	6,822	7,004	8,467	9,212	9,870	10,614	11,463	1.8%
Agriculture, mining, and construction	1,813	1,858	2,344	2,441	2,540	2,601	2,712	1.4%
Manufacturing	5,009	5,146	6,123	6,771	7,330	8,012	8,751	2.0%
Energy-intensive	1,675	1,685	1,946	2,084	2,168	2,237	2,317	1.2%
Non-energy-intensive	3,334	3,461	4,177	4,687	5,162	5,776	6,433	2.3%
Total shipments	**30,810**	**31,402**	**36,935**	**41,235**	**44,838**	**48,380**	**52,277**	**1.9%**
Population and employment (millions)								
Population, with armed forces overseas	315	317	334	347	359	370	380	0.7%
Population, aged 16 and over	249	251	267	277	288	298	307	0.7%
Population, aged 65 and over	43	45	56	65	73	78	80	2.2%
Employment, nonfarm	134	136	149	154	159	163	169	0.8%
Employment, manufacturing	11.8	11.9	11.8	11.3	10.7	10.3	9.7	-0.7%
Key labor indicators								
Labor force (millions)	155	155	166	170	174	179	185	0.6%
Nonfarm labor productivity (2009=1.00)	1.05	1.05	1.20	1.34	1.48	1.62	1.78	2.0%
Unemployment rate (percent)	8.08	7.35	5.40	4.96	5.03	5.02	4.85	- -
Key indicators for energy demand								
Real disposable personal income	11,676	11,651	14,411	16,318	18,487	20,610	22,957	2.5%
Housing starts (millions)	0.84	0.99	1.69	1.70	1.66	1.62	1.62	1.8%
Commercial floorspace (billion square feet)	82.3	82.8	89.0	94.1	98.4	103.2	109.1	1.0%
Unit sales of light-duty vehicles (millions)	14.4	15.5	17.0	17.2	17.5	17.7	18.2	0.6%

GDP = Gross domestic product.
Btu = British thermal unit.
- - = Not applicable.
Sources: 2012 and 2013: IHS Economics, Industry and Employment models, November 2014. **Projections:** U.S. Energy Information Administration, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A21. International petroleum and other liquids supply, disposition, and prices
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Crude oil spot prices								
(2013 dollars per barrel)								
Brent	113	109	79	91	106	122	141	1.0%
West Texas Intermediate	96	98	73	85	99	116	136	1.2%
(nominal dollars per barrel)								
Brent	112	109	90	112	142	180	229	2.8%
West Texas Intermediate	94	98	83	105	133	171	220	3.0%
Petroleum and other liquids consumption[1]								
OECD								
United States (50 states)	18.47	18.96	19.65	19.61	19.41	19.29	19.27	0.1%
United States territories	0.29	0.30	0.31	0.32	0.34	0.36	0.38	1.0%
Canada	2.29	2.29	2.31	2.25	2.21	2.17	2.14	-0.3%
Mexico and Chile	2.50	2.46	2.71	2.78	2.80	2.83	2.92	0.6%
OECD Europe[2]	14.07	13.96	14.20	14.15	14.09	14.03	14.12	0.0%
Japan	4.73	4.56	4.27	4.18	4.03	3.86	3.65	-0.8%
South Korea	2.41	2.43	2.58	2.57	2.53	2.46	2.40	0.0%
Australia and New Zealand	1.17	1.16	1.16	1.12	1.11	1.11	1.15	-0.1%
Total OECD consumption	**45.93**	**46.14**	**47.20**	**46.97**	**46.52**	**46.10**	**46.04**	**0.0%**
Non-OECD								
Russia	3.20	3.30	3.31	3.24	3.23	3.17	3.01	-0.3%
Other Europe and Eurasia[3]	2.00	2.06	2.22	2.28	2.39	2.50	2.59	0.9%
China	10.29	10.67	13.13	14.75	17.03	18.92	20.19	2.4%
India	3.63	3.70	4.30	4.89	5.52	6.13	6.79	2.3%
Other Asia[4]	7.35	7.37	9.08	10.69	12.35	14.20	16.49	3.0%
Middle East	7.32	7.61	8.40	8.81	9.56	10.28	11.13	1.4%
Africa	3.36	3.42	3.93	4.28	4.78	5.39	6.18	2.2%
Brazil	2.93	3.11	3.33	3.44	3.74	4.09	4.50	1.4%
Other Central and South America	3.35	3.38	3.49	3.55	3.72	3.90	4.15	0.8%
Total non-OECD consumption	**43.41**	**44.60**	**51.20**	**55.92**	**62.31**	**68.58**	**75.01**	**1.9%**
Total consumption	**89.3**	**90.7**	**98.4**	**102.9**	**108.8**	**114.7**	**121.0**	**1.1%**
Petroleum and other liquids production								
OPEC[5]								
Middle East	26.29	26.32	24.56	26.23	29.34	33.12	36.14	1.2%
North Africa	3.37	2.90	3.51	3.56	3.67	3.85	4.06	1.3%
West Africa	4.40	4.26	5.00	5.16	5.24	5.33	5.43	0.9%
South America	2.99	3.01	3.10	3.16	3.27	3.49	3.79	0.9%
Total OPEC production	**37.05**	**36.49**	**36.16**	**38.10**	**41.53**	**45.79**	**49.42**	**1.1%**
Non-OPEC								
OECD								
United States (50 states)	11.04	12.64	16.92	16.74	16.52	15.84	15.89	0.8%
Canada	4.00	4.15	5.05	5.68	6.26	6.61	6.76	1.8%
Mexico and Chile	2.96	2.94	2.93	3.12	3.32	3.52	3.79	0.9%
OECD Europe[2]	4.04	3.88	3.35	3.06	2.98	2.97	3.19	-0.7%
Japan and South Korea	0.18	0.18	0.17	0.17	0.18	0.18	0.18	0.1%
Australia and New Zealand	0.57	0.49	0.60	0.80	0.86	0.91	0.96	2.5%
Total OECD production	**22.80**	**24.29**	**29.03**	**29.58**	**30.12**	**30.03**	**30.77**	**0.9%**
Non-OECD								
Russia	10.52	10.50	10.71	10.78	11.22	11.81	12.16	0.5%
Other Europe and Eurasia[3]	3.20	3.27	3.41	4.14	4.42	4.70	5.18	1.7%
China	4.39	4.48	5.11	5.46	5.66	5.75	5.84	1.0%
Other Asia[4]	3.88	3.82	3.85	3.72	3.67	3.71	4.01	0.2%
Middle East	1.31	1.20	1.03	0.93	0.85	0.78	0.77	-1.6%
Africa	2.31	2.41	2.70	2.86	2.94	3.03	3.33	1.2%
Brazil	2.61	2.73	3.70	4.56	5.43	5.90	6.12	3.0%
Other Central and South America	2.17	2.21	2.71	2.76	2.97	3.16	3.47	1.7%
Total non-OECD production	**30.38**	**30.63**	**33.21**	**35.22**	**37.17**	**38.85**	**40.88**	**1.1%**
Total petroleum and other liquids production	**90.2**	**91.4**	**98.4**	**102.9**	**108.8**	**114.7**	**121.1**	**1.0%**
OPEC market share (percent)	41.1	39.9	36.7	37.0	38.2	39.9	40.8	- -

Table A21. International petroleum and other liquids supply, disposition, and prices (continued)
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Selected world production subtotals:								
Crude oil and equivalents[6]	77.35	77.93	82.19	85.20	89.77	94.33	99.09	0.9%
Tight oil	2.63	3.62	7.49	8.31	9.16	9.82	10.15	3.9%
Bitumen[7]	1.94	2.11	3.00	3.52	3.95	4.21	4.26	2.6%
Refinery processing gain[8]	2.37	2.40	2.42	2.61	2.74	2.88	2.97	0.8%
Natural gas plant liquids	9.11	9.36	11.28	11.93	12.42	12.93	13.79	1.4%
Liquids from renewable sources[9]	1.93	2.14	2.56	2.92	3.36	3.78	4.22	2.5%
Liquids from coal[10]	0.21	0.21	0.33	0.51	0.69	0.87	1.05	6.2%
Liquids from natural gas[11]	0.14	0.24	0.33	0.43	0.51	0.57	0.61	3.5%
Liquids from kerogen[12]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.7%
Crude oil production[6]								
OPEC[5]								
Middle East	23.24	23.13	21.20	22.66	25.59	29.11	31.79	1.2%
North Africa	2.91	2.43	2.93	2.93	2.92	2.93	2.96	0.7%
West Africa	4.34	4.20	4.89	5.05	5.13	5.21	5.29	0.9%
South America	2.80	2.82	2.86	2.86	2.98	3.20	3.48	0.8%
Total OPEC production	**33.30**	**32.60**	**31.89**	**33.51**	**36.62**	**40.46**	**43.52**	**1.1%**
Non-OPEC								
OECD								
United States (50 states)	7.54	8.90	11.58	11.28	11.01	10.37	10.41	0.6%
Canada	3.28	3.42	4.35	4.93	5.48	5.83	5.92	2.0%
Mexico and Chile	2.61	2.59	2.61	2.81	3.00	3.22	3.45	1.1%
OECD Europe[2]	2.99	2.82	2.17	1.80	1.66	1.58	1.69	-1.9%
Japan and South Korea	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-1.6%
Australia and New Zealand	0.45	0.37	0.47	0.61	0.67	0.71	0.75	2.7%
Total OECD production	**16.87**	**18.10**	**21.18**	**21.44**	**21.83**	**21.71**	**22.23**	**0.8%**
Non-OECD								
Russia	10.04	10.02	10.15	10.11	10.42	10.85	11.10	0.4%
Other Europe and Eurasia[3]	2.95	3.05	3.18	3.83	4.03	4.21	4.66	1.6%
China	4.07	4.16	4.54	4.68	4.56	4.36	4.13	0.0%
Other Asia[4]	3.14	3.04	2.94	2.63	2.45	2.38	2.47	-0.8%
Middle East	1.26	1.16	1.00	0.90	0.82	0.76	0.74	-1.6%
Africa	1.88	1.97	2.18	2.31	2.38	2.45	2.70	1.2%
Brazil	2.06	2.02	2.87	3.50	4.16	4.47	4.60	3.1%
Other Central and South America	1.77	1.81	2.25	2.29	2.49	2.67	2.94	1.8%
Total non-OECD production	**27.18**	**27.24**	**29.11**	**30.25**	**31.32**	**32.15**	**33.35**	**0.8%**
Total crude oil production[6]	**77.3**	**77.9**	**82.2**	**85.2**	**89.8**	**94.3**	**99.1**	**0.9%**
OPEC market share (percent)	43.1	41.8	38.8	39.3	40.8	42.9	43.9	- -

[1]Estimated consumption. Includes both OPEC and non-OPEC consumers in the regional breakdown.
[2]OECD Europe = Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.
[3]Other Europe and Eurasia = Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Macedonia, Malta, Moldova, Montenegro, Romania, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
[4]Other Asia = Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), Fiji, French Polynesia, Guam, Hong Kong, India (for production), Indonesia, Kiribati, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam.
[5]OPEC = Organization of the Petroleum Exporting Countries = Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
[6]Includes crude oil, lease condensate, tight oil (shale oil), extra-heavy oil, and bitumen (oil sands).
[7]Includes diluted and upgraded/synthetic bitumen (syncrude).
[8]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[9]Includes liquids produced from energy crops.
[10]Includes liquids converted from coal via the Fischer-Tropsch coal-to-liquids process.
[11]Includes liquids converted from natural gas via the Fischer-Tropsch gas-to-liquids process.
[12]Includes liquids produced from kerogen (oil shale, not to be confused with tight oil (shale oil)).
OECD = Organization for Economic Cooperation and Development.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2012 and 2013 are model results and may differ from official EIA data reports.
Sources: 2012 and 2013 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. 2012 quantities derived from: Energy Information Administration (EIA), International Energy Statistics database as of September 2014. **2013 quantities and projections:** EIA, AEO2015 National Energy Modeling System run REF2015.D021915A and EIA, Generate World Oil Balance application.

Economic growth case comparisons

Table B1. Total energy supply, disposition, and price summary
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Production										
Crude oil and lease condensate	15.6	22.2	22.2	22.2	20.8	21.1	21.3	19.4	19.9	20.3
Natural gas plant liquids	3.6	5.4	5.5	5.5	5.6	5.7	5.8	5.4	5.5	5.7
Dry natural gas	25.1	29.2	29.6	30.0	32.6	33.9	35.3	35.5	36.4	37.7
Coal[1]	20.0	20.8	21.7	22.0	21.8	22.5	23.0	21.7	22.6	23.5
Nuclear / uranium[2]	8.3	8.4	8.4	8.4	8.5	8.5	8.6	8.5	8.7	9.5
Conventional hydroelectric power	2.5	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Biomass[3]	4.2	4.5	4.4	4.5	4.4	4.6	5.0	4.5	5.0	6.0
Other renewable energy[4]	2.3	3.2	3.2	3.4	3.5	3.6	4.2	3.7	4.6	6.7
Other[5]	1.3	0.8	0.9	0.9	0.9	0.9	1.0	0.9	1.0	1.0
Total	**82.7**	**97.4**	**98.7**	**99.7**	**100.7**	**103.7**	**107.0**	**102.3**	**106.6**	**113.3**
Imports										
Crude oil	17.0	12.8	13.6	14.3	13.9	15.7	17.3	15.6	18.2	20.7
Petroleum and other liquids[6]	4.3	4.5	4.6	4.6	4.3	4.4	4.5	4.0	4.1	4.6
Natural gas[7]	2.9	1.8	1.9	2.0	1.4	1.6	1.7	1.6	1.7	1.9
Other imports[8]	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	**24.5**	**19.3**	**20.2**	**21.0**	**19.7**	**21.7**	**23.5**	**21.3**	**24.1**	**27.3**
Exports										
Petroleum and other liquids[9]	7.3	11.1	11.2	11.1	12.7	12.6	12.6	13.7	13.7	13.7
Natural gas[10]	1.6	4.5	4.5	4.1	6.8	6.4	5.9	8.1	7.4	6.7
Coal	2.9	2.5	2.5	2.5	3.3	3.3	3.3	3.5	3.5	3.5
Total	**11.7**	**18.1**	**18.1**	**17.7**	**22.8**	**22.4**	**21.7**	**25.3**	**24.6**	**23.9**
Discrepancy[11]	**-1.6**	**-0.1**	**-0.1**	**-0.1**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**	**0.4**
Consumption										
Petroleum and other liquids[12]	35.9	36.2	37.1	37.9	34.1	36.5	38.5	32.9	36.2	39.8
Natural gas	26.9	26.4	26.8	27.7	27.0	28.8	30.9	28.6	30.5	32.7
Coal[13]	18.0	18.3	19.2	19.5	18.4	19.2	19.6	18.1	19.0	19.9
Nuclear / uranium[2]	8.3	8.4	8.4	8.4	8.5	8.5	8.6	8.5	8.7	9.5
Conventional hydroelectric power	2.5	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Biomass[14]	2.9	3.0	3.0	3.1	2.9	3.2	3.6	3.1	3.5	4.4
Other renewable energy[4]	2.3	3.2	3.2	3.4	3.5	3.6	4.2	3.7	4.6	6.7
Other[15]	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Total	**97.1**	**98.7**	**100.8**	**103.1**	**97.5**	**102.9**	**108.5**	**98.0**	**105.7**	**116.2**
Prices (2013 dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	109	78	79	80	104	106	108	138	141	145
West Texas Intermediate	98	72	73	74	97	99	102	132	136	140
Natural gas at Henry Hub (dollars per million Btu)	3.73	4.53	4.88	5.03	5.43	5.69	6.02	7.46	7.85	8.45
Coal (dollars per ton) at the minemouth[16]	37.2	37.5	37.9	38.0	43.6	43.7	44.1	49.0	49.2	50.3
Coal (dollars per million Btu) at the minemouth[16]	1.84	1.86	1.88	1.89	2.17	2.18	2.20	2.43	2.44	2.49
Average end-use[17]	2.50	2.50	2.54	2.56	2.81	2.84	2.88	3.06	3.09	3.18
Average electricity (cents per kilowatthour)	10.1	10.3	10.5	10.6	10.7	11.1	11.1	11.4	11.8	12.3

Table B1. Total energy supply, disposition, and price summary (continued)
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Prices (nominal dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	109	95	90	90	178	142	139	345	229	224
West Texas Intermediate	98	87	83	83	168	133	132	331	220	216
Natural gas at Henry Hub										
(dollars per million Btu)	3.73	5.47	5.54	5.68	9.36	7.63	7.77	18.71	12.73	13.03
Coal (dollars per ton)										
at the minemouth[16]	37.2	45.2	43.0	42.8	75.0	58.6	57.0	122.9	79.8	77.6
Coal (dollars per million Btu)										
at the minemouth[16]	1.84	2.25	2.14	2.13	3.73	2.92	2.84	6.09	3.96	3.85
Average end-use[17]	2.50	3.02	2.88	2.89	4.84	3.81	3.71	7.67	5.00	4.90
Average electricity (cents per kilowatthour)	10.1	12.4	11.9	11.9	18.4	14.8	14.4	28.6	19.2	18.9

[1]Includes waste coal.
[2]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[3]Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table A17 for details.
[4]Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table A17 for selected nonmarketed residential and commercial renewable energy data.
[5]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.
[6]Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.
[7]Includes imports of liquefied natural gas that are later re-exported.
[8]Includes coal, coal coke (net), and electricity (net). Excludes imports of fuel used in nuclear power plants.
[9]Includes crude oil, petroleum products, ethanol, and biodiesel.
[10]Includes re-exported liquefied natural gas.
[11]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[12]Estimated consumption. Includes petroleum-derived fuels and non-petroleum derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel. Refer to Table A17 for detailed renewable liquid fuels consumption.
[13]Excludes coal converted to coal-based synthetic liquids and natural gas.
[14]Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.
[15]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[16]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[17]Prices weighted by consumption; weighted average excludes export free-alongside-ship (f.a.s.) prices.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 natural gas supply values: U.S. Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2013 coal minemouth and delivered coal prices: EIA, *Annual Coal Report 2013*, DOE/EIA-0584(2013) (Washington, DC, January 2015). 2013 petroleum supply values: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). 2013 crude oil spot prices and natural gas spot price at Henry Hub: Thomson Reuters. Other 2013 coal values: *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014). Other 2013 values: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWMACRO.D021915A, REF2015.D021915A, and HIGHMACRO.D021915A.

Table B2. Energy consumption by sector and source
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Energy consumption										
Residential										
Propane	0.43	0.32	0.32	0.33	0.27	0.28	0.30	0.23	0.25	0.28
Kerosene	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00
Distillate fuel oil	0.50	0.40	0.40	0.40	0.31	0.31	0.31	0.24	0.24	0.24
Petroleum and other liquids subtotal	0.93	0.73	0.73	0.74	0.58	0.59	0.62	0.47	0.49	0.53
Natural gas	5.05	4.59	4.63	4.70	4.32	4.52	4.76	3.98	4.31	4.67
Renewable energy[1]	0.58	0.41	0.41	0.42	0.36	0.38	0.39	0.34	0.35	0.37
Electricity	4.75	4.77	4.86	5.00	4.82	5.08	5.50	4.96	5.42	6.07
Delivered energy	**11.32**	**10.50**	**10.63**	**10.85**	**10.09**	**10.57**	**11.26**	**9.74**	**10.57**	**11.64**
Electricity related losses	9.79	9.57	9.75	9.97	9.56	9.91	10.52	9.60	10.33	11.51
Total	**21.10**	**20.07**	**20.38**	**20.82**	**19.66**	**20.48**	**21.78**	**19.35**	**20.91**	**23.15**
Commercial										
Propane	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.18
Motor gasoline[2]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distillate fuel oil	0.37	0.34	0.34	0.34	0.31	0.30	0.30	0.27	0.27	0.27
Residual fuel oil	0.03	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.07
Petroleum and other liquids subtotal	0.59	0.62	0.62	0.62	0.60	0.60	0.60	0.57	0.58	0.59
Natural gas	3.37	3.32	3.30	3.29	3.38	3.43	3.45	3.62	3.71	3.75
Coal	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Renewable energy[3]	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Electricity	4.57	4.82	4.82	4.83	5.17	5.19	5.27	5.59	5.66	5.77
Delivered energy	**8.69**	**8.92**	**8.90**	**8.91**	**9.31**	**9.38**	**9.48**	**9.95**	**10.12**	**10.27**
Electricity related losses	9.42	9.66	9.68	9.64	10.24	10.13	10.07	10.83	10.80	10.93
Total	**18.10**	**18.58**	**18.58**	**18.55**	**19.55**	**19.52**	**19.56**	**20.78**	**20.92**	**21.20**
Industrial[4]										
Liquefied petroleum gases and other[5]	2.51	3.13	3.20	3.23	3.51	3.72	3.81	3.60	3.67	3.76
Motor gasoline[2]	0.25	0.25	0.26	0.27	0.24	0.25	0.27	0.23	0.25	0.26
Distillate fuel oil	1.31	1.33	1.42	1.46	1.24	1.36	1.49	1.21	1.35	1.51
Residual fuel oil	0.06	0.11	0.10	0.13	0.12	0.13	0.14	0.11	0.13	0.15
Petrochemical feedstocks	0.74	0.94	0.95	0.98	1.07	1.14	1.17	1.16	1.20	1.23
Other petroleum[6]	3.52	3.53	3.67	3.90	3.42	3.83	4.20	3.44	3.99	4.56
Petroleum and other liquids subtotal	8.40	9.30	9.61	9.96	9.59	10.44	11.08	9.76	10.59	11.48
Natural gas	7.62	8.04	8.33	8.46	8.04	8.65	9.17	8.13	8.90	9.83
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.52	1.85	1.87	1.85	2.09	2.10	2.12	2.29	2.29	2.33
Natural gas subtotal	9.14	9.89	10.20	10.31	10.12	10.75	11.29	10.42	11.19	12.15
Metallurgical coal	0.62	0.55	0.61	0.65	0.49	0.56	0.66	0.43	0.51	0.69
Other industrial coal	0.88	0.89	0.93	1.00	0.87	0.96	1.09	0.87	0.99	1.25
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	0.00	0.00	0.01	-0.03	-0.03	-0.03	-0.05	-0.06	-0.07
Coal subtotal	1.48	1.44	1.54	1.65	1.33	1.48	1.72	1.25	1.44	1.86
Biofuels heat and coproducts	0.72	0.80	0.80	0.81	0.80	0.80	0.81	0.80	0.86	0.89
Renewable energy[8]	1.48	1.47	1.53	1.64	1.37	1.59	1.87	1.34	1.63	2.23
Electricity	3.26	3.58	3.74	3.99	3.58	4.04	4.49	3.60	4.12	4.88
Delivered energy	**24.48**	**26.48**	**27.42**	**28.35**	**26.80**	**29.10**	**31.27**	**27.17**	**29.82**	**33.50**
Electricity related losses	6.72	7.17	7.51	7.95	7.11	7.88	8.59	6.96	7.85	9.26
Total	**31.20**	**33.65**	**34.93**	**36.30**	**33.91**	**36.98**	**39.86**	**34.13**	**37.68**	**42.76**

Table B2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Transportation										
Propane	0.05	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.08
Motor gasoline[2]	15.94	15.26	15.35	15.42	12.75	13.30	13.57	11.28	12.55	13.19
of which: E85[9]	0.02	0.03	0.03	0.03	0.26	0.20	0.19	0.29	0.28	0.30
Jet fuel[10]	2.80	2.95	3.01	3.07	3.27	3.40	3.54	3.51	3.64	3.79
Distillate fuel oil[11]	6.50	6.91	7.35	7.77	6.93	7.76	8.79	6.88	7.97	10.01
Residual fuel oil	0.57	0.35	0.35	0.35	0.36	0.36	0.36	0.36	0.36	0.37
Other petroleum[12]	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Petroleum and other liquids subtotal	26.00	25.68	26.27	26.82	23.52	25.03	26.48	22.25	24.76	27.61
Pipeline fuel natural gas	0.88	0.84	0.85	0.87	0.91	0.94	0.98	0.93	0.96	1.00
Compressed / liquefied natural gas	0.05	0.06	0.07	0.06	0.16	0.17	0.16	0.68	0.71	0.89
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.06	0.06	0.06
Delivered energy	**26.96**	**26.61**	**27.22**	**27.79**	**24.63**	**26.18**	**27.67**	**23.93**	**26.49**	**29.57**
Electricity related losses	0.05	0.06	0.06	0.06	0.08	0.08	0.08	0.11	0.12	0.12
Total	**27.01**	**26.67**	**27.29**	**27.85**	**24.71**	**26.27**	**27.75**	**24.04**	**26.61**	**29.69**
Unspecified sector[13]	**-0.27**	**-0.30**	**-0.34**	**-0.37**	**-0.31**	**-0.37**	**-0.45**	**-0.30**	**-0.38**	**-0.55**
Delivered energy consumption for all sectors										
Liquefied petroleum gases and other[5]	3.14	3.66	3.73	3.76	4.00	4.23	4.35	4.06	4.17	4.31
Motor gasoline[2]	16.36	15.69	15.79	15.86	13.15	13.72	14.00	11.66	12.96	13.62
of which: E85[9]	0.02	0.03	0.03	0.03	0.26	0.20	0.19	0.29	0.28	0.30
Jet fuel[10]	2.97	3.13	3.20	3.26	3.47	3.61	3.75	3.73	3.86	4.03
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.10	8.37	8.86	9.28	8.17	9.05	10.11	7.99	9.13	11.15
Residual fuel oil	0.65	0.53	0.53	0.55	0.54	0.56	0.57	0.54	0.56	0.58
Petrochemical feedstocks	0.74	0.94	0.95	0.98	1.07	1.14	1.17	1.16	1.20	1.23
Other petroleum[14]	3.67	3.68	3.82	4.06	3.57	3.98	4.36	3.59	4.15	4.72
Petroleum and other liquids subtotal	35.65	36.02	36.89	37.77	33.98	36.30	38.33	32.75	36.03	39.65
Natural gas	16.10	16.01	16.32	16.51	15.89	16.76	17.54	16.42	17.64	19.14
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.52	1.85	1.87	1.85	2.09	2.10	2.12	2.29	2.29	2.33
Pipeline natural gas	0.88	0.84	0.85	0.87	0.91	0.94	0.98	0.93	0.96	1.00
Natural gas subtotal	18.50	18.70	19.05	19.23	18.89	19.80	20.64	19.64	20.88	22.47
Metallurgical coal	0.62	0.55	0.61	0.65	0.49	0.56	0.66	0.43	0.51	0.69
Other coal	0.92	0.94	0.98	1.04	0.91	1.00	1.14	0.92	1.04	1.30
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	0.00	0.00	0.01	-0.03	-0.03	-0.03	-0.05	-0.06	-0.07
Coal subtotal	1.52	1.49	1.59	1.69	1.38	1.53	1.77	1.30	1.49	1.91
Biofuels heat and coproducts	0.72	0.80	0.80	0.81	0.80	0.80	0.81	0.80	0.86	0.89
Renewable energy[15]	2.18	2.00	2.06	2.17	1.85	2.09	2.38	1.80	2.10	2.72
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	12.60	13.20	13.45	13.85	13.61	14.35	15.30	14.20	15.25	16.78
Delivered energy	**71.17**	**72.21**	**73.84**	**75.52**	**70.52**	**74.87**	**79.23**	**70.49**	**76.62**	**84.44**
Electricity related losses	25.97	26.45	27.00	27.62	26.99	28.01	29.27	27.51	29.10	31.81
Total	**97.14**	**98.67**	**100.84**	**103.15**	**97.52**	**102.87**	**108.50**	**97.99**	**105.73**	**116.25**
Electric power[16]										
Distillate fuel oil	0.05	0.09	0.09	0.09	0.08	0.08	0.09	0.08	0.08	0.08
Residual fuel oil	0.21	0.08	0.08	0.09	0.08	0.09	0.09	0.09	0.09	0.10
Petroleum and other liquids subtotal	0.26	0.17	0.17	0.18	0.17	0.17	0.18	0.17	0.18	0.18
Natural gas	8.36	7.66	7.80	8.42	8.14	9.03	10.24	8.97	9.61	10.23
Steam coal	16.49	16.84	17.59	17.85	17.00	17.63	17.85	16.81	17.52	17.95
Nuclear / uranium[17]	8.27	8.42	8.42	8.42	8.46	8.47	8.57	8.46	8.73	9.54
Renewable energy[18]	4.78	6.23	6.13	6.26	6.53	6.72	7.41	6.97	7.99	10.33
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.18	0.11	0.11	0.11	0.09	0.10	0.10	0.11	0.11	0.13
Total	**38.57**	**39.65**	**40.45**	**41.47**	**40.61**	**42.35**	**44.57**	**41.71**	**44.36**	**48.59**

Table B2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Total energy consumption										
Liquefied petroleum gases and other[5]	3.14	3.66	3.73	3.76	4.00	4.23	4.35	4.06	4.17	4.31
Motor gasoline[2]	16.36	15.69	15.79	15.86	13.15	13.72	14.00	11.66	12.96	13.62
of which: E85[9]	0.02	0.03	0.03	0.03	0.26	0.20	0.19	0.29	0.28	0.30
Jet fuel[10]	2.97	3.13	3.20	3.26	3.47	3.61	3.75	3.73	3.86	4.03
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.15	8.46	8.95	9.37	8.25	9.13	10.20	8.07	9.21	11.23
Residual fuel oil	0.87	0.62	0.61	0.64	0.63	0.64	0.66	0.63	0.65	0.68
Petrochemical feedstocks	0.74	0.94	0.95	0.98	1.07	1.14	1.17	1.16	1.20	1.23
Other petroleum[14]	3.67	3.68	3.82	4.06	3.57	3.98	4.36	3.59	4.15	4.72
Petroleum and other liquids subtotal	35.91	36.19	37.06	37.95	34.15	36.47	38.50	32.92	36.21	39.84
Natural gas	24.46	23.67	24.12	24.93	24.03	25.79	27.77	25.39	27.25	29.37
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.52	1.85	1.87	1.85	2.09	2.10	2.12	2.29	2.29	2.33
Pipeline natural gas	0.88	0.84	0.85	0.87	0.91	0.94	0.98	0.93	0.96	1.00
Natural gas subtotal	26.86	26.36	26.85	27.65	27.03	28.83	30.88	28.61	30.50	32.70
Metallurgical coal	0.62	0.55	0.61	0.65	0.49	0.56	0.66	0.43	0.51	0.69
Other coal	17.41	17.78	18.57	18.90	17.91	18.63	18.99	17.72	18.56	19.25
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	0.00	0.00	0.01	-0.03	-0.03	-0.03	-0.05	-0.06	-0.07
Coal subtotal	18.01	18.32	19.18	19.55	18.37	19.16	19.61	18.10	19.01	19.87
Nuclear / uranium[17]	8.27	8.42	8.42	8.42	8.46	8.47	8.57	8.46	8.73	9.54
Biofuels heat and coproducts	0.72	0.80	0.80	0.81	0.80	0.80	0.81	0.80	0.86	0.89
Renewable energy[19]	6.96	8.23	8.19	8.44	8.38	8.81	9.79	8.77	10.09	13.05
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.18	0.11	0.11	0.11	0.09	0.10	0.10	0.11	0.11	0.13
Total	**97.14**	**98.67**	**100.84**	**103.15**	**97.52**	**102.87**	**108.50**	**97.99**	**105.73**	**116.25**
Energy use and related statistics										
Delivered energy use	71.17	72.21	73.84	75.52	70.52	74.87	79.23	70.49	76.62	84.44
Total energy use	97.14	98.67	100.84	103.15	97.52	102.87	108.50	97.99	105.73	116.25
Ethanol consumed in motor gasoline and E85	1.12	1.12	1.12	1.13	1.12	1.12	1.14	1.16	1.27	1.34
Population (millions)	317	333	334	335	354	359	363	371	380	390
Gross domestic product (billion 2009 dollars)	15,710	17,747	18,801	19,590	21,224	23,894	26,146	25,763	29,898	34,146
Carbon dioxide emissions (million metric tons)	5,405	5,343	5,499	5,631	5,210	5,514	5,791	5,160	5,549	5,979

[1]Includes wood used for residential heating. See Table A4 and/or Table A17 for estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal water heating, and electricity generation from wind and solar photovoltaic sources.
[2]Includes ethanol and ethers blended into gasoline.
[3]Excludes ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. See Table A5 and/or Table A17 for estimates of nonmarketed renewable energy consumption for solar thermal water heating and electricity generation from wind and solar photovoltaic sources.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[5]Includes ethane, natural gasoline, and refinery olefins.
[6]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Represents natural gas used in well, field, and lease operations, in natural gas processing plant machinery, and for liquefaction in export facilities.
[8]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[9]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[10]Includes only kerosene type.
[11]Diesel fuel for on- and off- road use.
[12]Includes aviation gasoline and lubricants.
[13]Represents consumption unattributed to the sectors above.
[14]Includes aviation gasoline, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[15]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[16]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[17]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[18]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[19]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
Btu = British thermal unit.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 population and gross domestic product: IHS Economics, Industry and Employment models, November 2014. 2013 carbon dioxide emissions and emission factors: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWMACRO.D021915A, REF2015.D021915A, and HIGHMACRO.D021915A.

Table B3. Energy prices by sector and source
(2013 dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Residential										
Propane	23.3	22.8	23.0	23.1	24.2	24.4	24.6	26.4	26.6	26.9
Distillate fuel oil	27.2	21.2	21.5	21.7	25.5	26.3	26.9	31.8	32.9	34.2
Natural gas	10.0	11.1	11.6	11.9	12.5	12.8	13.4	14.7	15.5	16.6
Electricity	35.6	37.1	37.8	38.0	38.7	40.0	40.1	41.2	42.4	43.7
Commercial										
Propane	20.0	19.2	19.4	19.5	20.9	21.1	21.3	23.7	23.9	24.3
Distillate fuel oil	26.7	20.6	21.0	21.1	25.1	25.8	26.4	31.3	32.5	33.9
Residual fuel oil	22.1	14.1	14.2	14.3	17.8	18.1	18.4	24.0	24.3	24.0
Natural gas	8.1	9.1	9.6	9.8	10.3	10.4	10.8	12.1	12.6	13.4
Electricity	29.7	30.2	31.1	31.6	31.2	32.6	33.1	33.0	34.5	36.3
Industrial[1]										
Propane	20.3	19.4	19.6	19.8	21.2	21.5	21.7	24.2	24.5	24.9
Distillate fuel oil	27.3	20.9	21.2	21.4	25.5	26.1	26.7	31.6	32.7	34.2
Residual fuel oil	20.0	13.2	13.3	13.4	16.9	17.2	17.6	23.1	23.5	23.1
Natural gas[2]	4.6	5.7	6.2	6.4	6.6	6.8	7.1	8.4	8.8	9.2
Metallurgical coal	5.5	5.8	5.8	5.8	6.7	6.7	6.7	7.1	7.2	7.3
Other industrial coal	3.2	3.3	3.3	3.3	3.6	3.6	3.6	3.9	3.9	4.0
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	20.2	20.7	21.3	21.6	21.6	22.6	23.1	23.5	24.7	26.0
Transportation										
Propane	24.6	23.8	24.0	24.1	25.2	25.5	25.6	27.4	27.6	27.9
E85[3]	33.1	30.1	30.4	30.7	28.7	31.2	31.5	33.9	35.4	36.9
Motor gasoline[4]	29.3	22.3	22.5	22.6	25.8	26.4	26.7	31.3	32.3	33.5
Jet fuel[5]	21.8	15.8	16.1	16.3	20.7	21.3	22.0	27.4	28.3	29.7
Diesel fuel (distillate fuel oil)[6]	28.2	22.8	23.1	23.3	27.4	28.0	28.6	33.5	34.7	36.2
Residual fuel oil	19.3	11.4	11.7	11.9	15.0	15.4	15.8	19.8	20.3	21.0
Natural gas[7]	17.6	17.2	17.8	18.2	15.3	15.7	16.5	18.6	19.6	20.7
Electricity	28.5	29.3	30.2	31.0	31.5	32.9	33.2	34.5	36.0	37.7
Electric power[8]										
Distillate fuel oil	24.0	18.5	18.8	18.9	22.8	23.6	24.2	29.1	30.2	31.6
Residual fuel oil	18.9	11.3	11.5	11.5	15.0	15.4	15.7	21.3	21.6	21.3
Natural gas	4.4	4.9	5.4	5.6	6.0	6.2	6.6	7.9	8.3	8.7
Steam coal	2.3	2.3	2.4	2.4	2.7	2.7	2.7	2.9	2.9	3.0
Average price to all users[9]										
Propane	21.9	20.8	21.1	21.2	22.3	22.6	22.8	24.9	25.2	25.6
E85[3]	33.1	30.1	30.4	30.7	28.7	31.2	31.5	33.9	35.4	36.9
Motor gasoline[4]	29.0	22.3	22.5	22.6	25.8	26.4	26.7	31.3	32.3	33.5
Jet fuel[5]	21.8	15.8	16.1	16.3	20.7	21.3	22.0	27.4	28.3	29.7
Distillate fuel oil	27.9	22.3	22.6	22.8	26.9	27.6	28.2	33.1	34.2	35.8
Residual fuel oil	19.4	12.0	12.2	12.4	15.6	16.0	16.5	21.1	21.5	21.8
Natural gas	6.1	7.0	7.5	7.6	8.0	8.2	8.5	10.0	10.5	11.1
Metallurgical coal	5.5	5.8	5.8	5.8	6.7	6.7	6.7	7.1	7.2	7.3
Other coal	2.4	2.4	2.4	2.4	2.7	2.7	2.7	3.0	3.0	3.0
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	29.5	30.1	30.8	31.0	31.4	32.4	32.7	33.5	34.7	36.0
Non-renewable energy expenditures by sector (billion 2013 dollars)										
Residential	243	244	254	262	255	276	300	277	311	358
Commercial	177	188	194	197	210	219	226	245	259	277
Industrial[1]	224	247	264	279	286	323	356	344	389	454
Transportation	719	546	565	579	584	638	687	687	791	922
Total non-renewable expenditures	1,364	1,225	1,276	1,317	1,336	1,456	1,569	1,553	1,751	2,011
Transportation renewable expenditures	1	1	1	1	8	6	6	10	10	11
Total expenditures	**1,364**	**1,226**	**1,277**	**1,318**	**1,344**	**1,462**	**1,575**	**1,562**	**1,761**	**2,023**

Table B3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Residential										
Propane	23.3	27.6	26.1	26.1	41.7	32.8	31.8	66.3	43.1	41.5
Distillate fuel oil	27.2	25.6	24.4	24.5	44.0	35.3	34.8	79.7	53.3	52.8
Natural gas	10.0	13.4	13.2	13.4	21.6	17.1	17.2	36.9	25.1	25.6
Electricity	35.6	44.8	42.9	42.8	66.7	53.6	51.8	103.4	68.8	67.4
Commercial										
Propane	20.0	23.1	22.0	22.0	36.0	28.3	27.6	59.4	38.8	37.5
Distillate fuel oil	26.7	24.9	23.8	23.8	43.3	34.6	34.1	78.6	52.6	52.3
Residual fuel oil	22.1	17.0	16.1	16.1	30.6	24.3	23.8	60.3	39.4	37.0
Natural gas	8.1	11.0	10.8	11.1	17.7	13.9	14.0	30.4	20.5	20.7
Electricity	29.7	36.5	35.3	35.6	53.8	43.7	42.8	82.8	56.0	56.0
Industrial[1]										
Propane	20.3	23.4	22.3	22.3	36.6	28.8	28.1	60.7	39.7	38.4
Distillate fuel oil	27.3	25.2	24.1	24.1	43.8	35.0	34.5	79.3	53.0	52.7
Residual fuel oil	20.0	15.9	15.1	15.2	29.1	23.1	22.7	58.0	38.0	35.7
Natural gas[2]	4.6	6.9	7.0	7.2	11.4	9.1	9.2	21.0	14.2	14.2
Metallurgical coal	5.5	7.0	6.6	6.5	11.5	8.9	8.6	17.9	11.6	11.2
Other industrial coal	3.2	4.0	3.8	3.8	6.2	4.8	4.7	9.7	6.3	6.1
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	20.2	24.9	24.2	24.3	37.2	30.3	29.8	58.9	40.0	40.2
Transportation										
Propane	24.6	28.8	27.2	27.2	43.5	34.1	33.1	68.8	44.8	43.1
E85[3]	33.1	36.3	34.4	34.7	49.5	41.9	40.7	85.1	57.4	56.9
Motor gasoline[4]	29.3	27.0	25.5	25.5	44.5	35.3	34.5	78.4	52.4	51.7
Jet fuel[5]	21.8	19.1	18.3	18.3	35.6	28.6	28.4	68.7	45.8	45.9
Diesel fuel (distillate fuel oil)[6]	28.2	27.5	26.2	26.3	47.2	37.6	37.0	84.1	56.2	55.9
Residual fuel oil	19.3	13.8	13.2	13.4	25.7	20.6	20.5	49.8	32.9	32.4
Natural gas[7]	17.6	20.7	20.2	20.6	26.3	21.0	21.3	46.7	31.8	31.9
Electricity	28.5	35.4	34.3	35.0	54.3	44.1	42.8	86.6	58.4	58.1
Electric power[8]										
Distillate fuel oil	24.0	22.3	21.3	21.4	39.3	31.7	31.3	72.9	49.0	48.7
Residual fuel oil	18.9	13.7	13.0	13.0	25.9	20.6	20.3	53.4	35.0	32.8
Natural gas	4.4	6.0	6.1	6.4	10.4	8.3	8.5	19.8	13.4	13.4
Steam coal	2.3	2.8	2.7	2.7	4.6	3.6	3.5	7.3	4.7	4.6

Table B3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Average price to all users[9]										
Propane	21.9	25.1	23.9	23.9	38.4	30.3	29.5	62.4	40.9	39.5
E85[3]	33.1	36.3	34.4	34.7	49.5	41.9	40.7	85.1	57.4	56.9
Motor gasoline[4]	29.0	27.0	25.5	25.5	44.5	35.3	34.5	78.4	52.4	51.7
Jet fuel[5]	21.8	19.1	18.3	18.3	35.6	28.6	28.4	68.7	45.8	45.9
Distillate fuel oil	27.9	26.9	25.7	25.7	46.4	36.9	36.4	83.0	55.5	55.2
Residual fuel oil	19.4	14.5	13.8	14.0	26.9	21.5	21.3	52.8	34.8	33.6
Natural gas	6.1	8.5	8.5	8.6	13.9	11.0	11.0	25.1	17.0	17.1
Metallurgical coal	5.5	7.0	6.6	6.5	11.5	8.9	8.6	17.9	11.6	11.2
Other coal	2.4	2.9	2.8	2.8	4.7	3.7	3.5	7.4	4.8	4.7
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	29.5	36.4	34.9	35.0	54.0	43.4	42.2	83.9	56.2	55.5
Non-renewable energy expenditures by sector (billion nominal dollars)										
Residential	243	295	288	296	440	370	387	694	504	553
Commercial	177	227	220	223	362	294	292	614	420	428
Industrial[1]	224	298	299	314	493	433	460	863	631	700
Transportation	719	660	641	654	1,006	855	888	1,724	1,283	1,422
Total non-renewable expenditures	1,364	1,479	1,448	1,487	2,301	1,952	2,027	3,894	2,839	3,103
Transportation renewable expenditures	1	1	1	1	13	8	8	24	16	17
Total expenditures	**1,364**	**1,480**	**1,449**	**1,488**	**2,314**	**1,960**	**2,035**	**3,919**	**2,855**	**3,120**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Excludes use for lease and plant fuel.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Kerosene-type jet fuel. Includes Federal and State taxes while excluding county and local taxes.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Natural gas used as fuel in motor vehicles, trains, and ships. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[8]Includes electricity-only and combined heat and power plants that have a regulatory status.
[9]Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
- - = Not applicable.
Note: Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 prices for motor gasoline, distillate fuel oil, and jet fuel are based on prices in the U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2013 residential, commercial, and industrial natural gas delivered prices: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2013 transportation sector natural gas delivered prices are model results. 2013 electric power sector distillate and residual fuel oil prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 electric power sector natural gas prices: EIA, *Electric Power Monthly*, DOE/EIA-0226, April 2013 and April 2014, Table 4.2, and EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014). 2013 coal prices based on: EIA, *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014) and EIA, AEO2015 National Energy Modeling System run REF2015.D021915A. 2013 electricity prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 E85 prices derived from monthly prices in the Clean Cities Alternative Fuel Price Report. **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWMACRO.D021915A, REF2015.D021915A, and HIGHMACRO.D021915A.

Table B4. Macroeconomic indicators
(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	2013	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Real gross domestic product	**15,710**	**17,747**	**18,801**	**19,590**	**21,224**	**23,894**	**26,146**	**25,763**	**29,898**	**34,146**
Components of real gross domestic product										
Real consumption	10,700	12,214	12,832	13,285	14,388	16,275	17,804	17,094	20,476	22,973
Real investment	2,556	3,157	3,531	3,923	3,828	4,474	5,146	4,685	5,634	6,720
Real government spending	2,894	2,926	2,985	3,039	3,130	3,286	3,423	3,441	3,691	3,943
Real exports	2,020	2,623	2,813	2,935	4,039	4,815	5,395	5,818	7,338	9,163
Real imports	2,440	3,158	3,334	3,563	4,142	4,888	5,535	5,152	7,037	8,334
Energy intensity (thousand Btu per 2009 dollar of GDP)										
Delivered energy	4.53	4.07	3.93	3.86	3.32	3.13	3.03	2.74	2.56	2.47
Total energy	6.18	5.56	5.36	5.27	4.59	4.31	4.15	3.80	3.54	3.40
Price indices										
GDP chain-type price index (2009=1.000)	1.07	1.29	1.21	1.20	1.84	1.43	1.38	2.68	1.73	1.65
Consumer price index (1982-4=1.00)										
All-urban	2.33	2.79	2.63	2.62	4.06	3.18	3.06	6.08	3.95	3.77
Energy commodities and services	2.44	2.67	2.55	2.56	4.28	3.42	3.35	7.26	4.85	4.82
Wholesale price index (1982=1.00)										
All commodities	2.03	2.38	2.25	2.27	3.46	2.71	2.64	5.21	3.39	3.32
Fuel and power	2.12	2.34	2.26	2.28	3.84	3.08	3.03	6.84	4.56	4.56
Metals and metal products	2.14	2.55	2.43	2.54	3.54	2.85	2.89	4.96	3.42	3.59
Industrial commodities excluding energy	1.96	2.36	2.22	2.24	3.36	2.61	2.54	4.81	3.12	3.04
Interest rates (percent, nominal)										
Federal funds rate	0.11	5.28	3.40	3.07	6.92	3.69	3.60	7.72	4.04	3.89
10-year treasury note	2.35	5.29	4.12	3.87	6.60	4.28	4.16	7.52	4.63	4.53
AA utility bond rate	4.24	7.73	6.15	5.35	9.23	6.33	5.59	10.34	6.71	5.69
Value of shipments (billion 2009 dollars)										
Non-industrial and service sectors	24,398	27,029	28,468	29,598	31,111	34,968	38,353	34,777	40,814	46,610
Total industrial	7,004	7,848	8,467	8,967	8,608	9,870	11,081	9,755	11,463	13,786
Agriculture, mining, and construction	1,858	2,135	2,344	2,552	2,165	2,540	2,922	2,257	2,712	3,200
Manufacturing	5,146	5,713	6,123	6,415	6,443	7,330	8,159	7,498	8,751	10,586
Energy-intensive	1,685	1,866	1,946	2,006	1,994	2,168	2,331	2,121	2,317	2,607
Non-energy-intensive	3,461	3,847	4,177	4,409	4,449	5,162	5,828	5,377	6,433	7,979
Total shipments	**31,402**	**34,878**	**36,935**	**38,566**	**39,720**	**44,838**	**49,433**	**44,532**	**52,277**	**60,396**
Population and employment (millions)										
Population, with armed forces overseas	317	333	334	335	354	359	363	371	380	390
Population, aged 16 and over	251	266	267	267	284	288	291	300	307	315
Population, aged 65 and over	45	56	56	56	73	73	73	80	80	81
Employment, nonfarm	136	146	149	152	153	159	166	160	169	176
Employment, manufacturing	11.9	11.3	11.8	12.2	9.7	10.7	11.4	8.4	9.7	10.7
Key labor indicators										
Labor force (millions)	155	165	166	166	171	174	177	179	185	190
Non-farm labor productivity (2009=1.00)	1.05	1.16	1.20	1.22	1.38	1.48	1.54	1.59	1.78	1.90
Unemployment rate (percent)	7.35	5.70	5.40	5.20	5.41	5.03	4.50	4.89	4.85	4.57
Key indicators for energy demand										
Real disposable personal income	11,651	13,944	14,411	14,900	17,469	18,487	19,806	21,555	22,957	24,875
Housing starts (millions)	0.99	1.21	1.69	2.28	1.05	1.66	2.44	0.96	1.62	2.55
Commercial floorspace (billion square feet)	82.8	88.6	89.0	89.5	96.8	98.4	100.1	106.0	109.1	112.4
Unit sales of light-duty vehicles (millions)	15.5	16.1	17.0	17.8	15.6	17.5	18.3	15.0	18.2	19.9

GDP = Gross domestic product.
Btu = British thermal unit.
Sources: 2013: IHS Economics, Industry and Employment models, November 2014. **Projections:** U.S. Energy Information Administration, AEO2015 National Energy Modeling System runs LOWMACRO.D021915A, REF2015.D021915A, and HIGHMACRO.D021915A.

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Appendix C

Price case comparisons

Table C1. Total energy supply, disposition, and price summary

(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2013	Projections 2020 Low oil price	2020 Reference	2020 High oil price	2030 Low oil price	2030 Reference	2030 High oil price	2040 Low oil price	2040 Reference	2040 High oil price
Production										
Crude oil and lease condensate	15.6	20.9	22.2	25.6	18.2	21.1	26.2	15.0	19.9	20.9
Natural gas plant liquids	3.6	5.3	5.5	5.8	5.4	5.7	6.3	5.0	5.5	6.2
Dry natural gas	25.1	28.3	29.6	30.9	31.0	33.9	39.1	32.8	36.4	42.2
Coal[1]	20.0	21.4	21.7	21.4	22.5	22.5	23.5	22.6	22.6	25.4
Nuclear / uranium[2]	8.3	8.4	8.4	8.4	8.5	8.5	8.7	8.5	8.7	9.8
Conventional hydroelectric power	2.5	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Biomass[3]	4.2	4.4	4.4	4.5	4.6	4.6	4.8	4.7	5.0	5.7
Other renewable energy[4]	2.3	3.2	3.2	3.4	3.5	3.6	4.0	4.1	4.6	6.4
Other[5]	1.3	0.9	0.9	0.9	0.9	0.9	1.0	0.9	1.0	1.0
Total	**82.7**	**95.6**	**98.7**	**103.8**	**97.4**	**103.7**	**116.5**	**96.5**	**106.6**	**120.5**
Imports										
Crude oil	17.0	14.7	13.6	14.6	17.0	15.7	15.3	19.2	18.2	21.0
Petroleum and other liquids[6]	4.3	5.4	4.6	3.8	5.6	4.4	4.2	5.3	4.1	4.0
Natural gas[7]	2.9	1.9	1.9	1.9	1.6	1.6	1.7	2.0	1.7	2.0
Other imports[8]	0.3	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.9
Total	**24.5**	**22.1**	**20.2**	**20.4**	**24.3**	**21.7**	**21.4**	**26.6**	**24.1**	**28.0**
Exports										
Petroleum and other liquids[9]	7.3	10.9	11.2	16.5	10.7	12.6	21.2	8.1	13.7	24.0
Natural gas[10]	1.6	3.1	4.5	4.5	4.0	6.4	10.2	5.0	7.4	11.2
Coal	2.9	2.5	2.5	2.4	3.3	3.3	3.0	3.7	3.5	3.3
Total	**11.7**	**16.5**	**18.1**	**23.4**	**18.0**	**22.4**	**34.4**	**16.8**	**24.6**	**38.5**
Discrepancy[11]	**-1.6**	**-0.1**	**-0.1**	**-0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**
Consumption										
Petroleum and other liquids[12]	35.9	37.8	37.1	35.8	37.8	36.5	33.7	38.6	36.2	32.9
Natural gas	26.9	26.8	26.8	28.0	28.4	28.8	30.2	29.6	30.5	31.8
Coal[13]	18.0	18.9	19.2	19.0	19.1	19.2	20.1	18.8	19.0	21.6
Nuclear / uranium[2]	8.3	8.4	8.4	8.4	8.5	8.5	8.7	8.5	8.7	9.8
Conventional hydroelectric power	2.5	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Biomass[14]	2.9	3.0	3.0	3.1	3.1	3.2	3.4	3.3	3.5	4.0
Other renewable energy[4]	2.3	3.2	3.2	3.4	3.5	3.6	4.0	4.1	4.6	6.4
Other[15]	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Total	**97.1**	**101.2**	**100.8**	**100.8**	**103.6**	**102.9**	**103.3**	**106.1**	**105.7**	**109.7**
Prices (2013 dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	109	58	79	149	69	106	194	76	141	252
West Texas Intermediate	98	52	73	142	63	99	188	72	136	246
Natural gas at Henry Hub (dollars per million Btu)	3.73	4.30	4.88	4.61	5.49	5.69	7.89	7.15	7.85	10.63
Coal (dollars per ton) at the minemouth[16]	37.2	37.2	37.9	39.8	42.1	43.7	47.4	46.4	49.2	52.7
Coal (dollars per million Btu) at the minemouth[16]	1.84	1.85	1.88	1.98	2.11	2.18	2.35	2.31	2.44	2.62
Average end-use[17]	2.50	2.47	2.54	2.72	2.72	2.84	3.10	2.87	3.09	3.43
Average electricity (cents per kilowatthour)	10.1	10.4	10.5	10.5	11.0	11.1	11.8	11.5	11.8	12.9

Table C1. Total energy supply, disposition, and price summary (continued)
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Prices (nominal dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	109	65	90	167	91	142	263	120	229	416
West Texas Intermediate	98	58	83	159	83	133	255	115	220	407
Natural gas at Henry Hub (dollars per million Btu)	3.73	4.87	5.54	5.18	7.26	7.63	10.72	11.41	12.73	17.57
Coal (dollars per ton) at the minemouth[16]	37.2	42.1	43.0	44.8	55.7	58.6	64.4	74.0	79.8	87.1
Coal (dollars per million Btu) at the minemouth[16]	1.84	2.09	2.14	2.22	2.78	2.92	3.20	3.68	3.96	4.34
Average end-use[17]	2.50	2.79	2.88	3.06	3.60	3.81	4.22	4.58	5.00	5.67
Average electricity (cents per kilowatthour)	10.1	11.7	11.9	11.8	14.5	14.8	16.0	18.4	19.2	21.3

[1]Includes waste coal.
[2]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[3]Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table A17 for details.
[4]Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table A17 for selected nonmarketed residential and commercial renewable energy data.
[5]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.
[6]Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.
[7]Includes imports of liquefied natural gas that are later re-exported.
[8]Includes coal, coal coke (net), and electricity (net). Excludes imports of fuel used in nuclear power plants.
[9]Includes crude oil, petroleum products, ethanol, and biodiesel.
[10]Includes re-exported liquefied natural gas.
[11]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[12]Estimated consumption. Includes petroleum-derived fuels and non-petroleum derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel. Refer to Table A17 for detailed renewable liquid fuels consumption.
[13]Excludes coal converted to coal-based synthetic liquids and natural gas.
[14]Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.
[15]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[16]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[17]Prices weighted by consumption; weighted average excludes export free-alongside-ship (f.a.s.) prices.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 natural gas supply values: U.S. Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2013 coal minemouth and delivered coal prices: EIA, *Annual Coal Report 2013*, DOE/EIA-0584(2013) (Washington, DC, January 2015). 2013 petroleum supply values: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). 2013 crude oil spot prices and natural gas spot price at Henry Hub: Thomson Reuters. Other 2013 coal values: *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014). Other 2013 values: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWPRICE.D021915A, REF2015.D021915A, and HIGHPRICE.D021915A.

Table C2. Energy consumption by sector and source
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Energy consumption										
Residential										
Propane	0.43	0.33	0.32	0.31	0.29	0.28	0.26	0.26	0.25	0.23
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Distillate fuel oil	0.50	0.42	0.40	0.36	0.33	0.31	0.28	0.27	0.24	0.21
Petroleum and other liquids subtotal	0.93	0.76	0.73	0.68	0.63	0.59	0.54	0.53	0.49	0.45
Natural gas	5.05	4.65	4.63	4.64	4.53	4.52	4.43	4.35	4.31	4.20
Renewable energy[1]	0.58	0.37	0.41	0.53	0.32	0.38	0.48	0.28	0.35	0.45
Electricity	4.75	4.87	4.86	4.81	5.10	5.08	4.97	5.48	5.42	5.25
Delivered energy	**11.32**	**10.65**	**10.63**	**10.66**	**10.58**	**10.57**	**10.42**	**10.63**	**10.57**	**10.34**
Electricity related losses	9.79	9.75	9.75	9.58	9.94	9.91	9.74	10.38	10.33	10.30
Total	**21.10**	**20.40**	**20.38**	**20.25**	**20.52**	**20.48**	**20.16**	**21.01**	**20.91**	**20.64**
Commercial										
Propane	0.15	0.17	0.16	0.15	0.18	0.17	0.16	0.20	0.18	0.16
Motor gasoline[2]	0.05	0.05	0.05	0.04	0.06	0.05	0.05	0.06	0.06	0.05
Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Distillate fuel oil	0.37	0.36	0.34	0.29	0.33	0.30	0.26	0.32	0.27	0.23
Residual fuel oil	0.03	0.08	0.07	0.05	0.08	0.07	0.05	0.09	0.06	0.05
Petroleum and other liquids subtotal	0.59	0.66	0.62	0.54	0.66	0.60	0.52	0.67	0.58	0.50
Natural gas	3.37	3.33	3.30	3.33	3.43	3.43	3.29	3.75	3.71	3.53
Coal	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Renewable energy[3]	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Electricity	4.57	4.83	4.82	4.80	5.21	5.19	5.11	5.70	5.66	5.54
Delivered energy	**8.69**	**8.98**	**8.90**	**8.84**	**9.46**	**9.38**	**9.09**	**10.29**	**10.12**	**9.73**
Electricity related losses	9.42	9.66	9.68	9.57	10.14	10.13	10.01	10.80	10.80	10.87
Total	**18.10**	**18.64**	**18.58**	**18.41**	**19.60**	**19.52**	**19.10**	**21.09**	**20.92**	**20.60**
Industrial[4]										
Liquefied petroleum gases and other[5]	2.51	3.24	3.20	3.28	3.79	3.72	3.72	3.78	3.67	3.76
Motor gasoline[2]	0.25	0.26	0.26	0.27	0.25	0.25	0.26	0.24	0.25	0.24
Distillate fuel oil	1.31	1.39	1.42	1.39	1.37	1.36	1.33	1.36	1.35	1.28
Residual fuel oil	0.06	0.13	0.10	0.09	0.17	0.13	0.11	0.18	0.13	0.12
Petrochemical feedstocks	0.74	0.97	0.95	0.98	1.15	1.14	1.13	1.19	1.20	1.16
Other petroleum[6]	3.52	3.73	3.67	3.95	3.88	3.83	3.96	4.03	3.99	4.06
Petroleum and other liquids subtotal	8.40	9.72	9.61	9.96	10.61	10.44	10.52	10.79	10.59	10.62
Natural gas	7.62	8.20	8.33	8.50	8.56	8.65	8.82	8.50	8.90	9.29
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.96
Lease and plant fuel[7]	1.52	1.67	1.87	1.98	1.75	2.10	2.94	1.80	2.29	3.31
Natural gas subtotal	9.14	9.87	10.20	10.48	10.30	10.75	11.92	10.30	11.19	13.55
Metallurgical coal	0.62	0.58	0.61	0.65	0.55	0.56	0.61	0.48	0.51	0.58
Other industrial coal	0.88	0.92	0.93	0.97	0.94	0.96	1.04	0.95	0.99	1.13
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	1.97
Net coal coke imports	-0.02	0.00	0.00	0.01	-0.03	-0.03	-0.03	-0.06	-0.06	-0.05
Coal subtotal	1.48	1.50	1.54	1.63	1.46	1.48	2.29	1.38	1.44	3.63
Biofuels heat and coproducts	0.72	0.82	0.80	0.80	0.81	0.80	0.81	0.80	0.86	0.98
Renewable energy[8]	1.48	1.55	1.53	1.59	1.61	1.59	1.61	1.61	1.63	1.81
Electricity	3.26	3.75	3.74	3.98	4.02	4.04	4.21	4.00	4.12	4.35
Delivered energy	**24.48**	**27.21**	**27.42**	**28.43**	**28.81**	**29.10**	**31.36**	**28.86**	**29.82**	**34.95**
Electricity related losses	6.72	7.51	7.51	7.93	7.83	7.88	8.25	7.58	7.85	8.54
Total	**31.20**	**34.72**	**34.93**	**36.36**	**36.64**	**36.98**	**39.61**	**36.44**	**37.68**	**43.48**

Table C2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Transportation										
Propane	0.05	0.04	0.04	0.06	0.05	0.05	0.07	0.05	0.07	0.09
Motor gasoline[2]	15.94	15.94	15.35	13.98	14.31	13.30	11.44	14.18	12.55	10.54
of which: E85[9]	0.02	0.02	0.03	0.19	0.14	0.20	0.52	0.16	0.28	0.76
Jet fuel[10]	2.80	3.02	3.01	2.97	3.42	3.40	3.37	3.65	3.64	3.61
Distillate fuel oil[11]	6.50	7.27	7.35	7.26	7.84	7.76	6.88	8.44	7.97	6.68
Residual fuel oil	0.57	0.35	0.35	0.35	0.36	0.36	0.36	0.36	0.36	0.36
Other petroleum[12]	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Petroleum and other liquids subtotal	26.00	26.78	26.27	24.79	26.13	25.03	22.28	26.84	24.76	21.46
Pipeline fuel natural gas	0.88	0.83	0.85	0.89	0.90	0.94	1.04	0.91	0.96	1.07
Compressed / liquefied natural gas	0.05	0.06	0.07	0.39	0.06	0.17	1.31	0.06	0.71	2.47
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.08
Delivered energy	**26.96**	**27.70**	**27.22**	**26.10**	**27.13**	**26.18**	**24.68**	**27.87**	**26.49**	**25.08**
Electricity related losses	0.05	0.06	0.06	0.07	0.08	0.08	0.10	0.10	0.12	0.16
Total	**27.01**	**27.76**	**27.29**	**26.17**	**27.21**	**26.27**	**24.78**	**27.98**	**26.61**	**25.24**
Unspecified sector[13]	**-0.27**	**-0.33**	**-0.34**	**-0.35**	**-0.37**	**-0.37**	**-0.31**	**-0.41**	**-0.38**	**-0.29**
Delivered energy consumption for all sectors										
Liquefied petroleum gases and other[5]	3.14	3.78	3.73	3.79	4.31	4.23	4.21	4.29	4.17	4.25
Motor gasoline[2]	16.36	16.38	15.79	14.41	14.74	13.72	11.84	14.60	12.96	10.91
of which: E85[9]	0.02	0.02	0.03	0.19	0.14	0.20	0.52	0.16	0.28	0.76
Jet fuel[10]	2.97	3.20	3.20	3.15	3.62	3.61	3.57	3.88	3.86	3.83
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.10	8.80	8.86	8.66	9.18	9.05	8.14	9.63	9.13	7.81
Residual fuel oil	0.65	0.57	0.53	0.50	0.61	0.56	0.52	0.63	0.56	0.53
Petrochemical feedstocks	0.74	0.97	0.95	0.98	1.15	1.14	1.13	1.19	1.20	1.16
Other petroleum[14]	3.67	3.89	3.82	4.11	4.04	3.98	4.12	4.19	4.15	4.22
Petroleum and other liquids subtotal	35.65	37.59	36.89	35.61	37.66	36.30	33.54	38.43	36.03	32.73
Natural gas	16.10	16.24	16.32	16.86	16.57	16.76	17.84	16.67	17.64	19.48
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.96
Lease and plant fuel[7]	1.52	1.67	1.87	1.98	1.75	2.10	2.94	1.80	2.29	3.31
Pipeline natural gas	0.88	0.83	0.85	0.89	0.90	0.94	1.04	0.91	0.96	1.07
Natural gas subtotal	18.50	18.73	19.05	19.73	19.21	19.80	21.99	19.37	20.88	24.81
Metallurgical coal	0.62	0.58	0.61	0.65	0.55	0.56	0.61	0.48	0.51	0.58
Other coal	0.92	0.97	0.98	1.02	0.99	1.00	1.09	1.00	1.04	1.18
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	1.97
Net coal coke imports	-0.02	0.00	0.00	0.01	-0.03	-0.03	-0.03	-0.06	-0.06	-0.05
Coal subtotal	1.52	1.55	1.59	1.67	1.51	1.53	2.34	1.42	1.49	3.68
Biofuels heat and coproducts	0.72	0.82	0.80	0.80	0.81	0.80	0.81	0.80	0.86	0.98
Renewable energy[15]	2.18	2.04	2.06	2.23	2.05	2.09	2.22	2.01	2.10	2.38
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	12.60	13.48	13.45	13.63	14.37	14.35	14.34	15.23	15.25	15.21
Delivered energy	**71.17**	**74.22**	**73.84**	**73.68**	**75.61**	**74.87**	**75.24**	**77.25**	**76.62**	**79.80**
Electricity related losses	25.97	26.98	27.00	27.15	27.99	28.01	28.09	28.86	29.10	29.87
Total	**97.14**	**101.20**	**100.84**	**100.84**	**103.60**	**102.87**	**103.34**	**106.11**	**105.73**	**109.67**
Electric power[16]										
Distillate fuel oil	0.05	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08
Residual fuel oil	0.21	0.08	0.08	0.09	0.09	0.09	0.09	0.11	0.09	0.09
Petroleum and other liquids subtotal	0.26	0.17	0.17	0.17	0.18	0.17	0.17	0.19	0.18	0.18
Natural gas	8.36	8.07	7.80	8.28	9.21	9.03	8.25	10.19	9.61	7.02
Steam coal	16.49	17.37	17.59	17.33	17.58	17.63	17.77	17.41	17.52	17.88
Nuclear / uranium[17]	8.27	8.42	8.42	8.42	8.46	8.47	8.67	8.52	8.73	9.78
Renewable energy[18]	4.78	6.08	6.13	6.24	6.59	6.72	7.22	7.46	7.99	9.85
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.18	0.11	0.11	0.11	0.10	0.10	0.12	0.11	0.11	0.15
Total	**38.57**	**40.46**	**40.45**	**40.78**	**42.36**	**42.35**	**42.43**	**44.09**	**44.36**	**45.08**

Table C2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Total energy consumption										
Liquefied petroleum gases and other[5]	3.14	3.78	3.73	3.79	4.31	4.23	4.21	4.29	4.17	4.25
Motor gasoline[2]	16.36	16.38	15.79	14.41	14.74	13.72	11.84	14.60	12.96	10.91
of which: E85[9]	0.02	0.02	0.03	0.19	0.14	0.20	0.52	0.16	0.28	0.76
Jet fuel[10]	2.97	3.20	3.20	3.15	3.62	3.61	3.57	3.88	3.86	3.83
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.15	8.88	8.95	8.75	9.27	9.13	8.23	9.71	9.21	7.90
Residual fuel oil	0.87	0.65	0.61	0.59	0.70	0.64	0.61	0.74	0.65	0.62
Petrochemical feedstocks	0.74	0.97	0.95	0.98	1.15	1.14	1.13	1.19	1.20	1.16
Other petroleum[14]	3.67	3.89	3.82	4.11	4.04	3.98	4.12	4.19	4.15	4.22
Petroleum and other liquids subtotal	35.91	37.77	37.06	35.79	37.84	36.47	33.72	38.61	36.21	32.91
Natural gas	24.46	24.31	24.12	25.14	25.78	25.79	26.09	26.86	27.25	26.50
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.96
Lease and plant fuel[7]	1.52	1.67	1.87	1.98	1.75	2.10	2.94	1.80	2.29	3.31
Pipeline natural gas	0.88	0.83	0.85	0.89	0.90	0.94	1.04	0.91	0.96	1.07
Natural gas subtotal	26.86	26.81	26.85	28.02	28.43	28.83	30.24	29.56	30.50	31.83
Metallurgical coal	0.62	0.58	0.61	0.65	0.55	0.56	0.61	0.48	0.51	0.58
Other coal	17.41	18.34	18.57	18.35	18.57	18.63	18.86	18.40	18.56	19.06
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	1.97
Net coal coke imports	-0.02	0.00	0.00	0.01	-0.03	-0.03	-0.03	-0.06	-0.06	-0.05
Coal subtotal	18.01	18.92	19.18	19.00	19.09	19.16	20.11	18.83	19.01	21.56
Nuclear / uranium[17]	8.27	8.42	8.42	8.42	8.46	8.47	8.67	8.52	8.73	9.78
Biofuels heat and coproducts	0.72	0.82	0.80	0.80	0.81	0.80	0.81	0.80	0.86	0.98
Renewable energy[19]	6.96	8.12	8.19	8.47	8.64	8.81	9.44	9.46	10.09	12.23
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.18	0.11	0.11	0.11	0.10	0.10	0.12	0.11	0.11	0.15
Total	**97.14**	**101.20**	**100.84**	**100.84**	**103.60**	**102.87**	**103.34**	**106.11**	**105.73**	**109.67**
Energy use and related statistics										
Delivered energy use	71.17	74.22	73.84	73.68	75.61	74.87	75.24	77.25	76.62	79.80
Total energy use	97.14	101.20	100.84	100.84	103.60	102.87	103.34	106.11	105.73	109.67
Ethanol consumed in motor gasoline and E85	1.12	1.16	1.12	1.13	1.11	1.12	1.17	1.12	1.27	1.28
Population (millions)	317	334	334	334	359	359	359	380	380	380
Gross domestic product (billion 2009 dollars)	15,710	18,742	18,801	18,798	23,963	23,894	23,844	29,885	29,898	29,760
Carbon dioxide emissions (million metric tons)	5,405	5,523	5,499	5,441	5,585	5,514	5,461	5,671	5,549	5,584

[1]Includes wood used for residential heating. See Table A4 and/or Table A17 for estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal water heating, and electricity generation from wind and solar photovoltaic sources.
[2]Includes ethanol and ethers blended into gasoline.
[3]Excludes ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. See Table A5 and/or Table A17 for estimates of nonmarketed renewable energy consumption for solar thermal water heating and electricity generation from wind and solar photovoltaic sources.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[5]Includes ethane, natural gasoline, and refinery olefins.
[6]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Represents natural gas used in well, field, and lease operations, in natural gas processing plant machinery, and for liquefaction in export facilities.
[8]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[9]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[10]Includes only kerosene type.
[11]Diesel fuel for on- and off- road use.
[12]Includes aviation gasoline and lubricants.
[13]Represents consumption unattributed to the sectors above.
[14]Includes aviation gasoline, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[15]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[16]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[17]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[18]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[19]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
Btu = British thermal unit.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE-EIA-0035(2014/11) (Washington, DC, November 2014). 2013 population and gross domestic product: IHS Economics, Industry and Employment models, November 2014. 2013 carbon dioxide emissions and emission factors: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWPRICE.D021915A, REF2015.D021915A, and HIGHPRICE.D021915A.

Table C3. Energy prices by sector and source
(2013 dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil Price	Reference	High oil price
Residential										
Propane	23.3	21.2	23.0	26.6	22.2	24.4	28.6	23.0	26.6	30.8
Distillate fuel oil	27.2	17.5	21.5	34.6	19.5	26.3	43.3	20.5	32.9	53.7
Natural gas	10.0	11.1	11.6	11.3	12.8	12.8	14.7	14.8	15.5	17.9
Electricity	35.6	37.3	37.8	38.3	39.6	40.0	42.7	41.3	42.4	46.3
Commercial										
Propane	20.0	17.2	19.4	23.9	18.4	21.1	26.6	19.4	23.9	29.5
Distillate fuel oil	26.7	16.9	21.0	34.1	19.0	25.8	42.9	19.9	32.5	53.3
Residual fuel oil	22.1	11.0	14.2	24.4	12.6	18.1	31.7	13.5	24.3	42.7
Natural gas	8.1	9.1	9.6	9.3	10.4	10.4	12.2	12.0	12.6	15.0
Electricity	29.7	30.8	31.1	31.3	32.3	32.6	34.9	33.6	34.5	37.8
Industrial[1]										
Propane	20.3	17.3	19.6	24.5	18.6	21.5	27.3	19.7	24.5	30.5
Distillate fuel oil	27.3	17.1	21.2	34.3	19.3	26.1	43.2	20.2	32.7	53.6
Residual fuel oil	20.0	10.2	13.3	23.5	11.8	17.2	30.7	12.7	23.5	41.7
Natural gas[2]	4.6	5.6	6.2	5.8	6.8	6.8	8.7	8.2	8.8	11.0
Metallurgical coal	5.5	5.8	5.8	6.0	6.6	6.7	6.9	7.0	7.2	7.5
Other industrial coal	3.2	3.3	3.3	3.5	3.5	3.6	3.9	3.7	3.9	4.3
Coal to liquids	- -	- -	- -	- -	- -	- -	2.6	- -	- -	3.1
Electricity	20.2	20.9	21.3	21.3	22.4	22.6	24.5	24.0	24.7	27.3
Transportation										
Propane	24.6	22.2	24.0	27.6	23.2	25.5	29.6	24.1	27.6	31.8
E85[3]	33.1	28.4	30.4	36.6	25.6	31.2	39.3	28.2	35.4	47.5
Motor gasoline[4]	29.3	19.2	22.5	34.4	20.2	26.4	41.7	21.4	32.3	52.5
Jet fuel[5]	21.8	12.1	16.1	28.9	14.4	21.3	38.2	15.6	28.3	48.8
Diesel fuel (distillate fuel oil)[6]	28.2	19.1	23.1	36.3	21.3	28.0	45.0	22.1	34.7	55.6
Residual fuel oil	19.3	8.7	11.7	21.0	10.5	15.4	27.6	11.3	20.3	35.4
Natural gas[7]	17.6	17.8	17.8	18.8	18.6	15.7	20.9	19.7	19.6	22.9
Electricity	28.5	29.8	30.2	30.2	32.5	32.9	35.9	34.8	36.0	40.3
Electric power[8]										
Distillate fuel oil	24.0	14.7	18.8	31.8	16.7	23.6	40.6	17.7	30.2	51.0
Residual fuel oil	18.9	8.3	11.5	21.7	9.7	15.4	28.9	10.4	21.6	40.0
Natural gas	4.4	4.9	5.4	5.1	6.2	6.2	7.9	7.8	8.3	10.1
Steam coal	2.3	2.3	2.4	2.6	2.6	2.7	3.0	2.7	2.9	3.3
Average price to all users[9]										
Propane	21.9	19.0	21.1	25.3	19.8	22.6	27.7	20.8	25.2	30.5
E85[3]	33.1	28.4	30.4	36.6	25.6	31.2	39.3	28.2	35.4	47.5
Motor gasoline[4]	29.0	19.2	22.5	34.4	20.2	26.4	41.7	21.4	32.3	52.5
Jet fuel[5]	21.8	12.1	16.1	28.9	14.4	21.3	38.2	15.6	28.3	48.8
Distillate fuel oil	27.9	18.6	22.6	35.8	20.8	27.6	44.6	21.7	34.2	55.1
Residual fuel oil	19.4	9.3	12.2	21.8	10.9	16.0	28.7	11.8	21.5	37.8
Natural gas	6.1	6.9	7.5	7.3	8.1	8.2	10.5	9.7	10.5	13.4
Metallurgical coal	5.5	5.8	5.8	6.0	6.6	6.7	6.9	7.0	7.2	7.5
Other coal	2.4	2.4	2.4	2.6	2.6	2.7	3.0	2.8	3.0	3.4
Coal to liquids	- -	- -	- -	- -	- -	- -	2.6	- -	- -	3.1
Electricity	29.5	30.4	30.8	30.8	32.1	32.4	34.5	33.8	34.7	37.7
Non-renewable energy expenditures by sector (billion 2013 dollars)										
Residential	243	248	254	258	273	276	297	302	311	336
Commercial	177	190	194	198	216	219	238	249	259	284
Industrial[1]	224	236	264	334	285	323	439	312	389	547
Transportation	719	481	565	831	503	638	926	544	791	1,128
Total non-renewable expenditures	1,364	1,155	1,276	1,621	1,276	1,456	1,900	1,408	1,751	2,295
Transportation renewable expenditures	1	1	1	7	4	6	20	4	10	36
Total expenditures	**1,364**	**1,155**	**1,277**	**1,628**	**1,280**	**1,462**	**1,920**	**1,412**	**1,761**	**2,331**

Table C3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Residential										
Propane	23.3	24.0	26.1	29.9	29.3	32.8	38.9	36.7	43.1	50.9
Distillate fuel oil	27.2	19.8	24.4	38.8	25.8	35.3	58.8	32.7	53.3	88.7
Natural gas	10.0	12.5	13.2	12.7	16.9	17.1	20.0	23.6	25.1	29.6
Electricity	35.6	42.2	42.9	43.1	52.4	53.6	58.0	65.9	68.8	76.4
Commercial										
Propane	20.0	19.5	22.0	26.9	24.3	28.3	36.1	31.0	38.8	48.8
Distillate fuel oil	26.7	19.1	23.8	38.3	25.1	34.6	58.2	31.8	52.6	88.1
Residual fuel oil	22.1	12.4	16.1	27.5	16.7	24.3	43.0	21.5	39.4	70.6
Natural gas	8.1	10.3	10.8	10.4	13.8	13.9	16.6	19.1	20.5	24.7
Electricity	29.7	34.8	35.3	35.1	42.8	43.7	47.4	53.6	56.0	62.4
Industrial[1]										
Propane	20.3	19.6	22.3	27.5	24.5	28.8	37.1	31.4	39.7	50.4
Distillate fuel oil	27.3	19.4	24.1	38.6	25.5	35.0	58.6	32.2	53.0	88.6
Residual fuel oil	20.0	11.5	15.1	26.4	15.6	23.1	41.6	20.2	38.0	68.9
Natural gas[2]	4.6	6.4	7.0	6.5	9.0	9.1	11.8	13.2	14.2	18.2
Metallurgical coal	5.5	6.5	6.6	6.7	8.7	8.9	9.3	11.2	11.6	12.4
Other industrial coal	3.2	3.7	3.8	3.9	4.6	4.8	5.2	5.9	6.3	7.1
Coal to liquids	- -	- -	- -	- -	- -	- -	3.5	- -	- -	5.1
Electricity	20.2	23.6	24.2	24.0	29.6	30.3	33.2	38.2	40.0	45.1
Transportation										
Propane	24.6	25.1	27.2	31.1	30.6	34.1	40.3	38.4	44.8	52.6
E85[3]	33.1	32.1	34.4	41.1	33.9	41.9	53.3	44.9	57.4	78.5
Motor gasoline[4]	29.3	21.7	25.5	38.6	26.7	35.3	56.6	34.1	52.4	86.8
Jet fuel[5]	21.8	13.7	18.3	32.5	19.0	28.6	51.9	24.9	45.8	80.6
Diesel fuel (distillate fuel oil)[6]	28.2	21.6	26.2	40.7	28.1	37.6	61.2	35.3	56.2	91.8
Residual fuel oil	19.3	9.9	13.2	23.6	13.8	20.6	37.5	18.0	32.9	58.4
Natural gas[7]	17.6	20.2	20.2	21.2	24.6	21.0	28.5	31.4	31.8	37.8
Electricity	28.5	33.8	34.3	34.0	43.0	44.1	48.7	55.6	58.4	66.6
Electric power[8]										
Distillate fuel oil	24.0	16.7	21.3	35.8	22.1	31.7	55.2	28.3	49.0	84.3
Residual fuel oil	18.9	9.4	13.0	24.3	12.8	20.6	39.3	16.5	35.0	66.0
Natural gas	4.4	5.6	6.1	5.8	8.2	8.3	10.7	12.4	13.4	16.7
Steam coal	2.3	2.6	2.7	2.9	3.4	3.6	4.0	4.3	4.7	5.5

Table C3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Average price to all users[9]										
Propane	21.9	21.5	23.9	28.5	26.2	30.3	37.7	33.1	40.9	50.4
E85[3]	33.1	32.1	34.4	41.1	33.9	41.9	53.3	44.9	57.4	78.5
Motor gasoline[4]	29.0	21.7	25.5	38.6	26.7	35.3	56.6	34.1	52.4	86.8
Jet fuel[5]	21.8	13.7	18.3	32.5	19.0	28.6	51.9	24.9	45.8	80.6
Distillate fuel oil	27.9	21.0	25.7	40.2	27.5	36.9	60.6	34.6	55.5	91.0
Residual fuel oil	19.4	10.5	13.8	24.5	14.5	21.5	39.0	18.8	34.8	62.5
Natural gas	6.1	7.8	8.5	8.2	10.7	11.0	14.3	15.4	17.0	22.2
Metallurgical coal	5.5	6.5	6.6	6.7	8.7	8.9	9.3	11.2	11.6	12.4
Other coal	2.4	2.7	2.8	2.9	3.4	3.7	4.1	4.4	4.8	5.6
Coal to liquids	- -	- -	- -	- -	- -	- -	3.5	- -	- -	5.1
Electricity	29.5	34.4	34.9	34.7	42.5	43.4	46.9	54.0	56.2	62.3
Non-renewable energy expenditures by sector (billion nominal dollars)										
Residential	243	280	288	290	361	370	403	482	504	556
Commercial	177	215	220	222	286	294	323	398	420	470
Industrial[1]	224	267	299	376	376	433	597	498	631	903
Transportation	719	544	641	934	664	855	1,258	868	1,283	1,864
Total non-renewable expenditures	1,364	1,307	1,448	1,822	1,687	1,952	2,581	2,246	2,839	3,793
Transportation renewable expenditures	1	1	1	8	5	8	28	7	16	60
Total expenditures	**1,364**	**1,308**	**1,449**	**1,830**	**1,692**	**1,960**	**2,609**	**2,253**	**2,855**	**3,852**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Excludes use for lease and plant fuel.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Kerosene-type jet fuel. Includes Federal and State taxes while excluding county and local taxes.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Natural gas used as fuel in motor vehicles, trains, and ships. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[8]Includes electricity-only and combined heat and power plants that have a regulatory status.
[9]Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
- - = Not applicable.
Note: Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 prices for motor gasoline, distillate fuel oil, and jet fuel are based on prices in the U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2013 residential, commercial, and industrial natural gas delivered prices: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2013 transportation sector natural gas delivered prices are model results. 2013 electric power sector distillate and residual fuel oil prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 electric power sector natural gas prices: EIA, *Electric Power Monthly*, DOE/EIA-0226, April 2013 and April 2014, Table 4.2, and EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014). 2013 coal prices based on: EIA, *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014) and EIA, AEO2015 National Energy Modeling System run REF2015.D021915A. 2013 electricity prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 E85 prices derived from monthly prices in the Clean Cities Alternative Fuel Price Report. **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWPRICE.D021915A, REF2015.D021915A, and HIGHPRICE.D021915A.

Table C4. Petroleum and other liquids supply and disposition
(million barrels per day, unless otherwise noted)

Supply and disposition	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil										
Domestic crude production[1]	7.44	9.96	10.60	12.29	8.69	10.04	12.48	7.09	9.43	9.93
Alaska	0.52	0.42	0.42	0.42	0.00	0.24	0.57	0.00	0.34	0.45
Lower 48 states	6.92	9.55	10.18	11.87	8.69	9.80	11.92	7.09	9.09	9.48
Net imports	7.60	6.02	5.51	5.94	7.07	6.44	6.24	8.05	7.58	8.86
Gross imports	7.73	6.65	6.14	6.57	7.70	7.07	6.87	8.68	8.21	9.49
Exports	0.13	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Other crude supply[2]	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total crude supply	**15.30**	**15.99**	**16.11**	**18.23**	**15.76**	**16.48**	**18.72**	**15.14**	**17.01**	**18.78**
Net product imports	-1.37	-2.19	-2.80	-5.97	-1.88	-3.56	-8.06	-0.71	-4.26	-9.49
Gross refined product imports[3]	0.82	1.45	1.21	0.88	1.72	1.31	1.27	1.65	1.26	1.31
Unfinished oil imports	0.66	0.68	0.60	0.49	0.66	0.52	0.39	0.62	0.45	0.31
Blending component imports	0.60	0.72	0.59	0.51	0.62	0.49	0.50	0.53	0.40	0.44
Exports	3.43	5.04	5.20	7.86	4.88	5.89	10.23	3.51	6.36	11.54
Refinery processing gain[4]	1.09	0.96	0.98	1.07	0.94	0.97	0.99	1.00	0.98	1.01
Product stock withdrawal	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas plant liquids	2.61	3.92	4.04	4.29	3.99	4.19	4.65	3.71	4.07	4.55
Supply from renewable sources	0.93	1.03	1.01	1.02	1.00	1.01	1.05	1.00	1.12	1.25
Ethanol	0.83	0.87	0.84	0.85	0.83	0.84	0.88	0.83	0.95	0.96
Domestic production	0.85	0.88	0.86	0.86	0.87	0.86	0.87	0.86	0.93	0.90
Net imports	-0.02	-0.02	-0.02	-0.01	-0.04	-0.02	0.01	-0.02	0.02	0.06
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biodiesel	0.10	0.13	0.14	0.14	0.01	0.11	0.14	0.01	0.11	0.15
Domestic production	0.09	0.13	0.13	0.13	0.00	0.10	0.13	0.00	0.10	0.14
Net imports	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other biomass-derived liquids[5]	0.00	0.03	0.03	0.03	0.15	0.06	0.03	0.15	0.06	0.15
Domestic production	0.00	0.03	0.03	0.03	0.15	0.06	0.03	0.15	0.06	0.15
Net imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquids from gas	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.49
Liquids from coal	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.71
Other[6]	0.21	0.27	0.28	0.30	0.29	0.30	0.32	0.29	0.32	0.35
Total primary supply[7]	**18.87**	**19.98**	**19.62**	**18.94**	**20.10**	**19.38**	**18.00**	**20.43**	**19.24**	**17.66**
Product supplied										
by fuel										
Liquefied petroleum gases and other[8]	2.50	2.94	2.91	2.96	3.34	3.30	3.31	3.31	3.25	3.34
Motor gasoline[9]	8.85	8.80	8.49	7.77	7.94	7.41	6.44	7.86	7.05	6.02
of which: E85[10]	0.01	0.01	0.02	0.13	0.09	0.13	0.36	0.11	0.19	0.52
Jet fuel[11]	1.43	1.55	1.55	1.53	1.76	1.75	1.73	1.88	1.87	1.86
Distillate fuel oil[12]	3.83	4.22	4.26	4.16	4.41	4.34	3.91	4.62	4.38	3.77
of which: Diesel	3.56	3.90	3.94	3.88	4.13	4.09	3.68	4.38	4.17	3.57
Residual fuel oil	0.32	0.28	0.27	0.26	0.31	0.28	0.27	0.32	0.28	0.27
Other[13]	2.04	2.20	2.18	2.30	2.36	2.33	2.39	2.45	2.43	2.45
by sector										
Residential and commercial	0.86	0.79	0.76	0.69	0.72	0.67	0.60	0.68	0.61	0.54
Industrial[14]	4.69	5.54	5.50	5.66	6.12	6.04	6.09	6.17	6.09	6.16
Transportation	13.36	13.74	13.46	12.70	13.35	12.79	11.42	13.69	12.66	11.04
Electric power[15]	0.12	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Unspecified sector[16]	-0.12	-0.15	-0.15	-0.16	-0.17	-0.17	-0.14	-0.18	-0.17	-0.13
Total product supplied	**18.96**	**20.00**	**19.65**	**18.97**	**20.10**	**19.41**	**18.04**	**20.44**	**19.27**	**17.70**
Discrepancy[17]	-0.10	-0.02	-0.03	-0.03	0.00	-0.03	-0.04	-0.01	-0.03	-0.04

Table C4. Petroleum and other liquids supply and disposition (continued)
(million barrels per day, unless otherwise noted)

Supply and disposition	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Domestic refinery distillation capacity[18]	17.8	18.8	18.8	19.0	18.8	18.8	19.3	18.8	18.8	19.3
Capacity utilization rate (percent)[19]	88.3	87.4	87.8	97.6	86.1	89.4	98.6	82.7	92.0	98.6
Net import share of product supplied (percent)	33.0	19.1	13.7	-0.2	25.7	14.8	-10.0	35.9	17.4	-3.2
Net expenditures for imported crude oil and petroleum products (billion 2013 dollars)	308	130	167	345	180	259	468	225	405	836

[1]Includes lease condensate.
[2]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude oil stock withdrawals.
[3]Includes other hydrocarbons and alcohols.
[4]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[5]Includes pyrolysis oils, biomass-derived Fischer-Tropsch liquids, biobutanol, and renewable feedstocks used for the on-site production of diesel and gasoline.
[6]Includes domestic sources of other blending components, other hydrocarbons, and ethers.
[7]Total crude supply, net product imports, refinery processing gain, product stock withdrawal, natural gas plant liquids, supply from renewable sources, liquids from gas, liquids from coal, and other supply.
[8]Includes ethane, natural gasoline, and refinery olefins.
[9]Includes ethanol and ethers blended into gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Includes distillate fuel oil from petroleum and biomass feedstocks.
[13]Includes kerosene, aviation gasoline, petrochemical feedstocks, lubricants, waxes, asphalt, road oil, still gas, special naphthas, petroleum coke, crude oil product supplied, methanol, and miscellaneous petroleum products.
[14]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[15]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[16]Represents consumption unattributed to the sectors above.
[17]Balancing item. Includes unaccounted for supply, losses, and gains.
[18]End-of-year operable capacity.
[19]Rate is calculated by dividing the gross annual input to atmospheric crude oil distillation units by their operable refining capacity in barrels per calendar day.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 product supplied based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). Other 2013 data: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWPRICE.D021915A, REF2015.D021915A, and HIGHPRICE.D021915A.

Table C5. Petroleum and other liquids prices
(2013 dollars per gallon, unless otherwise noted)

Sector and fuel	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil prices (2013 dollars per barrel)										
Brent spot	109	58	79	149	69	106	194	76	141	252
West Texas Intermediate spot	98	52	73	142	63	99	188	72	136	246
Average imported refiners acquisition cost[1]	98	50	71	139	61	96	181	68	131	237
Brent / West Texas Intermediate spread	10.7	6.1	6.2	6.8	5.9	6.2	6.3	3.4	5.6	5.7
Delivered sector product prices										
Residential										
Propane	2.13	1.93	2.10	2.43	2.02	2.23	2.61	2.10	2.43	2.81
Distillate fuel oil	3.78	2.42	2.99	4.79	2.71	3.65	6.00	2.84	4.56	7.44
Commercial										
Distillate fuel oil	3.68	2.33	2.89	4.70	2.62	3.56	5.91	2.75	4.47	7.35
Residual fuel oil	3.31	1.64	2.12	3.66	1.89	2.71	4.74	2.02	3.64	6.40
Residual fuel oil (2013 dollars per barrel)	139	69	89	154	79	114	199	85	153	269
Industrial[2]										
Propane	1.85	1.58	1.79	2.24	1.70	1.96	2.49	1.80	2.24	2.78
Distillate fuel oil	3.75	2.35	2.91	4.71	2.65	3.58	5.92	2.77	4.49	7.36
Residual fuel oil	3.00	1.52	2.00	3.52	1.76	2.58	4.59	1.89	3.51	6.24
Residual fuel oil (2013 dollars per barrel)	126	64	84	148	74	108	193	80	147	262
Transportation										
Propane	2.24	2.03	2.19	2.52	2.12	2.32	2.71	2.20	2.52	2.91
E85[3]	3.14	2.71	2.90	3.49	2.44	2.98	3.75	2.69	3.38	4.53
Ethanol wholesale price	2.37	2.49	2.49	2.63	2.22	2.35	2.67	2.30	2.64	3.26
Motor gasoline[4]	3.55	2.33	2.74	4.17	2.45	3.20	5.05	2.60	3.90	6.33
Jet fuel[5]	2.94	1.63	2.17	3.90	1.95	2.88	5.16	2.11	3.81	6.58
Diesel fuel (distillate fuel oil)[6]	3.86	2.61	3.17	4.97	2.91	3.84	6.17	3.03	4.75	7.61
Residual fuel oil	2.89	1.31	1.74	3.14	1.57	2.30	4.13	1.69	3.03	5.29
Residual fuel oil (2013 dollars per barrel)	122	55	73	132	66	97	174	71	127	222
Electric power[7]										
Distillate fuel oil	3.33	2.04	2.60	4.42	2.32	3.28	5.63	2.46	4.19	7.07
Residual fuel oil	2.83	1.24	1.71	3.24	1.45	2.30	4.33	1.55	3.23	5.98
Residual fuel oil (2013 dollars per barrel)	119	52	72	136	61	97	182	65	136	251
Average prices, all sectors[8]										
Propane	2.00	1.73	1.93	2.31	1.81	2.06	2.53	1.90	2.30	2.79
Motor gasoline[4]	3.53	2.33	2.74	4.17	2.45	3.20	5.05	2.60	3.90	6.33
Jet fuel[5]	2.94	1.63	2.17	3.90	1.95	2.88	5.16	2.11	3.81	6.58
Distillate fuel oil	3.83	2.55	3.11	4.91	2.85	3.78	6.12	2.97	4.69	7.55
Residual fuel oil	2.90	1.38	1.83	3.26	1.64	2.40	4.30	1.76	3.22	5.66
Residual fuel oil (2013 dollars per barrel)	121.71	58.16	76.70	137.11	68.77	100.80	180.46	73.94	135.10	237.79
Average	**3.16**	**2.04**	**2.46**	**3.84**	**2.18**	**2.89**	**4.66**	**2.32**	**3.62**	**5.81**

Table C5. Petroleum and other liquids prices (continued)
(nominal dollars per gallon, unless otherwise noted)

Sector and fuel	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil prices (nominal dollars per barrel)										
Brent spot	109	65	90	167	91	142	263	120	229	416
West Texas Intermediate spot	98	58	83	159	83	133	255	115	220	407
Average imported refiners acquisition cost[1]	98	57	80	156	81	129	246	108	212	391
Delivered sector product prices										
Residential										
Propane	2.13	2.19	2.38	2.73	2.67	2.99	3.55	3.36	3.94	4.65
Distillate fuel oil	3.78	2.74	3.39	5.39	3.58	4.90	8.16	4.54	7.40	12.30
Commercial										
Distillate fuel oil	3.68	2.64	3.28	5.28	3.46	4.78	8.03	4.38	7.25	12.14
Residual fuel oil	3.31	1.86	2.41	4.11	2.50	3.63	6.44	3.22	5.90	10.57
Industrial[2]										
Propane	1.85	1.79	2.04	2.51	2.24	2.63	3.39	2.87	3.62	4.60
Distillate fuel oil	3.75	2.66	3.30	5.30	3.50	4.80	8.05	4.42	7.28	12.16
Residual fuel oil	3.00	1.72	2.26	3.95	2.33	3.46	6.23	3.02	5.69	10.31
Transportation										
Propane	2.24	2.30	2.49	2.84	2.80	3.12	3.68	3.50	4.09	4.80
E85[3]	3.14	3.06	3.29	3.92	3.23	3.99	5.09	4.28	5.48	7.49
Ethanol wholesale price	2.37	2.82	2.83	2.96	2.94	3.15	3.62	3.68	4.27	5.39
Motor gasoline[4]	3.55	2.64	3.10	4.69	3.24	4.29	6.86	4.15	6.32	10.46
Jet fuel[5]	2.94	1.85	2.47	4.38	2.57	3.86	7.01	3.36	6.18	10.88
Diesel fuel (distillate fuel oil)[6]	3.86	2.96	3.60	5.58	3.85	5.15	8.39	4.83	7.70	12.58
Residual fuel oil	2.89	1.48	1.98	3.53	2.07	3.08	5.61	2.70	4.92	8.75
Electric power[7]										
Distillate fuel oil	3.33	2.31	2.95	4.96	3.07	4.39	7.65	3.93	6.79	11.69
Residual fuel oil	2.83	1.40	1.94	3.64	1.92	3.09	5.88	2.48	5.24	9.88
Average prices, all sectors[8]										
Propane	2.00	1.96	2.19	2.60	2.40	2.77	3.44	3.02	3.73	4.61
Motor gasoline[4]	3.53	2.64	3.10	4.69	3.24	4.29	6.86	4.14	6.32	10.46
Jet fuel[5]	2.94	1.85	2.47	4.38	2.57	3.86	7.01	3.36	6.18	10.88
Distillate fuel oil	3.83	2.88	3.52	5.51	3.77	5.07	8.31	4.74	7.61	12.48
Residual fuel oil (nominal dollars per barrel)	122	66	87	154	91	135	245	118	219	393
Average	**3.16**	**2.30**	**2.79**	**4.32**	**2.88**	**3.88**	**6.33**	**3.70**	**5.86**	**9.61**

[1]Weighted average price delivered to U.S. refiners.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Includes only kerosene type.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Includes electricity-only and combined heat and power plants that have a regulatory status.
[8]Weighted averages of end-use fuel prices are derived from the prices in each sector and the corresponding sectoral consumption.
Note: Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. 2013 average imported crude oil price: Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 prices for motor gasoline, distillate fuel oil, and jet fuel are based on: EIA, *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2013 residential, commercial, industrial, and transportation sector petroleum product prices are derived from: EIA, Form EIA-782A, "Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales Report." 2013 electric power prices based on: *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 E85 prices derived from monthly prices in the Clean Cities Alternative Fuel Price Report. 2013 wholesale ethanol prices derived from Bloomberg U.S. average rack price. **Projections:** EIA, AEO2015 National Energy Modeling System runs LOWPRICE.D021915A, REF2015.D021915A, and HIGHPRICE.D021915A.

Table C6. International petroleum and other liquids supply, disposition, and prices
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil spot prices										
(2013 dollars per barrel)										
Brent	109	58	79	149	69	106	194	76	141	252
West Texas Intermediate	98	52	73	142	63	99	188	72	136	246
(nominal dollars per barrel)										
Brent	109	65	90	167	91	142	263	120	229	416
West Texas Intermediate	98	58	83	159	83	133	255	115	220	407
Petroleum and other liquids consumption[1]										
OECD										
United States (50 states)	18.96	20.00	19.65	18.97	20.10	19.41	18.04	20.44	19.27	17.70
United States territories	0.30	0.32	0.31	0.30	0.35	0.34	0.33	0.40	0.38	0.38
Canada	2.29	2.40	2.31	2.20	2.45	2.21	2.06	2.61	2.14	1.94
Mexico and Chile	2.46	2.79	2.71	2.63	2.95	2.80	2.78	3.19	2.92	2.88
OECD Europe[2]	13.96	14.75	14.20	13.74	15.30	14.09	13.70	16.03	14.12	13.54
Japan	4.56	4.47	4.27	4.05	4.36	4.03	3.79	4.05	3.65	3.31
South Korea	2.43	2.71	2.58	2.42	2.80	2.53	2.36	2.81	2.40	2.24
Australia and New Zealand	1.16	1.19	1.16	1.13	1.17	1.11	1.09	1.26	1.15	1.11
Total OECD consumption	**46.14**	**48.62**	**47.20**	**45.43**	**49.49**	**46.52**	**44.16**	**50.79**	**46.04**	**43.10**
Non-OECD										
Russia	3.30	3.32	3.31	3.19	3.32	3.23	3.01	3.22	3.01	2.67
Other Europe and Eurasia[3]	2.06	2.22	2.22	2.20	2.45	2.39	2.33	2.78	2.59	2.48
China	10.67	13.05	13.13	13.04	15.95	17.03	18.31	17.38	20.19	24.04
India	3.70	4.32	4.30	4.14	5.39	5.52	5.37	6.14	6.79	6.91
Other Asia[4]	7.37	9.14	9.08	8.83	12.37	12.35	12.26	16.24	16.49	16.84
Middle East	7.61	8.49	8.40	8.42	10.20	9.56	10.22	12.50	11.13	12.72
Africa	3.42	3.99	3.93	3.82	4.93	4.78	4.75	6.41	6.18	6.28
Brazil	3.11	3.44	3.33	3.15	3.93	3.74	3.62	4.80	4.50	4.50
Other Central and South America	3.38	3.56	3.49	3.38	3.86	3.72	3.64	4.39	4.15	4.11
Total non-OECD consumption	**44.60**	**51.54**	**51.20**	**50.17**	**62.41**	**62.31**	**63.50**	**73.87**	**75.01**	**80.54**
Total consumption	**90.7**	**100.2**	**98.4**	**95.6**	**111.9**	**108.8**	**107.7**	**124.7**	**121.0**	**123.6**
Petroleum and other liquids production										
OPEC[5]										
Middle East	26.32	27.65	24.56	19.33	35.80	29.34	21.86	45.31	36.14	29.01
North Africa	2.90	3.74	3.51	3.22	4.31	3.67	3.42	4.90	4.06	3.67
West Africa	4.26	5.51	5.00	4.43	6.85	5.24	4.81	7.50	5.43	5.01
South America	3.01	3.64	3.10	2.85	4.58	3.27	2.93	5.59	3.79	3.18
Total OPEC production	**36.49**	**40.54**	**36.16**	**29.83**	**51.54**	**41.53**	**33.01**	**63.30**	**49.42**	**40.87**
Non-OPEC										
OECD										
United States (50 states)	12.64	16.17	16.92	18.97	14.94	16.52	19.80	13.10	15.89	18.11
Canada	4.15	4.70	5.05	5.46	5.48	6.26	7.27	5.81	6.76	8.04
Mexico and Chile	2.94	2.41	2.93	3.07	2.04	3.32	3.65	2.23	3.79	4.18
OECD Europe[2]	3.88	3.18	3.35	3.22	2.61	2.98	3.05	2.57	3.19	3.18
Japan and South Korea	0.18	0.17	0.17	0.16	0.19	0.18	0.18	0.20	0.18	0.19
Australia and New Zealand	0.49	0.55	0.60	0.62	0.53	0.86	0.89	0.50	0.96	1.01
Total OECD production	**24.29**	**27.18**	**29.03**	**31.51**	**25.79**	**30.12**	**34.84**	**24.41**	**30.77**	**34.70**
Non-OECD										
Russia	10.50	10.63	10.71	10.97	10.80	11.22	11.58	11.35	12.16	12.67
Other Europe and Eurasia[3]	3.27	3.42	3.41	3.87	4.21	4.42	4.99	4.83	5.18	6.44
China	4.48	4.80	5.11	5.23	5.16	5.66	6.18	5.18	5.84	7.54
Other Asia[4]	3.82	3.72	3.85	3.80	3.54	3.67	3.80	3.73	4.01	4.06
Middle East	1.20	1.02	1.03	1.14	0.75	0.85	1.04	0.56	0.77	0.98
Africa	2.41	2.73	2.70	2.79	2.90	2.94	2.92	3.23	3.33	3.39
Brazil	2.73	3.62	3.70	4.01	4.68	5.43	6.05	4.96	6.12	8.34
Other Central and South America	2.21	2.51	2.71	2.59	2.53	2.97	3.25	3.13	3.47	4.70
Total non-OECD production	**30.63**	**32.44**	**33.21**	**34.41**	**34.57**	**37.17**	**39.80**	**36.96**	**40.88**	**48.10**
Total petroleum and other liquids production	**91.4**	**100.2**	**98.4**	**95.7**	**111.9**	**108.8**	**107.7**	**124.7**	**121.1**	**123.7**
OPEC market share (percent)	39.9	40.5	36.7	31.1	46.1	38.2	30.7	50.8	40.8	33.0

Table C6. International petroleum and other liquids supply, disposition, and prices (continued)
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	2013	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Selected world production subtotals:										
Crude oil and equivalents[6]	77.93	83.98	82.19	78.67	93.74	89.77	87.00	105.09	99.09	98.87
Tight oil	3.62	5.71	7.49	9.28	5.21	9.16	11.15	4.51	10.15	12.10
Bitumen[7]	2.11	2.91	3.00	3.31	3.57	3.95	4.72	3.86	4.26	5.36
Refinery processing gain[8]	2.40	2.45	2.42	2.26	2.80	2.74	2.50	3.20	2.97	2.89
Natural gas plant liquids	9.36	11.33	11.28	12.06	12.34	12.42	13.52	12.99	13.79	14.58
Liquids from renewable sources[9]	2.14	2.48	2.56	2.45	3.05	3.36	3.06	3.49	4.22	3.63
Liquids from coal[10]	0.21	0.30	0.33	0.53	0.30	0.69	1.40	0.30	1.05	3.16
Liquids from natural gas[11]	0.24	0.32	0.33	0.33	0.32	0.51	0.64	0.32	0.61	1.19
Liquids from kerogen[12]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Crude oil production[6]										
OPEC[5]										
Middle East	23.13	24.34	21.20	15.81	32.25	25.59	17.88	41.61	31.79	24.68
North Africa	2.43	3.19	2.93	2.63	3.61	2.92	2.65	4.06	2.96	2.71
West Africa	4.20	5.37	4.89	4.28	6.69	5.13	4.63	7.35	5.29	4.82
South America	2.82	3.34	2.86	2.54	4.23	2.98	2.55	5.25	3.48	2.80
Total OPEC production	**32.60**	**36.25**	**31.89**	**25.25**	**46.79**	**36.62**	**27.72**	**58.27**	**43.52**	**35.03**
Non-OPEC										
OECD										
United States (50 states)	8.90	10.93	11.58	13.36	9.63	11.01	13.47	8.09	10.41	10.94
Canada	3.42	4.01	4.35	4.76	4.76	5.48	6.50	5.08	5.92	7.24
Mexico and Chile	2.59	2.06	2.61	2.72	1.70	3.00	3.31	1.89	3.45	3.83
OECD Europe[2]	2.82	2.09	2.17	2.11	1.44	1.66	1.87	1.29	1.69	1.91
Japan and South Korea	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01
Australia and New Zealand	0.37	0.42	0.47	0.48	0.40	0.67	0.73	0.36	0.75	0.84
Total OECD production	**18.10**	**19.51**	**21.18**	**23.44**	**17.93**	**21.83**	**25.88**	**16.72**	**22.23**	**24.77**
Non-OECD										
Russia	10.02	10.03	10.15	10.38	9.95	10.42	10.72	10.07	11.10	11.37
Other Europe and Eurasia[3]	3.05	3.13	3.18	3.57	3.77	4.03	4.52	4.16	4.66	5.73
China	4.16	4.23	4.54	4.58	4.27	4.56	4.70	4.04	4.13	4.53
Other Asia[4]	3.04	2.81	2.94	2.89	2.46	2.45	2.64	2.41	2.47	2.66
Middle East	1.16	0.98	1.00	1.10	0.71	0.82	1.00	0.52	0.74	0.94
Africa	1.97	2.23	2.18	2.19	2.38	2.38	2.26	2.71	2.70	2.71
Brazil	2.02	2.75	2.87	3.14	3.42	4.16	4.78	3.55	4.60	6.93
Other Central and South America	1.81	2.06	2.25	2.14	2.05	2.49	2.77	2.65	2.94	4.21
Total non-OECD production	**27.24**	**28.22**	**29.11**	**29.98**	**29.03**	**31.32**	**33.40**	**30.10**	**33.35**	**39.07**
Total crude oil production[6]	**77.9**	**84.0**	**82.2**	**78.7**	**93.7**	**89.8**	**87.0**	**105.1**	**99.1**	**98.9**
OPEC market share (percent)	41.8	43.2	38.8	32.1	49.9	40.8	31.9	55.4	43.9	35.4

[1]Estimated consumption. Includes both OPEC and non-OPEC consumers in the regional breakdown.
[2]OECD Europe = Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.
[3]Other Europe and Eurasia = Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Macedonia, Malta, Moldova, Montenegro, Romania, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
[4]Other Asia = Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), Fiji, French Polynesia, Guam, Hong Kong, India (for production), Indonesia, Kiribati, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam.
[5]OPEC = Organization of the Petroleum Exporting Countries = Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
[6]Includes crude oil, lease condensate, tight oil (shale oil), extra-heavy oil, and bitumen (oil sands).
[7]Includes diluted and upgraded/synthetic bitumen (syncrude).
[8]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[9]Includes liquids produced from energy crops.
[10]Includes liquids converted from coal via the Fischer-Tropsch coal-to-liquids process.
[11]Includes liquids converted from natural gas via the Fischer-Tropsch natural-gas-to-liquids process.
[12]Includes liquids produced from kerogen (oil shale, not to be confused with tight oil (shale oil)).
OECD = Organization for Economic Cooperation and Development.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. **2013 quantities and projections:** Energy Information Administration (EIA), AEO2015 National Energy Modeling System runs LOWPRICE.D021915A, REF2015.D021915A, and HIGHPRICE.D021915A; and EIA, Generate World Oil Balance application.

Appendix D

High oil and gas resource case comparisons

Table D1. Total energy supply, disposition, and price summary

(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Production							
Crude oil and lease condensate	15.6	22.2	26.3	21.1	32.6	19.9	34.6
Natural gas plant liquids	3.6	5.5	6.3	5.7	7.9	5.5	9.0
Dry natural gas	25.1	29.6	33.1	33.9	43.8	36.4	52.0
Coal[1]	20.0	21.7	18.8	22.5	19.8	22.6	20.3
Nuclear / uranium[2]	8.3	8.4	8.4	8.5	8.5	8.7	8.5
Conventional hydroelectric power	2.5	2.8	2.8	2.8	2.8	2.8	2.8
Biomass[3]	4.2	4.4	4.5	4.6	4.7	5.0	5.1
Other renewable energy[4]	2.3	3.2	3.2	3.6	3.4	4.6	3.6
Other[5]	1.3	0.9	0.9	0.9	1.0	1.0	1.0
Total	**82.7**	**98.7**	**104.3**	**103.7**	**124.4**	**106.6**	**136.8**
Imports							
Crude oil	17.0	13.6	13.5	15.7	11.7	18.2	11.3
Petroleum and other liquids[6]	4.3	4.6	4.4	4.4	4.7	4.1	4.4
Natural gas[7]	2.9	1.9	1.8	1.6	1.7	1.7	2.5
Other imports[8]	0.3	0.1	0.1	0.1	0.1	0.1	0.0
Total	**24.5**	**20.2**	**19.9**	**21.7**	**18.2**	**24.1**	**18.3**
Exports							
Petroleum and other liquids[9]	7.3	11.2	15.4	12.6	21.6	13.7	24.3
Natural gas[10]	1.6	4.5	4.6	6.4	10.8	7.4	15.7
Coal	2.9	2.5	2.5	3.3	3.4	3.5	4.0
Total	**11.7**	**18.1**	**22.5**	**22.4**	**35.7**	**24.6**	**44.0**
Discrepancy[11]	**-1.6**	**-0.1**	**-0.1**	**0.2**	**0.1**	**0.3**	**0.3**
Consumption							
Petroleum and other liquids[12]	35.9	37.1	37.5	36.5	37.8	36.2	37.5
Natural gas	26.9	26.8	30.1	28.8	34.4	30.5	38.4
Coal[13]	18.0	19.2	16.3	19.2	16.3	19.0	16.3
Nuclear / uranium[2]	8.3	8.4	8.4	8.5	8.5	8.7	8.5
Conventional hydroelectric power	2.5	2.8	2.8	2.8	2.8	2.8	2.8
Biomass[14]	2.9	3.0	3.1	3.2	3.3	3.5	3.5
Other renewable energy[4]	2.3	3.2	3.2	3.6	3.4	4.6	3.6
Other[15]	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Total	**97.1**	**100.8**	**101.8**	**102.9**	**106.8**	**105.7**	**110.8**
Prices (2013 dollars per unit)							
Crude oil spot prices (dollars per barrel)							
Brent	109	79	76	106	98	141	129
West Texas Intermediate	98	73	64	99	84	136	115
Natural gas at Henry Hub (dollars per million Btu)	3.73	4.88	3.12	5.69	3.67	7.85	4.38
Coal (dollars per ton) at the minemouth[16]	37.2	37.9	37.2	43.7	42.3	49.2	47.8
Coal (dollars per million Btu)							
at the minemouth[16]	1.84	1.88	1.84	2.18	2.10	2.44	2.36
Average end-use[17]	2.50	2.54	2.43	2.84	2.66	3.09	2.88
Average electricity (cents per kilowatthour)	10.1	10.5	10.0	11.1	10.0	11.8	10.3

Table D1. Total energy supply, disposition, and price summary (continued)
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Prices (nominal dollars per unit)							
Crude oil spot prices (dollars per barrel)							
Brent	109	90	85	142	127	229	205
West Texas Intermediate	98	83	72	133	109	220	182
Natural gas at Henry Hub (dollars per million Btu)	3.73	5.54	3.51	7.63	4.76	12.73	6.93
Coal (dollars per ton) at the minemouth[16]	37.2	43.0	41.7	58.6	54.8	79.8	75.6
Coal (dollars per million Btu) at the minemouth[16]	1.84	2.14	2.07	2.92	2.72	3.96	3.73
Average end-use[17]	2.50	2.88	2.73	3.81	3.45	5.00	4.56
Average electricity (cents per kilowatthour)	10.1	11.9	11.2	14.8	13.0	19.2	16.2

[1]Includes waste coal.
[2]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[3]Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table A17 for details.
[4]Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table A17 for selected nonmarketed residential and commercial renewable energy data.
[5]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.
[6]Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.
[7]Includes imports of liquefied natural gas that are later re-exported.
[8]Includes coal, coal coke (net), and electricity (net). Excludes imports of fuel used in nuclear power plants.
[9]Includes crude oil, petroleum products, ethanol, and biodiesel.
[10]Includes re-exported liquefied natural gas.
[11]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[12]Estimated consumption. Includes petroleum-derived fuels and non-petroleum derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel. Refer to Table A17 for detailed renewable liquid fuels consumption.
[13]Excludes coal converted to coal-based synthetic liquids and natural gas.
[14]Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.
[15]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[16]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[17]Prices weighted by consumption; weighted average excludes export free-alongside-ship (f.a.s.) prices.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 natural gas supply values: U.S. Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2013 coal minemouth and delivered coal prices: EIA, *Annual Coal Report 2013*, DOE/EIA-0584(2013) (Washington, DC, January 2015). 2013 petroleum supply values: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). 2013 crude oil spot prices and natural gas spot price at Henry Hub: Thomson Reuters. Other 2013 coal values: *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014). Other 2013 values: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Table D2. Energy consumption by sector and source
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Energy consumption							
Residential							
Propane	0.43	0.32	0.33	0.28	0.28	0.25	0.25
Kerosene	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Distillate fuel oil	0.50	0.40	0.40	0.31	0.31	0.24	0.24
Petroleum and other liquids subtotal	0.93	0.73	0.74	0.59	0.60	0.49	0.49
Natural gas	5.05	4.63	4.75	4.52	4.70	4.31	4.52
Renewable energy[1]	0.58	0.41	0.41	0.38	0.37	0.35	0.35
Electricity	4.75	4.86	4.90	5.08	5.20	5.42	5.61
Delivered energy	**11.32**	**10.63**	**10.80**	**10.57**	**10.86**	**10.57**	**10.97**
Electricity related losses	9.79	9.75	9.53	9.91	9.76	10.33	10.20
Total	**21.10**	**20.38**	**20.33**	**20.48**	**20.62**	**20.91**	**21.17**
Commercial							
Propane	0.15	0.16	0.16	0.17	0.17	0.18	0.18
Motor gasoline[2]	0.05	0.05	0.05	0.05	0.05	0.06	0.06
Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distillate fuel oil	0.37	0.34	0.34	0.30	0.31	0.27	0.28
Residual fuel oil	0.03	0.07	0.07	0.07	0.07	0.06	0.07
Petroleum and other liquids subtotal	0.59	0.62	0.63	0.60	0.61	0.58	0.59
Natural gas	3.37	3.30	3.49	3.43	3.71	3.71	4.11
Coal	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Renewable energy[3]	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Electricity	4.57	4.82	4.85	5.19	5.32	5.66	5.85
Delivered energy	**8.69**	**8.90**	**9.14**	**9.38**	**9.81**	**10.12**	**10.72**
Electricity related losses	9.42	9.68	9.44	10.13	9.99	10.80	10.64
Total	**18.10**	**18.58**	**18.58**	**19.52**	**19.81**	**20.92**	**21.37**
Industrial[4]							
Liquefied petroleum gases and other[5]	2.51	3.20	3.26	3.72	3.81	3.67	3.82
Motor gasoline[2]	0.25	0.26	0.27	0.25	0.29	0.25	0.29
Distillate fuel oil	1.31	1.42	1.41	1.36	1.46	1.35	1.48
Residual fuel oil	0.06	0.10	0.10	0.13	0.12	0.13	0.11
Petrochemical feedstocks	0.74	0.95	0.95	1.14	1.14	1.20	1.12
Other petroleum[6]	3.52	3.67	3.94	3.83	4.28	3.99	4.46
Petroleum and other liquids subtotal	8.40	9.61	9.94	10.44	11.09	10.59	11.29
Natural gas	7.62	8.33	8.56	8.65	9.17	8.90	9.43
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.52	1.87	2.02	2.10	3.05	2.29	3.84
Natural gas subtotal	9.14	10.20	10.58	10.75	12.21	11.19	13.28
Metallurgical coal	0.62	0.61	0.59	0.56	0.59	0.51	0.53
Other industrial coal	0.88	0.93	0.93	0.96	0.97	0.99	1.01
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	0.00	0.00	-0.03	-0.03	-0.06	-0.06
Coal subtotal	1.48	1.54	1.52	1.48	1.53	1.44	1.48
Biofuels heat and coproducts	0.72	0.80	0.81	0.80	0.82	0.86	0.88
Renewable energy[8]	1.48	1.53	1.56	1.59	1.64	1.63	1.70
Electricity	3.26	3.74	3.83	4.04	4.27	4.12	4.35
Delivered energy	**24.48**	**27.42**	**28.24**	**29.10**	**31.55**	**29.82**	**32.98**
Electricity related losses	6.72	7.51	7.45	7.88	8.01	7.85	7.92
Total	**31.20**	**34.93**	**35.69**	**36.98**	**39.56**	**37.68**	**40.90**

Table D2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Transportation							
Propane	0.05	0.04	0.04	0.05	0.05	0.07	0.07
Motor gasoline[2]	15.94	15.35	15.42	13.30	13.56	12.55	12.83
of which: E85[9]	0.02	0.03	0.03	0.20	0.17	0.28	0.28
Jet fuel[10]	2.80	3.01	3.01	3.40	3.42	3.64	3.65
Distillate fuel oil[11]	6.50	7.35	7.42	7.76	8.22	7.97	8.33
Residual fuel oil	0.57	0.35	0.35	0.36	0.36	0.36	0.36
Other petroleum[12]	0.15	0.16	0.16	0.16	0.16	0.16	0.16
Petroleum and other liquids subtotal	26.00	26.27	26.42	25.03	25.77	24.76	25.42
Pipeline fuel natural gas	0.88	0.85	0.93	0.94	1.13	0.96	1.26
Compressed / liquefied natural gas	0.05	0.07	0.07	0.17	0.18	0.71	0.96
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	0.02	0.03	0.03	0.04	0.04	0.06	0.06
Delivered energy	**26.96**	**27.22**	**27.44**	**26.18**	**27.12**	**26.49**	**27.70**
Electricity related losses	0.05	0.06	0.06	0.08	0.08	0.12	0.11
Total	**27.01**	**27.29**	**27.50**	**26.27**	**27.20**	**26.61**	**27.81**
Unspecified sector[13]	**-0.27**	**-0.34**	**-0.34**	**-0.37**	**-0.41**	**-0.38**	**-0.41**
Delivered energy consumption for all sectors							
Liquefied petroleum gases and other[5]	3.14	3.73	3.80	4.23	4.31	4.17	4.33
Motor gasoline[2]	16.36	15.79	15.87	13.72	14.01	12.96	13.28
of which: E85[9]	0.02	0.03	0.03	0.20	0.17	0.28	0.28
Jet fuel[10]	2.97	3.20	3.20	3.61	3.63	3.86	3.88
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.10	8.86	8.92	9.05	9.57	9.13	9.60
Residual fuel oil	0.65	0.53	0.53	0.56	0.55	0.56	0.54
Petrochemical feedstocks	0.74	0.95	0.95	1.14	1.14	1.20	1.12
Other petroleum[14]	3.67	3.82	4.10	3.98	4.44	4.15	4.62
Petroleum and other liquids subtotal	35.65	36.89	37.38	36.30	37.66	36.03	37.38
Natural gas	16.10	16.32	16.86	16.76	17.75	17.64	19.03
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.52	1.87	2.02	2.10	3.05	2.29	3.84
Pipeline natural gas	0.88	0.85	0.93	0.94	1.13	0.96	1.26
Natural gas subtotal	18.50	19.05	19.81	19.80	21.93	20.88	24.13
Metallurgical coal	0.62	0.61	0.59	0.56	0.59	0.51	0.53
Other coal	0.92	0.98	0.98	1.00	1.01	1.04	1.05
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	0.00	0.00	-0.03	-0.03	-0.06	-0.06
Coal subtotal	1.52	1.59	1.57	1.53	1.57	1.49	1.53
Biofuels heat and coproducts	0.72	0.80	0.81	0.80	0.82	0.86	0.88
Renewable energy[15]	2.18	2.06	2.09	2.09	2.13	2.10	2.17
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	12.60	13.45	13.62	14.35	14.83	15.25	15.87
Delivered energy	**71.17**	**73.84**	**75.27**	**74.87**	**78.94**	**76.62**	**81.97**
Electricity related losses	25.97	27.00	26.48	28.01	27.83	29.10	28.87
Total	**97.14**	**100.84**	**101.75**	**102.87**	**106.78**	**105.73**	**110.84**
Electric power[16]							
Distillate fuel oil	0.05	0.09	0.08	0.08	0.07	0.08	0.07
Residual fuel oil	0.21	0.08	0.09	0.09	0.09	0.09	0.10
Petroleum and other liquids subtotal	0.26	0.17	0.16	0.17	0.16	0.18	0.17
Natural gas	8.36	7.80	10.29	9.03	12.46	9.61	14.24
Steam coal	16.49	17.59	14.77	17.63	14.78	17.52	14.76
Nuclear / uranium[17]	8.27	8.42	8.42	8.47	8.46	8.73	8.46
Renewable energy[18]	4.78	6.13	6.11	6.72	6.50	7.99	6.82
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.18	0.11	0.11	0.10	0.08	0.11	0.07
Total	**38.57**	**40.45**	**40.10**	**42.35**	**42.67**	**44.36**	**44.74**

Table D2. Energy consumption by sector and source (continued)
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Total energy consumption							
Liquefied petroleum gases and other[5]	3.14	3.73	3.80	4.23	4.31	4.17	4.33
Motor gasoline[2]	16.36	15.79	15.87	13.72	14.01	12.96	13.28
of which: E85[9]	0.02	0.03	0.03	0.20	0.17	0.28	0.28
Jet fuel[10]	2.97	3.20	3.20	3.61	3.63	3.86	3.88
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.15	8.95	9.00	9.13	9.65	9.21	9.67
Residual fuel oil	0.87	0.61	0.61	0.64	0.64	0.65	0.64
Petrochemical feedstocks	0.74	0.95	0.95	1.14	1.14	1.20	1.12
Other petroleum[14]	3.67	3.82	4.10	3.98	4.44	4.15	4.62
Petroleum and other liquids subtotal	35.91	37.06	37.54	36.47	37.82	36.21	37.54
Natural gas	24.46	24.12	27.15	25.79	30.21	27.25	33.27
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.52	1.87	2.02	2.10	3.05	2.29	3.84
Pipeline natural gas	0.88	0.85	0.93	0.94	1.13	0.96	1.26
Natural gas subtotal	26.86	26.85	30.10	28.83	34.39	30.50	38.37
Metallurgical coal	0.62	0.61	0.59	0.56	0.59	0.51	0.53
Other coal	17.41	18.57	15.75	18.63	15.79	18.56	15.81
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	0.00	0.00	-0.03	-0.03	-0.06	-0.06
Coal subtotal	18.01	19.18	16.34	19.16	16.35	19.01	16.29
Nuclear / uranium[17]	8.27	8.42	8.42	8.47	8.46	8.73	8.46
Biofuels heat and coproducts	0.72	0.80	0.81	0.80	0.82	0.86	0.88
Renewable energy[19]	6.96	8.19	8.20	8.81	8.63	10.09	8.99
Liquid hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.18	0.11	0.11	0.10	0.08	0.11	0.07
Total	**97.14**	**100.84**	**101.75**	**102.87**	**106.78**	**105.73**	**110.84**
Energy use and related statistics							
Delivered energy use	71.17	73.84	75.27	74.87	78.94	76.62	81.97
Total energy use	97.14	100.84	101.75	102.87	106.78	105.73	110.84
Ethanol consumed in motor gasoline and E85	1.12	1.12	1.13	1.12	1.13	1.27	1.30
Population (millions)	317	334	334	359	359	380	380
Gross domestic product (billion 2009 dollars)	15,710	18,801	18,841	23,894	24,222	29,898	30,236
Carbon dioxide emissions (million metric tons)	5,405	5,499	5,435	5,514	5,636	5,549	5,800

[1]Includes wood used for residential heating. See Table A4 and/or Table A17 for estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal water heating, and electricity generation from wind and solar photovoltaic sources.
[2]Includes ethanol and ethers blended into gasoline.
[3]Excludes ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. See Table A5 and/or Table A17 for estimates of nonmarketed renewable energy consumption for solar thermal water heating and electricity generation from wind and solar photovoltaic sources.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[5]Includes ethane, natural gasoline, and refinery olefins.
[6]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Represents natural gas used in well, field, and lease operations, in natural gas processing plant machinery, and for liquefaction in export facilities.
[8]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[9]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[10]Includes only kerosene type.
[11]Diesel fuel for on- and off- road use.
[12]Includes aviation gasoline and lubricants.
[13]Represents consumption unattributed to the sectors above.
[14]Includes aviation gasoline, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[15]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[16]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[17]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[18]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[19]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
Btu = British thermal unit.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE-EIA-0035(2014/11) (Washington, DC, November 2014). 2013 population and gross domestic product: IHS Economics, Industry and Employment models, November 2014. 2013 carbon dioxide emissions and emission factors: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Table D3. Energy prices by sector and source
(2013 dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Residential							
Propane	23.3	23.0	22.2	24.4	23.9	26.6	25.6
Distillate fuel oil	27.2	21.5	20.9	26.3	24.9	32.9	31.3
Natural gas	10.0	11.6	9.6	12.8	10.4	15.5	11.9
Electricity	35.6	37.8	36.1	40.0	36.9	42.4	37.6
Commercial							
Propane	20.0	19.4	18.5	21.1	20.4	23.9	22.6
Distillate fuel oil	26.7	21.0	20.3	25.8	24.3	32.5	31.0
Residual fuel oil	22.1	14.2	13.5	18.1	16.7	24.3	22.1
Natural gas	8.1	9.6	7.6	10.4	8.1	12.6	9.0
Electricity	29.7	31.1	29.6	32.6	29.4	34.5	29.8
Industrial[1]							
Propane	20.3	19.6	18.7	21.5	20.8	24.5	23.0
Distillate fuel oil	27.3	21.2	20.5	26.1	24.5	32.7	31.3
Residual fuel oil	20.0	13.3	12.6	17.2	15.7	23.5	21.1
Natural gas[2]	4.6	6.2	4.3	6.8	4.6	8.8	5.2
Metallurgical coal	5.5	5.8	5.8	6.7	6.6	7.2	7.1
Other industrial coal	3.2	3.3	3.2	3.6	3.4	3.9	3.7
Coal to liquids	- -	- -	- -	- -	- -	- -	- -
Electricity	20.2	21.3	19.9	22.6	20.0	24.7	20.7
Transportation							
Propane	24.6	24.0	23.3	25.5	24.9	27.6	26.6
E85[3]	33.1	30.4	29.9	31.2	30.2	35.4	34.5
Motor gasoline[4]	29.3	22.5	21.8	26.4	25.0	32.3	31.2
Jet fuel[5]	21.8	16.1	15.5	21.3	19.4	28.3	26.1
Diesel fuel (distillate fuel oil)[6]	28.2	23.1	22.5	28.0	26.4	34.7	33.2
Residual fuel oil	19.3	11.7	11.1	15.4	14.1	20.3	19.0
Natural gas[7]	17.6	17.8	16.0	15.7	13.9	19.6	16.8
Electricity	28.5	30.2	28.2	32.9	28.9	36.0	30.5
Electric power[8]							
Distillate fuel oil	24.0	18.8	18.1	23.6	22.1	30.2	28.7
Residual fuel oil	18.9	11.5	10.7	15.4	14.0	21.6	19.3
Natural gas	4.4	5.4	3.7	6.2	4.1	8.3	4.7
Steam coal	2.3	2.4	2.2	2.7	2.4	2.9	2.7
Average price to all users[9]							
Propane	21.9	21.1	20.2	22.6	21.9	25.2	23.9
E85[3]	33.1	30.4	29.9	31.2	30.2	35.4	34.5
Motor gasoline[4]	29.0	22.5	21.8	26.4	25.0	32.3	31.2
Jet fuel[5]	21.8	16.1	15.5	21.3	19.4	28.3	26.1
Distillate fuel oil	27.9	22.6	22.0	27.6	26.0	34.2	32.8
Residual fuel oil	19.4	12.2	11.6	16.0	14.7	21.5	19.8
Natural gas	6.1	7.5	5.4	8.2	5.8	10.5	6.7
Metallurgical coal	5.5	5.8	5.8	6.7	6.6	7.2	7.1
Other coal	2.4	2.4	2.3	2.7	2.5	3.0	2.7
Coal to liquids	- -	- -	- -	- -	- -	- -	- -
Electricity	29.5	30.8	29.2	32.4	29.3	34.7	30.1
Non-renewable energy expenditures by sector (billion 2013 dollars)							
Residential	243	254	238	276	256	311	278
Commercial	177	194	182	219	200	259	228
Industrial[1]	224	264	242	323	298	389	348
Transportation	719	565	550	638	619	791	781
Total non-renewable expenditures	1,364	1,276	1,213	1,456	1,373	1,751	1,635
Transportation renewable expenditures	1	1	1	6	5	10	10
Total expenditures	**1,364**	**1,277**	**1,214**	**1,462**	**1,378**	**1,761**	**1,645**

Table D3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Residential							
Propane	23.3	26.1	25.0	32.8	31.0	43.1	40.4
Distillate fuel oil	27.2	24.4	23.4	35.3	32.3	53.3	49.5
Natural gas	10.0	13.2	10.8	17.1	13.5	25.1	18.8
Electricity	35.6	42.9	40.5	53.6	47.9	68.8	59.4
Commercial							
Propane	20.0	22.0	20.7	28.3	26.5	38.8	35.7
Distillate fuel oil	26.7	23.8	22.8	34.6	31.5	52.6	49.1
Residual fuel oil	22.1	16.1	15.1	24.3	21.7	39.4	34.9
Natural gas	8.1	10.8	8.5	13.9	10.5	20.5	14.2
Electricity	29.7	35.3	33.2	43.7	38.1	56.0	47.1
Industrial[1]							
Propane	20.3	22.3	21.0	28.8	26.9	39.7	36.4
Distillate fuel oil	27.3	24.1	23.0	35.0	31.8	53.0	49.4
Residual fuel oil	20.0	15.1	14.2	23.1	20.4	38.0	33.4
Natural gas[2]	4.6	7.0	4.8	9.1	6.0	14.2	8.3
Metallurgical coal	5.5	6.6	6.5	8.9	8.5	11.6	11.2
Other industrial coal	3.2	3.8	3.6	4.8	4.5	6.3	5.9
Coal to liquids	- -	- -	- -	- -	- -	- -	- -
Electricity	20.2	24.2	22.3	30.3	26.0	40.0	32.7
Transportation							
Propane	24.6	27.2	26.1	34.1	32.3	44.8	42.0
E85[3]	33.1	34.4	33.5	41.9	39.3	57.4	54.6
Motor gasoline[4]	29.3	25.5	24.5	35.3	32.4	52.4	49.4
Jet fuel[5]	21.8	18.3	17.3	28.6	25.2	45.8	41.2
Diesel fuel (distillate fuel oil)[6]	28.2	26.2	25.2	37.6	34.3	56.2	52.5
Residual fuel oil	19.3	13.2	12.4	20.6	18.4	32.9	30.1
Natural gas[7]	17.6	20.2	18.0	21.0	18.0	31.8	26.5
Electricity	28.5	34.3	31.7	44.1	37.5	58.4	48.2
Electric power[8]							
Distillate fuel oil	24.0	21.3	20.3	31.7	28.7	49.0	45.4
Residual fuel oil	18.9	13.0	12.0	20.6	18.2	35.0	30.6
Natural gas	4.4	6.1	4.1	8.3	5.4	13.4	7.4
Steam coal	2.3	2.7	2.5	3.6	3.2	4.7	4.2

Table D3. Energy prices by sector and source (continued)
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Average price to all users[9]							
Propane	21.9	23.9	22.6	30.3	28.4	40.9	37.7
E85[3]	33.1	34.4	33.5	41.9	39.3	57.4	54.6
Motor gasoline[4]	29.0	25.5	24.5	35.3	32.4	52.4	49.4
Jet fuel[5]	21.8	18.3	17.3	28.6	25.2	45.8	41.2
Distillate fuel oil	27.9	25.7	24.6	36.9	33.7	55.5	51.9
Residual fuel oil	19.4	13.8	13.0	21.5	19.1	34.8	31.2
Natural gas	6.1	8.5	6.1	11.0	7.5	17.0	10.6
Metallurgical coal	5.5	6.6	6.5	8.9	8.5	11.6	11.2
Other coal	2.4	2.8	2.6	3.7	3.3	4.8	4.3
Coal to liquids	- -	- -	- -	- -	- -	- -	- -
Electricity	29.5	34.9	32.8	43.4	38.1	56.2	47.5
Non-renewable energy expenditures by sector (billion nominal dollars)							
Residential	243	288	268	370	332	504	440
Commercial	177	220	205	294	260	420	360
Industrial[1]	224	299	272	433	387	631	551
Transportation	719	641	617	855	803	1,283	1,235
Total non-renewable expenditures	1,364	1,448	1,361	1,952	1,782	2,839	2,586
Transportation renewable expenditures	1	1	1	8	7	16	15
Total expenditures	**1,364**	**1,449**	**1,362**	**1,960**	**1,788**	**2,855**	**2,601**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Excludes use for lease and plant fuel.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Kerosene-type jet fuel. Includes Federal and State taxes while excluding county and local taxes.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Natural gas used as fuel in motor vehicles, trains, and ships. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[8]Includes electricity-only and combined heat and power plants that have a regulatory status.
[9]Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
- - = Not applicable.
Note: Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 prices for motor gasoline, distillate fuel oil, and jet fuel are based on prices in the U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2013 residential, commercial, and industrial natural gas delivered prices: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). 2013 transportation sector natural gas delivered prices are model results. 2013 electric power sector distillate and residual fuel oil prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 electric power sector natural gas prices: EIA, *Electric Power Monthly*, DOE/EIA-0226, April 2013 and April 2014, Table 4.2, and EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014). 2013 coal prices based on: EIA, *Quarterly Coal Report, October-December 2013*, DOE/EIA-0121(2013/4Q) (Washington, DC, March 2014) and EIA, AEO2015 National Energy Modeling System run REF2015.D021915A. 2013 electricity prices: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 E85 prices derived from monthly prices in the Clean Cities Alternative Fuel Price Report. **Projections:** EIA, AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Table D4. Petroleum and other liquids supply and disposition
(million barrels per day, unless otherwise noted)

Supply and disposition	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Crude oil							
Domestic crude production[1]	7.44	10.60	12.61	10.04	15.64	9.43	16.59
Alaska	0.52	0.42	0.42	0.24	0.24	0.34	0.14
Lower 48 states	6.92	10.18	12.19	9.80	15.40	9.09	16.45
Net imports	7.60	5.51	5.16	6.44	4.02	7.58	4.08
Gross imports	7.73	6.14	6.03	7.07	5.18	8.21	5.02
Exports	0.13	0.63	0.87	0.63	1.16	0.63	0.94
Other crude supply[2]	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Total crude supply	**15.30**	**16.11**	**17.77**	**16.48**	**19.66**	**17.01**	**20.67**
Net product imports	-1.37	-2.80	-5.03	-3.56	-7.86	-4.26	-9.89
Gross refined product imports[3]	0.82	1.21	1.03	1.31	1.27	1.26	1.12
Unfinished oil imports	0.66	0.60	0.60	0.52	0.52	0.45	0.45
Blending component imports	0.60	0.59	0.58	0.49	0.57	0.40	0.52
Exports	3.43	5.20	7.24	5.89	10.22	6.36	11.97
Refinery processing gain[4]	1.09	0.98	1.14	0.97	1.10	0.98	1.06
Product stock withdrawal	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas plant liquids	2.61	4.04	4.65	4.19	5.78	4.07	6.59
Supply from renewable sources	0.93	1.01	1.02	1.01	1.01	1.12	1.14
Ethanol	0.83	0.84	0.85	0.84	0.84	0.95	0.97
Domestic production	0.85	0.86	0.87	0.86	0.88	0.93	0.96
Net imports	-0.02	-0.02	-0.03	-0.02	-0.03	0.02	0.02
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biodiesel	0.10	0.14	0.14	0.11	0.09	0.11	0.09
Domestic production	0.09	0.13	0.13	0.10	0.08	0.10	0.08
Net imports	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other biomass-derived liquids[5]	0.00	0.03	0.03	0.06	0.08	0.06	0.08
Domestic production	0.00	0.03	0.03	0.06	0.08	0.06	0.08
Net imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquids from gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquids from coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other[6]	0.21	0.28	0.30	0.30	0.34	0.32	0.34
Total primary supply[7]	**18.87**	**19.62**	**19.84**	**19.38**	**20.03**	**19.24**	**19.90**
Product supplied							
by fuel							
Liquefied petroleum gases and other[8]	2.50	2.91	2.95	3.30	3.38	3.25	3.39
Motor gasoline[9]	8.85	8.49	8.53	7.41	7.56	7.05	7.22
of which: E85[10]	0.01	0.02	0.02	0.13	0.12	0.19	0.19
Jet fuel[11]	1.43	1.55	1.55	1.75	1.76	1.87	1.88
Distillate fuel oil[12]	3.83	4.26	4.28	4.34	4.59	4.38	4.60
of which: Diesel	3.56	3.94	3.97	4.09	4.33	4.17	4.38
Residual fuel oil	0.32	0.27	0.27	0.28	0.28	0.28	0.28
Other[13]	2.04	2.18	2.29	2.33	2.53	2.43	2.60
by sector							
Residential and commercial	0.86	0.76	0.76	0.67	0.68	0.61	0.62
Industrial[14]	4.69	5.50	5.65	6.04	6.37	6.09	6.47
Transportation	13.36	13.46	13.54	12.79	13.15	12.66	13.00
Electric power[15]	0.12	0.08	0.07	0.08	0.07	0.08	0.08
Unspecified sector[16]	-0.12	-0.15	-0.15	-0.17	-0.19	-0.17	-0.19
Total product supplied	**18.96**	**19.65**	**19.87**	**19.41**	**20.09**	**19.27**	**19.97**
Discrepancy[17]	-0.10	-0.03	-0.03	-0.03	-0.06	-0.03	-0.07

Table D4. Petroleum and other liquids supply and disposition (continued)
(million barrels per day, unless otherwise noted)

Supply and disposition	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Domestic refinery distillation capacity[18]	17.8	18.8	19.0	18.8	20.1	18.8	20.9
Capacity utilization rate (percent)[19]	88.3	87.8	95.6	89.4	99.8	92.0	100.4
Net import share of product supplied (percent)	33.0	13.7	0.6	14.8	-19.3	17.4	-29.1
Net expenditures for imported crude oil and petroleum products (billion 2013 dollars)	308	167	153	259	165	405	214

[1]Includes lease condensate.
[2]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude oil stock withdrawals.
[3]Includes other hydrocarbons and alcohols.
[4]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[5]Includes pyrolysis oils, biomass-derived Fischer-Tropsch liquids, biobutanol, and renewable feedstocks used for the on-site production of diesel and gasoline.
[6]Includes domestic sources of other blending components, other hydrocarbons, and ethers.
[7]Total crude supply, net product imports, refinery processing gain, product stock withdrawal, natural gas plant liquids, supply from renewable sources, liquids from gas, liquids from coal, and other supply.
[8]Includes ethane, natural gasoline, and refinery olefins.
[9]Includes ethanol and ethers blended into gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Includes distillate fuel oil from petroleum and biomass feedstocks.
[13]Includes kerosene, aviation gasoline, petrochemical feedstocks, lubricants, waxes, asphalt, road oil, still gas, special naphthas, petroleum coke, crude oil product supplied, methanol, and miscellaneous petroleum products.
[14]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[15]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[16]Represents consumption unattributed to the sectors above.
[17]Balancing item. Includes unaccounted for supply, losses, and gains.
[18]End-of-year operable capacity.
[19]Rate is calculated by dividing the gross annual input to atmospheric crude oil distillation units by their operable refining capacity in barrels per calendar day.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 product supplied based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). Other 2013 data: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). **Projections:** EIA, AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Table D5. Petroleum and other liquids prices
(2013 dollars per gallon, unless otherwise noted)

Sector and fuel	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Crude oil prices (2013 dollars per barrel)							
Brent spot	109	79	76	106	98	141	129
West Texas Intermediate spot	98	73	64	99	84	136	115
Average imported refiners acquisition cost[1]	98	71	66	96	82	131	111
Brent / West Texas Intermediate spread	10.7	6.2	11.3	6.2	14.1	5.6	14.1
Delivered sector product prices							
Residential							
Propane	2.13	2.10	2.03	2.23	2.18	2.43	2.33
Distillate fuel oil	3.78	2.99	2.89	3.65	3.45	4.56	4.34
Commercial							
Distillate fuel oil	3.68	2.89	2.80	3.56	3.35	4.47	4.28
Residual fuel oil	3.31	2.12	2.02	2.71	2.50	3.64	3.31
Residual fuel oil (2013 dollars per barrel)	139	89	85	114	105	153	139
Industrial[2]							
Propane	1.85	1.79	1.70	1.96	1.90	2.24	2.10
Distillate fuel oil	3.75	2.91	2.82	3.58	3.36	4.49	4.29
Residual fuel oil	3.00	2.00	1.89	2.58	2.36	3.51	3.16
Residual fuel oil (2013 dollars per barrel)	126	84	79	108	99	147	133
Transportation							
Propane	2.24	2.19	2.12	2.32	2.27	2.52	2.43
E85[3]	3.14	2.90	2.85	2.98	2.88	3.38	3.29
Ethanol wholesale price	2.37	2.49	2.42	2.35	2.28	2.64	2.53
Motor gasoline[4]	3.55	2.74	2.65	3.20	3.03	3.90	3.77
Jet fuel[5]	2.94	2.17	2.09	2.88	2.62	3.81	3.52
Diesel fuel (distillate fuel oil)[6]	3.86	3.17	3.08	3.84	3.62	4.75	4.55
Residual fuel oil	2.89	1.74	1.66	2.30	2.12	3.03	2.85
Residual fuel oil (2013 dollars per barrel)	122	73	70	97	89	127	120
Electric power[7]							
Distillate fuel oil	3.33	2.60	2.51	3.28	3.07	4.19	3.98
Residual fuel oil	2.83	1.71	1.61	2.30	2.09	3.23	2.90
Residual fuel oil (2013 dollars per barrel)	119	72	67	97	88	136	122
Average prices, all sectors[8]							
Propane	2.00	1.93	1.84	2.06	2.00	2.30	2.18
Motor gasoline[4]	3.53	2.74	2.65	3.20	3.03	3.90	3.77
Jet fuel[5]	2.94	2.17	2.09	2.88	2.62	3.81	3.52
Distillate fuel oil	3.83	3.11	3.01	3.78	3.57	4.69	4.50
Residual fuel oil	2.90	1.83	1.73	2.40	2.20	3.22	2.96
Residual fuel oil (2013 dollars per barrel)	122	77	73	101	92	135	124
Average	**3.16**	**2.46**	**2.37**	**2.89**	**2.73**	**3.62**	**3.44**

Table D5. Petroleum and other liquids prices (continued)
(nominal dollars per gallon, unless otherwise noted)

Sector and fuel	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Crude oil prices (nominal dollars per barrel)							
Brent spot	109	90	85	142	127	229	205
West Texas Intermediate spot	98	83	72	133	109	220	182
Average imported refiners acquisition cost[1]	98	80	74	129	107	212	175
Delivered sector product prices							
Residential							
Propane	2.13	2.38	2.28	2.99	2.83	3.94	3.69
Distillate fuel oil	3.78	3.39	3.25	4.90	4.48	7.40	6.87
Commercial							
Distillate fuel oil	3.68	3.28	3.14	4.78	4.35	7.25	6.76
Residual fuel oil	3.31	2.41	2.26	3.63	3.25	5.90	5.23
Industrial[2]							
Propane	1.85	2.04	1.91	2.63	2.46	3.62	3.33
Distillate fuel oil	3.75	3.30	3.16	4.80	4.37	7.28	6.78
Residual fuel oil	3.00	2.26	2.12	3.46	3.06	5.69	4.99
Transportation							
Propane	2.24	2.49	2.38	3.12	2.95	4.09	3.84
E85[3]	3.14	3.29	3.20	3.99	3.74	5.48	5.21
Ethanol wholesale price	2.37	2.83	2.72	3.15	2.96	4.27	4.00
Motor gasoline[4]	3.55	3.10	2.98	4.29	3.93	6.32	5.96
Jet fuel[5]	2.94	2.47	2.34	3.86	3.40	6.18	5.57
Diesel fuel (distillate fuel oil)[6]	3.86	3.60	3.45	5.15	4.70	7.70	7.20
Residual fuel oil	2.89	1.98	1.86	3.08	2.75	4.92	4.50
Electric power[7]							
Distillate fuel oil	3.33	2.95	2.82	4.39	3.98	6.79	6.30
Residual fuel oil	2.83	1.94	1.80	3.09	2.72	5.24	4.58
Average prices, all sectors[8]							
Propane	2.00	2.19	2.07	2.77	2.59	3.73	3.45
Motor gasoline[4]	3.53	3.10	2.98	4.29	3.93	6.32	5.95
Jet fuel[5]	2.94	2.47	2.34	3.86	3.40	6.18	5.57
Distillate fuel oil	3.83	3.52	3.38	5.07	4.63	7.61	7.12
Residual fuel oil (nominal dollars per barrel)	122	87	82	135	120	219	196
Average	**3.16**	**2.79**	**2.66**	**3.88**	**3.54**	**5.86**	**5.43**

[1]Weighted average price delivered to U.S. refiners.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Includes only kerosene type.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Includes electricity-only and combined heat and power plants that have a regulatory status.
[8]Weighted averages of end-use fuel prices are derived from the prices in each sector and the corresponding sectoral consumption.
Note: Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. 2013 average imported crude oil price: Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 prices for motor gasoline, distillate fuel oil, and jet fuel are based on: EIA, *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2013 residential, commercial, industrial, and transportation sector petroleum product prices are derived from: EIA, Form EIA-782A, "Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales Report." 2013 electric power prices based on: *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 E85 prices derived from monthly prices in the Clean Cities Alternative Fuel Price Report. 2013 wholesale ethanol prices derived from Bloomberg U.S. average rack price. **Projections:** EIA, AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Table D6. Natural gas supply, disposition, and prices
(trillion cubic feet, unless otherwise noted)

Supply, disposition, and prices	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Supply							
Dry gas production[1]	24.40	28.82	32.18	33.01	42.66	35.45	50.61
Supplemental natural gas[2]	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Net imports	1.29	-2.55	-2.74	-4.81	-9.03	-5.62	-13.11
Pipeline[3]	1.20	-0.48	-0.66	-1.52	-1.78	-2.33	-2.85
Liquefied natural gas	0.09	-2.08	-2.08	-3.29	-7.26	-3.29	-10.26
Total supply	**25.75**	**26.33**	**29.51**	**28.27**	**33.69**	**29.90**	**37.57**
Consumption by sector							
Residential	4.92	4.50	4.62	4.40	4.57	4.20	4.40
Commercial	3.28	3.21	3.39	3.33	3.61	3.61	4.00
Industrial[4]	7.41	8.10	8.32	8.41	8.92	8.66	9.18
Natural gas-to-liquids heat and power[5]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas-to-liquids production[6]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric power[7]	8.16	7.61	10.04	8.81	12.16	9.38	13.89
Transportation[8]	0.05	0.07	0.07	0.17	0.18	0.70	0.94
Pipeline fuel	0.86	0.83	0.90	0.91	1.10	0.93	1.22
Lease and plant fuel[9]	1.48	1.82	1.97	2.05	2.97	2.23	3.74
Total consumption	**26.16**	**26.14**	**29.32**	**28.08**	**33.50**	**29.70**	**37.38**
Discrepancy[10]	**-0.41**	**0.19**	**0.19**	**0.19**	**0.19**	**0.19**	**0.19**
Natural gas spot price at Henry Hub							
(2013 dollars per million Btu)	3.73	4.88	3.12	5.69	3.67	7.85	4.38
(nominal dollars per million Btu)	3.73	5.54	3.51	7.63	4.76	12.73	6.93
Delivered prices							
(2013 dollars per thousand cubic feet)							
Residential	10.29	11.92	9.90	13.15	10.72	15.90	12.21
Commercial	8.35	9.82	7.83	10.69	8.31	12.97	9.24
Industrial[4]	4.68	6.35	4.40	6.99	4.78	9.03	5.37
Electric power[7]	4.51	5.52	3.77	6.38	4.25	8.49	4.79
Transportation[11]	18.13	18.27	16.49	16.13	14.27	20.18	17.24
Average[12]	**6.32**	**7.66**	**5.59**	**8.40**	**5.97**	**10.76**	**6.87**
(nominal dollars per thousand cubic feet)							
Residential	10.29	13.52	11.11	17.62	13.91	25.77	19.31
Commercial	8.35	11.14	8.79	14.33	10.78	21.03	14.61
Industrial[4]	4.68	7.20	4.94	9.37	6.20	14.64	8.49
Electric power[7]	4.51	6.26	4.24	8.55	5.52	13.76	7.57
Transportation[11]	18.13	20.73	18.51	21.62	18.52	32.72	27.26
Average[12]	**6.32**	**8.68**	**6.28**	**11.27**	**7.75**	**17.44**	**10.87**

[1]Marketed production (wet) minus extraction losses.
[2]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
[3]Includes any natural gas regasified in the Bahamas and transported via pipeline to Florida, as well as gas from Canada and Mexico.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems. Excludes use for lease and plant fuel.
[5]Includes any natural gas used in the process of converting natural gas to liquid fuel that is not actually converted.
[6]Includes any natural gas converted into liquid fuel.
[7]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[8]Natural gas used as fuel in motor vehicles, trains, and ships.
[9]Represents natural gas used in well, field, and lease operations, in natural gas processing plant machinery, and for liquefaction in export facilities.
[10]Balancing item. Natural gas lost as a result of converting flow data measured at varying temperatures and pressures to a standard temperature and pressure and the merger of different data reporting systems which vary in scope, format, definition, and respondent type. In addition, 2013 values include net storage injections.
[11]Natural gas used as fuel in motor vehicles, trains, and ships. Price includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[12]Weighted average prices. Weights used are the sectoral consumption values excluding lease, plant, and pipeline fuel.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 supply values; lease, plant, and pipeline fuel consumption; and residential, commercial, and industrial delivered prices: U.S. Energy Information Administration (EIA), *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). Other 2013 consumption based on: EIA, *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014). 2013 natural gas spot price at Henry Hub: Thomson Reuters. 2013 electric power prices: EIA, *Electric Power Monthly*, DOE/EIA-0226, April 2013 and April 2014, Table 4.2, and EIA, *State Energy Data Report 2012*, DOE/EIA-0214(2012) (Washington, DC, June 2014). 2013 transportation sector delivered prices are model results. **Projections:** EIA, AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Table D7. Oil and gas supply

Production and supply	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Crude oil							
Lower 48 average wellhead price[1]							
(2013 dollars per barrel)	**97**	**75**	**67**	**101**	**85**	**136**	**117**
Production (million barrels per day)[2]							
United States total	7.44	10.60	12.61	10.04	15.64	9.43	16.59
Lower 48 onshore	5.57	8.03	9.88	7.60	13.03	6.92	14.03
Tight oil[3]	3.15	5.60	7.45	4.83	10.23	4.29	11.56
Carbon dioxide enhanced oil recovery	0.28	0.35	0.32	0.58	0.46	0.83	0.44
Other	2.14	2.08	2.12	2.19	2.34	1.80	2.03
Lower 48 offshore	1.36	2.15	2.31	2.21	2.37	2.17	2.42
State	0.07	0.05	0.05	0.03	0.03	0.02	0.02
Federal	1.29	2.10	2.26	2.18	2.34	2.14	2.39
Alaska	0.52	0.42	0.42	0.24	0.24	0.34	0.14
Onshore	0.45	0.30	0.30	0.18	0.18	0.12	0.12
State offshore	0.06	0.12	0.12	0.06	0.06	0.02	0.02
Federal offshore	0.00	0.00	0.00	0.00	0.00	0.20	0.00
Lower 48 end of year reserves[2]							
(billion barrels)	**29.4**	**37.4**	**40.6**	**42.6**	**55.2**	**44.8**	**62.7**
Natural gas plant liquids production							
(million barrels per day)							
United States total	2.61	4.04	4.65	4.20	5.78	4.07	6.59
Lower 48 onshore	2.39	3.82	4.42	3.92	5.50	3.79	6.31
Lower 48 offshore	0.18	0.19	0.20	0.26	0.26	0.26	0.27
Alaska	0.03	0.02	0.02	0.01	0.01	0.02	0.01
Natural gas							
Natural gas spot price at Henry Hub							
(2013 dollars per million Btu)	**3.73**	**4.88**	**3.12**	**5.69**	**3.67**	**7.85**	**4.38**
Dry production (trillion cubic feet)[4]							
United States total	24.40	28.82	32.18	33.01	42.66	35.45	50.61
Lower 48 onshore	22.63	26.52	29.78	29.05	39.66	31.49	47.47
Tight gas	4.38	5.21	5.44	5.99	7.06	6.97	8.14
Shale gas and tight oil plays[3]	11.34	15.44	18.82	17.85	27.50	19.58	34.57
Coalbed methane	1.29	1.45	1.25	1.24	1.16	1.25	1.13
Other	5.61	4.42	4.27	3.97	3.95	3.69	3.63
Lower 48 offshore	1.46	2.03	2.14	2.79	2.77	2.81	2.95
State	0.11	0.06	0.06	0.03	0.03	0.02	0.02
Federal	1.35	1.98	2.08	2.76	2.74	2.79	2.93
Alaska	0.32	0.27	0.27	1.18	0.23	1.15	0.19
Onshore	0.32	0.27	0.27	1.18	0.23	1.15	0.19
State offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Federal offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower 48 end of year dry reserves[4]							
(trillion cubic feet)	**293**	**309**	**329**	**329**	**382**	**345**	**435**
Supplemental gas supplies (trillion cubic feet)[5]	**0.05**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**
Total lower 48 wells drilled (thousands)	**44.5**	**43.4**	**47.1**	**52.1**	**62.3**	**56.7**	**61.5**

[1]Represents lower 48 onshore and offshore supplies.
[2]Includes lease condensate.
[3]Tight oil represents resources in low-permeability reservoirs, including shale and chalk formations. The specific plays included in the tight oil category are Bakken/Three Forks/Sanish, Eagle Ford, Woodford, Austin Chalk, Spraberry, Niobrara, Avalon/Bone Springs, and Monterey.
[4]Marketed production (wet) minus extraction losses.
[5]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 crude oil lower 48 average wellhead price: U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, DOE/EIA-0380(2014/08) (Washington, DC, August 2014). 2013 lower 48 onshore, lower 48 offshore, and Alaska crude oil production: EIA, *Petroleum Supply Annual 2013*, DOE/EIA-0340(2013)/1 (Washington, DC, September 2014). 2013 natural gas spot price at Henry Hub: Thomson Reuters. 2013 Alaska and total natural gas production, and supplemental gas supplies: EIA, *Natural Gas Monthly*, DOE/EIA-0130(2014/07) (Washington, DC, July 2014). Other 2013 values: EIA, Office of Energy Analysis. **Projections:** EIA, AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B.

Table D8. International petroleum and other liquids supply, disposition, and prices
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Crude oil spot prices							
(2013 dollars per barrel)							
Brent	109	79	76	106	98	141	129
West Texas Intermediate	98	73	64	99	84	136	115
(nominal dollars per barrel)							
Brent	109	90	85	142	127	229	205
West Texas Intermediate	98	83	72	133	109	220	182
Petroleum and other liquids consumption[1]							
OECD							
United States (50 states)	18.96	19.65	19.87	19.41	20.09	19.27	19.97
United States territories	0.30	0.31	0.31	0.34	0.34	0.38	0.38
Canada	2.29	2.31	2.31	2.21	2.21	2.14	2.14
Mexico and Chile	2.46	2.71	2.71	2.80	2.80	2.92	2.92
OECD Europe[2]	13.96	14.20	14.20	14.09	14.09	14.12	14.12
Japan	4.56	4.27	4.27	4.03	4.03	3.65	3.65
South Korea	2.43	2.58	2.58	2.53	2.53	2.40	2.40
Australia and New Zealand	1.16	1.16	1.16	1.11	1.11	1.15	1.15
Total OECD consumption	**46.14**	**47.20**	**47.43**	**46.52**	**47.20**	**46.04**	**46.74**
Non-OECD							
Russia	3.30	3.31	3.31	3.23	3.23	3.01	3.01
Other Europe and Eurasia[3]	2.06	2.22	2.22	2.39	2.39	2.59	2.59
China	10.67	13.13	13.13	17.03	17.03	20.19	20.19
India	3.70	4.30	4.30	5.52	5.52	6.79	6.79
Other Asia[4]	7.37	9.08	9.08	12.35	12.35	16.49	16.49
Middle East	7.61	8.40	8.40	9.56	9.56	11.13	11.13
Africa	3.42	3.93	3.93	4.78	4.78	6.18	6.18
Brazil	3.11	3.33	3.33	3.74	3.74	4.50	4.50
Other Central and South America	3.38	3.49	3.49	3.72	3.72	4.15	4.15
Total non-OECD consumption	**44.60**	**51.20**	**51.20**	**62.31**	**62.31**	**75.01**	**75.01**
Total consumption	**90.7**	**98.4**	**98.6**	**108.8**	**109.5**	**121.0**	**121.8**
Petroleum and other liquids production							
OPEC[5]							
Middle East	26.32	24.56	21.99	29.34	22.69	36.14	27.03
North Africa	2.90	3.51	3.51	3.67	3.67	4.06	4.06
West Africa	4.26	5.00	5.00	5.24	5.24	5.43	5.43
South America	3.01	3.10	3.10	3.27	3.27	3.79	3.79
Total OPEC production	**36.49**	**36.16**	**33.59**	**41.53**	**34.87**	**49.42**	**40.31**
Non-OPEC							
OECD							
United States (50 states)	12.64	16.92	19.73	16.52	23.89	15.89	25.69
Canada	4.15	5.05	5.05	6.26	6.26	6.76	6.76
Mexico and Chile	2.94	2.93	2.93	3.32	3.32	3.79	3.79
OECD Europe[2]	3.88	3.35	3.35	2.98	2.98	3.19	3.19
Japan and South Korea	0.18	0.17	0.17	0.18	0.18	0.18	0.18
Australia and New Zealand	0.49	0.60	0.60	0.86	0.86	0.96	0.96
Total OECD production	**24.29**	**29.03**	**31.83**	**30.12**	**37.49**	**30.77**	**40.57**
Non-OECD							
Russia	10.50	10.71	10.71	11.22	11.22	12.16	12.16
Other Europe and Eurasia[3]	3.27	3.41	3.41	4.42	4.42	5.18	5.18
China	4.48	5.11	5.11	5.66	5.66	5.84	5.84
Other Asia[4]	3.82	3.85	3.85	3.67	3.67	4.01	4.01
Middle East	1.20	1.03	1.03	0.85	0.85	0.77	0.77
Africa	2.41	2.70	2.70	2.94	2.94	3.33	3.33
Brazil	2.73	3.70	3.70	5.43	5.43	6.12	6.12
Other Central and South America	2.21	2.71	2.71	2.97	2.97	3.47	3.47
Total non-OECD production	**30.63**	**33.21**	**33.21**	**37.17**	**37.17**	**40.88**	**40.88**
Total petroleum and other liquids production	**91.4**	**98.4**	**98.6**	**108.8**	**109.5**	**121.1**	**121.8**
OPEC market share (percent)	39.9	36.7	34.1	38.2	31.8	40.8	33.1

Table D8. International petroleum and other liquids supply, disposition, and prices (continued)
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	2013	Projections					
		2020		2030		2040	
		Reference	High oil and gas resource	Reference	High oil and gas resource	Reference	High oil and gas resource
Selected world production subtotals:							
Crude oil and equivalents[6]	77.93	82.19	81.78	89.77	88.84	99.09	97.22
Tight oil	3.62	7.49	9.33	9.16	14.57	10.15	17.40
Bitumen[7]	2.11	3.00	3.00	3.95	3.95	4.26	4.26
Refinery processing gain[8]	2.40	2.42	2.59	2.74	2.88	2.97	3.04
Natural gas plant liquids	9.36	11.28	11.89	12.42	13.99	13.79	16.31
Liquids from renewable sources[9]	2.14	2.56	2.57	3.36	3.38	4.22	4.24
Liquids from coal[10]	0.21	0.33	0.33	0.69	0.69	1.05	1.05
Liquids from natural gas[11]	0.24	0.33	0.33	0.51	0.51	0.61	0.61
Liquids from kerogen[12]	0.01	0.01	0.01	0.01	0.14	0.01	0.14
Crude oil production[6]							
OPEC[5]							
Middle East	23.13	21.20	18.63	25.59	18.93	31.79	22.68
North Africa	2.43	2.93	2.93	2.92	2.92	2.96	2.96
West Africa	4.20	4.89	4.89	5.13	5.13	5.29	5.29
South America	2.82	2.86	2.86	2.98	2.98	3.48	3.48
Total OPEC production	**32.60**	**31.89**	**29.32**	**36.62**	**30.10**	**43.52**	**34.54**
Non-OPEC							
OECD							
United States (50 states)	8.90	11.58	13.75	11.01	16.60	10.41	17.51
Canada	3.42	4.35	4.35	5.48	5.48	5.92	5.92
Mexico and Chile	2.59	2.61	2.61	3.00	3.00	3.45	3.45
OECD Europe[2]	2.82	2.17	2.17	1.66	1.66	1.69	1.69
Japan and South Korea	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Australia and New Zealand	0.37	0.47	0.47	0.67	0.67	0.75	0.75
Total OECD production	**18.10**	**21.18**	**23.35**	**21.83**	**27.42**	**22.23**	**29.33**
Non-OECD							
Russia	10.02	10.15	10.15	10.42	10.42	11.10	11.10
Other Europe and Eurasia[3]	3.05	3.18	3.18	4.03	4.03	4.66	4.66
China	4.16	4.54	4.54	4.56	4.56	4.13	4.13
Other Asia[4]	3.04	2.94	2.94	2.45	2.45	2.47	2.47
Middle East	1.16	1.00	1.00	0.82	0.82	0.74	0.74
Africa	1.97	2.18	2.18	2.38	2.38	2.70	2.70
Brazil	2.02	2.87	2.87	4.16	4.16	4.60	4.60
Other Central and South America	1.81	2.25	2.25	2.49	2.49	2.94	2.94
Total non-OECD production	**27.24**	**29.11**	**29.11**	**31.32**	**31.32**	**33.35**	**33.35**
Total crude oil production[6]	**77.9**	**82.2**	**81.8**	**89.8**	**88.8**	**99.1**	**97.2**
OPEC market share (percent)	41.8	38.8	35.8	40.8	33.9	43.9	35.5

[1]Estimated consumption. Includes both OPEC and non-OPEC consumers in the regional breakdown.
[2]OECD Europe = Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.
[3]Other Europe and Eurasia = Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Macedonia, Malta, Moldova, Montenegro, Romania, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
[4]Other Asia = Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), Fiji, French Polynesia, Guam, Hong Kong, India (for production), Indonesia, Kiribati, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam.
[5]OPEC = Organization of the Petroleum Exporting Countries = Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
[6]Includes crude oil, lease condensate, tight oil (shale oil), extra-heavy oil, and bitumen (oil sands).
[7]Includes diluted and upgraded/synthetic bitumen (syncrude).
[8]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[9]Includes liquids produced from energy crops.
[10]Includes liquids converted from coal via the Fischer-Tropsch coal-to-liquids process.
[11]Includes liquids converted from natural gas via the Fischer-Tropsch natural-gas-to-liquids process.
[12]Includes liquids produced from kerogen (oil shale, not to be confused with tight oil (shale oil)).
OECD = Organization for Economic Cooperation and Development.
Note: Totals may not equal sum of components due to independent rounding. Data for 2013 are model results and may differ from official EIA data reports.
Sources: 2013 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. **2013 quantities and projections:** Energy Information Administration (EIA), AEO2015 National Energy Modeling System runs REF2015.D021915A and HIGHRESOURCE.D021915B; and EIA, Generate World Oil Balance application.

Appendix E

Comparison of AEO2015 and AEO2014 Reference cases and key updates to models and data

Introduction

This appendix provides a summary comparison of the Reference case for EIA's *Annual Energy Outlook 2015* (AEO2015) with the Reference case for the *Annual Energy Outlook 2014* (AEO2014),[1] which was released in April 2014, including a list of major model and data updates and discussion of key differences in results between the two projections. Table E1 compares projections from the AEO2014 and AEO2015 reports.

Model and data updates

Key model and data updates made for the AEO2015 Reference case include the following:

Macroeconomic

- Incorporated the U.S. Bureau of Economic Analysis (BEA) gross domestic product component revision to 2009 dollars and investment definitional changes.[2] The AEO2015 macroeconomic projections are based on November 2014 IHS Global Insight projections.[3]
- Incorporated a new input-output matrix based on a 2007 benchmark year using 2009 dollars. The input-output matrix now continues to change over time, based on historical relationships developed using previous benchmark matrices to 2013.

Residential, commercial, and industrial

- Incorporated new standards for buildings equipment promulgated during the year, including standards affecting commercial refrigeration equipment, metal halide lamp fixtures, residential furnace fans, external power supplies, and set-top boxes (voluntary agreement).
- Updated cost and performance assumptions for end-use equipment in the buildings sector, based on a report by Navigant Consulting, Inc. and Leidos, reflecting recent and expected technological progress.[4]
- Incorporated more rapid adoption of commercial building codes related to building shell efficiency, based on a Pacific Northwest National Laboratory report.[5]
- Revised and refined market niches used in developing residential distributed generation projections to more accurately reflect solar insolation and marginal prices at the sub-Census division level, based on data from EIA's 2009 Residential Energy Consumption Survey and solar insolation data from the National Renewable Energy Laboratory. [6,7]
- Incorporated 2012 State Energy Data System (SEDS) data for regional benchmarking in the industrial sector.[8]
- Updated and implemented historical natural gas feedstock data in the industrial sector through 2013, based on data from GlobalData.[9]
- Introduced a new Bayesian Dynamic Linear Model (DLM) for ethane and propane price projections in the industrial sector. In the DLM regression, parameters are allowed to vary over time to allow for a dynamic representation of various drivers of ethane and propane prices—such as oil price, natural gas price, hydrocarbon gas liquids (HGL) supply and demand, and bulk chemical shipments. The DLM projects base ethane and propane prices only at Mont Belvieu. To compute sectoral propane prices, historical differences between the base and sectoral prices for propane were applied to the DLM projections for propane. The resulting AEO2015 ethane and propane price projections exhibit a dominant natural gas price influence in the near term and a growing oil price influence in the long term.

[1]U.S. Energy Information Administration, Annual Energy Outlook 2014, DOE/EIA-0383(2014) (Washington, DC, April 2014), www.eia.gov/forecasts/archive/aeo14.

[2]S.H. McCulla, A.E. Holdren, and S. Smith, "Improved Estimates of the National Income and Product Accounts: Results of the 2013 Comprehensive Revision" (U.S. Department of Commerce, Bureau of Economic Analysis, Washington, DC, September 2013), http://www.bea.gov/scb/pdf/2013/09%20September/0913_comprehensive_nipa_revision.pdf.

[3]The AEO2015 Reference case uses IHS Global Insight's November 2014 T301114 workfile. The AEO2015 High Economic Growth case uses the optimistic projection, and the AEO2015 Low Economic Growth case uses the pessimistic projection. In all cases, IHSGI's energy prices and quantities are replaced with EIA's projections.

[4]U.S. Energy Information Administration, EIA—*Technology Forecast Updates—Residential and Commercial Building Technologies—Reference case* (Navigant Consulting, Inc. with Leidos, May 2014).

[5]O.V. Livingston, P.C. Cole, D.B. Elliott, and R. Bartlett, *Building Energy Codes Program: National Benefits Assessment, 1992-2040* (Richland, WA, March 2014), prepared by Pacific Northwest National Laboratory for the U.S. Department of Energy, Building Energy Codes Program, http://www.energycodes.gov/building-energy-codes-program-national-benefits-assessment-1992-2040-0.

[6]U.S. Energy Information Administration, "Residential Energy Consumption Survey (RECS): 2009 RECS Survey Data" (Washington, DC, January 2013), http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=microdata.

[7]National Renewable Energy Laboratory (NREL) "Zip Code Solar Insolation Data Source," http://www.nrel.gov/gis/docs/SolarSummaries.xlsx.

[8]U.S. Energy Information Administration, "State Energy Data System (SEDS)" (Washington, DC, June 27, 2014), http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US.

[9]GlobalData (New York, NY, 2014) http://www.globaldata.com (subscription site).

Table E1. Comparison of projections in the AEO2015 and AEO2014 Reference cases, 2012-40

Energy and economic factors	2012	2013	2025 AEO2015	2025 AEO2014	2040 AEO2015	2040 AEO2014
Primary energy production (quadrillion Btu)						
Crude oil and natural gas plant liquids	17.0	19.2	27.2	23.0	25.4	20.0
Dry natural gas	24.6	25.1	31.3	32.6	36.4	38.4
Coal[a]	20.7	20.0	22.2	22.4	22.6	22.6
Nuclear/uranium	8.1	8.3	8.5	8.2	8.7	8.5
Conventional hydroelectric power	2.6	2.5	2.8	2.8	2.8	2.9
Biomass	4.0	4.2	4.6	5.1	5.0	5.6
Other renewable energy	1.9	2.3	3.4	3.1	4.6	3.9
Other[b]	0.8	1.3	0.9	0.2	1.0	0.2
Total production	**79.6**	**82.7**	**100.9**	**97.4**	**106.6**	**102.1**
Net imports (quadrillion Btu)						
Liquid fuels and other petroleum[c]	16.4	14.0	7.4	11.4	8.6	13.7
Natural gas (- indicates exports)	1.6	1.4	-3.5	-3.4	-5.6	-5.8
Coal, coal coke, and electricity (- indicates exports)	-2.8	-2.6	-2.7	-3.2	-3.5	-3.7
Total net imports	**15.2**	**12.8**	**1.1**	**4.8**	**-0.5**	**4.2**
Energy consumption by fuel (quadrillion Btu)						
Liquid fuels and other petroleum[d]	35.2	35.9	36.9	36.3	36.2	35.4
Natural gas	26.1	26.9	27.6	29.0	30.5	32.3
Coal[a]	17.3	18.0	19.3	19.0	19.0	18.7
Nuclear/uranium	8.1	8.3	8.5	8.2	8.7	8.5
Conventional hydroelectric power	2.6	2.5	2.8	2.8	2.8	2.9
Biomass	2.8	2.9	3.2	3.7	3.5	4.3
Other renewable energy	1.9	2.3	3.4	3.1	4.6	3.9
Other[e]	0.4	0.4	0.3	0.3	0.3	0.3
Total consumption	**94.4**	**97.1**	**102.0**	**102.5**	**105.7**	**106.3**
Energy consumption by sector (quadrillion Btu)[f]						
Residential	19.9	21.1	20.3	20.6	20.9	21.5
Commercial	17.5	18.1	18.9	18.8	20.9	20.9
Industrial	30.8	31.2	36.5	37.4	37.7	38.3
Transportation	26.2	27.0	26.7	25.7	26.6	25.6
Unspecified sector[g]	0.0	-0.3	-0.4	--	-0.4	--
Total consumption	**94.4**	**97.1**	**102.0**	**102.5**	**105.7**	**106.3**
Liquid fuels (million barrels per day)						
Domestic crude oil production	6.5	7.4	10.3	9.0	9.4	7.5
Other domestic production	4.5	5.2	6.5	5.1	6.5	5.2
Net imports	7.4	6.2	2.8	5.1	3.4	6.0
Consumption	18.5	19.0	19.6	19.3	19.3	18.7
Natural gas (trillion cubic feet)						
Dry gas production and supplemental gas	24.1	24.5	30.6	31.9	35.5	37.6
Net imports (- indicates exports)	1.5	1.3	-3.5	-3.4	-5.6	-5.8
Consumption	25.5	26.2	26.9	28.4	29.7	31.6

-- = Not applicable.
See notes at end of table.

Table E1. Comparison of projections in the AEO2015 and AEO2014 Reference cases, 2012-40 (continued)

			2025		2040	
Energy and economic factors	2012	2013	AEO2015	AEO2014	AEO2015	AEO2014
Coal (million short tons)						
Production[a]	1,028	995	1,116	1,128	1,128	1,139
Net exports[h]	118	110	110	135	140	160
Consumption[a]	889	925	1,005	993	988	979
Electricity						
Total capacity, all sectors (gigawatts)	1,063	1,065	1,091	1,110	1,261	1,316
Total net generation, all sectors (billion kilowatthours)	4,055	4,070	4,513	4,622	5,056	5,219
Total electricity use (billion kilowatthours)	3,834	3,836	4,282	4,385	4,797	4,954
Prices (2013 dollars)						
Brent spot crude oil (dollars per barrel)	113	109	91	111	141	144
West Texas Intermediate spot crude oil (dollars per barrel)	96	98	85	109	136	142
Natural gas at Henry Hub (dollars per million Btu)	2.79	3.73	5.46	5.31	7.85	7.77
Domestic coal at minemouth (dollars per short ton)	40.5	37.2	40.3	50.4	49.2	60.0
Average electricity (cents per kilowatthour)	10.0	10.1	11.0	10.3	11.8	11.3
Economic indicators						
Real gross domestic product (trillion 2009 dollars)[i]	15.4	15.7	21.3	--	29.9	--
GDP chain-type price index (2009 = 1.00)[i]	1.05	1.07	1.31	--	1.73	--
Real disposable personal income (trillion 2009 dollars)[i]	11.7	11.7	16.3	--	23.0	--
Value of industrial shipments (trillion 2009 dollars)[i]	6.82	7.00	9.21	--	11.46	--
Population (millions)	315	317	347	347	380	381
Energy-related carbon dioxide emissions (million metric tons)	**5,272**	**5,405**	**5,511**	**5,526**	**5,549**	**5,599**
Primary energy intensity (thousand Btu per 2009 dollar of GDP)	**6.14**	**6.18**	**4.79**	**--**	**3.54**	**--**

[a]Includes waste coal consumed in the industrial and electric power sectors.
[b]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some inputs to refineries.
[c]Includes crude oil, petroleum products, petroleum coke, unfinished oils, alcohols, ethers, blending components, hydrocarbon gas liquids, and non-petroleum-derived fuels such as ethanol and biodiesel.
[d]Includes petroleum-derived fuels and non-petroleum-derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel.
[e]Net electricity imports, liquid hydrogen, and non-biogenic municipal waste.
[f]Electric power sector consumption is distributed to the end-use sectors.
[g]Represents consumption unattributed to the sectors above.
[h]Excludes imports to Puerto Rico and the Virgin Islands.
[i]GDP, disposable income, value of shipments, and GDP price index were updated in AEO2015 consistent with the U.S. Bureau of Economic Analysis gross domestic product component revision to 2009 dollars and investment definitional changes. AEO2014 data are 2005-based and are not shown since they are not comparable with 2009-based figures.
Notes: Quantities reported in quadrillion Btu are derived from historical volumes and assumed thermal conversion factors.
-- = Not applicable.

Transportation

- Updated the following by aircraft type and region: sales, stocks, and active and parked aircraft using Jet Inventory Services data;[10] available seat-miles traveled, revenue seat-miles traveled, cargo travel, fuel use, and load factors, using U.S. Department of Transportation, Bureau of Transportation Statistics data;[11] and domestic and international yield[12] using fares and fees published by Airlines for America.[13]
- Updated historical light-duty vehicle and heavy-duty truck vehicle-miles traveled through 2012, using data from U.S. Department of Transportation, Federal Highway Administration,[14] extended through 2014 using the U.S. Department of Transportation, Federal Highway Administration, *Traffic Volume Trends* report.[15]
- Added historical freight rail ton miles through 2013, using Class 1 Railroad data as reported through the U.S. Department of Transportation, Surface Transportation Board.[16]
- Added historical domestic marine ton miles through 2012, based on U.S. Army Corps of Engineers data.[17]
- Revised heavy-duty vehicle, freight rail, and domestic marine travel demand projection methodologies based on a report from IHS Global Insight.[18] The new methodologies will use the Freight Analysis Framework[19] in the historical Census division and commodity ton-mile data, including derivation of ton mile per dollar of industrial output (a key metric used in the travel demand projection methodology). These data include a Geographic Information System modeling estimation of the share of freight truck travel between origin and destination points through intermediate Census divisions.
- Modified the technology adoption and fuel economy calculation for heavy-duty vehicles and added technology availability.
- Modified the domestic and international marine residual fuel oil and distillate fuel shares to match compliance with MARPOL Annex VI,[20] the International Convention for the Prevention of Pollution from Ships, concerned with preventing marine pollution from ships, as assumed in EIA's *Short-Term Energy Outlook*.
- Added an unspecified consumption sector to match the levels of travel and efficiency more consistently with implied fuel use in the transportation sector, and to allow total liquid fuels[21] consumption in AEO2015 to be closer to the totals for each fuel that are reported in EIA's statistical publications as being supplied to markets.

Oil and natural gas production

- Incorporated the impact of world oil prices that remain below $80/bbl (in 2013 dollars) through 2020, versus $98/bbl in AEO2014, to reflect market events through the end of 2014 and the growth of U.S. crude oil production. This change in price expectations limits the degree to which near-term U.S. crude oil and associated dry natural gas production increase, and limits the need for natural gas produced for liquefied natural gas (LNG) exports.
- Revised drilling costs in AEO2015 to directly incorporate assumptions regarding average lateral length and number of laterals per well.
- Updated natural gas plant liquid (NGPL) factors at the play and county levels for tight oil and shale gas formations.
- Updated the estimated ultimate recovery of tight and shale formations at the county level. For the Marcellus Shale, each county was further divided into productive tiers based on geologic dependencies.
- Updated the list of offshore discovered, non-producing fields and the expected resource sizes and startup dates of the fields.

[10]Jet Information Services, Inc., "World Jet Inventory" (Utica, NY, December 2013), http://www.jetinventory.com (subscription site).
[11]U.S. Department of Transportation, Bureau of Transportation Statistics, Form 41, Schedule T-2 (T-100), "Quarterly Traffic and Capacity Data of U.S. Air Carriers, Summarized by Aircraft Type" (Washington, DC, December 2013).
[12]Yield is defined as airline revenue divided by revenue passenger miles traveled.
[13]Airlines for America, "Annual Round Trip Fares and Fees" (Washington, DC, August 2014), http://airlines.org/data/annual-round-trip-fares-and-fees-domestic/ and http://airlines.org/data/annual-round-trip-fares-and-fees-international/.
[14]U.S. Department of Transportation, Federal Highway Administration, "Highway Statistics 2012: Table VM-1, Annual Vehicle Distance Traveled in Miles and Related Data—2012 by Highway Category and Vehicle Type" (Washington, DC, January 2014), http://www.fhwa.dot.gov/policyinformation/statistics/2012/vm1.cfm.
[15]U.S. Department of Transportation, Federal Highway Administration, "June 2014 Traffic Volume Trends" (Washington, DC, June 2014), https://www.fhwa.dot.gov/policyinformation/travel_monitoring/14juntvt/.
[16]U.S. Department of Transportation, Surface Transportation Board, "Annual Report Financial Data" (Washington, DC, 2013), http://www.stb.dot.gov/stb/industry/econ_reports.html.
[17]U.S. Department of Defense, U.S. Army Corps of Engineers, "Waterborne Commerce of the United States, Calendar Year 2012, Part 5—National Summaries, Table 1.4: Total Waterborne Commerce, 1993-2012" (Washington, DC, 2014), http://www.navigationdatacenter.us/wcsc/pdf/wcusnatl12.pdf.
[18]IHS Global, Inc., "NEMS Freight Transportation Module Improvement Study" (June 20, 2014).
[19]U.S. Department of Transportation, Federal Highway Administration, "Freight Analysis Framework," http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/.
[20]U.S. Environmental Protection Agency, "MARPOL Annex VI" (Washington, DC: January 14, 2015), http://www2.epa.gov/enforcement/marpol-annex-vi.
[21]Liquid fuels (or petroleum and other liquids) include crude oil and products of petroleum refining, natural gas liquids, biofuels, and liquids derived from other hydrocarbon sources (including coal-to-liquids and gas-to-liquids).

- Moved the projection of the composition of NGPL from the Liquid Fuels Market Module (LFMM) to the Oil and Gas Supply Module (OGSM). Added input data in the OGSM for the component (ethane, propane, butane, and pentanes plus) shares of total NGPL at the project level represented in the OGSM. Added capability to account for the volume of ethane that is left in the dry natural gas stream (commonly referred to as *ethane rejection*).

Natural gas transmission and distribution

- Expanded natural gas distribution in AEO2015 to represent a greater number of pipeline routes that allow for bidirectional flows.
- Allowed LNG projects to be added incrementally by a single train rather than by multiple trains and to phase-in over three years rather than two years.
- In circumstances when the Brent price is above (below) a mid-range value, the model can now set world natural gas prices to disconnect from the Brent price at a faster (slower) rate than it would have previously.
- Updated the pricing algorithm for offshore Atlantic and Pacific production.
- Adjusted the representation of Canadian dry natural gas production.
- Increased base-level production to account for a change in Mexico's constitution allowing for increased foreign investment.

Petroleum product and biofuels markets

- Added 40°-50° American Petroleum Institute (API) and 50°+ API crude oil types to reflect increases in tight oil production and potential constraints on refinery processing.
- Included the option to add new condensate splitter units to process 50°+ API crude.
- Modified the LFMM and International Energy Module to permit crude exports to accommodate analysis of the impact of potential relaxation of the current U.S. crude oil export ban.
- Relaxed export restrictions on processed condensate to better match the U.S. Department of Commerce, Bureau of Industry and Security, interpretation of export regulations that allow the export of processed condensate.
- Updated gasoline specifications to reflect Tier 3 gasoline regulations.
- Revised the renewable fuels standard mandate levels for biomass-based diesel to better match expected production capabilities.[22]

Electric power sector

- Revised the assumption for unannounced nuclear retirements in the Reference case downward, from 5.7 gigawatts (GW) in the AEO2014 Reference case to 2 GW in the AEO2015 Reference case. Unannounced nuclear retirements in the AEO2015 Reference case reflect market uncertainty. Announced nuclear retirements are incorporated as reported to the EIA.
- Updated the online start dates for Virgil C. Summer Nuclear Generating Station Units 2 and 3 to 2019 and 2020, respectively, to reflect company announcements.[23]
- Updated expiration dates of firm contractual arrangements for coal-fired power plants that serve California loads.[24] Adjusted the carbon emissions rate for firm imports in accordance with the expiration of contracts.
- Explicitly represented 4.1 GW of coal-fired units that are being converted to natural gas-fired steam units. Added model capability to convert additional coal-fired plants to natural gas-fired plants based on the relative economics, assuming a capital cost for conversion and connection to natural gas pipelines. Once converted, the oil and natural gas steam plants are assumed to have lower operating and maintenance costs than the original coal-fired plant but also a 5% loss in efficiency.
- Updated regional assumptions on transmission and distribution spending as a function of peak load growth, based on historical trends.
- Revised biomass supply model representation of agricultural residues/energy crop feedstocks, by incorporating fully-integrated agricultural model, Policy Analysis System (POLYSYS).

[22]U.S. Energy Information Administration, Monthly Biodiesel Production Report (Washington, DC: July 31, 2014), http://www.eia.gov/biofuels/biodiesel/production/.

[23]SCANA Corporation, "SCANA Corporation Management to Discuss New Nuclear Construction Schedule on August 11, 2014" (Cayce, SC: August 2014), https://www.scana.com/docs/librariesprovider15/pdfs/press-releases/8-11-2014-scana-dicuss-new-nuclear-schedule.pdf?sfvrsn=0.

[24]California Energy Commission, "Actual and Expected Energy from Coal for California" (Sacramento, CA: November 6, 2014), http://www.energy.ca.gov/renewables/tracking_progress/documents/current_expected_energy_from_coal.pdf. Changes in coal contract deliveries are largely related to the California Public Utilities Commission's adopted Greenhouse Gas Emissions Performance Standard (Decision 07-01-039, January 25, 2007, Interim Opinion on Phase 1 Issues: Greenhouse Gas Emissions Performance Standard, http://docs.cpuc.ca.gov/PublishedDocs/PUBLISHED/FINAL_DECISION/64072.htm), which implemented Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006, http://www.energy.ca.gov/emission_standards/documents/sb_1368_bill_20060929_chaptered.pdf).

- Reviewed and updated capital cost assumptions for utility-scale solar PV and wind plants based on assessment of costs reported in trade press and data compiled in Lawrence Berkeley National Laboratory publications *2013 Wind Technologies Market Report*[25] and *Utility-Scale Solar 2013*.[26]
- Added model capability to retrofit existing coal-fired generating units to improve their operating efficiency (heat rate), if economic. An analysis of the heat rate improvement potential of the existing coal fleet sorted existing coal-fired units into quartiles, to reflect varying levels of improvement potential, and developed cost estimates to reflect the investment required to achieve the improvement. The analysis then disaggregated the cost and improvement assumptions based on environmental control configurations, consistent with the coal plant types used in the electricity model. Heat rate improvement retrofits can provide a reduction in fuel use ranging from less than 1% to 10%, depending on the plant type and quartile.

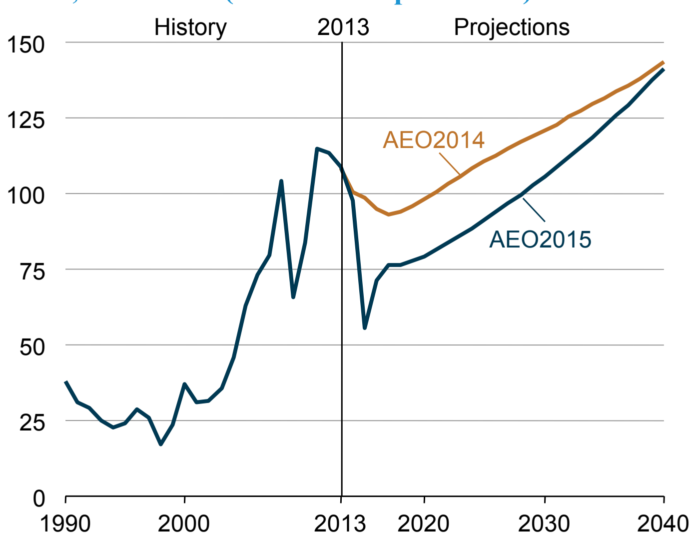
Comparison of AEO2015 and AEO2014 Reference cases

Economic growth

The macroeconomic projections used in AEO2015 are trend projections, with no major shocks anticipated. In long-term projections, the economy's supply capability determines its potential growth. Growth in aggregate supply depends on increases in the labor force, growth of capital stock, and improvements in productivity. Long-term demand growth depends on labor force growth, income growth, and population growth. In the AEO2015 Reference case, U.S. population grows by an average of 0.7%/year from 2013 to 2040, the same rate as in the AEO2014 Reference case over the same period. In the AEO2015 Reference case, real gross domestic product (GDP), labor force, and productivity grow by 2.4%/year, 0.6%/year, and 2.0%/year, respectively, over the same period. Those rates are similar to the annual growth rates for real GDP, labor force, and productivity of 2.5%, 0.6%, and 1.9%, respectively, from 2013 to 2040 in the AEO2014 Reference case.

The annual rate of growth in total industrial production, which includes manufacturing, construction, agriculture, and mining, in the AEO2015 Reference case is lower than the rate in the AEO2014 Reference case, primarily as a result of slower growth in key manufacturing industries, such as food, paper, non-bulk chemicals, and computers. Updated information on how industries supply other industries and meet the demand for different types of GDP expenditures influences the projections for certain industries.[27]For example, as a result of restructuring in the pulp and paper industry, trade in consumer goods and industrial supplies has a greater impact on the industry's production in AEO2015 than it did in previous AEOs. The annual rate of growth in total industrial production from 2013 to 2040 is 1.8% in AEO2015, compared with 2.1% in AEO2014. The manufacturing share of total gross output in 2040 is 17% in the AEO2015 Reference case, compared with 18% in AEO2014, mostly because of more-rapid growth in service and nonmanufacturing industries, such as wholesale trade, transportation, and warehousing.

Figure E1. Average annual Brent crude oil spot prices in the AEO2015 and AEO2014 Reference cases, 1990-2040 (2013 dollars per barrel)



Energy prices

Crude oil

In the AEO2015 Reference case, the Brent spot price for crude oil (in 2013 dollars) falls from $109/barrel (bbl) in 2013 to $56/bbl in 2015 and then increases to $76/bbl in 2018. After 2018, the Brent price increases, reaching $141/bbl in 2040 ($229/bbl in nominal dollars), as growing demand leads to the development of more costly resources (Figure E1). In the AEO2014 Reference case, the projected Brent price in 2040 was $144/bbl (2013 dollars).

Among the key assumptions that affect crude oil use in the AEO2015 Reference case are average economic growth of 1.9%/year for major U.S. trading partners;[28] average economic growth for other U.S. trading partners of 3.8%/year; and declining U.S. consumption of liquid fuels per unit of GDP. As a result, there is a slight decrease in liquids consumption by the Organization for Economic Cooperation and Development (OECD) countries.

[25]R. Wiser and M. Bolinger, 2013 Wind Technologies Market Report, DOE/GO-102014-4459 (Washington, DC: August 2014), http://emp.lbl.gov/sites/all/files/2013_Wind_Technologies_Market_Report_Final3.pdf.

[26]M. Bolinger and S. Weaver, Utility-Scale Solar 2013 (Washington, DC: September 2014), http://emp.lbl.gov/sites/all/files/LBNL_Utility-Scale_Solar_2013_report.pdf.

[27]The industrial output model of the NEMS Macroeconomic Activity Module now uses the Bureau of Economic Analysis (BEA) detailed input-output matrices for 2007 rather than for 2002 (http://bea.gov/industry/io_annual.htm) and now incorporates information from the aggregate input-output matrices (http://bea.gov/industry/gdpbyind_data.htm).

[28]Major trading partners include Australia, Canada, Switzerland, United Kingdom, Japan, Sweden, and the Eurozone.

The non-OECD consumption level of 75 million barrels per day (bbl/d) in 2040 in the AEO2015 Reference case is about 7% higher than the 2040 level in the AEO2014 Reference case, and the difference more than offsets the impact of lower consumption in the OECD countries. The result is an increase in total world consumption to 121 million bbl/d in 2040 in AEO2015, which is 3% higher than in AEO2014. Non-OPEC (particularly U.S.) liquids production in AEO2015 increases to levels above those in AEO2014, and the OPEC market share in the AEO2015 Reference case rises only slightly, from 40% in 2013 to 41% in 2040, as compared with a 44% market share in 2040 in AEO2014.

Liquid products

The real U.S. price of end-use motor gasoline (2013 dollars) in the AEO2015 Reference case falls from $3.53/gallon in 2013 to a low point of $2.31/gallon in 2015, before rising to $3.90/gallon in 2040, in response to decreasing—and then increasing—crude oil prices. The motor gasoline price in 2040 is 2% lower than the $3.96/gallon price in the AEO2014 Reference case, because of lower crude oil prices. The end-use price of diesel fuel to the transportation sector in the AEO2015 Reference case follows a similar pattern, dropping from $3.86/gallon in 2013 to $2.70/gallon in 2015 and then rising to $4.75/gallon in 2040 (compared with $4.80/gallon in 2040 in the AEO2014 Reference case).

Natural gas

On average, the Henry Hub spot price for natural gas in the AEO2015 Reference case is only 2% (or $0.13/million Btu in 2013 dollars) lower than in the AEO2014 Reference case from 2013 to 2040. The Henry Hub natural gas spot prices in AEO2015 are slightly lower than the AEO2014 spot prices in each year, with the exception of the period from 2020 to 2027 and in 2040. These price levels are consistent with 3% lower cumulative U.S. dry natural gas production through 2040 in the AEO2015 Reference case relative to the AEO2014 Reference case.

Although the average production, consumption, and price levels are similar in the AEO2015 and AEO2014 Reference cases, there are some notable differences in the components. For instance, while natural gas consumption by natural gas vehicles and electricity generators in AEO2015 is lower than in AEO2014, residential and commercial consumption are generally higher. On the supply side, higher dry natural gas production in the AEO2015 Reference case in the East region (which includes the Marcellus and Utica formations) compared with the AEO2014 Reference case is more than offset by lower production levels in the Gulf Coast and Midcontinent regions. The relative location and composition of supply and demand affect regional pricing and national averages. For this and other reasons, average delivered natural gas prices to residential and commercial customers from 2013 to 2040 are 4% lower in the AEO2015 Reference case than in the AEO2014 Reference case.

Coal

The average minemouth price of coal increases by 1.0%/year, from $1.84/million Btu in 2013 to $2.44/million Btu in 2040 (2013 dollars) in the AEO2015 Reference case. In comparison, the price in the AEO2014 Reference case increases by 1.5%/year, from $2.02/million Btu in 2013 to $3.00/million Btu in 2040. The average minemouth price of coal is about 19% lower, on average, across the projection timeframe in AEO2015 when compared with AEO2014, reflecting lower volumes and prices for high-priced coking coal exports, the shutdown of some high-cost mining operations, and a less pessimistic outlook for productivity. Similarly, with a few exceptions, the regional minemouth prices of coal in AEO2015 are lower than those in AEO2014.

The slower rate of increase in the minemouth price of coal in the AEO2015 Reference case reflects recent year-over-year improvements in labor productivity in 9 of the 14 coal supply regions, many of which have not seen productivity gains since 2000, and a slowing of productivity declines in 4 of the other regions. However, both the AEO2015 and AEO2014 Reference cases assume that cost savings from improvements in coal mining technology will continue to be outweighed by increases in production costs associated with moving into reserves that are more costly to mine. Thus, both projections show the average minemouth price of coal rising steadily after 2015.

Electricity

In the AEO2015 Reference case, end-use electricity prices are higher than in the AEO2014 Reference case throughout most of the projection. The higher price outlook reflects market dynamics, as well as revised assumptions for transmission and distribution costs in AEO2015.

The end-use price of electricity is defined by generation, transmission, and distribution cost components. Natural gas prices are a significant determinant of generation costs. In the AEO2015 Reference case, delivered natural gas prices to electricity generators are lower than in the AEO2014 Reference case in the first few years of the projection but higher throughout most of the 2020s. From 2020 to 2030, the generation cost component of end-use electricity prices is, on average, 4% higher in AEO2015 than in AEO2014.

The AEO2015 Reference case includes higher transmission and distribution cost components relative to the AEO2014 Reference case, reflecting an updated representation of trends in transmission and distribution costs. In 2040, the transmission cost component in the AEO2015 Reference case is 14% higher than it was in the AEO2014 Reference case—1.29 cents/kilowatthour (kWh), compared with 1.13 cents/kWh—while the distribution cost component is 15% higher (3.01 cents/kWh compared with 2.61 cents/kWh). The faster growth in the transmission and distribution cost components of end-use electricity prices in

AEO2015 reflects recent historical trends and an expectation that transmission and distribution costs will continue to increase as new transmission and distribution facilities and *smart grid* components (e.g., advanced meters, sensors, controls, etc.) are added, existing infrastructure is upgraded to enhance the reliability and resiliency of the grid, and new resources connect to the grid.

Average end-use electricity price in 2030 is 11.1 cents/kWh (2013 dollars) in the AEO2015 Reference case, compared to 10.6 cents/kWh in the AEO2014 Reference case. Prices continue rising to 11.8 cents/kWh in 2040 in the AEO2015 Reference case, compared to 11.3 cents/kWh in 2040 in the AEO2014 Reference case.

Energy consumption by sector

Transportation

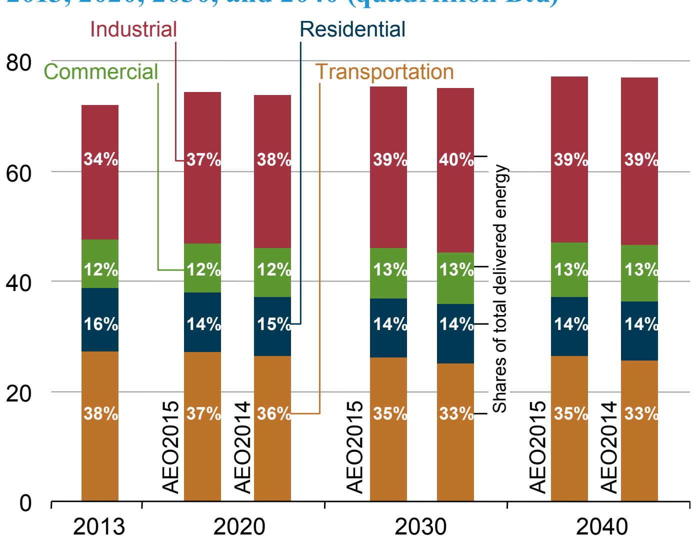
Delivered energy consumption in the transportation sector in the AEO2015 Reference case is higher than in AEO2014 (26.5 quadrillion Btu in 2040 compared with 25.5 quadrillion Btu), with energy consumption for nearly all transportation modes higher in AEO2015 throughout most of the projection, because of higher macroeconomic indicators and lower fuel prices (Figure E2).

Light-duty vehicle (LDV) energy consumption declines in the AEO2015 Reference case from 15.7 quadrillion Btu in 2013 to 12.6 quadrillion Btu in 2040, compared with 12.1 quadrillion Btu in 2040 in AEO2014. Greenhouse gas emission standards and corporate average fuel economy (CAFE) standards increase new LDV fuel economy through model year 2025 and beyond in the AEO2015 Reference case, with new, more fuel-efficient vehicles gradually replacing older vehicles on the road. The increase in fuel economy raises the LDV vehicle stock average miles per gallon by 2.0%/year, from 21.9 in 2013 to 37.0 in 2040. The increase in LDV fuel economy more than offsets modest growth in vehicle-miles traveled (VMT), which averages 1.1%/year from 2013 to 2040 as a result of changes in driving behavior related to demographics. Stock fuel economy is lower, and LDV VMT is higher, in the AEO2015 Reference case than in AEO2014.

LDVs powered exclusively by motor gasoline remain the predominant vehicle type in the AEO2015 Reference case, retaining a 78% share of new vehicle sales in 2040, down only somewhat from 83% in 2013. The fuel economy of LDVs fueled by motor gasoline continues to increase, and advanced technologies for fuel efficiency subsystems are added, such as micro hybridization, which is installed in 42% of new motor gasoline LDVs in 2040. Sales of new LDVs powered by fuels other than gasoline (such as diesel, electricity, or E85) and LDVs using hybrid drivetrains (such as plug-in hybrid or gasoline hybrid-electric vehicles) increase modestly in the AEO2015 Reference case, from 17% of new sales in 2013 to 22% in 2040. Ethanol-flex-fuel vehicles account for 10% of new LDV sales in 2040 followed by hybrid electric vehicles at 5%, up from 3% in 2013, diesel vehicles at 4% in 2040, up from 2% in 2013, and plug-in hybrid vehicles and electric vehicles at about 1% each, both up from negligible shares in 2013. In AEO2015, new vehicle sales shares in 2015 are generally similar to those in AEO2014. In AEO2014, the motor gasoline share of new LDVs sales was 78% in 2040 (with 42% including micro hybridization), followed by 11% ethanol-flex-fuel, 5% hybrid electric, 4% diesel, and 1% each for plug-in hybrid and electric vehicles.

In the AEO2015 Reference case, delivered energy use by heavy-duty vehicles (HDVs) increases from 5.8 quadrillion Btu in 2013 to 7.3 quadrillion Btu in 2040 (compared with 7.5 quadrillion Btu in 2040 in AEO2014). Industrial output growth in AEO2015 leads to solid growth in HDV VMT, averaging 1.5%/year from 2013 to 2040. Competitive natural gas prices significantly increase demand for LNG and compressed natural gas in AEO2015, from an insignificant share in 2013 to 7% of total HDV energy consumption in 2040 (which is less than the 9% share in AEO2014, as a result of differences in fuel price projections).

Figure E2. Delivered energy consumption by end-use sector in the AEO2015 and AEO2014 Reference cases, 2013, 2020, 2030, and 2040 (quadrillion Btu)



Industrial

Total industrial delivered energy consumption grows by 22% in the AEO2015 Reference case, to about 30 quadrillion Btu in 2040, which is about 0.4 quadrillion Btu lower than the 2040 projection in the AEO2014 Reference case. The lower level of total industrial energy consumption in AEO2015 results from lower annual growth in the total value of industrial shipments (1.8%/year) compared with AEO2014 (2.1%/year).

Although total energy consumption levels are similar in the AEO2015 and AEO2014 Reference cases, there are some notable changes in consumption of individual fuels. In AEO2015, the liquid feedstock slate for the bulk chemical industry includes relatively more HGL (ethane and liquefied petroleum gases (LPG)) and less heavy feedstock (naphtha and gasoil) compared with AEO2014. The higher level of HGL feedstock use results from relatively low ethane and LPG prices relative to the prices of oil-based naphtha/gasoil feedstock, as a result of more HGL supply in the AEO2015

Reference case than in AEO2014 and the implementation of a new ethane pricing model that links ethane prices more closely with natural gas prices.

Another notable change from AEO2014 in the AEO2015 Reference case is that total consumption of renewable fuels is more than 0.5 quadrillion Btu lower in AEO2015 as a result of lower shipments from the paper and pulp industry. Industrial electricity consumption is also lower in AEO2015, in part as a result of lower shipments of metal-based durables, especially computers. Through 2022, natural gas consumption is higher in the AEO2015 Reference case than in AEO2014, as a result of higher lease and plant fuel use and an increase in feedstock use, reflecting more optimistic assumptions for ammonia and methanol plant operations based on recent trends. However, after 2022 natural gas consumption is lower in the AEO2015 Reference case, because of lower lease and plant fuel use stemming from lower dry natural gas production, and because of lower shipments in the natural gas-intensive paper and pulp industry.

Residential

Residential delivered energy consumption decreases slightly in the AEO2015 Reference case from 2013 to 2040, with growth in electricity consumption offset by declining use of fossil fuels. Consumption levels are lower than those in the AEO2014 Reference case for most fuels, although natural gas use is slightly higher because of lower projected prices. Delivered electricity consumption is 5.4 quadrillion Btu and natural gas consumption is 4.3 quadrillion Btu in 2040 in AEO2015, compared with 5.7 quadrillion Btu and 4.2 quadrillion Btu, respectively, in AEO2014. The lower consumption levels in AEO2015 are explained in part by slower near-term growth in the number of households.

Commercial

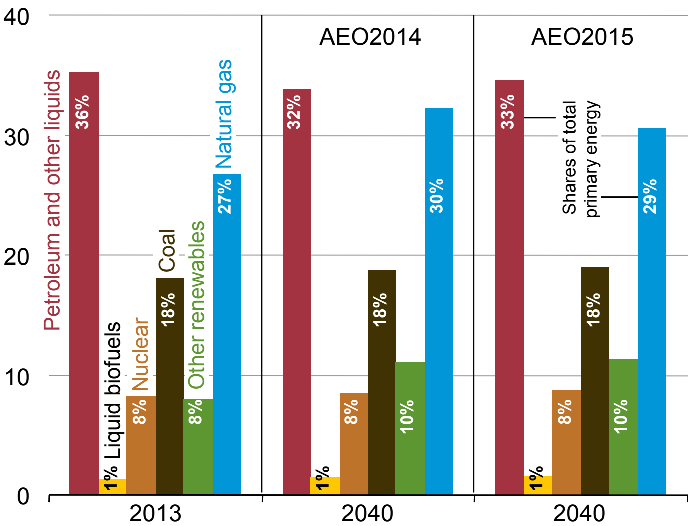
Commercial sector delivered energy consumption grows from 8.7 quadrillion Btu in 2013 to 10.1 quadrillion Btu in 2040 in the AEO2015 Reference case, similar to the AEO2014 Reference case, despite higher consumption in the near term. Commercial electricity consumption increases by 0.8%/year from 2013 to 2040 in AEO2015, lower than the 1.0% average annual growth in commercial floorspace, in part, because of lower demand for lighting and refrigeration than projected in AEO2014.

Energy consumption by primary fuel

Total primary energy consumption grows by 8.8% in the AEO2015 Reference case, from 97.1 quadrillion Btu in 2013 to 105.7 quadrillion Btu in 2040—600 trillion Btu less than in AEO2014, where total primary energy consumption grew by 10.2% to 106.3 quadrillion Btu in 2040 (Figure E3).

Total liquid fuels consumption increases slightly (300 trillion Btu) in the AEO2015 Reference case (the AEO2014 Reference case showed a decline of 600 trillion Btu), as declining consumption of motor gasoline offsets most of the growth in other liquids uses from 2013 to 2040. However, total liquid fuel consumption is 0.9 quadrillion Btu higher in 2040 in the AEO2015 Reference case than in the AEO2014 Reference case. Jet fuel, motor gasoline, and industrial propane use are each about 500 trillion Btu higher in 2040 in AEO2015 than in AEO2014, as a result of updates and revisions made in the air transportation model and lower petroleum fuel prices, as well as upward revisions in output projections for the chemical industry. Liquids consumption in the transportation sector also increases in AEO2015 as the result of the addition of an *unspecified* consumption sector, which was added to improve the consistency of matching travel and efficiency levels with implied fuel use in the transportation sector, so that total consumption of liquid fuels in AEO2015 agrees more closely with the combined total for all fuels reported as being supplied to markets in EIA statistical publications.

Figure E3. Primary energy consumption by fuel in the AEO2015 and AEO2014 Reference cases, 2013 and 2040 (quadrillion Btu)



In the AEO2015 Reference case, domestic natural gas consumption increases from 26.2 trillion cubic feet (Tcf) in 2013 to 29.7 Tcf in 2040, 1.9 Tcf lower than in the AEO2014 Reference case. The lower level of total natural gas consumption results from a 1.9 Tcf lower level of natural gas use in the electric power sector in 2040 in AEO2015. Natural gas consumption in the residential and commercial sectors is up slightly.

In the electric power sector, natural gas faces increased competition from nuclear power and renewables, particularly wind. Also, demand for electricity in the buildings sector in 2040 is about 0.3 quadrillion Btu lower than in AEO2014, as a result of increases in building efficiency standards and updates to lighting parameters in AEO2015. Electricity demand is also lower in some industrial sectors where output does not increase as rapidly in AEO2015 as was projected in AEO2014.

Total coal consumption in the AEO2015 Reference case is 19.0 quadrillion Btu (988 million short tons) in 2040—similar to the AEO2014 Reference case projection of 18.7 quadrillion Btu (979 million short tons) in 2040.

Total consumption of marketed renewable fuels grows by 1.3%/year in the AEO2015 Reference case, the same rate of growth as in the AEO2014 Reference case. However, the mix of renewable fuels is different in AEO2015, with more use of wind in the electric power sector, and less use of biomass in the industrial sector as a result of lower overall shipments in the paper industry. AEO2015 includes 3.0 quadrillion Btu of wind energy consumption in the electric power sector in 2040, compared with 2.4 quadrillion Btu in AEO2014, and the paper industry uses 1.2 quadrillion Btu of wood and pulping liquor in 2040 compared with 1.9 quadrillion Btu in 2040 in the AEO2014 Reference case.

Energy production and imports

In the AEO2015 Reference case, U.S. imports and exports of energy come into balance around 2028 as net energy imports decline both in absolute terms and as a share of total U.S. energy consumption (Figure E4). The United States is a net energy exporter in selected years—for example, from 2029 through 2032, and from 2037 through 2040. Over the projection period, the United States shifts from being a net importer of about 12.8 quadrillion Btu of energy in 2013 (about 13% of total U.S. energy demand) to a net exporter of about 0.5 quadrillion Btu in 2040. In the AEO2014 Reference case, the United States remained a net importer of energy, with net imports of about 4.2 quadrillion Btu in 2040.

Liquids

U.S. crude oil production in the AEO2015 Reference case increases from 7.4 million bbl/d in 2013 to 9.4 million bbl/d in 2040—26% higher than in the AEO2014 Reference case, despite lower prices. Production in AEO2015 reaches 10.6 million bbl/d in 2020, compared with a high of 9.6 million bbl/d in 2019 in AEO2014. Higher production volumes result mainly from increased onshore oil production, predominantly from tight (very low permeability) formations. Lower 48 onshore tight oil production reaches 5.6 million bbl/d in 2020 in the AEO2015 Reference case before declining to 4.3 million bbl/d in 2040, 34% higher than in AEO2014. The pace of oil-directed drilling in the near term is faster in AEO2015 than in AEO2014, as producers continue to locate and target the *sweet spots* of plays currently under development.

Lower 48 offshore crude oil supply grows from 1.4 million bbl/d in 2013 to 2.2 million bbl/d in 2019 in the AEO2015 Reference case, before fluctuating in accordance with the development of projects in the deepwater and ultra-deepwater portions of the Gulf of Mexico. In 2040, Lower 48 offshore production totals 2.2 million bbl/d in AEO2015, 9% more than in the AEO2014 Reference case.

U.S. net imports of liquid fuels as a share of total domestic consumption continue to decline in the AEO2015 Reference case, primarily as a result of increased domestic oil production. Net imports of liquid fuels as a share of total U.S. liquid fuel use reached 60% in 2005 before dipping below 50% in 2010 and falling to an estimated 33% in 2013 (Figure E5). The net import share of domestic liquid fuels consumption declines to 14% in 2020 in the AEO2015 Reference case—compared with 26% in the AEO2014 Reference case—as a result of faster growth of domestic liquid fuels supply[29] compared with growth in consumption. Domestic liquid fuels supply begins to decline after 2023 in the AEO2015 Reference case, and as a result, the net import share of domestic liquid fuels consumption rises from 14% in 2022 to 17% in 2040. However, domestic liquid fuels supply in the AEO2015 Reference case is 25% higher in 2040 than in the AEO2014 Reference case, while domestic consumption is only 3% higher. As a result, despite increasing after 2020, the percentage of U.S. liquid fuel supply from net imports in the AEO2015 Reference case remains just over half that in the AEO2014 Reference case through 2040.

Figure E4. Total energy production and consumption in the AEO2015 and AEO2014 Reference cases, 1980-2040 (quadrillion Btu)

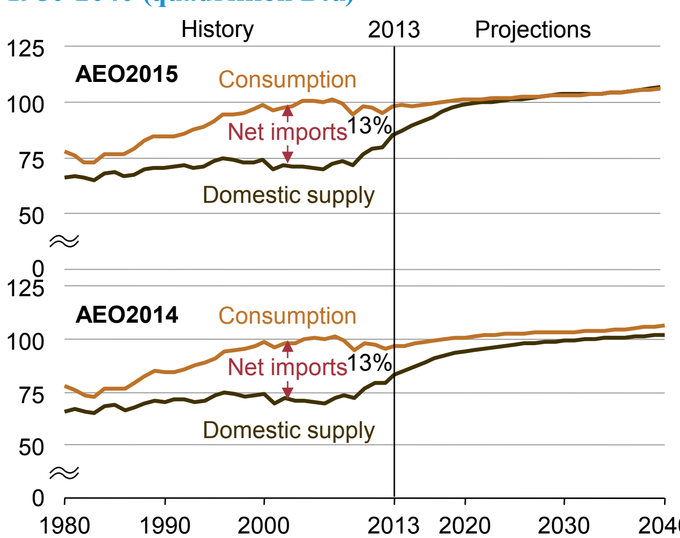
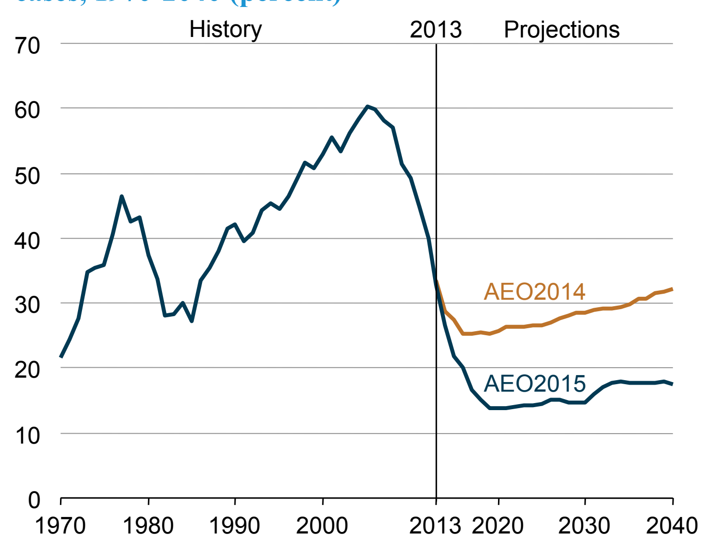


Figure E5. Share of U.S. liquid fuels supply from net imports in the AEO2015 and AEO2014 Reference cases, 1970-2040 (percent)



[29]Total domestic liquid fuels minus net imports, plus domestic HGL production.

Natural gas

In the AEO2015 Reference case, U.S. production of dry natural gas after 2019 is lower than in the AEO2014 Reference case projection, and in 2040 it is lower by more than 2 trillion cubic feet (Tcf). Lower production levels are a result of lower natural gas prices and a decrease in demand for natural gas by electricity generators because of fewer nuclear plant retirements and more renewable generation capacity in AEO2015. However, dry natural gas production from shale gas and tight oil plays is generally higher in AEO2015, offsetting some of the decreases in other areas. Increases in shale gas production are made possible by the dual application of horizontal drilling and hydraulic fracturing. Another contributing factor is ongoing drilling in shale plays and other resources with high concentrations of natural gas liquids and crude oil, which, in energy-equivalent terms, have a higher value than dry natural gas, even with lower crude oil prices.

In the AEO2015 Reference case, the United States becomes an overall net exporter of natural gas in 2017, one year earlier than in AEO2014, and a net pipeline exporter of natural gas in 2018, three years earlier than in AEO2014. In the AEO2015 Reference case, imports from Canada, which largely enter the western United States, and exports into Canada, which generally exit out of the East, are generally lower than in the AEO2014 Reference case. Imports from Canada remain lower in the AEO2015 Reference case than in the AEO2014 Reference case through 2040, while exports to Canada are higher in the AEO2015 Reference case from 2021 to 2028, before decreasing below AEO2014 levels through 2040. Net pipeline imports from Canada fall steadily until 2030 in AEO2015, then increase modestly through 2040, when growth in shale production stabilizes in the United States but continues to increase in Canada.

Net pipeline exports to Mexico increase almost twofold in the AEO2015 Reference case from 2017 to 2040, with additional pipeline infrastructure added to enable the Mexican market to receive more natural gas via pipeline from the United States. However, pipeline exports to Mexico in the later years of the AEO2015 Reference case are lower than projected in the AEO2014 Reference case, because Mexico is assumed to increase domestic production as a result of constitutional reforms that permit more foreign investment in its oil and natural gas industry.

Beginning in 2024, exports of liquefied natural gas (LNG) are slightly lower in the AEO2015 Reference case than in AEO2014, driven by lower crude oil prices. However, the impact of crude oil prices on the projection is dampened by changes in assumptions about how rapidly new LNG export terminals will be built.

Coal

Total U.S. coal production in the AEO2015 Reference case grows at an average rate of 0.5%/year, from 985 million short tons (19.9 quadrillion Btu) in 2013 to 1,117 million short tons (22.5 quadrillion Btu) in 2040. In comparison, U.S. production in the AEO2014 Reference case was projected to increase by 0.3%/year, from 1,022 million short tons (20.7 quadrillion Btu) in 2013 to 1,121 million short tons (22.4 quadrillion Btu) in 2040. Actual coal production in 2013 was 4% lower than projected in AEO2014, as a result of a large drawdown of coal inventories at coal-fired power plants.

From 2013 through 2020, coal production in the AEO2015 Reference case is lower than projected in the AEO2014 Reference case, as lower natural gas prices result in the substitution of natural gas for coal in power generation. After 2020, total coal production in the AEO2014 and AEO2015 projections are nearly identical, with both hovering around 1.1 billion short tons through 2040, because of similar patterns of capacity additions and retirements at coal-fired power plants and similar coal-fired capacity utilization rates in the two projections. The outlook for U.S. coal exports is lower in AEO2015 than in AEO2014 throughout the projection period. Between 2013 and 2015, U.S. coal exports decline sharply in the AEO2015 Reference case as a result of strong international competition and lower international coal prices; but from 2015 through 2040 they increase gradually. Compared with AEO2014, coal exports in AEO2015 are 27% lower in 2015 and 13% lower in 2040.

Overall, regional patterns of U.S. coal production are similar in the AEO2015 and AEO2014 Reference cases. Production in the Eastern Interior region increases in both projections by about 100 million short tons from 2013 to 2040. The AEO2015 outlook for Central Appalachian coal production is similar to the AEO2014, but is about 7 million short tons (7%) higher, on average, than the AEO2014 from 2015 through 2040. Northern Appalachian coal production in 2040 is 20 million short tons lower in AEO2015 than projected in the AEO2014 Reference case. Production from Wyoming's Powder River Basin, currently the lead coal-producing region in the United States, is lower from 2013 through 2018 in AEO2015 than projected in AEO2014, but then increases at a more rapid pace through 2026 before declining slightly and eventually moving to levels consistent with the AEO2014 projection from 2032 through 2040.

Electricity generation

Total electricity consumption in the AEO2015 Reference case, including both purchases from electric power producers and on-site generation, grows from 3,836 billion kWh in 2013 to 4,797 billion kWh in 2040. The average annual increase of 0.8% from 2013 to 2040 is slightly below the 1.0% annual rate in the AEO2014 Reference case. In all the end-use sectors, electricity demand growth is slower than projected in AEO2014, with the largest difference in growth in the residential sector.

Coal has traditionally been the largest energy source for electricity generation. However, the combination of slow growth in electricity demand, competitively priced natural gas, programs encouraging renewable fuel use, and the implementation of environmental rules dampens future coal use in both the AEO2015 and AEO2014 Reference cases. Beginning in 2019, coal-fired electricity generation is between 2% and 4% percent higher in the AEO2015 Reference case than in AEO2014 through 2025, as a result of higher natural gas prices. After 2025, coal-fired generation remains between one and two percent higher in AEO2015 than in AEO2014 (Figure E6). The AEO2015 Reference case does not include the proposed Clean Power Plan[30] for existing fossil-fuel-fired electric generating units, which, if implemented, could substantially change the generation mix.

Coal accounted for 39% of total generation in 2013, and its share falls to 34% in 2040 in the AEO2015 Reference case. The coal share of total generation was lower at 32% in 2040 in the AEO2014 Reference case. With retirements of coal-fired generating capacity far outpacing new additions, total coal-fired generating capacity falls in the AEO2015 Reference case from 304 GW in 2013 to 260 GW in 2040, which is similar to the 2040 capacity projection in the AEO2014 Reference case.

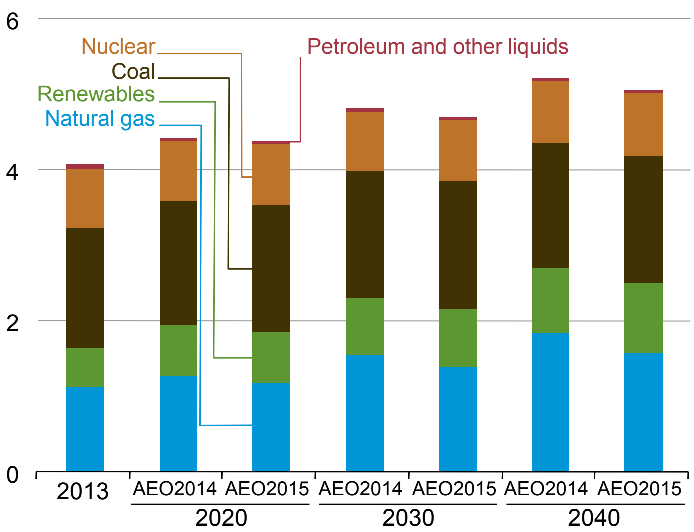
Electricity generation from natural gas grows at a slower rate in the AEO2015 Reference case than in the AEO2014 Reference case because of lower growth in overall electricity demand, higher natural gas prices in the midterm, fewer nuclear retirements, and more renewable capacity additions leading to less need for new natural gas-fired capacity. In the AEO2015 Reference case, natural gas-fired generation in 2040 is 15% lower than projected in the AEO2014 Reference case. Natural gas capacity additions still make up most (58%) of total capacity additions from 2014 to 2040 but represent a smaller share of new builds than the 74% of total additions projected in AEO2014. As a share of total generation, natural gas does not surpass the coal-fired generation share in the AEO2015 Reference case over the projection period as it did in the AEO2014 Reference case.

Increased generation from renewable energy accounts for 38% of the overall growth in electricity generation from 2013 to 2040 in the AEO2015 Reference case. Generation from renewable resources grows in the near term as new capacity under construction comes online in response to federal tax credits, state-level policies, and declining capital costs for wind and solar projects. In the final decade of the projection, renewable generation growth is almost exclusively the result of the increasing cost-competiveness of renewable generation with other, nonrenewable technologies.

Renewable generation is higher throughout most of the projection period in AEO2015 than was projected in AEO2014, and it is about 7% higher in 2040. Combined generation from solar and wind power in AEO2015 is about 28% higher in 2040 than projected in AEO2014, as a result of more planned renewable capacity additions and recent declines in the construction costs for new wind plants. Renewable generation accounts for 18% of total generation in 2040 in the AEO2015 Reference case, compared with 16% in AEO2014.

In the AEO2015 Reference case, electricity generation from nuclear power plants increases by 6%, from 789 billion kWh in 2013 to 833 billion kWh in 2040, and accounts for about 16% of total generation in 2040, slightly above the share in AEO2014. Over the projection period, nuclear generation in AEO2015 is on average 3% higher than projected in AEO2014, with about 4 GW less nuclear capacity retired from 2013 to 2020 in the AEO2015 Reference case, compared to the AEO2014 Reference case.

Figure E6. Electricity generation by fuel in the AEO2015 and AEO2014 Reference cases, 2013, 2020, 2030, and 2040 (trillion kilowatthours)



Energy-related CO2 emissions

Total U.S. energy-related CO2 emissions remain well below their 2005 level of 5,993 million metric tons (mt) through the end of the projection period in the AEO2015 Reference case.[31] Energy-related CO2 emissions in 2040 are 5,549 million mt, or 50 million mt (0.9%) below the AEO2014 Reference case projection. This decrease may appear counterintuitive, since coal consumption is 1.4% higher, petroleum and other liquids consumption is 2.4% higher, and total renewable energy consumption is lower, all putting upward pressure on emissions. However, natural gas consumption is 5.6% lower, and while it has a lower carbon factor than the other fossil fuels, it does emit CO2. Nuclear energy consumption in 2040 is 2.8% higher in AEO2015 than in AEO2014, and total energy demand is 0.5% lower. The net result is somewhat lower energy-related CO2 emissions in the AEO2015 Reference case than in the AEO2014 Reference case.

[30]U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," *Federal Register*, pp. 34829-34958 (Washington, DC: June 18, 2014) https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.

[31]The year 2005 is the base year for the Obama Administration's goal for emission reductions of 17% by 2020. In the AEO2015 Reference case, energy-related CO2 emissions in 2020 are 8% below the 2005 level.

Figure and table sources

Links current as of April 2015

Table E1. Comparison of projections in the AEO2015 and AEO2014 Reference cases, 2012-40: AEO2015 National Energy Modeling System, run REF2015.D021915A; and AEO2014 National Energy Modeling System, run REF2014.D102413A.

Figure E1. Average annual Brent crude oil spot prices in the AEO2015 and AEO2014 Reference cases, 1990-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A; and AEO2014 National Energy Modeling System, run REF2014.D102413A.

Figure E2. Delivered energy consumption by end-use sector in the AEO2015 and AEO2014 Reference cases, 2013, 2020, 2030, and 2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A; and AEO2014 National Energy Modeling System, run REF2014.D102413A.

Figure E3. Primary energy consumption by fuel in the AEO2015 and AEO2014 Reference cases, 2013 and 2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A; and AEO2014 National Energy Modeling System, run REF2014.D102413A.

Figure E4. Total energy production and consumption in the AEO2015 and AEO2014 Reference cases, 1980-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A; and AEO2014 National Energy Modeling System, run REF2014.D102413A.

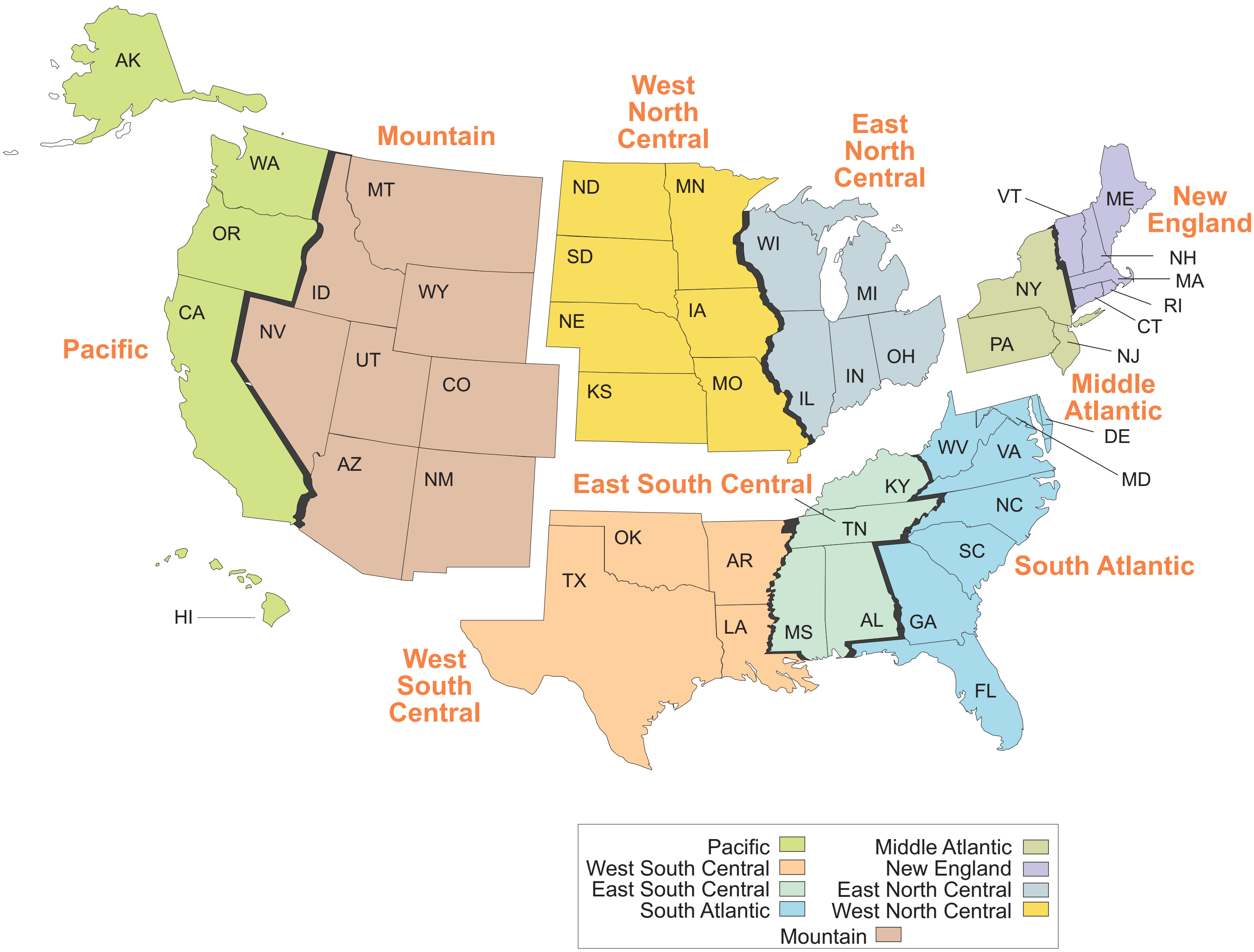
Figure E5. Share of U.S. liquid fuels supply from net imports in the AEO2015 and AEO2014 Reference cases, 1970-2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A; and AEO2014 National Energy Modeling System, run REF2014.D102413A.

Figure E6. Electricity generation by fuel in the AEO2015 and AEO2014 Reference cases, 2013, 2020, 2030, and 2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, November 2014, DOE/EIA-0035(2014/11). **Projections:** AEO2015 National Energy Modeling System, run REF2015.D021915A; and AEO2014 National Energy Modeling System, run REF2014.D102413A.

Appendix F

Regional Maps

Figure F1. United States Census Divisions



Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F1. United States Census Divisions (continued)

Division 1
New England

Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Division 2
Middle Atlantic

New Jersey
New York
Pennsylvania

Division 3
East North Central

Illinois
Indiana
Michigan
Ohio
Wisconsin

Division 4
West North Central

Iowa
Kansas
Minnesota
Missouri
Nebraska
North Dakota
South Dakota

Division 5
South Atlantic

Delaware
District of Columbia
Florida
Georgia
Maryland
North Carolina
South Carolina
Virginia
West Virginia

Division 6
East South Central

Alabama
Kentucky
Mississippi
Tennessee

Division 7
West South Central

Arkansas
Louisiana
Oklahoma
Texas

Division 8
Mountain

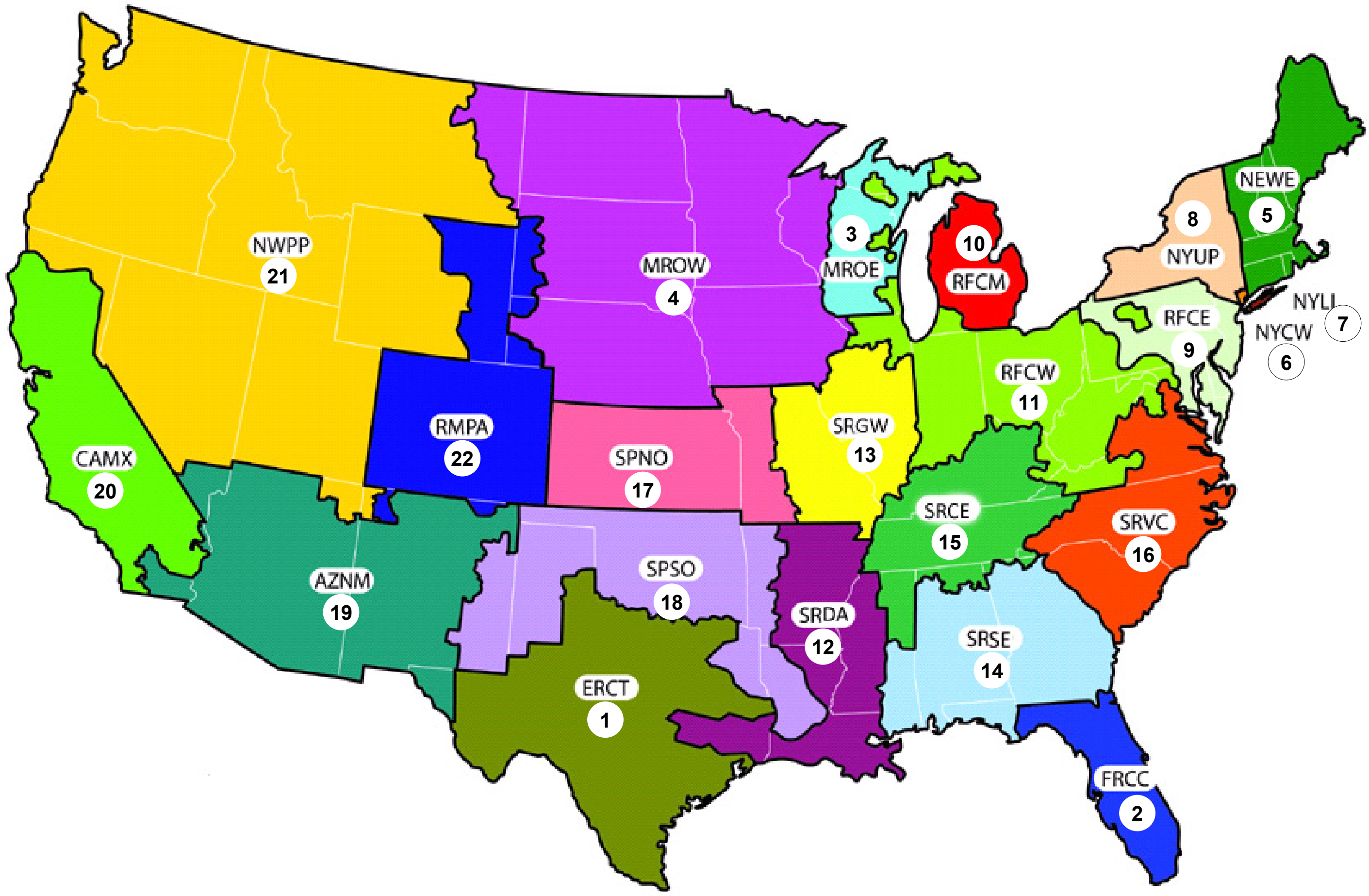
Arizona
Colorado
Idaho
Montana
Nevada
New Mexico
Utah
Wyoming

Division 9
Pacific

Alaska
California
Hawaii
Oregon
Washington

Source: U.S. Energy Information Administration, Office of Energy Analysis.

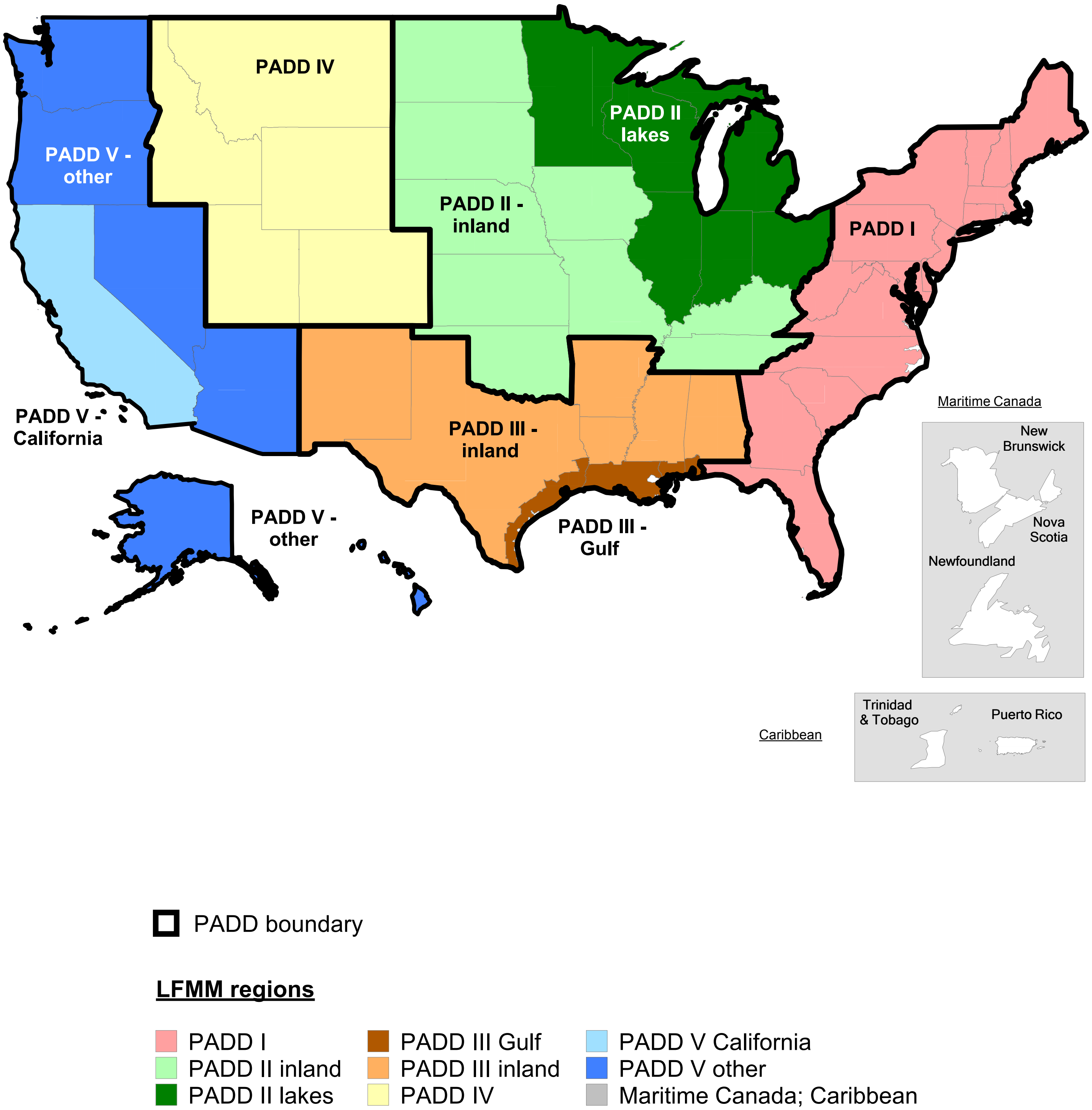
Figure F2. Electricity market module regions



1.	ERCT	TRE All	12.	SRDA	SERC Delta
2.	FRCC	FRCC All	13.	SRGW	SERC Gateway
3.	MROE	MRO East	14.	SRSE	SERC Southeastern
4.	MROW	MRO West	15.	SRCE	SERC Central
5.	NEWE	NPCC New England	16.	SRVC	SERC VACAR
6.	NYCW	NPCC NYC/Westchester	17.	SPNO	SPP North
7.	NYLI	NPCC Long Island	18.	SPSO	SPP South
8.	NYUP	NPCC Upstate NY	19.	AZNM	WECC Southwest
9.	RFCE	RFC East	20.	CAMX	WECC California
10.	RFCM	RFC Michigan	21.	NWPP	WECC Northwest
11.	RFCW	RFC West	22.	RMPA	WECC Rockies

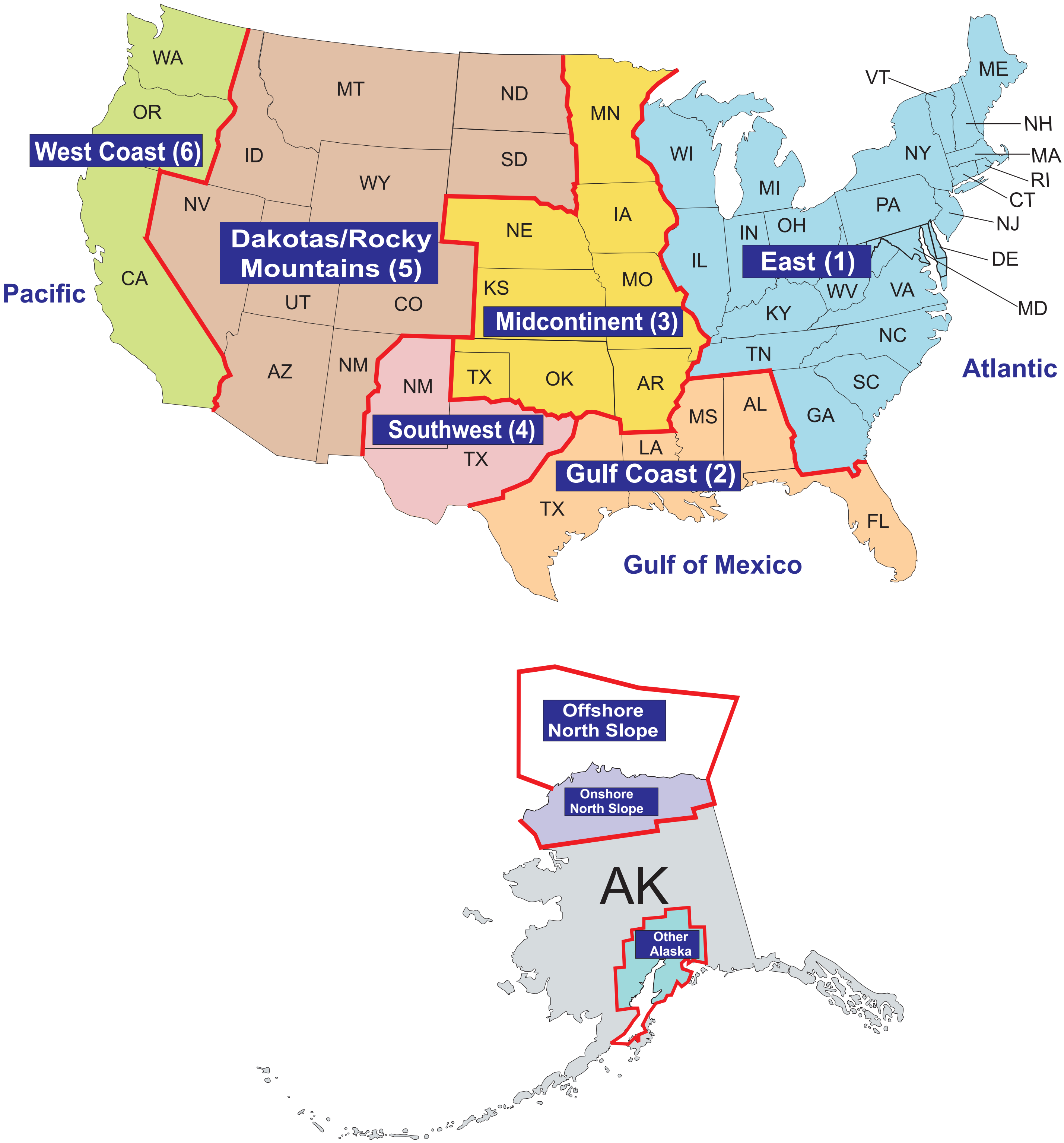
Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F3. Liquid fuels market module regions



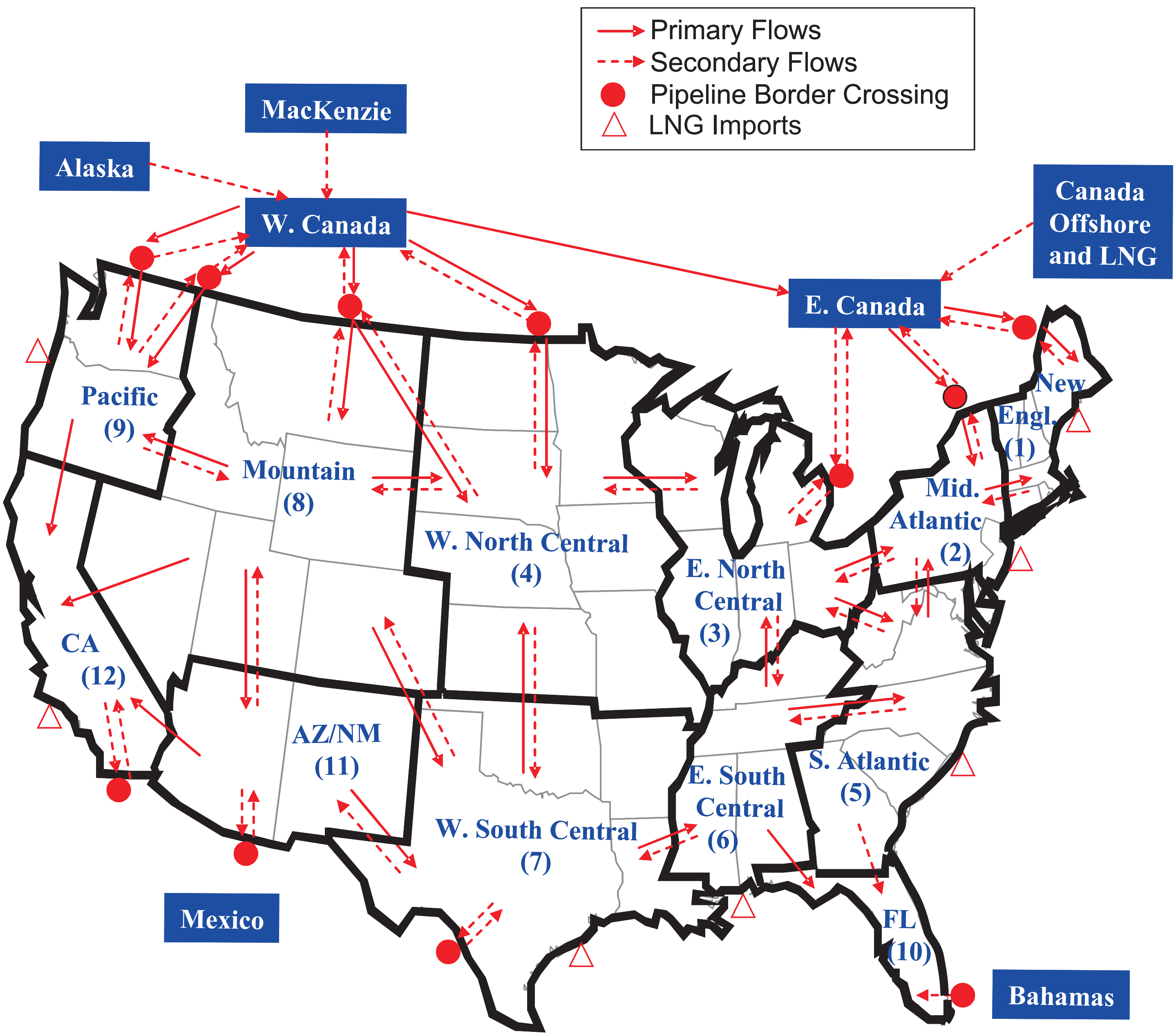
Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F4. Oil and gas supply model regions



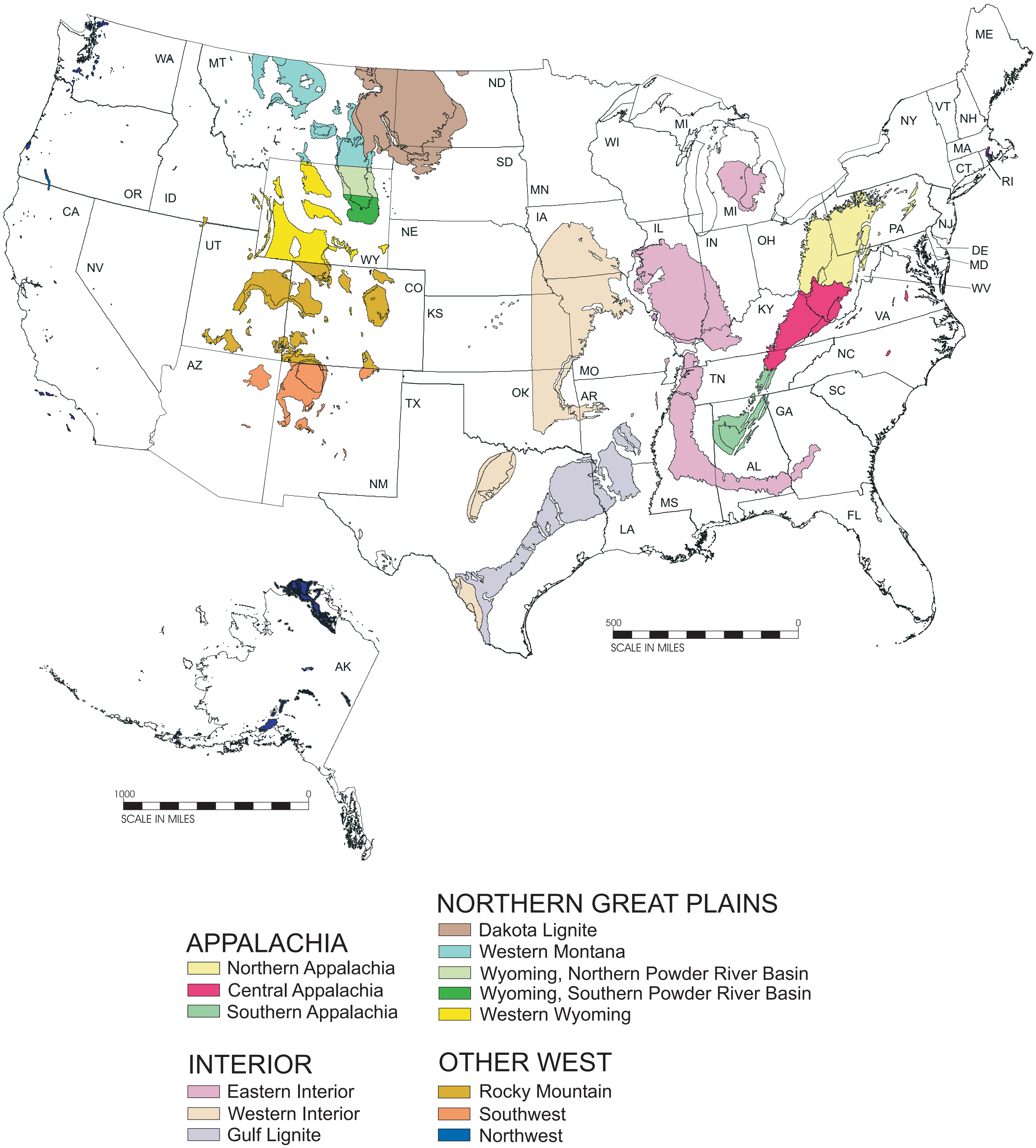
Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F5. Natural gas transmission and distribution model regions



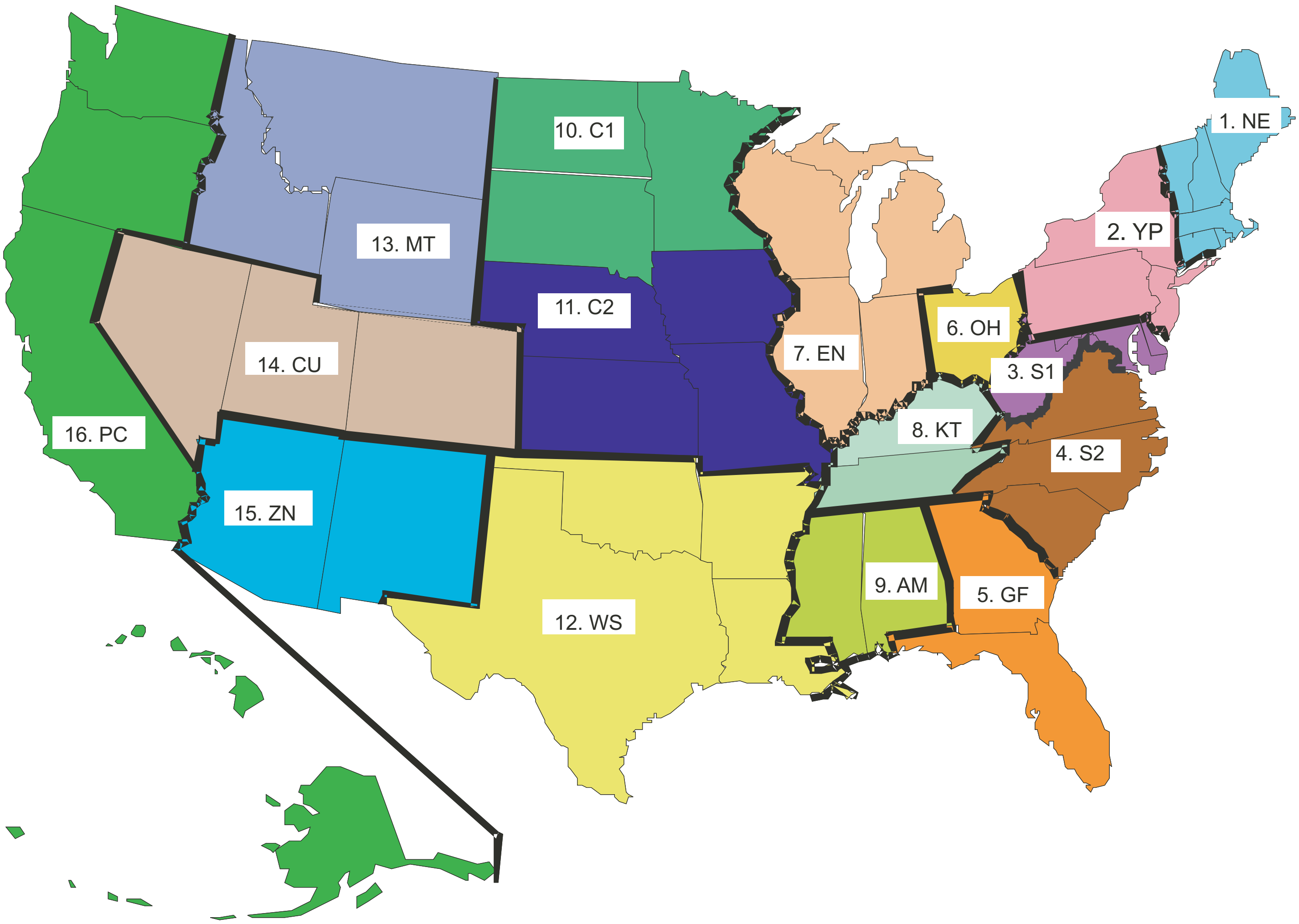
Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F6. Coal supply regions



Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F7. Coal demand regions



Region Code	Region Content
1. NE	CT,MA,ME,NH,RI,VT
2. YP	NY,PA,NJ
3. S1	WV,MD,DC,DE
4. S2	VA,NC,SC
5. GF	GA,FL
6. OH	OH
7. EN	IN,IL,MI,WI
8. KT	KY,TN

Region Code	Region Content
9. AM	AL,MS
10. C1	MN,ND,SD
11. C2	IA,NE,MO,KS
12. WS	TX,LA,OK,AR
13. MT	MT,WY,ID
14. CU	CO,UT,NV
15. ZN	AZ,NM
16. PC	AK,HI,WA,OR,CA

Source: U.S. Energy Information Administration, Office of Energy Analysis.

Appendix G

Conversion factors

Table G1. Heat contents

Fuel	Units	Approximate heat content
Coal[1]		
Production	million Btu per short ton	20.169
Consumption	million Btu per short ton	19.664
Coke plants	million Btu per short ton	28.710
Industrial	million Btu per short ton	21.622
Commercial and institutional	million Btu per short ton	21.246
Electric power sector	million Btu per short ton	19.210
Imports	million Btu per short ton	23.256
Exports	million Btu per short ton	24.562
Coal coke	million Btu per short ton	24.800
Crude oil[1]		
Production	million Btu per barrel	5.751
Imports	million Btu per barrel	6.012
Petroleum products and other liquids		
Consumption[1]	million Btu per barrel	5.188
Motor gasoline[1]	million Btu per barrel	5.101
Jet fuel	million Btu per barrel	5.670
Distillate fuel oil[1]	million Btu per barrel	5.760
Diesel fuel[1]	million Btu per barrel	5.755
Residual fuel oil	million Btu per barrel	6.287
Liquefied petroleum gases and other[1,2]	million Btu per barrel	3.565
Kerosene	million Btu per barrel	5.670
Petrochemical feedstocks[1]	million Btu per barrel	4.944
Unfinished oils[1]	million Btu per barrel	6.098
Imports[1]	million Btu per barrel	5.575
Exports[1]	million Btu per barrel	5.506
Ethanol[3]	million Btu per barrel	3.559
Biodiesel	million Btu per barrel	5.359
Natural gas plant liquids[1]		
Production	million Btu per barrel	3.735
Natural gas[1]		
Production, dry	Btu per cubic foot	1,027
Consumption	Btu per cubic foot	1,027
End-use sectors	Btu per cubic foot	1,028
Electric power sector	Btu per cubic foot	1,025
Imports	Btu per cubic foot	1,025
Exports	Btu per cubic foot	1,009
Electricity consumption	Btu per kilowatthour	3,412

[1]Conversion factor varies from year to year. The value shown is for 2013.
[2]Includes ethane, natural gasoline, and refinery olefins.
[3]Includes denaturant.
Btu = British thermal unit.
Sources: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2014/11) (Washington, DC, November 2014), and EIA, AEO2015 National Energy Modeling System run REF2015.D021915A.

Table A20. Macroeconomic indicators
(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	Reference case							Annual growth 2013-2040 (percent)
	2012	2013	2020	2025	2030	2035	2040	
Real gross domestic product	**15,369**	**15,710**	**18,801**	**21,295**	**23,894**	**26,659**	**29,898**	**2.4%**
Components of real gross domestic product								
Real consumption	10,450	10,700	12,832	14,484	16,275	18,179	20,476	2.4%
Real investment	2,436	2,556	3,531	4,025	4,474	4,984	5,634	3.0%
Real government spending	2,954	2,894	2,985	3,098	3,286	3,469	3,691	0.9%
Real exports	1,960	2,020	2,813	3,807	4,815	6,010	7,338	4.9%
Real imports	2,413	2,440	3,334	4,079	4,888	5,859	7,037	4.0%
Energy intensity								
(thousand Btu per 2009 dollar of GDP)								
Delivered energy	4.47	4.53	3.93	3.49	3.13	2.83	2.56	-2.1%
Total energy	6.14	6.18	5.36	4.79	4.31	3.90	3.54	-2.0%
Price indices								
GDP chain-type price index (2009=1.000)	1.05	1.07	1.21	1.31	1.43	1.57	1.73	1.8%
Consumer price index (1982-4=1.00)								
All-urban	2.30	2.33	2.63	2.89	3.18	3.54	3.95	2.0%
Energy commodities and services	2.46	2.44	2.55	2.98	3.42	4.03	4.85	2.6%
Wholesale price index (1982=1.00)								
All commodities	2.02	2.03	2.25	2.47	2.71	3.02	3.39	1.9%
Fuel and power	2.12	2.12	2.26	2.67	3.08	3.69	4.56	2.9%
Metals and metal products	2.20	2.14	2.43	2.62	2.85	3.13	3.42	1.8%
Industrial commodities excluding energy	1.94	1.96	2.22	2.40	2.61	2.85	3.12	1.7%
Interest rates (percent, nominal)								
Federal funds rate	0.14	0.11	3.40	3.56	3.69	3.76	4.04	- -
10-year treasury note	1.80	2.35	4.12	4.14	4.28	4.41	4.63	- -
AA utility bond rate	3.83	4.24	6.15	6.06	6.33	6.47	6.71	- -
Value of shipments (billion 2009 dollars)								
Non-industrial and service sectors	23,989	24,398	28,468	32,023	34,968	37,767	40,814	1.9%
Total industrial	6,822	7,004	8,467	9,212	9,870	10,614	11,463	1.8%
Agriculture, mining, and construction	1,813	1,858	2,344	2,441	2,540	2,601	2,712	1.4%
Manufacturing	5,009	5,146	6,123	6,771	7,330	8,012	8,751	2.0%
Energy-intensive	1,675	1,685	1,946	2,084	2,168	2,237	2,317	1.2%
Non-energy-intensive	3,334	3,461	4,177	4,687	5,162	5,776	6,433	2.3%
Total shipments	**30,810**	**31,402**	**36,935**	**41,235**	**44,838**	**48,380**	**52,277**	**1.9%**
Population and employment (millions)								
Population, with armed forces overseas	315	317	334	347	359	370	380	0.7%
Population, aged 16 and over	249	251	267	277	288	298	307	0.7%
Population, aged 65 and over	43	45	56	65	73	78	80	2.2%
Employment, nonfarm	134	136	149	154	159	163	169	0.8%
Employment, manufacturing	11.8	11.9	11.8	11.3	10.7	10.3	9.7	-0.7%
Key labor indicators								
Labor force (millions)	155	155	166	170	174	179	185	0.6%
Nonfarm labor productivity (2009=1.00)	1.05	1.05	1.20	1.34	1.48	1.62	1.78	2.0%
Unemployment rate (percent)	8.08	7.35	5.40	4.96	5.03	5.02	4.85	- -
Key indicators for energy demand								
Real disposable personal income	11,676	11,651	14,411	16,318	18,487	20,610	22,957	2.5%
Housing starts (millions)	0.84	0.99	1.69	1.70	1.66	1.62	1.62	1.8%
Commercial floorspace (billion square feet)	82.3	82.8	89.0	94.1	98.4	103.2	109.1	1.0%
Unit sales of light-duty vehicles (millions)	14.4	15.5	17.0	17.2	17.5	17.7	18.2	0.6%

GDP = Gross domestic product.
Btu = British thermal unit.
- - = Not applicable.
Sources: 2012 and 2013: IHS Economics, Industry and Employment models, November 2014. **Projections:** U.S. Energy Information Administration, AEO2015 National Energy Modeling System run REF2015.D021915A.

Congressional Budget Office

JANUARY 2016

The Budget and Economic Outlook: 2016 to 2026

Provided as a convenience, this "screen-friendly" version is identical in content to the principal ("printer-friendly") version of the report. Any tables, figures, and boxes appear at the end of this document; click the hyperlinked references in the text to view them.

Notes

The Congressional Budget Office's budget projections are built on its economic forecast. In mid-December 2015, after CBO had completed that forecast, lawmakers enacted legislation that affected certain aspects of the economic outlook. Consequently, CBO updated its economic forecast; that updated forecast is presented in this report. But the agency did not have enough time to incorporate that update into its budget projections. Therefore, the budget projections in this report are based on the economic forecast that CBO completed in early December (though they include the direct budgetary effects of legislation enacted through December).

Unless otherwise indicated, all years referred to in describing the budget outlook are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end. Years referred to in describing the economic outlook are calendar years.

Numbers in the text and tables may not add up to totals because of rounding. Also, some values are expressed as fractions to indicate numbers rounded to amounts greater than a tenth of a percentage point.

Some figures in this report have vertical bars that indicate the duration of recessions. (A recession extends from the peak of a business cycle to its trough.)

As referred to in this report, the Affordable Care Act comprises the Patient Protection and Affordable Care Act (Public Law 111-148), the health care provisions of the Health Care and Education Reconciliation Act of 2010 (P.L. 111-152), and the effects of subsequent judicial decisions, statutory changes, and administrative actions.

Unless otherwise noted, amounts for Medicare spending in this report are net of income received by the government from premiums paid by Medicare beneficiaries, recoveries of overpayments made to providers, amounts paid by states from savings on Medicaid's prescription drug costs, and other offsetting receipts.

Supplemental data for this analysis are available on CBO's website (www.cbo.gov/publication/51129), as is a glossary of common budgetary and economic terms (www.cbo.gov/publication/42904)

Summary

In 2016, the federal budget deficit will increase, in relation to the size of the economy, for the first time since 2009, according to the Congressional Budget Office's estimates. If current laws generally remained unchanged, the deficit would grow over the next 10 years, and by 2026 it would be considerably larger than its average over the past 50 years, CBO projects. Debt held by the public would also grow significantly from its already high level.

CBO anticipates that the economy will expand solidly this year and next. Increases in demand for goods and services are expected to reduce the quantity of underused labor and capital, or "slack," in the economy—thereby encouraging greater participation in the labor force by reducing the unemployment rate and pushing up compensation. That reduction in slack will also push up inflation and interest rates. Over the following years, CBO projects, output will grow at a more modest pace, constrained by relatively slow growth in the nation's supply of labor. Nevertheless, in those later years, output is anticipated to grow more quickly than it has during the past decade.

The Budget Deficit for 2016 Will Increase After Six Years of Decline

The 2016 deficit will be $544 billion, CBO estimates, $105 billion more than the deficit recorded last year (see Summary Table 1). At 2.9 percent of gross domestic product (GDP), the expected shortfall for 2016 will mark the first time that the deficit has risen in relation to the size of the economy since peaking at 9.8 percent in 2009. About $43 billion of this year's increase in the deficit results from a shift in the timing of some payments that the government would ordinarily have made in fiscal year 2017, but that will instead be made in fiscal year 2016, because October 1, 2016—the first day of fiscal year 2017—falls on a weekend.[1] If not for that shift, the projected deficit in 2016 would be $500 billion, or 2.7 percent of GDP.

The 2016 deficit that CBO currently projects is $130 billion higher than the one that the agency projected in August 2015.[2] That increase is largely attributable to legislation enacted since August—in particular, the retroactive extension of a number of provisions that reduce corporate and individual income taxes.

The deficit projected by CBO would increase debt held by the public to 76 percent of GDP by the end of 2016, the agency estimates—about 2 percentage points higher

1. October 1 will fall on a weekend not only in 2016 but also in 2017, 2022, and 2023. In all of those years, certain payments due on October 1 will instead be made at the end of September and thus be shifted into the previous fiscal year. The shifts noticeably boost projected spending and deficits in fiscal years 2016 and 2022 and reduce them in fiscal years 2018 and 2024.

2. For CBO's projections in August, see Congressional Budget Office, *An Update to the Budget and Economic Outlook: 2015 to 2025* (August 2015), www.cbo.gov/publication/50724.

than it was last year and higher than it has been since the years immediately following World War II (see Summary Figure 1).

Outlays

Federal outlays are projected to rise by 6 percent this year—to $3.9 trillion, or 21.2 percent of GDP. That increase is the result of a nearly 7 percent rise in mandatory spending, a 3 percent increase in discretionary outlays (which stem from annual appropriations), and a 14 percent jump in net interest spending.[3]

CBO anticipates that mandatory outlays will be $168 billion higher in 2016 than they were last year. A significant component of that growth is Social Security outlays, which are expected to increase by about $28 billion (or 3 percent)—a percentage increase that is smaller than last year's, primarily because beneficiaries did not receive a cost-of-living adjustment in 2016 but did receive one in 2015. Nevertheless, because the program is so large, even that smaller-than-average increase accounts for one-sixth of the growth in mandatory spending projected for 2016. Federal spending for the major health care programs accounts for a much larger fraction—more than 60 percent—of the projected growth in mandatory spending: Outlays for Medicare (net of premiums and other offsetting receipts), Medicaid, and the Children's Health Insurance Program, plus subsidies for health insurance purchased through exchanges and related spending, are expected to be $104 billion (or 11 percent) higher this year than they were in 2015.[4]

Discretionary outlays are projected to be $32 billion higher in 2016 than they were last year. That upturn results largely from the Bipartisan Budget Act of 2015 (Public Law 114-74), which increased statutory limits on discretionary funding, and from the resulting appropriations for 2016, which were equal to those limits. According to CBO's estimates, discretionary outlays for national defense—in their first increase in five years—will edge up slightly this year, and nondefense discretionary outlays will climb by 4 percent.

The substantial increase that CBO expects in net interest spending, $32 billion, results from two factors: Interest rates are beginning to rise, and federal debt is growing. But interest rates remain quite low by historical standards, so net interest spending is anticipated to equal only 1.4 percent of GDP in 2016, still well below its 50-year average of 2.0 percent.

3. About $39 billion of the increase in mandatory spending and $4 billion of the increase in discretionary spending result from the timing shift mentioned above. If not for that shift, total outlays would rise by 5 percent this year (and equal 21.0 percent of GDP); mandatory spending would rise by 6 percent and discretionary spending by 2 percent.

4. If not for the aforementioned shift in the timing of some spending—in this case, certain Medicare payments—spending for the major health care programs would increase by $80 billion, or 9 percent.

Revenues

CBO expects federal revenues to rise by 4 percent in 2016—to $3.4 trillion, or 18.3 percent of GDP. That overall increase results from growth in some sources of revenues and declines in others. Revenues from individual income taxes are projected to rise by 5 percent—more than the percentage increase in nominal GDP—because people's nominal income will increase and also because their income will rise more than will the tax brackets, which are indexed only to inflation. That phenomenon, real bracket creep, occurs in most years when the economy expands. Economic growth also will contribute to a rise of 3 percent in payroll taxes, CBO estimates. In contrast, corporate income taxes are projected to dip by 5 percent, largely because of recent legislation (the Consolidated Appropriations Act, 2016, P.L. 114-113) that extended several expired tax provisions retroactively to the beginning of calendar year 2015. Revenues from other sources are estimated to increase, on net, by 9 percent, primarily because of recent legislation (the Fixing America's Surface Transportation Act, also called the FAST Act, P.L. 114-94) that increases remittances to the Treasury from the Federal Reserve.

Growing Deficits Are Projected to Drive Up Debt

In CBO's baseline projections (which incorporate the assumption that current laws will generally remain the same), growth in spending—particularly for Social Security, health care, and interest payments on federal debt—outpaces growth in revenues over the coming 10 years. The budget deficit increases modestly through 2018 but then starts to rise more sharply, reaching $1.4 trillion in 2026. As a percentage of GDP, the deficit remains at roughly 2.9 percent through 2018, starts to rise, and reaches 4.9 percent by the end of the 10-year projection period. The projected cumulative deficit between 2017 and 2026 is $9.4 trillion.

The projected deficits would push debt held by the public up to 86 percent of GDP by the end of the 10-year period, a little more than twice the average over the past five decades. Beyond the 10-year period, if current laws remained in place, the pressures that had contributed to rising deficits during the baseline period would accelerate and push debt up even more sharply. Three decades from now, for instance, debt held by the public is projected to equal 155 percent of GDP, a higher percentage than any previously recorded in the United States.

Such high and rising debt would have serious negative consequences for the budget and the nation:

- When interest rates increased from their current levels to more typical ones, federal spending on interest payments would rise substantially.

- Because federal borrowing reduces total saving in the economy over time, the nation's capital stock would ultimately be smaller than it would be if debt was smaller, and productivity and total wages would be lower.

- Lawmakers would have less flexibility to use tax and spending policies to respond to unexpected challenges.

- The likelihood of a fiscal crisis in the United States would increase. There would be a greater risk that investors would become unwilling to finance the government's borrowing needs unless they were compensated with very high interest rates; if that happened, interest rates on federal debt would rise suddenly and sharply.

Outlays

In CBO's projections, federal outlays remain near 21 percent of GDP for the next few years—higher than their average of 20.2 percent over the past 50 years. Later in the coming decade, if current laws generally remained the same, growth in outlays would outstrip growth in the economy, and outlays would rise to 23 percent of GDP by 2026. That increase reflects significant growth in mandatory spending and interest payments, offset somewhat by a decline (in relation to the size of the economy) in discretionary spending.

Outlays for mandatory programs are projected to rise from their current 13.1 percent of GDP (a figure that has been adjusted for the timing shift mentioned above) to 15.0 percent by the end of the 10-year projection period. That increase is mainly attributable to the aging of the population and rising health care costs per person. (According to CBO's projections, the number of people who are at least 65 years old will increase by 37 percent between now and 2026.) Of the 1.8 percentage-point increase in projected mandatory outlays, 0.9 percentage points come from a projected increase in Social Security outlays, and 0.8 percentage points come from a projected increase in Medicare outlays (net of premiums and other offsetting receipts). Almost half of the projected $2.5 trillion increase in *total* outlays from 2016 to 2026 is for Social Security and Medicare.

Because of rising interest rates and growing federal debt held by the public, the government's interest payments on that debt are projected to rise sharply over the next 10 years—more than tripling in nominal terms and more than doubling as a percentage of GDP, from 1.4 percent to 3.0 percent. Interest rates are now very low by historical standards, so net outlays for interest (in nominal dollars) are similar to their levels 15 to 20 years ago, even though federal debt now equals a considerably larger share of the economy. As interest rates rise, the government's cost of financing its debt will climb—especially if that debt continues to mount, as it does in CBO's projections.

In contrast, discretionary spending is projected to drop from 6.5 percent of GDP this year to 5.2 percent in 2026, a smaller percentage than in any year since 1962 (the first year for which comparable data are available). That projection incorporates the assumptions that the limits on funding and the automatic spending reductions set by the Budget Control Act of 2011 (P.L. 112-25), as they were subsequently amended, will stay in place through 2021; that appropriations for those years will be equal to the limits; and that funding in later years will keep pace with inflation.

Revenues

If current laws generally remained unchanged, revenues would remain relatively stable in relation to the size of the economy, ranging between 17.9 percent and 18.2 percent of GDP through 2026. (They have averaged 17.4 percent of GDP over the past 50 years.)

The projected stability of revenues over the next decade stems mostly from offsetting changes in projections of revenues from various sources. In CBO's baseline, receipts from individual income taxes increase each year in relation to GDP, because of real bracket creep, an expected increase in the share of wage and salary income going to high-income taxpayers, rising distributions from tax-deferred retirement accounts, and other factors. But revenues from other sources decline in relation to GDP. Remittances from the Federal Reserve, which have been unusually high since 2010, return to more typical levels. Corporate profits as a share of GDP decline modestly because of rising labor costs, higher interest payments on businesses' debt, and other factors, reducing receipts from corporate income taxes. And payroll tax receipts decline slightly in relation to GDP, primarily because of the expected increase in the share of wages going to higher-income taxpayers.

Changes From CBO's August 2015 Budget Projections

Over the 2016–2025 period (which was the 10-year projection period that CBO used last year), CBO now projects a cumulative deficit that is $1.5 trillion larger than the $7.0 trillion that the agency projected in August 2015. The $1.5 trillion increase is the net result of projected revenues that are lower by $1.2 trillion and projected outlays that are higher by $323 billion.

About half of the $1.5 trillion increase stems from the effects of laws enacted since August—which will reduce revenues by $425 billion and increase outlays by $324 billion over the 2016–2025 period, CBO estimates, adding $749 billion to projected deficits. Much of that amount stems from the extension of tax provisions by the Consolidated Appropriations Act, 2016, which will reduce corporate and individual income taxes.

About 30 percent of the increase in CBO's projection of the cumulative deficit through 2025—$437 billion—results from revisions to CBO's economic forecast. Lowered expectations for growth in the economy and for wages and corporate profits led the agency to reduce its projections of tax receipts from all sources by $771 billion over the 2016–2025 period. Lower projections of inflation, interest, and unemployment rates, among other changes, led CBO to mark down projected outlays by a smaller amount, $334 billion.

Finally, technical estimating changes that CBO has made since August have increased the agency's projection of the cumulative deficit over the 2016–2025 period by $363 billion, largely by increasing projected outlays. The most significant adjustments to outlays involve Medicaid and veterans' benefits. CBO boosted its projections of federal outlays for Medicaid to reflect higher-than-expected spending and enrollment for newly eligible beneficiaries under the Affordable Care Act. Also, on the basis of recent trends in the size of the eligible population and in average benefit payments, CBO now projects that spending for veterans' disability compensation will increase substantially.

Solid Economic Growth Over the Next Few Years Will Reduce Slack in the Labor Market

CBO expects that the economy will grow more quickly in 2016 and 2017 than it did in 2015, when real (that is, inflation-adjusted) GDP grew by an estimated 2.0 percent. The agency anticipates moderate economic growth in subsequent years, constrained by relatively slow growth in the labor force.

The Economic Outlook for 2016 Through 2020

If current laws governing federal taxes and spending generally remained in place, by CBO's projections, real GDP would grow by 2.7 percent this calendar year and by 2.5 percent in 2017, as measured by the change from the fourth quarter of the previous year (see Summary Figure 2). From 2018 through 2020, the economy would grow at an average annual rate of 2.0 percent, CBO projects.

The agency anticipates that consumer spending will be the largest single component of that growth, as it has been in the past. However, the pickup in the growth of output from 2015 to 2016 and 2017 is likely to stem largely from faster growth in investment in business capital and housing.

Fiscal Policy and the Economy. The pattern of projected federal spending and revenues under current law would have a range of effects on the economy through 2020. Laws enacted since August—most notably the Bipartisan Budget Act of 2015 and the Consolidated Appropriations Act, 2016—are estimated to boost real GDP slightly this year and next year. In total, however, the fiscal policies embodied in CBO's baseline would dampen GDP growth in 2017 and 2018, CBO estimates. In addition, some aspects of fiscal policy under current law, particularly the Affordable Care Act and real bracket creep, are projected to dampen the supply of labor and therefore the growth of output through 2020.

The Labor Market. Since the end of the most recent recession in 2009, GDP has grown faster than potential GDP, on average. (Potential GDP is the maximum sustainable output of the economy.) The gap between the two has therefore shrunk, reducing the amount of slack in the economy. In its current projections, CBO expects slack to diminish over the next few years; for example, the agency projects that hiring will reduce the unemployment rate from 5.0 percent in the fourth quarter of 2015 to 4.5 percent in the fourth quarter of 2016, which would be temporarily below the estimated natural rate of unemployment (the rate that arises from all sources except fluctuations in the overall demand for goods and services).

That relatively low unemployment rate would not indicate that slack in the labor market had disappeared entirely. Indeed, some slack is expected to persist through 2020, because fewer people will be participating in the labor market than if the economy was operating at its potential. However, as hiring puts upward pressure on employees' compensation, it is also likely to encourage some people to enter or stay in the labor force, gradually reducing the shortfall between actual and potential labor force participation. (Potential labor force participation is nevertheless projected to decline as a result of underlying demographic trends and, to a smaller degree, federal policies.)

Inflation. CBO expects the economic expansion over the next two years to put upward pressure on prices, helping raise the rate of inflation to the Federal Reserve's goal of 2 percent per year, on average, as measured by the price index for personal consumption expenditures.

Interest Rates. In CBO's economic forecast, interest rates rise from their currently low levels. The Federal Reserve had held the target range for the federal funds rate (its primary policy rate) at zero to 0.25 percent since late 2008, but in December 2015, it raised the range to 0.25 percent to 0.5 percent. CBO projects that the federal funds rate will rise to 1.2 percent in the fourth quarter of 2016 and to 2.2 percent in the fourth quarter of 2017 before settling at 3.5 percent in the second quarter of 2019.

Interest rates on federal borrowing are also expected to rise steadily over the next few years, as the economy improves and the federal funds rate rises. CBO projects that the interest rate on 3-month Treasury bills will steadily rise from 0.1 percent in the fourth quarter of 2015 and settle at 3.2 percent by the middle of 2019. CBO also projects that the interest rate on 10-year Treasury notes will rise from 2.3 percent in the fourth quarter of 2015 to 4.1 percent by the second half of 2019.

The Economic Outlook for 2021 Through 2026

CBO's projections for the second half of the 10-year period are not based on forecasts of cyclical developments in the economy; rather, they are based on the projected trends of underlying factors, such as growth in the labor force, the number of hours worked, and productivity. According to those projections, productivity will grow faster than it did over the past decade, and both actual and potential GDP will expand at an annual average rate of 2.0 percent. That rate represents a significant slowdown from the average growth of potential output that was observed during the 1980s, 1990s, and early 2000s; the slowdown results largely from slower projected growth in the nation's supply of labor.

Real GDP is projected to be about one-half of one percentage point lower than real potential GDP from 2021 through 2026, reflecting the historical average over the several business cycles that occurred between 1961 and 2009. Correspondingly, the projected unemployment rate over the 2021–2026 period, 5.0 percent, remains slightly above the natural rate. Inflation, as measured by the price index for personal consumption expenditures, is projected to average 2.0 percent per year, and interest rates for 3-month Treasury bills and 10-year Treasury notes are projected to average 3.2 percent and 4.1 percent, respectively. Those interest rates would be well above current rates. However, they would be lower than the average rates over the 25 years before the most recent recession, primarily because of lower inflation and slower growth in the labor force and in productivity.

Changes From CBO's August 2015 Economic Projections

CBO's current economic projections differ in some important respects from those that the agency made in August 2015. For example, revisions to historical data lowered CBO's estimates of potential total factor productivity (TFP) in the nonfarm business sector through 2015. (TFP is the average real output per unit of combined labor and capital services.) Also, after reassessment, CBO concluded that the slow growth of potential TFP was likely to persist longer than the agency had projected in August. As a result, CBO has revised its projected path of potential output downward since August, an adjustment that left potential and real GDP nearly 3 percent lower at the end of the 10-year period.

In addition, economic developments since August point to a weaker outlook for output growth over the next few years. CBO also projects a lower rate of unemployment and lower interest rates than it did in August.

A Note About These Budget and Economic Projections

In mid-December 2015, after CBO had completed the economic forecast that underlies its budget projections for this report, lawmakers enacted legislation that affected certain aspects of the economic outlook. Consequently, CBO's economic forecast has been updated to reflect the enactment of that legislation, as well as economic developments through the end of the year; that updated forecast is presented in this report. But the agency did not have enough time to incorporate those later changes to its economic forecast into its budget projections. Therefore, even though the budget projections in this report include the direct budgetary effects of legislation enacted through December, they are based on the economic forecast that CBO completed in early December.

CBO's next set of budget projections will be issued in March. They will be based on the economic forecast completed at the end of December and will also incorporate revisions derived from information that becomes available when the President's budget is published and from other sources.

A preliminary analysis at this point suggests that if CBO had incorporated that updated economic forecast into these budget projections, revenues in the baseline would be between $100 billion and $200 billion (or 0.2 percent to 0.4 percent) higher over the 2016–2026 period than they are currently projected to be. Projected outlays would also be affected, but probably to a lesser extent. CBO will also make technical estimating changes in its March projections that could be larger than those amounts, in either direction.

Chapter 1: The Budget Outlook

If current laws generally remain in place, the federal budget deficit will total $544 billion in fiscal year 2016, the Congressional Budget Office estimates, well above the $439 billion deficit posted for fiscal year 2015. After six consecutive years in which the deficit has declined relative to the size of the economy, this year's deficit—at 2.9 percent of gross domestic product (GDP)—is anticipated to increase for the first time since it peaked at 9.8 percent in 2009 (see Figure 1-1). As a result, debt held by the public (relative to the size of the economy), which declined last year for the first time in several years, is expected to rise again (as it did each year from 2007 to 2014). By CBO's estimate, debt held by the public will reach 76 percent of GDP in 2016, about 2 percentage points above last year's mark and equal to a larger percentage of GDP than in any year since 1951.

CBO constructs its 10-year baseline projections of federal revenues and spending under the assumption that current laws generally remain unchanged, following rules for those projections set in law.[5] CBO's baseline is not intended to be a forecast of budgetary outcomes; rather, it is meant to provide a neutral benchmark that policymakers can use to assess the potential effects of policy decisions. Under that assumption, in CBO's current baseline:

- Revenues are projected to remain roughly steady as a percentage of GDP through 2026, ranging between 17.9 percent and 18.3 percent, which is above their average of 17.4 percent over the 50 years from 1966 to 2015.

5. Section 257 of the Balanced Budget and Emergency Deficit Control Act of 1985 (Public Law 99-177) specifies the rules for developing baseline projections.

- Outlays are projected to rise as a share of GDP over the coming decade from 21.2 percent in 2016 to 23.1 percent in 2026 (the 50-year average is 20.2 percent). The increase in outlays reflects substantial growth in costs—to amounts well above historical averages—for benefit programs for the elderly, health care programs, and interest on the government's debt. The increase in those three areas would more than offset a significant projected decline in discretionary outlays relative to the size of the economy—outlays that are already more than 2 percentage points below their 50-year average.

- The deficit as a percentage of GDP has an upward trajectory over the projection period, growing from 2.9 percent this year to 4.9 percent in 2026 (see Table 1-1). Over the past 50 years, the annual deficit has averaged 2.8 percent of GDP.

Such increasing deficits over the next 10 years would cause debt held by the public to rise steadily. Relative to the nation's output, debt held by the public is projected to increase from 76 percent of GDP in 2016 to 86 percent at the end of 2026. At that point, federal debt would be the highest as a percentage of GDP since just after World War II. Such high and rising debt would have significant consequences, both for the economy and for the federal budget, including these:

- When interest rates returned to more typical, higher levels, federal spending on interest payments would increase substantially.

- Because federal borrowing reduces national saving over time, the nation's capital stock ultimately would be smaller, and productivity and total wages would be lower, than would be the case if the debt was smaller.

- Lawmakers would have less flexibility than otherwise to use tax and spending policies to respond to unexpected challenges.

- The likelihood of a fiscal crisis in the United States would increase. Specifically, the risk would rise of investors' becoming unwilling to finance the government's borrowing unless they were compensated with very high interest rates. If that occurred, interest rates on federal debt would rise suddenly and sharply relative to rates of return on other assets.

Projected deficits and debt for the coming decade reflect the significant long-term budgetary challenges facing the nation. In particular, although revenues are projected to remain steady as a percentage of GDP over the coming decade, the aging of the population and the rising costs of health care are projected to substantially boost federal spending on Social Security and the government's major health care programs over the next 10 years and beyond. Unless spending for large benefit programs is reduced, revenues are allowed to rise more than they would under current law, or some combination of those approaches is adopted, debt will rise sharply relative to GDP after 2026.[6]

In addition, holding discretionary spending within the limits required under current law—an assumption that underlies CBO's current projections—may be quite difficult. Caps on discretionary budget authority were established by the Budget Control Act of 2011 (Public Law 112-25) for the 2012–2021 period, and automatic spending reductions further reduced those levels. Although subsequent legislation raised the limits for 2014 through 2017 relative to what they would have been after the automatic spending reductions, the caps and automatic spending reductions for 2018 through 2021 remain in place.[7] CBO's baseline reflects those constraints.

In CBO's current baseline, therefore, the caps on defense and nondefense spending together rise by a total of $3 billion in 2017 and then fall by $5 billion in 2018, after which they increase at roughly the same rate as inflation. For its baseline projections after 2021, CBO assumes that such funding continues to grow with inflation. As a result, discretionary outlays would fall to an unusually small amount relative to the size of the economy: 5.2 percent of GDP in 2026. By comparison, the lowest percentage for discretionary spending in any year since 1962 (the earliest year for which such data have been reported) was 6.0 percent in 1999, and the average over the past 50 years has been 8.7 percent.

CBO's current projections for the coming decade show a significant increase in deficits since its previous publication of 10-year projections, in August 2015.[8] Deficits under current law are now projected to total $8.6 trillion, or 3.8 percent of GDP, between 2016 and 2025 (which was the 10-year projection period that CBO used last year); in August, projected deficits for that period were about $1.5 trillion and 0.8 percentage points of GDP below the agency's current projection. Almost half of that change results from recently enacted legislation, primarily the Consolidated Appropriations Act, 2016 (P.L. 114-113), the Fixing America's Surface Transportation Act (also called the FAST Act, P.L. 114-94), the Bipartisan Budget Act of 2015, and the National Defense Authorization Act for Fiscal Year 2016 (P.L. 114-92). (The effects of those new laws are discussed in more detail later in this chapter and Appendix A.)

6. For a more detailed discussion of the consequences of elevated debt in particular and a long-term overview for the budget generally, see Congressional Budget Office, *The 2015 Long-Term Budget Outlook* (June 2015), www.cbo.gov/publication/50250.

7. Budget authority is provided by law to allow the government to incur financial obligations that will result in immediate or future outlays of federal funds. Most recently, the Bipartisan Budget Act of 2015 (P.L. 114-74) raised the limits for defense and nondefense funding by $25 billion each for 2016 and by $15 billion each for 2017 relative to what they would have been after the automatic spending reductions.

8. For CBO's previous baseline budget projections, see Congressional Budget Office, *An Update to the Budget and Economic Outlook: 2015 to 2025* (August 2015), www.cbo.gov/publication/50724.

CBO's revised economic forecast accounts for nearly 30 percent of the change to the cumulative deficit since August; other, technical, adjustments account for about 20 percent. All told, the agency has reduced its projection of revenues by 2.9 percent through 2025 and increased its projection of outlays by 0.7 percent.

Although CBO's baseline generally does not incorporate potential changes in law, this chapter shows the ways in which some alternative policies would affect the budget over the next 10 years. For example, CBO has constructed a policy alternative under which funding for discretionary programs for 2017 through 2026 is kept at the amount provided for 2016. Under that alternative, discretionary spending over the 2017–2026 period would be $746 billion less than the amounts projected in the baseline. Other alternative policies would result in larger deficits than those in the baseline. For example, current law provides for a gradual phaseout of the ability of companies with large investments in equipment to immediately deduct some of that expense from their taxable income. If, instead, the higher expensing rate currently in place (50 percent) was made permanent, revenues over the 2018–2026 period would be $248 billion lower than projected in the baseline. (For more details, see "Alternative Assumptions About Fiscal Policy.")

A Review of 2015

In fiscal year 2015, the budget deficit dropped once again, to $439 billion—almost 10 percent less than the $485 billion shortfall recorded in 2014 and about one-third of the $1.4 trillion deficit recorded in 2009. Revenues rose by $227 billion (or 8 percent) and outlays increased by $181 billion (or 5 percent). As a percentage of GDP, the deficit dropped from 2.8 percent in 2014 to 2.5 percent in 2015. Debt held by the public increased by $337 billion in 2015, ending up at 74 percent of GDP—slightly lower than the percentage recorded in 2014, marking the first decline in federal debt (relative to the size of the economy) since 2007. Nevertheless, debt held by the public in 2015 was more than double the amount recorded in 2007, when it equaled 35 percent of GDP.

Revenues

Total revenues increased from 17.6 percent of GDP in 2014 to 18.2 percent in 2015. Most of the increase in 2015 stemmed from collections of individual income taxes, the largest revenue source, which rose by $146 billion (or 10 percent), from 8.1 percent of GDP in 2014 to 8.7 percent in 2015—the highest percentage of GDP since 2001. In particular:

- Nonwithheld individual income taxes rose by $78 billion (or 16 percent), mostly as a result of increases in capital gains realizations and other nonwage income in 2014 that led to higher final tax payments for 2014 (as reflected in amounts paid with tax returns filed in 2015). In addition, increases in nonwage income in 2015 led to higher quarterly estimated payments of taxes for 2015.

- Receipts from withheld individual income taxes rose by $70 billion (or 6 percent), primarily because of increases in wages and salaries.

Receipts from payroll and corporate income taxes also increased but remained near the same percentage of GDP in 2015 as in 2014—together totaling 7.9 percent of GDP. Receipts from payroll taxes, the second-largest revenue source, grew by $42 billion (or 4 percent); those receipts rose largely as a result of increases in wages and salaries. Revenues from corporate income taxes increased by $23 billion (or 7 percent), reflecting growth in taxable profits.

In addition, miscellaneous fees and fines, a much smaller source of federal revenues, increased by $13 billion (or 35 percent), largely because of provisions of the Affordable Care Act (ACA) that established new collections from health insurers under the reinsurance and risk adjustment programs. (Those revenues were largely offset by associated outlays.) Revenues from fees and fines increased from 0.2 percent of GDP in 2014 to 0.3 percent in 2015.

Outlays

After declining relative to GDP for the preceding three years, federal spending rose in 2015 to 20.7 percent (or $3.7 trillion) of GDP. Mandatory spending increased in 2015; outlays for discretionary programs and net interest declined.

Mandatory Spending. Outlays for mandatory programs (including spending for many benefit programs and certain other payments to people, businesses, nonprofit institutions, and state and local governments) rose by $200 billion (or 9.5 percent) in 2015. By comparison, mandatory outlays grew at an average annual rate of 5.4 percent during the preceding decade (between 2004 and 2014).

Social Security. Spending for Social Security totaled $882 billion in 2015, $37 billion (or about 4 percent) more than in 2014. Beneficiaries received a 1.7 percent cost-of-living adjustment in January (which applied to three-quarters of fiscal year 2015); the increase in the previous year was 1.5 percent. In addition, the total number of people receiving benefits increased by 1.7 percent in 2015. That increase occurred only in the Old-Age and Survivors Insurance program; the total number of Disability Insurance beneficiaries (disabled workers and their dependents) declined by about 0.5 percent in 2015.

Major Health Care Programs. In 2015, federal spending for the major health care programs—Medicare, Medicaid, the Children's Health Insurance Program, and subsidies offered through health insurance exchanges and related spending—exceeded Social Security outlays for the first time.[9] In total, such spending equaled $936 billion last year, an increase of $105 billion (or about 13 percent).

9. Spending for Medicare is presented net of premium payments and other offsetting receipts, unless otherwise noted.

Medicaid spending, which grew by $48 billion (or 16 percent) last year—after increasing by $36 billion (or 14 percent) in 2014—represented the largest increase. The sharp rise over the past two years occurred mainly because of new enrollees added by the 30 states plus the District of Columbia that had adopted the optional expansion of coverage authorized by the ACA. CBO estimates that the average monthly enrollment of newly eligible Medicaid beneficiaries was 55 percent higher in 2015 than in the previous year—a total of 9.6 million compared with 6.1 million in 2014.

Similarly, subsidies for health insurance purchased through the exchanges that were established under the ACA, as well as related spending, increased by $23 billion in 2015, to a total of $38 billion.[10] That growth resulted from a significant increase in the number of people purchasing coverage through the exchanges as well as the fact that the subsidies were available for the entire fiscal year.[11] (The subsidies did not become available until January 2014, three months into fiscal year 2014.) That growth also reflects the first year of spending for the ACA's risk adjustment and transitional reinsurance programs, which together resulted in about $9 billion in outlays in 2015; under the ACA, payments to and from the government for those programs are specified to be equal and thus have no net budgetary effect over the life of the programs.[12]

Medicare spending in 2015 (net of premiums and other offsetting receipts) rose by $34 billion, or nearly 7 percent—the fastest rate of growth recorded for the program since 2009 (after adjusting for shifts in the timing of certain payments). Part of that increase reflected the fact that certain statutory changes that reduced the rate of growth in Medicare spending had already been implemented. Those provisions will continue to constrain Medicare spending, but to roughly the same extent each year, so they no longer reduce its rate of growth. The increase in 2015 also reflected an expansion of about 3 percent in the number of Medicare beneficiaries and an escalation in

10. Those subsidies are structured as refundable tax credits—the portions of such credits that exceed a taxpayer's other income tax liabilities are classified as outlays; the portions that reduce tax payments are classified in the budget as reductions in revenues.

11. In the March 2015 baseline, CBO and the staff of the Joint Committee on Taxation (JCT) projected that an average of about 8 million people per month would receive exchange subsidies in 2015. Additionally, the agencies projected that about 3 million people would not be eligible for subsidies but would purchase coverage through an exchange, for a total of 11 million people enrolled in coverage through exchanges in any given month, on average. CBO and JCT now estimate that about 9.5 million people enrolled in coverage purchased through the exchanges, on average, during 2015 and that 8 million of those enrollees received subsidies.

12. The risk adjustment program transfers resources from health insurance plans that attract a relatively small proportion of high-risk enrollees (people with serious chronic conditions, for example) to plans that attract a relatively large proportion of such people. The reinsurance program makes payments to all plans that operate in the individual insurance market whose enrollees incur particularly high costs for medical claims—that is, costs above a specified threshold and up to a certain maximum. To cover those costs, the government collects a per-enrollee assessment from most private insurance plans. The collections for both programs are recorded as revenues.

the number or cost of services furnished to those beneficiaries, particularly under Part D (which covers outpatient prescription drugs).

Fannie Mae and Freddie Mac. Payments to the Treasury from Fannie Mae and Freddie Mac fell from $74 billion in 2014 to $23 billion in 2015 (such payments are recorded as reductions in outlays). That decline was partially attributable to a onetime revaluation in 2014 of certain tax assets held by Freddie Mac, which boosted its payments to the Treasury by nearly $24 billion in that year. In addition, financial institutions made fewer payments to Fannie Mae and Freddie Mac in 2015 to settle allegations of fraud in connection with residential mortgages and certain other securities. The result is that the two entities' profits were smaller in 2015, as were their remittances to the Treasury.

Higher Education. Mandatory outlays for higher education include the estimated subsidy costs for federal student loans issued in the current year, revisions to the subsidy costs of loans made in past years, and mandatory spending for the Federal Pell Grant Program. Such outlays totaled $22 billion in 2015—amounting to a net increase of $34 billion over outlays in 2014 (which were –$12 billion in 2014). Outlays in 2015 were positive primarily because the Department of Education recorded a revision to the subsidy costs for past loans that resulted in an $18 billion increase in outlays (the 2014 revision increased outlays by $1 billion).

The estimated subsidy costs of new student loans made in 2014 and 2015 were negative; that is, over the life of those loans, the amounts expected to be received by the government are greater than the payments expected to be made by the government, as measured on a present-value basis—as required by the Federal Credit Reform Act of 1990.[13] In particular, the interest rates charged to student loan borrowers are well above the interest rates the federal government pays on its borrowing. Even after accounting for anticipated loan defaults, the federal government expects to receive more (on a present-value basis) in loan repayments and interest than

13. Under that act, a program's subsidy costs are calculated by subtracting the discounted present value of the government's projected receipts from the discounted present value of its projected payments. The estimated subsidy costs can be increased or decreased in subsequent years to reflect updated assessments of the payments and receipts associated with the program. Present value is a single number that expresses a flow of current and future income (or payments) in terms of an equivalent lump sum received (or paid) today. The present value depends on the rate of interest (the discount rate) that is used to translate future cash flows into current dollars.

it disburses for such loans.[14] However, the subsidy rates in 2015 were less negative than those used in 2014 to estimate the costs of new loans, a difference that boosted outlays in 2015 relative to those recorded in 2014.

Spectrum Auctions. Under current law, the Federal Communications Commission occasionally auctions licenses for commercial use of the electromagnetic spectrum. The auctions' receipts are recorded as reductions in mandatory outlays rather than as revenues collected by the federal government. In 2014, net receipts totaled $1 billion for a set of licenses that were of value primarily to a single business. By contrast, the 2015 auction awarded licenses for more bandwidth, which also had more desirable characteristics, thus spurring intense competition among several large telecommunications companies. As a result, collections surged to $30 billion last year.

Discretionary Spending. In total, discretionary outlays declined in 2015 by $13 billion (or 1 percent). For the fourth consecutive year, defense outlays dropped, declining by $14 billion (or 2 percent). That reduction stemmed from lower spending from funding designated for overseas contingency operations (war-related activities, primarily in Afghanistan), which fell by roughly $20 billion, CBO estimates; other defense spending rose by $6 billion. Measured as a share of GDP, outlays for defense declined from 3.5 percent in 2014 to 3.3 percent in 2015. By comparison, as recently as 2010, such outlays totaled 4.7 percent of GDP.

In contrast, nondefense discretionary outlays rose slightly last year, increasing by $1 billion (or 0.1 percent) because of relatively small increases or decreases in outlays for various programs. Such spending dipped from 3.4 percent of GDP in 2014 to 3.3 percent in 2015.

Net Interest. Outlays in this budget category totaled $223 billion in 2015, $6 billion (or 2 percent) less than the amount recorded in 2014. Net interest outlays consist of interest paid on Treasury securities and other interest that the government pays minus the interest that it collects from various sources. The reduction in 2015 resulted primarily from a lower rate of inflation (relative to the rate in 2014), which resulted in smaller adjustments to the principal of inflation-protected securities. Because interest rates remained very low by historical standards, total outlays for net interest in 2015 were similar, in dollar terms, to those recorded 15 to 20 years ago, when federal debt was much smaller.

14. Under an alternative approach to valuing federal subsidy costs, called the fair-value approach, estimates are based on market values—market prices when those prices are available or approximations of market prices when directly comparable figures are unavailable—which more fully account for the cost of the risk the government takes on. In 2014, CBO estimated that accounting for student loan programs on a fair-value basis would show a net cost for those programs and substantially increase the estimated subsidy costs over the following 10 years. For further discussion of the fair-value approach, see Congressional Budget Office, *Fair-Value Accounting for Federal Credit Programs* (March 2012), www.cbo.gov/publication/43027.

The Budget Outlook for 2016

If the laws that govern taxes and spending remain unchanged in fiscal year 2016, CBO projects, the budget deficit will increase by $105 billion, to $544 billion (see Table 1-2). At 2.9 percent of GDP, this year's deficit will be close to the 50-year average of 2.8 percent. Part of the increase in the deficit is attributable to a shift in the timing of some benefit payments from 2017 into 2016. Because October 1, 2016, falls on a weekend, certain payments that are due on that day will instead be made at the end of September, thus shifting them into fiscal year 2016. Without that shift, CBO estimates, the deficit would amount to $500 billion in 2016, or 2.7 percent of GDP.

The anticipated increase in the budget shortfall in 2016 would reverse a six-year trend of shrinking deficits. CBO estimates that revenues will increase by about 4 percent in 2016 (about half the rate of increase recorded in 2015), but that outlays will rise by 6 percent, a full percentage point faster than last year. A number of factors are responsible for those changes. After several years in which revenues grew faster than GDP—because of the economic recovery, among other circumstances—CBO now projects that in 2016 (and for the remainder of the projection period), revenue growth will be roughly in line with GDP. Receipts from individual income taxes are expected to grow more slowly in 2016 than in 2015 in part because rapid growth in nonwage income, especially capital gains realizations and business income, is not expected to continue. In addition, corporate income tax receipts are expected to decline this year for the first time since 2011, largely as a result of recently enacted tax legislation.

On the outlay side, this year's higher caps on discretionary funding will cause discretionary outlays to rise (after falling last year). In addition, net interest outlays are anticipated to increase rapidly in 2016 (after also falling last year), primarily because of higher interest rates. Mandatory spending is projected to continue to increase in 2016, although at a slower pace than in 2015 (the reasons are discussed below).

Revenues

CBO projects that if current laws remain unchanged, revenues will increase by $127 billion in 2016, reaching $3.4 trillion and edging up to 18.3 percent of GDP. Receipts of individual income taxes are expected to increase by about $80 billion, from 8.7 percent of GDP to 8.8 percent. The largest source of the rise relative to GDP is continued economic growth, which causes people's income, in the aggregate, to rise faster than the rate of inflation. The inflation rate is used to adjust the tax brackets each year, and when incomes rise faster than inflation, more income is pushed into higher tax brackets (a phenomenon known as real bracket creep).

In the other direction, corporate tax receipts are expected to fall by $17 billion in 2016, from 1.9 percent of GDP in 2015 to 1.8 percent this year, largely because of provisions in the Consolidated Appropriations Act, 2016, that extended, retroactively to the beginning of calendar year 2015, several expired tax provisions that reduce corporate (and individual) income taxes.

CBO expects remittances from the Federal Reserve to increase by $16 billion in 2016, from 0.5 percent of GDP to 0.6 percent, because of a provision in the FAST Act that requires the Federal Reserve to remit most of its surplus account to the Treasury.

Outlays

In the absence of changes to laws governing federal spending, CBO estimates, outlays in 2016 will total $3.9 trillion, $232 billion more than in 2015. Outlays are projected to total 21.2 percent of GDP this year, about 0.5 percentage points above the percentage recorded in 2015.

Outlays in 2016 will be boosted, however, by the shift in timing of some payments from fiscal year 2017 to 2016 (because October 1, 2016, falls on a weekend). If not for that shift, CBO estimates, outlays in 2016 would increase by $189 billion (or 5.1 percent)—still faster than the 4.3 percent average annual rate of growth between 2004 and 2014—and would equal 21.0 percent of GDP.

Mandatory Spending. Under current law, spending for mandatory programs will rise by $168 billion (or 7.3 percent) in 2016, CBO estimates, amounting to 13.3 percent of GDP, up from the 12.9 percent recorded in 2015. Without the shift in the timing of some payments, mandatory spending would grow by $129 billion (or 5.6 percent) and equal 13.1 percent of GDP. The largest year-over-year changes are as follows:

Social Security. CBO anticipates that, under current law, Social Security outlays will increase by $28 billion (or 3.2 percent) in 2016, a slower rate of increase than in 2015, primarily because there will be no cost-of-living adjustment for beneficiaries in 2016 (beneficiaries received a cost-of-living increase in 2015). The number of Social Security beneficiaries is projected to grow by 1.7 percent this year, about the same as the increase in 2015.

Major Health Care Programs. Outlays for the federal government's major health care programs will increase by $104 billion (or 11.1 percent) this year, CBO estimates. That amount overstates underlying growth in the major health care programs, however, because it reflects a $24 billion shift in the timing of certain Medicare payments from 2017 into 2016. After adjusting for those payments, CBO anticipates that spending for the major health care programs will rise by $80 billion (or 8.6 percent) in 2016, compared with $105 billion (or 12.6 percent) last year.

Medicaid spending is expected to increase by $31 billion (or 8.8 percent) in 2016; the projected rate of growth in outlays is a little over half the average rate of growth recorded over the two previous years, primarily because the optional expansion of coverage authorized by the ACA will have been in place for two years and the rapid growth in enrollment that occurred during the initial stage of the expansion will have begun to moderate. CBO projects that under current law, total enrollment in the program will increase by about 2 percent in 2016, about a third of the rate of increase in 2015.

Similarly, subsidies that help people who meet income and other eligibility criteria to purchase health insurance through exchanges and to meet their cost-sharing requirements, along with related spending, are expected to increase by $18 billion in 2016, reaching a total of $56 billion. The higher spending reflects an anticipated increase in the number of people expected to receive subsidies for coverage purchased through exchanges. CBO and the staff of the Joint Committee on Taxation (JCT) estimate that about 11 million people will receive exchange subsidies, on average, during calendar year 2016, compared with an average of 8 million in 2015. Additionally, the agencies project that about 2 million other people will purchase coverage through an exchange but will not be eligible for subsidies—for a total of 13 million people, on average, enrolled in policies purchased through exchanges.

The enrollment projections used in this report for estimating exchange subsidies authorized by the ACA have been updated to reflect available information about developments in 2016, but, other than to incorporate the effects of enacted legislation, projections for years after 2016 have not been updated since March 2015. CBO will revise those projections for its next baseline, to be published in March 2016.[15]

Spending for Medicare (net of premiums and other offsetting receipts and adjusted for shifts in the timing of certain payments) will rise by $28 billion, or 5.2 percent, in 2016, CBO projects. That growth is below last year's rate of 6.8 percent primarily because of higher premium receipts, on net, resulting from provisions of the Bipartisan Budget Act of 2015 and other legislation that modified Part B premiums for certain Medicare beneficiaries in calendar year 2016.

Higher Education. Reflecting the negative subsidy rates estimated for new student loans, CBO projects that mandatory outlays will total –$6 billion in 2016, compared with $22 billion in 2015. That $28 billion reduction will occur in part because in 2015 the Department of Education recorded a revision to the subsidy costs for past loans that resulted in an $18 billion increase in outlays; no such revision has yet been recorded in 2016, and CBO has no basis for predicting what revision, if any, might be made this year. Moreover, the estimated subsidy rates in 2016 are slightly more negative than those used in 2015 to estimate the costs of new loans.

15. Because of the complexity of the analysis involved, CBO and JCT generally produce one major update per year to those projections, which is incorporated into each year's March baseline and used as the basis for cost estimates for the remainder of the year. More discussion of the changes since August 2015 in CBO's projections for subsidies offered through health insurance exchanges is included in Appendix A; Chapter 3 presents a more detailed discussion of CBO's current baseline projections for such spending over the 2016–2026 period.

Receipts From Spectrum Auctions. In 2015, net offsetting receipts from the auctioning of licenses to use a portion of the electromagnetic spectrum—which are recorded as offsets to mandatory outlays—reduced outlays by $30 billion. A portion of the winning bids from the 2015 auction will reduce outlays in 2016 by $11 billion. That difference will boost outlays in 2016 by $19 billion relative to spending in 2015. Although the Federal Communications Commission plans to conduct another large auction in 2016, the receipts for those licenses will not be recorded in the budget until 2017.

Discretionary Spending. Discretionary budget authority enacted for 2016 totals $1,168 billion, $53 billion (or 4.7 percent) more than such funding in 2015: Defense funding has increased by $21 billion (or 3.6 percent), and budget authority for nondefense discretionary programs has risen by $32 billion (or 5.9 percent). If no additional appropriations are enacted for this year, discretionary outlays also will rise—by $32 billion (or 2.8 percent) from the 2015 amounts, CBO projects.

Although funding for defense programs increased by $21 billion in 2016, CBO estimates that outlays (adjusted for shifts in the timing of certain payments) will rise by only $3 billion (or 0.4 percent) because slower-spending accounts (primarily for procurement, but also for research and development) received increases in budget authority whereas some faster-spending accounts (such as those for operations and maintenance) received less funding than they did a year ago. Outlays from funding designated for overseas contingency operations will drop by roughly $5 billion (after declining by about $20 billion in 2015) but all other defense spending will rise by about $8 billion.[16] CBO estimates that defense outlays will total $589 billion in 2016.

Outlays for nondefense programs are expected to rise by $26 billion (or 4.4 percent) this year, to a total of $609 billion. Nearly a quarter of that increase results from lower estimates of receipts credited to the Federal Housing Administration because of a lower negative subsidy rate for mortgage guarantees and an expected decline in the dollar volume of new guarantees in 2016. Because such receipts are recorded as reductions in discretionary outlays, the decline in estimated receipts causes overall spending for nondefense programs to increase. The remaining amount is the result of several relatively small increases to various programs.

Net Interest. CBO estimates that outlays for net interest will rise by $32 billion (or 14 percent) in 2016, to $255 billion. Although interest rates on securities issued by the Treasury are expected to remain very low by historical standards, they probably will rise over the course of the year. Those higher rates, along with a larger amount of debt, will boost interest payments, which will edge up to 1.4 percent of GDP in 2016, CBO estimates (still well below their 50-year average of 2.0 percent).

16. Funding provided to the Department of Defense in 2016 for overseas contingency operations includes some amounts that are intended to be used for regular activities.

CBO's Baseline Budget Projections for 2017 to 2026

CBO constructs its baseline in accordance with provisions set forth in the Balanced Budget and Emergency Deficit Control Act of 1985 (P.L. 99-177) and the Congressional Budget and Impoundment Control Act of 1974 (P.L. 93-344). For the most part, those laws require that the agency's baseline projections incorporate the assumption that current laws governing taxes and spending in future years remain in place. Under that assumption for constructing CBO's baseline, the budget deficit is projected to remain just under 3.0 percent of GDP through 2018. After that, however, the deficit generally increases each year as a share of the economy, reaching 4.9 percent of GDP by 2026.

The pattern of stable deficits through 2018 is largely attributable to shifts in the timing of certain payments from one fiscal year to another because certain scheduled payment dates fall on weekends; without those shifts, the deficit would rise in each year of the projection period. Although revenues are projected to remain roughly flat as a share of GDP, outlays are projected to increase each year, driven by the aging of the population, the rising costs of health care, and increasing interest payments.[17]

Revenues

From 2017 through 2026, revenues in CBO's baseline remain between 17.9 percent and 18.2 percent of GDP, largely reflecting offsetting movements in individual and corporate income taxes, payroll taxes, and remittances from the Federal Reserve.

Individual income taxes are projected to generate increasing revenues, relative to the size of the economy, growing from 8.8 percent of GDP in 2016 to 9.6 percent in 2026 (see Figure 1-2). That change stems most significantly from real bracket creep. In addition, taxable distributions from tax-deferred retirement accounts are expected to grow more rapidly than GDP in coming years as the population ages. Also, earnings from wages and salaries are expected to continue the recent trend of increasing faster for higher-income people than for others, causing a larger share of income to be subject to higher income tax rates and, therefore, further increasing revenues.

Because of the changing wage distribution, however, a growing share of people's wages and salaries moves above the maximum annual amount that is subject to the Social Security tax (currently $118,500 for an individual taxpayer). That trend will reduce receipts from payroll taxes relative to GDP—by about three-fifths of the increase in income taxes stemming from the changing distribution. As a result, payroll tax receipts are projected to decline from 6.0 percent of GDP in 2016 to 5.8 percent by 2026.

17. Because October 1 will fall on a weekend in 2016, 2017, 2022, and 2023, certain payments that are due on those days will instead be made at the end of September, thus shifting them into the previous fiscal year. Those shifts noticeably boost projected deficits in fiscal years 2016 and 2022 but reduce them in fiscal years 2018 and 2024.

Remittances from the Federal Reserve, which have been quite high by historical standards since 2010, also are projected to decline relative to the size of the economy, primarily because of changes in the size and composition of the central bank's portfolio of securities. In CBO's baseline projections, those receipts fall to more typical levels, dropping from 0.6 percent of GDP in 2016 to about 0.2 percent of GDP for the 2018–2026 period.

CBO projects a decline in corporate income tax receipts, from 1.8 percent of GDP in 2016 to 1.6 percent by 2026, largely because of an anticipated drop in domestic economic profits relative to GDP. Profits are expected to decline because of rising labor costs and rising interest payments on businesses' debt over the next several years, and because, in later years, CBO projects that nonlabor income will grow less rapidly than output, reversing an unusual trend seen since 2000.

Outlays

The Deficit Control Act requires CBO's projections for most mandatory programs to be made in keeping with the assumption that current laws continue unchanged.[18] Thus, CBO's baseline projections for mandatory spending reflect expected changes in the economy, demographics, and other factors, as well as the across-the-board reductions in certain mandatory programs that are required under current law. CBO's baseline incorporates the caps on discretionary funding that are currently in place through 2021 and then reflects the assumption that such funding keeps pace with inflation in later years. Those elements of discretionary funding that are not constrained by the caps established by the Budget Control Act of 2011—for example, the appropriations designated for overseas contingency operations—are assumed to keep pace with inflation throughout the next decade. On that basis, total outlays in CBO's baseline are projected to increase relative to GDP in most years through 2026—averaging 22.1 percent over the decade, which is about 2 percentage points above the 50-year average.[19]

Mandatory spending (net of offsetting receipts and adjusted for shifts in the timing of certain payments) is projected to increase by 5 percent in 2017 and grow by an average of about 6 percent annually after that, reaching 15.0 percent of GDP in 2026 (compared with 12.9 percent in 2015). In particular, because of the aging of the population and rising health care costs, outlays for Social Security and the federal government's major

18. The Deficit Control Act specifies some exceptions. For example, spending programs whose authorizations are set to expire are assumed to continue if they have outlays of more than $50 million in the current year and were established at or before enactment of the Balanced Budget Act of 1997 (P.L. 105-33). Programs established after that law was enacted are not automatically assumed to continue but are considered individually by CBO in consultation with the House and Senate Budget Committees.

19. Without the shifts in the timing of certain payments, outlays would increase relative to GDP in each year of the projection period, CBO estimates.

health care programs are projected to rise substantially relative to the size of the economy over the next 10 years (see Figure 1-3). In addition, growing debt and rising interest rates will boost net interest payments. Specifically, in CBO's baseline:

- Outlays for Social Security are projected to increase from 4.9 percent of GDP in 2016 to 5.9 percent of GDP by 2026.
- Outlays for the major health care programs—Medicare, Medicaid, the Children's Health Insurance Program, and subsidies offered through health insurance exchanges and related spending—are estimated to total 5.5 percent of GDP in 2016 and to grow rapidly in ensuing years, reaching 6.6 percent of GDP in 2026. (Medicare accounts for roughly three-quarters of that growth; the estimates here are adjusted for shifts in the timing of certain payments.)
- Net interest payments are anticipated to increase from 1.4 percent of GDP in 2016 to 3.0 percent of GDP in 2026—the highest ratio since 1996. Two factors drive that sharp increase: rising interest rates and growing debt. The interest rate paid on 3-month Treasury bills is anticipated to increase from around 1 percent at the beginning of 2017 to 3.2 percent by mid-2019 (and remain there through 2026); and the interest rate on 10-year Treasury notes is projected to rise from around 3 percent early in 2017 to 4.1 percent by late 2019 (and remain there through 2026). Meanwhile, debt held by the public is projected to increase from 75.6 percent of GDP at the end of 2016 to 86.1 percent at the end of 2026.

Those three components of the budget account for 83 percent of the total increase in outlays over the coming decade and would be the largest categories of spending in the budget by the end of that period (see Figure 1-4). Social Security and Medicare alone account for nearly half of the total increase.

In contrast, CBO projects that under current law, all other spending (adjusted for shifts in the timing of certain payments) decreases from 9.2 percent of GDP in 2016 to 7.7 percent in 2026. That decline is projected to occur in part because spending for many of the other mandatory programs is expected to rise roughly with inflation (which itself is projected to be well below the rate of growth of nominal GDP). In addition, most discretionary funding is capped through 2021 at amounts that increase more slowly than the growth of the economy. As a result, projected spending for defense and nondefense discretionary programs grows relatively slowly and falls relative to GDP under CBO's baseline assumptions. Discretionary outlays (adjusted for shifts in the timing of certain payments) are estimated to increase by 1.0 percent in 2017 and then to grow at an average rate of 1.9 percent between 2018 and 2026; that rate is less than half of the projected growth rate of nominal GDP, and as a result, discretionary outlays would drop from 6.5 percent of GDP in 2016 to 5.2 percent in 2026.

Outlays for defense, which account for about half of discretionary outlays, are projected to drop from 3.2 percent of GDP in 2016 to 2.6 percent in 2026, 2.3 percentage points below the average from 1966 to 2015 and the lowest share in any year since 1962 (the earliest year for which such data have been reported). Spending for nondefense discretionary programs is projected to drop from 3.3 percent of GDP in 2016 to 2.6 percent in 2026, 1.2 percentage points below the average from 1966 to 2015 and also the lowest share in any year since 1962.

Federal Debt

Federal debt held by the public consists mostly of the securities that the Treasury issues to raise cash to fund the federal government's activities and to pay off its maturing liabilities.[20] The Treasury borrows money from the public by selling securities in the capital markets; that debt is purchased by various buyers in the United States, by private investors overseas, and by the central banks of other countries. Of the $13.1 trillion in federal debt held by the public at the end of 2015, 54 percent ($7.0 trillion) was held by domestic investors and 46 percent ($6.1 trillion) was held by foreign investors.[21] Other measures of federal debt are sometimes used for various purposes, such as to provide a more comprehensive picture of the government's financial condition or to account for debt held by federal trust funds.

Debt Held by the Public. Under the assumptions that govern CBO's baseline, the federal government is projected to borrow $9.8 trillion from the end of 2016 through 2026, boosting debt held by the public to 86 percent of GDP by the end of the projection period (see Table 1-3).

That amount of debt relative to the size of the economy would be the greatest since 1947 and more than double the 50-year average of 39 percent. By historical standards, debt that high—and heading higher—would have significant negative consequences for the budget and the economy.

The amount that the Treasury borrows by selling securities (net of the maturing securities it redeems) is determined primarily by the annual budget deficit. However, several factors—collectively labeled "other means of financing" and not directly included in budget totals—also affect the government's need to borrow from the public. Those factors include changes in the government's cash balance and investments in the Thrift Savings Plan's G Fund, as well as the cash flows associated with federal credit programs (such as student loans), because only the subsidy costs of those programs (calculated on a present-value basis) are reflected in the budget deficit.

20. A small amount of debt held by the public is issued by other agencies, mainly the Tennessee Valley Authority.

21. The largest U.S. holders of Treasury debt are the Federal Reserve System (21 percent), individual households (9 percent), and mutual funds (8 percent); investors in China and Japan have the largest foreign holdings of Treasury securities, accounting for nearly 20 percent of U.S. public debt. For additional information, see Congressional Budget Office, *Federal Debt and Interest Costs* (December 2010), Chapter 1, www.cbo.gov/publication/21960.

For two main reasons, CBO projects that the increase in debt held by the public will exceed the $544 billion deficit in 2016 by $318 billion. First, the Treasury has reinvested the Thrift Savings Plan's G Fund in Treasury securities after having disinvested about $200 billion in 2015 as a result of debt-ceiling constraints.[22] Second, the government's need for cash to finance new student loans and other credit programs will boost the debt by roughly $90 billion in 2016. The subsidy costs for those credit programs are part of the projected deficit for each year from 2017 to 2026, but the cash outlays needed to finance those programs each year are greater than the net subsidy costs, which are calculated on a present-value basis; CBO estimates that the government will need to borrow between $30 billion and $75 billion more per year during that period than the budget deficits would suggest.

Other Measures of Federal Debt. Three other measures are sometimes used in reference to federal debt:

- *Debt held by the public minus financial assets* subtracts from debt held by the public the value of the government's financial assets, such as student loans. That measure provides a more comprehensive picture of the government's financial condition and its overall impact on credit markets than does debt held by the public. Calculating that measure is not straightforward, however, because neither the financial assets to be included nor the methods for evaluating them are well defined. Under CBO's baseline assumptions, that measure is roughly 10 percent smaller than debt alone but varies roughly in line with it.

- *Gross federal debt* consists of debt held by the public and debt issued to government accounts (for example, the Social Security trust funds). The latter type of debt does not directly affect the economy and has no net effect on the budget. In CBO's projections, debt held by the public increases by $9.8 trillion between the end of 2016 and the end of 2026, and debt held by government accounts rises by $0.1 trillion. As a result, gross federal debt is projected to rise by $10.0 trillion over that period and to total $29.3 trillion at the end of 2026. About one-fifth of that sum would be debt held by government accounts.

- *Debt subject to limit* is the amount of debt that is subject to the statutory limit on federal borrowing; it differs from gross federal debt mainly because most debt issued by agencies other than the Treasury and the Federal Financing Bank is included in

22. The Thrift Savings Plan is a retirement program, similar to a 401(k) plan, for federal civilian employees and members of the uniformed services. One component of that plan, the G Fund, is invested entirely in Treasury securities. Because the amount of outstanding debt in March 2015 reached the statutory ceiling, the Treasury had no room to continue borrowing under its standard procedures. In response, the Treasury disinvested participants' savings in the G Fund, as permitted by law. The Bipartisan Budget Act of 2015 suspended the debt ceiling on November 2, 2015, thus allowing the Treasury the ability to fully restore the securities to the G Fund.

gross debt but excluded from the debt limit. Currently, there is no statutory limit on the issuance of new federal debt because the Bipartisan Budget Act of 2015 suspended the debt ceiling from November 2, 2015, through March 15, 2017. In the absence of any legislative action on the debt limit before the suspension ends, the amount of borrowing accumulated during that period will be added to the previous debt limit of $18.1 trillion on March 16, 2017. In CBO's baseline projections, the amount of outstanding debt subject to limit increases from $19.3 trillion at the end of 2016 to $29.3 trillion at the end of 2026. (For the purpose of those projections, CBO assumes that increases in the statutory ceiling will occur as necessary.)

Changes in CBO's Baseline Since August 2015

CBO completed its previous set of baseline projections in August 2015. Since then, the agency has increased its estimate of the deficit in 2016 by $130 billion and its baseline projection of the cumulative deficit from 2016 through 2025 by $1.5 trillion—from $7.0 trillion to $8.6 trillion—mostly because of a decline in its projections of revenues (see Table 1-4). Several factors led to those changes: Legislation enacted since last August was the largest factor, and it caused CBO to increase its deficit projection through 2025 by $749 billion; a revised economic outlook raised that projection by $437 billion; and other, technical, changes increased the projection by $363 billion. (For additional details about those changes, see Appendix A.)

Changes Attributable to Legislation

CBO has lowered its revenue projections by $425 billion over the 2016–2025 period as a result of legislation enacted since August. The largest effect on revenues stemmed from the Consolidated Appropriations Act, 2016, which, among other changes, retroactively and prospectively extended several provisions reducing corporate and individual income taxes that had expired at the end of calendar year 2014. According to estimates by JCT, the largest such reductions in revenues over the 2016–2025 period stem from permanent extensions of the research and experimentation tax credit (in modified form); the ability of businesses to defer certain foreign financing income; the ability of businesses with relatively small amounts of investment to immediately deduct all such investment (in modified form); and the option for individuals to take an itemized deduction for state and local sales taxes instead of state and local income taxes.

Also as a result of legislation, CBO has increased its projection of total outlays for the 2016–2025 period by $324 billion. Changes to refundable income tax credits—primarily as a result of provisions contained in the Consolidated Appropriations Act, 2016, to permanently extend the American Opportunity Tax Credit and also to extend the expansions of the earned income tax credit and the child tax credit—increased mandatory outlays by $154 billion. Also, discretionary spending in the baseline rose, on net, by $56 billion because of legislation, primarily from increases in the caps on such funding for 2016 and 2017 and increased funding for surface transportation programs. The resulting growth in the estimate of federal borrowing due to enacted legislation led CBO to raise its projection of interest payments on federal debt by $137 billion through 2025.

Changes Attributable to Revisions in the Economic Forecast

The baseline also reflects changes in CBO's economic forecast that were made through early December. They include updated projections of GDP, the unemployment rate, interest rates, inflation, and other factors that affect federal revenues and spending.[23]

Those updates to economic factors—primarily slower projected growth in economic output over the 10-year projection period—have caused the agency to lower its projections of revenues from each of the three major revenue sources (individual income taxes, corporate income taxes, and payroll taxes) between 2016 and 2025. All told, CBO reduced its projections of revenues by $771 billion for that 10-year period as a result of the changed economic outlook.

In addition, adjustments to economic factors caused CBO to reduce its estimates of outlays for the period by $334 billion. Lower spending for net interest costs—primarily because CBO now anticipates lower inflation in 2016 and lower interest rates for much of the projection period—accounts for roughly half of that change ($181 billion).

Technical Changes

CBO also made other, technical, changes to its projections. Those changes led to an increase of $333 billion in projected outlays for the 2016–2025 period, mostly for mandatory programs (higher by $258 billion). Higher spending for Medicaid (by $187 billion) and veterans' benefits ($152 billion) is partially offset by lower spending for Social Security ($97 billion) in CBO's projections. In addition, technical changes boosted net interest costs in the baseline by $72 billion, for two main reasons: Projected debt-service costs are higher—mostly because of the larger deficits attributable to technical factors—and projected receipts from the financing accounts associated with the government's credit programs are smaller (mostly stemming from a reduction in the projected volume of federal student loans). Projected revenues have been reduced by $30 billion over the period for technical reasons.

23. As noted in the Summary, CBO did not have enough time to incorporate into its budget projections the most recent updates to its economic forecast, which accounted for legislation enacted in December and for other developments through the end of that month. A preliminary analysis suggests that if CBO had incorporated those updates into its budget projections, as it will do in March, projected revenues would be between $100 billion and $200 billion (or 0.2 percent to 0.4 percent) higher over the 2016–2026 period than they are currently projected to be. Projected outlays also would be affected, but probably to a lesser extent. CBO will also make technical estimating changes in its March projections that could be larger than those amounts, in either direction.

Uncertainty in Budget Projections

Even if federal laws remained unchanged for the next decade, actual budgetary outcomes would differ from CBO's baseline projections because of unanticipated changes in economic conditions and in a host of other factors that affect federal spending and revenues. The agency aims for its projections to be in the middle of the distribution of possible outcomes, given the baseline assumptions about federal tax and spending policies, while recognizing that there will always be deviations from any such projections.

CBO's projections of outlays depend on the agency's economic projections for the coming decade, which include forecasts for such variables as interest rates, inflation, and the growth of real (inflation-adjusted) GDP. Discrepancies between those forecasts and actual economic outcomes can cause significant differences between baseline budgetary projections and budgetary outcomes.

For instance, CBO's current economic forecast anticipates that interest rates on 3-month Treasury bills will increase from around 1 percent at the beginning of 2017 to 3.2 percent by mid-2019 (and remain there through 2026) and that interest rates on 10-year Treasury notes will rise from around 3 percent early in 2017 to 4.1 percent by late 2019 (and remain there through 2026). If interest rates were 1 percentage point higher or lower each year from 2017 through 2026 and if all other economic variables were unchanged, cumulative deficits projected for the 10-year period would be about $1.6 trillion higher or lower, mostly as a result of changes in interest payments on Treasury debt. (For further discussion of how some key economic projections affect budget projections, see Appendix E.)

Uncertainty also surrounds myriad technical factors that can substantially affect CBO's baseline projections of outlays. For example, spending per enrollee for Medicare and Medicaid is very difficult to predict. If per capita costs in those programs rose 1 percentage point faster or slower per year than CBO has projected for the next decade, total federal outlays for Medicare and Medicaid would be roughly $1 trillion lower or higher for that period.

Projections of revenues also are quite sensitive to a variety of factors. Revenues depend on total amounts of wages and salaries, corporate profits, and other income, all of which are encompassed by CBO's economic projections. For example, if the growth of real GDP and taxable income was 0.1 percentage point higher or lower per year than in CBO's baseline projections, deficits would be $327 billion lower or higher over the 2017–2026 period.

Even fairly small deviations in revenues and outlays relative to CBO's projections could have a substantial effect on budget deficits. For example, if revenues projected for 2016 were too high or too low by 3 percent (a range that has included about two-thirds of the deviations between actual amounts and CBO's projections in the past), then actual revenues would be about $100 billion lower or higher than in the agency's baseline.[24] Similarly, if outlays projected for 2016 were too high or too low by 3 percent, then outlays would deviate from CBO's baseline by about $120 billion. Such differences for both revenues and outlays could largely offset each other, thus having little net effect on the deficit, or they could both push the deficit in the same direction, thus compounding the differences.

Alternative Assumptions About Fiscal Policy

CBO's baseline budget projections—which are constructed in accordance with provisions of law—are intended to show what would happen to federal spending, revenues, and deficits if current laws generally remained unchanged. Future legislative action, however, could lead to markedly different budgetary outcomes.

To assist policymakers and analysts who may hold differing views about the most useful benchmark against which to consider possible changes to laws, CBO has estimated the effects on budgetary projections of some alternative assumptions about future policies (see Table 1-5). The discussion below focuses on how those policy actions would directly affect revenues and outlays. Such changes also would influence the costs of servicing the federal debt (shown separately in the table).

Discretionary Spending

Policymakers could vary discretionary funding in many ways from the amounts projected in the baseline. For example, if appropriations grew each year through 2026 at the same rate as inflation after 2016 rather than being constrained by the caps, discretionary spending would be $757 billion higher over the 2017–2026 period than it is in CBO's baseline. If, by contrast, lawmakers kept appropriations for 2017 through 2026 at the nominal 2016 amount, total discretionary outlays would be $746 billion lower over that period. Under that scenario (sometimes called a freeze in appropriations), total discretionary spending would fall from 6.5 percent of GDP in fiscal year 2016 to 4.4 percent in 2026. (In CBO's baseline, such spending is already projected to fall to 5.2 percent of GDP in 2026, reflecting the caps on most new discretionary funding through 2021 and adjustments for inflation thereafter.)

Automatic Spending Reductions

The Budget Control Act of 2011 put in place automatic procedures to reduce discretionary and mandatory spending through 2021. Those procedures require equal

24. Projection errors have tended to be larger for longer horizons than for shorter ones. CBO's six-year revenue projections—those that estimate revenues for the fifth fiscal year after the year in which they are released—have, on average, overestimated revenues by 5.3 percent. The mean absolute error of those projections (that is, the average of the errors without regard to direction) is 10.4 percent. See Congressional Budget Office, *CBO's Revenue Forecasting Record* (November 2015), www.cbo.gov/publication/50831.

reductions (in dollar terms) in defense and nondefense spending. The Bipartisan Budget Act of 2015 canceled the discretionary reductions for 2016 and 2017 and instead set new caps for those years. That act also extended the required reductions to mandatory spending (through a process called sequestration) through 2025. If lawmakers chose to prevent those automatic cuts each year—starting in 2017—without making other changes that reduced spending, total outlays over the 2017–2026 period would be $897 billion (or about 2 percent) higher than the amounts in CBO's baseline. Total discretionary outlays would be $764 billion (or 5.9 percent) higher, and outlays for mandatory programs—most of which are not subject to sequestration—would be $134 billion (or 0.4 percent) higher.[25]

Revenues

A number of tax provisions are scheduled to expire over the next decade. Most have been extended several times. Most recently, the Consolidated Appropriations Act, 2016, made permanent some provisions that had expired or were scheduled to expire, and temporarily extended others. That law also phases out the ability of businesses with large amounts of investment to expense (immediately deduct from their taxable income) qualifying equipment investment, allowing those companies to expense 50 percent of such investment through 2017, 40 percent in 2018, and 30 percent in 2019, after which the partial-expensing provisions are scheduled to expire. That law also postponed for one or two years certain taxes related to health care.

If the provision allowing for 50 percent expensing became permanent after 2017, it would reduce revenues by about $248 billion over the 2018–2026 period, JCT estimates. If instead the provision allowing for 30 percent expensing became permanent after 2019, it would reduce revenues by about $149 billion from 2020 through 2026. If all other tax provisions scheduled to expire before 2027 were permanently extended, CBO and JCT estimate, revenues would be lower by a total of $178 billion over the 2017–2026 period.

Deficits also would increase if delays in the implementation of certain taxes established by the ACA were extended or made permanent. The Consolidated Appropriations Act, 2016, postponed for 2016 and 2017 the medical device tax, placed a moratorium on the health insurance tax for 2017, and postponed for two years (to 2020) the start of the tax on high-premium health insurance plans. Permanently repealing those taxes would reduce revenues (net of small reductions in outlays) by a total of $256 billion over the 2018–2026 period.

25. Because of interactions between the effects of different policy options, the estimated budgetary effects of this option cannot be added to the estimated budgetary effects of either of the other alternatives that affect discretionary spending.

The Long-Term Budget Outlook

Beyond the coming decade, the fiscal outlook is significantly more worrisome. In CBO's most recent long-term projections—which extend through 2046—budget deficits rise steadily under the extended baseline, which follows CBO's 10-year baseline projections for the first decade and then extends the baseline concept for subsequent years (see Table 1-6).[26] Although long-term budget projections are highly uncertain, the aging of the population and growth in per capita spending on health care would almost certainly boost federal spending significantly relative to GDP after 2026 if current laws remained in effect. Federal revenues also would continue to increase relative to GDP under current law, but they would not keep pace with outlays. As a result, public debt would reach 155 percent of GDP by 2046 (taking into account the effects on the economy of the rising debt), CBO estimates, higher than any percentage previously recorded in the United States.[27]

Such high and rising debt relative to the size of the economy would dampen economic growth and thus reduce people's incomes compared with what otherwise would be the case. It would also increasingly restrict policymakers' ability to use tax and spending policies to respond to unexpected challenges, and it would boost the risk of a fiscal crisis in which the government would lose its ability to borrow at affordable rates.

Moreover, debt would still be on an upward path relative to the size of the economy in 2046, a trend that would ultimately be unsustainable. To avoid the negative consequences of high and rising federal debt and to put debt on a sustainable path, lawmakers will have to make significant changes to tax and spending policies—letting revenues rise more than they would under current law, reducing spending for large benefit programs below the projected amounts, or adopting some combination of those approaches.

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26. CBO has not fully updated its long-term projections, which were most recently issued in June 2015. Instead, for this report, CBO adopted a simplified approach that it has regularly used between full updates: The long-term projections incorporate the most current baseline for the first 10 years; for subsequent periods, they incorporate the interest rates as well as the growth rates for revenues, spending, and GDP from the agency's extended baseline in its most recent full update. For that June 2015 update, see Congressional Budget Office, *The 2015 Long-Term Budget Outlook* (June 2015), www.cbo.gov/publication/50250. For additional information about the simplified approach used here, see Congressional Budget Office, *Budgetary and Economic Outcomes Under Paths for Federal Revenues and Noninterest Spending Specified by Chairman Price, March 2015* (March 2015), pp. 13–14, www.cbo.gov/publication/49977. CBO expects to publish its next complete update of its long-term projections in the summer of 2016.

27. In June 2015, CBO's long-term projections showed debt of roughly 100 percent of GDP in 2040; debt held by the public in the 10-year baseline was about $1.2 trillion less in 2025 than CBO currently estimates, and the projected deficits were smaller. As a result, CBO now estimates that debt held by the public in 2040 would be substantially higher if current laws remained in place.

Chapter 2: The Economic Outlook

The economy's real (inflation-adjusted) output will expand at an average annual rate of roughly 2½ percent over the next two years, the Congressional Budget Office projects, after last year's estimated 2 percent growth. Consumer spending is expected to provide the largest contribution to the growth of output over the next few years, as it has done on average in the past. However, the anticipated pickup in growth in 2016 and 2017 stems largely from faster growth in investment in business capital and in housing. CBO expects that the federal tax and spending policies embodied in CBO's baseline projections would boost growth in demand for goods and services in the economy in 2016 but dampen it in 2017 and 2018. CBO also expects the economic expansion over the next few years to put upward pressure on interest rates and inflation, helping to raise the rate of inflation to the Federal Reserve's goal of 2 percent per year, on average.[28]

The growth rates that CBO projects for the next two years are modestly faster than the average since the end of the recession in 2009. That postrecession average has been weak by historical standards, reflecting the nature and severity of the last recession as well as structural, longer-term factors such as declining growth in the labor force owing to an aging population. Because of the slow recovery in output, the amount of underused labor and capital resources, or "slack," in the economy has diminished slowly as well.

CBO expects the economic expansion over the next few years to reduce the slack in the labor market. For example, CBO projects that further hiring will reduce the unemployment rate from 5.0 percent in the fourth quarter of 2015 to 4.5 percent in the fourth quarter of 2016 and put some upward pressure on employee compensation. The hiring also will encourage some people to enter or stay in the labor force, slowing a long-term decline in labor force participation that is attributable to underlying demographic trends and, to a smaller degree, to federal policies.

The later years of CBO's economic projections through 2026 are based primarily on projections of underlying trends in variables such as growth of the labor force, of hours worked, and of productivity. Those projections do not include predictions of the timing or magnitude of economic fluctuations. Real output will grow faster through 2026 than it did during the past decade, CBO expects, because business investment will be

28. During December 2015, lawmakers enacted legislation that affected the economic outlook. Consequently, CBO's economic forecast, which is typically completed in early December, has been updated to incorporate the enactment of that legislation, as well as economic developments through the end of the year. In particular, as discussed in the section "Federal Fiscal Policy," recent legislation led CBO to boost its estimate of output over the next two years. In addition, economic developments in December suggested slightly more output and taxable income over the projection period.

stronger and the economy's productivity will grow faster. Nevertheless, slower growth in the nation's supply of labor will probably keep growth of output below the rates observed during the 1980s, 1990s, and early 2000s. On that basis, CBO projects annual growth averaging 2.0 percent over the 2021–2026 period.

Recognizing the uncertainty of economic forecasts, CBO constructs its forecasts to fall in the middle of the distribution of possible outcomes for the economy, given current law. Nevertheless, many developments—such as a quicker tightening of the labor market, slower-than-expected growth in productivity, or slower growth of foreign economies—could cause outcomes to differ substantially from those CBO has projected.

CBO's current economic projections differ in some significant respects from its August 2015 projections. Most important, CBO has lowered its projected paths of potential and actual output, reducing its estimate of potential and actual gross domestic product (GDP) by nearly 3 percent in 2025, the end of the projection period examined in the August report. Those revisions were made on the basis of revised historical data and a reassessment of future growth in total factor productivity (TFP), the average real output per unit of combined labor and capital services. In addition, economic developments since August point to a weaker outlook for output growth over the next few years. CBO also projects a lower rate of unemployment and lower interest rates than it estimated in August.

The economic projections in this report indicate a slightly stronger economy in the near term than do the *Blue Chip* consensus forecast (published in January) and the forecasts developed by the Federal Reserve (and presented at the Federal Open Market Committee's December 2015 meeting).

The Economic Outlook for 2016 Through 2020

CBO expects real GDP to grow by 2.7 percent this year and 2.5 percent next year—faster than last year's estimated 2.0 percent rate—but at a slower pace in later years (see Table 2-1). The agency anticipates that continued solid growth in spending by consumers and faster growth in investment spending by businesses and homebuilders will drive most of the growth over the next few years. Under current law, developments in the federal government's tax and spending policies would, on net, have a small positive effect on the growth in the demand for goods and services this year and a modest negative effect in 2017 and 2018, CBO projects. The agency also anticipates that monetary policy will support the growth of output this year and over the next few years, but by smaller degrees over time.

CBO expects the slack in the economy to diminish to a negligible amount over the next few years. Since the end of the last recession, GDP has grown faster than potential GDP, on average, reducing the gap between the two and hence the amount of slack in the economy. CBO expects that gap to continue narrowing through the middle of 2018 (see Figure 2-1). In the agency's projections, increased demand for workers reduces the unemployment rate this year and contributes to faster growth in hourly labor compensation as measured by the employment cost index. Those developments are expected to encourage more people to enter, reenter, or remain in the labor force. Reduced slack in the economy will also remove some of the downward pressure seen in recent years on the rate of inflation.

Unlike CBO's projections for 2016 and 2017, those for the 2018–2020 period do not reflect expected cyclical developments in the economy. Rather, the projections largely serve as transitional paths to values projected for the 2021–2026 period, which are based primarily on an assessment of underlying trends in variables such as growth of the labor force, of hours worked, and of productivity.

Federal Fiscal Policy

Changes projected to occur in federal spending and revenues under current law would have a variety of effects on the economy through 2020. Major legislation enacted since August is one source of those effects; as a whole, it is estimated to boost GDP this year and next, largely by increasing aggregate demand.[29] Other year-to-year changes in spending and revenues that are expected to occur under laws enacted before August are projected to have little effect on growth this year and modestly dampen demand for goods and services in 2017 and 2018. Altogether, the fiscal policies embodied in CBO's baseline would boost GDP growth in 2016 but dampen it in 2017 and 2018, CBO estimates. (Over the past several years, changes in spending and revenues generally reduced growth in real GDP.) In addition, some aspects of fiscal policy under current law are projected to dampen the supply of labor and therefore the growth of output.

Effects on the Economy From Major Legislation Enacted Since August 2015. Laws enacted since August 2015 raised spending and lowered revenue in comparison with the amounts in CBO's August 2015 baseline—adding an estimated $749 billion to the projected 10-year cumulative deficit (see Appendix A). The Consolidated Appropriations Act, 2016 (Public Law 114-113), accounts for most of those legislative changes.

29. Aggregate demand is total purchases by consumers, businesses, governments, and foreigners of a country's output of final goods and services during a given period.

CBO estimates that laws enacted since August would boost real GDP growth by 0.4 percentage points in 2016 and then dampen GDP growth in 2017 and 2018 by 0.2 percentage points in each year.[30] The effects on GDP growth through the rest of the projection period are likely to be small, and until later years the direction of those effects is uncertain. By the end of the projection period, the laws would probably lower real GDP somewhat as an increase in federal debt from the larger cumulative deficit would ultimately reduce private investment enough to more than offset any positive effects on output from other aspects of the legislation.

The estimated effects on growth in the near term, in part, reflect the laws' effects on projected discretionary spending. Together they boosted spending for discretionary programs by $25 billion (in nominal dollars) in 2016 over previously projected amounts, resulting in an increase of $32 billion over the 2015 level. That increase will tend to boost the growth of real output this year. In CBO's baseline, enacting the legislation increased discretionary outlays by the same amount in 2017 as it did in 2016 and increased them by less in 2018. After adjustment for inflation, those nominal increases imply a smaller boost to real federal spending in 2017 and 2018 than will occur this year. Hence, those changes to the baseline projections dampen CBO's estimate of real GDP growth slightly in 2017 and 2018.

In addition, the Consolidated Appropriations Act, 2016, includes major changes to tax provisions that will affect the economy over the 2016–2018 period and beyond. That law increased incentives for businesses to invest by changing the tax treatment of investment spending. As discussed later, those changes are expected over the next few years to increase business investment, another source of aggregate demand.[31] That outcome also implies faster growth of aggregate demand in 2016 and 2017 but slightly slower growth in 2018.

CBO anticipates that the laws enacted since August will affect the quantity of labor and capital services supplied in the economy in several ways. On net, those effects will probably have only a small impact on output in the later years of the projection period. In particular, the Consolidated Appropriations Act, 2016, will affect work incentives for

30. Although the legislation significantly affects spending and revenues over the next decade, several factors are estimated to restrain the economic effects over the next few years. Some of the reductions in revenues are estimated to have only a modest effect on private demand; moreover, some reductions in business taxes were retroactive and are expected to have little effect on investment. In addition, with short-term interest rates no longer constrained by the zero lower bound, monetary policy is expected to partly offset the boost to economic growth from stronger aggregate demand. For a description of CBO's approach to analyzing the economic effects of fiscal policy, see Congressional Budget Office, *How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy* (November 2014), www.cbo.gov/publication/49494.

31. Enacted in December 2015, the Consolidated Appropriations Act, 2016, retroactively extended many tax provisions that reduced tax liabilities and had been extended routinely in previous years. Those changes in law reduced income tax revenues more in 2016 than in future years, contributing slightly to the projected increase in revenues after 2016.

many households—but the effects are small and offsetting, and the net impact on labor supply is estimated to be minuscule. Also, the projected boost to business investment over the next several years will tend to result in a larger capital stock and greater capital services in the near term. However, in the longer term the legislation enacted since August will tend to dampen the growth of capital services because it increased projected deficits over the next decade. The agency estimates that those deficits would gradually reduce—or crowd out—private investment in productive capital because the portion of people's savings used to buy government securities would not be available to finance private investment.

Effects on Aggregate Demand From Other Changes in Fiscal Policy. Other year-to-year changes in spending and revenues projected under current law would have small negative effects on growth in output. Although recent legislation boosted spending for discretionary programs, the previously enacted limits on discretionary appropriations continue to apply for 2018 through 2021, reducing projected discretionary spending as a share of output over that period. CBO also expects that the automatic stabilizers (that is, the automatic increases in revenues and decreases in outlays in the federal budget that occur when the economy strengthens) will provide less economic stimulus over the next few years.[32]

Effects on the Supply of Labor From Other Changes in Fiscal Policy. CBO anticipates that several developments in federal fiscal policy under current law will affect the economy through their impact on the labor market. The most sizable effects stem from provisions of the Affordable Care Act (ACA). The ACA's largest effect on the labor market—especially as overall employment conditions improve—will come from provisions of the act that raise effective marginal tax rates on earnings, thereby reducing how much some people choose to work.[33] The health insurance subsidies that the act provides through the expansion of Medicaid and the exchanges are phased out for people with higher income, creating an implicit tax on some people's additional earnings. The act also directly imposes higher taxes on some people's labor income. Because both effects on labor supply will grow over the next few years, CBO projects, they will subtract from economic growth over that period.

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32. All else being equal, automatic stabilizers affect aggregate demand, and therefore output, because they are changes in the amount of taxes that households and businesses pay and the transfer payments that households receive. The change in aggregate demand, in turn, affects businesses' decisions about whether to increase production and hire workers, further affecting income, demand, and output. For more discussion of the automatic stabilizers, see Appendix C and Frank Russek and Kim Kowalewski, *How CBO Estimates Automatic Stabilizers*, Working Paper 2015-07 (Congressional Budget Office, November 2015), www.cbo.gov/publication/51005.

33. For more information on the effects of the ACA, see Edward Harris and Shannon Mok, *How CBO Estimates the Effects of the Affordable Care Act on the Labor Market*, Working Paper 2015-09 (Congressional Budget Office, December 2015), www.cbo.gov/publication/51065.

CBO expects that other aspects of the federal tax and transfer system also will affect incentives to work over the next decade. People's real incomes are projected to rise, on average, over the next decade, because of both a continuing recovery and underlying growth in productivity. That increase in income will tend to push some households into higher tax brackets, raising marginal tax rates and dampening growth in labor supply.

Monetary Policy and Interest Rates on Treasury Securities

CBO expects that the Federal Reserve will continue to gradually reduce the extent to which its monetary policy supports the growth of output as the economy improves and as the rate of inflation approaches the central bank's longer-run goal of 2 percent. After holding the target range for the federal funds interest rate (the Federal Reserve's primary policy rate) at zero to 0.25 percent since late 2008, the Federal Reserve raised the range to 0.25 percent to 0.50 percent at its December 2015 meeting. In CBO's forecast, the federal funds rate rises to 1.2 percent in the fourth quarter of 2016 and 2.2 percent in the fourth quarter of 2017, and it settles at 3.5 percent in the second quarter of 2019. CBO's projections not only take into account projections by Federal Reserve officials but also place some weight on the lower path for interest rates implied by prices in the futures market for federal funds (see Figure 2-2).

Interest rates on federal borrowing will rise steadily over the next few years, CBO projects, as the economy improves and the federal funds rate rises. CBO projects that the interest rate on 3-month Treasury bills will rise from 0.1 percent in the fourth quarter of 2015 and settle at 3.2 percent by mid-2019.[34] The interest rate on 10-year Treasury notes is projected to rise from 2.2 percent in the fourth quarter of 2015 to 4.1 percent by late 2019.

The projected increase in the 10-year rate reflects the anticipated increase in the 3-month rate and an expected increase in the term premium—the premium paid to bondholders for the extra risk associated with holding long-term bonds—from its historically low level at the end of last year. The term premium has probably been held down in recent years by an unusually heightened concern among investors that economic activity in the United States might be unexpectedly bad, which would lead monetary policymakers to keep short-term interest rates lower for a longer-than-expected period. CBO expects those concerns to diminish if, as it anticipates, the economy grows at a steady pace over the next few years. In addition, the term premium has probably been held down by the influence of the Federal Reserve's large portfolio of long-term assets. CBO expects the size of that portfolio to gradually diminish beginning at the end of this year; that development will begin to put upward pressure on the term premium and the 10-year rate. Because the reduction in the size of the

34. CBO expects the interest rate on 3-month Treasury bills to be lower than the federal funds rate over the next 10 years, consistent with their historical relationship. The 3-month Treasury bill rate is typically lower than the federal funds rate because Treasury securities are free of default risk, whereas the overnight unsecured loans made at the federal funds rate carry a small risk of default.

Federal Reserve's portfolio is expected to begin later than the rise in the federal funds rate, the interest rate on 10-year notes rises more slowly in CBO's projection and stabilizes slightly later than the rate on 3-month bills.[35]

Although CBO expects long-term rates to rise, it also anticipates that several factors, detailed below, will keep real interest rates from rising to levels that prevailed before the 2007–2009 recession (see "The Economic Outlook for 2021 Through 2026").

Contributions to Growth of Real GDP

CBO expects that consumer spending and both business and residential investment will drive growth of real GDP in coming years (see Figure 2-3). Consumer spending is expected to provide the largest contribution to the growth of output over the next few years, as it has done on average in the past. However, the anticipated pickup in growth in 2016 and 2017 stems largely from faster growth in investment in business capital and in housing (see Table 2-2). On net, purchases by the federal government and by state and local governments are projected to have a small positive effect on the growth of GDP through 2020. In contrast, net exports will restrain growth in 2016 and 2017 but contribute slightly to growth thereafter, CBO projects.

Consumer Spending. In CBO's estimation, solid growth in consumer spending on goods and services will be an important contributor to the growth of real output. That contribution this year will be nearly the same as in 2015—about 1.9 percentage points (as measured from the fourth quarter of the previous year)—and then fall slightly to 1.8 percentage points in 2017. CBO estimates that consumer spending will contribute less to the growth of output thereafter.

Several factors support that outlook for consumer spending over the next two years. The most important factor is real compensation of employees, which CBO expects will be spurred by the expected further recovery in the labor market (see Figure 2-4). CBO also expects low prices for energy goods and services to continue to support consumer spending; in particular, CBO projects prices for gasoline to remain below their 2015 average over the next few years. The agency also projects that further increases in housing prices will support consumer spending by raising household wealth. However, CBO does not expect a significant boost to consumer spending from changes in financial wealth over the next two years.[36]

35. The 10-year rate is projected to rise by less than the 3-month rate, because, in CBO's estimation, the current 10-year rate already largely incorporates the projected rise in the 3-month rate over the 10-year period.

36. Broad indexes of U.S. equity markets have fallen sharply since the end of 2015 when CBO completed its economic forecast, lowering the value of household equity wealth. If equity values remain below CBO's forecast, that development could dampen the growth of real consumer spending over the next year or two.

CBO also expects improvements in households' creditworthiness and in availability of credit to support consumer spending over the next few years. The projected growth in income will allow consumers to borrow more, CBO expects, and will diminish delinquency rates on consumer loans, which already are historically low by some measures. In recent years, banks have increased their willingness to make consumer loans, and CBO expects them to continue to do so over the next few years.

Business Investment. CBO expects investment by businesses to contribute significantly to the growth of real GDP over the next few years.[37] CBO estimates that real business investment will contribute 0.6 percentage points to the growth rate of real GDP in 2016 and 0.5 percentage points in 2017—up from a contribution of 0.2 percentage points in 2015. The contribution in 2016 accounts for most of this year's increase in the projected growth in real GDP. CBO estimates that real business investment will contribute less to the growth of output in later years. All of the contribution from business investment will be from investment in fixed assets rather than from inventory accumulation because businesses have largely restored the ratio of their inventories to sales to the desired level, in CBO's view.

Business investment remains in a cyclical expansion after the last recession. In addition to replacing worn-out or obsolete capital assets, businesses invest in new assets to meet the unexpected growth of demand for their goods and services since the last time they purchased capital and to meet expected growth of demand. Consequently, investment responds to both past and expected growth of real output. For that reason, the recession and slow recovery of the economy slowed the recovery in business investment. CBO expects that past output growth and expectations of growth will significantly boost investment this year and next but will provide a smaller boost in later years as output growth slows (see Figure 2-4).

Other factors also play a role in CBO's projection of business investment. Partial-expensing provisions will encourage investment by permitting businesses to deduct new investment from taxable income more rapidly, CBO expects. In the other direction, the agency expects that investment in mining structures will continue to slow in response to low oil prices through mid-2016, but by less than it did in 2015, and then begin to pick up again thereafter.[38] Moreover, the increase in interest rates anticipated in CBO's forecast will exert some downward pressure on investment, but not enough to offset the influence of the ongoing economic expansion. The recent lifting of restrictions on exports of crude oil will have little impact on oil prices and thus on investment over the next few years, in CBO's judgment. Because continuing the restrictions probably would

37. Business investment consists of fixed investment (investment in equipment, nonresidential structures, and intellectual property products such as research and development) and investment in inventories.

38. Oil prices have fallen considerably since CBO completed its forecast in late December. That decline implies somewhat lower oil prices over the projection period and a somewhat greater slowing of mining investment in 2016.

eventually have restrained domestic oil prices, lifting them is expected to increase investment beyond the next few years.

Residential Investment. CBO expects residential investment to grow rapidly in real terms over the next few years, even as mortgage rates begin to rise.[39] The sector's small size will limit its contribution to the growth of real GDP, but CBO expects the contribution will be noticeably larger than the historical average. CBO projects that residential investment will contribute 0.4 percentage points to the average growth rate of real GDP from 2016 through 2018—up slightly from 2015—and a smaller amount thereafter.

CBO anticipates that construction of new homes will be the primary contributor to residential investment, mainly because of expected continued strength in household formation (see Figure 2-4). Other factors include less restrictive mortgage lending standards and robust demand for replacement housing units. Although mortgage lending standards remain tighter than they were before the 2007–2009 recession, they have been loosening over the past few years and probably will continue to loosen.

CBO anticipates that stronger growth in demand for housing will put upward pressure on house prices. In 2015, house prices (as measured by the Federal Housing Finance Agency's price index for home purchases) rose by 4.4 percent (on a fourth-quarter-to-fourth-quarter basis), in CBO's estimation. CBO projects that they will increase by 2.1 percent in 2016 and by about 2.4 percent per year, on average, over the 2017–2020 period. That outlook accounts for the projected increase in the supply of housing units, which is expected to temper the price gains resulting from stronger housing demand.

Government Purchases. CBO projects that, in real terms, the purchases of goods and services by federal, state, and local governments will contribute 0.2 percentage points to the growth rate of output this year—about the same as last year—and contribute about 0.1 percentage point per year thereafter. The projected growth of the real value of overall government purchases in 2016 is attributable to an estimated increase of 1.9 percent in state and local purchases and an increase of 0.7 percent in federal purchases. After this year, the government sector's positive contribution to the growth of output will be small and due entirely to spending by state and local governments, CBO projects. The statutory caps on funding for discretionary programs constrain spending through 2021, reducing projected real purchases by the federal government in both 2017 and 2018 and leaving them roughly unchanged in 2019 and 2020.

39. Residential investment consists mostly of single-family construction, multifamily construction, residential improvements, real estate agents' commissions, and other ownership transfer costs.

Net Exports. CBO expects that real net exports will fall and slow the growth of GDP from 2016 through 2018, just as they did last year. In later years, net exports are expected to make a small contribution to growth.[40] CBO's projection of net exports is based primarily on the significant increase in the exchange value of the dollar during the past two years and on the agency's forecast of that value (see Figure 2-4). In the past two years, the trade-weighted U.S. dollar appreciated by approximately 19 percent.[41] That appreciation occurred because long-term interest rates declined among the United States' leading trading partners, particularly in Europe and Asia, and because the outlook for foreign growth deteriorated. Those developments increased the exchange value of the dollar by boosting the relative demand for dollar-denominated assets, which reduced net exports in the past year and will continue to do so this year. CBO expects the stronger growth in the United States compared with that among its trading partners to continue to contribute to an increasing divergence between interest rates in the United States and those abroad this year. That effect will further push up the exchange value of the dollar and contribute to weaker net exports over the next two years. As growth in foreign economies strengthens, however, foreign central banks will gradually tighten their monetary policies and foreign interest rates will generally rise, in CBO's estimation. As a result, the exchange value of the dollar is expected to decrease and contribute to stronger net exports in 2019 and beyond.

CBO's projection of net exports also is based partly on important differences in the expected pace of economic activity in the United States and among its leading trading partners. CBO expects growth in the United States this year to outpace that of the leading U.S. trading partners; for example, China's economic growth is projected to continue to slow over the next few years, and continued decline in commodity prices will dampen growth in Canada and Mexico over the next year. The effects of modest improvements to economic growth in the euro zone and Japan are expected to only partially offset the effects of slow growth in the economies of China, Canada, and Mexico. Consequently, U.S. spending on imports is projected to rise more than the trading partners' spending on U.S. exports will, reducing net exports. As commodity prices rebound, CBO expects growth among the nation's major trading partners (especially Canada, Mexico, and other commodity-producing economies) to rise and exceed the rate of U.S. economic growth—slightly boosting net exports.

The Labor Market

The labor market showed marked improvement in 2015. The primary measure CBO uses to assess the amount of slack in the labor market—the estimated shortfall in

40. Net exports are currently negative, meaning that the United States imports more than it exports. A decrease in net exports indicates that imports are increasing more than exports.

41. CBO's measure of the exchange value of the dollar is an export-weighted average of the exchange rates between the dollar and the currencies of leading U.S. trading partners. Similarly, CBO calculates the economic growth of leading U.S. trading partners by using a weighted average of their growth rates. That measure uses shares of U.S. exports as weights.

employment from its potential (maximum sustainable) amount—fell by an estimated 1½ million people, down to about 2½ million people at the end of last year. That decline reflects, in part, a drop in the unemployment rate to its lowest value since early 2008. (For more discussion of slack at the end of 2015, see Box 2-1.) Because of population growth, the labor force continued to grow modestly last year, despite a decline in the rate of labor force participation.[42]

According to CBO's estimates, the growth of output over the next two years will increase the demand for labor, leading to solid employment gains and virtually eliminating labor market slack. The employment shortfall is projected to shrink to a little more than 1 million people by the end of 2016 and reach ½ million people by the end of 2017 (see Figure 2-5). The projected employment shortfall over the next few years reflects CBO's expectation that the labor force will remain smaller than its estimated potential size. Partially offsetting that factor is the agency's projection that the unemployment rate will fall below the estimated natural rate of unemployment (the rate that arises from all sources except fluctuations in the overall demand for goods and services). That difference shrinks the projected employment shortfall in 2016 and 2017. With that increased demand for labor, CBO projects, the increased competition for workers will boost the growth of hourly labor compensation (wages, salaries, and benefits).

CBO's labor market projections for 2018 through 2020 do not reflect expected cyclical developments in the economy. Instead, the projections largely serve as a transition to values projected for later years, which primarily reflect estimated long-term trends. Consequently, the projected rate of unemployment rises to its historical relationship with the natural rate of unemployment over that period, increasing labor market slack, by a small amount, to its average level over past decades.

Employment. Nonfarm payroll employment rose solidly last year, and CBO expects it to continue to increase over the next few years, but more slowly. After an average increase of 228,000 jobs per month in 2015, employment is expected to rise by an average of about 172,000 jobs per month in 2016 and about 124,000 jobs per month in 2017, reflecting an anticipated slowdown in the decline in the unemployment rate and slower growth in the labor force because of the retirement of baby boomers (people born between 1946 and 1964). CBO's employment projections indicate that the number of people employed as a percentage of the population will be roughly unchanged over the next two years before falling steadily in later years as the rate of participation in the labor force falls (see Figure 2-6).

Labor Force Participation. The rate of labor force participation has dropped noticeably in recent years. It fell by 0.3 percentage points, to 62.5 percent in 2015. That rate was

42. The rate of labor force participation is the percentage of people in the civilian noninstitutionalized population who are at least 16 years old and are either working or seeking work.

roughly 1 percentage point below CBO's estimate of the potential participation rate. CBO projects that the participation rate will remain at 62.5 percent through 2016 and then fall by roughly 0.1 percentage point per year, reaching 62.1 percent at the end of 2019 (see Figure 2-7). At the same time, the potential participation rate continues to fall in CBO's projection, also reaching 62.1 percent by the end of 2019.

Those projected declines in actual and potential rates of labor force participation reflect several factors. The most important factor is the aging of members of the baby-boom generation, even though that generation apparently has a stronger attachment to the labor force than that of people age 60 and over in recent generations. The lingering effects of the recession and ensuing weak recovery also will continue to push down participation, in CBO's view. Although many workers who experienced long-term unemployment because of the deep recession and slow recovery later found jobs, a notable fraction also left the labor force and remain categorized as not participating in the labor force. In addition, federal tax and spending policies—in particular, certain aspects of the ACA and the structure of the tax code, which pushes some people with rising income into higher tax brackets—will tend to lower participation rates over the next several years. Finally, a set of long-term trends involving particular cohorts of people are projected to push down the participation rate slightly. Those trends include, for example, less participation in the labor force by younger and less-educated workers.

CBO's projection of the actual rate of labor force participation falls by less than its projection of the potential rate because the expected continued improvement in the labor market will bolster the actual rate. Some workers who left the labor force temporarily, or who stayed out of the labor force because of weak employment prospects, will enter it in the next few years as demand for labor strengthens.

Unemployment. The unemployment rate fell from 5.7 percent in the fourth quarter of 2014 to 5.0 percent in the fourth quarter of 2015. Most of that decline stemmed from a decline in long-term unemployment (that is, unemployment lasting at least 27 consecutive weeks) as those who had been unemployed long-term appeared to move into employment (see Figure 2-8). That outcome indicates possibly diminishing effects of the stigma and erosion of skills that can result from long-term unemployment.

CBO projects the unemployment rate to fall to 4.5 percent by the end of this year and reach 4.4 percent in 2017, leaving the rate roughly 0.4 percentage points below CBO's estimate of the natural rate of unemployment. That difference reflects a projected increase in the demand for labor that temporarily outstrips the boost to the labor force resulting from an improving labor market. However, the relatively low unemployment rate does not imply that slack is no longer present in the labor market beginning this year. Some slack is expected to persist through 2020 because fewer people will be participating in the labor market than would do so if the economy was operating at its potential.

CBO expects the natural rate of unemployment to fall by about 0.1 percentage point through 2020—from 4.9 percent last year—largely because of the demographic shift in composition of the workforce to older workers, who tend to have lower rates of unemployment.

Labor Compensation. Labor compensation has grown slowly since the end of the last recession. But CBO projects that compensation—as measured by the Bureau of Labor Statistics with the employment cost index (ECI)—will grow faster over the next several years (see Figure 2-9). CBO expects the ECI for workers in private industries to increase at an average annual rate of 3.3 percent in 2016 and 2017 and 3.6 percent from 2018 through 2020, compared with an average of 2.0 percent from 2010 through 2015. The growth of other measures of compensation, such as the average hourly earnings of production and nonsupervisory workers in private industries, is similarly expected to increase.

The projection of labor compensation is based on CBO's projections of demand for workers, slack in the labor market, productivity, and inflation. Historically, growth in labor compensation has been among the last labor market indicators to recover after a recession, picking up only when little slack was left in the labor market. As slack diminishes and firms must increasingly compete for a shrinking pool of unemployed or underemployed workers, growth in hourly compensation will pick up, CBO projects.

Inflation

CBO anticipates that prices will rise at a modest pace over the next few years, consistent with its projection of the remaining—but diminishing—slack in the economy and with widely held expectations for low and stable inflation. The agency projects that the rate of inflation in the price index for personal consumption expenditures (PCE price index) will rise to 1.5 percent this year, up from 0.5 percent in 2015 (see Figure 2-10). The decline in energy prices and the increase in the exchange value of the dollar exerted downward pressure on inflation last year. CBO expects inflation to rise in 2016 as the temporary downward pressure from the decline in energy prices dissipates and the remaining slack in the economy diminishes.[43]

In 2017, the agency projects, inflation will stabilize at 2.0 percent—the Federal Reserve's longer-run goal. That projection reflects CBO's judgment that consumers and businesses expect the Federal Reserve to adjust monetary policy to prevent inflation from exceeding or falling short of the 2 percent goal for a prolonged period. CBO has a similar projection for core PCE inflation, which excludes food and energy prices; in CBO's forecast, that inflation rate reaches 2 percent at the end of 2017.

43. The further declines in oil prices since CBO completed its forecast in late December imply slightly lower energy prices and overall inflation in the near term than is currently recognized in the forecast.

The consumer price index for all urban consumers (CPI-U) and its core version are expected to increase a little faster than their PCE counterparts because of the different methods used to calculate them. CBO projects that the difference between inflation as measured by the CPI-U and inflation in the PCE price index will generally be about 0.4 percentage points per year—close to the average difference over the past several decades.

The Economic Outlook for 2021 Through 2026

CBO's projections of real GDP, inflation, and real interest rates for 2021 through 2026—unlike its projections for the next few years—are not based on forecasts of cyclical developments. Rather, they are based primarily on projections of underlying trends in key variables, such as growth of the labor force, hours worked, capital formation, and productivity. CBO also considers the effects of federal tax and spending policies under current law, and in recent years it has taken into account the persistent effects of the 2007–2009 recession and subsequent weak recovery.

In CBO's projections for the 2021–2026 period:

- Actual and potential real GDP grow at an annual average of roughly 2.0 percent per year.
- The unemployment rate remains stable at 5.0 percent, slightly above the estimated natural rate of 4.8 percent.
- Both overall inflation and core inflation, as measured by the PCE price index, average 2.0 percent per year, and inflation as measured by the CPI-U is slightly higher, on average.
- The interest rates for 3-month Treasury bills and 10-year Treasury notes average 3.2 percent and 4.1 percent, respectively.

CBO projects that real GDP will be about one-half of one percent below its estimate of real potential GDP, on average, during the 2021–2026 period. That projection reflects CBO's estimate that output has been roughly that much lower, on average, over the seven complete business cycles (measured trough to trough) that occurred between 1961 and 2009.[44] CBO projects that, consistent with the average gap between actual and potential GDP, the unemployment rate will be slightly higher than its estimated natural rate, on average, during the 2021–2026 period.

44. See Congressional Budget Office, *Why CBO Projects That Actual Output Will Be Below Potential Output on Average* (February 2015), www.cbo.gov/publication/49890.

Future developments will undoubtedly differ from what those underlying trends and averages imply, so CBO's projections should be interpreted as the average of likely outcomes, given information available now.

Potential Output

In developing its projections of potential output, CBO projects underlying trends in the aggregate labor force; the distribution of employment across sectors of the economy; and hours worked, capital services, and TFP in the nonfarm business sector (which accounts for roughly three-quarters of total output). In doing so, CBO considers the effects on those trends of federal policies under current law as well as the persistent effects of the 2007–2009 recession and subsequent weak recovery.

The 2.1 percent average annual rate of increase in real potential output that CBO projects is substantially faster than the growth in potential output since the end of 2007, the beginning of the last recession (see Table 2-3). However, that rate represents a significant slowdown from average growth in potential output over the three complete business cycles that occurred between 1981 and 2007. Most of that projected slowdown reflects slower projected growth of the potential labor force. GDP is also expected to be lower from 2021 through 2026 than it otherwise would have been because of the lingering effects of the recession and slow recovery.

Growth in Potential Output Compared With Growth Since the Last Recession. The average projected rate of potential output growth of 2.1 percent over the 2021–2026 period is half again faster than the estimated average growth of about 1.4 percent per year over the 2008–2015 period. The projected increase arises primarily because CBO expects growth of the determinants of potential output in the nonfarm business sector to accelerate from their recent rates of growth. In particular, CBO expects potential TFP in the nonfarm business sector to quicken from its unusually slow postrecession pace of 0.8 percent to nearly 1.4 percent during the 2021–2026 period.[45] CBO also projects a modest pickup in growth of potential hours worked in the nonfarm business sector, reflecting a similar pickup in growth of the overall potential labor force.

Growth of capital services in the nonfarm business sector has been restrained since 2008 because of weak investment, itself a response to the cyclical weakness of the overall demand for goods and services. In the long term, however, growth of capital services depends mostly on increases in TFP and hours worked. As a result, faster growth in the sector's potential TFP and potential hours worked is expected to spur an increase in the growth of capital services in the sector as well.

45. CBO projects that growth in potential TFP will gradually return by 2020 to a rate equal to the weighted average of the growth rates estimated between 1991 and 2015. The projected rate is slightly slower than the average for the 1991–2015 period because CBO places more weight on the relatively slow growth of TFP during the recession and recovery than on the faster growth rates of the 1990s and early 2000s.

Because of those factors, CBO expects potential labor force productivity (the ratio of potential GDP to the potential labor force) for the economy as a whole to pick up to 1.5 percent. That growth rate is substantially higher than the 0.9 percent average rate that CBO estimates for the 2008–2015 period.

Growth in Potential Output Compared With Growth in Previous Business Cycles. Despite the anticipated acceleration in the growth of potential output, CBO's projection for the growth of potential output over the 2021–2026 period is a full percentage point slower than the estimated 3.1 percent average annual growth that the economy experienced between 1981 and 2007. Most of that decrease reflects the slower growth of the potential labor force, itself the consequence of several factors. Most important, growth in the labor force is declining because of the ongoing retirement of baby boomers and the relatively stable labor force participation rate among working-age women (after sharp increases from the 1960s to the mid-1990s). Federal tax and spending policies set in current law also are projected to cause some people to work less than in earlier decades.

CBO projects that productivity of the potential labor force also will grow more slowly, but only modestly so, during the 2021–2026 period than over the 1981–2007 period. That slowdown, attributable to both slower growth of capital per worker and slower potential TFP growth in nonfarm business, accounts for the remaining reduction in projected potential output growth from the average over recent business cycles.

Lingering Effects of the Recession and Slow Recovery. CBO expects the three major factors that determine potential output to be lower through 2026 than they would have been if not for the recession and slow recovery.

Potential labor hours will be lower because persistently weak demand for workers since the recession has led some people to weaken their attachment to the labor force permanently. For example, some people who left the labor force after experiencing long-term unemployment are not expected to return to full-time, stable employment over the next decade. The rate of labor force participation will thus be slightly lower—and the labor force slightly smaller—than it would have been otherwise.

Capital services also will be lower for several reasons. Fewer workers require proportionately less capital, all else being equal, and lower TFP (discussed below) tends to reduce investment as well. Because of automatic stabilizers and changes in fiscal policies implemented to bolster the economy during and after the recession, federal debt increased sharply. That higher debt will crowd out additional capital investment in the long term, CBO estimates.

Finally, in CBO's judgment, the protracted weakness in the economy and the large amount of slack in the labor market have lowered—and will continue to lower—potential TFP. They will do so by reducing the speed and efficiency with which resources are allocated to their most productive uses, thereby slowing the rate at which workers gain new skills and restraining businesses' spending on research and development.

How the recession and slow recovery will continue to affect those three factors is difficult to quantify with any precision. For instance, significant uncertainty surrounds estimates of how much of the recent weakness in TFP can be traced to the effects of the recession and slow recovery on potential TFP and how much reflects other developments in the economy. (For example, the rate of improvement in information technology may have begun to slow a few years before the recession began.)

The Labor Market

In CBO's projection, the unemployment rate settles down to its long-term relationship with the agency's estimate of the natural rate of unemployment. The unemployment rate remains steady at 5.0 percent from the first quarter of 2020 through the fourth quarter of 2026, roughly a quarter of a percentage point above the natural rate of 4.8 percent.[46]

For 2026, CBO projects a potential rate of labor force participation of 61 percent. That rate is about 1 percentage point lower than what the agency projects for 2021 and about 5½ percentage points lower than the estimated rate for the end of 2007. CBO estimates that roughly 4½ percentage points of the decline from 2007 to 2026 is attributable to the aging of the population, because older people tend to work less than younger ones. Roughly one-quarter of a percentage point of the decline in the potential participation rate from 2007 reflects the fact that some workers withdrew from the labor force in response to the most recent recession and slow recovery.

The rest of the projected fall in potential labor force participation stems from some people's reduced incentive to work as a result of the ACA and the structure of the tax code (whereby rising income pushes some people into higher tax brackets). Both effects reduce workers' incentive to supply labor.

Real labor compensation per hour in the nonfarm business sector, a measure of labor costs that is a useful gauge of longer-term trends, will grow at an average annual rate of 2.0 percent between 2021 and 2026, CBO projects. That projection is consistent with the agency's projection of the growth of labor productivity, reflecting the historical relationship between the two. In the early 2000s, however, that relationship broke down when compensation grew more slowly. In recent years, real compensation per hour and productivity have grown at more similar rates, suggesting that the relationship has been largely restored. CBO expects average historical patterns to be maintained in the future, with real compensation per hour growing about as fast as productivity over the 2021–2026 period. Another measure of hourly labor compensation, the ECI for

46. The difference between the projections of the unemployment rate and the natural rate over the 2021–2026 period corresponds to the projected gap between output and potential output, as discussed above.

private industry workers, shows a qualitatively similar pattern in the agency's projections.

Inflation

In CBO's projections, inflation as measured by the overall PCE and the core PCE price indexes averages 2.0 percent annually over the 2021–2026 period. That rate is consistent with the Federal Reserve's longer-run goal and is broadly in line with widely held expectations. As measured by the CPI-U and the core CPI-U, projected inflation is higher during that period, at 2.4 percent and 2.3 percent, respectively.[47] CPI-U and core CPI-U have maintained a close, long-run relationship. In the current forecast, the agency anticipates slightly faster growth in energy prices in the out years, which will cause CPI-U to grow faster than core CPI-U.

Interest Rates

CBO projects that, under fiscal policies embodied in current law, the interest rates on 3-month Treasury bills and 10-year Treasury notes will be 3.2 percent and 4.1 percent, respectively, from 2021 through 2026. CBO projects that the federal funds rate would be 3.5 percent during that period.

When the effect of expected inflation (as measured by the CPI-U) is removed, the projected real interest rate on 10-year Treasury notes equals 1.7 percent between 2021 and 2026. That rate would be well above the current real rate but more than a percentage point below the average real rate of 2.9 percent between 1990 and 2007. CBO uses that period for comparison because it featured fairly stable expectations for inflation and no severe economic downturns or financial crises.

According to CBO's analysis, average real interest rates on Treasury securities will be lower than their earlier average for several reasons:

- Slower growth in the labor force (reducing the return on capital),
- Slightly slower growth of productivity (also reducing the return on capital),
- A greater share of total income going to high-income households (tending to increase saving, thereby making more funds available for borrowing), and
- A higher risk premium on risky assets (increasing relative demand for Treasury securities, boosting their prices and thereby lowering their interest rates).

In addition to those factors, which affect both short-term and long-term securities, CBO also foresees a greater demand for long-term bonds as a hedge against unexpectedly low inflation. Investors' concerns that adverse economic surprises would lead to

47. Differences in how the two price indexes are calculated make the CPI-U grow faster than the PCE price index, on average.

unexpectedly low inflation appear to have increased over recent decades, and CBO expects those concerns to continue. The increased demand for long-term bonds as a hedge against that outcome is expected to push long-term interest rates down from their average levels during the 1990–2007 period.

Other factors will act to raise real interest rates from their earlier average, but not by enough to offset the factors pushing rates down:

- A larger amount of federal debt as a percentage of GDP (increasing the supply of Treasury securities),
- Smaller net inflows of capital from other countries as a percentage of GDP (making less funds available for borrowing),
- More older people, who will be drawing down their savings, than younger workers in their prime saving years (tending to decrease saving, thereby also making less funds available for borrowing), and
- A larger share of income going to capital (increasing return on capital assets with which Treasury securities compete).[48]

In addition to considering those factors, CBO also relies on information from financial markets in projecting interest rates over the long term. For example, the current interest rate on 30-year Treasury bonds implies a forecast of interest rates on shorter-term securities 30 years into the future. Incorporating that information tends to reduce the interest rates that CBO projects when compared with rates implied by the analysis of factors described above.

Projections of Income

Economic activity and federal tax revenues depend not only on the amount of total income in the economy but also on how that income is divided among labor income, domestic economic profits, proprietors' income, interest and dividend income, and other categories.[49] CBO projects various categories of income by estimating their shares of gross domestic income (GDI, the income earned in the production of GDP).[50]

48. For a more detailed discussion of the factors affecting future interest rates, see Congressional Budget Office, *The 2015 Long-Term Budget Outlook* (June 2015), pp. 116–117, www.cbo.gov/publication/50250.

49. Calculating domestic economic profits involves adjusting estimates of corporations' domestic profits to remove distortions in depreciation allowances caused by tax rules and to exclude the effects of inflation on the value of inventories. Estimates of domestic economic profits exclude certain income of U.S.-based multinational corporations that is derived from foreign sources, most of which does not generate corporate income tax receipts in the United States.

50. In principle, GDI equals GDP because each dollar of production yields a dollar of income; in practice, they differ because of difficulties in measuring both quantities.

Labor income (especially wage and salary payments) and domestic profits are the most important components of income for the tax base.

In CBO's projections, labor income grows faster than other components of GDI over the next decade, increasing its share from 57.6 percent in 2015 to 58.8 percent in 2026 (see Figure 2-11). CBO expects the labor share to rise because employment is expected to rise and real compensation per hour is projected to grow more strongly than productivity for several years as cyclical weakness in the labor market wanes. As a result, the bargaining power of workers will improve and the share of income going to corporate profits will be smaller. By the end of the projection period, however, real hourly compensation is projected to move in step with growth in labor productivity.

However, CBO expects that some factors that have depressed labor's share of GDI since 2000 will continue during the coming decade. As a result, that share will not return to its 1980–2007 average of nearly 60 percent. One such factor is globalization, which has tended to move the production of labor-intensive goods and services to countries with lower labor costs. Another factor is technological change, which may have increased returns to capital more than returns to labor.

In CBO's projection, domestic economic profits fall from an estimated 9.1 percent of GDI in 2015 to 7.5 percent in 2026. Over the next several years, that decline occurs largely because of the expected pickup in the growth of labor compensation and a projected increase in corporate interest payments, the result of rising interest rates. In later years, CBO expects the sum of all non–labor income components to grow less rapidly than output, reversing a trend seen since 2000 and making GDI equal to GDP by the latter half of the projection period.

Another measure of overall income, real gross national product (GNP), is projected to grow at an annual average of 2.0 percent per year between 2016 and 2026. Unlike the more commonly cited GDP, GNP includes income that U.S. residents earn abroad and excludes income that foreigners earn in this country. GNP is therefore a better measure than GDP of the resources available to U.S. households.

Some Uncertainties in the Economic Outlook

Significant uncertainty surrounds CBO's economic forecast, which the agency constructed to be in the middle of the distribution of possible outcomes given the federal policies embodied in current law. Even if no significant changes are made to those fiscal policies, economic outcomes will undoubtedly differ from CBO's projections. For example, CBO's forecasts of the average annual growth of real GDP over five-year periods since the early 1980s have a standard deviation around the actual values of 1.2 percentage points.[51] If the nature of CBO's forecast errors is the same in the future as in the past, then CBO's current forecast of average annual GDP growth for the next five years will, roughly speaking, have a two-thirds chance of being within a range of 1.2 percentage points above or below the actual amount. The forecasts of inflation as measured by the CPI-U have had a standard deviation around the actual values of 0.6 percentage points.

Many developments—such as unforeseen changes in the labor market, business confidence, the housing market, and international conditions—could cause economic growth and other variables to differ considerably from what CBO has projected. On the one hand, the agency's current forecast of employment and output for the 2016–2020 period may be too pessimistic. For example, firms might respond to the expected increase in overall demand for goods and services with more robust hiring than CBO anticipates. If so, the unemployment rate could fall more sharply and inflationary pressures could rise more quickly than CBO projects. In addition, a greater-than-expected easing of borrowing constraints in mortgage markets could support more rapid growth of residential investment than CBO anticipates, accelerating the housing market's recovery and further boosting house prices. Households' increased wealth could then buttress consumer spending, raising GDP.

On the other hand, CBO's forecast for 2016 through 2020 may be too optimistic. For example, if the increased tightness of labor markets does not lead to increases in wages and benefits, household income and consumer spending could grow more slowly than CBO anticipates. In addition, an unexpected worsening in international political or economic conditions, such as a more severe decline in China's stock market, could likewise weaken the U.S. economy by disrupting the international financial system, interfering with international trade, and reducing business and consumer confidence. Further declines in U.S. equity markets, if persistent, could significantly reduce household wealth and consumer spending. Also, household formation could be weaker than CBO expects. Weaker household formation would imply slower residential investment and slower overall growth of GDP.

In addition, the possibility exists that the economy will enter a recession. The current economic expansion is over 6 years old—slightly longer than the average expansion (about 5 years) over the past 11 business cycles back to 1945. Over the past 30 years, expansions lasting at least 6 years that are characterized by a relatively low

51. That standard deviation around the actual values is also known as the root mean square error. For more on the inherent uncertainty underlying economic forecasts, see Congressional Budget Office, *CBO's Economic Forecasting Record: 2015 Update* (February 2015), www.cbo.gov/publication/49891. That report presents an evaluation of the quality of CBO's economic forecasts, in comparison with the economy's performance and with forecasts by the Administration and the *Blue Chip* consensus. Such comparisons indicate the extent to which imperfect information and analysis—factors that affect all forecasters—might have caused CBO to misread patterns and turning points in the economy.

unemployment rate have tended to fall into recession within two years. However, the length of economic expansions has varied greatly. And, although the longest expansion over the past 11 business cycles has been 10 years, no statistical evidence suggests that the length of an expansion alone causes the economy to enter a recession.

Several factors that will determine the economy's output later in the coming decade are also uncertain—for example:

- The economy could grow considerably faster than CBO forecasts if the labor force grew more quickly than expected (say, because older workers chose to stay in the labor force longer than expected),
- The natural rate of unemployment could be lower than expected, or
- Productivity could grow more rapidly.

Similarly, lower-than-expected growth would occur if the stigma and erosion of skills that stem from elevated long-term unemployment dissipated more slowly than expected or if improving labor market conditions did not draw significant numbers of workers back into the labor force. In that case, future hours worked could be substantially fewer than CBO expects, and slower growth of the labor force would in turn imply less need for business investment.

Also uncertain is how income inequality affects economic growth. Economists have found mixed theoretical and empirical results on that question. Some studies conclude that income inequality leads to faster growth, others suggest that it slows growth, and still others find that it does not affect growth. Therefore, CBO's projection of economic growth does not explicitly include the effect of changes in income inequality. However, CBO's economic projections implicitly include some effects of income inequality insofar as past changes in inequality have affected economic growth. Economists continue to study the issue, and CBO will update its analysis if research in that area yields a more definitive conclusion.

Comparison With CBO's August 2015 Projections

CBO's current economic projections differ notably in one important respect from those issued in August 2015 and more modestly in other respects (see Table 2-4). Real GDP is now projected to be 2.7 percent lower in 2025 than CBO projected in August, the last year of CBO's previous projection (see Table 2-5). Other changes to the projection are more modest: The unemployment rate is lower throughout the 2016–2025 period, inflation is lower in the near term but unchanged later in the projection period, and interest rates are lower throughout the projection period.[52]

52. CBO uses the 2016–2025 period for comparison because the August forecast did not include 2026.

Output

CBO has revised its projected path of potential output downward since the August forecast. That revision results largely from the agency's lower estimate of potential TFP over recent history and over the projection period. That change was prompted by revisions to historical data that lowered CBO's estimates of potential TFP in the nonfarm business sector through 2015 and by CBO's reassessment of how long the slow growth in potential TFP is likely to persist. In particular, the Bureau of Economic Analysis revised downward its estimate of nonfarm business output for recent years. That downward revision resulted in about 1.0 percent lower actual TFP, on average, in 2013 and 2014. Combined with continued slow TFP growth in 2015, those new data resulted in a notably lower estimate of trend growth in potential TFP over the current business cycle, which has now finished its eighth year. For example, potential TFP is estimated to have grown at a 0.8 percent pace last year, down from CBO's previous projection of 1.1 percent.

In addition, to account for the possibility that the slow growth in potential TFP could persist for some time, CBO reduced the speed and extent to which the growth of potential TFP is projected to rebound from its current low rates. To do that, CBO calculated a weighted average of potential TFP growth over the past 25 years. That calculation placed more weight on the recent slow growth than on the faster growth of the 1990s and early 2000s. Reflecting those judgments, CBO projects that potential TFP growth will rebound to a 1.4 percent pace by 2022—later and to a slightly lower rate than appeared in CBO's previous projection.

Lower growth in potential TFP would also indirectly reduce potential output by reducing demand for capital goods and growth of capital services. That effect is responsible for most of the decline in projected growth of capital services, compared with the August forecast. In addition, CBO projects greater federal borrowing than in its August forecast, which would limit the money available for private investment and thus dampen growth in capital services. But an upward revision in the private saving rate roughly offsets that effect. CBO also has slightly revised down projected population growth, which suggests a slightly smaller potential labor force. However, a downward revision in CBO's estimate of the natural rate of unemployment slightly boosts potential output. That rate is projected to be more than 0.2 percentage points lower over the 2021–2025 period than in the August forecast (discussed below). In addition, a reassessment of the share of employment in the nonfarm business sector in comparison with other sectors dampens potential hours worked in the nonfarm business sector and boosts hours worked in other sectors.

In addition, economic developments since August point to a weaker outlook for output growth over the next few years. In particular, CBO's current projection for growth of real GDP during the 2016–2020 period averages 2.2 percent, compared with 2.5 percent in August. One source of the downward revision is that CBO expects net exports to contribute less to growth during the next few years, largely because the exchange value of the dollar is higher and foreign economic growth is likely to be lower than anticipated. Another source is expected slower growth in business investment spending. Oil prices declined more sharply from August through the end of December than CBO had anticipated; those prices are expected to remain lower than CBO had forecast, so the forecast for mining investment has been revised downward. A final source of the downward revision is the decline in the prices of equities from mid-2015 through the end of December, which has lowered CBO's near-term projection of household wealth. Lower estimates of wealth imply less support for consumer spending in CBO's near-term forecast. However, that negative effect is smaller than the boost to consumer spending expected from the downward revision to energy prices that results from the downward revision to oil prices.

CBO has made a smaller change to projected GDP growth in the later years of the coming decade. In CBO's forecast, growth of real GDP during the 2021–2025 period is slower by less than 0.1 percentage point per year, on average, than in CBO's August projection. That rate reflects slower growth in potential GDP during the same period. That attenuated growth, in turn, is due to slower projected potential growth in the three determinants of nonfarm business output: potential hours worked (due to slower population growth), capital services, and potential TFP. Higher employment and output in other sectors of the economy slightly offset that slower growth of potential output in the nonfarm business sector.

Labor Market

Compared with CBO's August estimates, the agency's current projection for the unemployment rate is lower and the pace of employment growth is higher during the 2016–2020 period. Those changes largely reflect a judgment that recent trends in certain labor market indicators will continue longer than CBO estimated earlier. For example, recent trends in rates of hiring, layoffs, and retirement suggest that the unemployment rate will decline slightly faster and job growth will be more rapid during the next few years than CBO had estimated. In particular, CBO now projects that the unemployment rate will temporarily fall below its estimated 4.8 percent natural rate. In the years after 2020, projected employment growth is similar to what CBO projected in August. However, the unemployment rate is roughly 0.2 percentage points lower than the August projection, largely because CBO lowered its estimate of the natural rate of unemployment.

CBO lowered its estimate of the natural rate of unemployment over the past decade and throughout the next decade after reassessing how demographic trends affect that rate. Reflecting those trends, the share of younger workers in the working-age population has declined and the share of older workers has increased since 2005. Because a higher proportion of younger workers are unemployed, on average, than older workers, incorporating those developments points to a downward revision in the agency's estimate of the average natural rate of unemployment across all workers in the labor market. Consequently, CBO has reduced its estimate of the economywide natural rate of unemployment to 4.9 percent in 2015 from 5.1 percent in its previous estimate. Because those trends are projected to continue, the natural rate is projected to decline to 4.8 percent in 2025, down from 5.0 percent in the previous projection. Correspondingly, CBO has lowered its estimate of the unemployment rate to 5.0 percent in 2025, down from 5.2 percent.

CBO projects that the rate of labor force participation will be roughly one-quarter of a percentage point lower in the near term than it projected in August. During the second half of 2015, that rate fell more than CBO had forecast in August. That larger-than-expected decline resulted from older workers leaving the labor force, probably to retire, and CBO does not expect them to return. CBO's projection for the participation rate during the 2021–2026 period is almost unchanged since August.

Inflation and Interest Rates

CBO projects that inflation through 2020 will be slightly lower, on average, than forecast in August. In the near term, CBO's forecast reflects lower-than-expected energy prices and an increase in the exchange value of the dollar; both moves through the end of December have been larger than CBO had forecast. CBO's projections for the rates of core and overall inflation during the years after 2020 are roughly the same as in the agency's August forecast.

The agency anticipates that interest rates will be lower on average during the 2016–2020 period than projected in August. The rate on 3-month Treasury bills is expected to be 0.1 percentage points lower, on average, and the rate on 10-year Treasury notes is expected to be 0.2 percentage points lower, on average, in the near term. CBO projects lower rates over that period, partly because interest rates since August were lower than expected and because the Federal Reserve is now projected to raise the federal funds rate by less than CBO expected through 2020.

CBO also anticipates that interest rates will be lower during the 2021–2025 period than projected in August. Both short- and long-term rates are expected to be 0.2 percentage points lower, on average, over that period than in CBO's previous forecast. That downward revision stems from revised forecasts of the factors that influence real interest rates, particularly the downward revision to projected growth of potential TFP. CBO projects larger federal deficits than it did in its August forecast, which would generally lead to higher interest rates. However, upward revisions in other components of saving left national saving as a share of GDP roughly unchanged. CBO's revised projection also reflects changes in expectations of future interest rates on the part of participants in the financial markets and private-sector forecasters.

Comparison With Other Economic Projections

The agency's projections of the growth of real GDP, the unemployment rate, inflation, and interest rates in 2016 and 2017 are similar to the *Blue Chip* consensus—the average of the roughly 50 forecasts by private-sector economists published in the January 2016 *Blue Chip Economic Indicators*. CBO's projection for real GDP growth is slightly above the *Blue Chip* consensus, which indicates a slightly stronger economy in the near term, and the agency's forecast of the unemployment rate is slightly below that consensus, which indicates a slightly stronger labor market. However, the agency's projections for GDP growth and other indicators are generally within the middle two-thirds of the range of private-sector forecasts included in the *Blue Chip* survey (see Figure 2-12). For example, the agency's projections of GDP price inflation, the 3-month Treasury bill rate, and the 10-year Treasury note rate also fall within the middle two-thirds of the range included in the *Blue Chip* survey.

CBO's projections suggest a slightly stronger economy than the forecasts produced by Federal Reserve officials and presented at the December 2015 meeting of the Federal Open Market Committee (see Figure 2-13). The Federal Reserve reports three sets of forecasts: a median, a range, and a central tendency. The range reflects the highest and lowest forecasts of the members of the Board of Governors of the Federal Reserve System and of the presidents of the Federal Reserve Banks. The central tendency reflects the range without the three highest and three lowest projections. CBO's projections for growth of real GDP in 2016 and 2017 are above the central tendency and at the upper end of the range. CBO's projections for the unemployment rate in 2016 and 2017 are within the full range and below the central tendency.

CBO's projections differ from those of other forecasters for a variety of reasons. For example, the other forecasts may not yet include all of the economic effects of the federal legislation enacted in late 2015. Differences in the economic news available when the forecasts were completed and differences in the economic and statistical models used might also account for the discrepancies.

Chapter 3: The Spending Outlook

Under the provisions of current law, federal outlays in 2016 will total $3.9 trillion, the Congressional Budget Office estimates, $232 billion (or 6 percent) more than the amount spent in 2015. They are projected to grow over the coming decade—at an average annual rate of more than 5 percent—and reach $6.4 trillion in 2026.

Most of the projected growth in outlays for 2016 is attributable to mandatory spending, which makes up just over 60 percent of the federal budget and is projected to rise by $168 billion, from $2.3 trillion last year to $2.5 trillion this year (see Table 3-1). Discretionary spending and the government's net interest payments are each expected to rise by $32 billion. CBO estimates that discretionary spending will reach $1.2 trillion this year and net outlays for interest, $255 billion. (See Box 3-1 for descriptions of the three major types of federal spending.)

All told, federal outlays in 2016 will equal 21.2 percent of gross domestic product (GDP), CBO estimates, up from 20.7 percent last year and above the 20.2 percent of GDP such spending has averaged over the past 50 years. But the mix of that spending has changed noticeably over time. Mandatory spending (net of the offsetting receipts that are credited against such spending) is expected to equal 13.3 percent of GDP in 2016, whereas over the 1966–2015 period, it averaged 9.5 percent. Meanwhile, measured as shares of GDP, the other major components of federal spending have fallen below their 50-year averages: Discretionary spending is anticipated to equal 6.5 percent of GDP this year, below its 8.7 percent average over the past 50 years, and net outlays for interest are expected to be 1.4 percent of GDP, below the 50-year average of 2.0 percent (see Figure 3-1).

About $43 billion of the increase in spending for 2016 occurs because the first day of fiscal year 2017—October 1, 2016—falls on a Saturday. When the first day of a month falls on a weekend, certain monthly payments (mostly for mandatory benefit programs) normally made on that day are shifted to the preceding month; when that date is October 1, the shift moves payments to the preceding fiscal year. Accordingly, 13 months of payments for certain benefit programs will be made in fiscal year 2016 rather than the usual 12. If that shift in the timing of payments did not occur, outlays for 2016 would rise by 5 percent this year.[53]

In CBO's baseline projections, outlays continue to rise in relation to the size of the economy over the coming decade, reaching 23.1 percent of GDP in 2026, an increase of 2.0 percentage points. Mandatory spending and outlays for net interest are each projected to increase by 1.6 percentage points. The projected rise in mandatory spending results from a combination of rapid growth in spending for Social Security and Medicare and a drop, relative to GDP, in outlays for most other mandatory programs; that growth is primarily attributable to the aging of the population and rising health care spending per beneficiary. As interest rates return to more typical levels and debt continues to mount, net outlays for interest are also projected to jump significantly. Discretionary spending, however, falls by 1.3 percentage points of GDP in CBO's baseline projections.

Specifically, CBO's baseline for federal spending includes the following projections:

- Outlays for the largest federal program, Social Security, are expected to rise from 4.9 percent of GDP in 2016 to 5.9 percent in 2026.

53. About $39 billion of the increase in mandatory spending and $4 billion of the increase in discretionary spending for 2016 result from a shift in the timing of payments that would otherwise have been made in 2017. (Similar amounts will be shifted from 2018 to 2017.) If not for that shift in the timing of payments, total outlays in 2016 would equal 20.9 percent of GDP, mandatory outlays would be 13.1 percent of GDP, and discretionary outlays would be 6.4 percent of GDP, CBO estimates.

- Federal outlays for the major health care programs—Medicare, Medicaid, subsidies offered through health insurance exchanges and related spending, and the Children's Health Insurance Program (CHIP)—are projected to increase by 1 percentage point of GDP, growing from 5.6 percent of GDP in 2016 to 6.6 percent in 2026, mostly because of growth in Medicare spending.[54]

- Outlays for all other mandatory programs (net of other offsetting receipts) are projected to decline from 2.8 percent of GDP in 2016 to 2.5 percent in 2026.

- Discretionary spending relative to the size of the economy is projected to fall by about 20 percent over the next 10 years, from 6.5 percent of GDP in 2016 to 5.2 percent in 2026.

- Net interest payments are projected to more than double, rising from 1.4 percent of GDP in 2016 to 3.0 percent of GDP in 2026.

In developing its baseline projections, CBO generally assumes, in accordance with the rules established by the Balanced Budget and Emergency Deficit Control Act of 1985 (Public Law 99-177), that the provisions of current law governing federal taxes and spending will remain unchanged. Therefore, when projecting spending for mandatory programs, CBO assumes that existing laws will not be altered and that future outlays will depend on changes in caseloads, benefit costs, economic variables, and other factors. When projecting spending for discretionary programs, CBO assumes that most discretionary appropriations provided between 2017 and 2021 will be constrained by the statutory caps and other provisions of the Budget Control Act of 2011 (P.L. 112-25), as amended, and that after 2021 appropriations in a given year will equal those in the prior year with an adjustment for inflation.[55]

Mandatory Spending

Mandatory—or direct—spending includes spending for some benefit programs and certain other payments to people, businesses, nonprofit institutions, and state and local governments. It is generally governed by statutory criteria and is not normally

54. Spending for Medicare is presented net of premium payments and other offsetting receipts, unless otherwise noted.

55. Appropriations for certain activities—those designated as overseas contingency operations, emergency requirements, and disaster relief, as well as initiatives designed to enhance program integrity by reducing overpayments in certain benefit programs—are not constrained by the caps and are thus generally assumed to grow with inflation from the amounts provided in 2016.

constrained by the annual appropriation process.[56] Certain types of payments that federal agencies receive from the public and from other government agencies are classified as offsetting receipts and reduce gross mandatory spending.

Total mandatory spending amounted to 12.9 percent of GDP in 2015. (For a more detailed discussion of 2015 spending, refer to Chapter 1.) Such spending will, under current law, jump by 7 percent in 2016, from $2.3 trillion in 2015 to $2.5 trillion (or 13.3 percent of GDP), CBO estimates. (Without the shift in the timing of certain payments, mandatory spending would increase by 6 percent this year, to $2.4 trillion, or 13.1 percent of GDP.) The major contributors to that growth include outlays for Medicaid and subsidies offered through health insurance exchanges.

Over the next 10 years, outlays for mandatory programs are projected to rise by an average of about 5 percent per year, reaching $4.1 trillion in 2026 (see Table 3-2). As a share of GDP, such spending is projected to be higher in each year of the coming decade than it was in 2015, rising to 15.0 percent of GDP in 2026. By comparison, mandatory spending averaged 12.2 percent of GDP over the past 10 years and 9.5 percent over the past 50 years.

Much of the growth in mandatory spending arises because the largest mandatory programs—Social Security and Medicare—provide benefits mostly to the elderly, a segment of the population that has been growing significantly and will continue doing so. The number of people age 65 and older is now more than twice what it was 50 years ago, and over the next 10 years, that number is expected to rise by more than one-third (see Figure 3-2).

Growth in per-enrollee health care spending also contributes to the growth in mandatory spending (and in federal spending as a whole). Although health care spending grew more slowly in the past several years than it has historically, CBO projects that over the coming decade, per-enrollee spending in federal health care programs will grow more rapidly than it has in recent years.

At $1.5 trillion in 2016, outlays for Social Security and Medicare will make up nearly 40 percent of all federal outlays and 60 percent of mandatory spending. Under current law, CBO projects, spending for those programs would increase by an average of 6 percent a year over the 2017–2026 period and total $2.7 trillion in 2026. Outlays for the other major health care programs would grow from $449 billion in 2016 to $756 billion in 2026. From 2016 through 2026, spending for Social Security and the major health care programs accounts for about 60 percent of the projected

56. Each year, some mandatory programs are modified by provisions in annual appropriation acts. Such changes may decrease or increase spending for the affected programs for either a single year or multiple years. Provisions of the Deficit Control Act and the Balanced Budget Act of 1997 (P.L. 105-33) govern how CBO projects spending for mandatory programs whose authorizations are scheduled to expire under current law, some of which are assumed to continue.

$2.5 trillion increase in total outlays; by 2026, it would rise to 12.5 percent of GDP (from 10.5 percent in 2016), CBO projects.

After Social Security and the major health care programs, the next largest component of mandatory outlays consists of spending designed to provide income security—including outlays for certain refundable tax credits, the Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI), and unemployment compensation.[57] Such spending will amount to $307 billion in 2016, or 1.7 percent of GDP, by CBO's estimate. Together, that spending is projected to grow by an average of 2 percent per year, more slowly than GDP is projected to grow. As a result, by 2026 those outlays are projected to shrink to 1.4 percent of GDP.

Other mandatory spending includes retirement benefits for federal civilian and military employees, certain benefits for veterans, spending for student loans, and support for agriculture. Under current law, all such spending is projected to grow at an average annual rate of about 3 percent from 2016 through 2026 and to decline as a share of GDP, from 1.8 percent in 2016 to 1.6 percent of GDP in 2026. (Civilian and military retirement benefits account for roughly half of those amounts.)

In CBO's projections, offsetting receipts (other than those for Medicare) reduce mandatory outlays by 0.7 percent of GDP in 2016 and by an average of 0.6 percent of GDP in subsequent years. Receipts from auctioning a portion of the electromagnetic spectrum have boosted that total this year, but they are expected to have much smaller effects, on average, in future years. In addition, because of the way CBO treats the activities of Fannie Mae and Freddie Mac in its baseline projections, offsetting receipts from those entities are not reflected in the baseline beyond the current year (see page 78 for more details).

Social Security

Social Security, the largest federal spending program, provides cash benefits to the elderly, to people with disabilities, and to their dependents and survivors. Social Security comprises two main parts: Old-Age and Survivors Insurance (OASI) and Disability Insurance (DI). Social Security outlays grew by about 4 percent in 2015 because of increases in caseloads and average benefits.

CBO estimates that, under current law, outlays for Social Security would total $910 billion, or 4.9 percent of GDP, in 2016 and climb steadily (by an average of about 6 percent per year) over the next decade as the nation's elderly population grew and as average benefits rose. By 2026, CBO estimates, Social Security outlays would total $1.6 trillion, or 5.9 percent of GDP, if current laws remained unchanged (see Figure 3-3).

57. Tax credits reduce a taxpayer's overall income tax liability; if a refundable credit exceeds a taxpayer's other income tax liabilities, all or a portion of the excess (depending on the particular credit) is refunded to the taxpayer, and that payment is recorded as an outlay in the budget.

Old-Age and Survivors Insurance. OASI, the larger of Social Security's two components, pays full benefits to workers who start collecting them at a specified full retirement age that depends on a worker's year of birth. Full retirement age rises incrementally from 65 (for people born before 1938) to 67 (for people born after 1959). Workers can, however, choose to start collecting reduced benefits as early as age 62. The program also makes payments to eligible spouses and children of workers (living and deceased). OASI spending totaled $738 billion in 2015, accounting for almost 85 percent of Social Security's outlays.

About 48 million people received OASI benefits in 2015. Over the 2016–2026 period, as more baby boomers (people born between 1946 and 1964) become eligible to receive benefits under the program, the number of people collecting those benefits is projected to increase by an average of about 3 percent per year. At that rate, by 2026 more than 65 million people will be receiving OASI benefits—35 percent more than the number of recipients in 2015 and 60 percent more than the number in 2007, the last year before the first baby boomers became eligible for benefits under the program.

Under current law, average benefits would also rise because beneficiaries generally receive annual cost-of-living adjustments (COLAs) and because initial benefits are based on people's lifetime earnings, which tend to increase over time. Each year's COLA is determined by the annual increase, if any, in the consumer price index for urban wage earners; when prices fall, beneficiaries of Social Security (and those of most other programs that provide COLAs) are protected from a drop in benefits. Because the consumer price index declined during 2015, OASI beneficiaries did not receive a COLA in January 2016; CBO anticipates that, under current law, beneficiaries would receive a COLA of 0.9 percent in 2017 and that COLAs would average 2.5 percent annually from 2017 through 2026. All told, the average benefit is projected to rise by about 3 percent per year over the 2016–2026 period. The increasing average benefit, in combination with the growing number of beneficiaries, is projected to boost outlays for OASI by an average of 6 percent per year over that period.[58]

Disability Insurance. Social Security's disability benefits are paid to workers who suffer debilitating health conditions before they reach OASI's full retirement age. Payments are also made to the eligible spouses and children of those recipients. In 2015, federal spending for DI totaled $144 billion.

The number of people receiving those benefits declined by 0.6 percent in 2015, to 11 million. CBO expects that total to decline again in 2016. In 2015, the number of new awards roughly equaled the number of disabled workers who left the program, and in 2016, CBO expects more people to leave the program than to be awarded

58. For additional background and an analysis of possible changes to Social Security, see Congressional Budget Office, *Social Security Policy Options, 2015* (December 2015), www.cbo.gov/publication/51011.

benefits. Additionally, the number of children and spouse beneficiaries declined in 2015, and CBO expects that trend to continue in 2016. After 2016, the DI caseload is anticipated to grow at a more modest rate than in the years before the most recent recession because the economy is expected to continue to expand and because more Americans will be reaching the age at which they qualify for benefits under OASI.

Before the Bipartisan Budget Act of 2015 (P.L. 114-74) was enacted, CBO projected that the balance of the DI trust fund would be exhausted during fiscal year 2017. That legislation shifted a share of payroll tax revenues for calendar years 2016 through 2018 from the OASI trust fund to the DI trust fund, delaying the exhaustion of the balance of the DI trust fund. CBO now projects that, under current law, the balance of that trust fund would be exhausted during fiscal year 2022.[59] In accordance with the rules in section 257 of the Deficit Control Act, CBO's baseline incorporates the assumption that full benefits will continue to be paid even after the trust fund has been exhausted, although without legislative action, there will be no legal authority to make such payments.

Medicare, Medicaid, and Other Major Health Care Programs

Totaling $1.0 trillion in 2015, gross federal outlays for Medicare, Medicaid, and other major programs related to health care accounted for 40 percent of gross mandatory spending and equaled 5.8 percent of GDP. Under current law, CBO estimates, gross federal outlays for those programs will jump to $1.1 trillion, or 6.2 percent of GDP, in 2016. In CBO's baseline projections, that spending grows robustly—at an average rate of nearly 6 percent per year—and thus nearly doubles in dollar terms between 2016 and 2026, reaching $2.0 trillion, or 7.4 percent of GDP, by the end of that period. About three-fifths of total spending on the major health care programs would finance care for people age 65 or older, CBO projects.

Medicare. Medicare provides subsidized medical insurance to the elderly and to some people with disabilities. The program has three principal components: Part A (Hospital Insurance), Part B (Medical Insurance, which covers doctors' services, outpatient care, home health services, and other medical services), and Part D (which covers outpatient prescription drugs).[60] People generally become eligible for Medicare at age 65 or two years after they qualify for Social Security disability benefits.

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59. In CBO's most recent long-term projections, which are consistent with the 10-year baseline projections that were issued in March 2015 adjusted for the effects of the Bipartisan Budget Act of 2015, the OASI trust fund is exhausted in calendar year 2030, a year earlier than would have been projected without the payroll tax shift. See Congressional Budget Office, *CBO's 2015 Long-Term Projections for Social Security: Additional Information* (December 2015), www.cbo.gov/publication/51047.

60. Medicare Part C (known as Medicare Advantage) specifies the rules under which private health care plans can assume responsibility for, and be compensated for, providing benefits covered under Parts A, B, and D.

Gross spending for Medicare will total $692 billion in 2016, CBO estimates, or 3.7 percent of GDP.[61] By 2026, spending for the program would reach nearly $1.3 trillion, or 4.7 percent of GDP, if current laws remained in place.[62] Medicare also collects substantial offsetting receipts—mostly in the form of premiums paid by beneficiaries—which, in CBO's baseline projections, rise from $101 billion in 2016 to $210 billion in 2026. (See page 78 for further details.) Under current law, spending for Medicare net of those offsetting receipts is projected to be 3.2 percent of GDP in 2016 and 3.9 percent in 2026.

Spending for Medicare (not including offsetting receipts) is projected to grow by an average of about 6 percent per year over the next 10 years under current law. Some of that growth stems from the increasing number of beneficiaries; CBO projects that, under current law, Medicare caseloads would expand at an average rate of 3 percent per year as growing numbers of baby boomers turned 65 and became eligible for benefits. In 2015, Medicare had about 55 million beneficiaries; that number is projected to climb to 75 million in 2026—36 percent more recipients than in 2015 and 60 percent more than in 2010, the last year before the first baby boomers became eligible for benefits under the program.

About 60 percent of the growth over the next 10 years results from rising costs per beneficiary, although those costs are rising much more slowly than they have in the past. CBO projects that, under current law, nominal spending per beneficiary would grow at an average rate of 4 percent per year over the coming decade. In real terms (adjusted for inflation using the price index for personal consumption expenditures), Medicare spending per beneficiary is projected to increase at an average annual rate of 1.6 percent between 2016 and 2026, whereas it averaged real annual growth of 4 percent between 1985 and 2007 (excluding the jump in spending that occurred in 2006 when Part D was implemented).

The comparatively slow growth in per-beneficiary spending that CBO projects for the next decade results from a combination of factors. One of those factors is the anticipated influx of new beneficiaries, which will bring down the average age of Medicare beneficiaries and therefore, all else equal, reduce average health care costs per beneficiary because younger beneficiaries tend to use fewer health care services.

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61. About $24 billion in Medicare spending in 2016 will occur because capitation payments to group health plans and prescription drug plans that are due on Saturday, October 1, 2016, will be made on September 30, the last day of the previous fiscal year. If that shift in the timing of payments did not occur, gross Medicare spending would amount to 3.6 percent of GDP in 2016.

62. Those amounts include the effects of sequestration (that is, the cancellation of funding) specified by the Budget Control Act of 2011, as amended. Those automatic procedures will reduce payments for most Medicare services by 2.0 percent through March 2025 and then by 4.0 percent through September 2025.

Another factor is the slowdown in the growth of Medicare spending across all types of services, beneficiaries, and major geographic regions in recent years. Although the reasons for that slower growth are not yet entirely clear, CBO projects that the slowdown will persist for some years to come.[63]

A third factor that contributes to the slow projected growth in Medicare spending per beneficiary over the next decade is the constraints on service payment rates that are built into current law. The Medicare Access and CHIP Reauthorization Act of 2015 (P.L. 114-10) specifies that annual increases in payment rates for physicians' services will range between zero and 0.75 percent during the 2016–2026 period. (Before that law was enacted, payment rates had been scheduled to drop by 21 percent in April 2015 and to be raised or lowered by small amounts thereafter.) In addition, program rules constrain annual increases in payment rates for Medicare services apart from those provided by physicians by adjusting for changes in productivity in the economy overall. Under CBO's economic projections, those payment rates are expected to increase by about 2 percent per year on average—roughly 1 percentage point lower than the rate at which prices of inputs to Medicare services are projected to increase.

Medicaid. Medicaid is a joint federal and state program that funds medical care for certain low-income, elderly, and disabled people. The federal government shares costs for approved services, as well as administrative costs, with states; the federal share varies from state to state but averaged about 57 percent in most years before 2014. (During some economic downturns, the federal government's share has temporarily increased.)

Beginning in January 2014, the Affordable Care Act (ACA) gave states the option of expanding eligibility for their Medicaid programs to people with income at or below 138 percent of the federal poverty guidelines. By the end of 2015, 30 states and the District of Columbia had expanded their programs. The federal government pays a greater share of the costs incurred by enrollees who were made eligible for Medicaid in those states than it does for traditional enrollees: The federal share for those newly eligible enrollees is 100 percent through 2016 and declines thereafter, falling to 90 percent in 2020. In 2015, the federal government's overall share of Medicaid expenditures was about 63 percent.

Federal outlays for Medicaid totaled $350 billion in 2015, 16 percent more than spending for the program in 2014. CBO estimates that about two-thirds of that

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63. See Michael Levine and Melinda Buntin, *Why Has Growth in Spending for Fee-for-Service Medicare Slowed?* Working Paper 2013-06 (Congressional Budget Office, August 22, 2013), www.cbo.gov/publication/44513. That analysis reviews the observed slowdown in growth in Medicare spending from the 2000–2005 period to the 2007–2010 period. It suggests that demand for health care by Medicare beneficiaries was not measurably diminished by the financial turmoil and recession and that, instead, much of the slowdown in spending growth was caused by other factors affecting beneficiaries' demand for care and by changes in providers' behavior.

increase resulted from enrollment of people who were newly eligible because of the ACA and from the greater share of costs paid by the federal government for those new enrollees.[64] Under current law, CBO projects, federal spending for Medicaid will jump by almost 9 percent this year as more people in those states that have expanded Medicaid eligibility enroll in the program. The average number of people enrolled in Medicaid on a monthly basis is expected to rise from 76 million in 2015 to 77 million in 2016. By 2026, 80 percent of the people who meet the new eligibility criteria will live in states that have extended Medicaid coverage, CBO anticipates; Medicaid enrollment in that year is projected to be 85 million.

Overall, federal spending for Medicaid from 2017 to 2026 is projected to increase more slowly than it has over the past two years, largely because the rapid growth in enrollment that occurred during the initial stage of the expansion of coverage authorized by the ACA will have slowed. Over that period, CBO projects, spending per beneficiary would grow at an average annual rate of 5 percent. In real terms (adjusted for inflation using the price index for personal consumption expenditures), Medicaid spending per enrollee is expected to increase at an average annual rate of 3 percent between 2017 and 2026. By 2026, federal outlays for Medicaid are projected to total $642 billion, or about 2.3 percent of GDP (up from 2.1 percent of GDP in 2016).

Exchange Subsidies and Related Spending. Individuals and families can purchase private health insurance coverage through marketplaces known as exchanges that are operated by the federal government, by state governments, or through a partnership between federal and state governments. Subsidies of purchases made through those exchanges fall into two categories: subsidies to cover a portion of participants' health insurance premiums and subsidies to reduce their cost-sharing amounts (out-of-pocket payments required under insurance policies). The first category of subsidies is available to people with household income between 100 percent and 400 percent of the federal poverty guidelines who meet certain other conditions, while the second category is available to those who are eligible for premium subsidies, have a household income between 100 percent and 250 percent of the federal poverty guidelines, and enroll in an eligible plan.[65]

Related spending consists of grants to states for establishing health insurance exchanges and outlays for risk adjustment and reinsurance. Outlays for exchange subsidies and

64. Provisions of the ACA also led many people who were previously eligible for Medicaid to enroll. CBO cannot, however, precisely determine the share of total growth in Medicaid enrollment between 2014 and 2015 attributable to such people because there is no way to know whether new enrollees who would have been eligible in the absence of the ACA would have signed up had it not been enacted.

65. In order to be eligible for cost-sharing subsidies, people must enroll in a plan that pays about 70 percent of the costs of covered benefits (sometimes referred to as a silver plan).

related spending are projected to rise from $38 billion in 2015 to $56 billion in 2016 and to $109 billion by 2026.

Exchange subsidies make up the largest portion of that spending: Outlays are projected to total $39 billion in 2016 (up from $27 billion in 2015) and to reach $93 billion by 2026. (In addition, a portion of the subsidies for health insurance premiums will be provided in the form of reductions in recipients' tax payments.)[66] During calendar year 2015, an estimated 8 million people per month, on average, received subsidies for health insurance purchased through the exchanges.[67]

On the basis of information about 2015 enrollment and information available as of the end of December 2015 on 2016 enrollment, CBO and the staff of the Joint Committee on Taxation (JCT) estimate that about 11 million people per month, on average, will receive such subsidies in calendar year 2016. Additionally, the agencies project that about 2 million people who are not eligible for subsidies will purchase coverage through an exchange, bringing the total number of people enrolled in coverage through exchanges in any given month to 13 million, on average.[68] (The enrollment projections and other factors underlying the estimates of exchange subsidies provided in this report for years after 2016 have not been updated since March 2015, except to incorporate the effects of enacted legislation.)[69]

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66. The subsidies for health insurance premiums are structured as refundable tax credits; the portions of such credits that exceed taxpayers' other income tax liabilities are classified as outlays, whereas the portions that reduce tax payments are classified as reductions in revenues.

67. Estimates reflect the average enrollment in each month over the course of a calendar year and include spouses and dependents covered under family policies; they include residents of the 50 states and District of Columbia who are younger than 65. In the March 2015 baseline, CBO and the staff of the Joint Committee on Taxation (JCT) projected that an average of about 8 million people per month would receive exchange subsidies in 2015. Additionally, the agencies projected that about 3 million people would not be eligible for subsidies but would purchase coverage through an exchange, bringing the total number of people enrolled in coverage purchased through exchanges in any given month to 11 million, on average. CBO and JCT now estimate that about 9.5 million people enrolled in coverage purchased through the exchanges, on average, during 2015 and that 8 million of those enrollees received subsidies.

68. Previously, CBO and JCT projected that an average of about 15 million people per month would receive exchange subsidies in 2016 and that an additional 6 million people would purchase unsubsidized coverage through an exchange, bringing the total number of people enrolled in coverage purchased through exchanges in any given month to 21 million, on average. Most of the unsubsidized people who are no longer expected to purchase insurance through an exchange are expected to purchase insurance directly from an insurer instead.

69. Because of the limited scope of the current update, this report does not include an appendix with updated estimates of the insurance coverage provisions analogous to the one published last March; see Congressional Budget Office, *Updated Budget Projections: 2015 to 2025* (March 2015), Appendix, www.cbo.gov/publication/49973. In March 2016, CBO and JCT will update their projections of exchange enrollment and subsidies to incorporate actual 2015 enrollment, information on 2016 enrollment, CBO's recent economic forecast, and other data.

CBO estimates that outlays for grants to states for exchange operations will be about $1 billion in 2016. Because funds for new grants needed to be obligated by the end of 2014, spending of such grants is winding down. In CBO's baseline, outlays associated with grants for operating state exchanges decline to zero by 2019.

In accordance with the ACA, new programs requiring the federal government to make payments to health insurance plans for risk adjustment (amounts paid to plans that attract less healthy enrollees) and for reinsurance (amounts paid to plans that enroll individuals who end up with high costs) became effective for insurance issued in 2014. The two programs are intended to spread more widely some of the risk that health insurers face when selling health insurance through the exchanges or in other individual or small-group markets. Outlays for the two programs totaled $9 billion in 2015, the first year in which payments were made; this year, they are expected to amount to $16 billion. Those payments are offset by associated revenues. Under current law, the risk adjustment program is permanent, but the reinsurance program is authorized only for insurance issued through 2016 (although spending associated with the program is expected to continue for an additional year).

Children's Health Insurance Program. The Children's Health Insurance Program provides health insurance coverage to children in families whose income, although modest, is too high for them to qualify for Medicaid. The program is jointly financed by the federal government and the states and is administered by the states within broad federal guidelines. Total federal spending for CHIP was approximately $9 billion in 2015 and is expected to rise to $13 billion in 2016. That projected growth stems almost entirely from an increase in the federal match rate that went into effect in January of this year. Without that change in the match rate, federal spending for CHIP would be about $9 billion in 2016, CBO estimates.

Funding for CHIP is authorized through 2017. Following the rules governing baseline projections, CBO assumes in its baseline that funding for the program after 2017 is set at about $6 billion a year (that is, at the annualized rate of the second of the semiannual allotments for 2017), almost $7 billion less than the outlays estimated for 2017, when the program is fully funded. Nevertheless, annual spending for CHIP is projected to reach $11 billion in 2018 because some of the funds allocated to states in previous years will be spent in that year; outlays are projected to fall to about $6 billion in 2019 and remain at that amount in subsequent years. Nearly 6 million people will be enrolled in CHIP on an average monthly basis in 2016 and 2017, CBO estimates. Enrollment drops in subsequent years in CBO's baseline projections, mostly because funding is assumed to decline after 2017.

Income Security

The federal government makes various payments to people and government entities in order to assist the poor, the unemployed, and others in need. Mandatory spending for those purposes totaled $302 billion in 2015. Under current law, that spending is projected to rise modestly in 2016 to $307 billion and then to grow at an average annual rate of about 2 percent. By 2026, income-security outlays are projected to be $376 billion, or 1.4 percent of GDP.

Earned Income, Child, and Other Tax Credits. Refundable tax credits for income security, like those for health insurance premiums discussed above, reduce a filer's overall income tax liability; if the credit exceeds the rest of the filer's income tax liability, the government pays all or some portion of that excess to the taxpayer.[70] Those payments—including the ones made for the refundable portions of the earned income tax credit (EITC), the child tax credit, and the American Opportunity Tax Credit (AOTC)—are categorized as outlays. The EITC is a fully refundable credit available primarily to people with earnings and income that fall below established maximums. The child tax credit is a partially refundable credit (limited to 15 percent of earnings over a predetermined threshold) available to qualifying families with dependent children. The AOTC allows certain individuals (including those who owe no taxes) to claim a credit for college expenses. Outlays for those credits totaled $85 billion in 2015.

Under current law, by 2026 outlays for refundable tax credits would total $103 billion, CBO projects. That projection incorporates the permanent extension—recently enacted in the Consolidated Appropriations Act, 2016 (P.L. 114-113)—of the AOTC and of the expansions of the child tax credit and the EITC that were first enacted in 2009 and that had been set to expire at the end of 2017. The tax credits also affect the budget, to a lesser extent, by reducing tax revenues. However, the portion of the refundable tax credits that reduces revenues is not reported separately in the federal budget.

Supplemental Nutrition Assistance Program. Outlays for SNAP, which provides benefits to help people in low-income households purchase food, held steady at $76 billion in 2015.[71] CBO estimates that the program's spending will decline slightly this year, to $75 billion, and that 45 million people will receive those benefits. The number of people collecting SNAP benefits, which increased dramatically in the wake of the most recent recession, is anticipated to continue to decline gradually over the coming years as the economy strengthens. Average per-person benefits are expected to remain the same in 2016 as they were last year, but they are projected to increase thereafter because of adjustments for inflation in prices of food. On the basis of the assumption (specified by the rules governing baseline projections) that the program will be extended after it expires at the end of fiscal year 2018, CBO projects that by 2026, 33 million people will be enrolled in SNAP and the program's outlays will total $74 billion.

70. For more information, see Congressional Budget Office, *Refundable Tax Credits* (January 2013), www.cbo.gov/publication/43767.

71. For more information on SNAP, see Congressional Budget Office, *The Supplemental Nutrition Assistance Program* (April 2012), www.cbo.gov/publication/43173.

Supplemental Security Income. SSI provides cash benefits to people with low income who are elderly or disabled.[72] Outlays for SSI rose by about 1 percent in 2015, to $55 billion. According to CBO's estimates, under current law spending for that program would increase at an average annual rate of about 2 percent over the coming decade. In CBO's projections, the number of beneficiaries for SSI edges up at an average annual rate of less than half of 1 percent; most of the anticipated growth in spending for that program through 2026 stems from COLA increases. Under current law, spending for SSI benefits is estimated to be $74 billion in 2026.

Unemployment Compensation. The federal-state unemployment compensation program provides benefits to people who lose their jobs through no fault of their own, are actively seeking work, and meet other criteria established by the laws in their states. In 2015, outlays for unemployment compensation were $33 billion, about 0.2 percent of GDP. That amount is well below the high-water mark of such spending during the recent recession: In 2010, outlays for unemployment compensation peaked at $159 billion, in part because of the exceptionally high unemployment rate and in part because of legislation that significantly expanded benefits for individuals who had been unemployed for long periods. In CBO's estimates, outlays for unemployment compensation grow at an average annual rate of nearly 6 percent (reflecting fluctuations in unemployment and growth in the labor force and wages, which serve as the basis for benefits); measured as a share of GDP, those outlays remain at their current level throughout the projection period. By 2026, outlays for the program would, under current law, amount to $55 billion, CBO projects.

Family Support and Foster Care. Spending for family support programs—grants to states that help fund welfare programs, foster care and adoption assistance, child support enforcement, and the Child Care Entitlement—is expected to remain about the same as last year, roughly $31 billion, in 2016. Spending for those programs is projected to rise only gradually through 2026, at an average annual rate of about 1 percent.

Funding for two major components of family support is capped: The primary Temporary Assistance for Needy Families (TANF) program is limited to roughly $17 billion annually (although some additional funding is available if a state's unemployment rate or SNAP caseload exceeds certain thresholds), and funding for the Child Care Entitlement is capped at just under $3 billion per year.[73] Under current law, the primary TANF program and the Child Care Entitlement are funded only through the end of this fiscal year, but CBO's baseline reflects the assumption (as specified in the Deficit Control Act) that such funding will continue throughout the projection period.

72. For more information on SSI, see Congressional Budget Office, *Supplemental Security Income: An Overview* (December 2012), www.cbo.gov/publication/43759.

73. For more information on the TANF program, see Congressional Budget Office, *Temporary Assistance for Needy Families: Spending and Policy Options* (January 2015), www.cbo.gov/publication/49887.

Outlays for federal grants to states for foster care and adoption assistance and for child support enforcement are expected to remain near the 2015 amounts—about $7 billion and $4 billion, respectively—in 2016. CBO estimates that, under current law, spending for the two programs would increase modestly over the coming decade and amount to $10 billion and $5 billion, respectively, in 2026.

Child Nutrition. CBO projects that federal spending for child nutrition—which provides cash and commodities for meals and snacks in schools, day care settings, and summer programs—will rise by 4 percent in 2016, to $23 billion.[74] Much of that growth stems from an increase in the number of free lunches served in the school lunch program. CBO anticipates that growth in the number of meals provided and in reimbursement rates would lead to spending increases averaging 4 percent per year from 2017 through 2026, boosting total spending to $34 billion in 2026.[75]

Civilian and Military Retirement

Retirement and survivors' benefits for federal civilian employees (along with benefits provided through several smaller retirement programs for employees of various government agencies and for retired railroad workers) amounted to $105 billion in 2015. Under current law, such outlays would grow by about 3 percent annually over the next 10 years, CBO projects, reaching $146 billion in 2026.

Growth in federal civil service retirement benefits is attributable primarily to COLAs for retirees and to increases in federal salaries, which boost benefits for people entering retirement. (CBO's projections reflect the assumption that federal salaries will rise in accordance with the employment cost index for wages and salaries of workers in private industry.) One factor that is restraining growth in spending for retirement benefits is the ongoing, gradual replacement of the Civil Service Retirement System (CSRS) with the Federal Employees Retirement System (FERS). FERS covers employees hired after 1983 and provides a smaller defined benefit than that provided by CSRS. FERS recipients are, however, eligible for Social Security benefits on the basis of their federal employment, whereas CSRS employees are not. In addition, under FERS, employees' contributions to the federal Thrift Savings Plan are matched in part by their employing agencies (but those matching funds are categorized as discretionary costs—not mandatory—because they come out of annual appropriations to the agencies).

The federal government also provides annuities to personnel who retire from the military and their survivors. Outlays for those annuities totaled $57 billion in 2015.

74. For more information on federal spending for child nutrition, see Congressional Budget Office, *Child Nutrition Programs: Spending and Policy Options* (September 2015), www.cbo.gov/publication/50737.

75. Spending for child nutrition includes roughly $1 billion in outlays each year related to the Funds for Strengthening Markets program (also known as Section 32), which, among other things, provides funds to purchase commodities that are distributed to schools as part of the child nutrition programs.

Most of the annual growth in those outlays results from COLAs and increases in military basic pay. Like their civilian counterpart, outlays for military retirement annuities are projected to grow over the next 10 years by an average of about 3 percent per year, rising to $74 billion in 2026.

Veterans' Benefits

Mandatory spending for veterans' benefits includes disability compensation, readjustment benefits, pensions, insurance, housing assistance, and burial benefits. Outlays for those benefits totaled $92 billion in 2015, of which roughly 75 percent represented disability compensation. That amount does not include most federal spending for veterans' health care, which is funded by discretionary appropriations.

Spending for mandatory veterans' benefits is projected to swell by 19 percent in 2016, to $110 billion. Nearly 40 percent of that increase arises because of the shift in payments that results in 13 monthly payments in 2016 rather than 12; without that shift in payments, the increase in outlays would be about 12 percent. Such growth occurs because CBO anticipates significant increases in both the number of veterans receiving disability compensation and the average benefit payment. CBO expects the number of beneficiaries to grow because the Department of Veterans Affairs (VA) has implemented increasingly effective initiatives to reduce its backlog of applications. In addition, the average disability rating (that is, the rating of the severity of the disability that a veteran either incurred or aggravated during active military service on which his or her benefits are based) now approaches 50 percent for veterans currently on the rolls and appears to be continuing its steady rise; therefore, CBO expects that newly rated veterans will enter the VA system with higher disability ratings than those in previous years, which will result in a higher average benefit payment per veteran.

Under current law, growth in mandatory spending for veterans' benefits is projected to grow more slowly after 2016, at an average rate of about 3 percent a year between 2016 and 2026, causing outlays to rise to $146 billion in 2026. CBO projects slower growth because the VA is expected to largely eliminate its claims backlog over the next several years, causing the flow of new veterans receiving disability compensation to decline.

Other Mandatory Spending

Other mandatory spending includes outlays for agricultural support and some smaller health care programs, net outlays for deposit insurance, subsidy costs for student loans, and other payments. Outlays in some of those categories fluctuate markedly from year to year and may be either positive or negative.

Agricultural Support. Mandatory spending for agricultural programs totaled $13 billion in 2015. Spending for agricultural support is projected to average $16 billion per year between 2016 and 2026 on the basis of the assumption (specified in the Deficit Control Act) that the current programs that are scheduled to expire during that period will be extended.

Deposit Insurance. Net outlays for deposit insurance were negative last year: The program's collections (premiums paid by financial institutions) exceeded its disbursements (the cost of resolving failed institutions) by $13 billion. In CBO's baseline projections, premium payments continue to exceed amounts spent on failed institutions, and net outlays for deposit insurance range from –$11 billion to –$15 billion annually over the coming decade.

Medicare-Eligible Retiree Health Care Fund. The Department of Defense's Medicare-Eligible Retiree Health Care Fund (MERHCF) provides health care benefits, mainly through the TRICARE for Life program, to retirees of the uniformed services (and to their dependents and surviving spouses) who are eligible for Medicare. Outlays for those benefits totaled $10 billion in 2015. Over the coming decade, spending from MERHCF is projected to rise at an average annual rate of roughly 5 percent, reaching $16 billion in 2026.

Fannie Mae and Freddie Mac. In September 2008, the government placed Fannie Mae and Freddie Mac, two institutions that facilitate the flow of funding for home loans nationwide, into conservatorship.[76] Because the Administration considers Fannie Mae and Freddie Mac to be nongovernmental entities for federal budgeting purposes, it records the Treasury's payments to those entities as outlays in the budget and reports payments by those entities to the Treasury, such as those made in 2015 and expected in 2016, as offsetting receipts. (For further details, see page 78.)

In contrast to the Administration, CBO projects the budgetary impact of the two entities' operations in future years as if they were being conducted by a federal agency because of the degree of management and financial control that the government exercises over them.[77] CBO therefore estimates the net lifetime costs—that is, the subsidy costs adjusted for market risk—of the guarantees that those entities will issue and of the loans that they will hold and shows those costs as federal outlays in the year of issuance. Those outlays are projected to amount to $12 billion from 2017 through 2026.

Higher Education. Mandatory outlays for higher education fall into three categories: the net costs (on a present-value basis) of student loans originated in a given year, which are frequently estimated to be negative (because expected repayments exceed expected costs); a portion of the costs of Pell grants provided in that year; and spending

76. Conservatorship is the legal process in which an entity is appointed to establish control and oversight of a company to put it in a sound and solvent condition.

77. See Congressional Budget Office, *CBO's Budgetary Treatment of Fannie Mae and Freddie Mac* (January 2010), www.cbo.gov/publication/41887.

for some smaller programs.[78] In 2015, total mandatory outlays for higher education were $22 billion. That amount included the following: the budgetary effects of student loans originated last year, which amounted to –$6 billion (on a present-value basis); an increase of $18 billion in the estimated cost of direct and guaranteed loans originated in previous years (also on a present-value basis); and mandatory spending for Pell grants, which totaled $10 billion.[79]

In 2016, CBO estimates, the net costs for new student loans will be –$13 billion, mandatory spending for the Federal Pell Grant Program will be $7 billion, and other spending will be $0.4 billion, resulting in net mandatory outlays for higher education of –$6 billion. In later years, projected mandatory outlays for higher education trend from modestly negative to around zero. In those years, under current law, rising interest rates would, in CBO's estimation, increase the subsidy cost of student loans (making it less negative) to the point that the negative outlays for new student loans would roughly offset the cost of mandatory spending for Pell grants and other higher education programs. (The projected outlays for 2016 and subsequent years do not include any potential revision to the estimated subsidy costs of loans or guarantees made before 2016.)

Additional Mandatory Spending Programs. Other mandatory spending is projected to rise from $55 billion in 2015 to $63 billion in 2016 and then continue rising by an average of about 1 percent annually over the rest of the decade. Included in such spending are outlays for a number of different programs; some of those outlays are associated with significant offsetting receipts or revenues collected by the federal government. For example, an average of $15 billion in mandatory outlays each year from 2016 through 2026 is related to the administration of justice, including some

78. CBO calculates the subsidy costs for student loans following the procedures specified in the Federal Credit Reform Act of 1990 (FCRA). Under FCRA accounting, the discounted present value of expected income from federal student loans made during the 2016–2026 period is projected to exceed the discounted present value of the government's costs. (Present value is a single number that expresses a flow of current and future income or payments in terms of an equivalent lump sum received or paid today; the present value depends on the rate of interest—known as the discount rate—that is used to translate future cash flows into current dollars.) Credit programs that produce net income rather than net outlays are said to have negative subsidy rates, which result in negative outlays. The original subsidy calculation for a set of loans or loan guarantees may be increased or decreased in subsequent years by a credit subsidy reestimate based on an updated assessment of the present value of the cash flows associated with the outstanding loans or loan guarantees.

    FCRA accounting does not, however, consider all costs borne by the government. In particular, it omits market risk—the risk taxpayers face because federal receipts from payments on student loans tend to be low when economic and financial conditions are poor and resources are therefore more valuable. Fair-value accounting methods account for such risk, so the program's savings are less (or its costs are greater) under fair-value accounting than they are under FCRA accounting. For further discussion, see Congressional Budget Office, *Fair-Value Accounting for Federal Credit Programs* (March 2012), www.cbo.gov/publication/43027, and *Costs and Policy Options for Federal Student Loan Programs* (March 2010), www.cbo.gov/publication/21018.

79. Under current law, the Federal Pell Grant Program also receives funding from discretionary appropriations. For 2015, those appropriations totaled $22 billion.

activities of the Department of Homeland Security. Most of that spending is offset by revenues and by fees, penalties, fines, and forfeited assets that are credited in the budget as offsetting receipts. An additional $11 billion in annual outlays over the next 10 years stems from the Universal Service Fund and is offset in the federal budget by revenues of similar amounts.[80] Other mandatory spending projected in the coming decade includes the following outlays:

- $6 billion per year for conservation activities on private lands;
- $6 billion per year for grants to states for social services, such as vocational rehabilitation;
- About $4 billion per year in subsidy payments to state and local governments related to the Build America Bonds program for infrastructure improvements; and
- About $3 billion per year in payments to states and territories, primarily from funds generated from mineral production on federal land.

Offsetting Receipts

Offsetting receipts are funds collected by federal agencies from other government accounts or from the public in businesslike or market-oriented transactions that are recorded as negative outlays (that is, as credits against direct spending). Such receipts include beneficiaries' premiums for Medicare, intragovernmental payments made by federal agencies for their employees' retirement benefits, royalties and other charges for the production of oil and natural gas on federal lands, proceeds from sales of timber harvested and minerals extracted from federal lands, payments by Fannie Mae and Freddie Mac (for 2015 and 2016 only), and various fees paid by users of public property and services.

CBO estimates that offsetting receipts will fall from $256 billion in 2015 to $237 billion in 2016. That drop is primarily due to receipts from the Federal Communications Commission's 2015 auction for licenses to use a portion of the electromagnetic spectrum. Some of the proceeds from that auction were collected in 2015 and reduced outlays by $30 billion that year. CBO estimates that additional proceeds from that auction will also reduce outlays in 2016, by $11 billion. Over the coming decade, offsetting receipts are projected to increase by 4 percent each year, on average, rising to $350 billion by 2026 (see Table 3-2).

80. Created by the Telecommunications Act of 1996, the Universal Service Fund (USF) redistributes income from interstate telecommunications carriers to other carriers that provide services to high-cost areas, low-income households, schools, libraries, and nonprofit health care providers in rural areas. The cash flows from the USF appear in the budget—fund collections, as revenues, and amounts distributed from the fund, as direct spending.

Some offsetting receipts come from sources outside of the federal government, and some are intragovernmental transfers. For example, offsetting receipts for Medicare and for natural resources are paid from sources outside the government, whereas offsetting receipts for federal employees' retirement benefits and for the Medicare-Eligible Retiree Health Care Fund are intragovernmental.

Medicare. Offsetting receipts for Medicare are primarily composed of premiums paid by Medicare beneficiaries, but they also include recoveries of overpayments made to providers and payments made by states to cover a portion of the prescription drug costs for low-income beneficiaries. In 2015, those receipts totaled $94 billion, constituting one-third of all offsetting receipts and covering about 15 percent of gross Medicare spending. Over the coming years, CBO estimates that a larger share of beneficiaries in Parts B and D will pay higher premiums based on their income. As a result, offsetting receipts for Medicare are projected to rise more rapidly than outlays for benefits—at a rate of nearly 8 percent annually, compared with the 6 percent growth rate expected for outlays—and to total $210 billion in 2026.

Federal Employees' Retirement. In 2015, $68 billion in offsetting receipts consisted of intragovernmental transfers from federal agencies to the federal funds from which employees' retirement benefits are eventually paid (mostly trust funds for Social Security and for military and civilian retirement). Those payments from agencies' operating accounts to the funds have no net effect on federal outlays. Such payments are projected to grow by nearly 3 percent per year, on average, CBO estimates, reaching $88 billion in 2026.

Natural Resources. Receipts stemming from the extraction of natural resources—most significantly oil, natural gas, and minerals—from federally owned lands totaled $11 billion in 2015. By 2026, those receipts are projected to be $17 billion. The royalty payments included in that category fluctuate depending on the price of the commodity extracted.

Medicare-Eligible Retiree Health Care Fund. Intragovernmental transfers are also made to the Department of Defense's MERHCF. Contributions to the fund are made annually on an accrual basis in an amount sufficient to cover the increase in the estimated future costs of retirement benefits for active-duty service members. Such payments totaled $7 billion in 2015 and, because of rising health care costs, are projected to grow to $12 billion by 2026. As with transfers to the federal retirement funds, these transfers have no net effect on total outlays.

Fannie Mae and Freddie Mac. In the first few years after they were placed into conservatorship, the Treasury made payments to Fannie Mae and Freddie Mac; however, over the past few years, those entities have been making payments to the government. The Administration has recorded the payments by the government as outlays and the payments to the government from those two entities as offsetting receipts. To match the reporting for the current year in the *Monthly Treasury Statements*, CBO adopts the Administration's presentation for 2016, but for later years, because of the extent of the government's control over the two entities, CBO treats them as if they were government agencies and considers their transactions with the Treasury to be intragovernmental (and therefore computes the cost of the programs on a net present-value basis and records those costs as mandatory outlays).

In 2015, the Treasury made no payments to those entities and received payments from them totaling $23 billion. CBO estimates that net payments from those entities to the Treasury will amount to $20 billion in 2016.

Assumptions About Legislation for Expiring Programs Incorporated Into the Baseline

In keeping with the rules established by the Deficit Control Act, CBO's baseline projections incorporate the assumption that some mandatory programs will be extended when their authorization expires, although the rules provide for different treatment for programs created before and after the Balanced Budget Act of 1997 (P.L. 105-33). All direct spending programs that predate that act and have current-year outlays greater than $50 million are assumed to continue in CBO's baseline projections. For programs established after 1997, continuation is assessed program by program, in consultation with the House and Senate Budget Committees.

CBO's baseline projections therefore incorporate the assumption that the following programs whose authorization expires within the current projection period will continue: SNAP, TANF, CHIP, rehabilitation services, the Child Care Entitlement, trade adjustment assistance for workers, child nutrition, family preservation and support, and most farm subsidies. In addition, the Deficit Control Act directs CBO to assume that a COLA for veterans' compensation will be granted each year. In CBO's projections, the assumption that expiring programs and that COLA will continue accounts for about $1 trillion in outlays between 2017 and 2026, most of which are for SNAP and TANF (see Table 3-3). That amount represents about 3 percent of all mandatory spending net of offsetting receipts.

Discretionary Spending

Roughly one-third of federal outlays in 2016 will stem from budget authority provided in annual appropriation acts.[81] That funding—referred to as discretionary—translates into outlays when the money is spent. Although some appropriations (for example, those designated for employees' salaries) are spent quickly, others (such as those intended for major construction projects) are disbursed over several years. In any given

81. Budget authority is the authority provided by law to incur financial obligations that will result in immediate or future outlays of federal funds. Budget authority may be provided in an appropriation act or an authorization act and may take the form of a direct appropriation of funds from the Treasury, borrowing authority, contract authority, entitlement authority, or authority to obligate and expend offsetting collections or receipts. Offsetting collections and receipts are shown as negative budget authority and outlays.

year, discretionary outlays include spending from new budget authority and from budget authority provided in previous appropriations.

Several transportation programs have an unusual budgetary treatment: Their budget authority is provided in authorizing legislation, rather than in appropriation acts, but their spending is constrained by *obligation limitations* imposed by appropriation bills. Consequently, their budget authority is considered mandatory, but their outlays are discretionary. (The largest of those programs is the Federal-Aid Highway program, which is funded from the Highway Trust Fund.) As a result, total discretionary outlays in the budget are greater than total discretionary budget authority. In some cases, the amounts of those obligation limitations are added to discretionary budget authority to produce a measure of the total *funding* provided for discretionary programs.

The Budget Control Act of 2011 established caps on discretionary spending through 2021 and provided for automatic spending reductions that further reduced those levels. Such limits have since been modified in subsequent legislation; most recently, the Bipartisan Budget Act of 2015 canceled the automatic reductions in discretionary spending for 2016 and 2017 and set caps for those years that are $50 billion and $30 billion higher, respectively, than they would have been if the automatic reductions had occurred. In CBO's baseline projections, most appropriations for the 2016–2021 period are assumed to be constrained by the modified caps. For the period from 2022 through 2026, CBO assumes that those appropriations will grow at the rate of inflation from the amounts estimated for 2021.[82]

By law, however, the caps are adjusted upward when appropriations are provided for certain purposes. Specifically, budget authority provided for military and diplomatic operations in Afghanistan and elsewhere that have been designated as overseas contingency operations (or OCO), responses to events designated as emergencies, disaster relief, or initiatives designed to enhance program integrity by reducing overpayments in some benefit programs leads to increases in the caps (although

82. CBO develops projections of discretionary spending by first inflating the appropriations provided for specific activities in 2016 (or for subsequent years through advance appropriations) and then reducing total projected defense and nondefense funding by the amounts necessary to bring them in line with the caps. In CBO's baseline, discretionary funding related to federal personnel is inflated using the employment cost index for wages and salaries; other discretionary funding is adjusted using the gross domestic product price index.

funding for program integrity and disaster relief is subject to certain limits).[83] CBO developed projections for such funding by assuming that it would grow at the rate of inflation from the amounts appropriated for 2016 and remain within the statutory constraints for program integrity efforts and disaster relief.

Under those assumptions about budget authority, discretionary outlays in CBO's baseline increase in 2016 (largely because the caps are higher than those in effect last year), increase slightly in 2017, and fall slightly in 2018. Starting in 2019, discretionary outlays grow by an average of 2.2 percent each year through 2026. As a share of GDP, discretionary outlays in CBO's baseline projections fall from 6.5 percent in 2016 to 5.2 percent in 2026, a smaller share than in any year since 1962, the first year for which comparable data are available (see Figure 3-4).

Discretionary Appropriations and Outlays in 2016

The caps for 2016 total $1,066.6 billion—$548.1 billion for defense programs and $518.5 billion for nondefense programs.[84] The Consolidated Appropriations Act, 2016, provided discretionary budget authority totaling $1,168 billion—$101 billion more than the sum of the two caps (see Table 3-4).[85] That additional amount of budget authority includes $74 billion for activities designated as OCO and $9 billion in other funding that triggers cap adjustments, bringing the 2016 cap to a revised total of $1,150 billion, CBO estimates. The remaining $18 billion in budget authority in excess of the adjusted caps stems from changes to mandatory programs, enacted in the Consolidated Appropriations Act, to keep funding within limits set by the caps. (When such reductions in mandatory funding are included in appropriation acts, the savings are credited for budget enforcement purposes against the full amount of discretionary funding provided in those acts.) In CBO's baseline, those changes to mandatory programs are reflected in the relevant mandatory accounts, and the full amount of discretionary budget authority is shown in the discretionary accounts.

In total, discretionary budget authority for 2016 is 4.7 percent more than the $1,116 billion appropriated for 2015. Assuming that no additional appropriations are made, CBO estimates that discretionary outlays will increase in 2016 to about $1,198 billion, which is 2.8 percent—or $33 billion—more than such outlays in 2015 and equal to 6.5 percent of GDP. That sum represents the first increase in discretionary outlays following their gradual decline over the 2010–2015 period.

83. Initiatives related to program integrity identify and reduce improper payments for benefit programs such as DI, SSI, Medicare, Medicaid, and CHIP.

84. See Congressional Budget Office, *Final Sequestration Report for Fiscal Year 2016* (December 2015), www.cbo.gov/publication/51038.

85. Obligation limitations for transportation programs in 2016 total an additional $56 billion, which is roughly $3 billion more than the amount legislated for 2015.

Defense Discretionary Funding and Outlays. Budget authority provided for defense discretionary programs in 2016 totals $607 billion—3.6 percent more than the 2015 amount of $586 billion. (Almost all defense spending is categorized as discretionary.) That amount includes $59 billion in appropriations designated for OCO, $6 billion (or 8.7 percent) less than the sum provided in 2015; the funding provided for OCO includes some amounts intended to be used for regular activities of the Defense Department. The latest drop in defense funding designated for OCO continues a marked decline in such funding, which has fallen by 63 percent (in nominal terms) since 2010. Excluding the amounts for OCO, funding for defense in 2016 is $27 billion (or 5.1 percent) higher than it was last year. As a whole, CBO estimates that discretionary outlays for defense programs will total $589 billion in 2016—1.1 percent more than the 2015 amount (but that increase is 0.4 percent if adjusted for shifts in the timing of certain payments). As a share of GDP, however, such outlays will fall by 0.1 percentage point to 3.2 percent, the lowest level since 2002.

Three major categories of funding for the Department of Defense account for most of the defense appropriation for 2016 (as they have in preceding years): Operation and maintenance ($244 billion), military personnel ($139 billion), and procurement ($119 billion) account for 83 percent of total funding. Research and development ($69 billion) accounts for an additional 11 percent of total funding for defense. The remaining 6 percent of the appropriation comprises funding for military construction, family housing, and other Department of Defense programs ($9 billion); funding for atomic energy activities, primarily within the Department of Energy ($19 billion); and funding for various defense-related programs in other departments and agencies ($8 billion).

Nondefense Discretionary Funding and Outlays. Nondefense discretionary programs encompass a broad array of activities, including transportation, education grants, housing assistance, health-related research, veterans' health care, most homeland security activities, the federal justice system, foreign aid, and environmental protection. Funding for nondefense programs in 2016 totals $618 billion. That amount represents $561 billion in appropriations and $56 billion in obligation limitations for several ground and air transportation programs. The 2016 amount is $37 billion (or 6.3 percent) more than the funding provided in 2015. CBO anticipates that nondefense discretionary outlays will rise from $583 billion in 2015 to $609 billion in 2016—an increase of 4.4 percent. As a share of GDP, however, those outlays will remain at the 2015 level of 3.3 percent in 2016.

Seven broad budget categories (referred to as budget functions) account for about 80 percent of the $618 billion in resources provided in 2016 for nondefense discretionary activities (see Table 3-5). Activities related to education, training, employment, and social services received $94 billion, claiming 15 percent of total non-defense discretionary funding.[86] Transportation programs accounted for $89 billion (including appropriations and obligation limitations), or 14 percent of the total. Programs related to veterans' benefits and services received $72 billion (or 12 percent); income-security programs received $67 billion (or 11 percent); and health programs received $60 billion (or 10 percent). Programs related to international affairs and to administration of justice each accounted for $55 billion, or 9 percent of total nondefense discretionary spending.[87]

Projections for 2017 Through 2026

CBO's projections reflect the assumption that most discretionary appropriations will be constrained at levels specified in the Budget Control Act of 2011 (as modified)—including the automatic spending reductions required by that act—and that the caps will be adjusted to accommodate additional appropriations designated for OCO and other activities that are not constrained by the caps.

For 2017, the caps are now set at $551 billion for defense and $519 billion for nondefense activities, for a total of $1,070 billion—about $3 billion (or 0.3 percent) higher than the 2016 caps (prior to adjustments for appropriations for OCO and other activities not constrained by the caps). In addition, for 2017 CBO projects funding totaling $85 billion (equal to the 2016 amounts after they are adjusted for inflation) for OCO and other activities not constrained by the caps, bringing total projected discretionary appropriations for that year to $1,154 billion—$611 billion for defense and $543 billion for nondefense activities. Those amounts represent a $4 billion (or 0.7 percent) increase in defense appropriations and an $18 billion (or 3.2 percent) reduction in nondefense funding for a total net reduction of $14 billion (or 1.2 percent) from the 2016 appropriation. Most of that reduction occurs because the budget authority enacted for 2016 includes the amount that was offset by reductions in mandatory programs; similar actions are not assumed in the baseline for subsequent years. (However, since 2012, the first year when caps specified in the Budget Control Act applied to discretionary spending, the amount of such mandatory offsets included in annual appropriation acts has averaged about $18 billion a year.)

CBO estimates that the caps for 2018 (before adjustments for OCO and other activities not constrained by the caps) will total $1,065 billion—about $5 billion (or 0.5 percent) less than the 2017 caps.[88] All told, discretionary appropriations for both defense and nondefense programs in 2018 are projected to fall below their

86. Spending for student loans and for several other federal programs in the category of education, training, employment, and social services is not included in that total because funding for those programs is considered mandatory.

87. Some significant income-security programs, such as unemployment compensation and TANF, are not reflected in that total because they are included in mandatory spending.

88. See Congressional Budget Office, *Final Sequestration Report for Fiscal Year 2016* (December 2015), www.cbo.gov/publication/51038.

2017 levels, by about $1 billion and $3 billion, respectively (about a 0.3 percent decline overall), and total $1,151 billion. Starting in 2019, the caps—and total discretionary appropriations—are projected to grow at an average rate of 2.5 percent per year.

Under those assumptions regarding the caps, CBO estimates, discretionary outlays would increase by 0.7 percent in 2017, primarily as a result of spending from the larger appropriations in 2016. Discretionary outlays are then projected to dip by 0.2 percent in 2018, mirroring the slight reduction in the caps for that year. In CBO's baseline projections, discretionary outlays grow at an average rate of about 2.2 percent annually over the 2019–2026 period, following the projected growth in funding. Because that pace is well below the expected growth rate of nominal GDP, discretionary outlays are projected to fall steadily in relation to the size of the economy, from 6.5 percent of GDP in 2016 to 5.2 percent in 2026.

Alternative Paths for Discretionary Spending

Total funding for discretionary activities in 2016 will amount to about $1,224 billion, CBO estimates—$1,168 billion in budget authority and $56 billion in transportation-related obligation limitations. In CBO's baseline projections, discretionary funding is projected for subsequent years on the basis of the amounts and procedures prescribed in the Budget Control Act of 2011 (as amended). If the policies governing discretionary appropriations changed, funding could differ greatly from the baseline projections. To illustrate such potential differences, CBO has estimated the budgetary consequences of three alternative paths for discretionary funding (see Table 3-6).

For the first alternative scenario, CBO assumed that most discretionary funding and obligation limitations would grow at the rate of inflation after 2016—an assumption that is consistent with the guidelines in the Deficit Control Act regarding account-level baseline projections. If that occurred, discretionary outlays would grow steadily by an average of 2.4 percent a year and surpass CBO's baseline projections by $757 billion (or 5.8 percent) over the 2017–2026 period; discretionary spending would equal 5.5 percent of GDP in 2026.

The second scenario reflects the assumption that most discretionary budget authority and obligation limitations—including funding designated for OCO and other activities that are exempt from caps—would be frozen at the 2016 level for the entire projection period.[89] In that case, discretionary outlays would remain relatively flat over the 10-year period, total $746 billion (or 5.7 percent) less than those projected in the baseline, and fall to 4.4 percent of GDP by 2026.

89. Some items, such as offsetting collections and payments made by the Treasury on behalf of the Department of Defense's TRICARE for Life program, would not be held constant.

Finally, CBO projected what would occur if lawmakers canceled the automatic reductions in the discretionary caps prescribed by the Budget Control Act. (In this scenario, projections of funding designated for OCO and other activities that are not constrained by the caps are assumed to grow with inflation unless constrained by other provisions of the Budget Control Act.) Overall, results under this scenario are similar to those under the scenario in which appropriations are assumed to grow with inflation: Total outlays over the 2017–2026 period exceed the amount projected in CBO's baseline by $764 billion (or 5.9 percent).

Net Interest

In 2015, net outlays for interest were $223 billion, about $6 billion less than the amount spent in 2014. However, CBO estimates that net outlays will increase by almost $32 billion in 2016, to a total of $255 billion, rising from 1.3 percent of GDP in 2015 to 1.4 percent in 2016.

Net interest outlays are dominated by the interest paid to holders of the debt that the Department of the Treasury issues to the public. The Treasury also pays interest on debt issued to trust funds and other government accounts, but such payments are intragovernmental transactions that have no effect on the budget deficit. Other federal accounts also pay and receive interest for various reasons.[90]

The federal government's interest payments depend primarily on market interest rates and the amount of debt held by the public; however, other factors, such as the rate of inflation for Treasury Inflation-Protected Securities and the maturity structure of outstanding securities, also affect interest costs. (For example, longer-term securities generally pay higher interest than do shorter-term securities.) Interest rates are determined by a combination of market forces and the policies of the Federal Open Market Committee. Debt held by the public is determined mostly by cumulative budget deficits, which depend on policy choices about noninterest spending and revenues as well as on economic conditions and other factors. At the end of 2015, debt held by the public reached $13.1 trillion, and in CBO's baseline, it is projected to total $23.8 trillion in 2026. (For detailed projections of debt held by the public, see Table 3-1.)

Although debt held by the public surged in the past few years to its highest levels relative to GDP since the early 1950s, the government's interest costs measured as a percentage of GDP have remained low because interest rates on Treasury securities have been remarkably low. Average rates on 3-month Treasury bills plummeted from nearly 5 percent in 2007 to 0.1 percent in 2010 and have remained at or below 0.1 percent since then. Similarly, average rates on 10-year Treasury notes dropped

90. See Congressional Budget Office, *Federal Debt and Interest Costs* (December 2010), www.cbo.gov/publication/21960.

from nearly 5 percent in 2007 to a low of 1.9 percent in 2012; since then, those rates have generally remained steady, increasing slightly in 2015 to 2.2 percent. As a result of those low rates, outlays for net interest fell from 1.7 percent of GDP in 2007 to 1.3 that period. By comparison, such outlays averaged about 3 percent of GDP in the 1980s and 1990s.

Baseline Projections of Net Interest

Net interest costs consist of gross interest (the amounts paid on all of the Treasury's debt issuances) minus interest payments received by trust funds (which are intragovernmental transfers) and from other sources. Under CBO's baseline assumptions, net interest costs are projected to more than triple over the next decade—surging from $255 billion in 2016 to $830 billion in 2026. One reason for that increase is that debt held by the public is projected to rise by 70 percent (in nominal terms) over the next 10 years (see Figure 3-5).[91] More significantly, the interest rate paid on 3-month Treasury bills is anticipated to increase from 0.04 percent in the last quarter of 2015 to 3.2 percent by mid-2019 (and remain there through 2026); the interest rate on 10-year Treasury notes is projected to rise from 2.2 percent in the last quarter of 2015 to 4.1 percent by late 2019 (and remain there through 2026). (For a more detailed discussion of CBO's forecast for interest rates, refer to Chapter 2.) As a result, under current law, net interest outlays are projected to reach 3.0 percent of GDP in 2026.

Gross Interest

In 2015, interest paid by the Treasury on all of its debt issuances totaled $402 billion (see Table 3-7). More than one-third of that total, $141 billion, represents payments to trust funds within the federal government; the remainder is paid to owners of Treasury debt issued to the public. In CBO's baseline, gross interest payments increase to $437 billion in 2016 and total $1.1 trillion in 2026. About 70 percent of that amount is interest paid on debt held by the public.

Interest Received by Trust Funds

As of the end of 2015, the Treasury has issued $5.0 trillion in securities to federal trust funds and other government accounts. Trust funds are the predominant holders of such securities, owning 90 percent of them. The interest paid on those securities has no net effect on federal spending because it is credited to accounts elsewhere in the budget. In 2016, trust funds will be credited with $141 billion of such intragovernmental interest, CBO estimates, mostly for the trust funds for Social Security, military retirement, civil service retirement, and disability insurance. The intragovernmental interest credited to

91. Debt held by the public does not include securities issued by the Treasury to federal trust funds and other government accounts. Those securities are included as part of the measure of gross debt. (For further details, see Chapter 1.)

the trust funds is projected to peak at $161 billion in 2021 as interest rates rise and then decline to $151 billion in 2026 as the balances held by the funds decrease.

Other Interest

CBO anticipates that the government will record $40 billion in net receipts of other interest in 2016 and projects that such receipts will total $619 billion over the 2017–2026 period, representing the net result of many transactions, both collections and payments of interest.

The largest interest collections come from the government's credit financing accounts, which were established to record the cash transactions related to federal direct loan and loan guarantee programs. For those programs, net subsidy costs are recorded in the budget, but the cash flows that move through the credit financing accounts are not. Credit financing accounts both pay interest to and receive interest from Treasury accounts that appear in the budget, but on net, they pay more interest to the Treasury than they receive from it. CBO estimates that net receipts from the credit financing accounts will total $32 billion in 2016; in CBO's baseline, they steadily increase to $54 billion in 2026. Interest payments associated with the direct student loan program dominate those totals.

Chapter 4: The Revenue Outlook

The Congressional Budget Office projects that, if current laws generally remain unchanged, total revenues will rise by about 4 percent in 2016, reaching almost $3.4 trillion. Revenues are expected to rise just slightly as a percentage of gross domestic product (GDP)—from 18.2 percent in 2015 to 18.3 percent in 2016—following five consecutive years in which revenues rose significantly as a percentage of GDP (see Figure 4-1). In CBO's baseline projections for 2017 through 2026, revenues remain relatively stable as a share of the economy, ranging from 17.9 percent to 18.2 percent of GDP—higher than the 50-year average of 17.4 percent of GDP. Revenues over that historical period had been as high as 20.0 percent of GDP (in 2000) and as low as 14.6 percent (in 2009 and 2010).

Revenues are projected to change little as a percentage of GDP between 2015 and 2016 because of the offsetting effects of small increases and decreases in various sources of revenues. The most significant increases in revenues in 2016 come from individual income tax receipts and remittances from the Federal Reserve System; revenues from both of those sources are expected to edge up by 0.1 percentage point relative to GDP. However, a decline in corporate income tax revenues as a percentage of GDP is expected to largely offset those increases. The projected increase in receipts from individual income taxes occurs mainly because people's income is expected to rise faster than inflation, pushing more income into higher tax brackets, which are indexed only to inflation. That phenomenon, known as real bracket creep, occurs in most years when the economy expands. The small upward shift in Federal Reserve remittances and the small downward shift in corporate income tax receipts relative to GDP stem largely from the expected effects of recently enacted legislation.

Beyond 2016, revenues are projected to decline slightly, to 17.9 percent of GDP by 2019, and then rise to 18.2 percent of GDP by 2026. The relative stability exhibited from 2017 to 2026 mainly reflects offsetting movements in four sources of revenues:

- *Individual income tax receipts* are projected to increase relative to GDP in each year because of real bracket creep, an expected increase in the share of wages and salaries earned by higher-income taxpayers, rising distributions from tax-deferred retirement accounts, and other factors.

- *Remittances from the Federal Reserve to the Treasury* are projected to decline to more typical amounts relative to GDP. They have been very large since 2010 because of substantial changes in the size and composition of the central bank's portfolio and will be further boosted in 2016 because of a recent change in law.

- *Corporate income tax receipts* are projected to decline as a percentage of GDP largely because of an expected drop in domestic economic profits relative to the size of the economy, the result of rising costs of labor, higher interest payments on businesses' debt, and other factors.

- *Payroll tax receipts* are projected to decline slightly relative to GDP over the next decade, primarily as a result of an expected continued increase in the share of wages earned by higher-income taxpayers; that increase will cause a greater share of wages to be above the maximum amount subject to Social Security payroll taxes. The resulting reduction in payroll taxes offsets about three-fifths of the expected increase in individual income tax receipts that is expected to occur for the same reason.

CBO's revenue projections for the 2016–2025 period are lower than those the agency released in August 2015. At that time, CBO published revenue projections for the 2015–2025 period; the projections in this report cover the 2016–2026 period. For the overlapping years—2016 through 2025—the current projections are below the previous ones by $1.2 trillion (or about 3 percent). About three-fifths of that change stems from changes to the agency's economic forecast, primarily to projections of GDP and the types of income that comprise GDP, such as wages and salaries, corporate profits, and proprietors' income. Most of the rest stems from the recent extension of expired tax provisions and other legislative changes. (For more information on changes to the revenue projections since August, see Appendix A.)

In mid-December 2015, after CBO had completed the economic forecast that underlies its budget projections for this report, lawmakers enacted legislation that affected certain aspects of the economic outlook. Consequently, CBO's economic forecast has been updated to reflect the enactment of that legislation, as well as economic developments through the end of the year; that updated forecast is presented in this report. However, the agency did not have enough time to incorporate those subsequent changes to its economic forecast into its budget projections for fiscal years 2016 through 2026. Therefore, even though the budget projections in this report include the direct budgetary effects of legislation enacted through December, they are based on the economic forecast CBO completed in early December. CBO's next set of budget projections, which will be issued in March, will be based on the economic forecast that the agency completed at the end of December and will also incorporate revisions derived from information that becomes available when the President's budget is published and from other sources. A preliminary analysis at this point suggests that if CBO had incorporated that updated economic forecast into its budget projections, revenues in the baseline would be between $100 billion and $200 billion (or 0.2 percent to 0.4 percent) higher over the 2016–2026 period than they are currently projected to be.

The tax rules that form the basis of CBO's projections include an array of exclusions, deductions, preferential rates, and credits that reduce revenues for any given level of tax rates, in both the individual and corporate income tax systems. Some of those provisions are called tax expenditures because, like government spending programs, they provide financial assistance for particular activities as well as to certain entities or groups of people. The tax expenditures with the largest effects on revenues are the following:

- The exclusion from workers' taxable income of employers' contributions for health care, health insurance premiums, and premiums for long-term-care insurance;
- The exclusion of contributions to and the earnings of pension funds (minus pension benefits that are included in taxable income);
- Preferential tax rates on dividends and long-term capital gains;
- The deductions for state and local taxes (on non-business income, sales, real estate, and personal property); and
- The deferral for profits earned abroad, which certain corporations may exclude from their taxable income until those profits are returned to the United States.

On the basis of estimates prepared by the staff of the Joint Committee on Taxation (JCT), which were published before the enactment of the Consolidated Appropriations Act, 2016 (Public Law 114-113), and do not include numerous changes made by that law that affect tax expenditures, CBO expects that those and other tax expenditures will total almost $1.5 trillion in 2016. That amount equals 7.9 percent of GDP—more than 40 percent of the revenues projected for the year. Most of that amount arises from the 10 largest tax expenditures, which CBO estimates would total 5.9 percent of GDP in 2016 and 6.2 percent of GDP from 2017 to 2026.

CBO's revenue projections since 1982 have, on average, been a bit too high—more so for projections spanning six years than for those spanning two—owing mostly to the difficulty of predicting when economic downturns will occur. However, their overall accuracy has been similar to that of the projections of other agencies.

The Evolving Composition of Revenues

Federal revenues come from various sources: individual income taxes; payroll taxes, which are dedicated to certain social insurance programs; corporate income taxes; excise taxes; earnings of the Federal Reserve System, which are remitted to the Treasury; customs duties; estate and gift taxes; and miscellaneous fees and fines. Individual income taxes constitute the largest source of federal revenues, having contributed, on average, about 45 percent of total revenues (equal to 7.9 percent of GDP) over the past 50 years. Payroll taxes—mainly for Social Security and Medicare Part A (the Hospital Insurance program)—are the second-largest source of revenues, averaging about one-third of total revenues (equal to 5.7 percent of GDP) over the same period. Corporate income taxes constituted 12 percent of revenues (or 2.1 percent of GDP) over the past 50 years, and all other sources combined contributed about 10 percent of revenues (or 1.7 percent of GDP).

Although that broad picture has remained roughly the same over the past several decades, the details have varied.

- Receipts from individual income taxes have fluctuated significantly over the past five decades, ranging from 41 percent to 50 percent of total revenues (and from 6.1 percent to 9.9 percent of GDP) between 1966 and 2015. Those fluctuations are attributable to changes in the economy and changes in law over that period, but show no consistent trend over time (see Figure 4-2).

- Receipts from payroll taxes rose as a share of revenues from the mid-1960s through the 1980s—largely because of an expansion of payroll taxes to finance the Medicare program (which was established in 1965) and because of legislated increases in tax rates for Social Security and in the amount of income to which those taxes applied. Those receipts accounted for about 37 percent of total revenues (and about 6.5 percent of GDP) by the late 1980s. Since 2001, payroll tax receipts have fallen slightly relative to the size of the economy, averaging 6.0 percent of GDP. That period includes two years, 2011 and 2012, when receipts fell because certain payroll tax rates were cut.

- Revenues from corporate income taxes declined as a share of total revenues and GDP from the 1960s to the mid-1980s, mainly because of declining profits relative to the size of the economy. Those revenues have fluctuated widely since then, the result both of changes in the economy and changes in law, with no consistent trend.

- Revenues from the remaining sources, particularly excise taxes, have slowly fallen relative to total revenues and GDP. However, that downward trend has reversed in the past several years because of the increase in remittances from the Federal Reserve System.

If current law generally remained in effect—an assumption underlying CBO's baseline—individual income taxes would generate a growing share of revenues over the next decade, CBO projects. By 2018, they would account for more than half of total revenues, and by 2026 they would reach 9.6 percent of GDP, well above the historical average. Receipts from payroll taxes are projected to decline slightly relative to GDP, from 6.0 percent in 2015 to 5.8 percent for the period from 2020 to 2026. Corporate income taxes would make a slightly lower contribution than they have made on average for the past 50 years, supplying about 9 percent of total revenues and averaging about 1.7 percent of GDP over the 2016–2026 period. Taken together, the remaining sources of revenue are projected to diminish somewhat relative to total revenues and GDP, averaging 1.3 percent of GDP from 2016 through 2026, largely because remittances from the Federal Reserve are expected to fall to more typical levels.

Individual Income Taxes

In 2015, receipts from individual income taxes totaled more than $1.5 trillion, or 8.7 percent of GDP. Under current law, individual income taxes in 2016 will total more than $1.6 trillion, CBO estimates—5 percent more than the amount collected in 2015. That percentage increase would be slightly greater than the 4 percent increase expected for GDP, and individual income tax receipts would edge up to 8.8 percent of GDP. If current laws generally remained unchanged, CBO projects, those receipts would continue to rise as a share of the economy after this year, reaching 9.6 percent of GDP by 2026, which would be the highest percentage since 2000 and well above the 50-year average of 7.9 percent (see Table 4-1).

In CBO's baseline, receipts climb in 2016 and beyond, in part as a result of projected growth in taxable personal income. (That measure of income includes wages, salaries, dividends, interest, rental income, and proprietors' income—each of which is defined by the Bureau of Economic Analysis for use in its national income and product accounts.) According to CBO's projections, taxable personal income would grow at a rate of 4 percent to 4½ percent per year over the next decade, roughly corresponding to expected growth in nominal GDP. However, receipts from individual income taxes are projected to rise even faster than taxable personal income—boosting receipts relative to GDP by 0.8 percentage points from 2016 to 2026. That increase relative to the size of the economy would result from real bracket creep, relatively faster growth in the earnings of higher-income taxpayers, rising taxable distributions from retirement accounts, and other factors.

Real Bracket Creep

The most significant factor pushing up taxes relative to income is real bracket creep. That phenomenon occurs because the income tax brackets and exemptions under both the regular income tax and the alternative minimum tax are indexed only to inflation.[92] If income grows faster than inflation, as generally occurs when the economy is growing, more income is pushed into higher tax brackets. That factor causes projected revenues measured as a percentage of GDP to rise in CBO's baseline by 0.4 percentage points from 2016 to 2026.

Relatively Faster Growth in Earnings of Higher-Income Taxpayers

In CBO's baseline projections, earnings from wages and salaries are expected to increase faster for higher-income people than for others during the next decade—as has been the case for the past several decades—causing a larger share of income to be subject to higher income tax rates. For example, the share of wages earned by the top one-fifth of workers is projected to increase by about 4 percentage points, from 57 projects, faster growth in earnings for higher-income people would boost estimated individual income tax revenues relative to GDP by about 0.3 percentage points; that increase would be partially offset by a projected decrease in payroll tax receipts, as explained in the section about payroll taxes.

Retirement Income

As the population ages, taxable distributions from tax-deferred retirement accounts will tend to grow more rapidly than GDP. CBO expects the retirement of members of the baby-boom generation to cause a gradual increase in distributions from tax-deferred retirement accounts, including individual retirement accounts, 401(k) plans, and traditional defined benefit pension plans. Under current law, CBO projects, those growing taxable distributions would boost revenues relative to GDP by 0.2 percentage points over the next decade.

Other Factors

CBO anticipates that over the next decade, other factors would have smaller, offsetting effects on individual income tax revenues. The Consolidated Appropriations Act, 2016, retroactively extended—in some cases, permanently—many tax provisions that reduced tax liabilities and that had been routinely extended in previous years. Those changes in law reduced individual income tax revenues by more in 2016 than in future years, contributing slightly to the projected increase in revenues after 2016. However, that

92. The alternative minimum tax is similar to the regular income tax but its calculation includes fewer exemptions, deductions, and rates. People who file individual income tax returns must calculate the tax owed under each system and pay the larger of the two amounts.

increase is roughly offset in CBO's projections by a decline in realizations of capital gains relative to the size of the economy—most of which occurs in CBO's baseline over the 2017–2020 period. The amounts of those realizations have been at relatively high levels recently, and CBO anticipates they will slowly return to levels consistent with their historical average share of GDP (after accounting for differences in applicable tax rates).

Payroll Taxes

Receipts from payroll taxes, which fund social insurance programs, totaled about $1.1 trillion in 2015, or 6.0 percent of GDP. Under current law, CBO projects, those receipts would slowly fall to 5.8 percent of GDP by 2026. The main reason for that decline is the expectation that wages and salaries will continue to grow faster for higher-earning taxpayers than for other taxpayers, which will push an increasing share of such earnings above the maximum amount per taxpayer that is subject to Social Security taxes. (That amount, which is indexed to growth in average earnings for all workers, is $118,500 in 2016.)

Sources of Payroll Tax Receipts

The two largest sources of payroll taxes are those that are dedicated to Social Security and Part A of Medicare (the Hospital Insurance program). Much smaller amounts come from unemployment insurance taxes (most of which are imposed by states but produce amounts that are classified as federal revenues); employers' and employees' contributions to the Railroad Retirement System; and other contributions to federal retirement programs, mainly those made by federal employees (see Table 4-2). The premiums that Medicare enrollees pay for Part B (the Medical Insurance program) and Part D (prescription drug benefits) are voluntary payments and thus are not counted as tax revenues; rather, they are considered offsets to spending and appear on the spending side of the budget as offsetting receipts.

Social Security and Medicare payroll taxes are calculated as a percentage of a worker's earnings. Almost all workers are in employment covered by Social Security, and the associated tax is usually 12.4 percent of earnings, with the employer and employee each paying half. It applies only up to a certain amount of a worker's annual earnings (the taxable maximum). The Medicare tax applies to all earnings (with no taxable maximum) and is levied at a rate of 2.9 percent; the employer and employee each pay half of that amount. Since the beginning of 2013, an additional Medicare tax of 0.9 percent has been levied on the amount of an individual's earnings over $200,000 (or $250,000 in combined earnings for married couples filing a joint income tax return), bringing the total Medicare tax on such earnings to 3.8 percent.

Slight Decline in Projected Receipts Relative to GDP

Although wages and salaries, the main tax bases for payroll taxes, are projected to be a relatively stable share of GDP over the next decade, payroll tax receipts are projected to decline slightly relative to GDP for two reasons. Most important, payroll taxes are expected to decrease relative to earnings (including wages, salaries, and proprietors' income) because a growing share of earnings is anticipated to be above the taxable maximum amount for Social Security taxes.[93] The share of covered earnings above the taxable maximum amount is projected to rise to more than 20 percent in 2026, 4 percentage points more than the share in 2015.

In addition, receipts from unemployment insurance taxes are projected to decline slightly relative to wages and salaries and GDP between 2015 and 2020. Those receipts grew rapidly from 2010 through 2012, as states raised their tax rates and tax bases to replenish unemployment insurance trust funds that had been depleted because of high unemployment. Unemployment insurance receipts have fallen in each of the past three years, and CBO expects them to further decline to more typical levels relative to GDP in coming years.

Corporate Income Taxes

In 2015, receipts from corporate income taxes totaled $344 billion, or 1.9 percent of GDP—near the 50-year average. CBO expects corporate tax receipts to fall by about $17 billion in 2016, to 1.8 percent of GDP, largely because of the recent extension of several expired tax provisions. After 2016, those receipts in CBO's baseline projections remain relatively stable as a percentage of GDP through 2020 and then decline to 1.6 percent of GDP by 2026. That pattern over the next decade is the net effect of three main factors: a projected decline in domestic economic profits relative to GDP; an expected increase in the use of certain strategies that many corporations employ to reduce their tax liabilities; and a temporary increase in receipts resulting from a phaseout of provisions that allow firms with large amounts of investment in equipment to immediately deduct from their taxable income a portion of the costs of those investments.

Receipts in 2016

CBO expects corporations' income tax payments, net of refunds, to decline by about 5 percent this year, to $327 billion—even though the agency projects that domestic economic profits will decline by only about 2 percent and that GDP will rise by about 4 percent. Because revenues from corporate income taxes are projected to fall even as GDP rises, those revenues are projected to decline slightly relative to GDP—to 1.8 percent.

That projected decline in corporate income tax receipts relative to domestic economic profits results mostly from the retroactive and prospective extension—enacted in the Consolidated Appropriations Act, 2016—of various provisions that reduce tax

93. Because of the progressive rate structure of the income tax, the increase in the share of earnings above the Social Security taxable maximum is projected to produce an increase in individual income tax receipts that will more than offset the decrease in payroll tax receipts.

liabilities. The largest part of the projected revenue decline in 2016 stems from the extension of rules that allow businesses with large amounts of investment to accelerate their deductions for those investments. That extension allows firms to continue deducting 50 percent of investments in equipment (and certain other property) that they made in 2015 or will make in 2016 or 2017 on the tax returns filed for each of those years, as opposed to allocating the total costs of those investments over specified numbers of years.[94] Those partial-expensing provisions are then scheduled to phase out, after which firms would deduct the total cost of those investments more evenly over time. Because those partial-expensing and other provisions were not initially extended when they expired at the end of 2014, many companies paid higher estimated taxes during calendar year 2015 than were ultimately required after the provisions were extended. Now that firms know in advance that the provisions have been extended for 2016, CBO expects that firms will lower their estimated payments this year relative to those they made in 2015.

Receipts After 2016

Under current law, receipts from corporate income taxes would remain at about 1.8 percent of GDP from 2017 through 2020, CBO projects, and decline thereafter to about 1.6 percent of GDP by 2026. Three factors explain that general pattern: a projected decline in domestic economic profits relative to GDP; an expected increase in the use of certain strategies that some corporations employ to reduce their tax liabilities; and a three-year phaseout of the partial-expensing provisions after 2017 that is projected to temporarily increase receipts relative to their 2017 amount.

Decline in Domestic Economic Profits Relative to GDP. CBO projects that domestic economic profits—the closest measure of the corporate income tax base in CBO's economic forecast—will decline significantly relative to GDP over the next decade. They are expected to decline because of rising labor costs and rising interest payments on businesses' debt over the next several years, and because in later years CBO projects that nonlabor income will grow less rapidly than output, reversing an unusual trend seen since 2000 (see Chapter 2). In isolation, the decline in profits in relation to GDP causes projected corporate income tax revenues to fall relative to GDP by about 0.3 percentage points over the next decade.

Greater Use of Tax-Minimizing Strategies. Other factors that contribute to the projected decline in corporate tax revenues relative to GDP include two strategies that CBO—on the basis of an analysis of historical trends and a recent uptick in certain activity—expects some corporations to increasingly employ to reduce their tax liabilities. One

94. By contrast, businesses with relatively small amounts of investment in new equipment have been allowed to fully deduct those costs in the year in which the equipment is placed in service. The maximum amount of those deductions has changed over time. That provision was made permanent by the Consolidated Appropriations Act, 2016, with a maximum annual deduction of $500,000 in 2015, an amount that will be adjusted annually for inflation.

such strategy is to decrease the share of business activity that occurs in C corporations (which are taxed under the corporate income tax) while increasing the share that occurs in pass-through entities, such as S corporations (which are taxed directly under the individual income tax rather than the corporate tax, increasing individual income tax receipts).[95] Another strategy is to increase the amount of corporate income that is shifted out of the United States through a combination of methods such as setting more aggressive transfer prices, increasing the use of intercompany loans, undertaking corporate inversions, and through other techniques.[96]

CBO expects that the increasing adoption of such strategies will result in progressively larger reductions in corporate tax receipts over the next 10 years. By 2026, in CBO's baseline, that increasing erosion of the corporate tax base lowers corporate income tax receipts by roughly 5 percent compared with collections in 2016, or by almost 0.1 percentage point relative to GDP. CBO projects that half of that difference is attributable to the shifting of additional income out of the United States and half to increases in the share of business activity occurring in pass-through entities.

Phaseout of Partial-Expensing Provisions. Although the partial-expensing provisions are scheduled under current law to continue unchanged from calendar year 2016 to 2017, they are scheduled to phase out from 2018 to 2020, causing associated deductions in CBO's baseline to decline relative to the size of the economy.[97] That factor causes projected revenues to rise as a share of GDP over the period spanning fiscal years 2018 through 2020 (as compared with the amount in 2017) by about 0.2 percentage points. That increase would roughly equal the decreases in revenues relative to the size of the economy during those years that result from the decline of domestic economic profits relative to GDP and the expanded use of certain tax-minimizing strategies.

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95. For a detailed analysis of the taxation of business income through the individual income tax, see Congressional Budget Office, *Taxing Businesses Through the Individual Income Tax* (December 2012), www.cbo.gov/publication/43750.

96. To allocate profits across U.S. and foreign affiliates, transactions between those affiliates must be assigned a price. The price that is set is known as the transfer price. By strategically setting transfer prices, a corporation can reduce the share of total profits that it reports on U.S. tax returns. A corporate inversion refers to a process through which a U.S. corporation changes its country of tax residence, often by merging with a foreign company. Inversions reduce U.S. corporate tax revenue both because the inverted U.S. corporation no longer must pay U.S. taxes on earnings in other countries and because a corporation can shift additional income out of the United States through the use of intercompany loans and the resulting interest expenses.

97. The Consolidated Appropriations Act, 2016, retroactively and prospectively extended for three years, generally for property placed in service through the end of calendar year 2017, the ability of firms to expense 50 percent of their equipment investment. The law also phased out the ability of firms to use the provisions over the 2018–2020 period, allowing firms to expense 40 percent of such investment in 2018 and 30 percent in 2019, after which the partial-expensing provisions are scheduled to expire.

However, the partial-expensing provisions affect the timing but not the overall magnitude of investment deductions; so over the long term, the deductions claimed in any year are similar whether or not the partial-expensing provisions are permanently in place. Hence, the increase in revenues relative to GDP that occurs between 2018 and 2020 as a result of the phaseout of the partial-expensing provisions would be offset, under current law, by a reduction of a similar amount in later years. Consequently, the overall effect of those changes to the rate at which firms can deduct their investments over time will have little effect on projected receipts relative to GDP in 2026 compared with those in 2017.

Smaller Sources of Revenues

The remaining sources of federal revenues are remittances from the Federal Reserve System to the Treasury, excise taxes, customs duties, estate and gift taxes, and miscellaneous fees and fines. Revenues from those sources totaled $299 billion in 2015, or 1.7 percent of GDP (see Table 4-3). CBO expects that those receipts will edge up to 1.8 percent of GDP in 2016 and then, under current law, would decline to 1.3 percent of GDP by 2018 and remain at that level through 2026. Most of those movements reflect projected remittances from the Federal Reserve, which will rise in 2016 as a result of recently enacted legislation and then fall as the central bank's interest expenses increase and the size and composition of its portfolio return to more typical conditions.

Remittances From the Federal Reserve System

The income produced by the various activities of the Federal Reserve System, minus the cost of generating that income and the cost of the system's operations, is remitted to the Treasury and counted as revenues. The largest component of such income is what the Federal Reserve earns as interest on its holdings of securities. Over the past eight years, the central bank has quintupled the size of its asset holdings through purchases of Treasury securities and mortgage-backed securities issued by Fannie Mae, Freddie Mac, and the Government National Mortgage Association (known as Ginnie Mae). Those purchases raised remittances of the Federal Reserve from $34 billion (0.2 percent of GDP) in 2008 to just under $100 billion in 2014 and 2015 (an average of 0.6 percent of GDP).

CBO expects remittances to increase to $113 billion in 2016. That increase is the result of recently enacted legislation (the Fixing America's Surface Transportation Act, also called the FAST Act, P.L. 114-94) that requires the Federal Reserve to remit most of its surplus account to the Treasury and to reduce dividends paid to large member banks on their capital stock in the Federal Reserve. CBO expects those changes to increase remittances by $22 billion for fiscal year 2016 (which was largely reflected in higher remittances made in late December 2015) and by much smaller annual amounts thereafter, for a total of $63 billion over the 2016–2026 period. That transfer of surplus funds to the Treasury has no practical effect on the fiscal status of the federal government, however. If the surplus funds had continued to be held at the Federal Reserve and were invested in Treasury securities, the interest generated would have been remitted to the Treasury anyway; the location of the funds has no significant economic importance.

Beginning in 2017, remittances are projected to decline sharply, falling to $69 billion that year and to $34 billion by 2019. Much of the expected drop in 2017 reflects the temporary nature of most of the increase in remittances in 2016 that resulted from the FAST Act. However, part of the drop in 2017, and most of it thereafter, reflects a projected increase in the rate at which the Federal Reserve pays interest to the financial institutions that hold deposits on reserve, thus increasing its interest expenses. CBO also projects an increase in interest rates on Treasury securities in the next several years, which will increase earnings for the Federal Reserve—but only gradually as it purchases new securities that earn higher yields. (See Chapter 2 for a discussion of CBO's forecasts of monetary policy and interest rates in the coming decade.) After 2019, CBO projects, the size and composition of the Federal Reserve's portfolio, along with its remittances to the Treasury, would gradually return to conditions more in line with historical experience. Remittances would equal the 2000–2009 average of 0.2 percent of GDP by the end of the forecast period, according to CBO's projections.

Excise Taxes

Unlike taxes on income, excise taxes are levied on the production or purchase of a particular type of good or service. In CBO's baseline projections, almost 90 percent of excise tax receipts over the coming decade come from taxes related to highways, tobacco and alcohol, aviation, and health insurance. Receipts from excise taxes are projected to decrease slightly as a share of GDP over the next decade, from 0.5 percent in 2016 to 0.4 percent in 2026, largely because of declines in receipts from taxes on gasoline and tobacco.

Highway Taxes. About 40 percent of excise tax receipts currently come from highway taxes—primarily taxes on the consumption of gasoline, diesel fuel, and blends of those fuels with ethanol, as well as on the retail sale of trucks. Annual receipts from highway taxes, which are largely dedicated to the Highway Trust Fund, are projected to stay between $38 billion and $41 billion between 2016 and 2026. Because of the scheduled expiration at the end of 2016 of tax credits for certain alcohol fuel mixtures, highway receipts are projected to increase by about $3 billion between 2016 and 2018, but they then decline in CBO's baseline in every year after 2018, steadily falling as a percentage of GDP.

CBO's projection for a general decline in highway revenues, excluding the effects of the expiring tax credits, is the net effect of falling receipts from taxes on gasoline and rising receipts from taxes on diesel fuel and trucks. Gasoline consumption is expected to decline because improvements in vehicles' fuel economy (resulting largely from increases in the government's fuel economy standards) will probably more than offset increases in the number of miles that people drive. Over the decade, miles driven largely reflects projected population growth, but it is also affected by other factors. In particular, for 2016 and 2017, the recent decline in gasoline prices is expected to boost miles driven more than would otherwise occur, such that the increase in miles driven offsets the effect of improving fuel economy in those years. That effect is subsequently expected to reverse because of rising gasoline prices. Increasing fuel economy will likewise reduce the consumption of diesel fuel per mile driven—but not by enough, according to CBO's projections, to offset an increase in the total number of miles driven by diesel-powered trucks as the economy continues to expand.

Under current law, most of the federal excise taxes used to fund highway programs are scheduled to expire on September 30, 2022. In general, CBO's baseline incorporates the assumption that expiring tax provisions will follow the schedules set forth in current law. However, the Balanced Budget and Emergency Deficit Control Act of 1985 (P.L. 99-177) requires that CBO's baseline incorporate the assumption that expiring excise taxes dedicated to trust funds (including most of the highway taxes) will be extended.[98]

Tobacco and Alcohol Taxes. Taxes on tobacco products will generate $14 billion in revenues in 2016, CBO projects. That amount is projected to decrease by roughly 2 percent a year over the next decade, as the decline in tobacco consumption that has been occurring for many years continues. By contrast, receipts from taxes on alcoholic beverages, which are expected to total $10 billion in 2016, are projected to rise at an average rate of between 1 percent and 2 percent a year through 2026, also continuing past trends in alcohol consumption.

Aviation Taxes. Under current law, most aviation-related taxes are scheduled to expire on March 31, 2016, but CBO's baseline projections are required to incorporate the assumption that they, like the highway taxes described above, will be extended. According to CBO's projections, if those taxes were extended, receipts from taxes on airline tickets, aviation fuels, and various aviation-related transactions would increase from $14 billion in 2016 to $21 billion in 2026, yielding an average annual rate of growth of about 4 percent. That growth is close to the projected increase of GDP over that period, in part because the largest component of aviation excise taxes (a tax on airline tickets) is levied not on the number of units transacted (as gasoline taxes are, for example) but as a percentage of the dollar value of transactions—which causes receipts to increase as both real (inflation-adjusted) economic activity and prices increase.

Tax on Health Insurance Providers. Under the Affordable Care Act, health insurers are subject to an excise tax. The law specifies the total amount of tax to be assessed, and that total is divided among insurers according to their share of total premiums charged.

98. Because the excise tax credits for alcohol fuel mixtures do not reduce revenues to the Highway Trust Fund, they are not assumed to be extended in CBO's baseline projections.

However, several categories of health insurers—such as self-insured plans, federal and state governments, and tax-exempt providers—are fully or partially exempt from the tax. Revenues from the tax, which began to be collected in 2014, are projected to total $11 billion in 2016 but fall to about $1 billion in 2017 as a result of recent legislation that placed a one-year moratorium on that tax for calendar year 2017. Receipts from the tax, under current law, would reach about $13 billion in 2018 and rise steadily thereafter to about $21 billion by 2026, CBO estimates.

Other Excise Taxes. Other excise taxes are projected to generate a total of about $9 billion in revenues in 2016 and $129 billion in revenues from 2017 to 2026. About three-fifths of that 10-year total stems from three charges instituted by the Affordable Care Act: an annual fee imposed on manufacturers and importers of brand-name drugs (projected to raise revenues by $31 billion over 10 years); a 2.3 percent tax on manufacturers and importers of certain medical devices, which is scheduled under current law to be reinstated in 2018 following a recently enacted postponement of two years ($29 billion); and a tax that will go into effect in 2020, also after a recently enacted two-year postponement, on certain health insurance plans with high premiums ($20 billion).[99]

Customs Duties, Estate and Gift Taxes, and Miscellaneous Fees and Fines

Customs duties, which are assessed on certain imports, have totaled 0.2 percent of GDP in recent years, amounting to $35 billion in 2015. CBO projects that, under current law, those receipts would continue at that level relative to GDP throughout the next decade.

Receipts from estate and gift taxes in 2015 totaled $19 billion, or 0.1 percent of GDP. CBO projects that, under current law, those receipts would remain at that same percentage of GDP through 2026.

Miscellaneous fees and fines measured $50 billion (0.3 percent of GDP) in 2015. Under current law, those fees and fines would continue to average 0.3 percent of GDP from 2016 through 2026, CBO projects.

Tax Expenditures

Many exclusions, deductions, preferential rates, and credits in the individual income tax, payroll tax, and corporate income tax systems cause revenues to be much lower over the projection period than they would otherwise be for any underlying structure of

99. The excise tax on high-cost health insurance plans also increases the amounts CBO projects for revenues from individual income and payroll taxes because businesses are expected to respond to the tax by shifting to lower-cost insurance plans—thereby reducing nontaxable labor compensation and increasing taxable compensation. In addition, business taxes are affected by a provision of the Consolidated Appropriations Act, 2016, that allows the excise tax paid by a business to be deductible from its taxable income.

tax rates. Some of those provisions, called tax expenditures, resemble federal spending in that they provide financial assistance for particular activities or to entities or groups of people.

Like conventional federal spending, tax expenditures contribute to the federal budget deficit. They also influence people's choices about working, saving, and investing, and they affect the distribution of income. The Congressional Budget and Impoundment Control Act of 1974 defines tax expenditures as "those revenue losses attributable to provisions of the Federal tax laws which allow a special exclusion, exemption, or deduction from gross income or which provide a special credit, a preferential rate of tax, or a deferral of tax liability."[100] That law requires the federal budget to list tax expenditures, and each year the staff of the Joint Committee on Taxation and the Treasury's Office of Tax Analysis each publish estimates of individual and corporate income tax expenditures.[101]

Tax expenditures are more similar to the largest benefit programs than they are to discretionary spending programs: Tax expenditures are not subject to annual appropriations, and any person or entity that meets the legal requirements can receive the benefits. Because of their budgetary treatment, however, tax expenditures are much less transparent than spending on benefit programs.

Magnitude of Tax Expenditures

Tax expenditures have a major impact on the federal budget. CBO projects the magnitude of tax expenditures on the basis of the estimates prepared by JCT. However, JCT's estimates were published before the enactment of the Consolidated Appropriations Act, 2016, which extended many expiring tax provisions that are also tax expenditures. (CBO's baseline projections incorporate the direct effects on revenues of that legislation.) Excluding the effects of those extensions, CBO projects that the more than 200 tax expenditures in the individual and corporate income tax systems will total almost $1.5 trillion in fiscal year 2016—or 7.9 percent of GDP—if their effects on

100. Sec. 3(3) of the Congressional Budget and Impoundment Control Act of 1974 (codified at 2 U.S.C. §622(3) (2006)).

101. For this analysis, CBO follows JCT's definition of tax expenditures as deviations from a "normal" income tax structure. For the individual income tax, that structure incorporates existing regular tax rates, the standard deduction, personal exemptions, and deductions of business expenses. For the corporate income tax, that structure includes the top statutory tax rate, defines income on an accrual basis, and allows for cost recovery according to a specified depreciation system. For more information, see Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2015–2019*, JCX-141R-15 (December 2015), http://go.usa.gov/cUK2G. Unlike JCT, CBO includes estimates of the largest payroll tax expenditures. As defined by CBO, a normal payroll tax structure includes the existing payroll tax rates as applied to a broad definition of compensation—which consists of cash wages and fringe benefits. The Office of Management and Budget's definition of tax expenditures is broadly similar to JCT's. See Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2016: Analytical Perspectives* (February 2015), pp. 219–262, http://go.usa.gov/cPrHC (PDF, 5.24 MB).

payroll taxes as well as on income taxes are included.[102] That amount equals nearly half of all federal revenues projected for 2016 and exceeds projected spending on Social Security, defense, or Medicare (see Figure 4-3). CBO estimates that if the effects of the recently enacted extensions were incorporated into the estimates, the total magnitude of tax expenditures in 2016 would be significantly larger, but by no more than 1 percentage point of GDP.

A simple total of the estimates for specific tax expenditures does not account for the interactions among them if they are considered together. For instance, the total tax expenditure for all itemized deductions taken as a group would be smaller than the sum of the separate tax expenditures for each deduction; the reason is that, if the entire group of deductions did not exist, more taxpayers would claim the standard deduction instead of itemizing deductions than would be the case if any single deduction did not exist. However, the progressive structure of the tax brackets ensures that the opposite would be the case with income exclusions; that is, the tax expenditure for all exclusions considered together would be greater than the sum of the separate tax expenditures for each exclusion. Currently, those and other factors are approximately offsetting, so the total amount of tax expenditures roughly equals the sum of all of the individual tax expenditures.

However, the total amount of tax expenditures does not represent the increase in revenues that would occur if all tax expenditures were eliminated, because repealing a tax provision would change incentives and lead taxpayers to modify their behavior in ways that would diminish the impact of the repeal on revenues. For example, if preferential tax rates on realizations of capital gains were eliminated, taxpayers would reduce the amount of capital gains they realized; as a result, the amount of additional revenues that would be produced by eliminating the preferential rates would be smaller than the estimated size of the tax expenditure.

Economic and Distributional Effects of Tax Expenditures

Tax expenditures are generally designed to further goals deemed important by lawmakers. For example, expenditures for health insurance costs, pension contributions, and mortgage interest payments may help promote a healthier population, adequate financial resources for retirement and greater national saving, and stable communities of homeowners. But tax expenditures also have a broad range of effects that may not always further those intended goals. They may lead to an inefficient allocation of economic

102. Most estimates of tax expenditures include only their effects on individual and corporate income taxes. However, tax expenditures can also reduce the amount of income subject to payroll taxes. JCT has previously estimated the effect on payroll taxes of the provision that excludes employers' contributions for health insurance premiums from their workers' taxable income. See Joint Committee on Taxation, *Background Materials for Senate Committee on Finance Roundtable on Health Care Financing*, JCX-27-09 (May 2009), http://go.usa.gov/cUKTR. Tax expenditures that reduce the tax base for payroll taxes will eventually decrease spending for Social Security by reducing the earnings base on which Social Security benefits are calculated.

resources by encouraging more consumption of the goods and services that receive preferential treatment, and they may subsidize an activity that would have taken place even without the tax incentives. Moreover, by providing benefits for particular activities or to entities or groups of people, tax expenditures increase the extent of federal involvement in the economy. Tax expenditures also reduce the amount of revenues collected for any given set of statutory tax rates—and therefore require higher rates to collect any particular amount of revenues. All else being equal, those higher tax rates lessen people's incentives to work and save, thus decreasing output and income.

Tax expenditures are distributed unevenly across the income scale. When measured in dollars, much more of the tax expenditures go to higher-income households than to lower-income households. As a percentage of people's income, tax expenditures are greater for the highest-income and lowest-income households than for households in the middle of the income distribution.[103]

The Largest Tax Expenditures

CBO estimates that, excluding the effects of recently enacted legislation, the 10 largest tax expenditures would account for almost three-quarters of the total budgetary effects of all tax expenditures in fiscal year 2016 and would total 6.2 percent of GDP over the period from 2017 to 2026.[104] Those 10 tax expenditures fall into four categories: exclusions from taxable income, itemized deductions, preferential tax rates, and tax credits.

Exclusions From Taxable Income. Exclusions of certain types of income from taxation account for the greatest share of total tax expenditures. The largest items in that category are employers' contributions to their employees' health care, health insurance premiums, and premiums for long-term-care insurance; contributions to and earnings of pension funds (minus pension benefits that are included in taxable income); and profits earned abroad, which certain corporations may exclude from their taxable income until those profits are returned to the United States.[105]

103. For a detailed analysis, see Congressional Budget Office, *The Distribution of Major Tax Expenditures in the Individual Income Tax System* (May 2013), www.cbo.gov/publication/43768.

104. Those 10 tax expenditures are the ones whose budgetary effects, according to JCT's estimates, will equal more than 0.25 percent of GDP over the 2015–2019 period. CBO combined the components of certain tax expenditures that JCT reported separately, such as tax expenditures for different types of charitable contributions. Furthermore, because JCT only provided estimates for the 2015–2019 period, CBO also extrapolated JCT's estimates through 2026 to cover the full budget window. (Those extrapolated estimates would not precisely match estimates produced by JCT.) See Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2015–2019*, JCX-141R-15 (December 2015), http://go.usa.gov/cUK2G.

105. JCT previously also considered the exclusion for Medicare benefits (net of premiums paid) to be a tax expenditure but no longer does so. For a more detailed explanation, see Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2015–2019*, JCX-141R-15 (December 2015), p. 20, http://go.usa.gov/cUK2G.

The exclusion of employers' health insurance contributions is the single largest tax expenditure in the tax code; including effects on payroll taxes, that exclusion is projected to equal 1.5 percent of GDP over the 2017–2026 period (see Figure 4-4). The exclusion of pension contributions and earnings has the next-largest impact, resulting in tax expenditures, including effects on payroll taxes, that are estimated to total 1.2 percent of GDP over the same period.[106] Over the coming decade, tax expenditures for the deferral of corporate profits earned abroad are projected to equal 0.6 percent of GDP.

Itemized Deductions. Itemized deductions for certain types of payments allow taxpayers to further reduce their taxable income. Tax expenditures for deductions for state and local taxes (on nonbusiness income, sales, real estate, and personal property) are projected to equal 0.6 percent of GDP between 2017 and 2026. (That estimate excludes the effect of recent legislation, which permanently extended the option to deduct state and local sales taxes instead of state and local income taxes.) Tax expenditures for interest paid on mortgages for owner-occupied residences and for charitable contributions are projected to equal 0.6 percent and 0.3 percent of GDP, respectively, over that period.

Preferential Tax Rates. Under the individual income tax, preferential tax rates apply to some forms of income, including dividends and long-term capital gains.[107] Tax expenditures for the preferential tax rates on dividends and long-term capital gains are projected to total 0.6 percent of GDP between 2017 and 2026.[108]

Tax Credits. Tax credits reduce eligible taxpayers' tax liability. Nonrefundable tax credits cannot reduce a taxpayer's income tax liability to less than zero, but refundable tax credits may provide direct payments to taxpayers who do not owe any income taxes.

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106. That total includes amounts from defined benefit and defined contribution plans offered by employers; it does not include amounts from self-directed individual retirement arrangements or from Keogh plans that cover partners and sole proprietors, although contributions to and earnings accrued in those plans are also excluded from taxable income until withdrawal.

107. Not all analysts agree that lower tax rates on investment income constitute tax expenditures. Although such tax preferences are tax expenditures relative to a pure income tax, which is the benchmark used by JCT and the Office of Management and Budget in calculating tax expenditures, they are not tax expenditures relative to a pure consumption tax because investment income generally is excluded from taxation under a consumption tax.

108. Taxpayers with income over certain thresholds—$200,000 for single filers and $250,000 for married couples filing joint returns—face a surtax equal to 3.8 percent of their investment income (including capital gains and dividend income, as well as interest income and some passive business income). That surtax effectively reduces the preferential tax rate on dividends and capital gains. JCT treats the surtax as a negative tax expenditure—that is, as a deviation from the tax system that increases rather than decreases taxes—and it is not included in the figures presented here.

The Affordable Care Act provides refundable tax credits, called premium assistance credits, to help low- and moderate-income people purchase health insurance through exchanges. Tax expenditures for those credits are projected to total 0.3 percent of GDP over the next decade.

The other largest refundable credits are the earned income tax credit and the child tax credit. Both credits were significantly expanded in 2001 and again in later years. Certain expansions were scheduled to expire at the end of December 2017; however, recently enacted legislation made those expansions in both credits permanent. Before the permanent extensions of those expansions, the tax expenditures for the earned income tax credit were projected to be 0.3 percent of GDP, and expenditures for the child tax credit were projected to be 0.2 percent of GDP over the 2017–2026 period. The projected size of expenditures for those credits, taken together, would be larger, probably by less than 0.1 percentage point of GDP, if the effects of the permanent extensions were included.

Accuracy of CBO's Revenue Projections

In analyzing its previous baseline projections of revenues since 1982, CBO found that, on average, the agency's projections have been a bit too high—more so for projections spanning six years than for those spanning two—owing mostly to the difficulty of predicting when economic downturns will occur.[109] The overall accuracy of CBO's revenue projections has been similar to that of the projections of other government agencies.

Projection errors have tended to be larger for longer horizons than for shorter ones. CBO's six-year revenue projections—those that estimate revenues for the fifth fiscal year after the year in which they are released—have, on average, overestimated revenues by 5.3 percent. The mean absolute error of those projections is 10.4 percent, and the projections had a standard deviation around the actual values of 12.1 percent.[110] A mean absolute error of that magnitude would correspond to an error of about $420 billion in the revenue estimate for 2021

109. The analysis discussed in this section summarizes the more detailed analysis in Congressional Budget Office, *CBO's Revenue Forecasting Record* (November 2015), www.cbo.gov/publication/50831.

110. Unlike the mean error, the mean absolute error is the average of the errors without regard to direction—the negative signs are removed from underestimates before averaging—so errors in different directions do not offset one another. The standard deviation around the actual values, the calculation of which involves squaring the errors (thus removing the negative signs), also measures the size of errors without regard to direction; but by squaring the errors, it places a greater weight on larger deviations. (For those reasons, that measure is also known as the root mean square error.) About two-thirds of the forecasts will have misestimates within a range of plus or minus 1 standard deviation if the errors of a given set of forecasts are normally distributed around a mean error of zero—that is, if the misestimates are roughly symmetrically distributed around zero and there are more relatively small errors than large ones.

in the current baseline. The preponderance of overestimates for that longer horizon results in part from the fact that many of the six-year periods encompassed a recession that reduced economic activity and tax revenues below projected amounts.

Both measures of accuracy that CBO used show some signs of stabilizing at the six-year horizon, measuring not much higher than those calculated for the five-year horizon. However, the general accuracy of CBO's forecasts extending beyond six years may not become clearer until well into the future, when enough such forecasts have been produced to allow for a comprehensive assessment.

CBO's six-year forecasts of revenues as a share of GDP have a standard deviation around the actual values of 1.1 percentage points and a mean absolute error of 0.9 percentage points. In CBO's current baseline projections, revenues for 2021, the sixth year of the projection, total 18.0 percent of GDP. On the basis of the mean absolute error of past forecasts, revenues for that year might be expected to be as low as 17.1 percent of GDP or as high as 18.9 percent if no changes are made to current law. (The actual error for that particular projection might still fall outside that range.)

Appendix A: Changes in CBO's Baseline Since August 2015

The Congressional Budget Office anticipates that in the absence of further legislation affecting spending and revenues, the budget deficit for fiscal year 2016 will total $544 billion. That amount is $130 billion greater than the $414 billion deficit CBO projected in August 2015, when the agency last reported on its baseline (see Table A-1).[111] Much of the projected increase in the deficit stems from legislation enacted since the August update; CBO estimates that the effects of those laws will boost this year's deficit by $164 billion. Changes related to CBO's economic forecast

111. See Congressional Budget Office, *An Update to the Budget and Economic Outlook: 2015 to 2025* (August 2015), www.cbo.gov/publication/50724. CBO constructs its baseline projections in accordance with provisions of the Balanced Budget and Emergency Deficit Control Act of 1985 (Public Law 99-177) and the Congressional Budget and Impoundment Control Act of 1974 (P.L. 93-344). To project revenues and mandatory spending, CBO assumes that current laws, with only a few exceptions, will remain unchanged throughout the 10-year projection period. To project discretionary spending, CBO assumes that most annual appropriations through 2021 will adhere to the caps and automatic spending reductions established in the Budget Control Act of 2011 (P.L. 112-25), as amended, and that appropriations thereafter will grow from the 2021 amounts at the rate of inflation. Certain discretionary appropriations are not constrained by the caps, such as those designated for overseas contingency operations. In CBO's baseline, those appropriations grow in future years at the rate of inflation. CBO's baseline is not intended to predict budgetary outcomes. Rather, it serves as a benchmark against which to measure the potential effects of changes in laws governing taxes and spending.

add another $17 billion to the deficit projected for 2016; other, technical, factors reduce the gap by $51 billion.

CBO now projects that the cumulative deficit for the 2016–2025 period would be about $1.5 trillion higher than shown in its August projections—$8.6 trillion rather than $7.0 trillion—if current laws generally remained the same. In the baseline described in this report, for all years of the projection period after 2016, revenues are lower and outlays are higher than the amounts projected in the August baseline. On net, about half of the total increase in the cumulative deficit arises from the enactment of new legislation, but CBO's updated economic forecast and other, technical, factors also increase the deficit projected for each year through 2025.[112]

Legislative Changes to Projections

The largest changes in CBO's projections of the deficit since August—both for the current year and for the 2016–2025 period—stem from a few laws enacted toward the end of 2015. The Consolidated Appropriations Act, 2016 (Public Law 114-113), had by far the greatest effect, but three other laws also had notable influence on CBO's projections: the Fixing America's Surface Transportation Act (also called the FAST Act, P.L. 114-94), the Bipartisan Budget Act of 2015 (P.L. 114-74), and the National Defense Authorization Act for Fiscal Year 2016 (often called the 2016 NDAA, P.L. 114-92). Other legislation enacted between August and the end of 2015 had small effects on CBO's baseline projections.

The $164 billion addition to the deficit for 2016 that arises from new legislation stems mostly from an estimated $134 billion reduction in revenues for that year. The increase in the cumulative deficit over 10 years is split more evenly between revenues and outlays: The new laws added an estimated $749 billion to the projected 10-year cumulative deficit—reducing projected revenues by $425 billion (or 1.0 percent) and increasing projected outlays by $324 billion (or 0.7 percent).

Changes to Revenues

The enactment of the Consolidated Appropriations Act, 2016, led CBO to lower projected revenues by $523 billion for the 2016–2025 period, although that change was partially offset by the effects of two other laws: the FAST Act, which CBO projects will increase revenues by $66 billion over the next 10 years, and the Bipartisan Budget Act of 2015, which is projected to increase revenues by $32 billion over the same period.

Among other actions, the Consolidated Appropriations Act, 2016, retroactively and prospectively extended, for two years or longer and sometimes in modified form,

112. Some late changes to CBO's economic forecast have not yet been incorporated into the budget projections, but they would probably not materially affect the overall outlook.

several provisions that had reduced corporate and individual income taxes and, to a much lesser extent, excise taxes; those provisions had expired at the end of calendar year 2014 or were scheduled to expire within the next several years. According to estimates by the staff of the Joint Committee on Taxation (JCT), the largest such reductions in revenues over the 2016–2025 period stem from permanent extensions of certain tax provisions, including a modified form of the research and experimentation tax credit ($113 billion), a provision that allows businesses to defer certain foreign financing income ($78 billion), a modified form of a provision that allows businesses with relatively small amounts of investment to take an immediate deduction for that investment ($77 billion), and a provision that offers people who itemize their deductions the option of deducting either state and local sales taxes or state and local income taxes from their taxable income ($42 billion).

The largest near-term effects on revenues stem from the extension for 2014 through 2017, and then a phase-out over the next three years, of the provision allowing businesses with large investments in equipment to immediately expense some of those investments. According to JCT's estimates, that change would reduce revenues by $151 billion over the 2016–2019 period and then increase them by $140 billion over the 2020–2025 period, for a net reduction of $11 billion over the next decade.

Less than one-fifth of the revenue reduction projected for the 2016–2025 period that is attributable to the Consolidated Appropriations Act, 2016, will be offset by the effects of the FAST Act and the Bipartisan Budget Act of 2015. The FAST Act, which authorized funding for federal highway programs, also requires the Federal Reserve to reduce its surplus account and remit the difference to the Treasury.[113] In addition, the FAST Act lowered the rate at which the Federal Reserve pays dividends to large member banks on capital contributed as a condition of membership. The Bipartisan Budget Act of 2015 also includes several provisions that affect revenues, including tax compliance initiatives aimed at partnerships.

Changes to Outlays

Since August, CBO has boosted its estimate of 2016 outlays by $30 billion ($5 billion in mandatory spending and $25 billion in discretionary spending) as a result of new legislation. CBO also anticipates that outlays would be higher for the full projection period than it projected in August, mainly as a result of increased spending for refundable tax credits and higher debt-service costs stemming from enacted legislation.

113. Such transfers have no practical effect on the government's fiscal condition because the Federal Reserve would have remitted its earnings on such funds to the Treasury anyway; the location of the funds has no significant economic importance. See Chapter 4 of this volume and Congressional Budget Office, letter to the Honorable Tom Price, concerning a revision to the CBO cost estimate for the Surface Transportation Reauthorization and Reform Act of 2015 transmitted on November 17, 2015 (November 19, 2015), pp. 3–4, www.cbo.gov/publication/51015.

Mandatory Spending. Recent legislative activity led CBO to boost its estimates of mandatory outlays by $5 billion for 2016 and by $130 billion for the 10-year projection period, largely because of the extension of certain refundable tax credits.

Refundable Tax Credits. The Consolidated Appropriations Act, 2016, permanently extended the American Opportunity Tax Credit and expansions of the child tax credit and earned income tax credit that were first enacted in 2009 and that had been set to expire at the end of 2017.[114] Those changes will increase outlays by $159 billion over the 2016–2025 period (and reduce revenues by $39 billion over the same period), according to estimates by JCT. Other provisions of the law, mainly dealing with tax compliance, will reduce outlays for refundable tax credits by about $5 billion over the 2016–2025 period, JCT estimates.

Military Retirement. The 2016 NDAA made changes to the way retirement benefits are calculated for certain members of the uniformed services. Among the differences are a reduction in the multiplier used to set retirement annuities (which will reduce the amount of those annuities) and an option for future retirees to exchange part of their annuity stream for a lump-sum payment at the time they separate from service. Over the long term, those changes will reduce mandatory spending. However, because future annuities will be smaller, the contributions that the Department of Defense will make to the Military Retirement Fund to cover the future cost of retirement benefits for current service members will also be smaller. Because those contributions are recorded as offsetting receipts to the Military Retirement Fund, reductions in them cause a net increase in mandatory spending.[115] As a result, CBO's projections of mandatory spending over the 2016–2025 period increased by about $30 billion.

Medicare. Several new laws led CBO to lower its cumulative projection of Medicare spending by $21 billion for the 2016–2025 period from the amount it published in August. The largest effect is attributable to the Bipartisan Budget Act of 2015, which modified the timing of certain Medicare Part B premium receipts and limited payments for certain outpatient hospital items and services. That act also replaced the varied-percentage cuts in payments to most providers (the result of a budgetary action known as sequestration) in 2023 and 2024 with a 2 percent annual reduction (as exists under current law for 2016 through 2022), and it extended those statutory, across-the-board reductions through September 2025, at a rate of 4 percent.

114. Refundable tax credits reduce a filer's income tax liability overall; if the credit exceeds the rest of the filer's income tax liability, the government pays all or some portion of that excess to the taxpayer. See Congressional Budget Office, *Refundable Tax Credits* (January 2013), www.cbo.gov/publication/43767.

115. Because the contributions to the Military Retirement Fund are subject to annual appropriation acts, any changes to those contributions and their associated mandatory offsetting receipts are generally not counted for budget enforcement purposes when legislation is being considered.

Strategic Petroleum Reserve. Together, the Bipartisan Budget Act of 2015 and the FAST Act direct the Department of Energy to sell a total of 124 million barrels of oil from the Strategic Petroleum Reserve over the 2018–2025 period. CBO expects that the receipts from those sales will total about $8 billion during that period.[116]

Pension Benefit Guaranty Corporation. The Bipartisan Budget Act of 2015 made changes to pension-funding rules, premium rates, and the timing of premium payments. CBO projects that those changes will decrease mandatory spending by $8 that period increased the premium rates paid by employers to the Pension Benefit Guaranty Corporation (a change that CBO estimates would increase premium payments by $4 billion) and accelerated the payment date of premiums that would have been paid in 2026 (for a $3 billion increase). Those changes decreased CBO's projection of mandatory spending because such premiums are considered offsetting collections.

Discretionary Spending. New legislation also prompted changes in CBO's baseline projections for discretionary spending, boosting projected outlays by $25 billion for the current year and by a total of $56 billion over the 2016–2025 period. For that period, CBO projects $37 billion less in defense spending but $93 billion more in nondefense spending than it projected in August.

The Bipartisan Budget Act of 2015 adjusted the caps on budget authority for defense and nondefense programs, raising the cap for each category by $25 billion for 2016 and by $15 billion for 2017 relative to the limits as originally set in the Budget Control Act of 2011 (P.L. 112-25) and subsequently reduced by the automatic spending reductions described in that act. The Bipartisan Budget Act of 2015, however, did not provide the actual appropriations for 2016—those were provided in the Consolidated Appropriations Act, 2016, which also provided appropriations for categories of spending that are not constrained by the caps established in the Budget Control Act of 2011, such as overseas contingency operations (OCO), disaster relief, emergency requirements, and program integrity initiatives.[117]

Defense Spending. Three changes affected CBO's projections of defense outlays: First, the additional 2016 funding provided by the Consolidated Appropriations Act, 2016, and the cap increase for 2017 boost projected outlays over the next several years. But two other changes reduced projected outlays over the 10-year period. The

116. As those pieces of legislation were being considered, CBO estimated, on the basis of its March 2015 baseline, that such receipts would total $11 billion for the period. Since then, however, oil prices have fallen significantly, as has CBO's projection for the price of oil over the next decade.

117. Program integrity initiatives are aimed at reducing improper benefit payments in one or more of the following programs: Disability Insurance, Supplemental Security Income, Medicare, Medicaid, and the Children's Health Insurance Program. For more information on the discretionary caps established in the Budget Control Act of 2011, see Congressional Budget Office, *Final Sequestration Report for Fiscal Year 2016* (December 2015), www.cbo.gov/publication/51038.

actual appropriations for 2016 shifted toward slower-spending categories (such as procurement and research and development) and away from faster-spending categories (such as operations and maintenance and military personnel). And OCO funding in 2016 is $6.5 billion less than the amount CBO projected in its August baseline (that amount was extrapolated from the appropriations provided for 2015). In the current baseline, that lower funding is extrapolated through 2026, thus reducing projected spending in each year. As a result of those three factors, defense outlays are projected to be slightly higher in 2016 and 2017 but lower by $4 billion to $6 billion annually thereafter.

Nondefense Spending. Recent legislation results in higher nondefense outlays in all years in CBO's current baseline projections. From 2016 to 2018, those outlays are $62 billion above the amount projected in August, mostly because of the increase in actual and projected appropriations that are constrained by the caps established in the Budget Control Act of 2011.

For the full 10-year period, nondefense outlays in the baseline are higher by $93 billion. In addition to the cap increases, some changes in funding levels for categories of spending not constrained by the caps contribute to that revision in projected outlays:

- The 2016 OCO appropriation for nondefense activities is nearly $6 billion more than the sum provided in the previous year. That increase in funding, when extrapolated through 2025, boosts projected outlays in CBO's baseline by about $50 billion, relative to the August projections.

- The FAST Act increased spending authority for certain surface transportation programs and authorized increases in obligation limitations.[118] Hence, as part of the appropriations for 2016, those obligation limitations were increased by about $3 billion; that increase is extrapolated through the end of the projection period in CBO's baseline. As a result, additional spending on surface transportation programs—which is not constrained by the caps established by the Budget Control Act of 2011—increased CBO's projection of nondefense discretionary outlays by about $15 billion from 2016 through 2025.

- In the other direction, funding designated as an emergency requirement is nearly $5 billion less in 2016 than the amount provided for 2015; extrapolating that difference reduces projected outlays in CBO's baseline by about $45 billion over the 2016–2025 period.

118. An obligation limitation is a provision of law or legislation that restricts or reduces the availability of budget authority that would have become available under another law. Spending for most surface transportation programs is governed by obligation limitations set in appropriation acts.

Debt Service. All told, the changes that CBO made to its projections of revenues and outlays because of recently enacted legislation increased its projection of the cumulative deficit for the 2016–2025 period by $612 billion (excluding debt-service costs). The resulting growth in the estimate of federal borrowing led CBO to raise its projection of outlays for interest payments on federal debt by $137 billion through 2025.

Economic Changes to Projections

CBO's economic forecast from early December, which underlies the budget projections in this report, incorporated updated projections of gross domestic product (GDP), the unemployment rate, interest rates, inflation, and other factors that affect federal spending and revenues. In total, that economic forecast led the agency to increase its estimate of the deficit by $17 billion for the current year and by $437 billion for the 10-year period.[119]

Changes to Revenues

The economic forecast underlying the current projections led CBO to reduce its revenue projections by $33 billion (or 0.9 percent) for 2016 and by $771 billion (or 1.9 percent) for the 2016–2025 period, from the amounts in the previous baseline. The chief cause is CBO's expectation of slower growth in economic output over the 10-year projection period.

Since August, CBO reduced its estimate of nominal GDP by about 2 percent, on average, over the 2016–2025 period. Lower projections for GDP led to lower projections for associated income—much of it taxable—including wages and salaries, corporate profits, and proprietors' income. Those changes led CBO to lower its projections of receipts from each of the three major revenue sources over the 2016–2025 period: In its projections, receipts of individual income taxes fell by $317 billion (or 1.5 percent), corporate income taxes fell by $232 billion (or 5.3 percent), and payroll taxes fell by $182 billion (or 1.4 percent).

Changes to Outlays

As a result of the economic forecast underlying the current projections, CBO reduced its estimates of outlays by $16 billion for 2016 and by $334 billion for the 2016–2025

119. As noted in the Summary, CBO did not have enough time to incorporate into its budget projections the most recent updates to its economic forecast, which accounted for legislation enacted in December and for other developments through the end of that month. A preliminary analysis suggests that if CBO had incorporated those updates into its budget projections, as it will in March, projected revenues would be between $100 billion and $200 billion (or 0.2 percent to 0.4 percent) higher over the 2016–2026 period than they are currently projected to be. Projected outlays also would be affected, but probably to a lesser extent. CBO will also make technical estimating changes in its March projections that could be larger than those amounts, in either direction.

period. That 10-year change is almost entirely the result of projections of lower spending for mandatory programs and of reduced net interest costs.

Mandatory Spending. Revisions to the economic forecast led CBO to reduce its projections of mandatory spending by $3 billion for 2016 and by $126 billion for the 2016–2025 period. The largest changes occurred in CBO's projections for Medicaid, unemployment compensation, Social Security, royalties from leases on the Outer Continental Shelf, and Medicare.

Medicaid. Reductions in the prices projected for most medical services and in projected labor costs for health care workers, combined with a downward revision to the unemployment rate (which lowers projected Medicaid enrollment), have reduced CBO's baseline projections of Medicaid spending by $41 billion (or 0.9 percent) for the 2016–2025 period.

Unemployment Compensation. CBO's forecast of the unemployment rate over the next 10 years was revised downward by about 0.5 percentage points for 2016 through 2018 and by an average of about 0.2 percentage points for 2019 through 2025. In addition, the labor force is projected to shrink by about 350,000 participants each year because of the lower participation rate projected for the next few years and, to a smaller extent, because of lower projected population growth. CBO also projects that wage growth will be slower than it previously anticipated. Combined, those changes are projected to reduce outlays for unemployment compensation by $31 billion over the 2016–2025 period.

Social Security. CBO now projects that Social Security beneficiaries will receive a cost-of-living adjustment of 0.9 percent in January 2017, an increase that is 0.6 percentage points less than CBO's estimate in August. That reduction is partially offset by an increase in projected cost-of-living adjustments for 2018 through 2021. Taken together, those changes reduce estimated benefit payments over the 2016–2025 period by $32 billion. When combined with other smaller changes, which boost CBO's estimate of initial benefit amounts for new retirees, the baseline projections of Social Security spending over the 2016–2025 period have declined by a total of $27 billion (or 0.2 percent).

Outer Continental Shelf. When CBO prepared its economic projections in early December 2015, the agency expected that crude oil prices would be lower in each year than it had expected in August. As a result, royalties from leases in the Outer Continental Shelf are $17 billion lower for the 2016–2025 period than they were in the August projections. A reduction in royalties leads to an increase in outlays.

Medicare. Under current law, payment rates for much of Medicare's fee-for-service sector (such as hospital care and services provided by home health agencies and skilled nursing facilities) are updated automatically. Those updates are tied to changes in the prices of the labor, goods, and services that health care providers purchase, coupled with an adjustment for economywide gains in productivity (the ability to produce the same output using fewer inputs, such as hours of labor, than before) over a 10-year period. In general, CBO's projections show a smaller difference between price growth and productivity growth than the agency forecast in August. Consequently, CBO now anticipates lower payment rates for Medicare services than it did in August—a change that decreases outlays in CBO's baseline projections for the 2016–2025 period by $16 billion (or 0.2 percent).

Net Interest. Since August, CBO has revised its projections of net interest costs because of changes in the agency's forecasts for interest rates and inflation as well as changes in its projections of government borrowing that result from changes in the economic outlook (labeled in Table A-1 as debt service). Together, those revisions led CBO to reduce—by $181 billion—its baseline projection for net interest spending for the period from 2016 through 2025, mostly because of the revisions related to interest rates and inflation.

Specifically, CBO expects that interest rates on most Treasury securities will be lower (by an average of about 0.2 percentage points) throughout the period. The agency also has markedly reduced (by about 0.6 percentage points) its estimate of inflation for 2016, which results in a lower projection of the cost of Treasury inflation-protected securities, but has left its estimate of inflation over the 2017–2025 period mostly unchanged. Overall, those and other changes to CBO's economic forecast since last August have led the agency to project net interest outlays that are $14 billion lower for 2016 and $228 billion lower for the 2016–2025 period.

In addition, the economic forecast led CBO to increase its projection of the total deficit for the 2016–2025 period by $390 billion (the net effect of updates to projections of revenues and outlays). Because of the greater borrowing associated with larger deficits, CBO has increased its projections of debt-service costs for the 2016–2025 period by $47 billion.

Technical Changes to Projections

Technical changes, which are those that are not related to recently enacted legislation or to revised economic factors, also affect CBO's baseline projections for revenues and outlays. Such changes caused CBO to reduce its estimate of the 2016 deficit by $51 billion but to increase its estimate of the 10-year deficit by $363 billion. Nearly equal changes to estimates of revenues and outlays contributed to the decline in the estimated deficit for the current year; however, almost all of the projected increase in the cumulative deficit for 2016 through 2025 stems from an increase in CBO's projection of outlays.

Changes to Revenues

Overall, CBO modified its August 2015 revenue projections by relatively small amounts to incorporate various technical adjustments. As a result, the agency increased its 2016 revenue projections by $28 billion (or 0.8 percent), but reduced the cumulative revenue projections for the 2016–2025 period by $30 billion (or 0.1 percent).

Most significantly, CBO reduced its projections of corporate income tax receipts for technical reasons by $101 billion over the 2016–2025 period. That change largely reflects an increase in CBO's projections of certain tax deductions as a share of domestic economic profits—the measure of profits from the Bureau of Economic Analysis that is projected as a part of CBO's economic outlook; those deductions have amounted to a larger percentage of domestic economic profits in recent years than CBO had expected, and CBO now expects the recent trend to continue. The higher projected tax deductions lower CBO's projections of taxable profits and tax receipts.

Those reductions were partially offset by the net effect of changes to the projections of individual income and payroll taxes. The most significant technical change in that regard was to increase the rate of growth of wages and salaries for higher-income taxpayers relative to the growth of such income for other taxpayers—anticipating a greater difference in those growth rates than CBO had previously incorporated into its projections. That adjustment, which reflects a reexamination of recent trends, causes a greater share of total wages and salaries in CBO's updated projections to be taxed at higher income tax rates. However, that same adjustment pushes more wages and salaries in CBO's projections above the maximum amount per taxpayer that is subject to the Social Security payroll tax (currently $118,500). As a result of that and other changes, for the 2016–2025 period, CBO raised its projections of receipts from individual income taxes by $117 billion and lowered its projections of receipts from payroll taxes by $41 billion.

Changes to Outlays

As a result of technical updates to spending estimates for various programs and to estimates for certain offsetting receipts, CBO lowered its estimate of 2016 outlays by $23 billion (largely as a result of the recording of cash receipts from Fannie Mae and Freddie Mac). In the other direction, CBO raised its projection of outlays for the 2016–2025 period by $333 billion (or 0.7 percent), mostly because of higher projections of mandatory outlays.

Mandatory Spending. Technical revisions have reduced the amount of spending projected for the current year by $27 billion. For the 2016–2025 period, technical updates increased the total projection for mandatory spending by $258 billion.

Medicaid. CBO's 10-year projections of spending for Medicaid are $187 billion (or 4 percent) higher than the agency estimated in August 2015. That change is largely attributable to an increase in the projection of spending for newly eligible enrollees under the Affordable Care Act (ACA). Actual enrollment and spending for that category in 2015 exceeded CBO's prior estimates, and the agency has significantly boosted its projections of enrollment and spending for the 2016–2025 period. CBO now projects that in 2025 about 14.5 million people who will be eligible for Medicaid as a result of the ACA will enroll in the program; in August, CBO had estimated that number at about 11.5 million. Similarly, CBO projects that spending for those newly eligible enrollees will be about $114 billion in 2025; its August 2015 projection was $97 billion.

Veterans' Compensation and Pensions. CBO has made significant changes to projections for veterans' disability compensation, increasing mandatory outlays by about $152 billion (or 14 percent) over the 2016–2025 period. Veterans' disability compensation is driven by two factors: the number of veterans receiving compensation and the amount of the average benefit payment. On the basis of its observation of sustained trends, CBO boosted its projection of the number of veterans receiving disability compensation for the 10-year projection period by 400,000. In addition, updated information from the Department of Veterans Affairs showed that, on average, benefit payments for disability compensation have risen by about 5 percent per year over the past decade—a faster rate of increase than CBO had used in its earlier projections. CBO's current baseline reflects monthly disability payments that are, on average, about $150 higher per veteran.

Social Security. CBO has reduced its projections of outlays for Social Security over the 2016–2025 period by $97 billion (or 0.8 percent). Two-thirds of that reduction is in Old-Age and Survivors Insurance (OASI); the other third is in Disability Insurance (DI). About half of the reduction in OASI outlays stems from updated population projections, which reduced the number of people eligible for benefits. Most of the remaining change occurred because CBO is now projecting slightly slower growth in the share of older people who will receive OASI benefits, based on recent trends. The reduction in DI outlays is based primarily on recent data showing smaller caseloads than previously projected.

Fannie Mae and Freddie Mac. Because the government placed Fannie Mae and Freddie Mac into conservatorship in 2008 and now controls their operations, CBO considers their activities governmental and includes the budgetary effects of their activities in its projections as if they were federal agencies. On that basis, for the 10-year period after the current fiscal year, CBO projects subsidy costs of their new activities using procedures that are similar to those specified in the Federal Credit Reform Act of 1990 for determining the costs of federal credit programs—but with adjustments to reflect the associated market risk. The Administration, in contrast, considers Fannie Mae and Freddie Mac to be outside the federal government for budgetary purposes and records cash transactions between those entities and the

Treasury as federal outlays or receipts. (In CBO's view, those transactions should be considered intragovernmental.)

In its baseline, CBO treats the current fiscal year differently, in order to provide its best estimate of the amount that the Treasury ultimately will report as the federal deficit for 2016. Toward that end, CBO's baseline includes an estimate of net cash payments from Fannie Mae and Freddie Mac to the Treasury this year (that is, adopting the Administration's treatment for 2016), but it retains the risk-adjusted projections of subsidy costs for later years. CBO estimates that net payments from Fannie Mae and Freddie Mac to the Treasury will total $20 billion in 2016 (on the basis of the entities' most recent quarterly financial releases); those payments are recorded in the budget as offsetting receipts (reductions in outlays). By comparison, CBO's August 2015 baseline showed an estimated subsidy cost—that is, additional outlays—of about $3 billion for their activities in 2016. All told, that mostly conceptual difference reduces 2016 outlays in the baseline by $23 billion.

For 2017 through 2025, CBO's baseline follows the agency's customary approach of showing the estimated subsidy costs of mortgage guarantees provided and by loans purchased by Fannie Mae and Freddie Mac. To reflect market risk, those estimates are calculated on a fair-value basis. For the 2017–2025 period, CBO now estimates that those subsidy costs will total $11 billion—about $7 billion less than it projected in August. CBO expects that Fannie Mae and Freddie Mac will guarantee fewer mortgages over the next decade and that those mortgages will have lower associated fair-value costs.

Medicare. CBO increased its projection of Medicare outlays by $28 billion for the 2016–2025 period as a result of technical revisions. Most of that increase stems from the Centers for Medicare & Medicaid Services' release in November 2015 of its annual update of actuarial rates, premium rates, and deductibles for Part B of Medicare. Incorporating those data led CBO to reduce its projections of premiums paid for Part B, thus boosting the net spending projected for Medicare.

Other Mandatory Programs. Technical updates to other mandatory programs led CBO to lower its outlay projections by $17 billion for 2016 but raise them by the same amount for the entire projection period. Increased outlays for the Supplemental Nutrition Assistance Program ($11 billion) and unemployment compensation ($11 billion) are the largest contributors to that 10-year total change. Partially offsetting those increases, CBO and JCT decreased, by $7 billion over the 2016–2025 period, estimated outlays for federal subsidies for health insurance purchased through the ACA's exchanges and for related spending. The spending decrease stems from a reduction of 4 million in the number of people estimated to receive subsidies in 2016 through enrollment in the exchanges.[120] Smaller increases and decreases to projections of outlays for a variety of other mandatory programs increase projected outlays by an additional $2 billion over the 2016–2025 period.

Discretionary Spending. As a result of technical updates, CBO's estimates of discretionary spending for 2016 are $3 billion lower than those in the August baseline; however, for the 2016–2025 period, such updates increase projected outlays by $3 billion. The largest changes over the 10-year period arise from a lower estimated negative subsidy rate (and thus higher outlays) related to mortgage guarantees provided by the Federal Housing Administration and from higher projected outlays for diplomatic and consular programs of the Department of State.

Net Interest. CBO's estimate of net interest outlays increased by $7 billion for 2016 and by $72 billion for the 2016–2025 period as a result of technical updates.

Higher debt-service costs—mostly resulting from larger deficits attributable to technical changes in CBO's baseline for revenues and outlays—add $41 billion to net interest outlays in CBO's baseline over the 10-year period.

In addition, CBO's estimate of interest outlays increased by $31 billion over the 2016–2025 period mostly because the agency now projects smaller receipts from the financing accounts associated with the government's credit programs (mostly stemming from a reduction in the projected volume of federal student loans).

Appendix B: How Changes in Economic Projections Might Affect Budget Projections

The federal budget is highly sensitive to economic conditions. Revenues depend on the amount of income that is subject to taxation, including wages and salaries, other income received by individuals, and corporate profits. Those types of income generally

120. CBO and JCT estimate that about 11 million people, on average, will use subsidies to purchase insurance through an exchange during calendar year 2016. Additionally, the agencies project that about 2 million people will not be eligible for subsidies, but will purchase coverage through an exchange, for a total of 13 million people enrolled in coverage purchased through exchanges. Previously, in the March 2015 baseline projections, CBO and JCT projected that about 15 million people would receive exchange subsidies, on average, in 2016 and that an additional 6 million people would purchase unsubsidized coverage through an exchange, for a total of 21 million people enrolled in coverage purchased through exchanges. As discussed in Chapter 3, the enrollment projections and other factors underlying the estimates of exchange subsidies for years after 2016 have not been updated since March 2015, except to incorporate the effects of enacted legislation.

rise or fall with overall economic activity, although not necessarily in proportion. In addition, the Treasury regularly refinances portions of the government's outstanding debt—and issues more debt to finance new deficits—at market interest rates. Thus, the amount that the federal government spends for interest on its debt is directly tied to those rates. And spending for many mandatory programs is affected by inflation, either explicitly through cost-of-living adjustments or in other ways.

To show how the economic outlook can affect projections of the federal budget, the Congressional Budget Office has constructed simplified "rules of thumb." The rules provide a rough sense of how differences in individual economic variables, taken in isolation, would affect the budget totals. Changes in any single variable, however, would quite likely affect many other variables in ways that would depend crucially on the cause of the original change and on the general economic conditions prevailing at the time. Estimating that full set of effects would require a more comprehensive analysis that could not be summarized in a simple rule.

The rules of thumb have been developed for three variables:

- Growth of real (inflation-adjusted) gross domestic product (GDP),
- Interest rates, and
- Inflation.

All three rules of thumb reflect alternative assumptions about economic conditions beginning in January 2016.

CBO's rule of thumb for the growth of real GDP shows the effects of growth rates that are 0.1 percentage point lower each year than the rates that underlie the agency's baseline budget projections. (The budget projections are summarized in Chapter 1, and the economic projections are described in Chapter 2.) The rule of thumb for interest rates shows the effects of rates that are 1 percentage point higher each year than the rates used in the baseline; because inflation is held equal to its baseline projection in this rule of thumb, the results show the effects of higher real interest rates. Finally, the rule of thumb for inflation shows the effects of inflation that is 1 percentage point higher each year than is projected in the baseline.

Each rule of thumb is roughly symmetrical. Thus, if economic growth was 0.1 percentage point higher than in CBO's baseline, or if interest rates or inflation were 1 percentage point lower, the effects would be about the same as those shown here, but with the opposite sign.[121]

121. Interest rates on short-term Treasury securities could not be much lower in the near term. Rates on three-month Treasury securities were 0.04 percent in the last quarter of 2015, and CBO forecasts that they will remain below 1 percent through most of this calendar year.

In addition to being symmetrical, the rules are also roughly scalable for moderate differences in growth rates. For example, a difference in economic growth of 0.2 percentage points in each year, rather than 0.1 percentage point, would change the deficit by about twice as much—but such a calculation would be less useful for a substantially different rate of economic growth.

CBO chose variations of 0.1 percentage point and 1 percentage point solely for simplicity. Those differences do not necessarily indicate the extent to which actual economic performance might differ from CBO's projections. For example, CBO's analysis of its economic forecasts from the past three decades found that the standard deviation of its five-year forecasts for the annual average growth of real GDP around the annual average growth rates of actual GDP was 1.2 percentage points. (If the nature of those differences is the same in the future as in the past, then CBO's current forecast for the next five years will, roughly speaking, have a two-thirds chance of being within a range of 1.2 percentage points above or below the actual amount.) Similarly, the standard deviation of its five-year forecasts for the annual average rate of inflation around the actual annual average rate of inflation was 0.6 percentage points.[122]

Slower Growth of Real GDP

Stronger economic growth improves the budget's bottom line, and weaker growth worsens it. The first rule of thumb illustrates the effects of economic growth that is slightly weaker than expected. A change in the rate of real economic growth could affect inflation, unemployment, wage rates, and interest rates; however, this rule of thumb does not include the effects of changes in those variables.

CBO's economic forecast includes growth of real GDP averaging 2.6 percent for the next two calendar years, dropping to an average of 2.0 percent from 2018 to 2026. If 0.1 percentage point was subtracted from each of those rates, by 2026 GDP would be roughly 1 percent smaller than the amount underlying CBO's baseline.

Slower growth of GDP would have several effects on the budget. If growth was 0.1 percentage point lower per year, it would result in less growth in taxable income and thus lower tax revenues—$2 billion less in 2016 and $58 billion less in 2026 (see Table B-1). With a smaller amount of revenues, the federal government would need to borrow more and thus would incur higher interest costs. Additional payments to service federal debt would be very small during the first few years of the projection period but larger in later years, reaching $10 billion by 2026. Mandatory spending, however,

122. See Congressional Budget Office, *CBO's Economic Forecasting Record: 2015 Update* (February 2015), www.cbo.gov/publication/49891.

would be affected only slightly by such a decline in economic growth—in the form of higher outlays for the refundable portions of the earned income and child tax credits.[123]

All told, if growth of real GDP each year was 0.1 percentage point lower than in CBO's baseline projections, annual deficits would be larger by amounts that would climb to $69 billion by 2026, CBO estimates. The cumulative deficit for 2017 through 2026 would be $327 billion higher.

Higher Interest Rates

The second rule of thumb illustrates the sensitivity of the budget to changes in interest rates, which affect the flow of interest payments to and from the federal government. When the budget is in deficit, the Treasury must borrow additional funds from the public to cover the shortfall. Moreover, each year the Treasury refinances a substantial portion of the nation's outstanding debt at market interest rates. Those rates also help determine how much the Federal Reserve remits to the Treasury. Changes in interest rates could affect economic growth, the allocation of taxable income, unemployment, and inflation; however, this rule of thumb does not include the effects of changes in those variables.

If interest rates on all types of Treasury securities were 1 percentage point higher each year through 2026 than is projected in the baseline and all other economic variables were unchanged, the government's interest costs would be substantially larger. The difference would amount to only $16 billion in 2016 because most marketable government debt is in the form of securities that have maturities greater than one year. As the Treasury replaced maturing securities, however, the budgetary effects of higher interest rates would mount. Added costs from higher interest rates on the debt projected in CBO's baseline would reach $200 billion in 2026 under this scenario (see Table B-1).

As part of its conduct of monetary policy, the Federal Reserve buys and sells Treasury and other securities, including, over the past several years, a large amount of mortgage-backed debt. The Federal Reserve also pays interest on reserves (deposits that banks hold at the central bank). The interest that the Federal Reserve earns on its portfolio of securities and the interest that it pays on reserves affect its remittances to the Treasury, which are counted as revenues. If all interest rates were 1 percentage point higher for the coming decade than CBO projects, the Federal Reserve's remittances would be smaller for a number of years because higher interest payments on reserves would outstrip additional interest earnings on its portfolio. However, over time, the current holdings in the portfolio would mature and be replaced with higher-yielding investments; CBO projects that by 2023 the Federal Reserve's remittances would be larger if interest rates were higher than

123. Tax credits reduce a taxpayer's income tax liability; if a refundable credit exceeds a taxpayer's other liability, all or a portion of the excess is refunded to the taxpayer and recorded as an outlay in the budget.

projected. Overall, rates that were 1 percentage point higher than in CBO's baseline (all else being equal) would cause revenues from the Federal Reserve's remittances to be $64 billion smaller between 2017 and 2026.

The larger deficits generated by the increase in interest rates would require the Treasury to borrow more than is projected in the baseline. That extra borrowing would raise the cost of servicing the debt by amounts that would reach $69 billion in 2026.

In sum, if interest rates were 1 percentage point higher than projected in CBO's baseline, the deficit would worsen progressively over the projection period by amounts increasing from $38 billion in 2016 to $260 billion in 2026. The cumulative deficit would be $1.6 trillion higher over the 2017–2026 period.

Higher Inflation

The third rule of thumb shows the budgetary effects of inflation that is 1 percentage point higher, for all price and wage indexes, than is projected in CBO's baseline—with no differences in other economic variables except for interest rates, as described below. Although higher inflation increases both revenues and outlays, the net effect would be substantially larger budget deficits. Changes in inflation could also lead to changes in economic growth and unemployment; however, this rule of thumb does not include the effect of changes in those variables.

Effects on Revenues

Larger increases in wage rates and prices generally lead to greater labor income, profits, and other income, which in turn generate larger collections of individual income taxes, payroll taxes, and corporate income taxes. The parameters in the individual income tax system that affect most taxpayers—including the income thresholds for both the regular and alternative minimum tax brackets, the standard deduction, and personal exemptions—are indexed for inflation. Therefore, the share of taxpayers' income that is taxed at certain rates does not change very much when income increases because of higher inflation, so tax collections tend to rise roughly proportionally with income under those circumstances. However, some parameters of the individual income tax system are not indexed for inflation: For example, the income thresholds for the surtax on investment income are fixed in nominal dollars, so if income rose because of higher inflation, the surtax would apply to a larger share of taxpayers' income.

For the payroll tax, rates are mostly the same across income levels, and the maximum amount of earnings subject to the Social Security tax rises (after a lag) with average wages in the economy; therefore, higher wage inflation leads to a roughly proportional increase in payroll tax revenues. Similarly, although the brackets under the corporate income tax are not indexed for inflation, nearly all corporate profits are taxed at the top rate; consequently, an increase in profits resulting from higher inflation generates a roughly proportional increase in corporate tax revenues. All told, inflation that was 1 percentage point higher than CBO projects in each year would add $2.5 trillion to projected revenues in CBO's baseline between 2016 and 2026.

Effects on Mandatory Spending

Higher inflation, however, would also increase the cost of a number of mandatory spending programs, adding $1.5 trillion to projected spending. Benefits for many mandatory programs are automatically adjusted each year to reflect increases in prices. Specifically, benefits paid for Social Security, federal employees' retirement programs, disability compensation for veterans, Supplemental Nutrition Assistance Program, Supplemental Security Income, the refundable portion of the earned income tax credit, and the child nutrition programs, among others, are adjusted (with a lag) for changes in the consumer price index or one of its components. Many of Medicare's payment rates are also adjusted annually for inflation. Spending for some other programs, such as Medicaid, is not formally indexed to price changes but tends to grow with inflation because the costs of providing benefits under those programs increase as prices rise. In addition, to the extent that initial benefit payments to participants in retirement and disability programs are linked to wages, increases in nominal wages resulting from higher wage inflation boost future outlays for those programs.

Effects on Discretionary Spending

Higher inflation would raise CBO's baseline projections of future spending for discretionary programs, but only by a modest amount. Two components of CBO's discretionary baseline would be affected by this rule of thumb.

First, the Budget Control Act of 2011 (Public Law 112-25), as modified by subsequent legislation, imposes caps on most discretionary budget authority through 2021, and CBO's baseline incorporates the assumption that appropriations for most purposes will be equal to those caps. Higher inflation would not alter the statutory caps and thus would have no effect on CBO's projections of spending constrained by those limits. For the years following 2021—when caps will no longer be in place—CBO's baseline projections incorporate the assumption that the discretionary funding subject to the caps will increase with inflation. As a result, inflation that was 1 percentage point higher than in the baseline would boost projected outlays from 2022 through 2026 by a total of $150 billion.

Although the caps on discretionary appropriations are not indexed for inflation, higher inflation would diminish the amount of goods that could be acquired and the benefits and services that could be provided under those fixed caps.[124] If, over time, higher inflation led lawmakers to adjust the discretionary caps, the effect on spending and on the deficit would be greater.

124. In CBO's baseline, the caps for 2017 and 2018 remain close to the total amount specified for 2016; the caps grow by about 2.5 percent a year from 2019 through 2021.

Second, higher inflation would slightly increase discretionary outlays in CBO's baseline over the 2017–2026 period because the law specifies that the caps may be adjusted to accommodate appropriations for certain purposes. In 2016, those adjustments include $74 billion designated for overseas contingency operations, $7 billion in funding provided for disaster relief, $1.5 billion for initiatives aimed at enhancing program integrity by reducing improper payments from certain benefit programs, and nearly $1 billion in funding for emergencies. CBO's baseline extrapolates the funding provided for those purposes in future years based on the amounts appropriated for 2016, with adjustments for inflation; if inflation was 1 percentage point higher, projected outlays for those purposes would increase by $46 billion between 2017 and 2026. Altogether, if inflation was 1 percentage point higher, CBO's projections of discretionary outlays would rise by $196 billion over the 10-year period.

Effects on Net Interest Costs

Inflation also has an impact on outlays for net interest because it affects interest rates. If inflation was 1 percentage point higher than CBO projects, for example, then interest rates would be 1 percentage point higher (all else being equal). As a result, new federal borrowing would incur higher interest costs, and outstanding inflation-indexed securities would be more costly for the federal government. In addition, higher interest rates would first reduce and then increase revenues from the Federal Reserve's remittances to the Treasury (as explained in the section on higher interest rates). The direct effect of such higher rates is that $1.6 trillion of additional interest costs would be added to CBO's baseline projection of outlays. In addition, the effects of higher inflation would increase debt by $826 billion over the 10-year period and therefore boost interest costs by another $186 billion.

Total Effects

If inflation each year was 1 percentage point higher than the rate underlying CBO's baseline, total revenues and outlays over the 10-year period would be about 6 percent and 7 percent greater, respectively, than is projected in the baseline. Over the 2017–2026 period, the deficit would be $1.0 trillion higher (see Table B-1).

Appendix C: The Automatic Stabilizers in the Federal Budget

Federal revenues and outlays regularly respond to cyclical movements in the economy in ways that tend to dampen those movements. When the economy is operating below its potential, personal income is less and other tax bases are smaller than they would have been if the economy was operating at its potential; as a result, federal revenues are lower as well. Meanwhile, outlays for un-employment insurance benefits and some other transfer programs are higher. Those changes in revenues and outlays tend to encourage private spending. By contrast, when the economy is operating above its potential, revenues are higher and transfer payments lower than they would have been if the economy was operating at its potential—changes that tend to restrain private spending. Those cyclical components of revenues and outlays are known as automatic stabilizers because they occur without any legislated changes in tax and spending policies and because they tend to dampen the magnitude of cyclical fluctuations in the economy.

The Congressional Budget Office estimates the automatic stabilizers in order to inform policymakers and analysts about the extent to which changes in the budget deficit are caused by cyclical developments in the economy and thus are likely to prove temporary. The automatic stabilizers are measured as the estimated effects of the cyclical components of gross domestic product (GDP) and the unemployment rate on federal revenues and outlays—and thus on federal budget deficits.[125] Those cyclical components are the difference or gap between GDP and potential (maximum sustainable) GDP and the gap between the rate of unemployment and the underlying long-term rate of unemployment.[126]

On the basis of CBO's current economic and budgetary projections, which incorporate the assumption that current law generally will not change, the agency projects that the automatic stabilizers would add to the budget deficit and support economic activity by small amounts throughout the period from 2016 to 2026. The automatic stabilizers are projected to shrink over the next three years as the GDP gap narrows and the unemployment rate falls below CBO's estimate of the underlying long-term rate of un-employment. In later years, CBO projects, the GDP gap and the unemployment gap would return to their average values, which would cause the automatic stabilizers to grow again, though their contributions to the budget deficit would remain small. (See Chapter 2 for a discussion of CBO's economic projections for the next 10 years.)

How Large Were the Automatic Stabilizers Last Year?

In fiscal year 2015, the automatic stabilizers added $141 billion to the federal budget deficit, an amount equal to 0.8 percent of potential GDP, according to CBO's analysis

125. CBO's estimates of the automatic stabilizers reflect the assumption that discretionary spending and interest payments do not respond automatically to the business cycle. For a description of the methods that CBO uses to estimate automatic stabilizers, see Frank Russek and Kim Kowalewski, *How CBO Estimates Automatic Stabilizers*, Working Paper 2015-07 (Congressional Budget Office, November 2015), www.cbo.gov/publication/51005.

126. The underlying long-term rate of unemployment is CBO's estimate of the rate that would occur when output was at its potential.

(see Table C-1 and Table C-2).[127] (The estimated sizes of the automatic stabilizers in different years are presented as percentages of potential rather than actual GDP because potential GDP excludes fluctuations that are attributable to the business cycle.) It was the first time since the conclusion of the last recession that the automatic stabilizers added less than 1 percent of potential GDP to the deficit (see Figure C-1).

How Large Would the Automatic Stabilizers Be Over the Next Decade?

CBO expects that, if current law generally did not change, the automatic stabilizers would be much smaller in future years than they were in the seven preceding years, reflecting the projected declines in the GDP gap and the unemployment gap. For this fiscal year, the agency projects that the automatic stabilizers will add $89 billion to the federal budget deficit, an amount equal to 0.5 percent of potential GDP, after adding, on average, an amount equal to 1.5 percent of potential GDP over the period from 2009 to 2015. In later years, the automatic stabilizers are projected to shrink further—to essentially zero in 2018 and 2019—and then to increase slightly, adding to the deficit an amount equal to 0.2 percent of potential GDP, as the GDP and unemployment gaps return to their average values of –0.5 percent and 0.2 percent, respectively.[128]

How Large Would Budget Deficits Without the Automatic Stabilizers Be Over the Next Decade?

Removing CBO's estimate of the automatic stabilizers from the federal budget deficit yields an estimate of what the deficit would be if GDP was at its potential, the unemployment rate was at its underlying long-term rate, and all other factors were unchanged. The budget deficit without the automatic stabilizers can help analysts evaluate the extent to which changes in the deficit are not caused by cyclical developments in the economy and thus are likely to prove enduring.[129]

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127. For CBO's previous estimates of the automatic stabilizers, see Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), Appendix D, www.cbo.gov/publication/49892. CBO's revisions to those estimates stem from the July 2015 annual revision of the national income and product accounts by the Bureau of Economic Analysis, changes to CBO's economic estimates and projections, and technical improvements in CBO's approach to estimating automatic stabilizers.

128. The average GDP gap is based on CBO's estimate that output has been that much lower than potential output, on average, over the period from 1961 to 2009. For further discussion, see Congressional Budget Office, *Why CBO Projects That Actual Output Will Be Below Potential Output on Average* (February 2015), www.cbo.gov/publication/49890. CBO's estimate of the average unemployment gap is consistent with its estimate of the average GDP gap.

129. The budget deficit without automatic stabilizers has also been called the cyclically adjusted or structural deficit.

If current law generally does not change, CBO projects, the budget deficit without the automatic stabilizers will equal 2.4 percent of potential GDP in fiscal year 2016, up from 1.6 percent in 2015 but still well below the values in the period from 2008 through 2013 (see Figure C-2). The increase between 2015 and 2016 results almost entirely from a projected rise in outlays without automatic stabilizers in relation to potential GDP.

For the decade after 2016, CBO's current-law projections show ongoing increases in the budget deficit without the automatic stabilizers. By 2026, the projected budget deficit without the automatic stabilizers equals 4.7 percent of potential GDP, and the deficit with the automatic stabilizers equals 4.9 percent of potential GDP. Essentially all of the anticipated 10-year increase in the deficit without the automatic stabilizers can be attributed to increases in mandatory spending without automatic stabilizers and increases in net interest payments that are only partly offset by a decline in discretionary spending (all measured as a percentage of potential GDP).

Why Do Budget Deficits Appear Cyclical Even After the Estimated Effects of the Automatic Stabilizers Are Filtered Out?

Despite the exclusion of the estimated effects of the business cycle, the deficit without the automatic stabilizers appears to be correlated with the business cycle. In particular, the deficit without the automatic stabilizers tends to increase during times of recession and early in recoveries. One reason for that correlation is that during times of recession or high unemployment, policymakers often legislate changes to support the weak economy, such as cutting taxes and increasing government spending, that increase the deficit (or reduce the surplus). Those changes require legislation, so their budgetary effects are not automatic, and they are not viewed as automatic stabilizers. During the past decade, for instance, lawmakers have enacted the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010; the American Recovery and Reinvestment Act of 2009; the Emergency Economic Stabilization Act of 2008; and the Housing and Economic Recovery Act of 2008. Another reason for the correlation is that CBO's methods for estimating the automatic stabilizers may only partly remove the budgetary effects of certain changes, such as large fluctuations in the stock market, that have not had a sufficiently regular relationship to business cycles to be viewed as mostly cyclical.

Appendix D: Trust Funds

The federal government uses several accounting mechanisms to link earmarked receipts (that is, money designated for a specific purpose) with corresponding expenditures. Those mechanisms include trust funds (such as the Social Security trust funds), special funds (such as the fund that the Department of Defense uses to finance its health care program for military retirees), and revolving funds (such as the Federal Employees' Group Life Insurance fund). When the receipts designated for those funds exceed the amounts needed for expenditures, the funds are credited with nonmarketable debt instruments known as Government Account Series (GAS) securities, which are issued by the Treasury. At the end of fiscal year 2015, there was $5.0 trillion in such securities outstanding, 90 percent of which was held by trust funds.[130]

The federal budget has numerous trust funds, although most of the money credited to such funds goes to fewer than a dozen of them. By far the largest trust funds are Social Security's Old-Age and Survivors Insurance (OASI) Trust Fund, the funds dedicated to the government's retirement programs for its civilian and military personnel, and Medicare's Hospital Insurance (HI) Trust Fund (see Table D-1).

Ordinarily, when a trust fund receives cash that is not needed immediately to pay benefits or cover other expenses, the Treasury issues GAS securities in that amount to the fund and then uses the extra income to reduce the amount of new federal borrowing that is necessary to finance government activities. In other words, in the absence of changes to other tax and spending policies, the government borrows less from the public than it would without that extra net income. The reverse happens when revenues for a trust fund program fall short of expenses.

The balance of a trust fund at any given time is a measure of the historical relationship between the related program's receipts and expenditures. That balance (in the form of GAS securities) is an asset for the individual program, such as Social Security, but a liability for the rest of the government. The resources to redeem a trust fund's securities—and thereby pay for benefits or other spending—in some future year must be generated through taxes, income from other government sources, or borrowing from the public in that year. Trust funds have an important legal meaning in that their balances are a measure of the amounts that the government has the legal authority to spend for certain purposes under current law, but they have little relevance in an economic or budgetary sense unless the limits of that authority are reached.[131]

To assess how all federal activities, taken together, affect the economy and financial markets, it is useful to include the cash receipts and expenditures of trust funds in the

130. Debt issued in the form of GAS securities is included in a measure of federal debt called gross debt. Because such debt is intragovernmental in nature, however, it is not included in the measure called debt held by the public. (For a discussion of different measures of federal debt, see Chapter 1.)

131. For example, if the Disability Insurance Trust Fund's balance declined to zero and current revenues were insufficient to cover benefits specified in law, the Social Security Administration would no longer be permitted to pay full benefits when they were due. For additional discussion, see Noah P. Meyerson, *Social Security: What Would Happen If the Trust Funds Ran Out?* Report for Congress RL33514 (Congressional Research Service, August 28, 2014), available from U.S. House of Representatives, Committee on Ways and Means, *2014 Green Book*, Chapter 1: Social Security, "Social Security Congressional Research Service Reports" (accessed January 15, 2016), http://go.usa.gov/cCXcG.

budget totals along with the receipts and expenditures of other federal programs. Therefore, the Congressional Budget Office, the Office of Management and Budget, and other fiscal analysts generally focus on the total deficit in that unified budget, which includes the transactions of trust funds.

According to CBO's current baseline projections, the balances held by federal trust funds will increase by $307 billion in 2016. That increase is abnormally large because about $140 billion of deposits that were not credited to the Civil Service Retirement Trust Fund during the impasse over the debt limit last year were credited to the fund after the debt limit was suspended in November 2015; thus, those deposits add to the inflows into the fund this year.

Under current law, income credited to the trust funds is also projected to exceed outlays in each year from 2017 through 2020; however, each year thereafter, spending from the trust funds is projected to exceed income by an increasing amount. All told, CBO projects a cumulative net decrease in trust fund balances of $456 billion over the 2017–2026 period (see Table D-2).

Some of the trust funds' income is in the form of intragovernmental transfers. Examples of such transfers include interest credited to the trust funds, payments from general funds to cover most of the costs of payments for outpatient services (including payments to physicians) and prescription drugs under Parts B and D of Medicare, and the government's share of payments for federal employees' retirement. Such transfers shift resources from one category of the budget to another, but they do not directly change the total deficit or the government's borrowing needs. Intragovernmental transfers are projected to total $709 billion in 2016 and to exceed $1.1 trillion in 2026. With those transfers excluded and only income from sources outside the government (such as payroll taxes and Medicare premiums) counted, the trust fund programs will add $402 billion to the federal deficit in 2016. They are projected to add to deficits throughout the 2017–2026 period by amounts that grow from $617 billion in 2017 to $1.4 trillion in 2026.

Without legislative action to address shortfalls, balances in three trust funds are projected to be exhausted during that period: the Highway Trust Fund (in 2021), Social Security's Disability Insurance (DI) Trust Fund (in 2022), and Medicare's HI trust fund (in 2026).

Social Security Trust Funds

Social Security provides benefits to retired workers, their families, and some survivors of deceased workers through the OASI program; it also provides benefits to some people with disabilities and their families through the DI program. Those benefits are financed mainly through payroll taxes that are collected on workers' earnings at a rate of 12.4 percent—6.2 percentage points of which are paid by the worker and 6.2 percentage points by the employer. Since January 2000, 10.6 percentage points of the payroll tax have been credited to the OASI trust fund and 1.8 percentage points to the DI trust fund. The Bipartisan Budget Act of 2015 (Public Law 114-74) temporarily increased the share allocated to the DI trust fund, to 2.37 percentage points for calendar years 2016 through 2018. In those years, 10.03 percentage points of the payroll tax will be credited to the OASI trust fund.

Old-Age and Survivors Insurance

The OASI trust fund, which held $2.8 trillion in GAS securities at the end of 2015, is by far the largest of all federal trust funds. CBO projects that the fund's annual income, excluding interest on those securities, will decline from $702 billion last year to $699 billion in 2016 as a result of the payroll tax reallocation enacted in the Bipartisan Budget Act of 2015. Under current law, income received by the fund would increase over the remainder of the period, growing to nearly $1.1 trillion by 2026, CBO estimates (see Table D-3).[132] Expenditures from the fund are projected to be greater than and to grow faster than noninterest income each year over that period, rising from $769 billion in 2016 to $1.4 trillion in 2026. With expenditures growing by an average of about 6 percent a year and noninterest income (mostly from payroll taxes) increasing by an average of about 4 percent a year, the annual cash flows of the OASI program, excluding interest credited to the trust fund, would add to federal deficits in every year of the coming decade by amounts reaching $346 billion in 2026, CBO estimates. With interest receipts included, the OASI trust fund is projected to show a surplus in 2016 and 2017; however, by 2018, even with interest receipts taken into account, the trust fund is projected to start recording deficits that will reach $281 billion in 2026 (see Figure D-1).[133]

Disability Insurance

The DI trust fund is much smaller than the OASI fund; its balance at the end of 2015 was $42 billion. In CBO's current baseline, the annual income of the DI fund, excluding interest, jumps from $115 billion in 2015 to $148 billion in 2016 as a larger share of Social Security payroll taxes is credited to that fund. It then grows to $170 billion in 2018 but drops when the temporary increase in the payroll tax allocation expires at the end of that calendar year. The fund's income is projected to grow gradually beginning in 2021 and to reach $171 billion in 2026 (see

132. Although it is an employer, the federal government does not pay taxes. However, it makes an intragovernmental transfer from the general fund of the Treasury to the OASI and DI trust funds to cover the employer's share of the Social Security payroll tax for federal workers. That transfer is included in the income line in Table D-3.

133. According to CBO's most recent long-term projections, which are consistent with the 10-year baseline projections that were issued in March 2015 (modified to account for the payroll tax reallocation enacted in the Bipartisan Budget Act of 2015), the balance of the OASI trust fund will be exhausted in calendar year 2030. See Congressional Budget Office, *CBO's 2015 Long-Term Projections for Social Security: Additional Information* (December 2015), www.cbo.gov/publication/51047.

Table D-3). As with the OASI fund, annual expenditures from the DI fund are projected to increase steadily over the next decade, but at a slower rate—about 4 percent—rising from $147 billion in 2016 to $219 billion in 2026. Under current law, annual noninterest income to the DI fund would exceed expenditures from 2016 through 2018 because of the payroll tax reallocation, but the DI trust fund would add to the federal deficit each year thereafter, CBO estimates. Even with interest receipts included, the trust fund is projected to run an annual deficit starting in 2019 (see Figure D-1).

Under current law, the balance of the DI fund is expected to be exhausted in 2022.[134] If the outlays were limited thereafter to revenues credited to the trust fund, then in 2022 they would be 19 percent below the amounts scheduled under the law, CBO estimates.

Trust Funds for Federal Employees' Retirement Programs

After Social Security, the largest trust fund balances at the end of 2015 were held by various civilian employee retirement funds (a total of $750 billion) and by the Military Retirement Trust Fund ($531 billion).[135] Unlike the Social Security and Medicare trust funds, those retirement funds are projected to run surpluses throughout the coming decade, growing from a combined total of $83 billion in 2017 to $159 billion in 2026; about 90 percent of the increased annual surplus is attributable to the Military Retirement Trust Fund (see Table D-2).

As a result, in CBO's current baseline, the balance of the military retirement fund increases rapidly over the coming decade, reaching nearly $1.7 trillion in 2026. That growth is primarily attributable to additional payments that the Treasury is expected to make to the fund to reduce the amount of its unfunded liabilities.

The balance of the Civil Service Retirement Trust Fund, the largest of the civilian retirement trust funds, was affected by the impasse over the debt limit last year. During the impasse, certain deposits were not credited to the fund (thereby resulting in a net outflow for fiscal year 2015), and the balance of the combined civilian retirement funds dropped from $876 billion at the end of 2014 to $750 billion in 2015. Those deposits were credited to the fund in December (after the debt limit was suspended again), contributing to a projected boost in the balance of the combined funds to $903 billion at the end of this year. The civilian retirement funds are projected to grow gradually over the next decade and total $1.0 trillion by the end of 2026.

134. CBO projected that the DI trust fund would be exhausted in 2021 in *CBO's 2015 Long-Term Projections for Social Security: Additional Information* (December 2015), www.cbo.gov/publication/51047. Recent data have shown that DI caseloads are smaller than anticipated, so CBO has revised its projection of outlays for benefits, resulting in a later exhaustion date.

135. Those civilian retirement funds include the Civil Service Retirement Trust Fund, the Foreign Service Retirement Trust Fund, and several smaller retirement funds.

Medicare Trust Funds

Payments to hospitals and for other services covered by Medicare are made from two trust funds. The HI Trust Fund is used to make payments to hospitals and providers of post-acute care services under Part A of the Medicare program, and the Supplementary Medical Insurance (SMI) Trust Fund is used to make payments for outpatient services (including physicians' services) and prescription drugs under Parts B and D of Medicare.[136]

Hospital Insurance

The HI trust fund, which had a balance of $195 billion at the end of 2015, is the larger of the two Medicare trust funds. The fund's income is derived largely from the Medicare payroll tax (2.9 percent of workers' earnings, divided equally between the worker and the employer); in 2015, those taxes accounted for 89 percent of the $269 billion in noninterest income credited to the HI trust fund. An additional 8 percent came from part of the income taxes on Social Security benefits collected from beneficiaries with relatively high income. The remaining 4 percent of noninterest income credited to the HI trust fund consisted of premiums paid by beneficiaries; amounts recovered from overpayments to providers; fines, penalties, and other amounts collected by the Health Care Fraud and Abuse Control program; and other transfers and appropriations. In addition, the trust fund is credited with interest on its balances; that interest amounted to $9 billion in 2015.

The fund's noninterest income is projected to increase from $285 billion in 2016 to $450 billion in 2026—an average annual increase of about 5 percent. But annual expenditures from the HI fund are projected to grow more rapidly—at an average annual rate of close to 6 percent—rising from $299 billion in 2016 to $517 billion in 2026. CBO estimates that if current laws governing the program remained in place, expenditures would outstrip noninterest income in all years through 2026 except for 2018, producing annual deficits that were relatively small in the first half of the period but that would rise to $54 billion in 2025, the final year before the fund was exhausted.[137] Even including interest receipts, the trust fund is projected to run deficits in most years during the baseline period (see Table D-3 and Figure D-1).

Supplementary Medical Insurance

The SMI trust fund contains two separate accounts: one that pays for physicians' services and other health care provided on an outpatient basis under Part B of

136. Part C of Medicare (known as Medicare Advantage) specifies the rules under which private health care plans can assume responsibility for, and be compensated for, providing benefits covered under Parts A, B, and D.
137. The small surplus in 2018 occurs because a shift in the timing of payments to private Medicare plans will result in one fewer payment during fiscal year 2018: Because October 1, 2017, falls on a Sunday, the payments to private Medicare plans for that month will be made on September 29. (The same type of shift occurs from 2017 to 2016, from 2023 to 2022, and from 2024 to 2023.)

Medicare and one that pays for prescription drug benefits under Part D. The funding mechanisms used for the two accounts differ slightly:

- The Part B portion of the SMI fund is financed primarily through transfers from the general fund of the Treasury and through monthly premium payments from Medicare beneficiaries. The basic monthly premium for the SMI program is set to cover approximately 25 percent of the program's spending (with adjustments to maintain a contingency reserve to cover unexpected spikes in spending); beneficiaries with relatively high income pay a higher premium. The amount that will be transferred from the general fund equals about three times the amount expected to be collected from basic premiums after the amount collected from the income-related premiums and fees from drug manufacturers are deducted.

- The Part D portion of the SMI fund is financed mainly through transfers from the general fund, monthly premium payments from beneficiaries, and transfers from states (which are based on the number of people in a state who would have received prescription drug coverage under Medicaid in the absence of Part D). The basic monthly premium for Part D is set to cover 25.5 percent of the program's estimated spending if all participants paid it. But low-income people who receive subsidies available under Part D are not required to pay Part D premiums, so receipts are projected to cover less than 25.5 percent of the program's costs even though higher-income participants in Part D pay an income-related premium. The amount transferred from the general fund is set to cover total expected spending for benefits and administrative costs net of the amounts transferred from states and collected from basic and income-related premiums.

Unlike the HI trust fund's income, most of the income to the SMI fund (other than interest) does not come from a specified set of revenues collected from the public. Rather, the amounts credited to those accounts from the general fund of the Treasury are automatically adjusted to cover the differences between the program's spending and specified revenues. (In 2015, for example, $263 billion was transferred from the general fund to the SMI fund, accounting for about three-quarters of its income.) Thus, the balance in the SMI fund cannot be exhausted.

The SMI fund currently holds $66 billion in GAS securities; those holdings are projected to reach $101 billion in 2026.

Highway Trust Fund

The Highway Trust Fund comprises two accounts: the highway account, which funds construction of highways and highway safety programs, and the transit account, which funds mass transit programs. Revenues credited to the Highway Trust Fund are derived primarily from excise taxes on gasoline and certain other motor fuels.[138] Almost all spending from the fund is controlled by limitations on obligations set in appropriation acts.

Over the past nine years, spending has exceeded the fund's revenues by a total of $74 billion. Since 2008, lawmakers have authorized a series of transfers to the Highway Trust Fund to avoid delaying payments to state and local governments. Most recently, the Fixing America's Surface Transportation Act (also called the FAST Act, P.L. 114-94) transferred $70 billion to the Highway Trust Fund, mostly from the general fund of the Treasury, in December 2015 as the fund balance neared exhaustion. Including that amount, transfers since 2008 have totaled almost $143 billion.

Spending from the fund is projected to total $53 billion in 2016 while revenues and interest credited to the fund are expected to total $41 billion. For its baseline spending projections, CBO assumes that future limitations on obligations will be equal to the amounts set in the appropriation act for 2016, adjusted annually for inflation. The FAST Act extended the authorization for surface transportation programs funded by the Highway Trust Fund through 2020 and taxes credited to the trust fund through 2022. In CBO's baseline, which is based on the assumption that both funding and taxes are extended beyond those dates, the Highway Trust Fund is able to meet all obligations through 2020 but becomes exhausted in 2021.

Appendix E: CBO's Economic Projections for 2016 to 2026

The tables in this appendix expand on the information in Chapter 2 by showing the Congressional Budget Office's economic projections for each year from 2016 to 2026 (by calendar year in Table E-1 and by fiscal year in Table E-2). For years after 2020, CBO did not attempt to forecast the frequency or size of fluctuations in the business cycle. Instead, the values shown in these tables for 2021 to 2026 reflect CBO's projections of underlying trends in key variables such as growth of the labor force, hours worked, capital formation, and productivity; federal tax and spending policies under current law; and the persistent effects of the 2007–2009 recession and subsequent weak economic recovery.

138. The other revenues credited to the Highway Trust Fund come from excise taxes on trucks and trailers, on truck tires, and on the use of certain kinds of vehicles.

Appendix F:
Historical Budget Data

This appendix provides historical data on revenues, outlays, and the deficit or surplus—in forms consistent with the projections in Chapters 1, 3, and 4—for fiscal years 1966 to 2015. The data, which come from the Congressional Budget Office and the Office of Management and Budget, are shown both in nominal dollars and as a percentage of gross domestic product. Some of the numbers have been revised since August 2015, when these tables were previously published on CBO's website (www.cbo.gov/publication/50724).

Federal revenues, outlays, the deficit or surplus, and debt held by the public are shown in Table F-1. Revenues, outlays, and the deficit or surplus have both on-budget and off-budget components. Social Security's receipts and outlays were placed off-budget by the Balanced Budget and Emergency Deficit Control Act of 1985 (Public Law 99-177). For the sake of consistency, Table F-1 shows the budgetary components of Social Security as off-budget before that year. The Postal Service was classified as off-budget by the Omnibus Budget Reconciliation Act of 1989 (P.L. 101-239).

The major sources of federal revenues (including off-budget revenues) are presented in Table F-2. Payroll taxes include payments by employers and employees for Social Security, Medicare, Railroad Retirement, and unemployment insurance, as well as pension contributions by federal workers. Excise taxes are levied on certain products and services, such as gasoline, alcoholic beverages, and air travel. Estate and gift taxes are levied on assets when they are transferred. Miscellaneous receipts consist of earnings of the Federal Reserve System and income from numerous fees and charges.

Total outlays for major categories of spending (including off-budget outlays) appear in Table F-3. Spending controlled by the appropriation process is classified as discretionary. Spending governed by laws other than appropriation acts, such as laws that set eligibility requirements for certain programs, is considered mandatory. Offsetting receipts include the government's contributions to retirement programs for its employees, as well as fees, charges (such as Medicare premiums), and receipts from the use of federally controlled land and offshore territory. Net interest consists mostly of the government's interest payments on federal debt offset by its interest income.

Table F-4 divides discretionary spending into its defense and nondefense components. Table F-5 shows mandatory outlays for three major benefit programs—Social Security, Medicare, and Medicaid—and for other categories of mandatory spending. Income security programs provide benefits to recipients with limited income and assets; those programs include unemployment compensation, Supplemental Security Income, and the Supplemental Nutrition Assistance Program (formerly known as the Food Stamp program). Other federal retirement and disability programs provide benefits to federal civilian employees, members of the military, and veterans. The category of other mandatory programs includes the activities of the Commodity Credit Corporation, the Medicare-Eligible Retiree Health Care Fund, the subsidy costs of federal student loan programs, and the Children's Health Insurance Program.

About This Document

This volume is one of a series of reports on the state of the budget and the economy that the Congressional Budget Office issues each year. It satisfies the requirement of section 202(e) of the Congressional Budget Act of 1974 for CBO to submit to the Committees on the Budget periodic reports about fiscal policy and to provide baseline projections of the federal budget. In keeping with CBO's mandate to provide objective, impartial analysis, this report makes no recommendations.

CBO's Panel of Economic Advisers commented on an early version of the economic forecast underlying this report. Members of the panel are Katharine Abraham, Alan Auerbach, Markus Brunnermeier, Mary Daly, Steven Davis, Claudia Goldin, Robert Hall, Jan Hatzius, Anil Kashyap, Lawrence Katz, Donald Kohn, Nellie Liang, Gregory Mankiw, Jonathan Parker, Adam Posen, James Poterba, Valerie Ramey, Carmen Reinhart, Brian Sack, Robert Shimer, Justin Wolfers, and Mark Zandi. Troy Davig, Peter Hooper, Dale Jorgenson, Lawrence Summers, and John Walker attended the panel's meeting as guests. Although CBO's outside advisers provided considerable assistance, they are not responsible for the contents of this report.

The CBO staff members who contributed to this report—by preparing the economic, revenue, and spending projections; writing the report; reviewing, editing, and publishing it; compiling the supplemental materials posted along with it on CBO's website (www.cbo.gov/publication/51129); and providing other support—are listed on the following pages.

Economic Projections

The economic projections were prepared by the Macroeconomic Analysis Division, with contributions from analysts in other divisions. That work was supervised by Wendy Edelberg, Kim Kowalewski, Robert Arnold, and Benjamin Page.

Lauren Bresnahan	Inflation, house prices
Daniel Fried	Net exports, exchange rates, energy prices
Edward Gamber	Interest rates, monetary policy, current-quarter analysis
Ronald Gecan	Energy prices
Mark Lasky	Business investment, housing

Jason Levine	Financial markets
Leah Loversky	Motor vehicle sector, research assistance
Joshua Montes	Labor markets
Jeffrey Perry	Financial markets
John Seliski	Federal, state, and local government spending and revenues
Robert Shackleton	Potential output, productivity
Christopher Williams	Consumer spending, incomes
Shiqi Zheng	Housing, model and data management

Revenue Projections

The revenue projections were prepared by the Tax Analysis Division, supervised by David Weiner, Mark Booth, Ed Harris, and Janet Holtzblatt. In addition, the staff of the Joint Committee on Taxation provided valuable assistance.

Paul Burnham	Retirement income
Nathaniel Frentz	Federal Reserve System earnings, customs duties, miscellaneous fees and fines
Pamela Greene	Corporate income taxes
Peter Huether	Excise taxes
Robert McClelland	Capital gains realizations
Shannon Mok	Estate and gift taxes, refundable tax credits
Kevin Perese	Tax modeling, Federal Reserve System earnings
Molly Saunders-Scott	International taxation, business taxation
Kurt Seibert	Payroll taxes, depreciation, tax modeling
Joshua Shakin	Individual income taxes, refundable tax credits
Naveen Singhal	Capital gains realizations, tax modeling
Marvin Ward	Tax modeling

Spending Projections

The spending projections were prepared by the Budget Analysis Division, with contributions from analysts in other divisions; that work was supervised by Theresa Gullo, Holly Harvey, Sam Papenfuss, Janet Airis, Tom Bradley, Kim Cawley, Chad Chirico, Sheila Dacey, Jeffrey Holland, and Sarah Jennings of the Budget Analysis Division, as well as by Jessica Banthin of the Health, Retirement, and Long-Term Analysis Division and Damien Moore of the Financial Analysis Division.

Defense, International Affairs, and Veterans' Affairs

Kent Christensen	Defense (projections, working capital funds, operation and maintenance, procurement, scorekeeping)
Sunita D'Monte	International affairs
Ann Futrell	Veterans' health care and employment training services, international food assistance
Raymond Hall	Defense (research and development, stockpile sales, atomic energy, Navy procurement)
William Ma	Defense (operation and maintenance, procurement, compensation for radiation exposure and energy employees' occupational illness, other defense programs)
David Newman	Defense (military construction and family housing, military activities in Afghanistan), veterans' housing and education benefits, reservists' education benefits
David Rafferty	Military retirement
Dawn Sauter Regan	Defense (military personnel)
Matthew Schmit	Military health care
Dwayne Wright	Veterans' compensation and pensions, vocational and adaptive benefits

Health

Susan Yeh Beyer	Health insurance coverage
Julia Christensen	Food and Drug Administration, prescription drugs
Kate Fritzsche	Health insurance exchanges, other programs
Daniel Hoople	Medicaid, Children's Health Insurance Program
Lori Housman	Medicare
Jamease Kowalczyk	Medicare
Sean Lyons	Health insurance coverage
Paul Masi	Medicare, Federal Employees Health Benefits program
Sarah Masi	Health insurance exchanges, other programs
Kevin McNellis	Medicare
Alexandra Minicozzi	Health insurance coverage
Eamon Molloy	Health insurance coverage
Andrea Noda	Medicaid prescription drugs, long-term care, Public Health Service
Romain Parsad	Health insurance coverage
Allison Percy	Health insurance coverage
Lisa Ramirez-Branum	Medicaid, health insurance coverage, Health Resources and Services Administration
Kyle Redfield	Health insurance coverage
Lara Robillard	Medicare
Robert Stewart	Medicaid, Children's Health Insurance Program, Indian Health Service
Ellen Werble	Prescription drugs, Public Health Service, National Institutes of Health
Zoe Williams	Medicare
Rebecca Yip	Medicare Part D, prescription drugs, Public Health Service

Income Security and Education

Christina Hawley Anthony	Unemployment insurance, training programs, Administration on Aging, Smithsonian Institution, arts and humanities
Elizabeth Cove Delisle	Housing assistance
Kathleen FitzGerald	Supplemental Nutrition Assistance Program and other nutrition programs
Jennifer Gray	Social Services Block Grant, children and families services programs, child nutrition and other nutrition programs
Justin Humphrey	Student loans, higher education
Leah Koestner	Elementary and secondary education, Pell grants
Susanne Mehlman	Temporary Assistance for Needy Families, Child Support Enforcement program, foster care, child care programs, Low Income Home Energy Assistance Program, refugee assistance
Noah Meyerson	Old-Age and Survivors Insurance, Social Security trust funds, Pension Benefit Guaranty Corporation
Emily Stern	Disability Insurance, Supplemental Security Income

Natural and Physical Resources

Tiffany Arthur	Agriculture
Marin Burnett	Administration of justice, science and space exploration, recreational resources
Megan Carroll	Energy, air and water transportation
Mark Grabowicz	Administration of justice, Postal Service
Kathleen Gramp	Energy, Outer Continental Shelf receipts, spectrum auction receipts, Orderly Liquidation Fund
David Hull	Agriculture
Jeff LaFave	Conservation and land management, other natural resources, Federal Housing Administration and other housing credit programs
James Langley	Agriculture
Matthew Pickford	General government, legislative branch

Natural and Physical Resources (Continued)

Sarah Puro	Highways, mass transit, Amtrak, deposit insurance, credit unions
Jon Sperl	Pollution control and abatement
Aurora Swanson	Water resources, Fannie Mae and Freddie Mac, community and regional development, Federal Emergency Management Agency, Bureau of Indian Affairs
Susan Willie	Commerce, Small Business Administration, Universal Service Fund, agricultural trade and credit

Other Areas and Functions

Janet Airis	Appropriation bill (Legislative Branch)
Shane Beaulieu	Computer support
Barry Blom	Federal pay, monthly Treasury data
Joanna Capps	Appropriation bills (Labor, Health and Human Services, and Education; State and Foreign Operations)
Meredith Decker	Other interest, debt limit
Mary Froehlich	Computer support
Avi Lerner	Troubled Asset Relief Program, automatic budget enforcement and sequestration, interest on the public debt
Amber Marcellino	Federal civilian retirement, historical data
Virginia Myers	Appropriation bills (Commerce, Justice, and Science; Financial Services and General Government)
Jeffrey Perry	Fannie Mae and Freddie Mac, Federal Housing Administration
Dan Ready	Various federal retirement programs, national income and product accounts, federal pay
Mitchell Remy	Fannie Mae and Freddie Mac, Federal Housing Administration
Mark Sanford	Appropriation bills (Agriculture and Food and Drug Administration; Defense)

Other Areas and Functions (Continued)

Esther Steinbock	Appropriation bills (Transportation and Housing and Urban Development; Military Construction and Veterans Affairs; Energy and Water Development)
J'nell Blanco Suchy	Authorization bills
Patrice Watson	Database system administrator
Adam Wilson	Appropriation bills (Homeland Security; Interior)

Long-Term Projections

The long-term projections were prepared by the Health, Retirement, and Long-Term Analysis Division and the Macroeconomic Analysis Division. That work was supervised by Julie Topoleski and Benjamin Page. Stephanie Hugie Barello and Michael Simpson prepared the long-term projections without macroeconomic feedback. Jonathan Huntley prepared the long-term projections with macroeconomic feedback.

Writing

Christina Hawley Anthony wrote the summary. Barry Blom wrote Chapter 1, with assistance from Nathaniel Frentz. Edward Gamber and Charles Whalen wrote Chapter 2. Christina Hawley Anthony, Megan Carroll, Meredith Decker, and Avi Lerner wrote Chapter 3. Mark Booth, Pamela Greene, Joshua Shakin, and David Weiner wrote Chapter 4. Amber Marcellino wrote Appendix A, with assistance from Mark Booth and Nathaniel Frentz. Dan Ready wrote Appendix B, with assistance from Nathaniel Frentz. John Seliski wrote Appendix C; Avi Lerner wrote Appendix D. Shiqi Zheng compiled Appendix E, and Amber Marcellino compiled Appendix F.

Review, Editing, and Publishing

Jeffrey Kling and Robert Sunshine reviewed the report. The editing and publishing were handled by CBO's editing and publishing group, supervised by John Skeen, and the agency's web team, supervised by Deborah Kilroe.

Christine Bogusz, Kate Kelly, Loretta Lettner, Bo Peery, Benjamin Plotinsky, and Gabe Waggoner edited the report; Maureen Costantino and Jeanine Rees prepared it for publication; and Robert Dean, Annette Kalicki, Adam Russell, and Simone Thomas published it on CBO's website.

Sarah Puro coordinated the preparation of tables of baseline projections for selected programs, and Peter Huether, Leah Loversky, and Shiqi Zheng compiled supplemental economic and tax data—all posted with this report on the agency's website. Jeanine Rees and Simone Thomas coordinated the presentation of those materials.

Keith Hall
Director

January 2016

Summary Table 1.

CBO's Baseline Budget Projections

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
							In Billions of Dollars							
Revenues														
Individual income taxes	1,541	1,621	1,739	1,827	1,902	1,987	2,084	2,184	2,292	2,406	2,529	2,657	9,539	21,608
Payroll taxes	1,065	1,101	1,143	1,182	1,222	1,264	1,314	1,365	1,417	1,471	1,531	1,593	6,126	13,503
Corporate income taxes	344	327	348	353	358	391	391	397	402	410	421	434	1,842	3,907
Other	299	327	280	272	264	274	287	298	310	322	337	351	1,376	2,993
Total	**3,249**	**3,376**	**3,511**	**3,633**	**3,747**	**3,917**	**4,076**	**4,244**	**4,421**	**4,610**	**4,818**	**5,035**	**18,883**	**42,010**
On-budget	2,478	2,580	2,682	2,774	2,859	2,999	3,126	3,260	3,401	3,552	3,720	3,895	14,441	32,269
Off-budget[a]	770	796	829	859	888	917	949	984	1,020	1,058	1,098	1,139	4,442	9,741
Outlays														
Mandatory	2,299	2,466	2,558	2,633	2,825	2,981	3,143	3,375	3,500	3,622	3,875	4,142	14,140	32,653
Discretionary	1,165	1,198	1,206	1,203	1,222	1,248	1,274	1,307	1,332	1,358	1,397	1,429	6,152	12,975
Net interest	223	255	308	369	438	498	551	607	666	719	772	830	2,165	5,759
Total	**3,687**	**3,919**	**4,072**	**4,206**	**4,485**	**4,727**	**4,968**	**5,288**	**5,498**	**5,699**	**6,044**	**6,401**	**22,458**	**51,388**
On-budget	2,944	3,147	3,258	3,343	3,563	3,741	3,914	4,158	4,291	4,411	4,668	4,932	17,818	40,278
Off-budget[a]	743	772	814	863	922	986	1,055	1,130	1,207	1,288	1,376	1,469	4,640	11,110
Deficit (-) or Surplus	**-439**	**-544**	**-561**	**-572**	**-738**	**-810**	**-893**	**-1,044**	**-1,077**	**-1,089**	**-1,226**	**-1,366**	**-3,575**	**-9,378**
On-budget	-466	-567	-576	-569	-704	-741	-787	-899	-890	-859	-948	-1,036	-3,377	-8,010
Off-budget[a]	27	23	15	-4	-34	-69	-105	-146	-187	-230	-278	-330	-197	-1,369
Debt Held by the Public	13,117	13,978	14,613	15,244	16,033	16,886	17,813	18,891	20,003	21,129	22,399	23,817	n.a.	n.a.
Memorandum:														
Gross Domestic Product	17,810	18,494	19,297	20,127	20,906	21,710	22,593	23,528	24,497	25,506	26,559	27,660	104,632	232,382
							As a Percentage of Gross Domestic Product							
Revenues														
Individual income taxes	8.7	8.8	9.0	9.1	9.1	9.2	9.2	9.3	9.4	9.4	9.5	9.6	9.1	9.3
Payroll taxes	6.0	6.0	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.8
Corporate income taxes	1.9	1.8	1.8	1.8	1.7	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.8	1.7
Other	1.7	1.8	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Total	**18.2**	**18.3**	**18.2**	**18.1**	**17.9**	**18.0**	**18.0**	**18.0**	**18.0**	**18.1**	**18.1**	**18.2**	**18.0**	**18.1**
On-budget	13.9	13.9	13.9	13.8	13.7	13.8	13.8	13.9	13.9	13.9	14.0	14.1	13.8	13.9
Off-budget[a]	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.2	4.2
Outlays														
Mandatory	12.9	13.3	13.3	13.1	13.5	13.7	13.9	14.3	14.3	14.2	14.6	15.0	13.5	14.1
Discretionary	6.5	6.5	6.2	6.0	5.8	5.7	5.6	5.6	5.4	5.3	5.3	5.2	5.9	5.6
Net interest	1.3	1.4	1.6	1.8	2.1	2.3	2.4	2.6	2.7	2.8	2.9	3.0	2.1	2.5
Total	**20.7**	**21.2**	**21.1**	**20.9**	**21.5**	**21.8**	**22.0**	**22.5**	**22.4**	**22.3**	**22.8**	**23.1**	**21.5**	**22.1**
On-budget	16.5	17.0	16.9	16.6	17.0	17.2	17.3	17.7	17.5	17.3	17.6	17.8	17.0	17.3
Off-budget[a]	4.2	4.2	4.2	4.3	4.4	4.5	4.7	4.8	4.9	5.1	5.2	5.3	4.4	4.8
Deficit (-) or Surplus	**-2.5**	**-2.9**	**-2.9**	**-2.8**	**-3.5**	**-3.7**	**-4.0**	**-4.4**	**-4.4**	**-4.3**	**-4.6**	**-4.9**	**-3.4**	**-4.0**
On-budget	-2.6	-3.1	-3.0	-2.8	-3.4	-3.4	-3.5	-3.8	-3.6	-3.4	-3.6	-3.7	-3.2	-3.4
Off-budget[a]	0.2	0.1	0.1	*	-0.2	-0.3	-0.5	-0.6	-0.8	-0.9	-1.0	-1.2	-0.2	-0.6
Debt Held by the Public	73.6	75.6	75.7	75.7	76.7	77.8	78.8	80.3	81.7	82.8	84.3	86.1	n.a.	n.a.

Source: Congressional Budget Office.

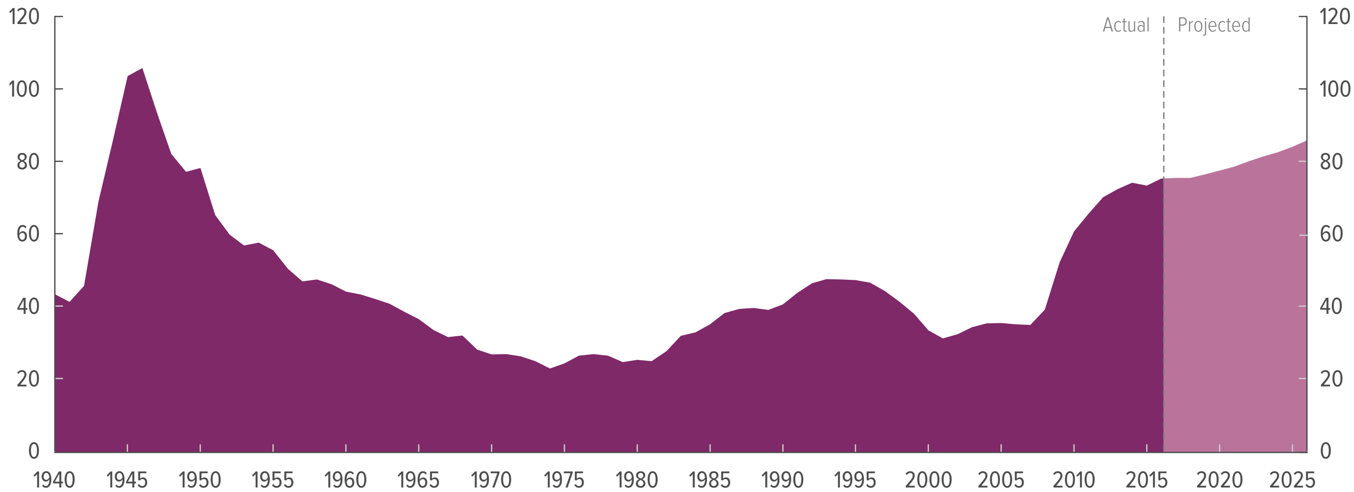
n.a. = not applicable; * = between -0.05 percent and zero.

a. The revenues and outlays of the Social Security trust funds and the net cash flow of the Postal Service are classified as off-budget.

Summary Figure 1. Return to Reference

Federal Debt Held by the Public

Percentage of Gross Domestic Product



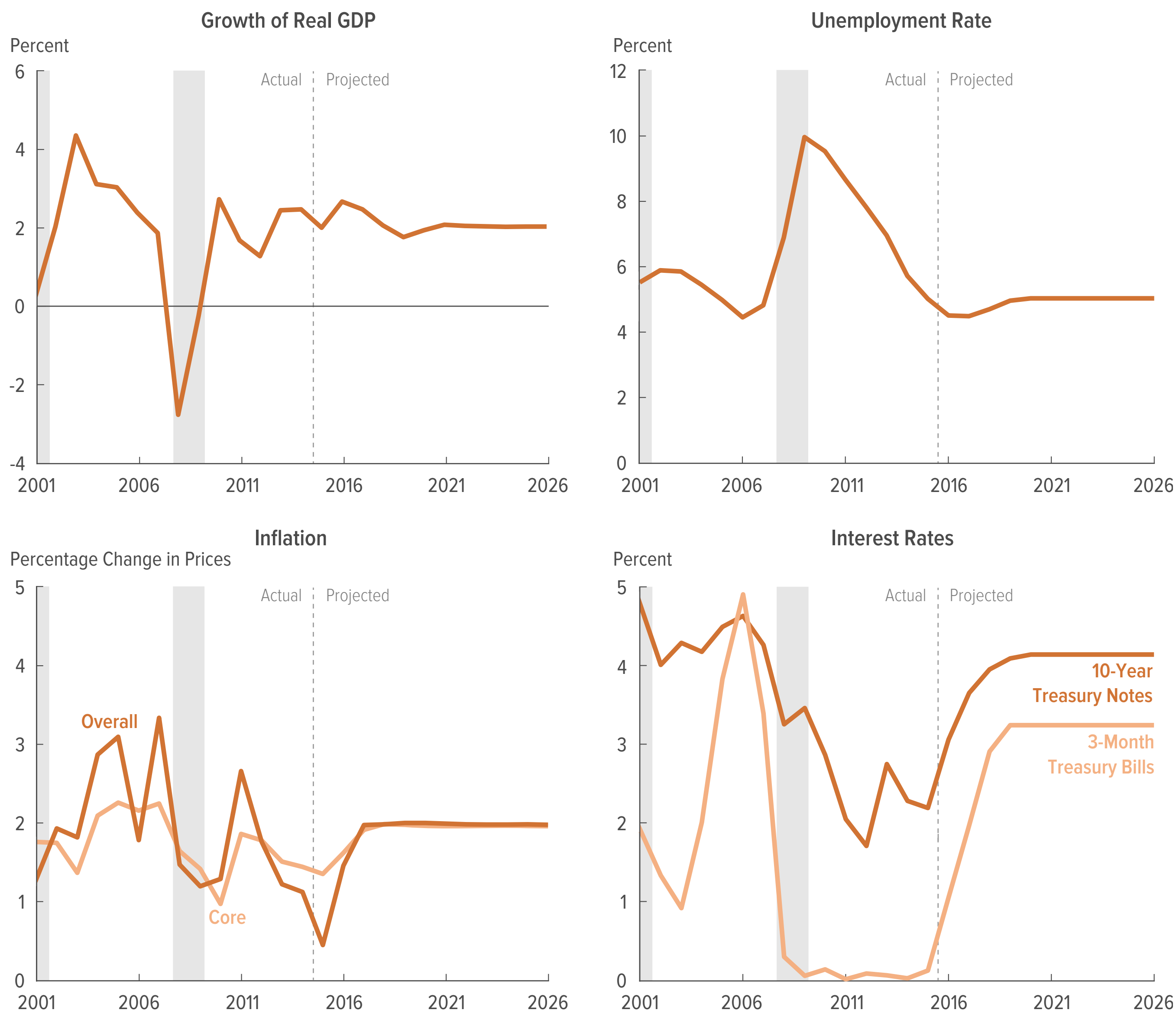
Source: Congressional Budget Office.

Summary Figure 2.

Return to Reference

Key Economic Indicators

CBO projects that economic activity will expand at a solid pace this year and next, lowering the unemployment rate and putting upward pressure on inflation and interest rates.



Source: Congressional Budget Office, using data from the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the Federal Reserve.

Real gross domestic product is the output of the economy adjusted to remove the effects of inflation. The unemployment rate is a measure of the number of jobless people who are available for work and are actively seeking jobs, expressed as a percentage of the labor force. The overall inflation rate is based on the price index for personal consumption expenditures; the core rate excludes prices for food and energy.

Data are annual. For real GDP growth and inflation, actual data are plotted through 2014, and percentage changes are measured from the fourth quarter of one calendar year to the fourth quarter of the next year. For the unemployment rate and interest rates, actual data are plotted through 2015, and all data are fourth-quarter values.

GDP = gross domestic product.

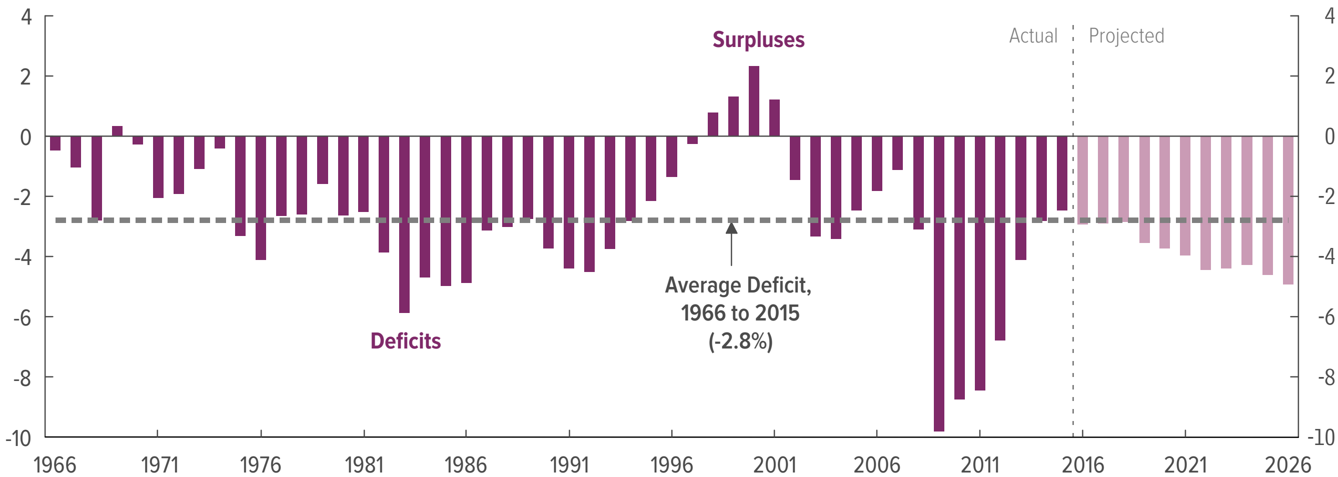
Figure 1-1.

Return to Reference

Total Deficits or Surpluses

CBO projects that deficits will exceed 4 percent of GDP by 2022 as mandatory spending and interest payments rise while revenues remain relatively flat.

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

Table 1-1.

Return to Reference

Deficits Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Revenues	3,249	3,376	3,511	3,633	3,747	3,917	4,076	4,244	4,421	4,610	4,818	5,035	18,883	42,010
Outlays	3,687	3,919	4,072	4,206	4,485	4,727	4,968	5,288	5,498	5,699	6,044	6,401	22,458	51,388
Total Deficit	**-439**	**-544**	**-561**	**-572**	**-738**	**-810**	**-893**	**-1,044**	**-1,077**	**-1,089**	**-1,226**	**-1,366**	**-3,575**	**-9,378**
Net Interest	223	255	308	369	438	498	551	607	666	719	772	830	2,165	5,759
Primary Deficit[a]	-215	-289	-253	-203	-300	-312	-341	-438	-411	-370	-454	-536	-1,410	-3,619
Memorandum (As a percentage of GDP):														
Total Deficit	-2.5	-2.9	-2.9	-2.8	-3.5	-3.7	-4.0	-4.4	-4.4	-4.3	-4.6	-4.9	-3.4	-4.0
Primary Deficit[a]	-1.2	-1.6	-1.3	-1.0	-1.4	-1.4	-1.5	-1.9	-1.7	-1.5	-1.7	-1.9	-1.3	-1.6
Debt Held by the Public at the End of the Year	73.6	75.6	75.7	75.7	76.7	77.8	78.8	80.3	81.7	82.8	84.3	86.1	n.a.	n.a.

Source: Congressional Budget Office.

GDP = gross domestic product; n.a. = not applicable.

a. Excludes net interest.

Table 1-2.

Return to Reference

CBO's Baseline Budget Projections

													Total	
	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2017-2021	2017-2026
							In Billions of Dollars							
Revenues														
Individual income taxes	1,541	1,621	1,739	1,827	1,902	1,987	2,084	2,184	2,292	2,406	2,529	2,657	9,539	21,608
Payroll taxes	1,065	1,101	1,143	1,182	1,222	1,264	1,314	1,365	1,417	1,471	1,531	1,593	6,126	13,503
Corporate income taxes	344	327	348	353	358	391	391	397	402	410	421	434	1,842	3,907
Other	299	327	280	272	264	274	287	298	310	322	337	351	1,376	2,993
Total	**3,249**	**3,376**	**3,511**	**3,633**	**3,747**	**3,917**	**4,076**	**4,244**	**4,421**	**4,610**	**4,818**	**5,035**	**18,883**	**42,010**
On-budget	2,478	2,580	2,682	2,774	2,859	2,999	3,126	3,260	3,401	3,552	3,720	3,895	14,441	32,269
Off-budget[a]	770	796	829	859	888	917	949	984	1,020	1,058	1,098	1,139	4,442	9,741
Outlays														
Mandatory	2,299	2,466	2,558	2,633	2,825	2,981	3,143	3,375	3,500	3,622	3,875	4,142	14,140	32,653
Discretionary	1,165	1,198	1,206	1,203	1,222	1,248	1,274	1,307	1,332	1,358	1,397	1,429	6,152	12,975
Net interest	223	255	308	369	438	498	551	607	666	719	772	830	2,165	5,759
Total	**3,687**	**3,919**	**4,072**	**4,206**	**4,485**	**4,727**	**4,968**	**5,288**	**5,498**	**5,699**	**6,044**	**6,401**	**22,458**	**51,388**
On-budget	2,944	3,147	3,258	3,343	3,563	3,741	3,914	4,158	4,291	4,411	4,668	4,932	17,818	40,278
Off-budget[a]	743	772	814	863	922	986	1,055	1,130	1,207	1,288	1,376	1,469	4,640	11,110
Deficit (-) or Surplus	**-439**	**-544**	**-561**	**-572**	**-738**	**-810**	**-893**	**-1,044**	**-1,077**	**-1,089**	**-1,226**	**-1,366**	**-3,575**	**-9,378**
On-budget	-466	-567	-576	-569	-704	-741	-787	-899	-890	-859	-948	-1,036	-3,377	-8,010
Off-budget[a]	27	23	15	-4	-34	-69	-105	-146	-187	-230	-278	-330	-197	-1,369
Debt Held by the Public	13,117	13,978	14,613	15,244	16,033	16,886	17,813	18,891	20,003	21,129	22,399	23,817	n.a.	n.a.
Memorandum:														
Gross Domestic Product	17,810	18,494	19,297	20,127	20,906	21,710	22,593	23,528	24,497	25,506	26,559	27,660	104,632	232,382
							As a Percentage of Gross Domestic Product							
Revenues														
Individual income taxes	8.7	8.8	9.0	9.1	9.1	9.2	9.2	9.3	9.4	9.4	9.5	9.6	9.1	9.3
Payroll taxes	6.0	6.0	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.8
Corporate income taxes	1.9	1.8	1.8	1.8	1.7	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.8	1.7
Other	1.7	1.8	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Total	**18.2**	**18.3**	**18.2**	**18.1**	**17.9**	**18.0**	**18.0**	**18.0**	**18.0**	**18.1**	**18.1**	**18.2**	**18.0**	**18.1**
On-budget	13.9	13.9	13.9	13.8	13.7	13.8	13.8	13.9	13.9	13.9	14.0	14.1	13.8	13.9
Off-budget[a]	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.2	4.2
Outlays														
Mandatory	12.9	13.3	13.3	13.1	13.5	13.7	13.9	14.3	14.3	14.2	14.6	15.0	13.5	14.1
Discretionary	6.5	6.5	6.2	6.0	5.8	5.7	5.6	5.6	5.4	5.3	5.3	5.2	5.9	5.6
Net interest	1.3	1.4	1.6	1.8	2.1	2.3	2.4	2.6	2.7	2.8	2.9	3.0	2.1	2.5
Total	**20.7**	**21.2**	**21.1**	**20.9**	**21.5**	**21.8**	**22.0**	**22.5**	**22.4**	**22.3**	**22.8**	**23.1**	**21.5**	**22.1**
On-budget	16.5	17.0	16.9	16.6	17.0	17.2	17.3	17.7	17.5	17.3	17.6	17.8	17.0	17.3
Off-budget[a]	4.2	4.2	4.2	4.3	4.4	4.5	4.7	4.8	4.9	5.1	5.2	5.3	4.4	4.8
Deficit (-) or Surplus	**-2.5**	**-2.9**	**-2.9**	**-2.8**	**-3.5**	**-3.7**	**-4.0**	**-4.4**	**-4.4**	**-4.3**	**-4.6**	**-4.9**	**-3.4**	**-4.0**
On-budget	-2.6	-3.1	-3.0	-2.8	-3.4	-3.4	-3.5	-3.8	-3.6	-3.4	-3.6	-3.7	-3.2	-3.4
Off-budget[a]	0.2	0.1	0.1	*	-0.2	-0.3	-0.5	-0.6	-0.8	-0.9	-1.0	-1.2	-0.2	-0.6
Debt Held by the Public	73.6	75.6	75.7	75.7	76.7	77.8	78.8	80.3	81.7	82.8	84.3	86.1	n.a.	n.a.

Source: Congressional Budget Office.

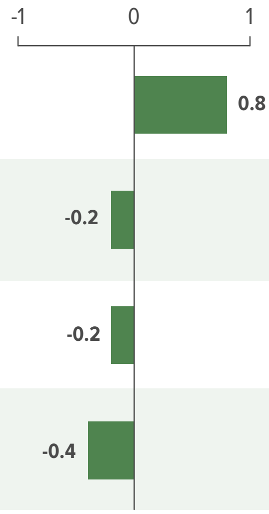
n.a. = not applicable; * = between -0.05 percent and zero.

a. The revenues and outlays of the Social Security trust funds and the net cash flow of the Postal Service are classified as off-budget.

Figure 1-2.

Return to Reference

Major Changes in Projected Revenues From 2016 to 2026



Revenues as a Percentage of GDP	2016	2026	Percentage-Point Change	Major Reasons for Change
Individual Income Taxes	8.8	9.6	0.8	• Real bracket creep[a] • Increased distributions from retirement accounts, relative to GDP • Rising income inequality
Payroll Taxes	6.0	5.8	-0.2	Rising income inequality
Corporate Income Taxes	1.8	1.6	-0.2	Smaller domestic profits, relative to GDP
Federal Reserve Remittances	0.6	0.2	-0.4	Return to historical averages

Source: Congressional Budget Office.

GDP = gross domestic product.

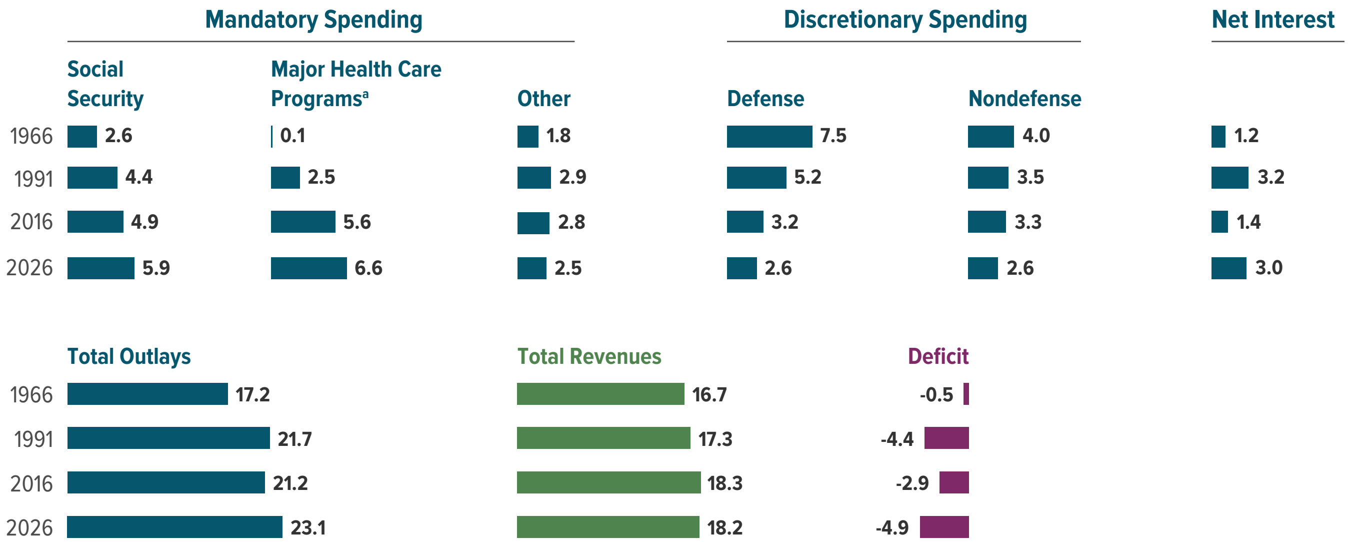
a. Real bracket creep occurs when more income is pushed into higher tax brackets because people's incomes are rising faster than inflation.

Figure 1-3.

Return to Reference

Spending and Revenues Projected in CBO's Baseline, Compared With Actual Values in 1966 and 1991

Percentage of Gross Domestic Product



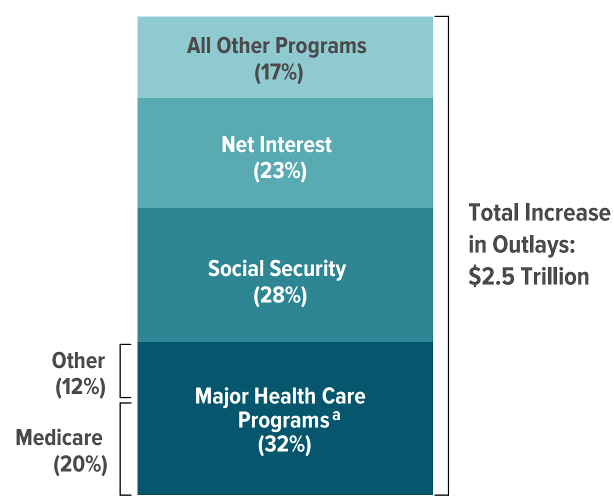
Source: Congressional Budget Office.

a. Consists of Medicare (net of premiums and other offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through exchanges and related spending.

Figure 1-4.

Return to Reference

Components of the Total Increase in Outlays in CBO's Baseline Between 2016 and 2026



Source: Congressional Budget Office.

Because October 1, 2016, falls on a weekend, certain payments that are due on that day will instead be made at the end of September, thus shifting them into fiscal year 2016. The data shown here are adjusted for the effects of those shifts.

a. Consists of Medicare (net of premiums and other offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through exchanges and related spending.

Table 1-3.

Return to Reference

Federal Debt Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Debt Held by the Public at the Beginning of the Year	12,779	13,117	13,978	14,613	15,244	16,033	16,886	17,813	18,891	20,003	21,129	22,399
Changes in Debt Held by the Public												
Deficit	439	544	561	572	738	810	893	1,044	1,077	1,089	1,226	1,366
Other means of financing	-102	318	74	58	51	43	34	33	35	36	44	52
Total	337	862	635	630	789	853	927	1,078	1,112	1,126	1,270	1,418
Debt Held by the Public at the End of the Year	**13,117**	**13,978**	**14,613**	**15,244**	**16,033**	**16,886**	**17,813**	**18,891**	**20,003**	**21,129**	**22,399**	**23,817**
Debt Held by the Public at the End of the Year (As a percentage of GDP)	**73.6**	**75.6**	**75.7**	**75.7**	**76.7**	**77.8**	**78.8**	**80.3**	**81.7**	**82.8**	**84.3**	**86.1**
Memorandum:												
Debt Held by the Public Minus Financial Assets[a]												
In billions of dollars	11,755	12,501	13,042	13,593	14,309	15,096	15,965	16,985	18,037	19,100	20,300	21,641
As a percentage of GDP	66.0	67.6	67.6	67.5	68.4	69.5	70.7	72.2	73.6	74.9	76.4	78.2
Gross Federal Debt[b]	18,143	19,332	20,093	20,864	21,737	22,635	23,574	24,649	25,745	26,834	28,003	29,314
Debt Subject to Limit[c]	18,113	19,301	20,062	20,833	21,706	22,603	23,542	24,617	25,712	26,801	27,970	29,280
Average Interest Rate on Debt Held by the Public (Percent)[d]	1.7	1.8	2.1	2.4	2.7	2.9	3.1	3.2	3.3	3.4	3.4	3.5

Source: Congressional Budget Office.

GDP = gross domestic product.

a. Debt held by the public minus the value of outstanding student loans and other credit transactions, cash balances, and other financial instruments.

b. Federal debt held by the public plus Treasury securities held by federal trust funds and other government accounts.

c. The amount of federal debt that is subject to the overall limit set in law. Debt subject to limit differs from gross federal debt mainly because most debt issued by agencies other than the Treasury and the Federal Financing Bank is excluded from the debt limit. That limit was most recently set at $18.4 trillion but has been suspended through March 15, 2017. On March 16, 2017, the debt limit will be raised to its previous level plus the amount
of federal borrowing that occurred while the limit was suspended.

d. The average interest rate is calculated as net interest divided by debt held by the public.

Table 1-4.

Return to Reference

Changes in CBO's Baseline Projections of the Deficit Since August 2015

Billions of Dollars

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total 2016-2020	Total 2016-2025
Deficit in CBO's August 2015 Baseline	-414	-416	-454	-596	-687	-767	-885	-895	-886	-1,008	-2,566	-7,007
Changes												
Legislative												
Revenues	-134	-91	-62	-48	-8	8	-7	-19	-29	-36	-343	-425
Outlays	30	31	16	31	35	37	39	42	45	17	143	324
Subtotal	-164	-123	-78	-78	-43	-29	-46	-61	-74	-53	-487	-749
Economic												
Revenues	-33	-39	-40	-53	-67	-82	-95	-108	-120	-132	-233	-771
Outlays	-16	-23	-32	-34	-37	-36	-37	-38	-42	-40	-142	-334
Subtotal	-17	-16	-9	-19	-30	-46	-58	-69	-79	-93	-92	-437
Technical												
Revenues	28	13	6	1	-12	-15	-13	-13	-13	-14	37	-30
Outlays	-23	20	37	46	38	36	42	39	39	59	118	333
Subtotal	51	-7	-31	-45	-50	-51	-55	-52	-51	-73	-81	-363
Increase (-) in the Deficit	**-130**	**-146**	**-118**	**-142**	**-123**	**-126**	**-159**	**-182**	**-204**	**-218**	**-659**	**-1,549**
Deficit in CBO's January 2016 Baseline	-544	-561	-572	-738	-810	-893	-1,044	-1,077	-1,089	-1,226	-3,225	-8,556
Memorandum:												
Changes in Revenues	-139	-117	-96	-100	-87	-88	-115	-139	-162	-182	-540	-1,226
Changes in Outlays	-9	28	22	42	37	38	44	43	42	37	120	323

Source: Congressional Budget Office.

Table 1-5.

Return to Reference

Budgetary Effects of Selected Policy Alternatives Not Included in CBO's Baseline

Billions of Dollars

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Policy Alternatives That Affect Discretionary Outlays													
Increase Discretionary Appropriations at the Rate of Inflation After 2016[a]													
Increase (-) in the deficit[b]	0	-23	-55	-69	-75	-81	-85	-88	-91	-94	-97	-303	-757
Debt service	0	*	-1	-4	-6	-10	-13	-16	-20	-24	-29	-21	-124
Freeze Discretionary Appropriations at the 2016 Amount[c]													
Increase (-) or decrease in the deficit[b]	0	-9	-16	-2	22	48	77	108	139	172	207	43	746
Debt service	0	*	*	-1	-1	1	3	6	11	17	24	-1	61
Policy Alternative That Affects Both Discretionary and Mandatory Outlays													
Prevent the Automatic Spending Reductions Specified in the Budget Control Act[d]													
Increase (-) in the deficit[b]	n.a.	-7	-65	-89	-97	-100	-105	-107	-110	-120	-97	-358	-897
Debt service	n.a.	*	-1	-4	-7	-11	-15	-20	-24	-29	-34	-24	-147
Policy Alternatives That Affect the Tax Code[e]													
Extend Partial Expensing of Equipment Property[f]													
At 50 percent rate													
Increase (-) in the deficit[b]	n.a.	n.a.	-9	-21	-52	-56	-38	-27	-20	-15	-11	-138	-248
Debt service	n.a.	n.a.	*	-1	-2	-4	-6	-7	-8	-9	-10	-7	-47
At 30 percent rate													
Increase (-) in the deficit[b]	n.a.	n.a.	n.a.	n.a.	-30	-41	-27	-19	-14	-10	-7	-72	-149
Debt service	n.a.	n.a.	n.a.	n.a.	-1	-2	-3	-4	-5	-5	-6	-2	-26
Extend Other Expiring Tax Provisions[g]													
Increase (-) in the deficit[b]	0	-4	-12	-13	-15	-18	-19	-21	-23	-25	-28	-61	-178
Debt service	0	*	*	-1	-1	-2	-3	-3	-4	-5	-7	-4	-27

Continued

Table 1-5. Continued

Budgetary Effects of Selected Policy Alternatives Not Included in CBO's Baseline

Billions of Dollars

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
						Policy Alternatives That Affect the Tax Code[e] (Continued)							
Repeal Certain Postponed Health Taxes[h]													
Increase (-) in the deficit[b]	n.a.	n.a.	-13	-15	-18	-26	-29	-32	-36	-41	-46	-72	-256
Debt service	n.a.	n.a.	*	-1	-1	-2	-3	-4	-6	-7	-9	-4	-34
Memorandum:													
Deficit in CBO's Baseline	-544	-561	-572	-738	-810	-893	-1,044	-1,077	-1,089	-1,226	-1,366	-3,575	-9,378

Sources: Congressional Budget Office; staff of the Joint Committee on Taxation.

n.a. = not applicable; * = between -$500 million and zero.

a. These estimates reflect the assumption that appropriations will not be constrained by caps set by the Budget Control Act of 2011 as amended and will instead grow at the rate of inflation from their 2016 level. Discretionary funding related to federal personnel is inflated using the employment cost index for wages and salaries; other discretionary funding is inflated using the gross domestic product price index.

b. Excludes debt service.

c. This option reflects the assumption that appropriations would generally be frozen at the 2016 level through 2026.

d. The Budget Control Act of 2011 specified that if lawmakers did not enact legislation originating from the Joint Select Committee on Deficit Reduction that would reduce projected deficits by at least $1.2 trillion, automatic procedures would go into effect to reduce both discretionary and mandatory spending during the 2013–2021 period. Those procedures are now in effect and take the form of equal cuts (in dollar terms) in funding for defense and nondefense programs. For the 2018–2021 period, the automatic procedures lower the caps on discretionary budget authority specified in the Budget Control Act (caps for 2016 and 2017 were revised by the Bipartisan Budget Act of 2015); for the 2022–2026 period, CBO has extrapolated the reductions estimated for 2021. Nonexempt mandatory programs will be reduced through sequestration; those provisions have been extended through 2025. The budgetary effects of this option cannot be combined with either of the other alternatives that affect discretionary spending.

e. The estimates are from CBO and the staff of the Joint Committee on Taxation and are preliminary.

f. This alternative would extend the provisions that allow businesses with large amounts of investment to expense (immediately deduct from their taxable income) a portion of the cost of their investment in equipment and certain other property. Under current law, the portion that can be expensed is 50 percent through 2017, 40 percent in 2018, and 30 percent in 2019, after which the provisions expire. One option would extend the 50 percent allowance permanently beyond 2017, and the other option would extend the 30 percent allowance permanently beyond 2019. In both cases, the alternative would include provisions that allow businesses to accelerate alternative minimum tax credits in lieu of the partial-expensing provisions, which expire under current law after 2019. Policymakers could choose to extend the partial-expensing provisions at a percentage of either 30 percent or 50 percent, but not both; that is, the options could not be applied together and the separate budgetary estimates added together.

g. This option would extend about 40 tax provisions that are scheduled under current law to expire before 2027. It does not include an extension of the partial-expensing provisions or a repeal of certain health provisions; those effects are shown separately.

h. This option would repeal the health insurance provider tax, the medical device excise tax, and the excise tax on certain health insurance plans with high premiums. All were postponed for either one or two years in the Consolidated Appropriations Act, 2016. The estimate includes a decrease in revenues of $277 billion over the 2018–2026 period and a decrease in outlays of $21 billion over the 2020–2026 period; that decrease in outlays occurs because some people who would have otherwise been enrolled in insurance obtained through Medicaid and the exchanges would instead enroll in employment-based coverage if the tax on certain health insurance plans with high premiums was repealed.

Table 1-6.

Return to Reference

Key Projections in CBO's Extended Baseline

Percentage of Gross Domestic Product

			Projected Annual Average			
	2016	2017	2018-2021	2022-2026	2027-2036[a]	2037-2046[a]
Revenues						
Individual income taxes	8.8	9.0	9.1	9.4	9.9	10.5
Payroll taxes	6.0	5.9	5.8	5.8	5.7	5.8
Corporate income taxes	1.8	1.8	1.8	1.6	1.6	1.6
Other sources of revenues	1.8	1.5	1.3	1.3	1.3	1.5
Total Revenues	**18.3**	**18.2**	**18.0**	**18.1**	**18.6**	**19.4**
Outlays						
Mandatory						
Social Security	4.9	4.9	5.2	5.7	6.2	6.3
Major health care programs[b]	5.6	5.6	5.7	6.3	7.4	8.7
Other mandatory programs	2.8	2.8	2.7	2.5	2.3	2.0
Subtotal	13.3	13.3	13.6	14.5	15.9	17.0
Discretionary	6.5	6.2	5.8	5.3	5.2	5.2
Net interest	1.4	1.6	2.2	2.8	4.0	5.4
Total Outlays	**21.2**	**21.1**	**21.5**	**22.6**	**25.1**	**27.6**
Deficit	**-2.9**	**-2.9**	**-3.5**	**-4.5**	**-6.6**	**-8.2**
Debt Held by the Public at the End of the Period	**76**	**76**	**79**	**86**	**116**	**155**
Memorandum:						
Social Security						
Revenues[c]	4.5	4.5	4.4	4.4	4.4	4.4
Outlays[d]	4.9	4.9	5.2	5.7	6.2	6.3
Net Increase (-) in the Deficit[e]	-0.4	-0.4	-0.7	-1.3	-1.9	-2.0
Medicare						
Revenues	1.3	1.3	1.4	1.4	1.3	1.3
Outlays[d]	3.7	3.6	3.8	4.4	5.4	6.7
Offsetting Receipts	-0.5	-0.6	-0.6	-0.7	-0.9	-1.1
Net Increase (-) in the Deficit[e]	-1.9	-1.7	-1.8	-2.3	-3.2	-4.3
Gross Domestic Product at the End of the Period (Trillions of dollars)	18.5	19.3	22.6	27.7	41.4	63.7

Source: Congressional Budget Office.

This table satisfies a requirement specified in section 3111 of S. Con. Res. 11, the Concurrent Resolution on the Budget for Fiscal Year 2016.

The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2026 and then extending the baseline concept for the following 20 years.

a. These projections do not reflect the macroeconomic feedback of the policies underlying the extended baseline after 2026, except for debt held by the public.

b. Consists of Medicare (net of premiums and other offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through exchanges and related spending.

c. Includes payroll taxes other than those paid by the federal government (which are intragovernmental transactions). Also includes income taxes paid on Social Security benefits, which are credited to the trust funds.

d. Does not include outlays related to administration of the program, which are discretionary. For Social Security, outlays do not include intragovernmental offsetting receipts stemming from payroll taxes paid on behalf of federal employees to the Social Security trust fund.

e. The net increase in the deficit shown in this table differs from the changes in the trust fund balance for the associated programs. It does not include intragovernmental transactions, interest earned on balances, and outlays related to administration of the programs.

Table 2-1.

Return to Reference

CBO's Economic Projections for Calendar Years 2016 to 2026

	Estimated,	Forecast		Projected Annual Average	
	2015	2016	2017	2018–2020	2021–2026
	Percentage Change From Fourth Quarter to Fourth Quarter				
Gross Domestic Product					
Real (Inflation-adjusted)	2.0	2.7	2.5	1.9	2.0
Nominal	3.4	4.3	4.4	3.9	4.1
Inflation					
PCE price index	0.5	1.5	2.0	2.0	2.0
Core PCE price index[a]	1.4	1.6	1.9	2.0	2.0
Consumer price index[b]	0.4	1.7	2.4	2.4	2.4
Core consumer price index[a]	2.0	2.0	2.2	2.3	2.3
GDP price index	1.3	1.6	1.9	2.0	2.0
Employment Cost Index[c]	2.2	2.9	3.3	3.3	3.2
	Fourth-Quarter Level (Percent)				
Unemployment Rate	5.0 [d]	4.5	4.5	5.0 [e]	5.0 [f]
	Percentage Change From Year to Year				
Gross Domestic Product					
Real	2.4	2.5	2.6	2.0	2.0
Nominal	3.5	4.1	4.4	4.0	4.1
Inflation					
PCE price index	0.3	1.1	1.9	2.0	2.0
Core PCE price index[a]	1.3	1.5	1.8	2.0	2.0
Consumer price index[b]	0.1	1.3	2.3	2.4	2.4
Core consumer price index[a]	1.8	2.0	2.2	2.3	2.3
GDP price index	1.1	1.6	1.8	2.0	2.0
Employment Cost Index[c]	2.3	2.6	3.2	3.3	3.2
	Calendar Year Average				
Unemployment Rate (Percent)	5.3 [d]	4.7	4.4	4.8	5.0
Payroll Employment (Monthly change, in thousands)[g]	228 [d]	172	124	65	75
Interest Rates (Percent)					
Three-month Treasury bills	0.1 [d]	0.7	1.6	3.0	3.2
Ten-year Treasury notes	2.1 [d]	2.8	3.5	4.0	4.1
Tax Bases (Percentage of GDP)					
Wages and salaries	43.6	43.9	43.9	43.9	43.9
Domestic economic profits	9.2	8.7	8.6	8.1	7.5

Source: Congressional Budget Office, using data from the Bureau of Labor Statistics and the Federal Reserve.

Economic projections for each year from 2016 to 2026 appear in Appendix E.

GDP = gross domestic product; PCE = personal consumption expenditures.

a. Excludes prices for food and energy.

b. The consumer price index for all urban consumers.

c. The employment cost index for wages and salaries of workers in private industries.

d. Actual value for 2015.

e. Value for 2020.

f. Value for 2026.

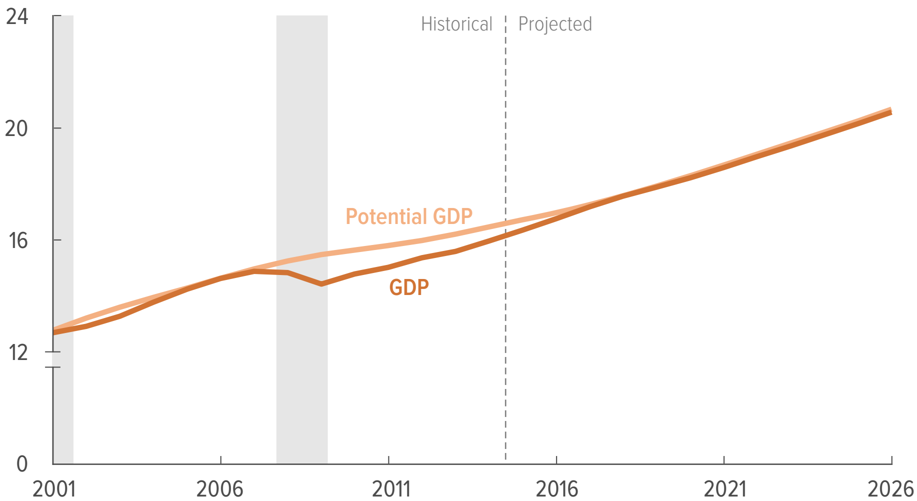
g. Calculated as the monthly average of the fourth-quarter-to-fourth-quarter change in payroll employment.

Figure 2-1.

Return to Reference

GDP and Potential GDP

Trillions of 2009 Dollars



The gap between the economy's actual and potential output will be largely eliminated by the middle of 2018 and then increase to its historical average—about one-half of one percent of potential GDP—by 2020 in CBO's projection.

Source: Congressional Budget Office, using data from the Bureau of Economic Analysis and the Bureau of Labor Statistics.

Potential gross domestic product is CBO's estimate of the maximum sustainable output of the economy.

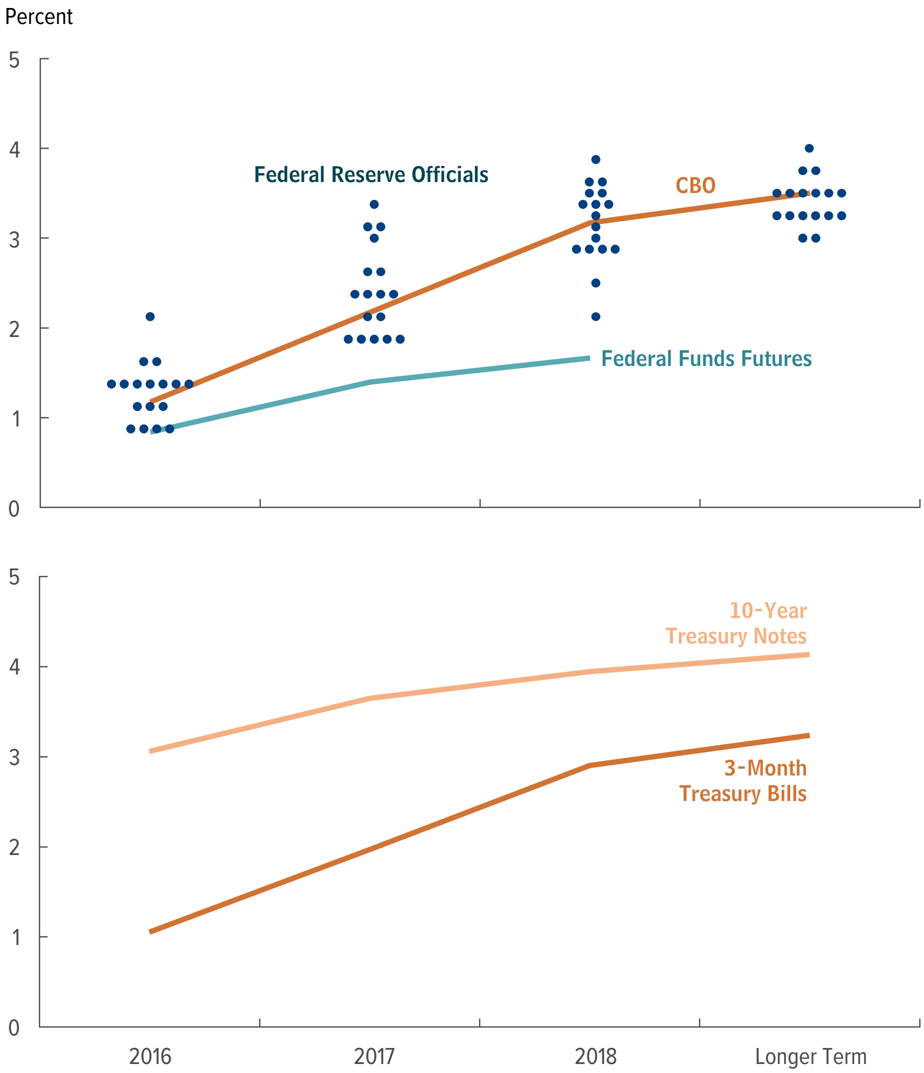
Data are calendar year averages.

GDP = gross domestic product.

Figure 2-2.

Return to Reference

Forecasts of Interest Rates by CBO, by Federal Reserve Officials, and Derived From Federal Funds Futures



CBO's forecast for the **federal funds rate** is below forecasts by most Federal Reserve officials for the next two years. CBO's forecast places some weight on the lower path for interest rates implied by prices in the futures market for federal funds.

CBO projects that **interest rates on Treasury securities** will rise steadily over the next few years, reflecting continued economic improvement and increases in the federal funds rate.

Sources: Congressional Budget Office; Bloomberg; Board of Governors of the Federal Reserve System, "Economic Projections of Federal Reserve Board Members and Federal Reserve Bank Presidents, December 2015" (December 16, 2015), http://go.usa.gov/cUkyR.

The 17 data points for each year in the top panel represent forecasts made by members of the Federal Reserve Board and presidents of the Federal Reserve Banks in December 2015. Forecasts are expected values at the end of the year. For the Federal Reserve, longer-term projections are described as the value at which each variable would settle under appropriate monetary policy and in the absence of further shocks to the economy.

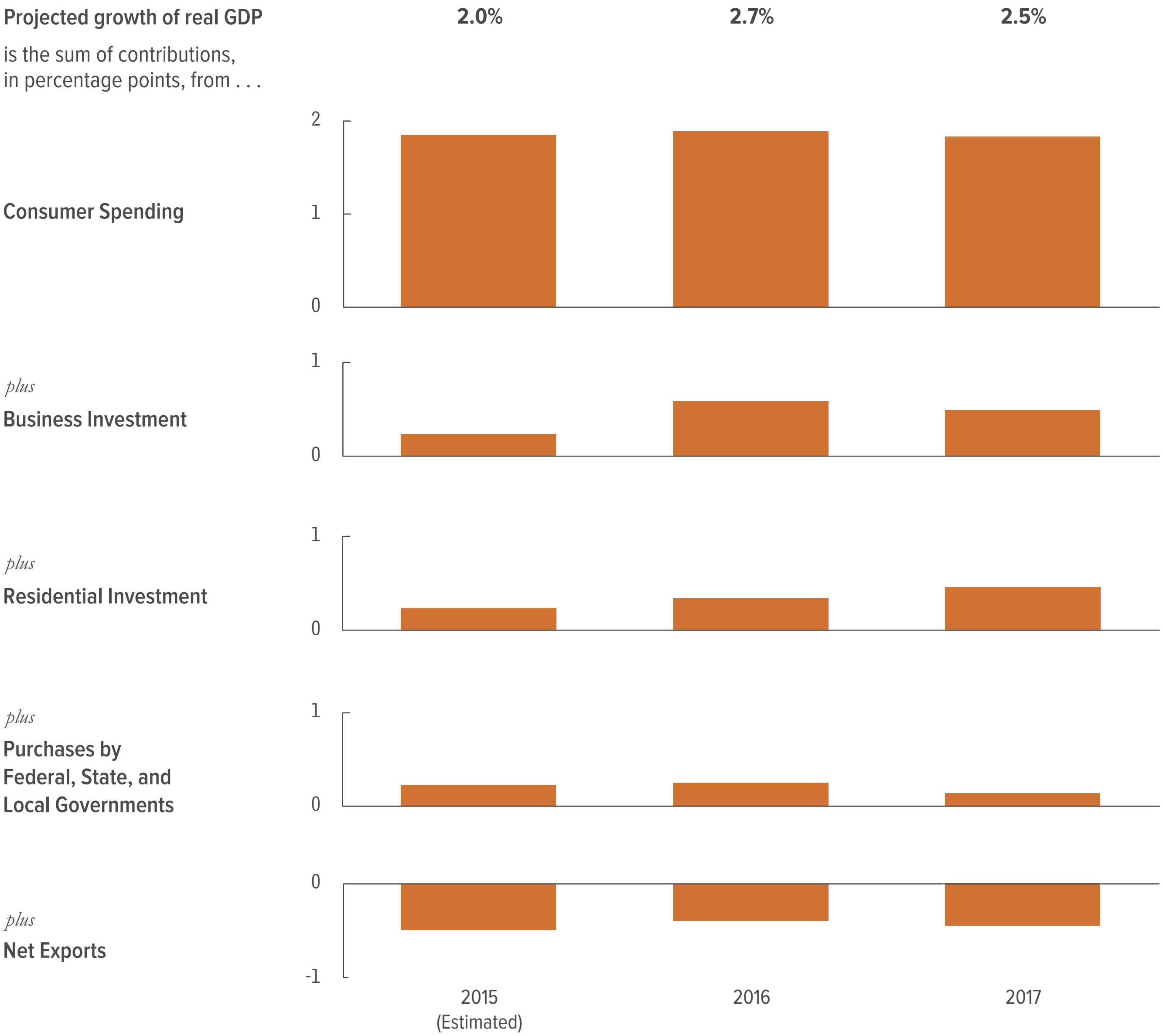
The forecast from the futures market for federal funds is dated December 31, 2015, corresponding to the last observation used for CBO's forecast. Values for 2016 and 2017 are averages for the fourth quarter of the year; the value for 2018 is the average of July and August of 2018, the last values available at the time of the forecast.

CBO's forecast values are for the fourth quarter of the year shown. CBO's forecast for the longer term is the value for 2026.

Figure 2-3.

Return to Reference

Projected Contributions to the Growth of Real GDP



Source: Congressional Budget Office.

The values show the projected contribution of the major components of GDP to the projected growth rate of real (inflation-adjusted) GDP. Consumer spending consists of personal consumption expenditures. Business investment includes purchases of equipment, nonresidential structures, and intellectual property products, as well as the change in inventories. Residential investment includes the construction of single-family and multifamily structures, manufactured homes, and dormitories; spending on home improvements; and brokers' commissions and other ownership-transfer costs. Purchases by federal, state, and local governments are taken from the national income and product accounts. Net exports are exports minus imports.

Changes are measured from the fourth quarter of one calendar year to the fourth quarter of the next year.

GDP = gross domestic product.

Table 2-2.

Return to Reference

Projected Growth in Components of Real GDP

	Estimated, 2015	Forecast 2016	Forecast 2017
	Change From Fourth Quarter to Fourth Quarter (Percent)		
Real GDP	2.0	2.7	2.5
Consumer Spending	2.7	2.7	2.6
Business Investment	1.9	4.8	4.0
Business Fixed Investment	2.6	5.4	4.5
Residential Investment	7.2	10.0	12.6
Purchases by Federal, State, and Local Governments	1.3	1.4	0.8
Federal	0.2	0.7	-0.7
State and local	1.9	1.9	1.7
Exports	0.9	3.0	4.7
Imports	4.1	5.2	6.9
	Change From Fourth Quarter to Fourth Quarter (Billions of 2009 dollars, annualized)		
Net Exports	-88	-77	-92

Source: Congressional Budget Office.

Real gross domestic product is the output of the economy adjusted to remove the effects of inflation. Consumer spending consists of personal consumption expenditures. Business investment includes purchases of equipment, nonresidential structures, and intellectual property products, as well as the change in inventories. Business fixed investment is the spending by businesses on structures, equipment, and software. Residential investment includes the construction of single-family and multifamily structures, manufactured homes, and dormitories; spending on home improvements; and brokers' commissions and other ownership-transfer costs. Purchases by federal, state, and local governments are taken from the national income and product accounts. Net exports are exports minus imports.

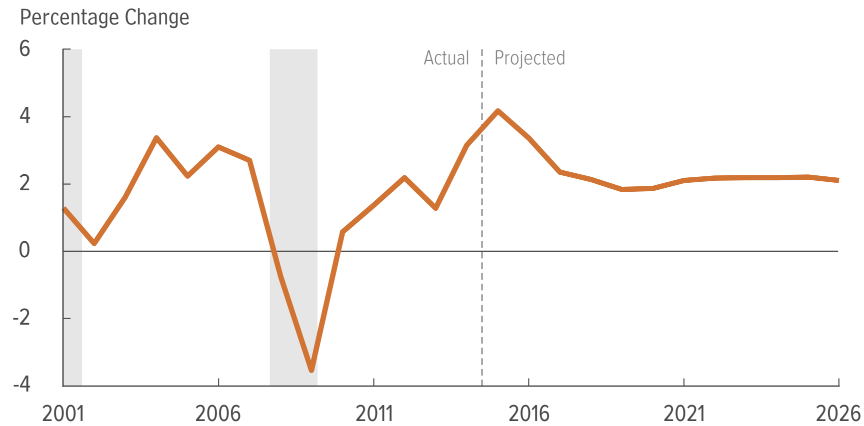
GDP = gross domestic product.

Figure 2-4.

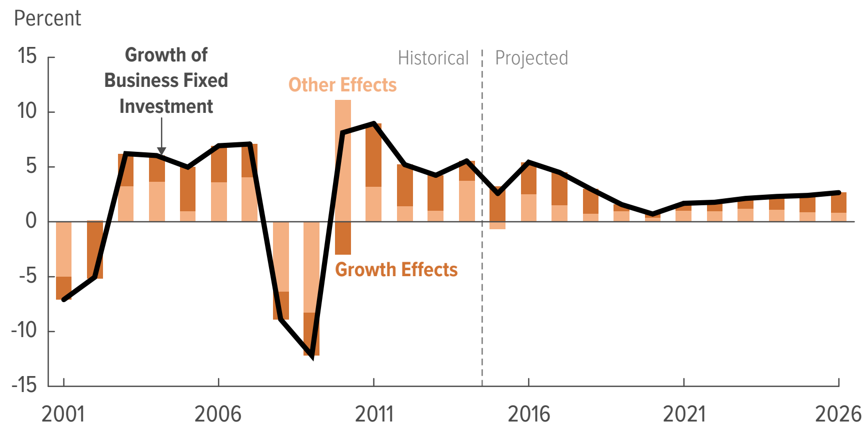
Return to Reference 1, 2, 3, 4

Factors Underlying the Projected Contributions to the Growth of Real GDP

Solid growth in the total amount of **inflation-adjusted compensation of employees** is projected to support growth in consumer spending in the next few years.



CBO expects the **effects of past and expected future growth of output** to drive the growth of business fixed investment over the next few years.



Source: Congressional Budget Office, using data from the Bureau of Economic Analysis, the Bureau of the Census, and the Federal Reserve.

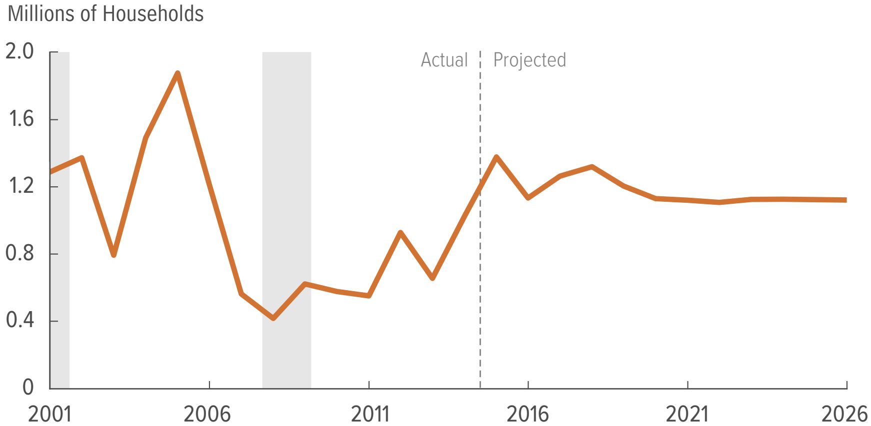
The total amount of real (inflation-adjusted) compensation of employees is the sum of total wages, salaries, and supplements divided by the price index for personal consumption expenditures. Percentage changes are measured from the average of one calendar year to the next year.

Growth effects are the estimated effects of past and expected future growth of output on the growth of real business fixed investment (purchases of equipment, nonresidential structures, and intellectual property products). In addition to replacing worn out and obsolete capital, businesses buy new capital to meet the growth of demand for their goods and services since the last time they purchased capital and to meet expected future growth of demand. All other effects include such factors as taxes and the cost of financing investments. Percentage changes are measured from the fourth quarter of one calendar year to the fourth quarter of the next year.

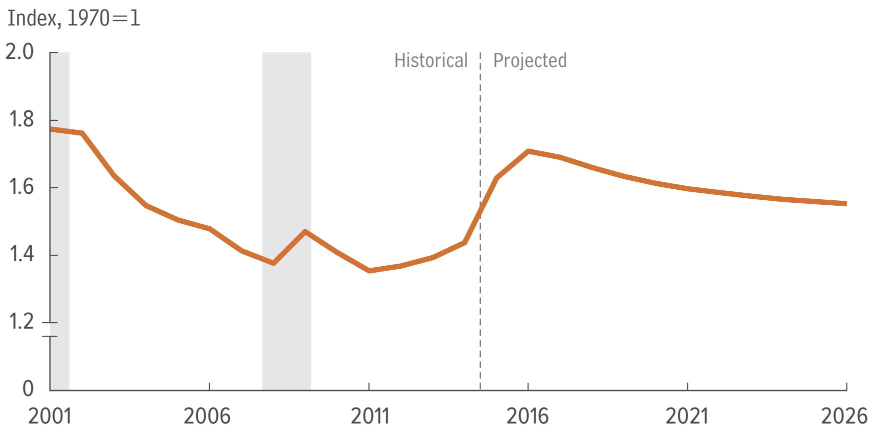
Continued

Figure 2-4. Continued

Factors Underlying the Projected Contributions to the Growth of Real GDP



Household formation, along with robust demand for replacement housing units and less restrictive mortgage lending standards, will contribute to solid growth in residential investment over the next few years.



The continued appreciation of the **exchange rate of the U.S. dollar** through 2016 is projected to contribute to lower net exports this year and next.

Household formation is the change in the average number of households from one calendar year to the next.

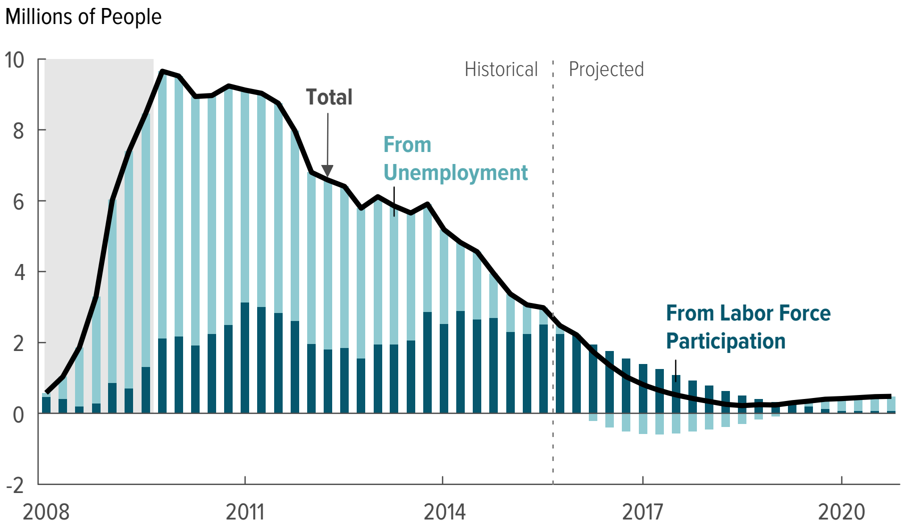
The measure of the exchange rate of the dollar is an export-weighted average of exchange rates between the dollar and the currencies of the United States' leading trading partners. Data are calendar year averages.

GDP = gross domestic product.

Figure 2-5.

Return to Reference

Employment Shortfall



The employment shortfall has dropped sharply since 2009 because of a decline in the unemployment rate; it currently remains elevated, however, mostly from low labor force participation.

Source: Congressional Budget Office, using data from the Bureau of Labor Statistics.

The employment shortfall from unemployment is the number of people who would be employed if the unemployment rate equaled its natural rate. (The natural rate is CBO's estimate of the rate arising from all sources except fluctuations in the overall demand for goods and services.) The shortfall from unemployment falls below zero from 2016 through early 2019, reflecting CBO's forecast that the unemployment rate will be below its natural rate during that period. The employment shortfall from labor force participation is the number of people who would be employed if the rate of labor force participation equaled its potential.

Data are quarterly.

Box 2-1.

Return to Reference

Slack in the Labor Market at the End of 2015

Slack in the labor market decreased last year but remained elevated. The Congressional Budget Office based that assessment on its analysis of the employment shortfall and measures of underused labor as well as indicators such as growth of compensation and rates of hiring and quitting.

The employment shortfall, CBO's primary measure of slack in the labor market, is the difference between actual employment and the agency's estimate of potential (maximum sustainable) employment. Potential employment is the employment that would exist if the unemployment rate was at the natural rate of unemployment (the rate that arises from all sources except fluctuations in the overall demand for goods and services) and the rate of labor force participation was at its potential rate. The contribution to the shortfall from the difference in unemployment rates is the difference between the number of jobless people searching for work at the current rate of unemployment and the number who would be jobless at the natural rate of unemployment. The contribution to the shortfall from the difference in participation rates is the difference between the number of people who are employed at the current labor force participation rate and the number who would potentially be employed if the participation rate reflected a labor market with healthy job prospects. CBO estimates that the employment shortfall was about 2½ million people at the end of last year. That shortfall was almost entirely accounted for by the depressed rate of labor force participation; CBO estimates that the unemployment rate was only slightly above its natural rate.

CBO's primary measure of labor market slack incorporates the most important sources of slack during the current recovery but does not include all possible sources. For example, another source of slack in the labor market is the continued unusually large percentage of part-time workers who would prefer to work full time. About 4 percent of all workers were employed part time for economic reasons (that is, because of weakness in the overall demand for goods and services) at the end of 2015, down from 4¾ percent at the end of 2014. Yet that rate is still about 1 percentage point above the rate in the fourth quarter of 2007. But how much of that difference is a measure of slack is hard to determine because part of the increase since 2007 may also be related to structural factors such as a changing composition of employment by industry. One such factor is a shift of employment to industries that employ a larger fraction of part-time workers, such as service industries. That development suggests that the share of workers working fewer hours than they prefer may be elevated as workers and firms adjust to those structural changes.[139]

Another source of slack is the number of people said to be marginally attached to the labor force (that is, who are not looking for work now but have looked for work in the past 12 months). That number is larger than before the recession, for example—about 1.8 million people at the end of last year, up from about 1.4 million in the fourth quarter of 2007. Since the elevated level of the number of people who are marginally attached to the labor force is closely related to the depressed rate of labor force participation, CBO's measure of the employment shortfall largely reflects that factor. Marginally attached people are included in the U-6 measure of underused labor computed by the Bureau of Labor Statistics, along with the number of unemployed people and the number of people employed part time for economic reasons. U-6 is expressed as a percentage of the number of people in the labor force plus the number of marginally attached workers. At the end of last year, the U-6 measure stood at 9.9 percent, greater than the 8.5 percent observed before the last recession.

Another measure of slack could focus on the number of hours worked, such as the average number of hours worked per week. CBO does not use hours to measure slack because the agency forecasts average hours worked per week for only a portion of the economy (the nonfarm business sector). Nonetheless, in 2015 the average number of hours worked per week had returned to its prerecession value, and average hours worked per week in the nonfarm business sector had returned to its historic relationship with potential average hours worked per week. That outcome suggests that any cyclical influence on average hours worked per week was not a significant source of slack in the labor market last year.[140]

Other economic indicators offered mixed signals about the amount of slack remaining in the labor market. The continued slow growth in hourly labor compensation compared with the growth in labor productivity and inflation indicated slack at the end of 2015. But two other indicators—the rate at which job seekers are hired and the rate at which workers are quitting their jobs (as a fraction of total employment)—suggested that slack had diminished considerably.

139. See Rob Valletta and Catherine van der List, "Involuntary Part-Time Work: Here to Stay?" FRBSF Economic Letter 2015-19 (Federal Reserve Bank of San Francisco, June 8, 2015), http://tinyurl.com/pbywpck.

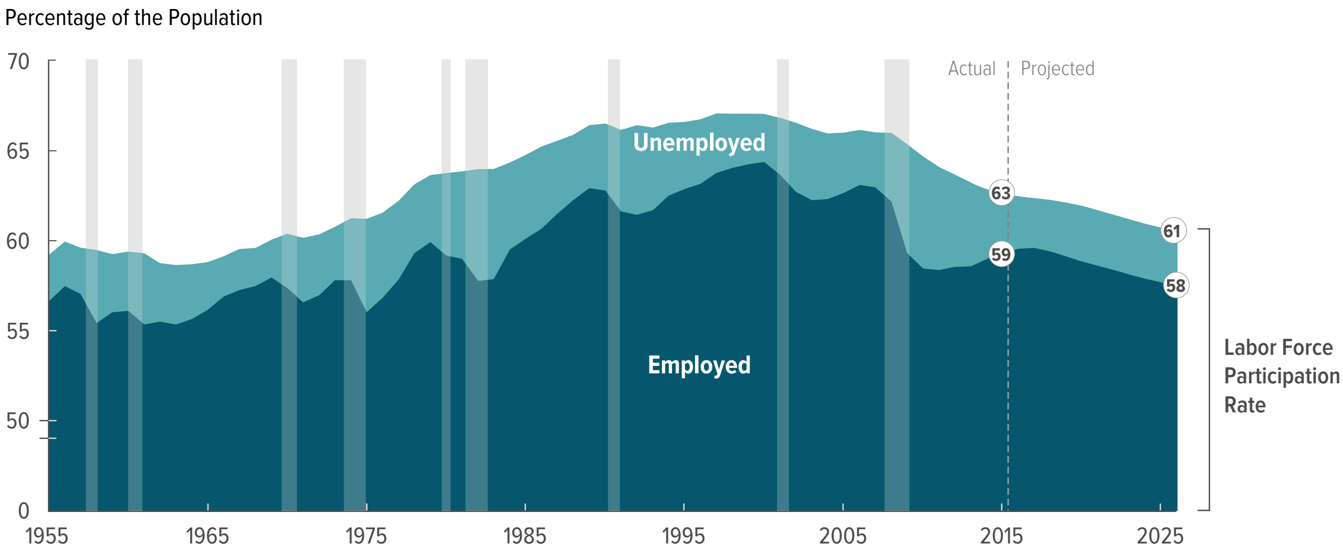
140. As measured by the number of people who work part time for economic reasons, the percentage of workers who would prefer to work more hours is higher than before the recession. Yet the average number of weekly hours worked per job has returned to its prerecession value. Those two developments can be reconciled by noting the following: First, the number of workers holding multiple jobs is depressed, putting downward pressure on average hours worked per worker. Second, the improvement in average weekly hours worked per job reflects in part more overtime hours. If those increases in overtime are concentrated in some jobs, average weekly hours may have rebounded even as a large share of workers would prefer more hours.

Figure 2-6.

Return to Reference

The Labor Force, Employment, and Unemployment

The percentage of the population that is employed is projected to remain roughly unchanged over the next few years and then decrease through 2026 because of declining participation in the labor force, mainly by baby boomers as they age and move into retirement.



Source: Congressional Budget Office, using data from the Bureau of Labor Statistics.

The labor force consists of people who are employed and people who are unemployed but who are available for work and are actively seeking jobs. Unemployment as a percentage of the population is not the same as the official unemployment rate, which is expressed as a percentage of the labor force. The population is the civilian noninstitutionalized population age 16 or older.

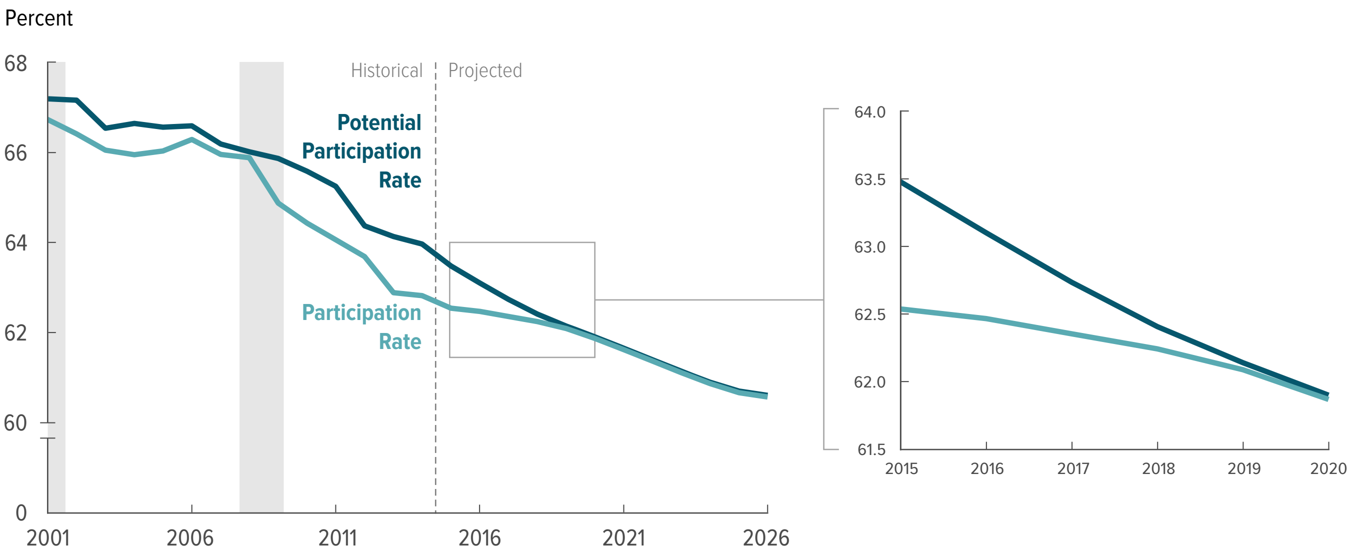
Data are calendar year averages.

Figure 2-7.

Return to Reference

Labor Force Participation Rates

CBO expects the rate of labor force participation to remain largely unchanged over the coming year and then to decline through 2026.



Source: Congressional Budget Office, using data from the Bureau of Labor Statistics.

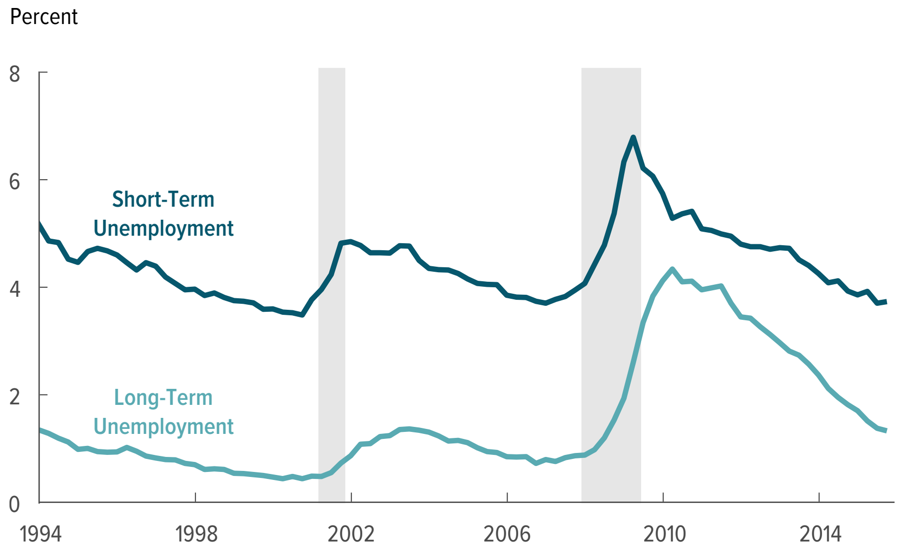
The participation rate is the percentage of people in the civilian noninstitutionalized population who are at least 16 years old and in the labor force. The labor force consists of people who are employed and people who are unemployed but who are available for work and are actively seeking jobs. The potential participation rate is the participation rate excluding the effects of the business cycle.

Data are fourth-quarter values.

Figure 2-8.

Return to Reference

Rates of Short- and Long-Term Unemployment



Most of the decline in the overall unemployment rate in the past few years reflected a drop in long-term unemployment, suggesting that the effects of stigma and the erosion of skills that can stem from long-term unemployment are diminishing.

Source: Congressional Budget Office, using data from the Bureau of Labor Statistics.

The rate of short-term unemployment is the percentage of the labor force that has been out of work for 26 weeks or less. The rate of long-term unemployment is the percentage of the labor force that has been out of work for at least 27 consecutive weeks.

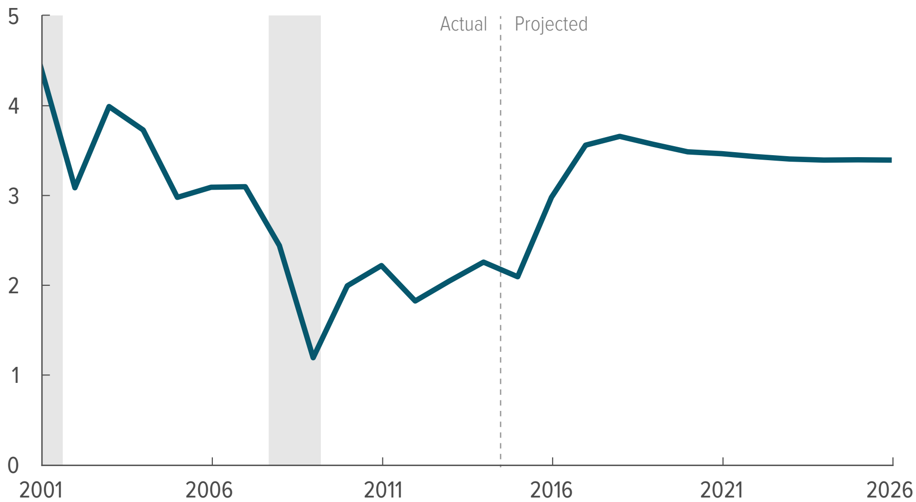
Data are quarterly and are plotted through 2015.

Figure 2-9.

Return to Reference

Hourly Labor Compensation

Percentage Change



CBO projects that growth over the next several years will be stronger than that in 2015, spurred by continued gains in the demand for labor, which will lower slack in the labor market, and faster growth in productivity and prices.

Source: Congressional Budget Office, using data from the Bureau of Labor Statistics.

Hourly labor compensation is measured by the employment cost index for total compensation—wages, salaries, and employers' costs for employees' benefits—of workers in private industry.

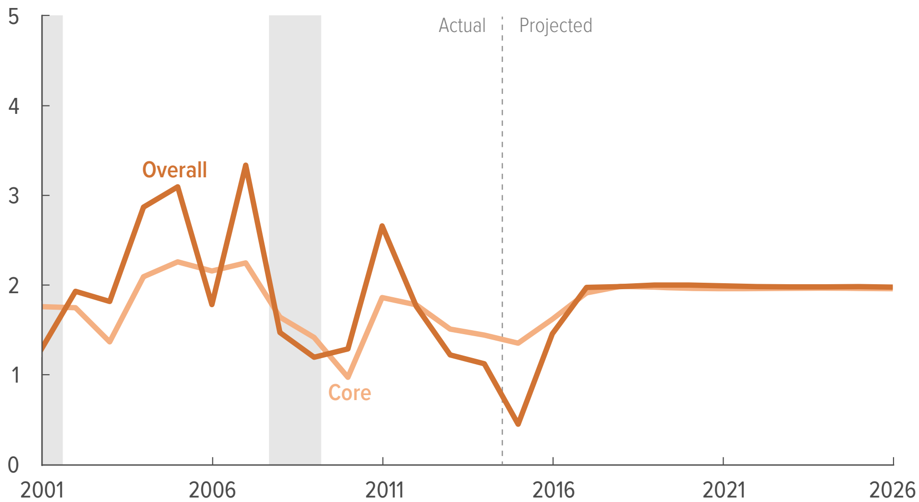
Percentage changes are measured from the fourth quarter of one calendar year to the fourth quarter of the next year.

Figure 2-10.

Return to Reference

Inflation

Percentage Change in Prices



CBO anticipates that inflation will rise to the Federal Reserve's goal of 2 percent over the next two years, which is consistent with CBO's projection of the diminishing slack in the economy.

Source: Congressional Budget Office, using data from the Bureau of Economic Analysis.

The overall inflation rate is based on the price index for personal consumption expenditures; the core rate excludes prices for food and energy.

Percentage changes are measured from the fourth quarter of one calendar year to the fourth quarter of the next year.

Table 2-3.

Return to Reference

Key Inputs in CBO's Projections of Potential GDP

Percent, by Calendar Year

	Average Annual Growth							Projected Average Annual Growth		
	1950-1973	1974-1981	1982-1990	1991-2001	2002-2007	2008-2015	Total, 1950-2015	2016-2020	2021-2026	Total, 2016-2026
Overall Economy										
Potential GDP	4.0	3.2	3.2	3.3	2.7	1.4	3.2	1.8	2.1	1.9
Potential Labor Force	1.6	2.5	1.6	1.3	1.0	0.5	1.5	0.4	0.5	0.5
Potential Labor Force Productivity[a]	2.4	0.7	1.5	2.0	1.6	0.9	1.7	1.4	1.5	1.4
Nonfarm Business Sector										
Potential Output	4.1	3.6	3.3	3.7	3.0	1.6	3.5	2.1	2.4	2.3
Potential Hours Worked	1.4	2.3	1.5	1.5	0.3	0.4	1.3	0.4	0.5	0.5
Capital Services	3.8	3.8	3.5	3.8	2.8	1.7	3.4	2.7	2.2	2.4
Potential TFP	1.9	0.9	1.1	1.5	1.9	0.8	1.5	1.1	1.4	1.2
Potential TFP excluding adjustments	1.9	0.9	1.1	1.5	1.5	0.8	1.4	1.1	1.4	1.2
Adjustments to TFP (Percentage points)[b]	0	0	0	0.1	0.4	*	0.1	*	*	*
Contributions to the Growth of Potential Output (Percentage points)										
Potential hours worked	1.0	1.6	1.1	1.0	0.2	0.3	0.9	0.3	0.4	0.3
Capital input	1.1	1.1	1.1	1.2	0.8	0.5	1.0	0.8	0.7	0.7
Potential TFP	1.9	0.9	1.1	1.5	1.9	0.8	1.5	1.1	1.4	1.2
Total Contributions	4.0	3.6	3.3	3.7	3.0	1.6	3.4	2.1	2.4	2.3
Potential Labor Productivity[c]	2.7	1.3	1.7	2.2	2.7	1.2	2.1	1.7	1.8	1.8

Source: Congressional Budget Office.

Potential GDP is CBO's estimate of the maximum sustainable output of the economy, adjusted to remove the effects of inflation.

GDP = gross domestic product; TFP = total factor productivity; * = between -0.05 percentage points and zero.

a. The ratio of potential GDP to the potential labor force.

b. The adjustments reflect CBO's estimate of the unusually rapid growth of TFP between 2001 and 2003, and changes in the average level of education and experience of the labor force.

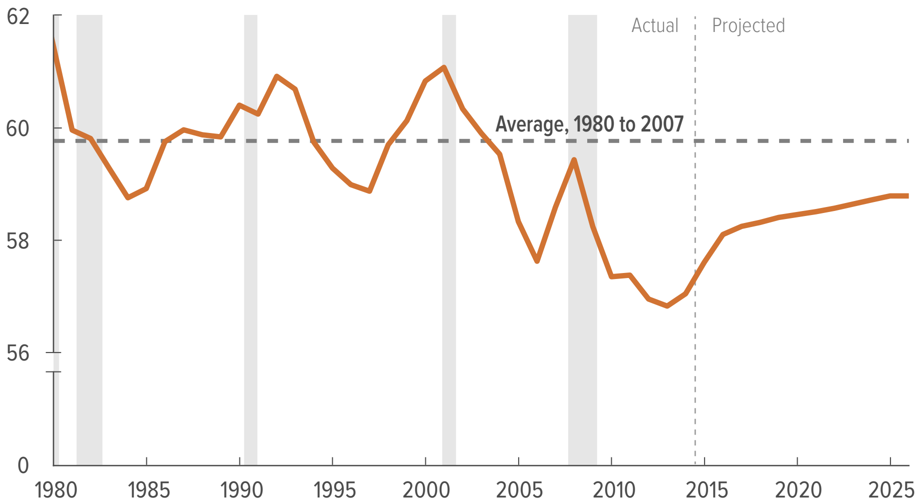
c. The ratio of potential output to potential hours worked in the nonfarm business sector.

Figure 2-11.

Return to Reference

Labor Income

Percentage of Gross Domestic Income



CBO expects the labor share of income to rise but remain below its average from 1980 to the beginning of the recession in 2007.

Source: Congressional Budget Office, using data from the Bureau of Economic Analysis.

Labor income is the sum of employees' compensation and CBO's estimate of the share of proprietors' income that is attributable to labor. Gross domestic income is all income earned in the production of gross domestic product. For further discussion of the labor share of income, see Congressional Budget Office, *How CBO Projects Income* (July 2013), www.cbo.gov/publication/44433.

Data are calendar year averages and are plotted through 2026.

Table 2-4.

Return to Reference

Comparison of CBO's Current and Previous Economic Projections for Calendar Years 2015 to 2025

	Estimated, 2015	Forecast		Projected Annual Average		
		2016	2017	2015–2020	2021–2025	2015–2025
			Percentage Change From Fourth Quarter to Fourth Quarter			
Real (Inflation-adjusted) GDP						
January 2016	2.0	2.7	2.5	2.2	2.0	2.1
August 2015	2.0	3.1	2.7	2.4	2.1	2.3
Nominal GDP						
January 2016	3.4	4.3	4.4	4.0	4.1	4.0
August 2015	3.2	4.7	4.7	4.3	4.3	4.3
PCE Price Index						
January 2016	0.5	1.5	2.0	1.6	2.0	1.8
August 2015	0.6	1.8	2.0	1.7	2.0	1.9
Core PCE Price Index[a]						
January 2016	1.4	1.6	1.9	1.8	2.0	1.9
August 2015	1.4	1.7	1.9	1.8	2.0	1.9
Consumer Price Index[b]						
January 2016	0.4	1.7	2.4	2.0	2.4	2.2
August 2015	0.7	2.3	2.3	2.1	2.4	2.2
Core Consumer Price Index[a]						
January 2016	2.0	2.0	2.2	2.2	2.3	2.3
August 2015	2.0	2.1	2.3	2.2	2.3	2.3
GDP Price Index						
January 2016	1.3	1.6	1.9	1.8	2.0	1.9
August 2015	1.1	1.6	2.0	1.8	2.1	1.9
Employment Cost Index[c]						
January 2016	2.2	2.9	3.3	3.1	3.2	3.1
August 2015	2.8	3.3	3.5	3.3	3.3	3.3
Real Potential GDP						
January 2016	1.5	1.6	1.7	1.8	2.0	1.9
August 2015	1.7	1.9	2.1	2.1	2.1	2.1
			Calendar Year Average			
Unemployment Rate (Percent)						
January 2016	5.3 [d]	4.7	4.4	4.8	5.0	4.9
August 2015	5.4	5.1	5.0	5.2	5.2	5.2
Interest Rates (Percent)						
Three-month Treasury bills						
January 2016	0.1 [d]	0.7	1.6	1.9	3.2	2.5
August 2015	0.1	0.7	1.7	2.0	3.4	2.6
Ten-year Treasury notes						
January 2016	2.1 [d]	2.8	3.5	3.4	4.1	3.7
August 2015	2.3	3.0	3.7	3.6	4.3	3.9
Tax Bases (Percentage of GDP)						
Wages and salaries						
January 2016	43.6	43.9	43.9	43.9	43.9	43.9
August 2015	43.4	43.5	43.5	43.5	43.5	43.5
Domestic economic profits						
January 2016	9.2	8.7	8.6	8.4	7.5	8.0
August 2015	9.7	9.3	8.9	8.7	7.6	8.1

Source: Congressional Budget Office, using data from the Bureau of Labor Statistics and the Federal Reserve.

GDP = gross domestic product; PCE = personal consumption expenditures.

a. Excludes prices for food and energy.

b. The consumer price index for all urban consumers.

c. The employment cost index for wages and salaries of workers in private industries.

d. Actual value for 2015.

Table 2-5.

Return to Reference

Sources of Revision Since August 2015 in CBO's Estimate of Potential Output in 2025

Percent

Source	Reduction in Potential Output
Potential Output in the Nonfarm Business Sector	
Total factor productivity	
New data	-1.1
New methodology	-0.8
Subtotal	-2.0
Capital services	-0.4
Potential hours worked	-0.2
Subtotal	-2.5
Potential Output in Other Sectors	-0.1
Total Revision	**-2.7**

Source: Congressional Budget Office.

Potential output is CBO's estimate of the maximum sustainable output of the economy.

Total factor productivity is average real (inflation-adjusted) output per unit of combined labor and capital services.

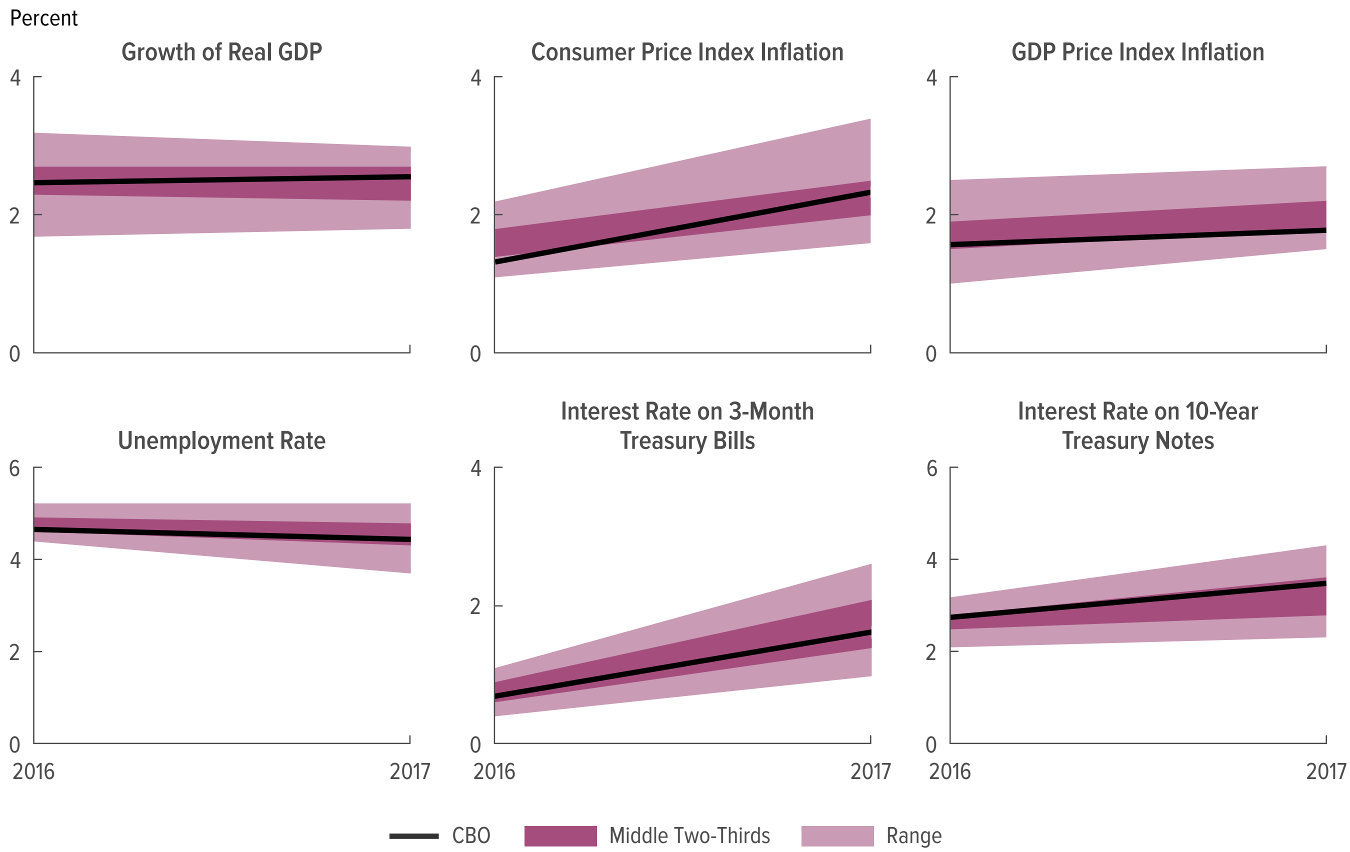
Capital services are a measure of the flow of services available for production from the stock of capital goods.

Other sectors include farm businesses, owner-occupied housing, nonprofit institutions serving households, the federal government, and state and local governments.

Figure 2-12. Return to Reference

Comparison of Economic Projections by CBO and *Blue Chip* Forecasters

CBO's projections of the growth of real GDP, inflation, the unemployment rate, and interest rates are generally within the middle two-thirds of the range of forecasts from the *Blue Chip* survey.



Sources: Congressional Budget Office; Wolters Kluwer, *Blue Chip Economic Indicators* (January 10, 2016).

The full range of forecasts from the *Blue Chip* reflects the highest and lowest forecasts among the roughly 50 forecasts in the survey. The middle two-thirds of that range omits the top one-sixth of the forecasts and the bottom one-sixth.

Real GDP is the output of the economy adjusted to remove the effects of inflation.

Consumer price index inflation uses the consumer price index for all urban consumers.

The unemployment rate is a measure of the number of jobless people who are available for work and are actively seeking jobs, expressed as a percentage of the labor force.

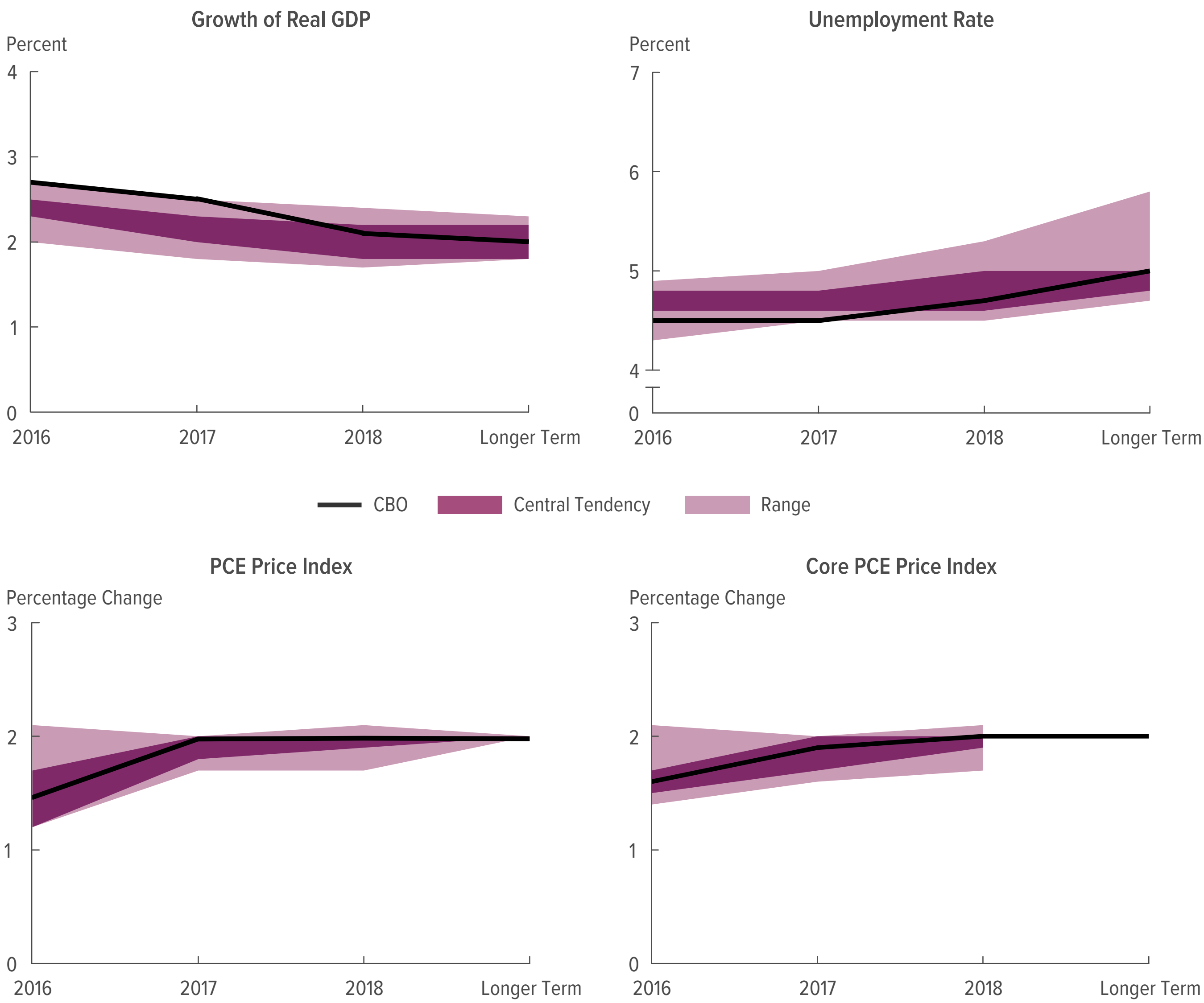
Growth of real GDP and inflation are measured from the average of one calendar year to the next year. The unemployment rate and interest rates are calendar year averages.

GDP = gross domestic product.

Figure 2-13. Return to Reference

Comparison of Economic Projections by CBO and Federal Reserve Officials

Over the next two years, CBO's forecast for the growth of real GDP is at the upper end of the range, and its forecast for the unemployment rate is at the lower end of the range, of forecasts by Federal Reserve officials.



Sources: Congressional Budget Office; Board of Governors of the Federal Reserve System, "Economic Projections of Federal Reserve Board Members and Federal Reserve Bank Presidents, December 2015" (December 16, 2015), http://go.usa.gov/cUkyR.

Each range of estimates from the Federal Reserve reflects the 17 projections by the Board of Governors and the president of each Federal Reserve Bank. The central tendency is that range without the three highest and three lowest projections, roughly indicating the middle two-thirds of the range.

For CBO, longer-term projections are values for 2026. For the Federal Reserve, longer-term projections are described as the value at which each variable would settle under appropriate monetary policy and in the absence of further shocks to the economy.

Real GDP is the output of the economy adjusted to remove the effects of inflation.

The unemployment rate is a measure of the number of jobless people who are available for work and are actively seeking jobs, expressed as a percentage of the labor force.

The core PCE price index excludes prices for food and energy.

Growth of real GDP and growth of price indexes are measured from the fourth quarter of one calendar year to the fourth quarter of the next year. The unemployment rate is a fourth-quarter value.

GDP = gross domestic product; PCE = personal consumption expenditures.

Table 3-1.

Return to Reference 1, 2

Outlays Projected in CBO's Baseline

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
							In Billions of Dollars							
Mandatory														
Social Security	882	910	946	1,002	1,066	1,133	1,205	1,281	1,360	1,441	1,528	1,618	5,352	12,580
Medicare[a]	634	692	699	711	787	845	907	1,015	1,048	1,075	1,193	1,288	3,949	9,569
Medicaid	350	381	401	420	439	460	484	509	536	564	593	642	2,205	5,049
Other spending	690	721	750	747	781	804	823	863	865	864	907	943	3,905	8,347
Offsetting receipts	-256	-237	-238	-247	-248	-262	-276	-294	-309	-323	-346	-350	-1,270	-2,892
Subtotal	2,299	2,466	2,558	2,633	2,825	2,981	3,143	3,375	3,500	3,622	3,875	4,142	14,140	32,653
Discretionary														
Defense	582	589	592	593	609	623	638	657	669	680	702	719	3,055	6,481
Nondefense	583	609	614	610	613	624	636	649	664	679	695	710	3,098	6,494
Subtotal	1,165	1,198	1,206	1,203	1,222	1,248	1,274	1,307	1,332	1,358	1,397	1,429	6,152	12,975
Net Interest	223	255	308	369	438	498	551	607	666	719	772	830	2,165	5,759
Total	**3,687**	**3,919**	**4,072**	**4,206**	**4,485**	**4,727**	**4,968**	**5,288**	**5,498**	**5,699**	**6,044**	**6,401**	**22,458**	**51,388**
On-budget	2,944	3,147	3,258	3,343	3,563	3,741	3,914	4,158	4,291	4,411	4,668	4,932	17,818	40,278
Off-budget[b]	743	772	814	863	922	986	1,055	1,130	1,207	1,288	1,376	1,469	4,640	11,110
Memorandum:														
Gross Domestic Product	17,810	18,494	19,297	20,127	20,906	21,710	22,593	23,528	24,497	25,506	26,559	27,660	104,632	232,382
							As a Percentage of Gross Domestic Product							
Mandatory														
Social Security	5.0	4.9	4.9	5.0	5.1	5.2	5.3	5.4	5.6	5.7	5.8	5.9	5.1	5.4
Medicare[a]	3.6	3.7	3.6	3.5	3.8	3.9	4.0	4.3	4.3	4.2	4.5	4.7	3.8	4.1
Medicaid	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.3	2.1	2.2
Other spending	3.9	3.9	3.9	3.7	3.7	3.7	3.6	3.7	3.5	3.4	3.4	3.4	3.7	3.6
Offsetting receipts	-1.4	-1.3	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3	-1.2	-1.2
Subtotal	12.9	13.3	13.3	13.1	13.5	13.7	13.9	14.3	14.3	14.2	14.6	15.0	13.5	14.1
Discretionary														
Defense	3.3	3.2	3.1	2.9	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.9	2.8
Nondefense	3.3	3.3	3.2	3.0	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	3.0	2.8
Subtotal	6.5	6.5	6.2	6.0	5.8	5.7	5.6	5.6	5.4	5.3	5.3	5.2	5.9	5.6
Net Interest	1.3	1.4	1.6	1.8	2.1	2.3	2.4	2.6	2.7	2.8	2.9	3.0	2.1	2.5
Total	**20.7**	**21.2**	**21.1**	**20.9**	**21.5**	**21.8**	**22.0**	**22.5**	**22.4**	**22.3**	**22.8**	**23.1**	**21.5**	**22.1**
On-budget	16.5	17.0	16.9	16.6	17.0	17.2	17.3	17.7	17.5	17.3	17.6	17.8	17.0	17.3
Off-budget[b]	4.2	4.2	4.2	4.3	4.4	4.5	4.7	4.8	4.9	5.1	5.2	5.3	4.4	4.8

Source: Congressional Budget Office.

a. Gross spending, excluding the effects of Medicare premiums and other offsetting receipts. (Net Medicare spending is included in the memorandum section of Table 3-2.)

b. Off-budget outlays stem from transactions related to the Social Security trust funds and the net cash flow of the Postal Service.

Box 3-1. Return to Reference

Categories of Federal Spending

On the basis of its treatment in the budget process, federal spending can be divided into three broad categories: mandatory spending, discretionary spending, and net interest.

Mandatory spending consists primarily of spending for benefit programs, such as Social Security, Medicare, and Medicaid. The Congress largely determines funding for those programs by setting rules for eligibility, benefit formulas, and other parameters rather than by appropriating specific amounts each year. In making baseline projections, the Congressional Budget Office generally assumes that the existing laws and policies governing those programs will remain unchanged. Mandatory spending also includes offsetting receipts—fees and other charges that are recorded as negative budget authority and outlays. Offsetting receipts differ from revenues in that revenues are collected in the exercise of the government's sovereign powers (income taxes, for example), whereas offsetting receipts are mostly collected from other government accounts or from members of the public for businesslike transactions (premiums for Medicare or rental payments and royalties for the drilling of oil or gas on public lands, for example).

Discretionary spending is controlled by annual appropriation acts in which policymakers specify how much money will be provided for certain government programs in specific years. Appropriations fund a broad array of government activities, including defense, law enforcement, and transportation. They also fund the national park system, disaster relief, and foreign aid. Some of the fees and charges triggered by appropriation acts are classified as offsetting collections and are credited against discretionary spending for the particular accounts affected.

CBO's baseline depicts the path of spending for individual discretionary accounts as directed by the provisions of the Balanced Budget and Emergency Deficit Control Act of 1985 (Public Law 99-177). That act stated that current appropriations should be assumed to grow with inflation in the future.[141] However, the Budget Control Act of 2011 (P.L. 112-25) imposed caps on discretionary appropriations through 2021 (and subsequent legislation modified those limits), so the baseline also incorporates the assumption that discretionary funding will not exceed the current caps.

The caps can, however, be adjusted upward for appropriations for certain activities, including war-related activities known as overseas contingency operations, certain disaster assistance efforts, specified program integrity initiatives, or designated emergencies. In CBO's baseline, the most recent appropriations for those categories,

141. In CBO's baseline, discretionary funding related to federal personnel is inflated using the employment cost index for wages and salaries; other discretionary funding is adjusted using the gross domestic product price index.

with increases for inflation and accounting for any statutory restrictions on those categories, are used to project future adjustments to the caps.

In addition to outlays from appropriations subject to caps, the baseline also includes discretionary spending for highway and airport infrastructure programs and public transit programs, all of which receive mandatory budget authority from authorizing legislation. Each year, however, appropriation acts control spending for those programs by limiting how much of the budget authority the Department of Transportation can obligate. For that reason, those obligation limitations are often treated as a measure of discretionary resources, and the resulting outlays are considered discretionary spending.

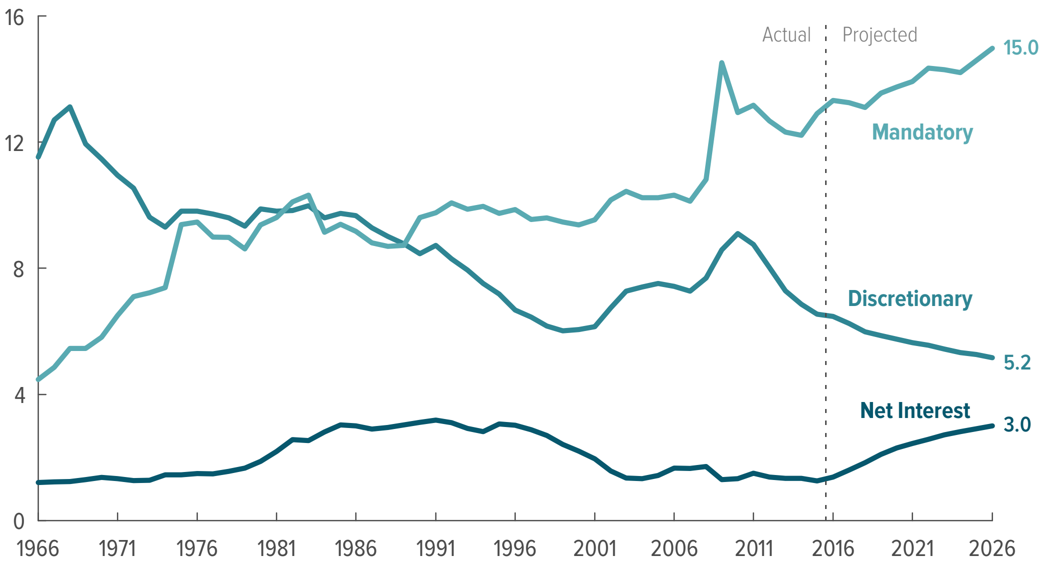
Net interest includes interest paid on Treasury securities and other interest that the government pays (for example, that paid on late refunds issued by the Internal Revenue Service) minus the interest that it collects from various sources (for example, from states that pay the federal unemployment insurance trust fund interest on advances they received when the balances of their state unemployment insurance accounts were insufficient to pay benefits in a timely fashion). Net interest is determined by the size and composition of the government's debt and by market interest rates.

Figure 3-1.

Return to Reference

Outlays, by Type of Spending

Percentage of Gross Domestic Product



Under current law, rising spending for Social Security and Medicare would boost mandatory outlays.

Total discretionary spending is projected to fall relative to GDP as funding grows modestly in nominal terms.

At the same time, higher interest rates and growing debt are projected to push up net interest payments.

Source: Congressional Budget Office.

GDP = gross domestic product.

Table 3-2. Return to Reference 1, 2

Mandatory Outlays Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Social Security														
Old-Age and Survivors Insurance	738	766	800	851	908	970	1,034	1,101	1,171	1,245	1,322	1,403	4,562	10,805
Disability Insurance	144	144	146	151	157	164	172	180	188	197	206	215	790	1,776
Subtotal	882	910	946	1,002	1,066	1,133	1,205	1,281	1,360	1,441	1,528	1,618	5,352	12,580
Major Health Care Programs														
Medicare[a]	634	692	699	711	787	845	907	1,015	1,048	1,075	1,193	1,288	3,949	9,569
Medicaid	350	381	401	420	439	460	484	509	536	564	593	642	2,205	5,049
Health insurance subsidies and related spending[b]	38	56	73	80	85	87	91	95	99	102	105	109	415	925
Children's Health Insurance Program	9	13	13	11	6	6	6	6	6	6	6	6	41	70
Subtotal[a]	1,030	1,141	1,186	1,222	1,316	1,398	1,488	1,625	1,688	1,747	1,897	2,045	6,610	15,612
Income Security														
Earned income, child, and other tax credits[c]	85	87	86	86	88	91	93	95	97	99	101	103	443	939
Supplemental Nutrition Assistance Program	76	75	74	73	73	72	72	72	72	72	73	74	364	728
Supplemental Security Income	55	59	56	53	60	61	63	70	67	64	71	74	293	639
Unemployment compensation	33	32	31	33	37	42	44	46	48	50	53	55	188	440
Family support and foster care[d]	31	31	32	32	33	33	33	34	34	34	35	35	163	336
Child nutrition	22	23	24	25	26	27	28	29	30	32	33	34	128	286
Subtotal	302	307	302	303	316	326	333	346	349	351	366	376	1,580	3,368
Federal Civilian and Military Retirement														
Civilian[e]	97	98	101	103	107	110	114	118	122	126	130	134	535	1,165
Military	57	62	58	55	61	63	65	72	68	65	72	74	303	653
Other	7	5	6	5	5	5	6	7	8	8	5	11	28	66
Subtotal	162	165	164	164	173	179	185	196	198	198	207	220	866	1,885
Veterans' Programs[f]														
Income security	76	89	87	84	95	99	103	115	110	105	118	122	468	1,038
Other	16	21	22	17	17	18	19	21	21	21	23	24	94	203
Subtotal	92	110	109	101	113	117	122	136	131	126	141	146	562	1,241
Other Programs														
Agriculture	13	15	19	18	16	15	15	15	15	15	15	15	84	159
Deposit Insurance	-13	-11	-13	-15	-12	-11	-12	-12	-14	-15	-14	-14	-63	-132
MERHCF	10	10	10	11	11	12	13	13	14	14	15	16	57	130
Fannie Mae and Freddie Mac[g]	0	0	3	2	1	1	*	1	1	1	1	2	7	12
Higher education	22	-6	-4	*	*	1	1	1	1	*	*	*	-2	*
Other	55	63	73	72	72	73	69	67	66	64	65	68	359	689
Subtotal	87	71	88	88	89	90	86	84	83	81	83	88	441	858

Continued

Table 3-2. Continued

Mandatory Outlays Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Offsetting Receipts														
Medicare[h]	-94	-101	-110	-118	-126	-136	-146	-161	-172	-180	-194	-210	-637	-1,552
Federal share of federal employees' retirement														
Social Security	-16	-16	-17	-17	-18	-19	-19	-20	-21	-21	-22	-23	-90	-196
Military retirement	-20	-19	-18	-18	-18	-19	-19	-19	-20	-20	-20	-21	-91	-192
Civil service retirement and other	-32	-32	-35	-36	-37	-38	-39	-40	-41	-42	-43	-44	-184	-395
Subtotal	-68	-68	-69	-71	-73	-75	-77	-79	-81	-84	-86	-88	-365	-783
Fannie Mae and Freddie Mac[g]	-23	-20	0	0	0	0	0	0	0	0	0	0	0	0
MERHCF	-7	-7	-7	-8	-8	-9	-9	-10	-10	-11	-11	-12	-41	-94
Receipts related to natural resources	-11	-9	-10	-13	-13	-13	-14	-14	-14	-16	-16	-17	-63	-139
Other	-54	-32	-41	-37	-28	-29	-30	-30	-31	-33	-39	-24	-165	-323
Subtotal	-256	-237	-238	-247	-248	-262	-276	-294	-309	-323	-346	-350	-1,270	-2,892
Total Mandatory Outlays	**2,299**	**2,466**	**2,558**	**2,633**	**2,825**	**2,981**	**3,143**	**3,375**	**3,500**	**3,622**	**3,875**	**4,142**	**14,140**	**32,653**
Memorandum:														
Mandatory Spending Excluding the Effects of Offsetting Receipts	2,555	2,703	2,796	2,880	3,073	3,243	3,419	3,669	3,808	3,944	4,221	4,492	15,411	35,545
Spending for Medicare Net of Offsetting Receipts	539	591	589	593	661	708	761	854	876	895	999	1,079	3,312	8,016
Spending for Major Health Care Programs Net of Offsetting Receipts[i]	936	1,040	1,076	1,104	1,190	1,262	1,341	1,465	1,516	1,567	1,703	1,835	5,974	14,060

Source: Congressional Budget Office.

Data on spending for benefit programs in this table generally exclude administrative costs, which are discretionary.

MERHCF = Department of Defense Medicare-Eligible Retiree Health Care Fund (including TRICARE for Life); * = between -$500 million and $500 million.

a. Gross spending, excluding the effects of Medicare premiums and other offsetting receipts. (Net Medicare spending is included in the memorandum section of the table.)

b. Subsidies for health insurance purchased through the exchanges established under the Affordable Care Act.

c. Includes outlays for the American Opportunity Tax Credit and other credits.

d. Includes the Temporary Assistance for Needy Families program, the Child Support Enforcement program, the Child Care Entitlement program, and other programs that benefit children.

e. Includes Civil Service, Foreign Service, Coast Guard, and smaller retirement programs as well as annuitants' health care benefits.

f. "Income security" includes veterans' compensation, pensions, and life insurance programs. "Other" benefits are primarily education subsidies. Most of the costs of veterans' health care are classified as discretionary spending and thus are not shown in this table.

g. The cash payments from Fannie Mae and Freddie Mac to the Treasury are recorded as offsetting receipts in 2015 and 2016. Beginning in 2017, CBO's estimates reflect the net lifetime costs—that is, the subsidy costs adjusted for market risk—of the guarantees that those entities will issue and of the loans that they will hold, counted as federal outlays in the year of issuance.

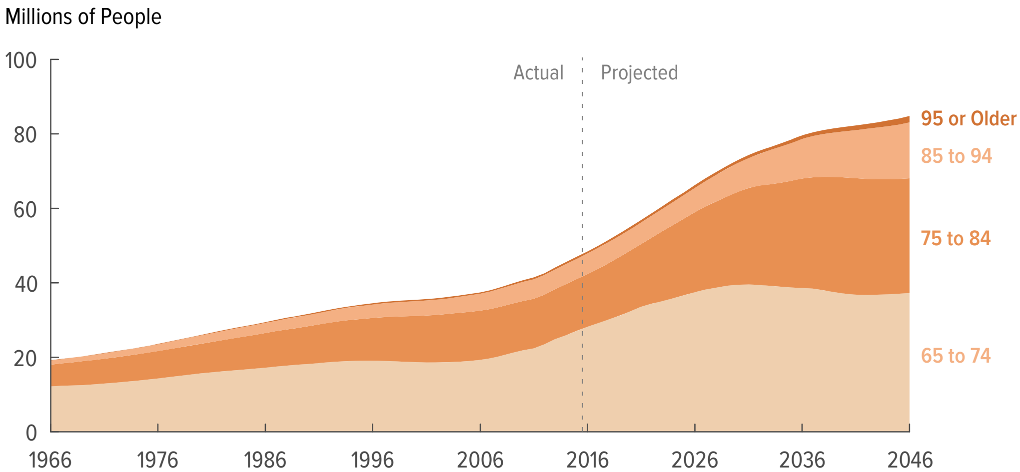
h. Includes premium payments, recoveries of overpayments made to providers, and amounts paid by states from savings on Medicaid's prescription drug costs.

i. Consists of outlays for Medicare (net of offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through exchanges and related spending.

Figure 3-2.

Return to Reference

Number of People Age 65 or Older, by Age Group



Enrollment in Social Security and Medicare is expected to rise as the number of people age 65 or older grows.

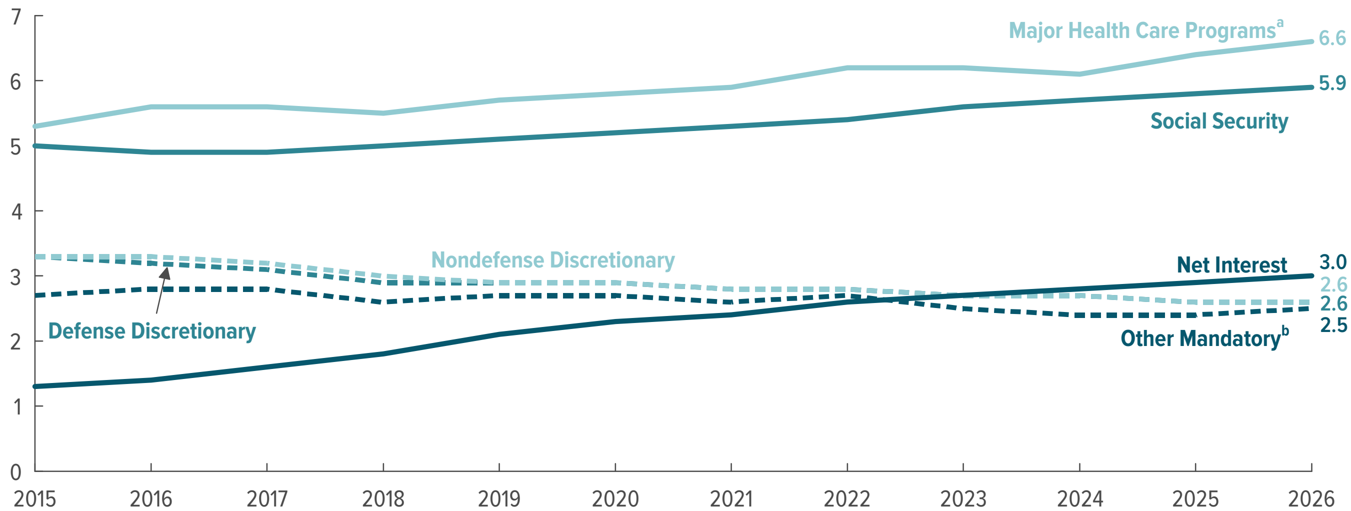
Source: Congressional Budget Office.

Figure 3-3.

Return to Reference

Projected Outlays in Major Budget Categories

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

a. Consists of Medicare (net of premiums and other offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through exchanges and related spending.

b. All mandatory spending other than that for the major health care programs and Social Security.

Table 3-3.

Return to Reference

Costs for Mandatory Programs That Continue Beyond Their Current Expiration Date in CBO's Baseline

Billions of Dollars

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Supplemental Nutrition Assistance Program													
Budget authority	0	0	0	73	72	72	72	72	72	73	75	217	581
Outlays	0	0	0	70	72	72	72	72	72	73	74	215	579
Temporary Assistance for Needy Families													
Budget authority	0	17	17	17	17	17	17	17	17	17	17	86	173
Outlays	0	13	16	17	17	17	17	17	17	17	17	79	166
Veterans' Compensation COLAs													
Budget authority	0	1	2	4	7	9	13	14	16	20	23	23	108
Outlays	0	1	2	4	6	9	12	14	15	19	22	22	106
Commodity Credit Corporation[a]													
Budget authority	0	0	0	2	2	9	8	9	9	10	10	13	61
Outlays	0	0	0	1	1	8	8	9	9	10	10	10	56
Children's Health Insurance Program													
Budget authority	0	0	6	6	6	6	6	6	6	6	6	23	51
Outlays	0	0	6	6	6	6	6	6	6	6	6	23	51
Child Care Entitlements to States													
Budget authority	0	3	3	3	3	3	3	3	3	3	3	15	29
Outlays	0	2	3	3	3	3	3	3	3	3	3	14	28
Rehabilitation Services													
Budget authority	0	0	0	0	0	0	0	4	4	4	4	0	16
Outlays	0	0	0	0	0	0	0	2	4	4	4	0	14
Child Nutrition[b]													
Budget authority	0	1	1	1	1	1	1	1	1	1	1	4	10
Outlays	0	1	1	1	1	1	1	1	1	1	1	4	9
Promoting Safe and Stable Families													
Budget authority	0	*	*	*	*	*	*	*	*	*	*	2	3
Outlays	0	*	*	*	*	*	*	*	*	*	*	1	3

Continued

Table 3-3. Continued

Costs for Mandatory Programs That Continue Beyond Their Current Expiration Date in CBO's Baseline

Billions of Dollars

												Total	
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2017-2021	2017-2026
Trade Adjustment Assistance for Workers[c]													
Budget authority	0	0	0	0	0	0	0	1	1	1	1	0	3
Outlays	0	0	0	0	0	0	0	*	1	1	1	0	3
Ground Transportation Programs Not Subject to Annual Obligation Limitations													
Budget authority	0	0	0	0	0	1	1	1	1	1	1	1	4
Outlays	0	0	0	0	0	*	1	1	1	1	1	0	3
Ground Transportation Programs Controlled by Obligation Limitations[d]													
Budget authority	0	0	0	0	0	50	50	50	50	50	50	50	302
Outlays	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Transportation Programs Controlled by Obligation Limitations[d]													
Budget authority	2	3	3	3	3	3	3	3	3	3	3	17	34
Outlays	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Resources													
Budget authority	0	0	0	0	0	0	0	0	0	0	0	0	0
Outlays	0	*	*	*	*	*	*	*	*	*	*	*	*
Total													
Budget authority	**2**	**25**	**33**	**110**	**112**	**172**	**175**	**182**	**184**	**190**	**194**	**451**	**1,376**
Outlays	**0**	**16**	**28**	**101**	**107**	**116**	**120**	**125**	**129**	**135**	**140**	**368**	**1,018**

Source: Congressional Budget Office.

COLAs = cost-of-living adjustments; * = between -$500 million and $500 million.

a. Agricultural commodity price and income supports and conservation programs under the Agricultural Act of 2014 generally expire after 2018. Although permanent price support authority under the Agricultural Adjustment Act of 1938 and the Agricultural Act of 1949 would then become effective, CBO adheres to the rule in section 257(b)(2)(ii) of the Balanced Budget and Emergency Deficit Control Act of 1985 that indicates that the baseline should incorporate the assumption that the provisions of the Agricultural Act of 2014 remain in effect.

b. Includes the Summer Food Service program and states' administrative expenses.

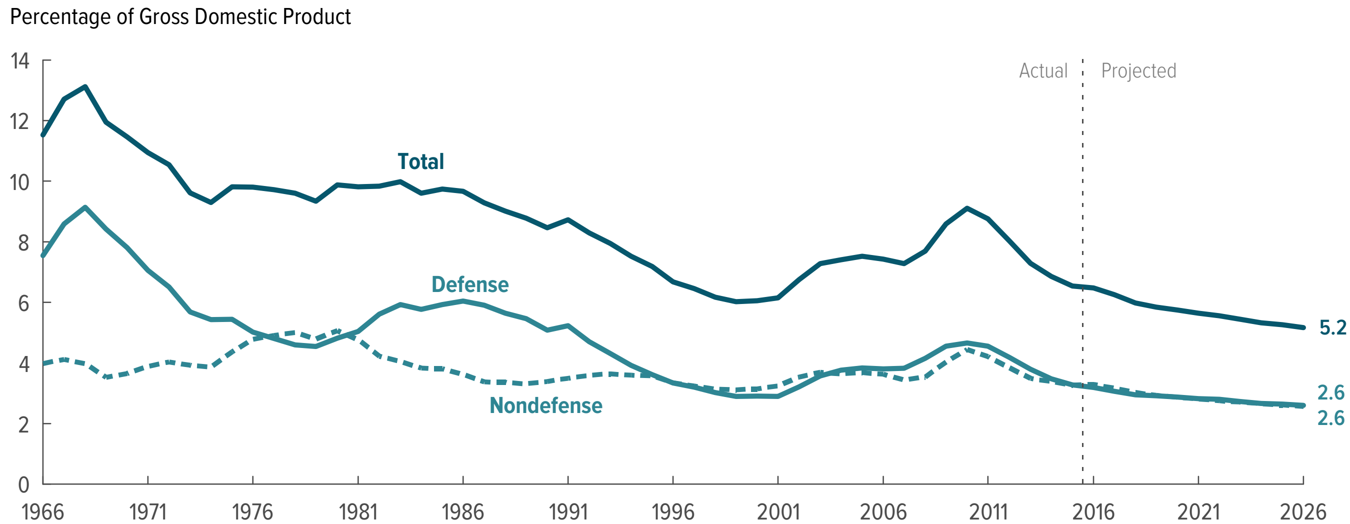
c. Excludes the cost of extending Reemployment Trade Adjustment Assistance.

d. Authorizing legislation for those programs provides contract authority, which is counted as mandatory budget authority. However, because the programs' spending is subject to obligation limitations specified in annual appropriation acts, outlays are considered discretionary.

Figure 3-4.

Return to Reference

Discretionary Outlays, by Category



Source: Congressional Budget Office.

Table 3-4.

Return to Reference

Changes in Discretionary Budget Authority From 2015 to 2016

Billions of Dollars

	Actual, 2015	Estimated, 2016	Percentage Change
Defense			
Funding constrained by caps	521	548	5.1
Overseas contingency operations	64	59	-8.7
Other cap adjustments	*	0	n.a.
Subtotal	586	607	3.6
Nondefense			
Funding constrained by caps	507	537	5.9
Overseas contingency operations	9	15	60.9
Other cap adjustments	13	9	-29.6
Subtotal	530	561	5.9
Total Discretionary Budget Authority			
Funding constrained by caps	1,029	1,085	5.5
Overseas contingency operations	74	74	**
Other cap adjustments	13	9	-30.2
Total	**1,116**	**1,168**	**4.7**

Source: Congressional Budget Office.

Excludes budgetary resources provided by obligation limitations for certain ground and air transportation programs.

Budget authority designated as an emergency requirement or provided for overseas contingency operations leads to an increase in the caps, as does budget authority provided for some types of disaster relief or for certain program integrity initiatives.

n.a. = not applicable; * = between zero and $500 million; ** = between zero and 0.05 percent.

Table 3-5.

Return to Reference

Changes in Nondefense Discretionary Funding From 2015 to 2016

Billions of Dollars

Budget Function	Actual, 2015	Estimated, 2016	Change
Education, Training, Employment, and Social Services	92	94	3
Transportation[a]	85	89	4
Veterans' Benefits and Services	64	72	8
Income Security	66	67	2
Health	56	60	3
Administration of Justice	52	55	3
International Affairs	51	55	4
Natural Resources and Environment	35	37	3
General Science, Space, and Technology	29	31	2
Community and Regional Development	17	18	1
General Government	19	18	-1
Medicare	6	7	*
Agriculture	6	6	*
Social Security	5	6	1
Energy	5	6	1
Commerce and Housing Credit	-6	-3	3
Total	**581**	**618**	**37**

Source: Congressional Budget Office.

* = between zero and $500 million.

a. Includes budgetary resources provided by obligation limitations for certain ground and air transportation programs.

Table 3-6.

Return to Reference

CBO's Projections of Discretionary Spending Under Selected Policy Alternatives

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
CBO's January 2016 Baseline (Budget Control Act Caps and Automatic Enforcement Procedures in Effect Through 2021)														
Budget Authority														
Defense	586	607	611	610	624	640	655	671	687	704	722	739	3,140	6,663
Nondefense	530	561	543	540	554	568	581	595	610	625	641	657	2,786	5,916
Total	1,116	1,168	1,154	1,150	1,178	1,208	1,236	1,266	1,298	1,330	1,363	1,396	5,926	12,579
Outlays														
Defense	582	589	592	593	609	623	638	657	669	680	702	719	3,055	6,481
Nondefense	583	609	614	610	613	624	636	649	664	679	695	710	3,098	6,494
Total	1,165	1,198	1,206	1,203	1,222	1,248	1,274	1,307	1,332	1,358	1,397	1,429	6,152	12,975
Increase Discretionary Appropriations at the Rate of Inflation After 2016[a]														
Budget Authority														
Defense	586	607	620	635	650	666	682	699	717	734	753	772	3,254	6,928
Nondefense	530	561	577	592	608	624	640	657	673	691	708	726	3,041	6,496
Total	1,116	1,168	1,197	1,227	1,258	1,290	1,323	1,356	1,390	1,425	1,461	1,497	6,295	13,423
Outlays														
Defense	582	589	598	611	631	648	664	685	697	709	732	750	3,151	6,724
Nondefense	583	609	632	648	659	675	691	707	723	740	759	776	3,304	7,009
Total	1,165	1,198	1,229	1,258	1,290	1,323	1,355	1,392	1,420	1,449	1,490	1,526	6,455	13,732
Freeze Most Discretionary Appropriations at the 2015 Amount[b]														
Budget Authority														
Defense	586	607	607	608	608	609	609	610	610	611	611	612	3,041	6,095
Nondefense	530	561	566	567	567	568	569	569	569	569	569	567	2,837	5,678
Total	1,116	1,168	1,173	1,174	1,176	1,177	1,178	1,178	1,179	1,179	1,180	1,179	5,878	11,773
Outlays														
Defense	582	589	590	591	598	600	601	605	602	598	603	603	2,980	5,992
Nondefense	583	609	625	628	625	625	625	624	623	622	621	619	3,129	6,237
Total	1,165	1,198	1,215	1,220	1,223	1,226	1,226	1,229	1,224	1,220	1,224	1,222	6,109	12,229
Prevent the Automatic Spending Reductions Specified in the Budget Control Act[c]														
Budget Authority														
Defense	586	607	611	664	678	693	709	726	744	762	781	800	3,355	7,170
Nondefense	530	561	543	578	590	603	616	631	647	663	679	696	2,930	6,246
Total	1,116	1,168	1,154	1,242	1,268	1,297	1,325	1,357	1,391	1,425	1,461	1,497	6,285	13,416
Outlays														
Defense	582	589	592	627	655	673	689	712	724	737	760	778	3,236	6,946
Nondefense	583	609	614	630	643	657	670	684	699	715	732	748	3,215	6,792
Total	1,165	1,198	1,206	1,257	1,298	1,331	1,359	1,396	1,423	1,451	1,492	1,526	6,451	13,739

Source: Congressional Budget Office.

Nondefense discretionary outlays are usually higher than budget authority because of spending from the Highway Trust Fund and the Airport and Airway Trust Fund that is subject to obligation limitations set in appropriation acts. The budget authority for such programs is provided in authorizing legislation and is not considered discretionary.

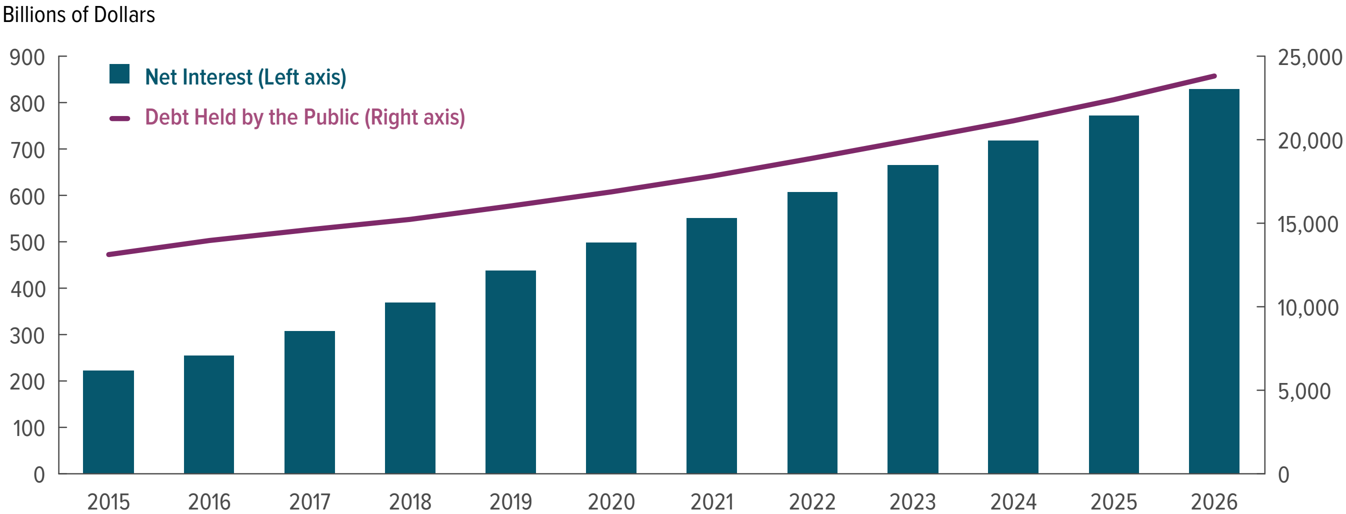
a. These estimates reflect the assumption that most appropriations will not be constrained by caps and will instead grow at the rate of inflation from their 2016 level. Discretionary funding related to federal personnel is inflated using the employment cost index for wages and salaries; other discretionary funding is adjusted using the gross domestic product price index.

b. This option reflects the assumption that appropriations generally would be frozen at the 2016 level through 2026. Some items, such as offsetting collections and payments made by the Treasury on behalf of the Department of Defense's TRICARE for Life program, would not be held constant.

c. The Budget Control Act of 2011 specified that if lawmakers did not enact legislation originating from the Joint Select Committee on Deficit Reduction that would reduce projected deficits by at least $1.2 trillion, automatic procedures would go into effect to reduce both discretionary and mandatory spending during the 2013–2021 period (and mandatory spending through 2025). Those procedures take the form of equal cuts (in dollar terms) in funding for defense and nondefense programs. The Bipartisan Budget Act of 2015 canceled those procedures for 2016 and 2017, but they will take effect again in 2018 and reduce discretionary spending over the 2018–2021 period. In its projections for the 2022–2025 period, CBO assumes that appropriations will grow at the rate of inflation from the amounts estimated for 2021.

Figure 3-5. Return to Reference

Projected Debt Held by the Public and Net Interest



Source: Congressional Budget Office.

Table 3-7.

Return to Reference

Federal Interest Outlays Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Interest on Treasury Debt Securities (Gross interest)[a]	402	437	498	569	650	716	774	831	891	946	1,000	1,059	3,207	7,933
Interest Received by Trust Funds														
Social Security	-96	-92	-87	-88	-89	-89	-88	-85	-82	-78	-72	-64	-441	-822
Other[b]	-45	-49	-56	-61	-69	-71	-73	-74	-75	-78	-81	-87	-330	-726
Subtotal	-141	-141	-144	-148	-157	-160	-161	-159	-157	-156	-154	-151	-770	-1,547
Other Interest[c]	-38	-40	-46	-51	-54	-57	-61	-64	-67	-70	-74	-77	-267	-619
NRRIT Investment Income (Non-Treasury holdings)[d]	*	*	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-4	-8
Net Interest Outlays	**223**	**255**	**308**	**369**	**438**	**498**	**551**	**607**	**666**	**719**	**772**	**830**	**2,165**	**5,759**

Source: Congressional Budget Office.

NRRIT = National Railroad Retirement Investment Trust; * = between -$500 million and $500 million.

a. Excludes interest costs on debt issued by agencies other than the Treasury (primarily the Tennessee Valley Authority).

b. Mainly the Civil Service Retirement, Military Retirement, Medicare, and Unemployment Insurance Trust Funds.

c. Primarily interest on loans to the public.

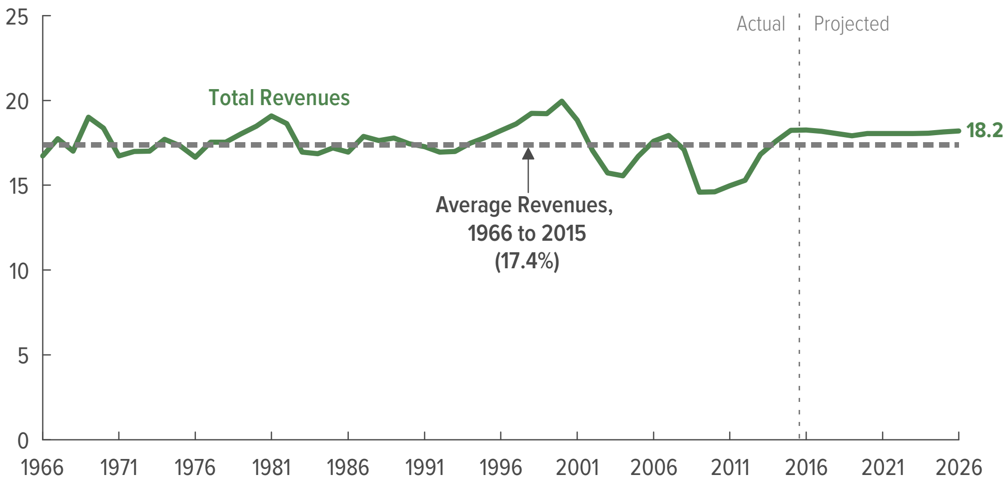
d. Earnings on investments by the NRRIT, an entity created to manage and invest assets of the Railroad Retirement program.

Figure 4-1.

Return to Reference

Total Revenues

Percentage of Gross Domestic Product



CBO projects that, under current law, total revenues over the next decade would remain relatively stable as a share of GDP because of the offsetting effects of changes in various sources of revenues.

Source: Congressional Budget Office.

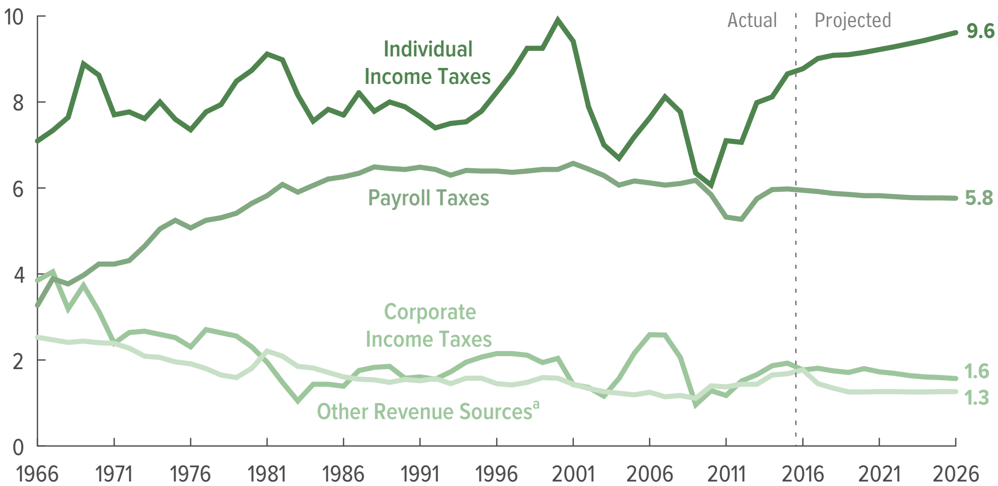
GDP = gross domestic product.

Figure 4-2.

Return to Reference

Revenues, by Major Source

Percentage of Gross Domestic Product



Over the next decade, individual income taxes are projected to grow at a faster rate than other major tax sources, most significantly because of "real bracket creep," which occurs when income grows faster than inflation and more income is pushed into higher tax brackets.

Source: Congressional Budget Office.

a. Consists of excise taxes, remittances from the Federal Reserve to the Treasury, customs duties, estate and gift taxes, and miscellaneous fees and fines.

Table 4-1.

Return to Reference

Revenues Projected in CBO's Baseline

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
							In Billions of Dollars							
Individual Income Taxes	1,541	1,621	1,739	1,827	1,902	1,987	2,084	2,184	2,292	2,406	2,529	2,657	9,539	21,608
Payroll Taxes	1,065	1,101	1,143	1,182	1,222	1,264	1,314	1,365	1,417	1,471	1,531	1,593	6,126	13,503
Corporate Income Taxes	344	327	348	353	358	391	391	397	402	410	421	434	1,842	3,907
Other														
Excise taxes	98	97	90	104	106	107	110	112	114	116	118	120	517	1,097
Federal Reserve remittances	96	113	69	46	34	36	40	44	49	53	59	64	225	493
Customs duties	35	36	37	39	41	43	45	46	48	51	54	58	205	463
Estate and gift taxes	19	20	21	22	23	23	24	25	26	27	29	30	113	250
Miscellaneous fees and fines	50	61	63	61	61	64	67	70	72	75	77	79	316	689
Subtotal	299	327	280	272	264	274	287	298	310	322	337	351	1,376	2,993
Total	**3,249**	**3,376**	**3,511**	**3,633**	**3,747**	**3,917**	**4,076**	**4,244**	**4,421**	**4,610**	**4,818**	**5,035**	**18,883**	**42,010**
On-budget	2,478	2,580	2,682	2,774	2,859	2,999	3,126	3,260	3,401	3,552	3,720	3,895	14,441	32,269
Off-budget[a]	770	796	829	859	888	917	949	984	1,020	1,058	1,098	1,139	4,442	9,741
Memorandum:														
Gross Domestic Product	17,810	18,494	19,297	20,127	20,906	21,710	22,593	23,528	24,497	25,506	26,559	27,660	104,632	232,382
							As a Percentage of Gross Domestic Product							
Individual Income Taxes	8.7	8.8	9.0	9.1	9.1	9.2	9.2	9.3	9.4	9.4	9.5	9.6	9.1	9.3
Payroll Taxes	6.0	6.0	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.8
Corporate Income Taxes	1.9	1.8	1.8	1.8	1.7	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.8	1.7
Other														
Excise taxes	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.5
Federal Reserve remittances	0.5	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Customs duties	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Estate and gift taxes	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous fees and fines	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Subtotal	1.7	1.8	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Total	**18.2**	**18.3**	**18.2**	**18.1**	**17.9**	**18.0**	**18.0**	**18.0**	**18.0**	**18.1**	**18.1**	**18.2**	**18.0**	**18.1**
On-budget	13.9	13.9	13.9	13.8	13.7	13.8	13.8	13.9	13.9	13.9	14.0	14.1	13.8	13.9
Off-budget[a]	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.2	4.2

Source: Congressional Budget Office.

a. Receipts from Social Security payroll taxes.

Table 4-2.

Return to Reference

Payroll Tax Revenues Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Social Security	770	796	829	859	888	917	949	984	1,020	1,058	1,098	1,139	4,442	9,741
Medicare	234	248	260	271	282	294	306	319	333	348	364	380	1,413	3,157
Unemployment Insurance	51	47	45	41	42	42	47	49	51	51	56	58	217	482
Railroad Retirement	6	6	6	6	6	7	7	7	7	7	7	7	32	68
Other Retirement[a]	4	4	4	4	4	5	5	6	6	6	7	7	22	54
Total	**1,065**	**1,101**	**1,143**	**1,182**	**1,222**	**1,264**	**1,314**	**1,365**	**1,417**	**1,471**	**1,531**	**1,593**	**6,126**	**13,503**

Source: Congressional Budget Office.

a. Consists largely of federal employees' contributions to the Federal Employees Retirement System and the Civil Service Retirement System.

Table 4-3.

Return to Reference

Smaller Sources of Revenues Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Excise Taxes														
Highway	39	38	40	41	41	40	40	40	40	39	39	39	202	398
Tobacco	14	14	14	13	13	13	13	12	12	12	12	11	66	126
Aviation	14	14	15	16	16	17	17	18	19	19	20	21	81	179
Alcohol	10	10	10	10	11	11	11	11	11	11	12	12	53	109
Health insurance providers	11	11	1	13	15	15	16	17	18	19	20	21	60	156
Other	11	9	9	11	10	11	13	14	14	15	15	16	55	129
Subtotal	98	97	90	104	106	107	110	112	114	116	118	120	517	1,097
Federal Reserve Remittances	96	113	69	46	34	36	40	44	49	53	59	64	225	493
Customs Duties	35	36	37	39	41	43	45	46	48	51	54	58	205	463
Estate and Gift Taxes	19	20	21	22	23	23	24	25	26	27	29	30	113	250
Miscellaneous Fees and Fines														
Universal Service Fund fees	9	10	11	12	12	12	12	12	12	12	13	13	58	119
Other fees and fines	40	51	53	49	49	52	55	58	60	62	64	66	259	569
Subtotal	50	61	63	61	61	64	67	70	72	75	77	79	316	689
Total	**299**	**327**	**280**	**272**	**264**	**274**	**287**	**298**	**310**	**322**	**337**	**351**	**1,376**	**2,993**

Source: Congressional Budget Office.

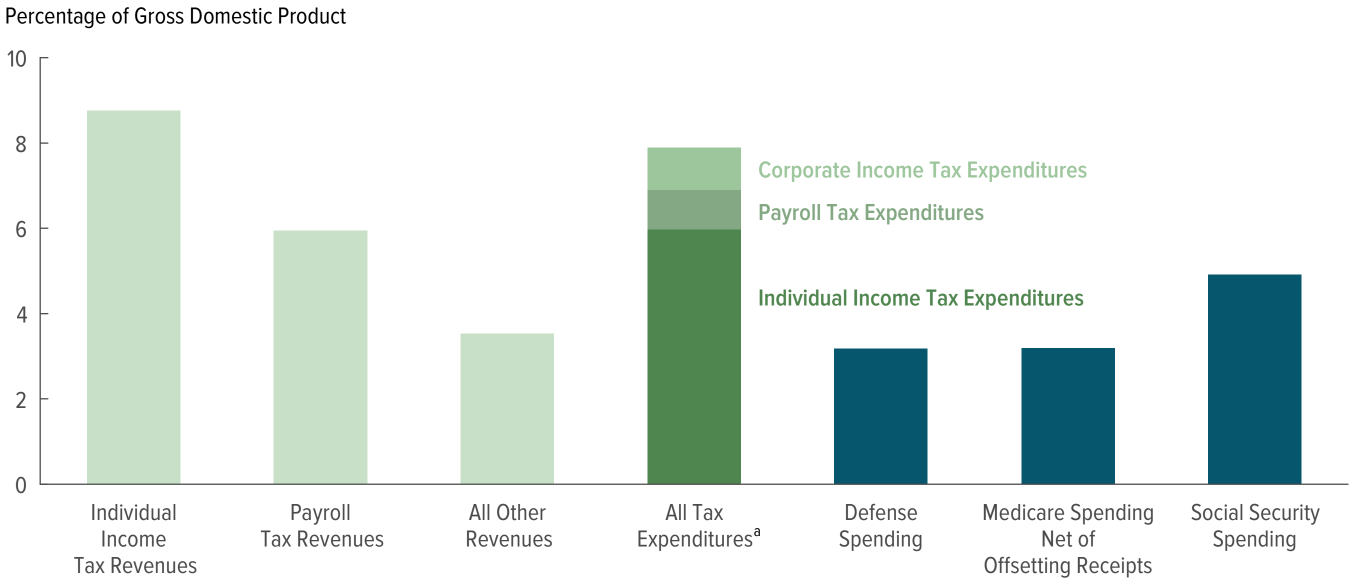
This table shows all sources of revenues other than individual and corporate income taxes and payroll taxes.

Figure 4-3.

Return to Reference

Revenues, Tax Expenditures, and Selected Components of Spending in 2016

Tax expenditures, projected to total $1.5 trillion in 2016, cause revenues to be lower than they would be otherwise and, like spending programs, contribute to the federal deficit.



Source: Congressional Budget Office, using estimates by the staff of the Joint Committee on Taxation, which were prepared before the enactment of the Consolidated Appropriations Act, 2016, and do not include the effects of that law.

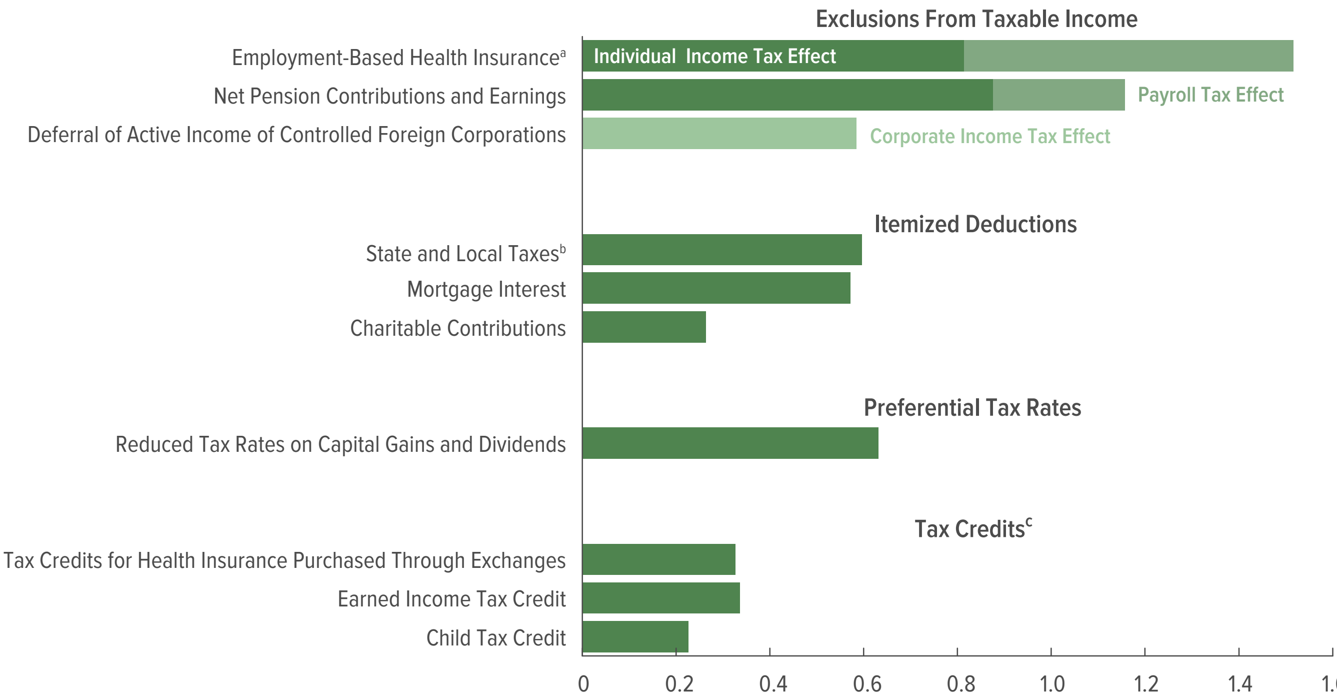
a. This total is the sum of the estimates for all of the separate tax expenditures and does not account for any interactions among them. However, CBO estimates that in 2016, the total of all tax expenditures roughly equals the sum of each considered separately. Furthermore, because estimates of tax expenditures are based on people's behavior with the tax expenditures in place, the estimates do not reflect the amount of revenue that would be raised if those provisions of the tax code were eliminated and taxpayers adjusted their activities in response to the changes. The outlay portions of refundable tax credits are included in tax expenditures. Those payments would be reported in the budget as "other mandatory spending," a category not shown in this figure.

Figure 4-4.

Return to Reference

Budgetary Effects of the Largest Tax Expenditures From 2017 to 2026

Percentage of Gross Domestic Product



Source: Congressional Budget Office, using estimates by the staff of the Joint Committee on Taxation, which were prepared before the enactment of the Consolidated Appropriations Act, 2016, and do not include the effects of that law.

These effects are calculated as the sum of the tax expenditures over the 2017–2026 period divided by the sum of gross domestic product over the same 10 years. Because estimates of tax expenditures are based on people's behavior with the tax expenditures in place, the estimates do not reflect the amount of revenue that would be raised if those provisions of the tax code were eliminated and taxpayers adjusted their activities in response to the changes.

a. Includes employers' contributions for health care, health insurance premiums, and long-term-care insurance premiums.

b. Consists of nonbusiness income, sales, real estate, and personal property taxes paid to state and local governments.

c. Includes effect on outlays.

Table A-1.

Return to Reference 1, 2

Changes in CBO's Baseline Projections of the Deficit Since August 2015

Billions of Dollars

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total 2016-2020	Total 2016-2025
Deficit in CBO's August 2015 Baseline	-414	-416	-454	-596	-687	-767	-885	-895	-886	-1,008	-2,566	-7,007
Legislative Changes												
Changes to Revenues												
Individual income taxes	-56	-29	-24	-21	-9	-4	-8	-10	-13	-15	-139	-190
Corporate income taxes	-96	-52	-40	-27	*	7	-6	-15	-23	-28	-215	-280
Payroll taxes	*	*	*	*	*	1	1	1	1	1	*	4
Other	18	-10	2	1	1	5	5	6	6	7	11	41
All Changes in Revenues	-134	-91	-62	-48	-8	8	-7	-19	-29	-36	-343	-425
Changes in Outlays												
Mandatory outlays												
Refundable tax credits	0	-1	-1	22	22	22	22	22	23	23	42	154
Military retirement	0	2	2	3	3	3	4	4	4	5	10	30
Medicare	5	1	-2	-3	-3	-2	-1	1	2	-19	-2	-21
Strategic Petroleum Reserve	0	0	*	*	*	*	*	-2	-2	-2	-1	-8
Pension Benefit Guaranty Corporation	0	0	*	-1	-1	-1	-1	-1	-1	-4	-2	-8
Other	*	*	-1	-3	-1	*	-1	-1	-2	-8	-5	-17
Subtotal, mandatory	5	3	-2	18	20	22	23	24	24	-6	43	130
Discretionary outlays												
Defense	2	1	-5	-5	-4	-5	-5	-5	-5	-6	-11	-37
Nondefense	23	24	15	6	5	4	4	4	4	4	74	93
Subtotal, discretionary	25	25	10	1	1	*	-1	-1	-1	-2	63	56
Debt service	1	4	7	12	14	16	17	20	22	25	38	137
All Changes in Outlays	30	31	16	31	35	37	39	42	45	17	143	324
Increase (-) in the Deficit From Legislative Changes	**-164**	**-123**	**-78**	**-78**	**-43**	**-29**	**-46**	**-61**	**-74**	**-53**	**-487**	**-749**
Economic Changes												
Changes in Revenues												
Individual income taxes	-8	-11	-13	-16	-24	-36	-43	-49	-55	-61	-72	-317
Corporate income taxes	-27	-29	-27	-22	-20	-18	-18	-20	-24	-27	-125	-232
Payroll taxes	3	*	-5	-13	-19	-23	-27	-30	-33	-36	-33	-182
Other	-1	1	4	-2	-4	-5	-7	-8	-8	-9	-3	-40
All Changes in Revenues	-33	-39	-40	-53	-67	-82	-95	-108	-120	-132	-233	-771
Changes in Outlays												
Mandatory outlays												
Medicaid	-2	-3	-3	-3	-4	-4	-5	-5	-6	-6	-15	-41
Unemployment compensation	-2	-4	-4	-3	-3	-3	-3	-3	-3	-4	-16	-31
Social Security	*	-4	-4	-3	-3	-2	-1	-2	-4	-5	-13	-27
Outer Continental Shelf	2	2	2	2	2	2	2	2	2	2	8	17
Medicare	*	-1	-1	-2	-2	-2	-2	-2	-2	-2	-6	-16
Other	-1	-4	-4	-3	-3	-3	-3	-3	-3	-3	-15	-29
Subtotal, mandatory	-3	-14	-15	-13	-12	-11	-11	-13	-17	-16	-56	-126
Discretionary outlays	0	-1	-2	-3	-3	-4	-4	-4	-4	-4	-8	-27
Net interest outlays												
Debt service	*	*	1	2	2	4	6	8	11	14	5	47
Effect of rates and inflation	-14	-9	-16	-20	-24	-25	-28	-29	-32	-33	-82	-228
Subtotal, net interest	-13	-9	-15	-19	-21	-21	-22	-21	-21	-20	-77	-181
All Changes in Outlays	-16	-23	-32	-34	-37	-36	-37	-38	-42	-40	-142	-334
Increase (-) in the Deficit From Economic Changes	**-17**	**-16**	**-9**	**-19**	**-30**	**-46**	**-58**	**-69**	**-79**	**-93**	**-92**	**-437**

Continued

Table A-1. Continued

Changes in CBO’s Baseline Projections of the Deficit Since August 2015

Billions of Dollars

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total 2016-2020	Total 2016-2025
						Technical Changes						
Changes in Revenues												
Individual income taxes	20	12	13	13	6	9	10	11	12	12	64	117
Corporate income taxes	5	*	-7	-11	-14	-16	-14	-14	-14	-15	-27	-101
Payroll taxes	-3	*	-1	*	-4	-5	-6	-7	-8	-8	-7	-41
Other	6	2	1	*	*	-2	-3	-3	-3	-3	8	-5
All Changes in Revenues	28	13	6	1	-12	-15	-13	-13	-13	-14	37	-30
Changes in Outlays												
Mandatory outlays												
Medicaid	6	10	14	16	18	21	23	25	27	28	64	187
Veterans' compensation and pensions	5	8	9	12	14	16	20	21	21	25	47	152
Social Security	-2	-3	-6	-7	-10	-12	-13	-14	-15	-15	-28	-97
Fannie Mae and Freddie Mac	-23	-1	-1	-1	-1	*	-1	-1	-1	-1	-27	-30
Medicare	4	2	5	4	4	4	3	-3	-4	8	20	28
Other	-17	-2	6	13	9	2	3	2	*	-1	10	17
Subtotal, mandatory	-27	15	27	37	35	31	36	30	29	45	87	258
Discretionary outlays	-3	-4	*	1	1	2	2	2	2	2	-5	3
Net interest outlays												
Debt service	*	-1	*	1	2	4	6	8	10	12	1	41
Other	7	10	11	7	*	-1	-1	-1	-2	*	35	31
Subtotal, net interest	7	9	10	8	2	3	5	7	8	12	36	72
All Changes in Outlays	-23	20	37	46	38	36	42	39	39	59	118	333
Increase (-) or Decrease in the Deficit From Technical Changes	**51**	**-7**	**-31**	**-45**	**-50**	**-51**	**-55**	**-52**	**-51**	**-73**	**-81**	**-363**
						All Changes						
Increase (-) in the Deficit	**-130**	**-146**	**-118**	**-142**	**-123**	**-126**	**-159**	**-182**	**-204**	**-218**	**-659**	**-1,549**
Deficit in CBO's January 2016 Baseline	-544	-561	-572	-738	-810	-893	-1,044	-1,077	-1,089	-1,226	-3,225	-8,556
Memorandum:												
Changes in Revenues	-139	-117	-96	-100	-87	-88	-115	-139	-162	-182	-540	-1,226
Changes in Outlays	-9	28	22	42	37	38	44	43	42	37	120	323

Source: Congressional Budget Office.

* = between -$500 million and $500 million.

Table B-1.

Return to Reference 1, 2, 3

How Selected Economic Changes Might Affect CBO's Baseline Budget Projections

Billions of Dollars

												Total	
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2017-2021	2017-2026
	Growth Rate of Real GDP Is 0.1 Percentage Point Lower per Year												
Change in Revenues	-2	-5	-9	-14	-19	-24	-30	-36	-43	-50	-58	-70	-286
Change in Outlays													
Mandatory spending	*	*	*	*	*	*	*	1	1	1	1	1	4
Debt service	*	*	*	1	1	2	3	5	6	8	10	5	37
Total	*	*	*	1	2	3	4	5	7	9	11	6	41
Increase (-) in the Deficit	**-2**	**-5**	**-10**	**-15**	**-20**	**-26**	**-33**	**-41**	**-49**	**-59**	**-69**	**-76**	**-327**
	Interest Rates Are 1 Percentage Point Higher per Year												
Change in Revenues	-21	-26	-21	-15	-11	-7	-3	1	4	6	8	-80	-64
Change in Outlays													
Higher interest rates	16	43	64	83	102	121	138	155	169	184	200	414	1,261
Debt service	*	2	5	10	16	22	30	38	47	57	69	56	297
Total	16	45	70	94	118	143	168	193	217	242	269	470	1,558
Increase (-) in the Deficit	**-38**	**-71**	**-91**	**-109**	**-129**	**-150**	**-171**	**-192**	**-213**	**-236**	**-260**	**-549**	**-1,622**
	Inflation Is 1 Percentage Point Higher per Year												
Change in Revenues	-5	23	64	109	156	207	261	320	384	454	529	559	2,507
Change in Outlays													
Discretionary spending[a]	0	1	1	2	3	4	12	23	36	50	65	12	196
Mandatory spending	*	14	34	60	89	121	159	195	234	286	340	318	1,532
Higher interest rates[b]	23	59	84	106	129	152	174	195	215	235	256	530	1,605
Debt service	*	2	4	7	10	14	18	23	29	35	43	37	186
Total	24	75	123	176	232	291	363	437	514	605	704	897	3,519
Increase (-) in the Deficit	**-29**	**-52**	**-58**	**-67**	**-76**	**-84**	**-101**	**-117**	**-130**	**-152**	**-175**	**-337**	**-1,012**
Memorandum:													
Deficit in CBO's January 2016 Baseline	-544	-561	-572	-738	-810	-893	-1,044	-1,077	-1,089	-1,226	-1,366	-3,575	-9,378

Source: Congressional Budget Office.

GDP = gross domestic product; * = between zero and $500 million.

a. Most discretionary spending through 2021 is governed by caps established by the Budget Control Act of 2011; in CBO's baseline, that spending would not be affected by changes in projected inflation.

b. The change in outlays attributable to higher interest rates in this scenario differs from the estimate in the scenario for interest rates because the principal of inflation-protected securities issued by the Treasury grows with inflation.

Table C-1.

Return to Reference

Deficit or Surplus With and Without CBO's Estimate of Automatic Stabilizers, and Related Estimates, in Billions of Dollars

	Deficit (-) or Surplus With Automatic Stabilizers	– Automatic Stabilizers	= Deficit (-) or Surplus Without Automatic Stabilizers	Revenues and Outlays Without Automatic Stabilizers: Revenues	Outlays	GDP Gap[a]	Unemployment Gap (Percent)[b]
1965	-1	3	-4	115	119	8	-0.7
1966	-4	10	-13	123	137	33	-1.7
1967	-9	10	-19	142	161	31	-2.0
1968	-25	9	-34	148	182	27	-2.0
1969	3	12	-8	180	188	31	-2.4
1970	-3	5	-7	192	200	8	-1.9
1971	-23	-4	-19	192	211	-12	-0.2
1972	-23	-2	-21	210	231	-3	-0.1
1973	-15	11	-26	222	248	39	-0.9
1974	-6	10	-16	257	273	26	-1.2
1975	-53	-19	-34	295	329	-61	1.2
1976	-74	-25	-49	315	365	-59	1.8
1977	-54	-14	-39	365	404	-36	1.1
1978	-59	*	-59	399	458	-4	**
1979	-41	9	-50	457	506	14	-0.4
1980	-74	-18	-56	532	588	-61	0.6
1981	-79	-30	-49	621	670	-66	1.2
1982	-128	-72	-56	670	726	-201	3.0
1983	-208	-97	-110	667	777	-238	4.1
1984	-185	-29	-156	685	841	-79	1.8
1985	-212	-8	-204	736	940	-35	1.2
1986	-221	-4	-217	768	985	-18	1.0
1987	-150	-7	-143	858	1,002	-27	0.4
1988	-155	12	-167	899	1,066	31	-0.3
1989	-153	27	-180	968	1,148	74	-0.7
1990	-221	18	-239	1,017	1,256	42	-0.5
1991	-269	-48	-221	1,098	1,319	-154	0.8
1992	-290	-68	-222	1,146	1,369	-170	1.7
1993	-255	-65	-190	1,208	1,397	-170	1.5
1994	-203	-56	-147	1,307	1,454	-149	0.9
1995	-164	-55	-108	1,405	1,513	-170	0.3
1996	-107	-61	-46	1,512	1,558	-174	0.2
1997	-22	-26	4	1,611	1,606	-80	**
1998	69	-2	71	1,729	1,658	-12	-0.5
1999	126	39	87	1,797	1,710	107	-0.7

Continued

Table C-1. Continued

Deficit or Surplus With and Without CBO's Estimate of Automatic Stabilizers, and Related Estimates, in Billions of Dollars

	Deficit (-) or Surplus With Automatic Stabilizers	– Automatic Stabilizers	= Deficit (-) or Surplus Without Automatic Stabilizers	Revenues and Outlays Without Automatic Stabilizers: Revenues	Revenues and Outlays Without Automatic Stabilizers: Outlays	GDP Gap[a]	Unemployment Gap (Percent)[b]
2000	236	78	158	1,960	1,802	217	-1.0
2001	128	27	101	1,975	1,873	23	-0.7
2002	-158	-64	-94	1,910	2,004	-215	0.7
2003	-378	-102	-275	1,871	2,146	-319	1.0
2004	-413	-61	-352	1,929	2,281	-169	0.6
2005	-318	-22	-296	2,171	2,467	-59	0.2
2006	-248	2	-250	2,407	2,658	-8	-0.2
2007	-161	-11	-149	2,587	2,736	-74	-0.4
2008	-459	-65	-393	2,585	2,978	-238	0.4
2009	-1,413	-291	-1,122	2,333	3,455	-992	3.6
2010	-1,294	-343	-952	2,413	3,364	-922	4.7
2011	-1,300	-304	-996	2,518	3,514	-820	4.0
2012	-1,087	-235	-852	2,610	3,462	-648	3.2
2013	-680	-239	-440	2,951	3,392	-698	2.5
2014	-485	-202	-283	3,181	3,464	-585	1.5
2015	-439	-141	-298	3,370	3,668	-423	0.6
2016	-544	-89	-455	3,462	3,917	-294	-0.1
2017	-561	-34	-528	3,552	4,080	-124	-0.4
2018	-572	-3	-570	3,643	4,213	-21	-0.3
2019	-738	-9	-729	3,757	4,487	-33	**
2020	-810	-31	-779	3,943	4,722	-88	0.2
2021	-893	-41	-852	4,109	4,961	-109	0.2
2022	-1,044	-42	-1,002	4,278	5,280	-114	0.2
2023	-1,077	-43	-1,034	4,455	5,490	-119	0.2
2024	-1,089	-45	-1,045	4,646	5,691	-124	0.2
2025	-1,226	-47	-1,180	4,855	6,035	-129	0.2
2026	-1,366	-49	-1,318	5,074	6,391	-135	0.2

Source: Congressional Budget Office, using data from the Office of Management and Budget.

Automatic stabilizers are automatic changes in revenues and outlays that are attributable to cyclical movements in GDP and unemployment.

Shaded amounts are actual deficits or surpluses.

GDP = gross domestic product; * = between zero and $500 million; ** = between -0.05 percent and 0.05 percent.

a. The GDP gap equals actual or projected GDP minus CBO's estimate of potential GDP (the maximum sustainable output of the economy).

b. The unemployment gap equals the actual or projected rate of unemployment minus the underlying long-term rate of unemployment.

Table C-2.

Return to Reference

Deficit or Surplus With and Without CBO's Estimate of Automatic Stabilizers, and Related Estimates, as a Percentage of Potential Gross Domestic Product

	Deficit (-) or Surplus With Automatic Stabilizers	–	Automatic Stabilizers	=	Deficit (-) or Surplus Without Automatic Stabilizers	Revenues and Outlays Without Automatic Stabilizers: Revenues	Revenues and Outlays Without Automatic Stabilizers: Outlays	GDP Gap[a]	Unemployment Gap (Percent)[b]
1965	-0.2		0.4		-0.6	16.3	17.0	1.1	-0.7
1966	-0.5		1.3		-1.8	16.5	18.3	4.4	-1.7
1967	-1.1		1.3		-2.3	17.6	19.9	3.9	-2.0
1968	-2.9		1.0		-3.9	16.9	20.8	3.1	-2.0
1969	0.3		1.2		-0.9	18.9	19.8	3.3	-2.4
1970	-0.3		0.4		-0.7	18.5	19.2	0.8	-1.9
1971	-2.0		-0.4		-1.7	17.0	18.6	-1.1	-0.2
1972	-1.9		-0.2		-1.7	17.2	18.9	-0.3	-0.1
1973	-1.1		0.8		-2.0	16.9	18.8	3.0	-0.9
1974	-0.4		0.7		-1.1	17.6	18.7	1.8	-1.2
1975	-3.2		-1.1		-2.1	17.7	19.7	-3.6	1.2
1976	-4.0		-1.3		-2.7	17.1	19.7	-3.2	1.8
1977	-2.6		-0.7		-1.9	17.7	19.6	-1.8	1.1
1978	-2.6		*		-2.6	17.5	20.1	-0.2	*
1979	-1.6		0.3		-1.9	17.9	19.8	0.6	-0.4
1980	-2.6		-0.6		-2.0	18.6	20.6	-2.2	0.6
1981	-2.5		-0.9		-1.5	19.4	20.9	-2.1	1.2
1982	-3.6		-2.0		-1.6	19.1	20.7	-5.7	3.0
1983	-5.5		-2.6		-2.9	17.7	20.6	-6.3	4.1
1984	-4.6		-0.7		-3.9	17.0	20.9	-2.0	1.8
1985	-4.9		-0.2		-4.7	17.1	21.8	-0.8	1.2
1986	-4.9		-0.1		-4.8	16.9	21.6	-0.4	1.0
1987	-3.1		-0.1		-3.0	17.9	20.8	-0.6	0.4
1988	-3.0		0.2		-3.3	17.5	20.8	0.6	-0.3
1989	-2.8		0.5		-3.3	17.6	20.9	1.3	-0.7
1990	-3.8		0.3		-4.1	17.3	21.4	0.7	-0.5
1991	-4.3		-0.8		-3.5	17.5	21.0	-2.5	0.8
1992	-4.4		-1.0		-3.4	17.4	20.7	-2.6	1.7
1993	-3.7		-0.9		-2.7	17.3	20.1	-2.4	1.5
1994	-2.8		-0.8		-2.0	17.8	19.8	-2.0	0.9
1995	-2.1		-0.7		-1.4	18.1	19.5	-2.2	0.3
1996	-1.3		-0.8		-0.6	18.5	19.1	-2.1	0.2
1997	-0.3		-0.3		0.1	18.8	18.8	-0.9	*
1998	0.8		*		0.8	19.3	18.5	-0.1	-0.5
1999	1.3		0.4		0.9	19.1	18.2	1.1	-0.7

Continued

Table C-2. Continued

Deficit or Surplus With and Without CBO's Estimate of Automatic Stabilizers, and Related Estimates, as a Percentage of Potential Gross Domestic Product

	Deficit (-) or Surplus With Automatic Stabilizers	– Automatic Stabilizers	= Deficit (-) or Surplus Without Automatic Stabilizers	Revenues and Outlays Without Automatic Stabilizers: Revenues	Revenues and Outlays Without Automatic Stabilizers: Outlays	GDP Gap[a]	Unemployment Gap (Percent)[b]
2000	2.4	0.8	1.6	19.7	18.1	2.2	-1.0
2001	1.2	0.3	1.0	18.7	17.8	0.2	-0.7
2002	-1.4	-0.6	-0.8	17.2	18.1	-1.9	0.7
2003	-3.2	-0.9	-2.4	16.1	18.4	-2.7	1.0
2004	-3.4	-0.5	-2.9	15.7	18.6	-1.4	0.6
2005	-2.5	-0.2	-2.3	16.8	19.1	-0.5	0.2
2006	-1.8	*	-1.8	17.6	19.4	-0.1	-0.2
2007	-1.1	-0.1	-1.0	18.0	19.0	-0.5	-0.4
2008	-3.1	-0.4	-2.6	17.2	19.9	-1.6	0.4
2009	-9.2	-1.9	-7.3	15.1	22.4	-6.4	3.6
2010	-8.2	-2.2	-6.1	15.3	21.4	-5.9	4.7
2011	-8.0	-1.9	-6.1	15.5	21.7	-5.1	4.0
2012	-6.5	-1.4	-5.1	15.6	20.8	-3.9	3.2
2013	-4.0	-1.4	-2.6	17.2	19.7	-4.1	2.5
2014	-2.7	-1.1	-1.6	17.9	19.5	-3.3	1.5
2015	-2.4	-0.8	-1.6	18.5	20.1	-2.3	0.6
2016	-2.9	-0.5	-2.4	18.4	20.8	-1.6	-0.1
2017	-2.9	-0.2	-2.7	18.3	21.0	-0.6	-0.4
2018	-2.8	*	-2.8	18.1	20.9	-0.1	-0.3
2019	-3.5	*	-3.5	17.9	21.4	-0.2	*
2020	-3.7	-0.1	-3.6	18.1	21.7	-0.4	0.2
2021	-3.9	-0.2	-3.8	18.1	21.9	-0.5	0.2
2022	-4.4	-0.2	-4.2	18.1	22.3	-0.5	0.2
2023	-4.4	-0.2	-4.2	18.1	22.3	-0.5	0.2
2024	-4.3	-0.2	-4.1	18.1	22.2	-0.5	0.2
2025	-4.6	-0.2	-4.4	18.2	22.6	-0.5	0.2
2026	-4.9	-0.2	-4.7	18.3	23.0	-0.5	0.2

Source: Congressional Budget Office, using data from the Office of Management and Budget.

Automatic stabilizers are automatic changes in revenues and outlays that are attributable to cyclical movements in GDP and unemployment.

Shaded amounts are actual deficits or surpluses.

GDP = gross domestic product; * = between -0.05 percent and 0.05 percent.

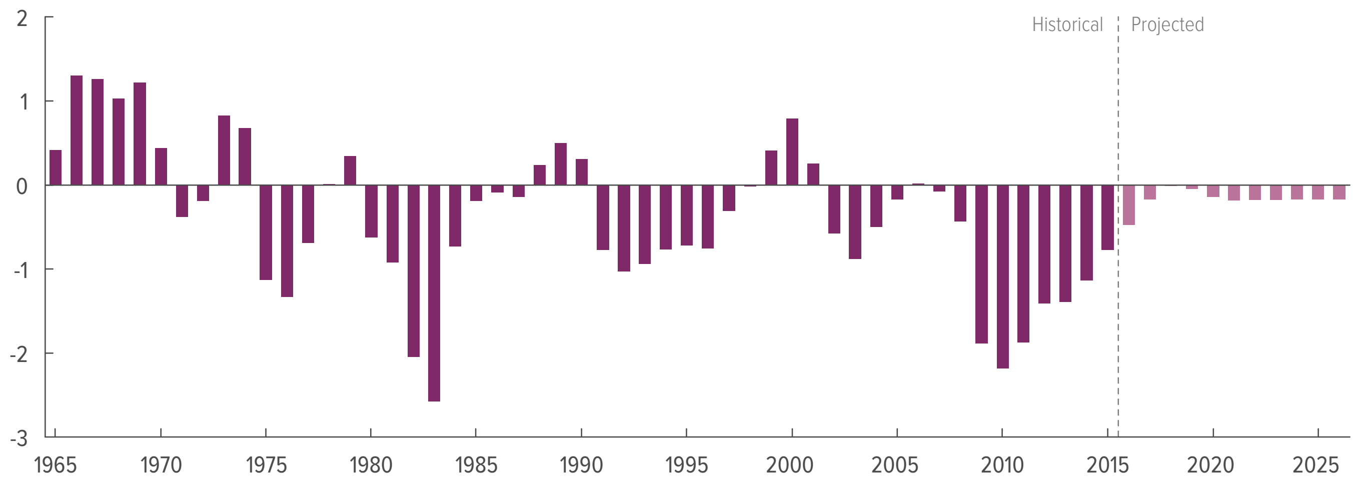
a. The GDP gap equals actual or projected GDP minus CBO's estimate of potential GDP (the maximum sustainable output of the economy), expressed as a percentage of potential GDP.

b. The unemployment gap equals the actual or projected rate of unemployment minus the underlying long-term rate of unemployment.

Figure C-1. Return to Reference

Contribution of Automatic Stabilizers to Budget Deficits and Surpluses

Percentage of Potential Gross Domestic Product



Source: Congressional Budget Office.

Automatic stabilizers are automatic changes in revenues and outlays that are attributable to cyclical movements in gross domestic product and unemployment.

Potential gross domestic product is CBO's estimate of the maximum sustainable output of the economy.

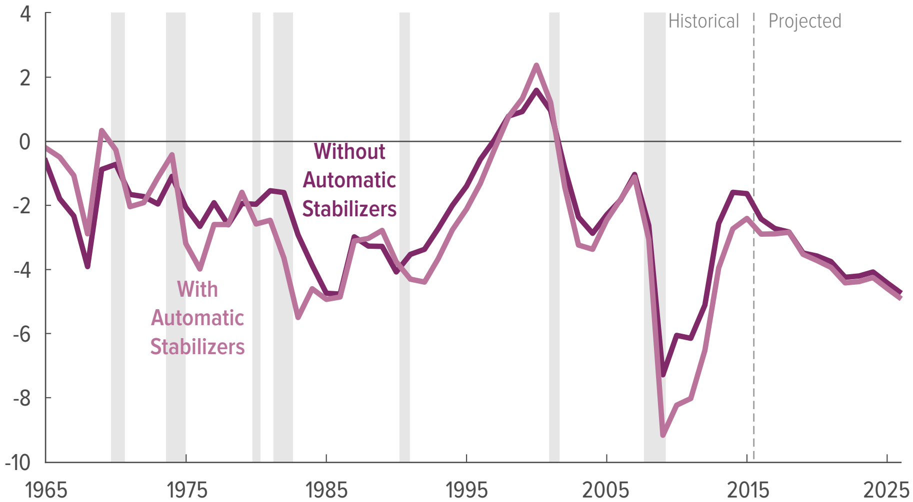
Data are fiscal year values.

Figure C-2.

Return to Reference

Budget Deficits and Surpluses With and Without Automatic Stabilizers

Percentage of Potential Gross Domestic Product



The estimated deficit without automatic stabilizers has tended to increase during recessions and early in recoveries in part as a result of legislation enacted to boost the economy.

Source: Congressional Budget Office, using data from the Office of Management and Budget.

Automatic stabilizers are automatic changes in revenues and outlays that are attributable to cyclical movements in gross domestic product and unemployment.

Potential gross domestic product is CBO's estimate of the maximum sustainable output of the economy.

Data are fiscal year values.

Table D-1.

Return to Reference

Trust Fund Balances Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Social Security												
Old-Age and Survivors Insurance	2,767	2,787	2,789	2,768	2,748	2,706	2,632	2,522	2,374	2,186	1,952	1,671
Disability Insurance[a]	42	44	60	78	64	38	6	0	0	0	0	0
Subtotal	2,808	2,831	2,849	2,846	2,812	2,744	2,639	2,522	2,374	2,186	1,952	1,671
Civilian Retirement[b]	750	903	918	932	947	961	975	989	1,003	1,017	1,031	1,044
Military Retirement	531	590	659	747	837	933	1,037	1,143	1,261	1,393	1,529	1,674
Medicare												
Hospital Insurance (Part A)[a]	195	190	192	203	201	192	177	139	105	76	25	0
Supplementary Medical Insurance (Part B)	66	70	73	83	84	85	86	87	90	95	95	101
Subtotal	262	260	265	286	284	277	262	226	194	170	120	101
Highway and Mass Transit[a]	8	66	54	41	26	10	0	0	0	0	0	0
Unemployment Insurance	29	40	49	54	58	58	61	64	66	66	69	72
Airport and Airway	13	13	13	15	16	16	16	18	19	19	19	20
Railroad Retirement (Treasury holdings)[c]	3	3	3	3	3	3	3	3	3	3	3	3
Other[d]	119	125	125	126	128	130	133	135	138	142	146	150
Total Trust Fund Balance	**4,523**	**4,830**	**4,935**	**5,050**	**5,111**	**5,133**	**5,126**	**5,100**	**5,058**	**4,995**	**4,868**	**4,735**
Memorandum:												
Railroad Retirement (Non-Treasury holdings)[c]	24	23	22	21	21	20	19	18	18	17	17	16

Source: Congressional Budget Office.

These balances are for the end of the fiscal year and include securities invested in Treasury holdings.

a. In keeping with the rules in section 257 of the Balanced Budget and Emergency Deficit Control Act of 1985, CBO's baseline incorporates the assumption that scheduled payments will continue to be made in full after the trust fund has been exhausted, although there is no legal authority to make such payments. Because the manner by which those payments continued would depend on future legislation, CBO shows zero rather than a cumulative negative balance in the trust fund after the exhaustion date.

b. Includes Civil Service Retirement, Foreign Service Retirement, and several smaller retirement trust funds.

c. The Railroad Retirement and Survivors' Improvement Act of 2001 established the National Railroad Retirement Investment Trust, which is allowed to invest in non-Treasury securities such as stocks and corporate bonds.

d. Consists primarily of trust funds for federal employees' health and life insurance, Superfund, and various insurance programs for veterans.

Table D-2.

Return to Reference 1, 2

Trust Fund Deficits or Surpluses Projected in CBO's Baseline

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
Social Security														
Old-Age and Survivors Insurance	54	20	2	-21	-20	-42	-74	-110	-148	-188	-233	-281	-154	-1,116
Disability Insurance[a]	-28	2	16	18	-14	-27	-31	-35	-38	-41	-44	-48	-38	-245
Subtotal	25	23	18	-3	-34	-68	-105	-145	-187	-230	-277	-329	-192	-1,361
Civilian Retirement[b]	-126	152	15	15	14	14	14	14	14	14	14	13	72	141
Military Retirement	48	59	68	88	90	97	104	106	118	132	136	146	447	1,084
Medicare														
Hospital Insurance (Part A)[a]	-7	-5	2	11	-2	-8	-16	-37	-35	-29	-51	-68	-14	-233
Supplementary Medical Insurance (Part B)	-2	3	3	11	*	1	1	1	3	5	*	6	16	31
Subtotal	-9	-2	5	21	-2	-7	-15	-36	-32	-24	-50	-62	3	-201
Highway and Mass Transit[a]	-3	58	-12	-13	-14	-16	-18	-19	-21	-22	-24	-24	-74	-184
Unemployment Insurance	8	10	9	5	4	*	3	3	2	*	3	3	21	32
Airport and Airway	*	*	*	1	1	*	*	1	1	*	*	1	4	7
Other[c]	-5	5	1	1	2	2	3	3	3	4	4	4	8	26
Total Trust Fund Deficit (-) or Surplus	**-61**	**307**	**105**	**116**	**61**	**22**	**-15**	**-75**	**-101**	**-126**	**-195**	**-248**	**288**	**-456**
Intragovernmental Transfers to Trust Funds[d]	657	709	722	745	788	836	880	945	981	1,006	1,072	1,128	3,971	9,104
Net Budgetary Impact of Trust Fund Programs	**-718**	**-402**	**-617**	**-629**	**-727**	**-814**	**-895**	**-1,020**	**-1,082**	**-1,133**	**-1,267**	**-1,376**	**-3,683**	**-9,561**

Source: Congressional Budget Office.

Negative numbers indicate that the trust fund transactions add to total budget deficits.

* = between -$500 million and $500 million.

a. CBO projects that the balance of this trust fund will be exhausted during the 2017–2026 period. However, in keeping with the rules in section 257 of the Balanced Budget and Emergency Deficit Control Act of 1985, CBO's baseline incorporates the assumption that scheduled payments will continue to be made in full after the trust fund has been exhausted, although there is no legal authority to make such payments. The manner by which those payments continued would depend on future legislation.

b. Includes Civil Service Retirement, Foreign Service Retirement, and several smaller retirement trust funds.

c. Consists primarily of trust funds for railroad workers' retirement, federal employees' health and life insurance, Superfund, and various insurance programs for veterans.

d. Includes interest paid to trust funds, payments from the Treasury's general fund to the Supplementary Medical Insurance Trust Fund, the government's share of payments for federal employees' retirement, lump-sum payments to the Civil Service and Military Retirement Trust Funds, taxes on Social Security benefits, and smaller miscellaneous payments.

Table D-3.

Return to Reference 1, 2, 3, 4

Balances Projected in CBO's Baseline for the OASI, DI, and HI Trust Funds

Billions of Dollars

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total 2017-2021	Total 2017-2026
							OASI Trust Fund							
Beginning-of-Year Balance	2,713	2,767	2,787	2,789	2,768	2,748	2,706	2,632	2,522	2,374	2,186	1,952	n.a.	n.a.
Income (Excluding interest)	702	699	719	748	805	845	876	910	945	982	1,021	1,061	3,993	8,910
Expenditures	-741	-769	-802	-854	-911	-973	-1,037	-1,105	-1,175	-1,248	-1,326	-1,407	-4,577	-10,838
Noninterest Deficit	-39	-70	-83	-106	-106	-128	-161	-195	-230	-266	-305	-346	-584	-1,927
Interest received	93	90	85	85	86	87	87	85	82	78	72	64	430	811
Total Deficit (-) or Surplus	54	20	2	-21	-20	-42	-74	-110	-148	-188	-233	-281	-154	-1,116
End-of-Year Balance	**2,767**	**2,787**	**2,789**	**2,768**	**2,748**	**2,706**	**2,632**	**2,522**	**2,374**	**2,186**	**1,952**	**1,671**	**n.a.**	**n.a.**
							DI Trust Fund[a]							
Beginning-of-Year Balance	70	42	44	60	78	64	38	6	0	0	0	0	n.a.	n.a.
Income (Excluding interest)	115	148	163	170	144	138	143	148	153	159	165	171	758	1,555
Expenditures	-146	-147	-149	-154	-161	-167	-175	-183	-192	-201	-209	-219	-806	-1,811
Noninterest Deficit (-) or Surplus	-31	1	14	15	-17	-29	-32	-35	-38	-41	-44	-48	-48	-256
Interest received	3	2	2	3	3	2	1	0	0	0	0	0	11	11
Total Deficit (-) or Surplus	-28	2	16	18	-14	-27	-31	-35	-38	-41	-44	-48	-38	-245
End-of-Year Balance	**42**	**44**	**60**	**78**	**64**	**38**	**6**	**0**	**0**	**0**	**0**	**0**	**n.a.**	**n.a.**
							HI Trust Fund[a]							
Beginning-of-Year Balance	202	195	190	192	203	201	192	177	139	105	76	25	n.a.	n.a.
Income (Excluding interest)	269	285	299	313	326	341	356	373	391	409	429	450	1,636	3,688
Expenditures	-284	-299	-306	-311	-338	-358	-381	-418	-431	-443	-483	-517	-1,693	-3,986
Noninterest Deficit (-) or Surplus	-15	-14	-7	2	-11	-17	-24	-45	-41	-34	-54	-68	-58	-299
Interest received	9	9	9	9	9	9	8	8	6	5	3	0	44	66
Total Deficit (-) or Surplus	-7	-5	2	11	-2	-8	-16	-37	-35	-29	-51	-68	-14	-233
End-of-Year Balance	**195**	**190**	**192**	**203**	**201**	**192**	**177**	**139**	**105**	**76**	**25**	**0**	**n.a.**	**n.a.**

Source: Congressional Budget Office.

Balances shown are invested in Government Account Series securities issued by the Treasury.

DI = Disability Insurance; HI = Hospital Insurance; OASI = Old-Age and Survivors Insurance; n.a. = not applicable.

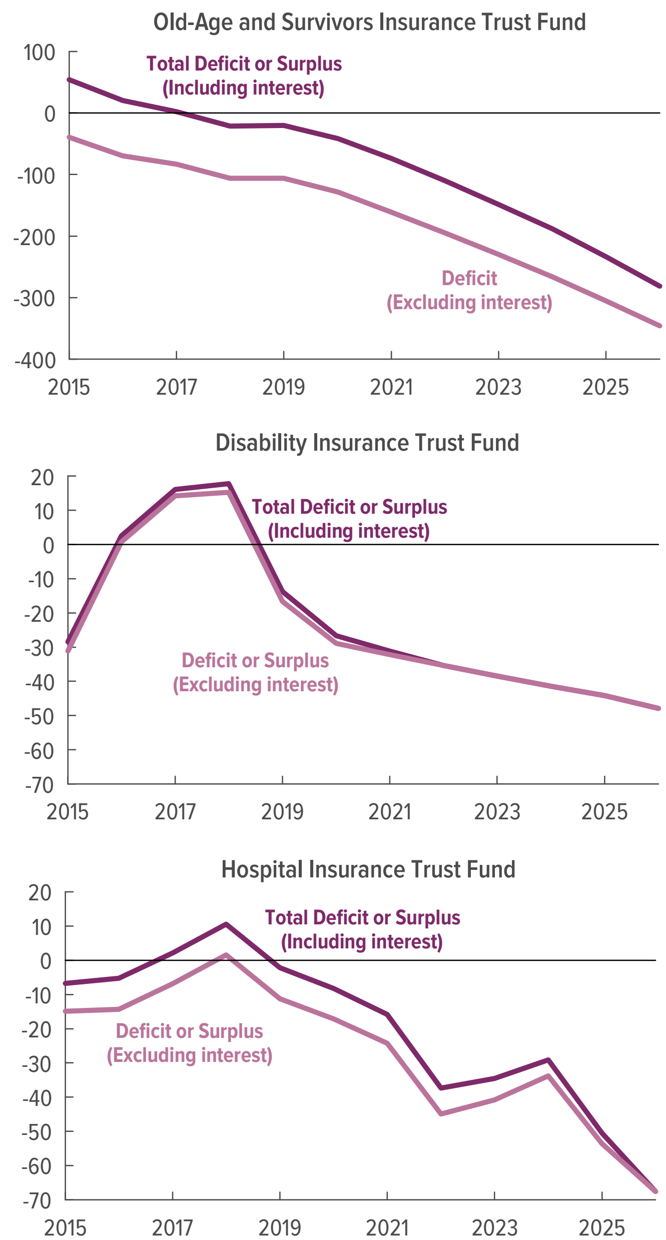
a. In keeping with the rules in section 257 of the Balanced Budget and Emergency Deficit Control Act of 1985, CBO's baseline incorporates the assumption that scheduled payments will continue to be made in full after the trust fund has been exhausted, although there is no legal authority to make such payments. Because the manner by which those payments continued would depend on future legislation, CBO shows zero rather than a cumulative negative balance in the trust fund after the exhaustion date. For the same reason, this table shows zero interest received rather than an interest payment, which implicitly reflects the assumption that future legislation would not require the funds to pay financing costs.

Figure D-1.

Return to Reference 1, 2, 3

Annual Deficits or Surpluses Projected in CBO's Baseline for the OASI, DI, and HI Trust Funds

Billions of Dollars



Source: Congressional Budget Office.

DI = Disability Insurance; HI = Hospital Insurance; OASI = Old-Age and Survivors Insurance.

Table E-1.

Return to Reference

CBO's Economic Projections, by Calendar Year

	Estimated, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
					Percentage Change From Year to Year							
Gross Domestic Product												
Real (Inflation-adjusted)	2.4	2.5	2.6	2.2	1.8	1.9	2.1	2.1	2.0	2.0	2.0	2.0
Nominal	3.5	4.1	4.4	4.2	3.8	3.9	4.1	4.1	4.1	4.1	4.1	4.1
Inflation												
PCE price index	0.3	1.1	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Core PCE price index[a]	1.3	1.5	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Consumer price index[b]	0.1	1.3	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Core consumer price index[a]	1.8	2.0	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
GDP price index	1.1	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1
Employment Cost Index[c]	2.3	2.6	3.2	3.4	3.4	3.3	3.2	3.2	3.2	3.1	3.1	3.2
					Calendar Year Average							
Unemployment Rate (Percent)	5.3 [d]	4.7	4.4	4.6	4.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Payroll Employment (Monthly change, in thousands)[e]	228 [d]	172	124	81	54	61	78	75	73	74	74	74
Interest Rates (Percent)												
Three-month Treasury bills	0.1 [d]	0.7	1.6	2.5	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Ten-year Treasury notes	2.1 [d]	2.8	3.5	3.8	4.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Tax Bases (Percentage of GDP)												
Wages and salaries	43.6	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9
Domestic economic profits	9.2	8.7	8.6	8.3	8.0	7.8	7.7	7.6	7.5	7.5	7.4	7.5
Tax Bases (Billions of dollars)												
Wages and salaries	7,835	8,210	8,572	8,932	9,274	9,627	10,015	10,428	10,863	11,316	11,786	12,276
Domestic economic profits	1,657	1,626	1,676	1,695	1,698	1,718	1,758	1,807	1,861	1,924	1,997	2,095
Nominal GDP (Billions of dollars)	17,957	18,689	19,505	20,325	21,102	21,923	22,823	23,766	24,746	25,764	26,831	27,942

Source: Congressional Budget Office, using data from the Bureau of Labor Statistics and the Federal Reserve.

GDP = gross domestic product; PCE = personal consumption expenditures.

a. Excludes prices for food and energy.

b. The consumer price index for all urban consumers.

c. The employment cost index for wages and salaries of workers in private industries.

d. Actual value for 2015.

e. Calculated as the monthly average of the fourth-quarter-to-fourth-quarter change in payroll employment.

Table E-2.

Return to Reference

CBO's Economic Projections, by Fiscal Year

	Actual, 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
					Percentage Change From Year to Year							
Gross Domestic Product												
Real (Inflation-adjusted)	2.6	2.3	2.6	2.3	1.9	1.8	2.0	2.1	2.0	2.0	2.0	2.0
Nominal	3.6	3.8	4.3	4.3	3.9	3.8	4.1	4.1	4.1	4.1	4.1	4.1
Inflation												
PCE price index	0.5	0.9	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Core PCE price index[a]	1.3	1.4	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Consumer price index[b]	0.3	1.0	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Core consumer price index[a]	1.8	2.0	2.1	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
GDP price index	1.1	1.5	1.7	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.1	2.1
Employment Cost Index[c]	2.3	2.5	3.1	3.4	3.4	3.3	3.2	3.2	3.2	3.2	3.1	3.2
					Fiscal Year Average							
Unemployment Rate (Percent)	5.5	4.8	4.4	4.5	4.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Payroll Employment (Monthly change, in thousands)[d]	239	193	137	92	57	55	77	75	74	74	74	74
Interest Rates (Percent)												
Three-month Treasury bills	*	0.5	1.4	2.3	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Ten-year Treasury notes	2.2	2.6	3.3	3.8	4.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Tax Bases (Percentage of GDP)												
Wages and salaries	43.5	43.9	44.0	43.9	44.0	43.9	43.9	43.9	43.9	43.9	43.9	43.9
Domestic economic profits	9.4	8.8	8.6	8.4	8.1	7.9	7.7	7.6	7.5	7.5	7.4	7.5
Tax Bases (Billions of dollars)												
Wages and salaries	7,751	8,116	8,482	8,842	9,189	9,536	9,915	10,323	10,753	11,201	11,667	12,152
Domestic economic profits	1,669	1,631	1,664	1,695	1,695	1,711	1,748	1,794	1,846	1,909	1,977	2,068
Nominal GDP (Billions of dollars)	17,810	18,494	19,297	20,127	20,906	21,710	22,593	23,528	24,497	25,506	26,559	27,660

Source: Congressional Budget Office, using data from the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the Federal Reserve.

GDP = gross domestic product; PCE = personal consumption expenditures; * = between zero and 0.05 percent.

a. Excludes prices for food and energy.

b. The consumer price index for all urban consumers.

c. The employment cost index for wages and salaries of workers in private industries.

d. Calculated as the monthly average of the fourth-quarter-to-fourth-quarter change in payroll employment.

Table F-1.

Return to Reference 1, 2

Revenues, Outlays, Deficits, Surpluses, and Debt Held by the Public Since 1966

			Deficit (-) or Surplus				
	Revenues	Outlays	On-Budget	Social Security	Postal Service	Total	Debt Held by the Public[a]
				In Billions of Dollars			
1966	130.8	134.5	-3.1	-0.6	n.a.	-3.7	263.7
1967	148.8	157.5	-12.6	4.0	n.a.	-8.6	266.6
1968	153.0	178.1	-27.7	2.6	n.a.	-25.2	289.5
1969	186.9	183.6	-0.5	3.7	n.a.	3.2	278.1
1970	192.8	195.6	-8.7	5.9	n.a.	-2.8	283.2
1971	187.1	210.2	-26.1	3.0	n.a.	-23.0	303.0
1972	207.3	230.7	-26.1	2.3	*	-23.4	322.4
1973	230.8	245.7	-15.2	0.2	-0.2	-14.9	340.9
1974	263.2	269.4	-7.2	0.3	-0.8	-6.1	343.7
1975	279.1	332.3	-54.1	-0.2	-1.1	-53.2	394.7
1976	298.1	371.8	-69.4	-5.4	-1.1	-73.7	477.4
1977	355.6	409.2	-49.9	-3.6	0.2	-53.7	549.1
1978	399.6	458.7	-55.4	-3.3	0.5	-59.2	607.1
1979	463.3	504.0	-39.6	-0.2	0.9	-40.7	640.3
1980	517.1	590.9	-73.1	-0.3	0.4	-73.8	711.9
1981	599.3	678.2	-73.9	-5.2	-0.1	-79.0	789.4
1982	617.8	745.7	-120.6	-6.8	0.6	-128.0	924.6
1983	600.6	808.4	-207.7	-0.4	-0.3	-207.8	1,137.3
1984	666.4	851.8	-185.3	-0.5	-0.4	-185.4	1,307.0
1985	734.0	946.3	-221.5	9.1	-0.1	-212.3	1,507.3
1986	769.2	990.4	-237.9	16.6	*	-221.2	1,740.6
1987	854.3	1,004.0	-168.4	17.7	-0.9	-149.7	1,889.8
1988	909.2	1,064.4	-192.3	35.4	-1.7	-155.2	2,051.6
1989	991.1	1,143.7	-205.4	53.1	0.3	-152.6	2,190.7
1990	1,032.0	1,253.0	-277.6	55.0	-1.6	-221.0	2,411.6
1991	1,055.0	1,324.2	-321.4	50.9	-1.3	-269.2	2,689.0
1992	1,091.2	1,381.5	-340.4	49.4	-0.7	-290.3	2,999.7
1993	1,154.3	1,409.4	-300.4	43.9	-1.4	-255.1	3,248.4
1994	1,258.6	1,461.8	-258.8	54.6	-1.1	-203.2	3,433.1
1995	1,351.8	1,515.7	-226.4	64.4	2.0	-164.0	3,604.4
1996	1,453.1	1,560.5	-174.0	66.8	0.2	-107.4	3,734.1
1997	1,579.2	1,601.1	-103.2	81.4	*	-21.9	3,772.3
1998	1,721.7	1,652.5	-29.9	99.0	-0.2	69.3	3,721.1
1999	1,827.5	1,701.8	1.9	122.7	-1.0	125.6	3,632.4
2000	2,025.2	1,789.0	86.4	149.8	-1.0	236.2	3,409.8
2001	1,991.1	1,862.8	-32.4	158.7	-2.0	128.2	3,319.6
2002	1,853.1	2,010.9	-317.4	157.4	-2.3	-157.8	3,540.4
2003	1,782.3	2,159.9	-538.4	161.5	0.7	-377.6	3,913.4
2004	1,880.1	2,292.8	-568.0	160.5	5.2	-412.7	4,295.5
2005	2,153.6	2,472.0	-493.6	179.4	4.1	-318.3	4,592.2
2006	2,406.9	2,655.1	-434.5	188.1	1.8	-248.2	4,829.0
2007	2,568.0	2,728.7	-342.2	182.5	1.1	-160.7	5,035.1
2008	2,524.0	2,982.5	-641.8	178.2	-5.1	-458.6	5,803.1
2009	2,105.0	3,517.7	-1,549.7	134.6	-2.4	-1,412.7	7,544.7
2010	2,162.7	3,457.1	-1,371.4	72.3	-4.7	-1,294.4	9,018.9
2011	2,303.5	3,603.1	-1,366.8	66.4	-0.8	-1,299.6	10,128.2
2012	2,450.0	3,537.0	-1,148.9	59.2	-2.7	-1,087.0	11,281.1
2013	2,775.1	3,454.6	-719.0	41.4	1.9	-679.5	11,982.7
2014	3,021.5	3,506.1	-514.1	32.0	2.5	-484.6	12,779.9
2015	3,248.7	3,687.4	-466.0	29.0	1.7	-438.7	13,116.6

Continued

Table F-1. Continued

Revenues, Outlays, Deficits, Surpluses, and Debt Held by the Public Since 1966

			Deficit (-) or Surplus				
	Revenues	Outlays	On-Budget	Social Security	Postal Service	Total	Debt Held by the Public[a]
			As a Percentage of Gross Domestic Product				
1966	16.7	17.2	-0.4	-0.1	n.a.	-0.5	33.7
1967	17.8	18.8	-1.5	0.5	n.a.	-1.0	31.8
1968	17.0	19.8	-3.1	0.3	n.a.	-2.8	32.2
1969	19.0	18.7	-0.1	0.4	n.a.	0.3	28.3
1970	18.4	18.7	-0.8	0.6	n.a.	-0.3	27.0
1971	16.7	18.8	-2.3	0.3	n.a.	-2.1	27.1
1972	17.0	18.9	-2.1	0.2	**	-1.9	26.4
1973	17.0	18.1	-1.1	**	**	-1.1	25.1
1974	17.7	18.1	-0.5	**	0.1	-0.4	23.1
1975	17.3	20.6	-3.4	**	0.1	-3.3	24.5
1976	16.6	20.8	-3.9	-0.3	0.1	-4.1	26.7
1977	17.5	20.2	-2.5	-0.2	**	-2.6	27.1
1978	17.5	20.1	-2.4	-0.1	**	-2.6	26.6
1979	18.0	19.6	-1.5	**	**	-1.6	24.9
1980	18.5	21.1	-2.6	**	**	-2.6	25.5
1981	19.1	21.6	-2.4	-0.2	**	-2.5	25.2
1982	18.6	22.5	-3.6	-0.2	**	-3.9	27.9
1983	17.0	22.8	-5.9	**	**	-5.9	32.1
1984	16.9	21.5	-4.7	**	**	-4.7	33.1
1985	17.2	22.2	-5.2	0.2	**	-5.0	35.3
1986	17.0	21.8	-5.2	0.4	**	-4.9	38.4
1987	17.9	21.0	-3.5	0.4	**	-3.1	39.5
1988	17.6	20.6	-3.7	0.7	**	-3.0	39.8
1989	17.8	20.5	-3.7	1.0	**	-2.7	39.3
1990	17.4	21.2	-4.7	0.9	**	-3.7	40.8
1991	17.3	21.7	-5.3	0.8	**	-4.4	44.0
1992	17.0	21.5	-5.3	0.8	**	-4.5	46.6
1993	17.0	20.7	-4.4	0.6	**	-3.8	47.8
1994	17.5	20.3	-3.6	0.8	**	-2.8	47.7
1995	17.8	20.0	-3.0	0.8	**	-2.2	47.5
1996	18.2	19.6	-2.2	0.8	**	-1.3	46.8
1997	18.6	18.9	-1.2	1.0	**	-0.3	44.5
1998	19.2	18.5	-0.3	1.1	**	0.8	41.6
1999	19.2	17.9	**	1.3	**	1.3	38.2
2000	20.0	17.6	0.9	1.5	**	2.3	33.6
2001	18.8	17.6	-0.3	1.5	**	1.2	31.4
2002	17.0	18.5	-2.9	1.4	**	-1.5	32.6
2003	15.7	19.1	-4.8	1.4	**	-3.3	34.5
2004	15.6	19.0	-4.7	1.3	**	-3.4	35.5
2005	16.7	19.2	-3.8	1.4	**	-2.5	35.6
2006	17.6	19.4	-3.2	1.4	**	-1.8	35.3
2007	17.9	19.1	-2.4	1.3	**	-1.1	35.2
2008	17.1	20.2	-4.4	1.2	**	-3.1	39.3
2009	14.6	24.4	-10.8	0.9	**	-9.8	52.3
2010	14.6	23.4	-9.3	0.5	**	-8.7	60.9
2011	15.0	23.4	-8.9	0.4	**	-8.5	65.9
2012	15.3	22.1	-7.2	0.4	**	-6.8	70.4
2013	16.8	20.9	-4.4	0.3	**	-4.1	72.6
2014	17.6	20.4	-3.0	0.2	**	-2.8	74.4
2015	18.2	20.7	-2.6	0.2	**	-2.5	73.6

Sources: Congressional Budget Office; Office of Management and Budget.

n.a. = not applicable (the Postal Service was not an independent agency until 1972); * = between -$50 million and $50 million; ** = between -0.05 percent and 0.05 percent.

a. End of year.

Table F-2.

Return to Reference

Revenues, by Major Source, Since 1966

	Individual Income Taxes	Payroll Taxes	Corporate Income Taxes	Excise Taxes	Estate and Gift Taxes	Customs Duties	Miscellaneous Receipts	Total
				In Billions of Dollars				
1966	55.4	25.5	30.1	13.1	3.1	1.8	1.9	130.8
1967	61.5	32.6	34.0	13.7	3.0	1.9	2.1	148.8
1968	68.7	33.9	28.7	14.1	3.1	2.0	2.5	153.0
1969	87.2	39.0	36.7	15.2	3.5	2.3	2.9	186.9
1970	90.4	44.4	32.8	15.7	3.6	2.4	3.4	192.8
1971	86.2	47.3	26.8	16.6	3.7	2.6	3.9	187.1
1972	94.7	52.6	32.2	15.5	5.4	3.3	3.6	207.3
1973	103.2	63.1	36.2	16.3	4.9	3.2	3.9	230.8
1974	119.0	75.1	38.6	16.8	5.0	3.3	5.4	263.2
1975	122.4	84.5	40.6	16.6	4.6	3.7	6.7	279.1
1976	131.6	90.8	41.4	17.0	5.2	4.1	8.0	298.1
1977	157.6	106.5	54.9	17.5	7.3	5.2	6.5	355.6
1978	181.0	121.0	60.0	18.4	5.3	6.6	7.4	399.6
1979	217.8	138.9	65.7	18.7	5.4	7.4	9.3	463.3
1980	244.1	157.8	64.6	24.3	6.4	7.2	12.7	517.1
1981	285.9	182.7	61.1	40.8	6.8	8.1	13.8	599.3
1982	297.7	201.5	49.2	36.3	8.0	8.9	16.2	617.8
1983	288.9	209.0	37.0	35.3	6.1	8.7	15.6	600.6
1984	298.4	239.4	56.9	37.4	6.0	11.4	17.0	666.4
1985	334.5	265.2	61.3	36.0	6.4	12.1	18.5	734.0
1986	349.0	283.9	63.1	32.9	7.0	13.3	19.9	769.2
1987	392.6	303.3	83.9	32.5	7.5	15.1	19.5	854.3
1988	401.2	334.3	94.5	35.2	7.6	16.2	20.2	909.2
1989	445.7	359.4	103.3	34.4	8.7	16.3	23.2	991.1
1990	466.9	380.0	93.5	35.3	11.5	16.7	28.0	1,032.0
1991	467.8	396.0	98.1	42.4	11.1	15.9	23.6	1,055.0
1992	476.0	413.7	100.3	45.6	11.1	17.4	27.2	1,091.2
1993	509.7	428.3	117.5	48.1	12.6	18.8	19.4	1,154.3
1994	543.1	461.5	140.4	55.2	15.2	20.1	23.1	1,258.6
1995	590.2	484.5	157.0	57.5	14.8	19.3	28.5	1,351.8
1996	656.4	509.4	171.8	54.0	17.2	18.7	25.5	1,453.1
1997	737.5	539.4	182.3	56.9	19.8	17.9	25.4	1,579.2
1998	828.6	571.8	188.7	57.7	24.1	18.3	32.6	1,721.7
1999	879.5	611.8	184.7	70.4	27.8	18.3	34.9	1,827.5
2000	1,004.5	652.9	207.3	68.9	29.0	19.9	42.8	2,025.2
2001	994.3	694.0	151.1	66.2	28.4	19.4	37.7	1,991.1
2002	858.3	700.8	148.0	67.0	26.5	18.6	33.9	1,853.1
2003	793.7	713.0	131.8	67.5	22.0	19.9	34.5	1,782.3
2004	809.0	733.4	189.4	69.9	24.8	21.1	32.6	1,880.1
2005	927.2	794.1	278.3	73.1	24.8	23.4	32.7	2,153.6
2006	1,043.9	837.8	353.9	74.0	27.9	24.8	44.6	2,406.9
2007	1,163.5	869.6	370.2	65.1	26.0	26.0	47.5	2,568.0
2008	1,145.7	900.2	304.3	67.3	28.8	27.6	50.0	2,524.0
2009	915.3	890.9	138.2	62.5	23.5	22.5	52.1	2,105.0
2010	898.5	864.8	191.4	66.9	18.9	25.3	96.8	2,162.7
2011	1,091.5	818.8	181.1	72.4	7.4	29.5	102.8	2,303.5
2012	1,132.2	845.3	242.3	79.1	14.0	30.3	106.8	2,450.0
2013	1,316.4	947.8	273.5	84.0	18.9	31.8	102.6	2,775.1
2014	1,394.6	1,023.5	320.7	93.4	19.3	33.9	136.1	3,021.5
2015	1,540.8	1,065.3	343.8	98.3	19.2	35.0	146.3	3,248.7

Continued

Table F-2. Continued

Revenues, by Major Source, Since 1966

	Individual Income Taxes	Payroll Taxes	Corporate Income Taxes	Excise Taxes	Estate and Gift Taxes	Customs Duties	Miscellaneous Receipts	Total
				As a Percentage of Gross Domestic Product				
1966	7.1	3.3	3.8	1.7	0.4	0.2	0.2	16.7
1967	7.3	3.9	4.1	1.6	0.4	0.2	0.3	17.8
1968	7.6	3.8	3.2	1.6	0.3	0.2	0.3	17.0
1969	8.9	4.0	3.7	1.6	0.4	0.2	0.3	19.0
1970	8.6	4.2	3.1	1.5	0.3	0.2	0.3	18.4
1971	7.7	4.2	2.4	1.5	0.3	0.2	0.3	16.7
1972	7.8	4.3	2.6	1.3	0.4	0.3	0.3	17.0
1973	7.6	4.7	2.7	1.2	0.4	0.2	0.3	17.0
1974	8.0	5.1	2.6	1.1	0.3	0.2	0.4	17.7
1975	7.6	5.2	2.5	1.0	0.3	0.2	0.4	17.3
1976	7.4	5.1	2.3	0.9	0.3	0.2	0.4	16.6
1977	7.8	5.3	2.7	0.9	0.4	0.3	0.3	17.5
1978	7.9	5.3	2.6	0.8	0.2	0.3	0.3	17.5
1979	8.5	5.4	2.6	0.7	0.2	0.3	0.4	18.0
1980	8.7	5.6	2.3	0.9	0.2	0.3	0.5	18.5
1981	9.1	5.8	1.9	1.3	0.2	0.3	0.4	19.1
1982	9.0	6.1	1.5	1.1	0.2	0.3	0.5	18.6
1983	8.2	5.9	1.0	1.0	0.2	0.2	0.4	17.0
1984	7.5	6.1	1.4	0.9	0.2	0.3	0.4	16.9
1985	7.8	6.2	1.4	0.8	0.2	0.3	0.4	17.2
1986	7.7	6.3	1.4	0.7	0.2	0.3	0.4	17.0
1987	8.2	6.3	1.8	0.7	0.2	0.3	0.4	17.9
1988	7.8	6.5	1.8	0.7	0.1	0.3	0.4	17.6
1989	8.0	6.5	1.9	0.6	0.2	0.3	0.4	17.8
1990	7.9	6.4	1.6	0.6	0.2	0.3	0.5	17.4
1991	7.7	6.5	1.6	0.7	0.2	0.3	0.4	17.3
1992	7.4	6.4	1.6	0.7	0.2	0.3	0.4	17.0
1993	7.5	6.3	1.7	0.7	0.2	0.3	0.3	17.0
1994	7.5	6.4	2.0	0.8	0.2	0.3	0.3	17.5
1995	7.8	6.4	2.1	0.8	0.2	0.3	0.4	17.8
1996	8.2	6.4	2.2	0.7	0.2	0.2	0.3	18.2
1997	8.7	6.4	2.1	0.7	0.2	0.2	0.3	18.6
1998	9.3	6.4	2.1	0.6	0.3	0.2	0.4	19.2
1999	9.2	6.4	1.9	0.7	0.3	0.2	0.4	19.2
2000	9.9	6.4	2.0	0.7	0.3	0.2	0.4	20.0
2001	9.4	6.6	1.4	0.6	0.3	0.2	0.4	18.8
2002	7.9	6.4	1.4	0.6	0.2	0.2	0.3	17.0
2003	7.0	6.3	1.2	0.6	0.2	0.2	0.3	15.7
2004	6.7	6.1	1.6	0.6	0.2	0.2	0.3	15.6
2005	7.2	6.2	2.2	0.6	0.2	0.2	0.3	16.7
2006	7.6	6.1	2.6	0.5	0.2	0.2	0.3	17.6
2007	8.1	6.1	2.6	0.5	0.2	0.2	0.3	17.9
2008	7.8	6.1	2.1	0.5	0.2	0.2	0.3	17.1
2009	6.4	6.2	1.0	0.4	0.2	0.2	0.4	14.6
2010	6.1	5.8	1.3	0.5	0.1	0.2	0.7	14.6
2011	7.1	5.3	1.2	0.5	*	0.2	0.7	15.0
2012	7.1	5.3	1.5	0.5	0.1	0.2	0.7	15.3
2013	8.0	5.7	1.7	0.5	0.1	0.2	0.6	16.8
2014	8.1	6.0	1.9	0.5	0.1	0.2	0.8	17.6
2015	8.7	6.0	1.9	0.6	0.1	0.2	0.8	18.2

Sources: Congressional Budget Office; Office of Management and Budget.

* = between zero and 0.05 percent.

Table F-3.

Return to Reference

Outlays, by Major Category, Since 1966

	Discretionary	Mandatory: Programmatic Outlays[a]	Mandatory: Offsetting Receipts	Net Interest	Total
			In Billions of Dollars		
1966	90.1	43.4	-8.4	9.4	134.5
1967	106.5	50.9	-10.2	10.3	157.5
1968	118.0	59.7	-10.6	11.1	178.1
1969	117.3	64.6	-11.0	12.7	183.6
1970	120.3	72.5	-11.5	14.4	195.6
1971	122.5	86.9	-14.1	14.8	210.2
1972	128.5	100.8	-14.1	15.5	230.7
1973	130.4	116.0	-18.0	17.3	245.7
1974	138.2	130.9	-21.2	21.4	269.4
1975	158.0	169.4	-18.3	23.2	332.3
1976	175.6	189.1	-19.6	26.7	371.8
1977	197.1	203.7	-21.5	29.9	409.2
1978	218.7	227.4	-22.8	35.5	458.7
1979	240.0	247.0	-25.6	42.6	504.0
1980	276.3	291.2	-29.2	52.5	590.9
1981	307.9	339.4	-37.9	68.8	678.2
1982	326.0	370.8	-36.0	85.0	745.7
1983	353.3	410.6	-45.3	89.8	808.4
1984	379.4	405.5	-44.2	111.1	851.8
1985	415.8	448.2	-47.1	129.5	946.3
1986	438.5	461.7	-45.9	136.0	990.4
1987	444.2	474.2	-52.9	138.6	1,004.0
1988	464.4	505.0	-56.8	151.8	1,064.4
1989	488.8	546.1	-60.1	169.0	1,143.7
1990	500.6	625.6	-57.5	184.3	1,253.0
1991	533.3	702.0	-105.5	194.4	1,324.2
1992	533.8	717.7	-69.3	199.3	1,381.5
1993	539.8	736.8	-65.9	198.7	1,409.4
1994	541.3	786.0	-68.5	202.9	1,461.8
1995	544.8	817.5	-78.7	232.1	1,515.7
1996	532.7	857.6	-70.9	241.1	1,560.5
1997	547.0	895.5	-85.4	244.0	1,601.1
1998	552.0	942.9	-83.5	241.1	1,652.5
1999	572.1	979.4	-79.4	229.8	1,701.8
2000	614.6	1,032.4	-81.0	222.9	1,789.0
2001	649.0	1,096.8	-89.2	206.2	1,862.8
2002	734.0	1,196.3	-90.3	170.9	2,010.9
2003	824.3	1,283.4	-100.9	153.1	2,159.9
2004	895.1	1,346.4	-108.9	160.2	2,292.8
2005	968.5	1,448.1	-128.7	184.0	2,472.0
2006	1,016.6	1,556.1	-144.3	226.6	2,655.1
2007	1,041.6	1,627.9	-177.9	237.1	2,728.7
2008	1,134.9	1,780.3	-185.4	252.8	2,982.5
2009	1,237.5	2,287.8	-194.6	186.9	3,517.7
2010	1,347.2	2,110.2	-196.5	196.2	3,457.1
2011	1,347.1	2,234.9	-209.0	230.0	3,603.1
2012	1,286.1	2,258.8	-228.3	220.4	3,537.0
2013	1,202.1	2,336.4	-304.8	220.9	3,454.6
2014	1,178.7	2,375.8	-277.3	229.0	3,506.1
2015	1,165.2	2,555.3	-256.5	223.4	3,687.4

Continued

Table F-3. Continued

Outlays, by Major Category, Since 1966

		Mandatory			
	Discretionary	Programmatic Outlays[a]	Offsetting Receipts	Net Interest	Total
		As a Percentage of Gross Domestic Product			
1966	11.5	5.5	-1.1	1.2	17.2
1967	12.7	6.1	-1.2	1.2	18.8
1968	13.1	6.6	-1.2	1.2	19.8
1969	11.9	6.6	-1.1	1.3	18.7
1970	11.5	6.9	-1.1	1.4	18.7
1971	10.9	7.8	-1.3	1.3	18.8
1972	10.5	8.3	-1.2	1.3	18.9
1973	9.6	8.6	-1.3	1.3	18.1
1974	9.3	8.8	-1.4	1.4	18.1
1975	9.8	10.5	-1.1	1.4	20.6
1976	9.8	10.6	-1.1	1.5	20.8
1977	9.7	10.0	-1.1	1.5	20.2
1978	9.6	10.0	-1.0	1.6	20.1
1979	9.3	9.6	-1.0	1.7	19.6
1980	9.9	10.4	-1.0	1.9	21.1
1981	9.8	10.8	-1.2	2.2	21.6
1982	9.8	11.2	-1.1	2.6	22.5
1983	10.0	11.6	-1.3	2.5	22.8
1984	9.6	10.3	-1.1	2.8	21.5
1985	9.7	10.5	-1.1	3.0	22.2
1986	9.7	10.2	-1.0	3.0	21.8
1987	9.3	9.9	-1.1	2.9	21.0
1988	9.0	9.8	-1.1	2.9	20.6
1989	8.8	9.8	-1.1	3.0	20.5
1990	8.5	10.6	-1.0	3.1	21.2
1991	8.7	11.5	-1.7	3.2	21.7
1992	8.3	11.2	-1.1	3.1	21.5
1993	7.9	10.8	-1.0	2.9	20.7
1994	7.5	10.9	-1.0	2.8	20.3
1995	7.2	10.8	-1.0	3.1	20.0
1996	6.7	10.7	-0.9	3.0	19.6
1997	6.4	10.6	-1.0	2.9	18.9
1998	6.2	10.5	-0.9	2.7	18.5
1999	6.0	10.3	-0.8	2.4	17.9
2000	6.1	10.2	-0.8	2.2	17.6
2001	6.1	10.4	-0.8	2.0	17.6
2002	6.7	11.0	-0.8	1.6	18.5
2003	7.3	11.3	-0.9	1.4	19.1
2004	7.4	11.1	-0.9	1.3	19.0
2005	7.5	11.2	-1.0	1.4	19.2
2006	7.4	11.4	-1.1	1.7	19.4
2007	7.3	11.4	-1.2	1.7	19.1
2008	7.7	12.1	-1.3	1.7	20.2
2009	8.6	15.9	-1.4	1.3	24.4
2010	9.1	14.3	-1.3	1.3	23.4
2011	8.8	14.5	-1.4	1.5	23.4
2012	8.0	14.1	-1.4	1.4	22.1
2013	7.3	14.2	-1.8	1.3	20.9
2014	6.9	13.8	-1.6	1.3	20.4
2015	6.5	14.3	-1.4	1.3	20.7

Sources: Congressional Budget Office; Office of Management and Budget.

a. Excludes offsetting receipts.

Table F-4.

Return to Reference

Discretionary Outlays Since 1966

	Defense	Nondefense	Total
		In Billions of Dollars	
1966	59.0	31.1	90.1
1967	72.0	34.5	106.5
1968	82.2	35.8	118.0
1969	82.7	34.6	117.3
1970	81.9	38.4	120.3
1971	79.0	43.5	122.5
1972	79.3	49.2	128.5
1973	77.1	53.3	130.4
1974	80.7	57.5	138.2
1975	87.6	70.4	158.0
1976	89.9	85.7	175.6
1977	97.5	99.6	197.1
1978	104.6	114.1	218.7
1979	116.8	123.2	240.0
1980	134.6	141.7	276.3
1981	158.0	149.9	307.9
1982	185.9	140.0	326.0
1983	209.9	143.4	353.3
1984	228.0	151.4	379.4
1985	253.1	162.7	415.8
1986	273.8	164.7	438.5
1987	282.5	161.6	444.2
1988	290.9	173.5	464.4
1989	304.0	184.8	488.8
1990	300.1	200.4	500.6
1991	319.7	213.6	533.3
1992	302.6	231.2	533.8
1993	292.4	247.3	539.8
1994	282.3	259.1	541.3
1995	273.6	271.2	544.8
1996	266.0	266.8	532.7
1997	271.7	275.4	547.0
1998	270.3	281.7	552.0
1999	275.5	296.7	572.1
2000	295.0	319.7	614.6
2001	306.1	343.0	649.0
2002	349.0	385.0	734.0
2003	404.9	419.4	824.3
2004	454.1	441.0	895.1
2005	493.6	474.9	968.5
2006	520.0	496.7	1,016.6
2007	547.9	493.7	1,041.6
2008	612.4	522.5	1,134.9
2009	656.7	580.8	1,237.5
2010	688.9	658.3	1,347.2
2011	699.4	647.7	1,347.1
2012	670.5	615.6	1,286.1
2013	625.8	576.4	1,202.1
2014	596.4	582.2	1,178.7
2015	582.2	583.0	1,165.2

Continued

Table F-4. Continued

Discretionary Outlays Since 1966

	Defense	Nondefense	Total
	As a Percentage of Gross Domestic Product		
1966	7.5	4.0	11.5
1967	8.6	4.1	12.7
1968	9.1	4.0	13.1
1969	8.4	3.5	11.9
1970	7.8	3.7	11.5
1971	7.1	3.9	10.9
1972	6.5	4.0	10.5
1973	5.7	3.9	9.6
1974	5.4	3.9	9.3
1975	5.4	4.4	9.8
1976	5.0	4.8	9.8
1977	4.8	4.9	9.7
1978	4.6	5.0	9.6
1979	4.5	4.8	9.3
1980	4.8	5.1	9.9
1981	5.0	4.8	9.8
1982	5.6	4.2	9.8
1983	5.9	4.1	10.0
1984	5.8	3.8	9.6
1985	5.9	3.8	9.7
1986	6.0	3.6	9.7
1987	5.9	3.4	9.3
1988	5.6	3.4	9.0
1989	5.5	3.3	8.8
1990	5.1	3.4	8.5
1991	5.2	3.5	8.7
1992	4.7	3.6	8.3
1993	4.3	3.6	7.9
1994	3.9	3.6	7.5
1995	3.6	3.6	7.2
1996	3.3	3.3	6.7
1997	3.2	3.2	6.4
1998	3.0	3.1	6.2
1999	2.9	3.1	6.0
2000	2.9	3.2	6.1
2001	2.9	3.2	6.1
2002	3.2	3.5	6.7
2003	3.6	3.7	7.3
2004	3.8	3.6	7.4
2005	3.8	3.7	7.5
2006	3.8	3.6	7.4
2007	3.8	3.4	7.3
2008	4.2	3.5	7.7
2009	4.6	4.0	8.6
2010	4.7	4.4	9.1
2011	4.5	4.2	8.8
2012	4.2	3.8	8.0
2013	3.8	3.5	7.3
2014	3.5	3.4	6.9
2015	3.3	3.3	6.5

Sources: Congressional Budget Office; Office of Management and Budget.

Table F-5.

Return to Reference

Mandatory Outlays Since 1966

	Social Security	Medicare[a]	Medicaid	Income Security[b]	Other Retirement and Disability	Other Programs	Offsetting Receipts	Total	Memorandum: Major Health Care Programs (Net)[c]
					In Billions of Dollars				
1966	20.3	0	0.8	5.1	8.4	8.8	-8.4	35.0	0.8
1967	21.3	3.2	1.2	5.1	9.3	10.9	-10.2	40.7	3.7
1968	23.3	5.1	1.8	5.9	10.1	13.4	-10.6	49.1	6.2
1969	26.7	6.3	2.3	6.5	11.1	11.8	-11.0	53.6	7.7
1970	29.6	6.8	2.7	8.2	12.4	12.8	-11.5	61.0	8.6
1971	35.1	7.5	3.4	13.4	14.5	13.0	-14.1	72.8	9.6
1972	39.4	8.4	4.6	16.4	16.2	15.8	-14.1	86.7	11.6
1973	48.2	9.0	4.6	14.5	18.5	21.3	-18.0	98.0	12.2
1974	55.0	10.7	5.8	17.4	20.9	21.1	-21.2	109.7	14.8
1975	63.6	14.1	6.8	28.9	26.4	29.6	-18.3	151.1	19.1
1976	72.7	16.9	8.6	37.6	27.7	25.6	-19.6	169.5	23.6
1977	83.7	20.8	9.9	34.6	31.2	23.6	-21.5	182.2	28.5
1978	92.4	24.3	10.7	32.1	33.9	34.0	-22.8	204.6	32.5
1979	102.6	28.2	12.4	32.2	38.7	32.9	-25.6	221.4	37.9
1980	117.1	34.0	14.0	44.3	44.4	37.5	-29.2	262.1	45.0
1981	137.9	41.3	16.8	49.9	50.8	42.6	-37.9	301.6	54.8
1982	153.9	49.2	17.4	53.2	55.0	42.1	-36.0	334.8	62.7
1983	168.5	55.5	19.0	64.0	58.0	45.5	-45.3	365.2	70.2
1984	176.1	61.1	20.1	51.7	59.8	36.7	-44.2	361.3	76.1
1985	186.4	69.7	22.7	52.3	61.0	56.2	-47.1	401.1	86.7
1986	196.5	74.2	25.0	54.2	63.4	48.4	-45.9	415.8	93.4
1987	205.1	79.9	27.4	55.0	66.5	40.2	-52.9	421.2	100.8
1988	216.8	85.7	30.5	57.3	71.1	43.7	-56.8	448.2	107.4
1989	230.4	93.2	34.6	62.9	57.3	67.6	-60.1	485.9	117.3
1990	246.5	107.0	41.1	68.7	60.0	102.2	-57.5	568.1	136.9
1991	266.8	114.2	52.5	86.9	64.4	117.1	-105.5	596.5	154.6
1992	285.2	129.4	67.8	110.8	66.5	58.0	-69.3	648.4	184.0
1993	302.0	143.2	75.8	117.1	68.3	30.4	-65.9	670.9	203.7
1994	316.9	159.6	82.0	116.1	72.3	39.1	-68.5	717.5	223.9
1995	333.3	177.1	89.1	116.6	75.2	26.2	-78.7	738.8	246.0
1996	347.1	191.3	92.0	121.6	77.3	28.4	-70.9	786.7	263.3
1997	362.3	207.9	95.6	122.5	80.5	26.8	-85.4	810.1	283.0
1998	376.1	211.0	101.2	122.1	82.5	49.8	-83.5	859.3	291.5
1999	387.0	209.3	108.0	129.0	85.3	60.8	-79.4	900.0	296.3
2000	406.0	216.0	117.9	133.9	87.8	70.6	-81.0	951.4	313.3
2001	429.4	237.9	129.4	143.1	92.7	64.4	-89.2	1,007.6	347.1
2002	452.1	253.7	147.5	180.3	96.1	66.6	-90.3	1,106.0	378.9
2003	470.5	274.2	160.7	196.2	99.8	82.1	-100.9	1,182.5	410.8
2004	491.5	297.0	176.2	190.6	103.6	87.4	-108.9	1,237.5	445.7
2005	518.7	335.1	181.7	196.9	109.7	105.9	-128.7	1,319.4	481.2
2006	543.9	376.8	180.6	200.0	113.1	141.6	-144.3	1,411.8	511.0
2007	581.4	436.1	190.6	203.1	122.4	94.2	-177.9	1,450.0	567.4
2008	612.1	456.0	201.4	260.7	128.9	121.3	-185.4	1,594.9	594.1
2009	677.7	499.9	250.9	350.2	137.7	371.4	-194.6	2,093.2	683.6
2010	700.8	520.5	272.8	437.3	138.4	40.5	-196.5	1,913.7	727.1
2011	724.9	559.6	275.0	404.1	144.2	127.2	-209.0	2,026.0	763.5
2012	767.7	551.2	250.5	353.6	143.5	192.2	-228.3	2,030.5	725.8
2013	807.8	585.2	265.4	339.5	152.5	185.9	-304.8	2,031.6	767.6
2014	844.9	599.8	301.5	310.9	157.5	161.2	-277.3	2,098.5	831.0
2015	881.9	633.7	349.8	301.8	161.5	226.7	-256.5	2,298.8	936.0

Continued

Table F-5. Continued

Mandatory Outlays Since 1966

	Social Security	Medicare[a]	Medicaid	Income Security[b]	Other Retirement and Disability	Other Programs	Offsetting Receipts	Total	Memorandum: Major Health Care Programs (Net)[c]
				As a Percentage of Gross Domestic Product					
1966	2.6	0	0.1	0.7	1.1	1.1	-1.1	4.5	0.1
1967	2.5	0.4	0.1	0.6	1.1	1.3	-1.2	4.9	0.4
1968	2.6	0.6	0.2	0.7	1.1	1.5	-1.2	5.5	0.7
1969	2.7	0.6	0.2	0.7	1.1	1.2	-1.1	5.5	0.8
1970	2.8	0.6	0.3	0.8	1.2	1.2	-1.1	5.8	0.8
1971	3.1	0.7	0.3	1.2	1.3	1.2	-1.3	6.5	0.9
1972	3.2	0.7	0.4	1.3	1.3	1.3	-1.2	7.1	1.0
1973	3.6	0.7	0.3	1.1	1.4	1.6	-1.3	7.2	0.9
1974	3.7	0.7	0.4	1.2	1.4	1.4	-1.4	7.4	1.0
1975	3.9	0.9	0.4	1.8	1.6	1.8	-1.1	9.4	1.2
1976	4.1	0.9	0.5	2.1	1.5	1.4	-1.1	9.5	1.3
1977	4.1	1.0	0.5	1.7	1.5	1.2	-1.1	9.0	1.4
1978	4.1	1.1	0.5	1.4	1.5	1.5	-1.0	9.0	1.4
1979	4.0	1.1	0.5	1.3	1.5	1.3	-1.0	8.6	1.5
1980	4.2	1.2	0.5	1.6	1.6	1.3	-1.0	9.4	1.6
1981	4.4	1.3	0.5	1.6	1.6	1.4	-1.2	9.6	1.7
1982	4.6	1.5	0.5	1.6	1.7	1.3	-1.1	10.1	1.9
1983	4.8	1.6	0.5	1.8	1.6	1.3	-1.3	10.3	2.0
1984	4.5	1.5	0.5	1.3	1.5	0.9	-1.1	9.1	1.9
1985	4.4	1.6	0.5	1.2	1.4	1.3	-1.1	9.4	2.0
1986	4.3	1.6	0.6	1.2	1.4	1.1	-1.0	9.2	2.1
1987	4.3	1.7	0.6	1.2	1.4	0.8	-1.1	8.8	2.1
1988	4.2	1.7	0.6	1.1	1.4	0.8	-1.1	8.7	2.1
1989	4.1	1.7	0.6	1.1	1.0	1.2	-1.1	8.7	2.1
1990	4.2	1.8	0.7	1.2	1.0	1.7	-1.0	9.6	2.3
1991	4.4	1.9	0.9	1.4	1.1	1.9	-1.7	9.8	2.5
1992	4.4	2.0	1.1	1.7	1.0	0.9	-1.1	10.1	2.9
1993	4.4	2.1	1.1	1.7	1.0	0.4	-1.0	9.9	3.0
1994	4.4	2.2	1.1	1.6	1.0	0.5	-1.0	10.0	3.1
1995	4.4	2.3	1.2	1.5	1.0	0.3	-1.0	9.7	3.2
1996	4.4	2.4	1.2	1.5	1.0	0.4	-0.9	9.9	3.3
1997	4.3	2.5	1.1	1.4	0.9	0.3	-1.0	9.5	3.3
1998	4.2	2.4	1.1	1.4	0.9	0.6	-0.9	9.6	3.3
1999	4.1	2.2	1.1	1.4	0.9	0.6	-0.8	9.5	3.1
2000	4.0	2.1	1.2	1.3	0.9	0.7	-0.8	9.4	3.1
2001	4.1	2.3	1.2	1.4	0.9	0.6	-0.8	9.5	3.3
2002	4.2	2.3	1.4	1.7	0.9	0.6	-0.8	10.2	3.5
2003	4.2	2.4	1.4	1.7	0.9	0.7	-0.9	10.4	3.6
2004	4.1	2.5	1.5	1.6	0.9	0.7	-0.9	10.2	3.7
2005	4.0	2.6	1.4	1.5	0.9	0.8	-1.0	10.2	3.7
2006	4.0	2.8	1.3	1.5	0.8	1.0	-1.1	10.3	3.7
2007	4.1	3.0	1.3	1.4	0.9	0.7	-1.2	10.1	4.0
2008	4.1	3.1	1.4	1.8	0.9	0.8	-1.3	10.8	4.0
2009	4.7	3.5	1.7	2.4	1.0	2.6	-1.4	14.5	4.7
2010	4.7	3.5	1.8	3.0	0.9	0.3	-1.3	12.9	4.9
2011	4.7	3.6	1.8	2.6	0.9	0.8	-1.4	13.2	5.0
2012	4.8	3.4	1.6	2.2	0.9	1.2	-1.4	12.7	4.5
2013	4.9	3.5	1.6	2.1	0.9	1.1	-1.8	12.3	4.7
2014	4.9	3.5	1.8	1.8	0.9	0.9	-1.6	12.2	4.8
2015	5.0	3.6	2.0	1.7	0.9	1.3	-1.4	12.9	5.3

Sources: Congressional Budget Office; Office of Management and Budget.

a. Excludes offsetting receipts.

b. Includes unemployment compensation, Supplemental Security Income, the refundable portion of the earned income and child tax credits, the Supplemental Nutrition Assistance Program, family support, child nutrition, and foster care.

c. Spending on Medicare (net of offsetting receipts), Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through exchanges and related spending.

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Annual Energy Outlook 2017
Table: Macroeconomic Indicators
Case: Reference case

PUBLICATIONS & TABLES

Macroeconomic Indicators: Real Gross Domestic Product

Case: Reference case

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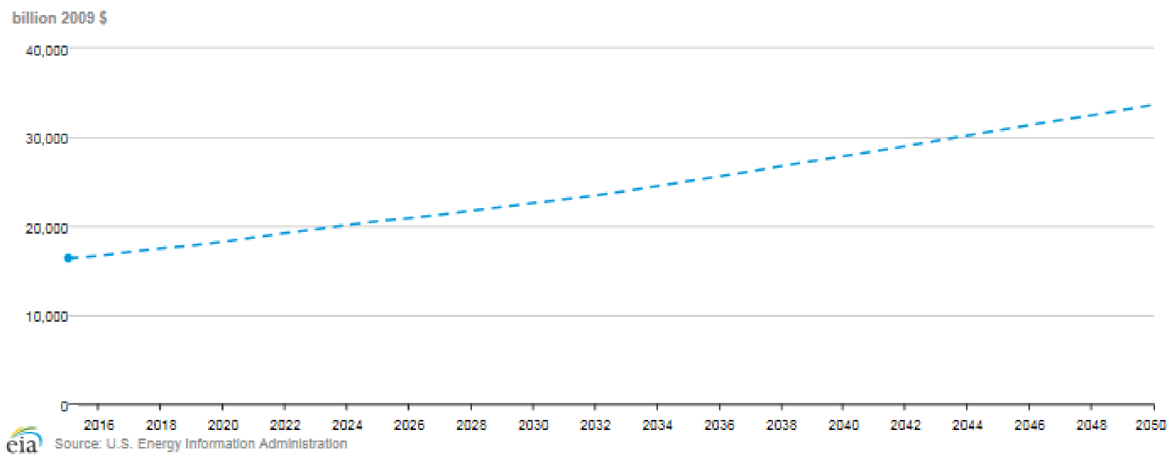

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Time-series | Map | Annual | Every 5th Year | 2015 | 2050

PIN | API		2047	2048	2049	2050	Growth (2016-2050)
Real Gross Domestic Product (billion 2009 $)	1	31,923	32,468	33,062	33,653	2.1%
Components of Real Gross Domestic Product						
Real Consumption (billion 2009 $)	4	22,948	23,390	23,861	24,332	2.2%
Real Investment (billion 2009 $)	4	6,429	6,537	6,674	6,806	2.6%
Real Government Spending (billion 2009 $)	9	3,871	3,914	3,959	4,013	0.9%
Real Exports (billion 2009 $)	0	7,109	7,292	7,493	7,685	3.9%
Real Imports (billion 2009 $)	6	8,423	8,663	8,930	9,200	3.7%
Energy Intensity						
(thousand Btu per 2009 dollar of GDP)						
Delivered Energy (thousand Btu/$ GDP)	0	2.47	2.45	2.42	2.40	-1.7%
Total Energy (thousand Btu/$ GDP)	3	3.29	3.25	3.21	3.17	-1.8%
Price Indices						
GDP Chain-type Price Index (2009=1.000) (2009=1.000)	2	2.118	2.164	2.211	2.258	2.1%
Consumer Price Index (1982-84=1.00)						
All-urban (1982-84=1.00)	0	5.02	5.15	5.27	5.40	2.4%
Energy Commodities and Services (1982-84=1.00)	0	5.04	5.16	5.29	5.46	3.2%
Wholesale Price Index (1982=1.00)						
All Commodities (1982=1.00)	4	3.29	3.35	3.40	3.46	1.9%
Fuel and Power (1982=1.00)	1	4.23	4.35	4.47	4.60	3.5%
Metals and Metal Products (1982=1.00)	9	2.61	2.62	2.64	2.66	0.9%
Industrial Commodities excluding Energy (1982=1.00)	9	3.03	3.07	3.11	3.15	1.4%

Table A20. Macroeconomic indicators

(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Real gross domestic product	**15,962**	**16,349**	**18,555**	**20,765**	**23,113**	**25,598**	**28,397**	**2.2%**
Components of real gross domestic product								
Real consumption	10,876	11,221	12,861	14,348	16,092	17,881	19,870	2.3%
Real investment	2,718	2,842	3,513	4,068	4,520	5,051	5,661	2.8%
Real government spending	2,838	2,860	2,967	3,056	3,222	3,396	3,602	0.9%
Real exports	2,086	2,119	2,615	3,374	4,178	5,105	6,113	4.3%
Real imports	2,529	2,662	3,374	4,032	4,824	5,721	6,683	3.8%
Energy intensity								
(thousand Btu per 2009 dollar of GDP)								
Delivered energy	4.52	4.38	4.03	3.65	3.29	3.04	2.83	-1.7%
Total energy	6.15	5.92	5.42	4.89	4.39	4.06	3.77	-1.8%
Price indices								
GDP chain-type price index (2009=1.000)	1.09	1.10	1.21	1.34	1.49	1.66	1.85	2.1%
Consumer price index (1982-4=1.00)								
All-urban	2.37	2.37	2.65	2.99	3.35	3.78	4.27	2.4%
Energy commodities and services	2.43	2.02	2.41	2.87	3.34	3.92	4.61	3.4%
Wholesale price index (1982=1.00)								
All commodities	2.05	1.91	2.14	2.37	2.59	2.87	3.16	2.0%
Fuel and power	2.10	1.60	2.10	2.53	2.91	3.39	3.92	3.7%
Metals and metal products	2.15	2.01	2.15	2.35	2.55	2.80	3.06	1.7%
Industrial commodities excluding energy	1.98	1.94	2.13	2.33	2.53	2.76	3.01	1.8%
Interest rates (percent, nominal)								
Federal funds rate	0.09	0.13	3.32	3.22	3.24	3.23	3.08	- -
10-year treasury note	2.54	2.14	3.83	3.66	3.77	3.82	3.72	- -
AA utility bond rate	4.19	4.01	5.87	5.41	5.73	5.85	5.71	- -
Value of shipments (billion 2009 dollars)								
Non-industrial and service sectors	23,338	24,085	26,750	29,265	32,042	34,833	37,701	1.8%
Total industrial	7,165	7,229	8,351	9,146	9,776	10,562	11,483	1.9%
Agriculture, mining, and construction	1,957	1,931	2,493	2,620	2,710	2,828	2,955	1.7%
Manufacturing	5,208	5,299	5,858	6,527	7,066	7,734	8,528	1.9%
Energy-intensive	1,718	1,704	1,892	2,046	2,147	2,267	2,417	1.4%
Non-energy-intensive	3,490	3,594	3,967	4,481	4,920	5,467	6,111	2.1%
Total shipments	**30,504**	**31,314**	**35,101**	**38,411**	**41,818**	**45,396**	**49,184**	**1.8%**
Population and employment (millions)								
Population, with armed forces overseas	319	322	335	348	360	371	381	0.7%
Population, aged 16 and over	254	257	269	281	292	302	311	0.8%
Population, aged 65 and over	46	48	57	66	74	79	82	2.2%
Employment, nonfarm	138	142	150	156	161	165	170	0.7%
Employment, manufacturing	12.2	12.5	13.1	13.4	13.0	12.6	12.3	-0.1%
Key labor indicators								
Labor force (millions)	156	157	167	171	177	183	188	0.7%
Nonfarm labor productivity (2009=1.00)	1.05	1.06	1.15	1.25	1.37	1.50	1.63	1.7%
Unemployment rate (percent)	6.15	5.31	4.72	4.90	4.78	4.76	4.78	- -
Key indicators for energy demand								
Real disposable personal income	11,836	12,225	14,197	15,888	17,826	19,689	21,789	2.3%
Housing starts (millions)	1.06	1.18	1.74	1.71	1.66	1.66	1.65	1.3%
Commercial floorspace (billion square feet)	83.1	83.8	88.7	94.0	99.3	104.6	109.8	1.1%
Unit sales of light-duty vehicles (millions)	16.4	17.4	17.1	17.3	17.7	18.2	19.0	0.4%

GDP = Gross domestic product.
Btu = British thermal unit.
- - = Not applicable.
Sources: 2014 and 2015: IHS Economics, Industry and Employment models, November 2015. **Projections:** U.S. Energy Information Administration, AEO2016 National Energy Modeling System run ref2016.d032416a.

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Annual Energy Outlook 2016

with projections to 2040

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For further information . . .

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AEO2016 is available on the EIA website at www.eia.gov/forecasts/aeo. Assumptions underlying the projections, tables of regional results, and other detailed results will also be available, at www.eia.gov/forecasts/aeo/assumptions. Model documentation reports for the National Energy Modeling System are available at website www.eia.gov/forecasts/aeo/nems/documentation and will be updated for the AEO2016 during 2016.

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Annual Energy Outlook 2016

With Projections to 2040

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Preface

The *Annual Energy Outlook 2016* (AEO2016), prepared by the U.S. Energy Information Administration (EIA), presents long-term projections of energy supply, demand, and prices through 2040. The projections, focused on U.S. energy markets, are based on results from EIA's National Energy Modeling System (NEMS). NEMS enables EIA to make projections under alternative, internally-consistent sets of assumptions. The analysis in AEO2016 focuses on the Reference case and 17 alternative cases. EIA published an Early Release version of the AEO2016 Reference case (including U.S. Environmental Protection Agency's (EPA) Clean Power Plan (CPP)) and a No CPP case (excluding the CPP) in May 2016.

The AEO2016 report is a complete edition of the *Annual Energy Outlook* (AEO) and includes the following major sections:

Executive summary: highlighting key results of the projections

Legislation and regulations: discussing evolving legislative and regulatory issues, including a summary of recently enacted legislation and regulations as incorporated in AEO2016, such as: the EPA's final rules for the CPP [*1*]; the California Air Resource Board Zero-Emission Vehicle program [*2*]; the extension of the production tax credit for wind and 30% investment tax credit for solar [*3*]; the International Convention for the Prevention of Pollution from Ships [*4*]; adoption of newly added or modified federal efficiency standards for residential and commercial appliances and equipment; and modifications to existing state renewable portfolio standard or similar laws [*5*].

Issues in focus: containing discussions of selected energy topics, including the effects of the CPP under alternative implementation approaches; the impact of Phase 2 standards for medium- and heavy-duty vehicles; a discussion that compares the Reference case to alternative cases based on different assumptions about the future course of existing energy policies; the impact on hydrocarbon gas liquids output from changing oil prices and related industrial development; and the sensitivity of steel industry energy consumption to technology choice.

Market trends: complete summary by sector of the projections for energy markets comparing the AEO2016 Reference case and the alternative cases, illustrating uncertainties associated with the Reference case projections for energy demand, supply, and prices.

Comparisons with other projections: comparing the AEO2016 Reference case to comparable aspects of projections provided by ExxonMobil, IHS Global Insight, International Energy Agency, ICF, BP p.l.c., National Renewable Energy Laboratory, Energy Ventures Analysis, Inc., and Wood Mackenzie, Inc., among others.

Summary tables for the Reference and alternative cases are provided in Appendixes A through D. Complete tables are available in a table browser on EIA's website, at http://www.eia.gov/forecasts/aeo/data/browser/. Appendix E provide a short description of the NEMS modules and a complete listing and discussion of the assumptions made for the alternative cases. Appendix F provides a summary of the regional formats, and Appendix G provides a summary of the energy conversion factors used in AEO2016.

The AEO2016 projections are based generally on federal, state, and local laws and regulations in effect as of the end of February 2016. The AEO2016 Reference case assumes that current laws and regulations affecting the energy sector are largely unchanged throughout the projection period (including the implication that laws which include sunset dates are no longer in effect at the time of those sunset dates) [*6*]. The potential impacts of proposed legislation, regulations, or standards—or of sections of authorizing legislation that have been enacted but are not funded, or for which parameters will be set in a future regulatory process—are not reflected in the AEO2016 Reference case, but some are considered in alternative cases. However, where it is clear that a law or regulation will take effect shortly after the *Annual Energy Outlook* (AEO) is completed, it may be considered in the projection.

AEO2016 is published in accordance with Section 205c of the U.S. Department of Energy (DOE) Organization Act of 1977 (Public Law 95-91), which requires the EIA Administrator to prepare annual reports on trends and projections for energy use and supply.

Objectives of the AEO2016 projections

Projections by the U.S. Energy Information Administration (EIA) are not statements of what will happen but of what might happen, given the assumptions and methodologies used for any particular scenario. The AEO2016 Reference case projection is a business-as-usual trend estimate, given known technology and technological and demographic trends. EIA explores the impacts of alternative assumptions in other cases with different macroeconomic growth rates, world oil prices, rates of technology progress, and different paths for the implementation of public policy. The main cases in AEO2016 generally assume that current laws and regulations are maintained throughout the projections. Thus, the projections provide policy-neutral baselines that can be used to analyze policy initiatives.

While energy markets are complex, energy models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. Behavioral characteristics are indicative of real-world tendencies rather than representations of specific outcomes.

Energy market projections are subject to much uncertainty. Many of the events that shape energy markets are random and cannot be anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Many key uncertainties in the AEO2016 projections are addressed through alternative cases.

EIA has endeavored to make these projections as objective, reliable, and useful as possible; however, they should serve as an adjunct to, not a substitute for, a complete and focused analysis of public policy initiatives.

Updated *Annual Energy Outlook 2016* Reference case (August 2016)

The *Annual Energy Outlook 2016* (AEO2016) Reference case included as part of this complete report (released in July 2016) has been updated from the *Annual Energy Outlook 2015* Reference case (released in April 2015). The updated Reference case reflects new legislation and regulations enacted since April 2015, model changes, and data updates. The key model and data updates include:

Macroeconomic

- Updated historical data on industries and employment
- Updated information on natural gas extraction from the National Energy Modeling System (NEMS)
- Extended dynamic Input-Output framework from 2013 to 2040
- Disaggregation of three pulp and paper subindustries included in the NEMS macroeconomic model: pulp and paper mills, paperboard and containers, and all other pulp and paper
- Disaggregated ethanol, flat glass, and lime and gypsum subindustries in the Industrial Output and Employment Model
- Incremental electricity investment required to meet the standards in the U.S. Environmental Protection Agency (EPA) Clean Power Plan (CPP) [*7*]
- Re-estimated commercial floorspace model, using data from Dodge Data and Analytics, and transformation of floorspace estimates to projected growth rates rather than levels

Residential, commercial, and industrial

- New buildings equipment standards promulgated since the AEO2015 Reference case was completed, including standards affecting commercial cooling equipment, commercial furnaces, residential boilers, commercial oil-fired water heaters, fluorescent lamps, commercial pumps, and commercial ice makers and beverage vending machines
- Cost and energy impacts of energy efficiency activities in support of the CPP through rebates for energy-efficient buildings end-use equipment, based on EIA analysis and a report by Leidos [*8*]
- Updated cost and performance assumptions for distributed generation and combined heat and power technologies in the buildings sector, based on a draft report by Leidos and a joint presentation by the National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory, reflecting recent and expected technological progress [*9*, *10*]
- Extension and phaseout of the investment tax credit for residential and commercial solar energy systems, included as part of the December 2015 budget reconciliation bill [*11*]
- Updated cost assumptions associated with switching of fuels and/or technologies for residential end-use services and updated estimates for efficiency of the installed stock of residential end-use equipment, based on reports by Navigant Consulting, Inc. and Leidos [*12*, *13*]
- A new NEMS submodule estimates energy use in the steel and pulp and paper industries and allows for detailed technology choice
- Updated motors model in NEMS to reflect increased efficiency standards for motors [*14*]
- Updated construction [*15*] and mining [*16*] input data to reflect the 2012 Economic Census
- Benchmarks added to individual industry tables in the Industrial Demand Module to allow comparison with aggregate industrial figures and application of benchmark factors in the Reference case to alternative cases

Transportation

- Implementation of a new regional (Census Division) marine model that captures impacts of International Convention for the Prevention of Pollution from Ships (MARPOL) emissions regulations, including modeling of fuel consumption in U.S. Emission Control Areas (ECAs); and incorporation of compliance options addressing fuel switching and the adoption of emission control technologies [*17*]
- New light-duty and heavy-duty vehicle regional (Census Division) sales and stock models, including updated data or revisions to scrappage rates, historical distributions of vehicles by car and light truck class, weight class categories for medium-duty and heavy-duty trucks, fleet use, fuel economy, and fuel type
- Modified calculations for technology adoption and fuel economics for heavy-duty vehicles, and addition of technology availability
- Updated historical data on light-duty and heavy-duty truck vehicle miles traveled through 2013 based on U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA) data [*18*], extended through 2014 using the DOT/FHWA Traffic Volume Trends report [*19*]
- Addition of most recent California Zero-Emission Vehicle Program, starting in model year 2018 and reaching complete implementation in model year 2025, which mandates the sale of zero-emission vehicles and transitional zero-emission vehicles [*20*].

- Addition of historical data in freight rail ton-miles through 2013, using Class 1 Railroad data as reported through the DOT Surface Transportation Board [*21*]

Oil and natural gas production and product markets

- Adoption of a simplified approach to modeling the impact of technology advancement on U.S. oil and natural gas production to better capture a continually changing technological landscape, incorporating assumptions for ongoing innovation in upstream technologies and reflecting average annual growth rates for natural gas and oil resources, and cumulative production from 1990 between the AEO2000 and AEO2015 Reference cases
- Revision of resource assumptions for the offshore North Slope to reflect disappointing results in the Chukchi Sea, BOEM's cancellation of upcoming Arctic lease sales, and Repsol's deferral of exploration in the Arctic
- Updated natural gas plant liquids (NGPL) factors for tight oil and shale gas formations at the play and county levels
- Updated estimated ultimate recovery of tight and shale formations at the county level
- Updated list of offshore discovered and nonproducing fields in the Lower 48 states and their expected resource sizes and startup dates

Natural gas transmission and distribution

- Updated liquefaction capacity to represent the five liquefied natural gas (LNG) export facilities already under construction, updated data from the International Energy Outlook 2016 used in estimating representative world natural gas prices, and calibration of related equations to latest historical data
- Change in accounting for fuel used at LNG export terminals to a separate category, moved from the general category of lease and plant fuel to pipeline and distribution fuel use
- Inclusion of pipeline flow on bidirectional arcs in output report and addition of East North Central to South Atlantic as a bidirectional pipeline flow option
- Basing of fuel prices for compressed natural gas vehicles on data from the Alternative Fuels Data Center of DOE's Energy Efficiency and Renewable Energy Office [*22*] rather than on EIA data; updated federal and state motor fuels taxes for LNG vehicles
- Updated equations in NEMS for projecting consumption in Alaska and production in Canada and Mexico

Oil product markets and biofuels

- Allowing all crude types (not only processed condensate) to be exported from the United States
- Limiting the amount of crude exports from the PADD2-lakes region into Sarnia
- Explicit representation of crude oil withdrawals from the Strategic Petroleum Reserve (SPR), based on SPR plans dated December 2015 [*23*, *24*]
- Revised renewable fuel standard levels for historical and near-term years (through 2016), based on EPA decision [*25*]
- Expanded NEMS price curves for selected product imports and exports
- Revised Liquid Fuels Market Module in NEMS to reflect receipt of NGPL by state and paraffin type, as defined in the Oil and Gas Supply Module
- Change in first build years in NEMS, to 2020 for biomass-based liquids production and gas-to-liquids units and to 2025 for coal-to-liquids units
- Updated fuel use data for corn ethanol plants
- Allowing unplanned builds of splitters and atmospheric cracking units (ACUs) in the Gulf Coast region
- Inclusion of 0.4% capacity "creep" through 2020 for ACUs only
- Revised methodology for pricing fuel oil to electric utilities in Census Division 9
- Increased flexibility of the International Energy Model to choose between crude oil price quality differentials and product exports/imports for better representation of U.S. refinery processes and domestic and foreign oil markets

Electric power sector

- Representation of 3 gigawatts (GW) of unannounced nuclear retirements in the Reference case in the ReliabilityFirst East and West regions [*26*] and announced retirement of the James A. Fitzpatrick (December 2016), Pilgrim (June 2019), and Oyster Creek (December 2019) plants.
- Explicit representation of 8.8 GW of coal-fired units that are being converted to natural gas-fired steam units between 2016 and 2025
- Review of model representation of state RPS policies and incorporation of changes in NEMS

- Updated cost estimates for several electricity generation technologies, based on a draft report provided by external consultants [27]
- Modified Electricity Market Module (EMM) to include representation of the CPP [28]
- Added model structure to Electricity Fuel Dispatch linear programs to adjust model dispatch dynamically and align it with inputs based on EIA's Short-Term Energy Outlook results for specific model years; and made changes to allow benchmarking of coal and natural gas generation and consumption and of nuclear, hydroelectric, wind, solar, and geothermal generation at the national level

Endnotes

Links current as of July 2016

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26. The unannounced nuclear retirements in the Reference case reflect market uncertainty.
27. This report will be available on the EIA website when finalized. Costs were updated for coal with carbon capture and storage (CCS), combined cycle (without CCS) technologies, combustion turbine technologies, advanced nuclear, and onshore wind and solar photovoltaic technologies. Costs for other technologies are consistent with AEO2015 assumptions.
28. Model constraints were added in both the Electricity Capacity Planning (ECP) and Electricity Fuel Dispatch (EFD) linear programs, to allow modeling of either carbon dioxide (CO2) emission caps or CO2 emission rate standards by EMM region. Model structure was also added to allow trading of allowances between regions, including pricing impacts. The model was updated so that CO2 allowances can be assumed to be allocated to generator or load entities, or auctioned, with appropriate feedback to electricity prices, under a mass-based standard.

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Executive summary

Projections in the *Annual Energy Outlook 2016* (AEO2016) focus on the factors expected to shape U.S. energy markets through 2040. The projections provide a basis for examination and discussion of energy market trends and serve as a starting point for analysis of potential changes in U.S. energy policies, rules, and regulations, as well as the potential role of advanced technologies.

Key issues addressed in the AEO2016 Reference and alternative cases and discussed in this Executive summary include:

- Recent changes in laws and regulations, including the U.S. Environmental Protection Agency's (EPA) Clean Power Plan (CPP) [*1*], which requires states to reduce carbon dioxide (CO2) emissions from existing fossil fuel generators, and an extension of tax credits for wind and solar energy. Together with lower natural gas prices, these changes significantly affect the projected electricity generation fuel mix.
- Implications of the changing electricity generation fuel mix for overall coal demand and the coal production outlook across U.S. coal supply regions.
- Slower electricity demand growth and increases in onsite generation, which together determine the demand for generation from central power stations.
- The effects of resource and technology improvements and prices on the outlook for U.S. oil and natural gas production, and the effect of changing production levels on prices projected consumption.
- Implications of the California Air Resources Board's Zero-Emission Vehicle program [*2*], which nine states have joined, representing 33% of the total U.S. market for new light-duty vehicles.
- Implications of EPA's proposed medium- and heavy-duty vehicle Phase 2 standards [*3*] for CO2 emissions and projected fuel use.
- Implications of alternative economic, energy market, and policy scenarios for energy-related CO2 emissions.

The Clean Power Plan's requirement to reduce carbon dioxide emissions accelerates the shift in the generation mix

The CPP requirement for states to develop plans to reduce CO2 emissions imposes additional costs on higher-emitting energy sources. Combined with lower natural gas prices and the extension of renewable tax credits, the CPP accelerates the shift toward less carbon-intensive generation. In the AEO2016 Reference case, which includes the CPP, 92 gigawatts (GW) of coal-fired capacity is retired by 2030—32 GW more than is retired by 2030 in the No CPP case, which excludes the CPP. In the Reference case, coal-fired generation in 2040 is 32% lower than the 2015 total (Figure ES-1).

From 2015 levels, natural gas-fired electricity generation in the Reference case increases by 26% in 2030 and by 44% in 2040, and generation from renewables increases by 99% in 2030 and by 152% in 2040. These projected changes result in electricity generation with both natural gas and renewables surpassing coal generation in 2024 (natural gas) and in 2028 (renewables). In the No CPP case, electricity generation with natural gas does not surpass coal generation until 2029, and renewable generation does not overtake coal-fired generation in the 2015–40 time frame of the projection (Figure ES-2).

How the states implement the Clean Power Plan influences its effect on electricity generators

The EPA provides several kinds of flexibility to states in implementing the CPP [*4*]. This flexibility allows the states to choose between a mass-based approach (with a cap on total CO2 emissions) and a rate-based approach (with a cap on pounds of CO2 emitted per megawatthour of electricity produced), with different potential consequences for electricity generators and customers. In the CPP Rate case, a rate-based target provides a more direct incentive for switching to carbon-free sources of energy by

Figure ES-1. Net electricity generation from coal, natural gas, and renewables in the AEO2016 Reference case, 2013–40 (billion kilowatthours)

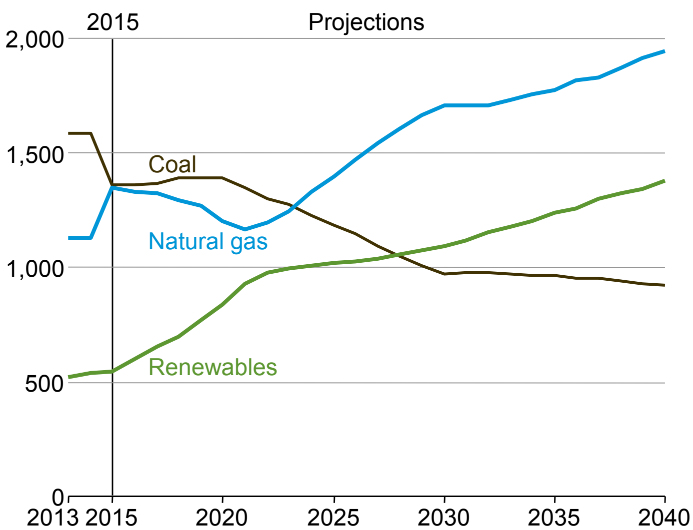
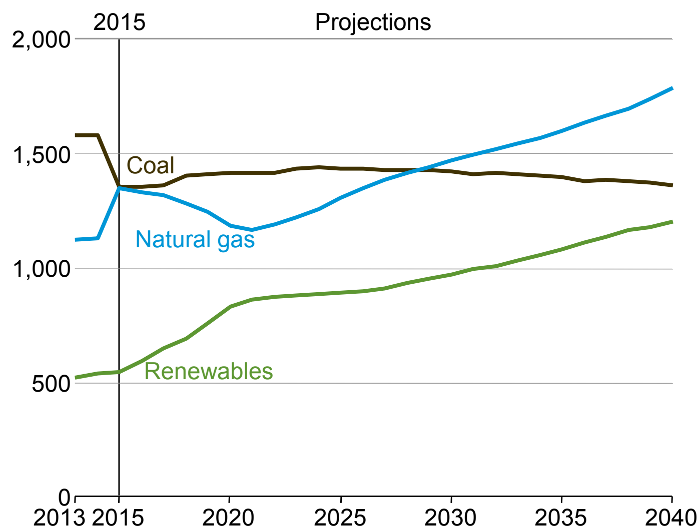


Figure ES-2. Net electricity generation from coal, natural gas, and renewables in the No CPP case, 2013–40 (billion kilowatthours)



rewarding generators that produce emissions below the intensity target and penalizing those with emissions above the target. The mass-based target in the AEO2016 Reference case, as modeled by EIA, treats every ton of CO2 emitted by fossil-fired generation uniformly, which does not provide the same incentive.

The changes in the mix of generating capacity (including central station and end-use generators) are affected differently by the two implementation approaches. In the CPP Rate case, with a rate-based approach, more renewable capacity is added (an additional 28 GW by 2040) than in the AEO2016 Reference case that assumes mass-based implementation. In the Reference case, 14 GW more coal-fired capacity is retired, and 48 GW more natural gas capacity is added between 2015 and 2040 than in the CPP Rate case.

With the mass-based implementation approach assumed in the Reference case in 2040, coal-fired generation is 436 billion kWh lower than in 2015; natural gas-fired generation is 594 billion kWh higher than in 2015; and renewable generation is 828 billion kWh higher than in 2015. With the rate-based approach adopted in the CPP Rate case in 2040, coal-fired generation is 275 billion kWh lower than in 2015, natural gas-fired generation is 375 billion kWh higher than in 2015; and renewable generation is 898 billion kWh higher than in 2015.

Allocating emissions allowances under a mass-based program can also affect how overall program costs are passed along to suppliers, service providers, and consumers. In the Reference case, the allocation of allowances to load-serving entities reduces the impact on retail electricity prices by reducing retailers' costs of compliance. With this allocation method, the average real (2015 dollars) electricity price in 2030 in the Reference Case is 1.7% lower than in the Allocation to Generators case, which assumes allocation of CPP carbon allowances to generators rather than to load-serving entities.

The coal-fired generation share of total electricity production continues to decline, even in the absence of the Clean Power Plan, and natural gas becomes the predominant fuel for electricity generation

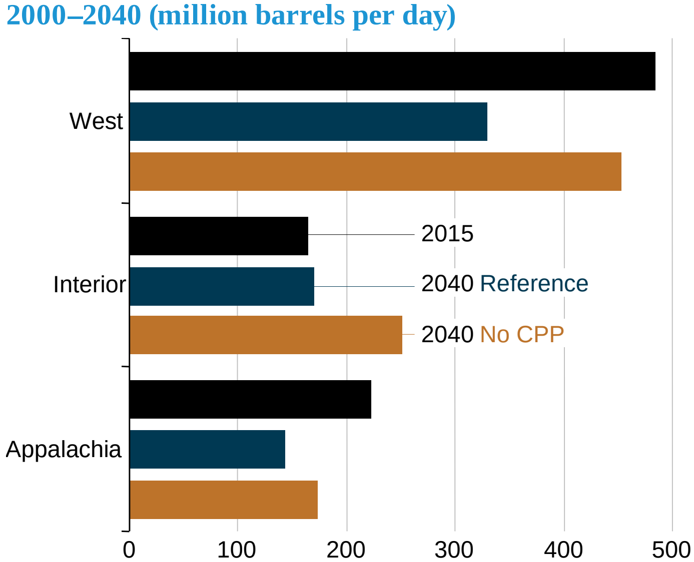
Even in the absence of the CPP, the extension of renewable tax credits, as well as declining capital costs for solar photovoltaics (PV), other emissions regulations that affect coal, and low natural gas prices contribute to a reduction in coal's share of total generation. In the No CPP case, coal-fired generation changes little from 2015–40, and the coal share of total electricity generation falls from 33% in 2015 to 26% in 2040. Additions to coal-fired capacity are limited in the near term by emission regulations and in the long term by low natural gas prices and increased pressure from renewable generation. In the No CPP case, 60 GW of coal-fired generating capacity is retired from 2016–30.

Natural gas-fired generation declines from 2016–20 in response to a surge in wind and solar capacity builds resulting from both declining installation costs and the extension of key federal tax credits for these technologies. After 2020, however, the natural gas share of total generation increases steadily in the No CPP case, overtaking coal before 2030 and accounting for 34% of total generation in 2040.

All coal supply regions are affected—though not equally—when the Clean Power Plan is implemented

The West region—which accounted for the largest share of total coal production in 2015—experiences the biggest decline in coal production, at about 155 million short tons from 2015–40 (Figure ES-3). Implementation of the Mercury and Air Toxics Standards beginning in 2015 and 2016 encouraged near-universal adoption of emissions control equipment at existing coal-fired plants, which enables more coal-fired generators to use high-sulfur coal from the Interior region. The lower demand for coal in the AEO2016 Reference case, which includes the CPP, results in slow growth of coal production in the Interior region over the projection period. In the No CPP case, production of higher sulfur coal from the Interior region increases by nearly 90 million short tons. The lower level of Appalachian coal production in the Reference case in 2040 compared to the No CPP case represents the smallest difference among the coal-producing regions. Production of coal in the Appalachian region declined sharply before 2015 as domestic coal buyers shifted from Appalachian steam coal toward other coal sources or to other fuels for economic reasons. The Appalachian region remains a major source of metallurgical coal, whose markets are not directly affected by the CPP. With or without the CPP, Appalachia's producers have a relatively high dependence on sales of both metallurgical and steam coal in international coal markets.

Figure ES-3. Petroleum and other liquid fuels production by region and type in the Reference case, 2000–2040 (million barrels per day)



Electricity demand growth slows as more on-site generation reduces the need for central-station generation

The extension of federal tax credits for PV systems, combined with a continued decline in PV prices, spurs the adoption of residential and commercial PV in the AEO2016 Reference case (Figure ES-4). Installed residential PV capacity increases by an average of 10%/year from 2015–40, while installed commercial PV capacity increases by an average of 6%/year. In 2040, generation from residential systems totals 90 billion kWh, and generation from commercial systems totals 37 billion kWh in the Reference case. Without the electricity generated by residential PV systems that is used onsite, electricity sales to residential customers would be nearly 6% higher in 2040. In addition, net PV generation accounts for more than 2% of commercial sector electricity sales in 2040.

Spurred by higher energy demand and lower interest rates in the High Economic Growth case, solar PV net generation is 16% higher in the residential sector and 4% higher in the commercial sector in 2040 than in the Reference case. With the higher level of total electricity generation in the High Economic Growth case, residential electricity sales back to the grid are 15% higher in 2040 than in the Reference case. In the Low Economic Growth case, solar PV net generation is 30% lower in the residential sector and 4% lower in the commercial sector in 2040 than in the Reference case.

After 2017, U.S. oil production increases as prices rise

Total U.S. oil production in the AEO2016 Reference case falls from 9.4 million barrels per day (b/d) in 2015 to 8.6 million b/d in 2017. After 2017, the total production grows to 11.3 million b/d in 2040 as real (2016 dollars) crude oil prices recover from an annual average of less than $50/barrel (b) in 2017 to more than $130/b in 2040 (Figure ES-5). The Lower 48 states lead the increase in crude oil production, which results largely from higher oil prices, continued advances in industry practices, and further development of technologies that reduce costs and allow for increased recovery of tight oil resources.

The Bakken, Western Gulf Basin (including the Eagle Ford play), and Permian Basin lead the continued development of tight oil resources in the Lower 48 states in the Reference case. With the recent decline in oil prices, tight oil production shows the largest reduction, from 4.9 million b/d in 2015 to 4.2 million b/d in 2017, before increasing to 7.1 million b/d in 2040. After 2017, higher oil prices, as well as ongoing exploration, appraisal, and development programs that expand operator knowledge about producing reservoirs, could result in the identification of additional tight oil resources and the development of technologies that reduce costs and increase oil recovery.

In the Lower 48 states, offshore production (which is less sensitive to short-term price movements than onshore production), increases to 2.0 million b/d in 2021, led by new deepwater projects in the Gulf of Mexico, including the Heidelberg and Appomattox fields that are scheduled to begin operations in 2016 and 2017, respectively. After 2021, Lower 48 offshore crude oil production declines to roughly 1.6 million b/d in 2030 and remains at about that level through 2040, as production from newly developed fields is offset by declines in legacy fields.

Lower 48 onshore crude oil production using CO2-enhanced oil recovery increases from 0.3 million b/d in 2015 to 0.7 million b/d in 2040 as oil prices rise and affordable sources of CO2 become available. Both onshore and offshore production in Alaska continue to decline, from a total of nearly 0.5 million b/d in 2015 to less than 0.2 million b/d in 2040.

U.S. natural gas production continues to rise despite low or moderately rising prices

Total U.S. dry natural gas production increases in the Reference case from 27.2 trillion cubic feet (Tcf) in 2015 to 42.1 Tcf in 2040, while average annual U.S. natural gas prices at the Henry Hub (in 2015 dollars) remain at about $5.00/million British thermal units (Btu) (Figure ES-6). Although natural gas prices remain relatively low and stable, projected development of natural gas

Figure ES-4. Electricity generation from solar power in the buildings sectors in three cases, 2010–40 (billion kilowatthours)

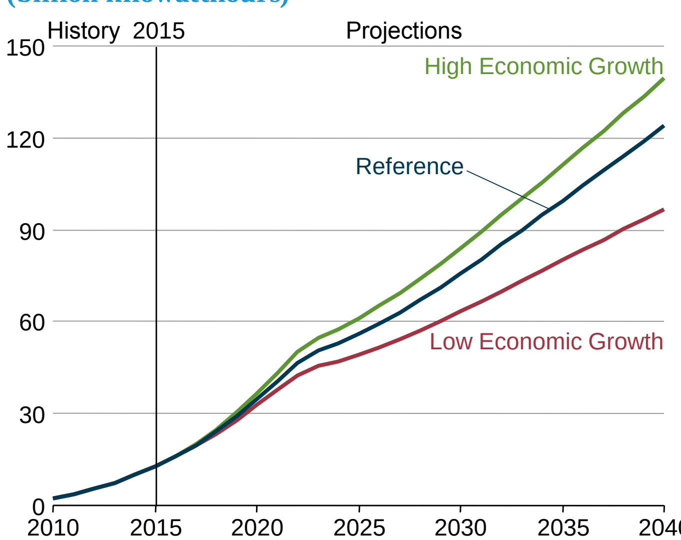
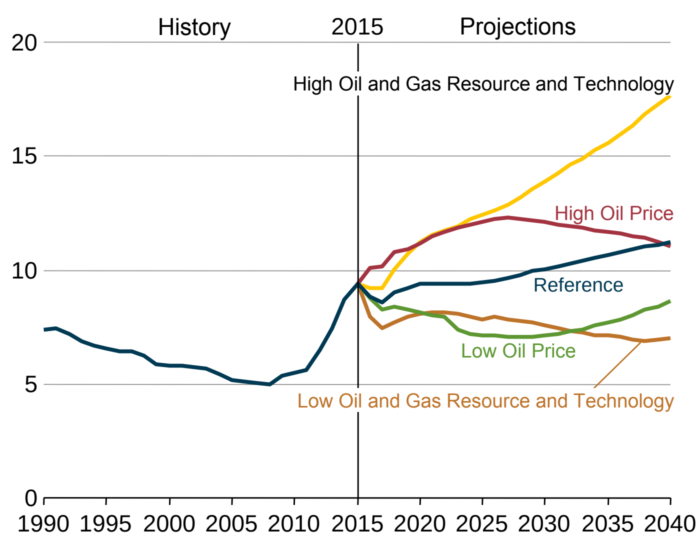


Figure ES-5. Total U.S. crude oil production in five cases, 1990–2040 (million barrels per day)



resources in shale gas and tight oil plays, tight gas, and offshore increases as a result of abundant domestic resources and technology improvements.

Production from shale gas and tight oil plays leads the increase in natural gas production in the Reference case from 13.6 Tcf in 2015 to 29.0 Tcf in 2040, as their share of total U.S. dry natural gas production grows from 50% in 2015 to 69% in 2040 (Figure ES-7). Shale gas and tight oil plays are resources in low-permeability reservoirs. They include the Sanish-Three Forks Formation beneath the Bakken, Eagle Ford, Woodford, Austin Chalk, Spraberry, Niobrara, Avalon/Bone Springs, and Monterey formations.

U.S. offshore natural gas supply, after declining from 2015 to 2016 to around 1.4 Tcf, remains stable from 2015–20 in the Reference case, then falls to 1.2 Tcf in 2023, reflecting declines in production from legacy offshore fields. After 2027, as increased production from new discoveries offsets the decline in legacy fields, offshore natural gas production increases to 1.7 Tcf in 2040.

Growing natural gas demand in the industrial and electric power sectors and increasing exports of liquefied natural gas (LNG) place upward pressure on domestic natural gas prices. Improvements in drilling technology allow production to keep pace with demand (both for domestic consumption and for export), resulting in relatively stable prices throughout the projection period.

Technology improvements increase U.S. production from tight and shale formations

Growth in U.S. oil and natural gas resources (proved reserves and technically recoverable resources) and cumulative production have averaged 1.8%/year and 2.5%/year for crude oil and natural gas, respectively, from 1990–2005, and 3.6%/year and 3.1%/year from 2005–15. Examples of technology improvements include better rigs and drill bits that can drill wells faster at lower unit costs, improved hydraulic fracturing techniques that expose more of the rock to the well, better control of the drill bit path, and better offshore rigs and platforms that can reach great depths and handle extreme pressures and temperatures. Multi well pad drilling and improvements in logistics also have contributed to the cost reductions. These technology improvements have allowed, and are likely to continue to allow, the expansion of tight and shale gas production, as indicated in Figure ES-7.

The Reference case incorporates assumptions about changes in upstream technologies and industry practices in developing tight oil, tight gas, and shale gas plays. The plays are divided into two tiers, with different aggregate technology change rates depending on their levels of development, which are based on the potential effects of future breakthrough technologies on resource recovery rates and drilling and operating costs, particularly in areas that are less developed.

Natural gas trade and LNG exports depend on the differential between U.S. and world natural gas prices

The size of the domestic oil and natural gas resource and technology improvement rates affect the ability of U.S. producers to supply natural gas and the cost of domestic supplies. Lower world oil prices reduce the competitiveness of U.S. LNG in world markets, while exports to Canada and Mexico are affected more directly by U.S. natural gas prices, with exports falling when natural gas prices rise and increasing when natural gas prices fall.

In the Reference case, total U.S. exports of natural gas increase to 8.9 Tcf in 2040, with LNG exports of 6.7 Tcf (Figure ES-8). In the High Oil Price case, with higher international natural gas prices, particularly in Asia, U.S. LNG exports are more competitive. The greater growth in LNG exports in the High Oil Price case increases the call on domestic production, which in turn leads to higher domestic natural gas prices. The increased demand for LNG exports is offset somewhat by lower natural gas exports to Canada and Mexico as prices rise. U.S. exports of natural gas increase in the High Oil Price case to 12.5 Tcf in 2035 and remain near that

Figure ES-6. Annual average Henry Hub natural gas spot market prices in the Reference case, 1990–2040 (2015 dollars per million Btu)

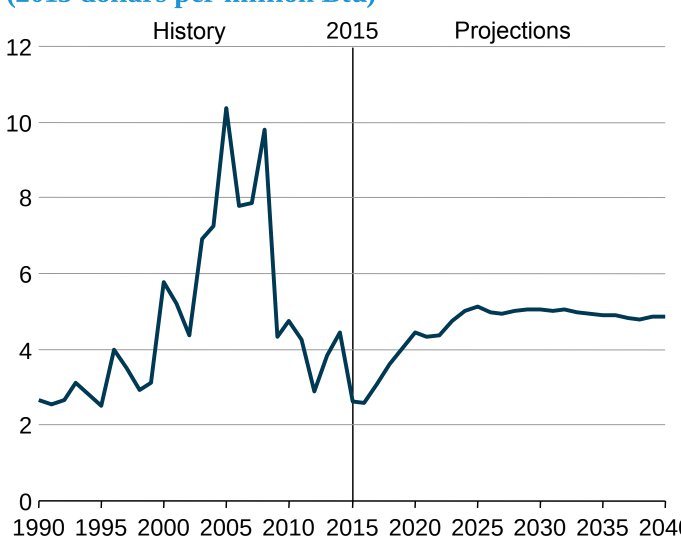
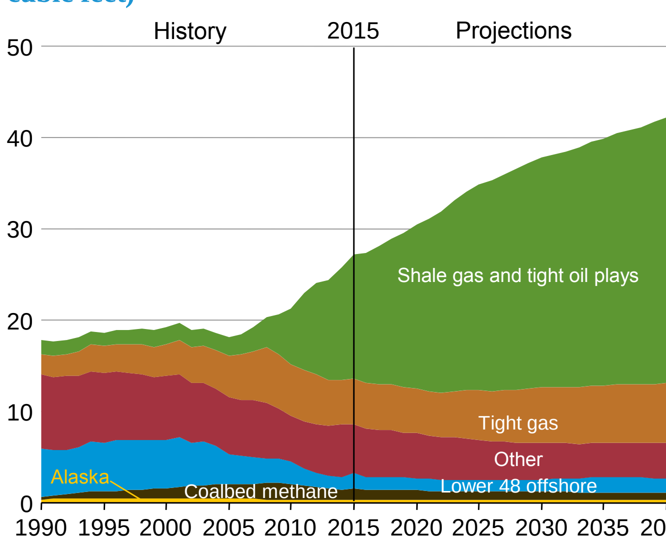


Figure ES-7. U.S. dry natural gas production by source in the Reference case, 1990–2040 (trillion cubic feet)



level through 2040, and LNG exports increase to 10.5 Tcf in 2040. In the Low Oil Price case, where there is less incentive for LNG exports, total U.S. exports of natural gas increase only to 6.8 Tcf in 2040, with LNG exports of 5.6 Tcf.

In the High Oil and Gas Resource and Technology case, lower production costs lead to more natural gas production. With assumptions of a larger resource base and more rapid improvement in production technologies in the High Oil and Gas Resource and Technology case than in the Reference case, the United States becomes a net exporter of natural gas to Canada in 2029 and U.S. LNG exports increase to 10.3 Tcf in 2035–40. In the Low Oil and Gas Resource and Technology case, U.S. natural gas production is lower because of a smaller resource base and slower improvement in technology than in the Reference case. In this case, U.S. natural gas exports total 4.7 Tcf in 2020, with LNG exports of 2.3 Tcf in that year, and remain at roughly the same level through 2034 before declining slightly through 2040.

California zero-emission vehicle program drives increasing sales of zero-emissions vehicles and transitional zero-emissions vehicles

The California zero-emissions vehicles (ZEV) (electric and hydrogen fuel cell) program issued in July 2014 is part of California's Advanced Clean Cars Program. The Advanced Clean Cars Program was adopted in the Annual Energy Outlook as part of AEO2016. The Advanced Clean Cars Program combines control of Clean Air Act-defined criteria emissions, including greenhouse gases, and the ZEV program. The program was enacted in addition to national corporate average fuel economy standards, primarily to increase the percentage of ZEVs and transitional zero-emissions vehicles (TZEV)s (plug-in hybrid-electric and hydrogen internal combustion engine vehicles) to combat California-specific smog and emissions concerns. Nine other states have adopted the California ZEV program. California and those 9 states represented 33% of the total U.S. market for new light-duty vehicles in 2015.

Manufacturers are required to produce ZEV credits equal to a percentage of their average conventional vehicle sales. Large manufacturers (more than 20,000 annual sales in California) are required to produce a minimum percentage of ZEVs. The remainder of the credits can be earned with TZEVs. Starting in model year (MY) 2018, manufacturers are required to produce ZEV credits equal to 4.5% of their conventional vehicle sales, and in MY 2025 the percentage requirement increases to 22%, with a minimum of 16% ZEVs. The credits awarded vary, depending on the vehicle type and driving range. With limitations, credits may be traded between manufacturers and between states, and requirements are lessened for smaller manufacturers.

The updated California ZEV program for MY 2018 and later drives increasing ZEV sales. In the AEO2016 Reference case, total U.S. annual sales increase to 590,000 ZEVs and 348,000 TZEVs in 2025, partly as a result of the ZEV program (Figure ES-9). Combined ZEV and TZEV sales account for 6% of national light-duty vehicle (LDV) sales in 2025, the first year of complete implementation. In 2025, states in the ZEV program account for 415,000 combined ZEV and TZEV sales, or 50% of total ZEV and TZEV sales. Currently, ZEV and TZEV sales in covered states account for 39% of total ZEV and TZEV sales. This represents compliance, as the credits earned would meet the credit percentage required. By 2040, nationwide ZEV and TZEV sales reach a combined 1.1 million sales.

Proposed medium- and heavy-duty vehicle Phase 2 standards reduce diesel fuel demand and carbon dioxide emissions

AEO2016 includes a Phase 2 Standards case that analyzes the estimated effects of more stringent regulations for fuel consumption and greenhouse gas emissions from medium- and heavy-duty vehicles. The proposed Phase 2 standards, issued jointly by the

Figure ES-8. U.S. exports of liquefied natural gas in five cases, 2005–40 (trillion cubic feet)

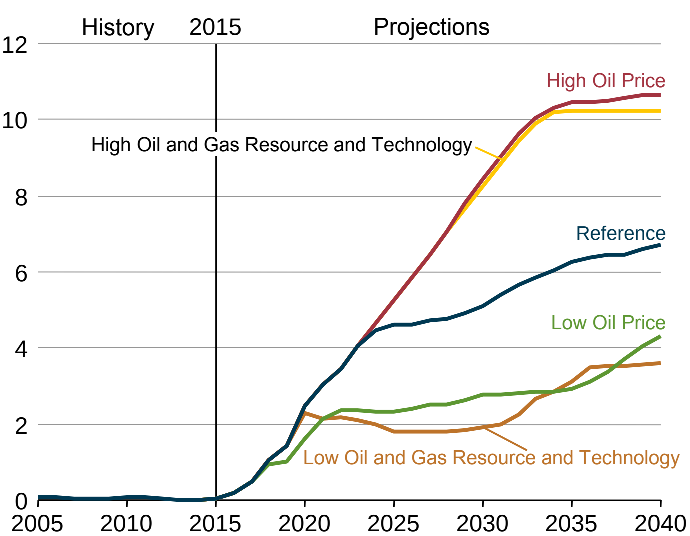
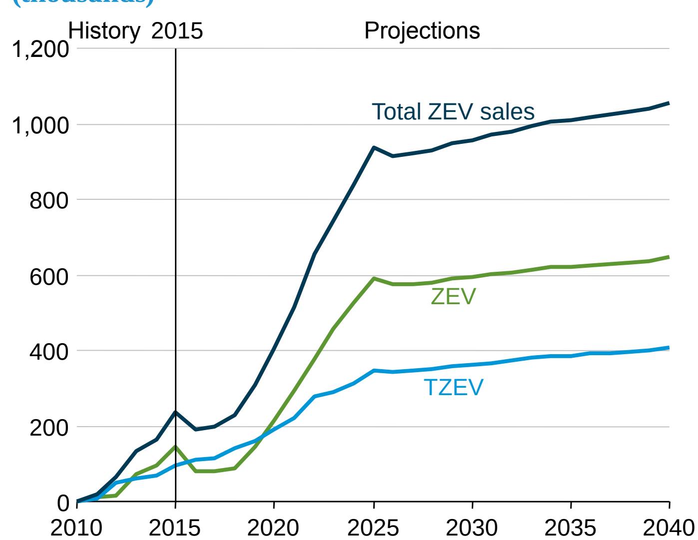


Figure ES-9. Sales of zero-emission vehicles and transitional zero-emission vehicles, 2010–40 (thousands)



National Highway Transportation Safety Administration and the EPA, are a continuation of the Phase 1 standards, which expire at the end of MY 2018. The Phase 2 standards would take effect in MY 2021, with total implementation in MY 2027, addressing vehicles in four discrete categories: combination tractors, trailers, heavy-duty pickup trucks and vans, and vocational vehicles [5].

In the AEO2016 Phase 2 Standards case, the vehicle categories are reduced to three gross vehicle weight groups: Class 3, Classes 4–6, and Classes 7–8. Compared with average new vehicle fuel economy in 2027 in the AEO2016 Reference case, average new vehicle fuel economy in the Phase 2 Standards case for combined Classes 3–8 increases by 28%. After 2027, the standards remain constant, but technology adoption continues as new cost-effective technologies become available. In 2040, the combined average fuel economy for vehicles in all three categories in the Phase 2 Standards case is 10.6 miles per gallon (mpg)—compared to 8.0 mpg in the Reference case—a 33% improvement. Higher on-road fuel economy of the medium- and heavy-duty truck stock, which is slowly affected by the introduction of new vehicles, reduces energy consumption in the Phase 2 Standards case by 22% in 2040 compared with the Reference case level. Cumulative medium- and heavy-duty vehicle consumption of diesel fuel from 2021–40 in the Phase 2 Standards case is 2.5 billion barrels lower than in the Reference case (Figure ES-10). Consequently, cumulative CO2 emissions in the transportation sector from 2021–40 are 1,186 million metric tons (3%) lower in the Phase 2 Standards case than in the Reference case.

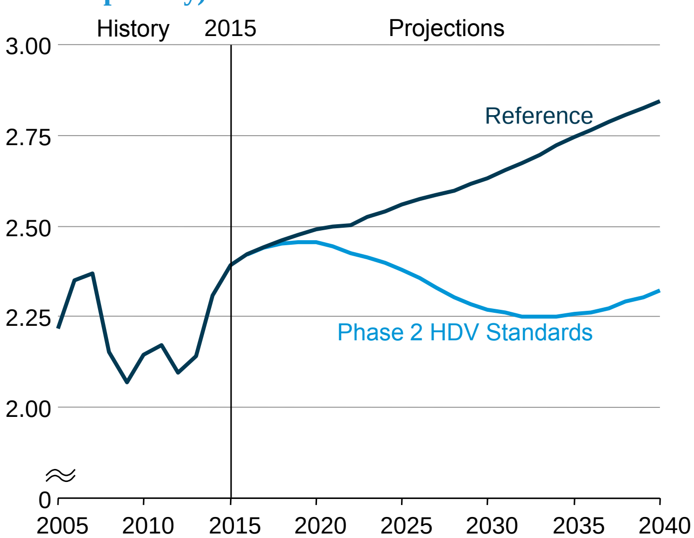
Class 2b pickup trucks and vans are included in the Phase 2 Standards case; however, the fuel economy and fuel consumption for these vehicles are not reported individually in AEO2016. Class 2b is included in the data for total transportation fuel consumption and emissions. Trailers are not explicitly modeled in the Phase 2 Standards case because of a lack of inventory and usage data. Despite improvements since the start of Phase 1, many limitations still exist in the availability of data on the technologies used to meet the Phase 1 compliance standards and on Phase 2 vehicle baseline performance, which makes it difficult to estimate future energy effects. The EPA baseline for Phase 2 is established by assuming compliance with Phase 1 in MY 2017, which is evaluated differently. Therefore, it is unknown whether Phase 1-compliant vehicles in MY 2017 accurately represent the proposed Phase 2 baseline. The discussion of the Phase 2 Standards case in the AEO2016 Issues in Focus details the proposed standards, the vehicles affected, and regulatory and modeling issues.

With lower natural gas prices, industrial sector energy consumption increases through 2040

The AEO2016 Reference case projects robust growth in industrial energy use of natural gas as shipments increase over the 2015–40 period. Low natural gas prices and increased availability of natural gas and related resources, including hydrocarbon gas liquids (HGL), benefit the U.S. industrial sector and the manufacturing sector, in particular, in several ways. Natural gas is used as a fuel to produce heat and to generate electricity. Natural gas is also used, along with HGL products, as a feedstock to produce chemicals, pharmaceuticals, and plastics. Low energy prices result in more rapid economic growth and increasing demand for industrial products.

Industrial shipments and improvements in energy efficiency over time have significant effects on energy consumption in the industrial sector in the Reference case. As a result of efficiency improvements, industrial energy consumption grows more slowly than shipments. Total delivered energy consumption in the industrial sector grows by 1.2%/year from 2015–40. In the near term, energy consumption grows by 1.8%/year in the Reference case between 2015 and 2025, more than twice the rate from 2025 to 2040, as a result of more rapid growth in shipments in the near term, 2.4%/year from 2015–25, compared with 1.5%/year from 2025–40.

Figure ES-10. Diesel fuel consumption by large trucks, Classes 3–8, in two cases, 2005–40 (million barrels per day)



Growth in industrial production leads to increased natural gas consumption in the industrial sector, from 9.4 quadrillion Btu in 2015 to 11.3 quadrillion Btu in 2025 and to 12.9 quadrillion Btu in 2040. The projected rate of growth in natural gas consumption, at 1.3%/year from 2015–40, is slightly higher than the rate of growth for total industrial sector energy consumption. The bulk chemical industry is the largest user of natural gas in the industrial sector. Other large users include refining, food products, mining, iron and steel, paper products, and metal-based durables.

The bulk chemical industry accounts for much of the growth in industrial energy consumption, with a competitive price advantage for feedstocks, especially HGL, reflected in the growth of shipments from 2015–40. In the Reference case, energy consumption in the bulk chemical industry grows by 80% from 2015–40, compared with 18% for other manufacturing and 30% for nonmanufacturing industries (Figure ES-11). Energy consumption growth in the bulk chemical industry is concentrated in the 2015–25 period

(4.3%/year, compared with 1.1%/year from 2025–40), and shipments of bulk chemicals increase by 4.8%/year from 2015–25, compared with 1.4%/year from 2025–40.

Different assumptions about the rate of economic growth and the levels of oil and natural gas prices also affect energy consumption growth rates in the industrial sector (Figure ES-12). In both the High Economic Growth case and the High Oil Price case, energy consumption growth slows in the later years of the projections. In the High Oil Price case, energy consumption growth in the mining industry is considerably higher than in the Reference case and higher than in the High Economic Growth case, as shipments from the oil and gas extraction industry grow rapidly when energy prices are high. Energy consumption in the bulk chemical industry grows by more than 2%/year in the Reference, High Oil Price, Low Economic Growth, and High Economic Growth cases.

Energy-related CO2 emissions vary widely with different assumptions about economic growth, energy prices, and policies

The AEO2016 Reference case assumes that current laws and regulations remain in effect through 2040; however, the status of the CPP, which is on hold pending judicial review, is uncertain. In the Reference case, the CPP is assumed to be implemented as scheduled, using mass-based standards that impose limits on CO2 emissions from fossil fuel-fired generators. The No CPP case assumes that no federal carbon reduction program is implemented.

Across the alternative AEO2016 cases, total energy-related CO2 emissions in 2040 vary by more than 800 million metric tons, depending on the assumptions in each case about economic growth, energy prices, and energy policies (Figure ES-13). In the High Economic Growth case, which includes the CPP, total emissions in 2040 are close to the No CPP case total of 5,468 million metric tons because emissions from sectors other than electric power increase as the economy grows. In the Extended Policies case, CO2 emissions fall to 4,623 million metric tons in 2040, which is 23% lower than the 2005 total. The Extended Policies case assumes that existing policies and regulations remain in effect or are extended beyond sunset dates specified in current regulation; that efficiency policies—including corporate average fuel economy standards, appliance standards, and building codes—are expanded beyond current provisions; and that EPA CPP regulations that reduce CO2 emissions from electric power generation are tightened after 2030. As a result, energy-related CO2 emissions in 2040 in the Extended Policies case are 845 million metric tons lower than in the No CPP case.

Variations in energy prices have a smaller effect than the CPP requirements on total CO2 emissions. Because the CPP imposes a limit on CO2 emissions in the electric power sector that are met in all cases, differences in energy-related emissions are seen only in the end-use sectors. As a result, the difference in 2040 CO2 emissions between the Low Oil Price and High Oil Price cases is smaller than the difference between the No CPP case and the Extended Policies case.

Figure ES-11. Industrial sector energy consumption by application in the Reference case, 2010–40 (quadrillion Btu)

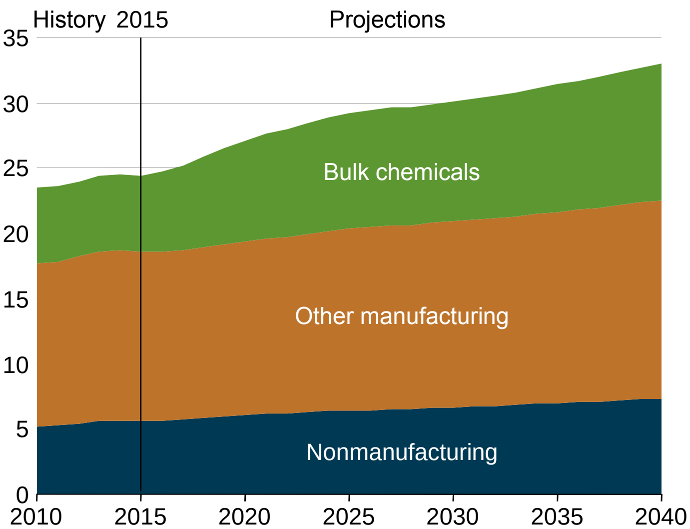


Figure ES-12. Industrial sector delivered energy consumption in four cases, 2010–40 (quadrillion Btu)

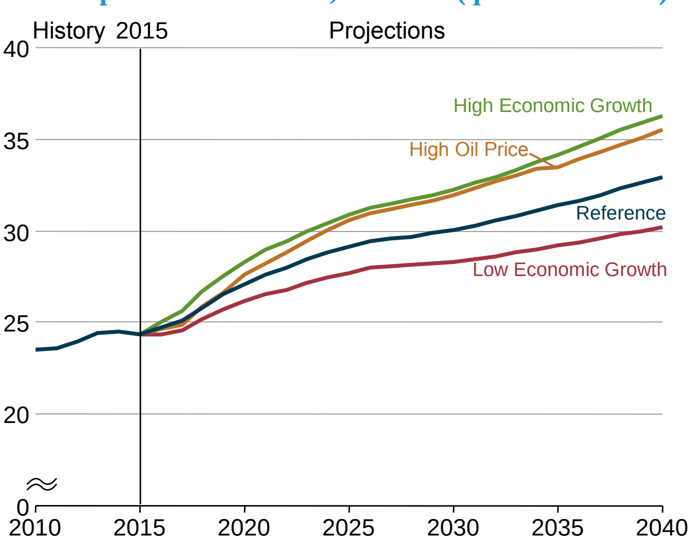
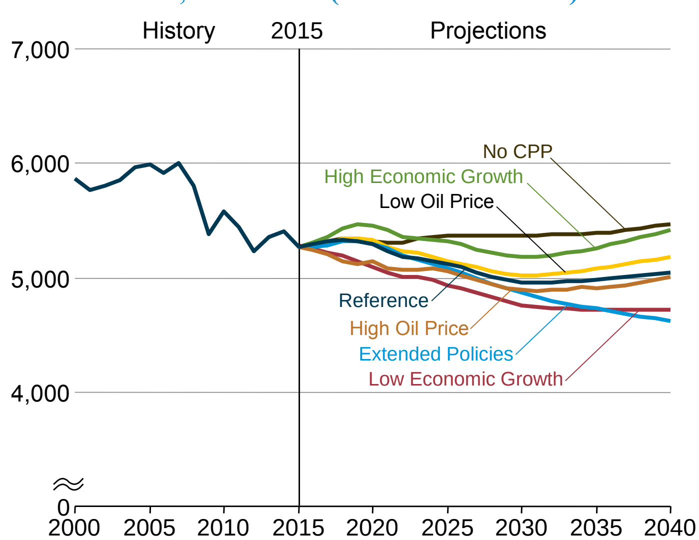


Figure ES-13. Energy-related carbon dioxide emissions in seven cases, 2000–2040 (million metric tons)



Endnotes for executive summary

Links current as of July 2016

1. U.S. Environmental Protection Agency, "Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015) https://www.federalregister.gov/articles/2015/10/23/2015-22837/standards-of-performance-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed-stationary; and U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015) https://www.federalregister.gov/articles/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.

2. California Environmental Protection Agency, Air Resources Board, "Zero-Emission Vehicle Standards for 2018 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" (Sacramento, CA: July 10, 2014), http://www.arb.ca.gov/msprog/zevprog/zevregs/1962.2_Clean.pdf.

3. U.S. Environmental Protection Agency and National Highway Transportation Safety Administration, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2" (Washington, DC: June 19, 2015), http://www.nhtsa.gov/fuel-economy.

4. For example, whether or not to engage in interstate trading programs, to allow credits for *outside-the-fence* options like energy efficiency, to auction allowances or to allocate them freely if electing a mass-based approach, how to credit renewable energy projects under a rate-based program, and other options.

5. Vocational vehicles include any medium- or heavy-duty vehicle that is not a heavy-duty pickup or van or a semi-truck tractor with a 5th wheel trailer attachment (including vehicles like box or delivery trucks, buses, dump trucks, tow trucks, refuse haulers, and cement trucks).

Figure sources for executive summary

Links current as of July 2016

Figure ES-1. Net electricity generation from coal, natural gas, and renewables in the AEO2016 Reference case, 2013–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure ES-2. Net electricity generation from coal, natural gas, and renewables in the No CPP case, 2013–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF_NO_CPP.D032316A.

Figure ES-3. Petroleum and other liquid fuels production by region and type in the Reference case, 2000–2040: AEO2016 National Energy Modeling System, run REF2016.D032416A and REF_NO_CPP.D032316A.

Figure ES-4. Electricity generation from solar power in the buildings sectors in three cases, 2010–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWMACRO.D032516A, and HIGHMACRO.D032516A.

Figure ES-5. Total U.S. crude oil production in five cases, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** REF2016.D032416A, LOWRT.D032516A, HIGHRT.D032516A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure ES-6. Annual average Henry Hub natural gas spot market prices in the Reference case, 1990–2040: History: 1990–2014, U.S. Energy Information Administration, *Natural Gas Annual 2014,* DOE/EIA-0131(2014) (Washington, DC, September 2015). **Projection:** AEO2016 National Energy Modeling System, runs REF2016.D032416A.

Figure ES-7. U.S. dry natural gas production by source in the Reference case, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projection:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure ES-8. U.S. exports of liquefied natural gas in five cases, 2005–40: History: 1990–2014, U.S. Energy Information Administration, *Natural Gas Annual 2014,* DOE/EIA-0131(2014) (Washington, DC, September 2015). **Projection:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWRT.D032516A, HIGHRT.D032516A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure ES-9. Sales of zero-emission vehicles and transitional zero-emission vehicles, 2010–40: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure ES-10. Diesel fuel consumption by large trucks, Classes 3–8, in two cases, 2005–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02), http://www.eia.gov/totalenergy/data/monthly/archive/00351602.pdf. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D0324A and PHASEII.D041316A.

Figure ES-11. Industrial sector energy consumption by application in the Reference case, 2010–40: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure ES-12. Industrial sector delivered energy consumption in four cases, 2010–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02), http://www.eia.gov/totalenergy/data/monthly/archive/00351602.pdf. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, HIGHPRICE.D041916A, LOWMACRO.D032516A, and HIGHMACRO.D032516A.

Figure ES-13. Energy-related carbon dioxide emissions in seven cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, LOWMACRO.D032516A, HIGHMACRO.D032516A, LOWPRICE.D041916A, HIGHPRICE.D041916A, and TAXTENDED.D050216A.

Legislation and regulations

Introduction

The *Annual Energy Outlook 2016* (AEO2016) represents current federal and state legislation and final implementation of regulations as of the end of February 2016. The AEO2016 Reference case assumes that current laws and regulations affecting the energy sector are largely unchanged throughout the projection period (including the implication that laws that include sunset dates are no longer in effect at the time of those sunset dates) [*1*]. The potential effects of proposed legislation, regulations, or standards—or of sections of authorizing legislation that have been enacted but are not funded, or for which parameters will be set in a future regulatory process—are not reflected in the AEO2016 Reference case, but some are considered in alternative cases. This section summarizes federal and state legislation and regulations newly incorporated or updated in AEO2016 since the completion of the *Annual Energy Outlook 2015* (AEO2015) in April 2015. This section also summarizes selected rules and regulations that have been proposed recently and have the potential to affect the projection significantly.

Examples of federal and state legislation and regulations incorporated in the AEO2016 Reference case, or whose handling has been modified, include:

- Incorporation of the U.S. Environmental Protection Agency's final rules for the Clean Power Plan (CPP) [*2*] under the Clean Air Act (CAA) Section 111(b) and 111(d). Section 111(b) sets carbon pollution standards for new, modified, and reconstructed power plants. Section 111(d) sets performance standards for existing fossil fuel-fired plants. Final rules to support the performance standards and model trading rules were in effect by October 2015. However, in February 2016, the U.S. Supreme Court issued a stay on enforcement of the existing power plant rule, pending resolution of legal challenges [*3*]. The AEO2016 Reference case includes the CPP. An alternative No CPP case, which assumes that the CPP is not enforced, also is included in AEO2016, as are several cases that consider the implication of alternative approaches to CPP implementation.
- Incorporation of the California Air Resource Board (CARB) Zero-Emission Vehicle (ZEV) program for model year (MY) 2018 and later vehicles [*4*]. The ZEV program is part of California's Advanced Clean Cars Program. Nine other states have fully adopted the CARB Advanced Clean Cars program standards. The latest amendment to the ZEV program, which affects model year (MY) 2018 and later vehicles, requires a certain percentage of an automaker's sales to be made up of ZEVs and Transitional Zero-Emission Vehicles (TZEVs). The ZEV sales requirement is administered through credits, with the required allowable credits calculated as a percentage of the automaker's conventional gasoline and diesel light-duty vehicle (LDV) sales, averaged over the previous three model years.
- Revisions to reflect the extension of the production tax credit (PTC) for wind and a 30% investment tax credit (ITC) for solar, enacted in December 2015 as part of the 2016 Consolidated Appropriations Act [*5*]. Unlike previous extensions, which maintained the inflation-adjusted value of the PTCs for the duration of the extensions, the current extension introduces a phaseout that reduces the value of the credit over time before final expiration.
- Adoption of newly added or modified federal efficiency standards for residential and commercial appliances and equipment established under authority of the Energy Policy and Conservation Act of 1975, the National Appliance Energy Conservation Act of 1987, and the Energy Independence and Security Act of 2007. The Reference case includes only promulgated standards and comprehensive consensus agreements.
- Incorporation of modifications to existing state Renewable Portfolio Standards (RPS) or similar laws, to reflect the addition of a new RPS policy in Vermont and expanded RPS targets in California and Hawaii [*6*]. The Reference case does not include laws and regulations with either voluntary goals or targets that can be substantially satisfied with nonrenewable resources.
- Updates in AEO2016 to better reflect the International Convention for the Prevention of Pollution from Ships (MARPOL) [*7*], which mandates that existing ships either burn fuel containing a maximum of 0.1% sulfur or use scrubbers to remove sulfur emissions. The U.S. Energy Information Administration (EIA) has updated AEO2016 to improve the calculation of the amount of fuel consumed by ocean-going vessels traveling though North American and Caribbean emissions control areas, including the effects of compliance strategies. Further, EIA has updated the methodology for calculating energy demand for oceangoing vessels to include estimations of fuel consumption by ship type and commodity moved.
- Laws and regulations will continue to evolve over time, and some laws include sunset provisions that may be extended. However, even in situations where existing legislation contains provisions to allow revision of implementing regulations, those provisions may not be exercised consistently. The implications of some pending and possible developments are examined in alternative cases included in AEO2016. In addition, at the request of both federal agencies and Congress, EIA has regularly examined the potential implications of other possible energy options in special analyses that can be found on the EIA website at http://www.eia.gov/analysis/reports.cfm?t=138.

LR1. Clean Power Plan with New Source Performance Standards for power generation

The Clean Air Act (CAA) sets the regulatory framework for federal efforts to control emissions of air pollutants in the United States, requiring, among other things, the application of preferred technology standards to limit pollutants found to pose a threat to human health and the environment. Using CAA provisions, the U.S. Environmental Protection Agency (EPA) has developed a three-part program to limit carbon dioxide (CO2) emissions from the electric power sector:

1. CO_2 performance standards for new power plants
2. CO_2 performance standards for existing power plants (the CPP)
3. Rules for states electing federal implementation options and model trading program design

Final rules to support the performance standards were published in October 2015, with the performance standards for existing power plants and the proposed model trading rule scheduled to take effect starting in 2022. However, in February 2016 the Supreme Court issued a stay on enforcement of the existing power plant CPP, pending resolution of legal challenges. At the time the stay was issued, no lower court had considered the merits of the legal challenges to the rule, and there was no enforceable judgment either affirming or vacating the CPP. Under these circumstances the AEO2016 Reference case includes the CPP and an alternative No CPP case that excludes the CPP for comparison.

Regulatory background: legal basis for CPP/NSPS rules

In Section 111 of the CAA, Congress provided for the development of emissions standards to limit pollutants from new sources. The new source performance standards (NSPS) were intended to be nationwide and uniform, as a complement to the regional application of ambient air quality standards to control emissions from existing sources. However, the CAA requires that, once EPA has established standards for new sources EPA must require states to develop standards for existing sources.

For CO_2 emissions from electricity generation units, EPA developed the following regulations for new and existing sources concurrently:

- *Performance standards for new sources* (as well as modified and reconstructed sources) under authority of Section 111(b) [*8*]
- *Performance standards for existing sources* under Section 111(d), published in October 2015 [9] and stayed in February 2016 [*10*]
- *Federal plan and model trading rules,* proposed in October 2015 [*11*], with EPA's announced intent to finalize the rules for both mass-based (cap and trade) and rate-based versions by summer 2016

EPA provides for the exclusion of units subject to the Section 111(b) rule from Section 111(d) plans, so that if a source covered by a Section 111(d) plan is modified or reconstructed, it drops out of Section 111(d) coverage and only needs to meet the Section 111(b) requirements.

Representing new source CO_2 emission standards: Sec 111(b) rules

The CAA requires that standards issued under Section 111 reflect the degree of emissions limitation achievable through the best system of emission reduction (BSER) found by EPA to have been adequately demonstrated. In its final rule, for new sources, which also covers modified and reconstructed sources, EPA specified CO_2 standards for four types of new electric generating units (EGUs):

1. *New fossil steam EGUs:* 1,400 pounds CO_2/megawatthour (MWh) gross
2. *Modified fossil steam EGUs:* limit determined by unit's best historical annual CO_2 rate (from 2002 to the date of the modification) but no greater than reconstructed coal EGUs
3. *Reconstructed coal steam EGUs:*
   a. 1,800 pounds CO_2/MWh gross (if heat input is more than 2,000 million British thermal units (Btu)/hour)
   b. 2,000 pounds CO_2/MWh gross (if heat input is 2,000 million Btu/hour or less)
4. *New combined-cycle combustion turbine:* 1,000 pounds CO_2/MWh gross, or 1,030 pounds CO_2/MWh net, where the state has the option to choose between having combustion turbine operators report their generation output on a gross basis (including total electric output) or a net basis (excluding the power necessary to operate the plant itself)

The new coal plant technology modeled in the AEO2016 National Energy Modeling System (NEMS) includes 30% carbon capture to ensure the ability to meet the standard. New coal plants without carbon capture and storage technology are not allowed to be built. The new natural gas combined-cycle plants modeled in previous AEOs were already below the 1,000 pounds CO_2/MWh standard, and no change was necessary to the natural gas technology assumptions to reflect the final rule. The NEMS electricity model does not explicitly represent modified or reconstructed power plants.

Representing existing-source CO_2 emissions standards: Section 111(d) rules

EPA adopted interim and final CO_2 emission performance rates for two subcategories of fossil fuel-fired EGUs:

1. *Existing fossil steam EGUs:* interim/final rate, 1,534/1,305 pounds CO_2/MWh net
2. *Existing stationary CTs:* interim/final rate, 832/731 pounds CO_2/MWh net [*12*]

The emission performance rates, which are set uniformly for the nation for both subcategories, were determined using an analysis of BSER that reflects an emission adjustment according to EPA's assessment of the potential mass emission reductions associated with lower-emitting compliance options (e.g., new renewable energy generation or more efficient thermal plant operation). The adjustment is made by:

- Estimating the annual net generation from an achievable amount of qualifying incrementally lower-carbon and zero-carbon generation
- Substituting that generation to displace baseline electricity generation and CO2 emissions from the affected EGUs that have higher emissions
- Replacing fossil steam and natural gas-fired combined-cycle generation with regionally identified incremental (2012 and beyond) potential renewable generation on a pro rata basis corresponding to the baseline mix of fossil generation in each region [*13*]

To facilitate flexibility in state implementation of the CPP rule, EPA developed both rate-based and mass-based state-specific standards, with states able to choose between the two program types. In so doing, each state must determine whether to apply its emissions reduction requirements to affected EGUs, or to meet the equivalent state-wide CPP rate-based goal or the mass-based goal. After choosing the rate-based or mass-based compliance option, states must then choose between: (1) an Emission Standards Plan Type, in which the state places all requirements directly on its affected EGUs, with all requirements federally enforceable; and (2) a State Measures Plan Type, which can include a mix of measures that may apply to affected EGUs and/or other entities, and may lead to CO2 reductions from affected EGUs, but are not federally enforceable. States may use a wide variety of measures to comply with the rate-based standards, including options not assumed by EPA in the calculation of the standard. For example, new nuclear generation, new end-use renewable generation, and incremental demand reductions as a result of energy efficiency can be used as zero-emitting compliance options to offset emissions from affected generators.

Implementation of the CPP rule in AEO2016 reflects four key design choices:

- First, an assumption is made about which type of trading program states choosing interstate cooperation would elect: rate-based or mass-based. Based on a review of the existing literature, including comments made to EPA and in other public forums, a majority of comments (from state regulatory authorities and/or the regulated utilities) suggested a preference for a mass-based trading program. This preference appeared to be based on the states' familiarity with mass-based (cap and trade) programs and their ability to use mass-based allowance allocation to compensate affected parties, such as ratepayers and energy-intensive industries. The AEO2016 Reference case assumes that all states use the mass-based approach for all sources. In addition to the Reference case, the CPP Rate case assumes rate-based regulation in all states, and the CPP Hybrid case assumes a hybrid approach, in which some states use mass-based regulation and others use rate-based regulation.
- Second, an assumption is made about the level at which states would choose to cooperate (for example, regional, Independent System Operator/Regional Transmission Organization, interconnect, or national). Based on a review of public commentary and analysis, the AEO2016 Reference case assumes trading at the regional level, designed to replicate current power market trading patterns. The CPP Interregional Trading case examines the implications of trading beyond regional boundaries.
- Third, under a mass-based program, there is a need to specify the method by which allowances would be allocated. A review of the literature indicated that over time there has been an evolution in allowance allocation approaches in similar programs that tends to favor the offset of potential increases in electricity rates (for example, allocations to affected electric utilities under California's AB 32 program). The allocation of CPP allowances to load-serving entities in the AEO2016 Reference case is a broad approach with potential to minimize price impacts for consumers. The CPP Allocation to Generators case considers the implications of an allowance auction or allocation directly to generators, which can result in higher price impacts for electricity customers, even as they reduce effective costs for generators.
- Finally, to ensure the integrity of emissions reductions achieved under the program, EPA required states to warrant that their use of mass-based goals does not result in shifts of generation to unaffected sources (leakage). EPA allows states to design their own leakage control policies, or to regulate total mass emissions from both existing and new sources under a single limit for carbon emissions. The AEO2016 Reference case assumes a mass-based program using EPA's budgets that include new sources (rather than the budgets for existing units only), given that other policies to control for leakage are not yet well specified.

LR2. Other rules affecting the power sector

In addition to the CPP, many regulations or guidelines were either ruled upon by the Supreme Court or were finalized by EPA and the U.S. Department of the Interior (DOI) after the publication of the AEO2015. Several of the regulations or guidelines primarily affect the use of coal in electricity generation. Furthermore, the Cross State Air Pollution Rule (CSAPR) [*14*], which was upheld recently by the Supreme Court, replaces the Clean Air Interstate Rule (CAIR) [*15*], which was modeled in AEO2015. AEO2016 also includes the Mercury Air Toxics Standard (MATS) [*16*], despite the recent remand by the Supreme Court to incorporate an analysis of costs [*17*]. Although not included in AEO2016, EPA has finalized three additional rules that allow for site-specific compliance methods:

- The Clean Water Act Section 316(b) rule [*18*], which affects all electricity generating and manufacturing facilities with cooling water intakes that have the potential to use at least 2 million gallons of water per day
- Revised Steam Electric Power Generating Effluent Guidelines and Standards (EG) [*19*] specifying permissible levels of emissions in wastewater streams
- Coal Combustion Residual rule (CCR) [*20*] affecting the disposal of coal ash (a waste byproduct from coal-fired generation)

EPA regulatory analyses indicate a relatively small increase in coal plant retirements and costs to the power industry as a result of these regulations. These and other pending regulations or actions with the potential to affect coal supply for the power sector and other end-use sectors are discussed in detail in the following sections.

CAA rules. AEO2016 includes representation of CSAPR, which addresses the interstate transport of air emissions from power plants. After a series of court rulings over the years, the Supreme Court in October 2014, lifted its stay and upheld CSAPR as a replacement for CAIR. In an interim final rule in December 2014 (and reaffirmed in a ministerial action in February 2016), EPA realigned the CSAPR schedule to comply with the Court's ruling. Phase I began that month, and more stringent Phase II targets will take effect in January 2017. Although CSAPR remains in place, the courts remanded CSAPR back to EPA in June 2015 for additional refinement that affected the Phase II implementation of NOx emission limits.

Under CSAPR, 28 eastern states must restrict emissions of sulfur dioxide and nitrogen oxide, which are precursors to the formation of fine particulate matter (PM2.5) and ozone. CSAPR establishes four distinct cap-and-trade system groups composed of different member states. CSAPR permits allowance trading between states within a group (approximated in NEMS by trade between coal demand regions) but not between groups.

Under the authority of the CAA, EPA also established the Mercury and Air Toxics Standard (MATS), which regulates acid gases and mercury from coal-fired generators with capacities of 25 megawatts (MW) or greater. In June 2015, the Supreme Court remanded MATS to the District of Columbia Court of Appeals, stating that EPA failed to consider costs in developing the regulation. AEO2016 includes MATS, because many generators already have complied either by investing in retrofit equipment or by retiring capacity, and the court did not vacate or stay the regulation, thereby leaving MATS in place and enforceable.

Under MATS, mercury emissions must be 90% below their uncontrolled levels, which can be achieved through the application of various types of pollution control equipment and activated carbon injection. To simulate compliance with MATS restrictions on other hazardous air pollutants (such as acid gases), NEMS requires the installation of either a scrubber or a dry sorbent injection (DSI) system. A full fabric filter is modeled in combination with DSI to further meet the standard's acid gas requirement. Because 141 gigawatts of coal-fired generators were granted EPA's one-year extension for compliance [*21*], AEO2016 assumes that MATS is fully in place in 2016 (rather than in 2015).

Clean Water Act (CWA) rules. In August 2014, EPA promulgated Section 316(b) of the CWA, regulating electric power and manufacturing facilities that require cooling water structures to address the trapping of aquatic organisms against water intake structures (impingement) or within cooling water systems where they encounter thermal and mechanical stresses (entrainment). With consideration of costs, the rule establishes that best available technology (BAT) must be used for compliance and must be implemented in accordance with the expiration of a facility's National Pollutant Discharge Elimination System (NPDES) permits. Some negotiation of the compliance timeline between the facility and EPA may occur, depending on the date of expiration of the permit, but all facilities must provide a compliance plan by July 2018. Variation in compliance methods is expected, given that site-specific considerations may affect the practicality of some technologies. Existing technologies deemed as BAT for impingement include a closed-cycle system, reduction of intake flows to 0.5 feet per second, and a minimum distance of 800 feet from shore for intakes that use bar screens. Under the Section 316(b) rule, repowered units will be regulated as existing rather than new units.

The 316(b) rule also provides for some potential aberration from BAT compliance. Facilities that operate with a capacity utilization of 8% or less over a 24-month period may negotiate less stringent compliance standards. A power plant that is scheduled to be retired may also avoid implementation of BAT. Additional options include restriction of aquatic mortality to 24% over a two-year span. In some cases, facilities that use impoundments for cooling water, or that stock and manage fisheries, may be able to negotiate deviations from the BAT requirements provided that endangered species are not present at the site. Other methods or combinations of methods may be negotiated with EPA. For entrainment, NPDES state directors are responsible for determining the BAT required, and they can do so on a site-specific basis.

EPA's regulatory impact analysis found that about 1 gigawatt of coal-fired generation capacity would be retired as a result of implementation of Section 316(b), and that the industry would incur costs of $275 million to $297 million annually (excluding entrainment costs)—assuming that CSAPR and MATS already are in place but without accounting for costs associated with the CPP. Section 316(b) is not represented in AEO2016.

Under the authority of the CWA, EPA also promulgated revisions to the Steam Electric Power Generating Effluent Guidelines (EG) in September 2015. The guidelines, which are not included in AEO2016, address liquid waste streams from power plants (primarily coal-fired power plants) discharged directly or indirectly into water bodies and, for the first time, emissions of toxic or bio-accumulating chemicals (including arsenic, nickel, selenium, chromium, and cadmium) in the wastewater of coal power plants, which will be restricted using BAT.

Last updated in 1982, the guidelines are intended in part to address pollutants potentially detoured to wastewater streams as the result of compliance with CAA regulations. Under the rule, flue gas desulfurization wastewater (a byproduct of the use of air emission control equipment) must be treated chemically or biologically to address the potential presence of arsenic, mercury, selenium, and nitrate/nitrite. Flue gas mercury control wastewater, as well as fly ash transport water and bottom ash (including boiler slag) transport water, also must achieve zero discharge levels through use of dry handling. The rule also sets limits on total suspended solids in gasification wastewater and combustion residual leachate.

Although the EG became effective as of January 2016, specific compliance deadlines vary by power plant, according to the expiration date of each plant's NPDES permit. For all power plants, compliance must be achieved between 2018 and 2023. Because there are synergies between the EG and CCR compliance options (described below), it is likely that the facilities' compliance plans will meet the EG and CCR goals simultaneously to minimize costs. In particular, many facilities are expected to dispose of coal ash via dry methods to comply with both regulations.

EPA's regulatory impact analysis found that about 1 gigawatt of coal-fired plant capacity would be retired as a result of the changes in the EG, and that the industry as a whole would incur costs of $471 million to $480 million annually, assuming that CSAPR, MATS, 316(b), the CCR rule, and the CPP are in place before the EG takes effect.

In June 2015, under the authority of the CWA, EPA also published its final "Waters of the United States" rule, specifying the waterways that are subject to the jurisdiction of EPA and the U.S. Army Corps of Engineers. The rule defines the scope of a navigable body of water to include tributaries that contain flowing water for some portion of a year [*22*]. Although the rule is final, it was stayed by the U.S. Court of Appeals for the Sixth Circuit in October 2015 [*23*], and it is not included in AEO2016. If upheld, the rule could pose additional permitting responsibilities for the coal industry, requiring the added burden of considering nonperennial tributaries that previously were outside the scope of the permitting process and potentially affecting coal supplies.

Resource Conservation Recovery Act rules. According to the American Ash Association [*24*], 130 million tons of coal ash (an inorganic waste byproduct of coal combustion) were produced in 2014. Generators dispose of coal ash in a variety of ways. In some cases, coal ash is disposed directly in landfills, with or without liners to mitigate leaching. In other cases the ash is mixed with water to produce a wet slurry that can be transported via pipeline or truck and discarded in waste ponds or impoundments rather than as a dry solid. In still other cases, coal ash may be discarded in abandoned mines. Generators have also sold coal ash waste for use in consumer and industrial products.

In 2008, the failure of the Kingston coal ash impoundment in Tennessee highlighted issues surrounding coal ash disposal, and EPA considered whether coal ash should be regulated as a hazardous waste. Since the Kingston spill, additional accidents and citizen complaints and suits about groundwater leaching from coal ash containment structures have contributed to continued concerns about coal ash disposal.

In April 2015, EPA published its final CCR rule, which took effect in October 2015. The rule sets regulations for both new and existing landfills and impoundments used for the disposal of coal ash. As a result of the rule, coal ash will continue to be regulated as a nonhazardous waste under Subtitle D of the Resource Conservation Recovery Act [*25*]. However, any method of disposal via impoundments or landfills must comply with certain national minimum criteria. The compliance criteria were established with consideration of groundwater leaching, dust control, and avoidance of catastrophic failure. The rule also requires long-term recordkeeping and monitoring beyond the closure of the disposal site. Waivers for retrofitting include the closure of existing disposal sites. Although no regulatory enforcement mechanism is in place under the rule, responsible parties are susceptible to litigation from citizen groups or other stakeholders if compliance is not achieved.

In 2014, an estimated 48% of coal ash [*26*] was used for beneficial purposes as an input for consumer and industrial products, avoiding both disposal in an impoundment or similar structure and disposal costs while also providing revenue for the generator. A label of hazardous would have severely restricted this option. To the benefit of the generators, the final CCR rule allows for CCR products to remain unregulated if the CCR is encapsulated in a product that displaces the use of virgin materials. These products include gypsum wall board and concrete, but the use of coal ash as ground fill is specifically excluded.

EPA's regulatory impact analysis found that an incremental 0.8 gigawatts of coal-fired capacity retire as a result of the CCR rule, and that the industry would incur incremental costs of $509 million to $735 million annually evaluated over a 100-year period (2013 dollars). For its analysis, EPA assumed that CSAPR, MATS, and 316(b) were already in place, but the EG and CPP were not. EPA also included a sensitivity case in which the CPP was included. As indicated above, certain compliance synergies between the CCR and the amended Effluent Guidelines are expected.

U.S. Department of Interior (DOI) actions: In July 2015, the Office of Surface Mining Reclamation and Enforcement proposed the Stream Protection Rule (SPR) under the authority of the Surface Mining and Reclamation Act of 1977 [*27*]. The proposed rule would affect all surface mining operations and any underground mining operations that disturb the surface. The earliest implementation date for the rule is January 2017. Under the proposed rule, permits specifying the maximum allowable damage to the area would be a condition of mining, and the SPR would stipulate that the mining area be returned to a condition appropriate for its pre-mining use after operations cease. The rule would require data collection before beginning mining operations to provide baseline environmental conditions for the area. Critics have said that the rule would strand coal assets and pose additional permitting difficulties for the coal industry. The SPR is not final and is not represented in AEO2016.

In January 2016, DOI issued a temporary moratorium on additional coal leases on federal lands while it reviews the coal royalty program and leasing process [*28*]. DOI expects to complete the review process within three years and has stated that exceptions will be granted to ensure the reliability of coal supply. In particular, some pending leases that already are in progress may continue to be processed [*29*]. Three of those pending leases are located in the Wyoming Powder River Basin (PRB), where 100% of coal production comes from federal lands. About 40% of U.S. coal production is from federal and Indian lands, and about 80% of that amount is produced in Wyoming. Most of the current PRB leases contain enough coal to last 20 years or longer. Existing annual permit levels at individual mines [30], in combination with total recoverable reserves (reported to EIA by the mine operators), will allow the PRB region to reach its projected production levels in the AEO2016 Reference case until the mid- to late-2030s in the absence of further lease sales, although some individual mines may have difficulty maintaining production levels before then. In addition to Wyoming, regulations on coal production from federal lands largely affect western states. Alabama, Oklahoma, North Dakota, Arizona, New Mexico, Utah, Colorado, and Montana (in order from lowest to highest levels) produced between 0.8 million tons and 25 million tons of coal on federal and Indian lands in 2013, accounting for different percentages of each state's total coal production. The final outcome of DOI's leasing moratorium is uncertain, and it is not represented in AEO2016.

LR3. Impact of a Renewable Energy Tax Credit extension and phaseout

As part of the 2016 Consolidated Appropriations Act enacted in December 2015 (H.R. 2029) [31], Congress extended the qualifying deadlines for the production tax credit (PTC) and investment tax credit (ITC) for renewable generation technologies. The deadline for PTC-eligible technologies to receive the full production credit was extended by two years. Wind technologies are eligible to receive the PTC beyond the two-year extension, but the value of the PTC declines gradually over time before final expiration. This extension is unlike the treatment in previous years, in which the tax credit maintained a constant inflation-adjusted value. The five-year ITC extension for solar projects also includes a gradual reduction in the value of the credit, as well as a provision that allows it to begin when construction starts.

History

Energy Production Tax Credit

The Energy Policy Act of 1992 [32] established a production tax credit (PTC) under 26 U.S.C. 45 [33], which now applies to wind and other renewable generation. With enactment of the American Recovery and Reinvestment Act (ARRA) in 2009 [34], a qualified wind facility was given the option to elect either a 30% ITC, or an equivalent cash grant (authority for which has since expired) in lieu of the PTC. EIA has generally assumed that wind energy projects prefer the PTC over the ITC, because the PTC typically is more valuable for power plants with high capacity factors and lower capital costs. The PTC is adjusted annually for inflation. As of the end of 2015, the PTC provided 2.3 cents/kilowatthour (kWh) for qualifying electricity production from wind, closed-loop biomass, geothermal, and certain waste energy facilities. The PTC also provided a half-value credit of 1.1 cents per kWh for qualifying electricity production from open-loop biomass, incremental hydroelectric, marine, tidal, and certain other waste energy facilities. Facilities qualified to receive the PTC if they were built within the timeframe specified by the law and its various extensions, and they were able to claim the tax credit on generation sold during their first 10 years of operation.

Energy Investment Tax Credit (26 U.S.C. 48 and 26 U.S.C. 25D)

The Energy Investment Tax Credit is a federal tax credit primarily claimed by solar systems on individually-owned residential systems (Section 25D) and business-owned systems (Section 48) [35, 36]. ARRA expanded the scope of the business credit, giving renewable electricity technologies otherwise eligible to receive the PTC the option to take the ITC instead. The ITC, based on a percentage of the amount invested in an eligible property, reduces the income tax paid by the person or company claiming the credit.

Originally established in the 1970s as a business tax credit for 10% of investment costs, the Energy Policy Act of 2005 (EPACT2005) [37] increased the value of the ITC to 30% and established a 30% tax credit for residential owners as well. Subsequently, the Energy Improvement and Extension Act of 2008 (EIEA2008) [38] extended the expiration date for projects entering service to the end of 2016, reverting to a permanent 10% credit for eligible commercial facilities entering service in 2017 and later, and ending the residential credit. EIEA2008 also extended the credit to 2017 for small wind energy systems and geothermal heat pumps, and the credits were further enhanced by the 2009 ARRA, which removed the maximum credit amount for all eligible technologies (except fuel cells) placed in service after 2008.

PTC and ITC provisions in the 2016 Consolidated Appropriation Act

The 2016 Consolidated Appropriation Act passed in December 2015 retroactively extended the PTC to the end of 2015. For wind projects, the tax credit retains its full value of 2.3 cents/kWh through 2016 and starts to phase out beginning in January 2017. Wind projects under construction after 2016 but before the end of 2017 are eligible to receive a credit equal to 80% of the current PTC value; those under construction in 2018 will receive a credit equal to 60% of the current value; and those under construction before the end of 2019 will receive a credit equal to 40% of the current value. The credits can be claimed during the first 10 years of a plant's operation. For other eligible technologies—including open- and closed-loop biomass, geothermal, certain waste energy facilities, incremental hydroelectric, marine, and tidal—the PTC was extended for two years, until January 1, 2017, with no reduction in value. Technologies eligible for the PTC still will have the option to claim the ITC in lieu of the PTC, but the subsidy will be subjected to the same value phaseout as the PTC.

Before December 2015, the value of the ITC was scheduled to drop from 30% to 10% of capital costs at the end of 2016. The 2016 Consolidated Appropriation Act enacted that month delayed the credit reduction, introduced a gradual phaseout of the credit, and changed the eligibility criteria. Qualifying projects now can claim the ITC for the year construction starts, as opposed to the year the project begins operation. For solar technology to be eligible, it must generate electricity or heat, or cool a structure. Passive solar building design and solar pool-heating systems are not eligible, but solar hot water heaters do qualify. Solar projects under construction before the end of 2019 will qualify for the full 30% ITC, and those starting construction in 2020 and 2021 will qualify for credits of 26% and 22%, respectively. Commercial projects under construction after 2021 will receive a credit equivalent to 10% of capital costs. Residential projects started in 2021 and finished by 2024 will receive a credit of 10%, but new residential projects constructed after 2022 will not receive a credit. Although the recent federal budget reconciliation bill extended residential and commercial tax credits for solar technologies, credits for technologies such as distributed wind and ground-source heat pumps were not extended.

The AEO2016 Reference case incorporates the gradual reduction in PTC value for wind and the extended expiration dates for all PTC-eligible biomass, geothermal, municipal solid waste, conventional hydroelectric, and onshore and offshore wind technologies. The ITC extension, phaseout, and change in qualifying criteria also are included in the AEO2016 Reference case for solar photovoltaic and solar thermal technologies. AEO2016 further reflects the extended tax credits for both residential and commercial buildings (Table LR3-1).

LR4. Recent federal energy efficiency standards for appliances and other end-use equipment

The Energy Policy and Conservation Act of 1975 [*39*] gave the U.S. Department of Energy (DOE) authority to develop, revise, and implement minimum energy conservation standards for appliances and equipment. The National Appliance Energy Conservation Act of 1987 [*40*] first established minimum efficiency standards for 13 consumer products. Since 1988, DOE has issued many energy efficiency standards for residential and commercial appliances. DOE's Buildings Technologies Office currently sets minimum energy conservation standards for more than 60 categories of appliances and equipment. For most products, Congress has passed laws that set initial federal energy efficiency standards and test procedures and has established schedules for DOE to review and update the standards and test procedures (Table LR4-1) [*41*]. Based on the laws, DOE maintains a rulemaking schedule and provides reports on its rulemakings to Congress every six months.

A key component of the AEO2016 residential and commercial sector projections is the inclusion of federal equipment efficiency standards. The AEO2016 Reference case includes only promulgated standards and comprehensive consensus agreements; the Extended Policies case includes optional updates and future standards. When DOE promulgates a new or updated efficiency standard, AEO assumptions are adjusted to include only compliant equipment choices after the new standards have taken effect.

Some individual states have mandated their own efficiency standards for certain appliances not covered by federal efficiency standards. The state standards are not explicitly represented in the AEO projections. If several states have adopted standards for a product, manufacturers often negotiate with the states and with efficiency advocates to develop recommendations for national standards, which in most cases would preempt state standards.

The passage of the Energy Independence and Security Act of 2007 (EISA) in December 2007 [*42*] provided additional minimum efficiency standards for various types of residential equipment. The EISA standards include: reductions of nearly 30% in the wattage of general service lighting in 2012–14 and about 65% by 2020; boiler standards in 2012; wattage reductions for external power supplies after 2008; and standards for clothes washers, dishwashers, and dehumidifiers to be implemented between 2010 and 2012. Determination of an updated federal residential furnace standard is still in progress. Stakeholder input halted implementation of an earlier regional standard that was issued in 2011 and slated to go into effect in 2015.

The Energy Policy and Conservation Act requires that, if the commercial equipment efficiency standards of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) are amended, DOE must establish either standards at ASHRAE levels or more stringent standards if the additional energy savings are cost-effective. Recently, ASHRAE amended standards for commercial central air conditioners, heat pumps, and furnaces. As a result, DOE set new standards that will take effect in 2018

Table LR3-1. Production tax credits and investment tax credits included in the AEO2016 Reference case, 2015–23

Year	Wind PTC	Other PTC-eligible technologies	Commercial solar ITC	Residential solar ITC
2015	100%	100%	30%	30%
2016	100%	100%	30%	30%
2017	80%	--	30%	30%
2018	60%	--	30%	30%
2019	40%	--	30%	30%
2020	--	--	26%	26%
2021	--	--	22%	22%
2022	--	--	10%	0%
2023 and after	--	--	10%	0%

Note: For commercial solar projects under construction before January 1, 2022, but not placed in service before January 1, 2024, the tax credit will be 10%.

and 2023. Other recently promulgated standards incorporated in the AEO2016 Reference case include standards for commercial vending machines, ice makers, and oil-fired water heaters.

LR5. California Zero-Emission Vehicle regulations for model years 2018 and beyond

On July 10, 2014, the California Air Resource Board (CARB) issued a new rule for its Zero Emission Vehicle (ZEV) program for MY 2018 and later [*43*]. The ZEV program is part of California's Advanced Clean Cars Program, which also includes control of criteria emissions (including greenhouse gas emissions (GHG)). California is the only state that has the right to enact its own emissions standards for new engines and vehicles, and its standards often are more stringent than those established by the U.S. Environmental Protection Agency (EPA). Clean Air Act (CAA) Section 177 allows other states to adopt either the federal standards or the California standards. To date, nine other states have fully adopted the CARB Advanced Clean Cars program standards. CARB was involved in developing the latest corporate average fuel economy (CAFE) standards for light-duty vehicles (LDV), jointly issued by EPA and the U.S. National Highway Traffic Safety Administration (NHTSA), which set national fuel economy and GHG standards for model year (MY) 2017 and later. In addition, CARB issued the state-based ZEV program to address its California-specific smog and emissions concerns.

The latest amendment to the ZEV program, which affects MY 2018 and later, requires a certain percentage of an automaker's sales to be made up of ZEVs and Transitional Zero-Emission Vehicles (TZEVs). Advanced Technology Partial Zero-Emission Vehicles (ATPZEVs) and conventional Partial Zero-Emission Vehicles (PZEVs) can make up a small part of the required percentage. ZEVs are battery electric and hydrogen fuel cell vehicles; TZEVs are plug-in hybrid electric vehicles and hydrogen internal combustion vehicles; ATPZEVs are hybrid, compressed natural gas, and methanol fuel cell vehicles with near-zero emissions and extended emissions system warranties; PZEVs are extremely clean conventional vehicles with extended emissions system warranties.

The ZEV sales requirement is administered through credits, with the required allowable credits calculated as a percentage of an automaker's conventional gasoline and diesel LDV sales, averaged over the previous three model years. The ZEV sales requirement for large manufacturers is 4.5% starting in MY 2018 and increasing by 2.5 percentage points each MY through 2025, to a total of 22.0%. Large manufacturers must produce credits from ZEVs and TZEVs with increasing sales volumes through 2025 (Figure LR5-1). There are limits on the number of credits that can be claimed for TZEVs, and ZEVs are expected to account for a minimum of 16% of the required credits in MY 2025.

Table LR4-1. Effective dates of initial and current appliance efficiency standards for selected equipment

Appliance type	2011 and earlier	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Central air conditioners	Initial				Current								
Clothes dryers	Initial				Current								
Clothes washers	Initial				Current								
Dishwashers	Initial		Current					Current					
Furnaces	Initial / Current												
Water heaters	Initial				Current								
Boilers	Initial	Current									Current		
Boilers	Initial	Current											
Central air conditioners (rooftop)	Initial							Current					Current
Heat pumps	Initial							Current					Current
Gas and oil furnaces	Initial												Current
Incandescent reflector lamps	Initial	Current											
Fluorescent lamp ballasts	Initial			Current									
General service fluorescent lamps	Initial	Current						Current					
General service incandescent lamps	Initial			Current									

The number of credits assigned to a vehicle varies according to its zero-emission range, with more credits allotted to vehicles with higher ranges. To receive credits, ZEV vehicles must have a minimum driving range of 50 miles, determined in accordance with California Exhaust Emission Standards and Test Procedures [*44*]. The ZEV credit is calculated as:

$$\text{ZEV credit} = (0.01) \times (\text{ZEV range}) + 0.50.$$

Credits are administered for TZEV vehicles that have a zero-emission range of 10 miles or more, as calculated by the same procedure. An amendment in May 30, 2014, incorporated an equivalent all-electric range (EAER) for better comparisons with ZEVs, which generate the TZEV credit equation. TZEVs with a range of 80 miles or more have a credit cap of 1.10. The TZEV credit is calculated as follows:

$$\text{TZEV credit } (10 \text{ mi} \leq \text{ZEV range} < 80 \text{ mi}) = (0.01) * \text{EAER} + 0.30.$$

Credits for PZEVs and ATPZEVs may not account for more than one-quarter of a large manufacturer's allowed TZEV credit limit. PZEVs earn 0.2 credits each. ATPZEVs earn the same 0.2 credits, with the addition of credits for advanced components and low-emission fuels, which typically result in totals of 0.6 credits to 0.7 credits, depending on the vehicle. Manufacturers also can receive small amounts of credits for low-speed neighborhood electric vehicles and for vehicles used for advanced technology demonstration programs and transportation systems.

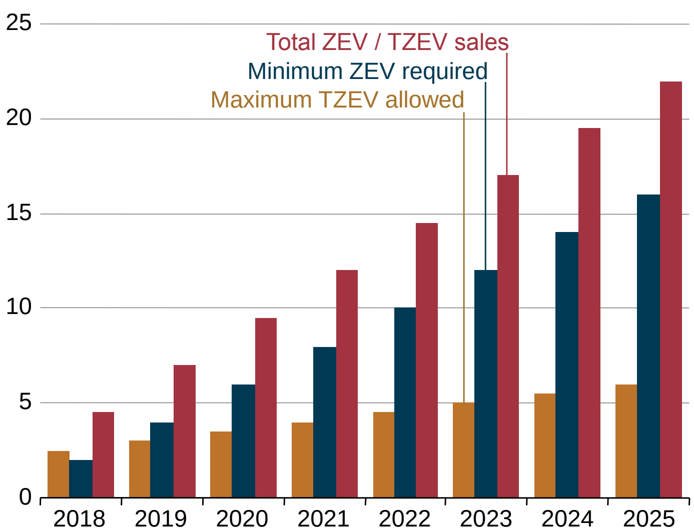
Credits are tradable and transferable with limitations, allowing manufacturers to meet their credit requirements when their vehicle sales do not meet the required minimums. Manufacturers that comply fully with the 10 Section 177 state requirements may trade and transfer credits from western states to eastern states with no penalty, and from eastern states to western states with a 30% penalty. However, credits can never be traded or transferred to or from California. Excess credits earned in MY 2012 and later also can be banked for future MYs, and can be used retroactively for the previous MY. The credit system provides greater flexibility for manufacturers to reach compliance.

Requirements are reduced for intermediate-volume manufacturers, who must meet the same total credit requirements but who are allowed to do so entirely with TZEVs. Small-volume manufacturers are not required to meet the credit percentage requirements, but they may participate in credit earning, marketing, trading, and banking.

If a manufacturer's sales increase or drop sufficiently over a sustained period of time, its size classification will change. If a manufacturer's average MY sales in California over a three-year period for three consecutive running averages crosses the sales threshold, it will be reclassified to the new manufacturer size for the next MY. The threshold between small and intermediate volume is 4,500 averaged sales per MY, and the threshold between intermediate and large volume is 20,000 averaged sales per MY. For example, if an intermediate-volume manufacturer exceeded 20,000 sales on average (more than 60,000 total sales over a three-MY period) for MY 2018–20, 2019–21, and 2020–22, that manufacturer would be reclassified as a large-volume manufacturer starting in MY 2023.

The AEO2016 Reference case includes the latest ZEV regulation for MY 2018 and later, with implementation applied to California and the other nine complying states. Projected sales of passenger cars, light-duty trucks, and combined LDVs, along with other alternative-vehicle sales, including ZEVs and TZEVs, reflect the impacts of the California Zero-Emission Vehicle regulations on a U.S. Census-division basis for model years 2018 and beyond, including their impacts on fuel demand and new LDV fuel economy.

Figure LR5-1. ZEV credit percentage requirements, model years 2018–25 (percent of average manufacturer conventional vehicle sales)



LR6. State RPS programs

To the extent possible, AEO2016 reflects state laws and regulations in effect at the end of December 2015 that mandate levels of renewable generation or capacity for utilities doing business in the state. These mandates are known as renewable portfolio standards (RPS) requirements. The AEO2016 projections do not include laws and regulations with either voluntary goals or targets that can be substantially satisfied with nonrenewable resources. In addition, the projections do not account for fuel-specific provisions—such as those for solar and offshore wind energy—as distinct targets. Where applicable, such distinct targets (sometimes referred to as tiers, set-asides, or carveouts) are subsumed into the broader targets, or they may not be included in the model because they are related to nonutility-scale generation.

The AEO2016 Reference case assumes that states will meet their ultimate RPS targets, but not necessarily targets for interim years. RPS compliance constraints in most regions are approximated, however, because NEMS is not a state-level model, and each state generally represents only a portion of one of the NEMS electricity regions. In general, EIA has confirmed requirements for each state through original legislative or regulatory documentation, and using the Database of State Incentives for Renewables & Efficiency (DSIRE) to support those efforts [*45*].

At present, most states are meeting or exceeding their required levels of renewable generation, based on qualified generation or purchase of renewable energy credits [*46*]. A number of factors helped create an environment favorable for RPS compliance, including:

- A surge of new RPS-qualified generation capacity timed to take advantage of federal incentives, some of which were set to decline or expire at the end of 2015 or 2016 but have since been extended
- Continued reductions in the cost of wind, solar, and other renewable technologies
- EPA's recently finalized mandatory carbon dioxide reduction program (the Clean Power Plan) [*47*]
- Complementary state and local policies that either reduce costs (for example, equipment rebates) or increase revenue streams (for example, net metering) associated with RPS-eligible technologies

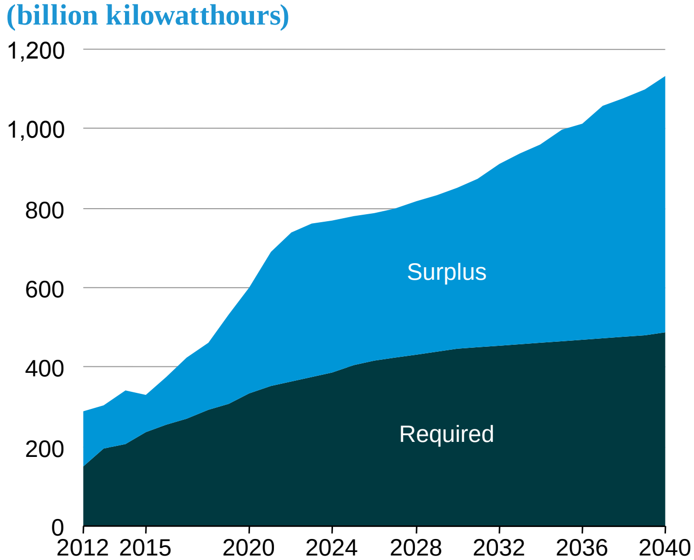
The aggregate RPS requirement for various mandatory state programs, as modeled for AEO2016, is shown in Figure LR6-1, along with total projected renewable generation. In 2025, the targets account for 40% of renewable generation and about 10% of U.S. electricity sales. However, the aggregate targets and qualifying generation shown in Figure LR6-1 may mask significant regional variation, as well as technology-specific or tier-specific shortfalls. Although some regions may produce excess qualifying generation, others may produce just enough to meet the requirement or may need to import electricity from adjoining regions to meet state targets.

One factor that could cause states to miss their RPS goals is slow or no growth in electricity demand. Reduced need for new generation would have the most significant effects on sources that are on the margin. To date, slowing demand has not been a problem, but the situation could change if demand is stagnant for an extended period of time. Implementation of EPA's CPP rule may mitigate the effects of slow demand growth on reaching RPS goals to the extent that it results in retirement of more existing coal-fired generation capacity.

Further, although there is now more qualifying generation in aggregate than needed to meet the targets, states with technology-specific goals could still have shortages of certain technologies. Also, the projected pattern of aggregate surplus does not necessarily imply that projected generation would be the same without state RPS policies, which may encourage investment in places where it would not occur otherwise or would not occur in the amounts projected, even as other parts of the country see substantial growth above state targets or the absence of targets. The results do, however, suggest that state RPS programs will not be the sole motivation for future growth in renewable generation.

Currently, 29 states and the District of Columbia have enforceable RPS or similar laws (Table LR6-1) [*48*]. Under such standards, each state determines its own levels of renewable generation, eligible technologies [*49*], and noncompliance penalties. Only one new RPS program has been enacted since 2009, but there have been a number of modifications to existing programs in recent years, building on state implementation experience and changing market conditions.

Figure LR6-1. Total qualifying renewable generation required for combined state renewable portfolio standards and projected total achieved, 2012–40 (billion kilowatthours)



In 2014 and 2015, a large number of proposed legislative modifications were made to existing RPS programs [*50*, *51*]—including some attempts to weaken the targets of existing programs significantly—but only a small subset were enacted. One state froze progress toward its RPS, and another state repealed its mandate. Other states increased their targets. States making major changes to their RPS programs are discussed below.

California

By raising its 2030 commitment for total renewable generation from 33% to 50% (an estimated increase of more than 40 billion kWh), California made the largest absolute increase in its RPS generation requirement in 2015. Renewable resources provided 29% of California's total generation and 22% of its retail sales in 2014. Senate Bill 350 (SB350) [*52*], the legislation enacting the 50% mandate, specifies that 25% of retail sales in 2016 must come from qualified renewable generation. Other interim targets are 33% by 2020, 40% by 2024, and 45% by 2027. Solar photovoltaic (PV) technology has dominated recent capacity additions, and additions of wind capacity continue to provide more generation.

Table LR6-1. Renewable portfolio standards in the 29 states and District of Columbia with current mandates

State	Renewable target for total electricity sales	Qualifying renewables	Qualifying other (thermal, efficiency, nonrenewable, distributed generation, etc.)	Compliance mechanisms
AZ	15% by 2025	Solar, wind, biomass, hydro, landfill gas (LFG), anaerobic digestion built after January 1, 1997	Direct use of solar heat, ground-source heat pumps, renewable-fueled combined heat and power (CHP), and fuel cells using renewable fuels	Credit trading is allowed, with some bundling restrictions. Includes distributed generation requirement, starting at 5% of target in 2007, growing to 30% by 2012 and beyond.
CA	50% by 2030	Geothermal electric, solar thermal electric, solar photovoltaics, wind (all), biomass, municipal solid waste (MSW), landfill gas (LFG), tidal, wave, ocean thermal, wind (small), hydroelectric (small), and anaerobic digestion	Energy storage, fuel cells using renewable energy	Credit trading is allowed, with some restrictions. Renewable energy credit prices capped at $50 per MWh.
CO	30% by 2020 for investor-owned utilities; 20% by 2020 for large electric cooperatives; 10% by 2020 for other cooperatives and municipal utilities serving more than 40,000 customers	Solar, wind, biomass, hydro, biomass, geothermal	Recycled energy, coal-mine methane, pyrolysis gas produced from MSW, and fuel cells	Credit trading is allowed. Renewable distributed generation requirement applies to investor-owned utilities (3% of sales by 2020) and electric cooperatives (0.75% or 1% of sales by 2020, depending on size). Generation associated with certain projects that have specific ownership or transmission ties with small utilities, entities, or individuals is eligible to earn credit multipliers.
CT	27% by 2020 (23% renewables, 4% efficiency and CHP)	Solar, wind, biomass, hydro (with exceptions), geothermal, LFG/MSW, anaerobic digestion, and marine	CHP, fuel cells	Credit trading is allowed. Obligated providers may comply via an alternative compliance payment of $55 per MWh. The target is made up of three class tiers, with tier-specific targets.
DE	25% by 2026	Solar, wind, biomass, hydro, geothermal, LFG, anaerobic digestion, and marine	Fuel cells	Credit trading is allowed. Credit multipliers are awarded for several compliance specifications, including a 300% credit awarded for generation from in-state distributed solar and renewable-fueled fuel cells. Target increases for some suppliers can be subject to a cost threshold.
DC	20% by 2020	Solar, wind, biomass, hydro, geothermal, LFG/ MSW, and marine	Direct use of solar, cofiring	Credit trading is allowed. The target includes a solar-specific set-aside, equivalent to 2.5% of sales by 2023. Obligated providers may also comply via a tier-specific alternative compliance payment.
HI	100% by 2045	Geothermal electric, solar thermal electric, solar photovoltaics, wind (all), biomass, hydroelectric, hydrogen, geothermal heat pumps, MSW, combined heat and power, LFG, tidal, wave, ocean thermal, wind (small), anaerobic digestion, and fuel cells using renewable fuels	Solar water heat, solar space heat, and solar thermal process heat	Credits cannot be traded. Eligibility of several of the qualifying other displacement technologies is restricted after 2015. Utility companies can calculate compliance over all utility affiliates.

(continued on page LR-13)

Table LR6-1. Renewable portfolio standards in the 29 states and District of Columbia with current mandates *(cont.)*

State	Renewable target for total electricity sales	Qualifying renewables	Qualifying other (thermal, efficiency, nonrenewable, distributed generation, etc.)	Compliance mechanisms
IL	25% by 2026	Solar, wind, biomass, hydro, anaerobic digestion, and biodiesel	None	Credit trading is allowed. Target includes specific requirements for wind, solar, and distributed generation. The procurement process is subject to a cost cap.
IA	105 MW of eligible renewable resources	Solar, wind, some types of biomass and waste, small hydro	None	Iowa's investor-owned utilities are currently in full compliance with this standard, achieved primarily through wind capacity.
KS	20% of each peak demand capacity by 2020	Solar, wind, hydro, biomass, LFG	Direct use of solar heat, fuel cells	Credit trading is allowed. Eligible in-state capacity counts for 1.1 times its actual capacity.
ME	40% total by 2017, 10% by 2017 from new resources entering service in 2005 and beyond	Solar, wind, biomass, hydro, geothermal, LFG/MSW, and marine	CHP, fuel cells	Credit trading is allowed. The Maine Public Utilities Commission sets an annually adjusted alternative compliance payment. Community-based generation projects are eligible to earn credit multipliers.
MD	20% by 2022	Solar, wind, biomass, geothermal, LFG/MSW, anaerobic digestion, and marine	Solar water heating, ground-source heat pumps, and fuel cells	Credit trading is allowed. The target includes minimum levels of compliance from solar and offshore wind. Utilities may pay an alternative compliance payment in lieu of procuring eligible sources, with a tier-specific compliance schedule.
MA	22.1% by 2020 (and an additional 1% per year thereafter)	Solar, wind, hydro, some biomass technologies, LFG/MSW, geothermal electric, anaerobic digestion, and marine	Fuel cells	Credit trading is allowed. The target for new resources includes a solar-specific goal to achieve 400 MW of in-state solar capacity, which is translated into an annual target for obligated providers. Obligated providers may comply via an alternative compliance payment (ACP), which varies in level by the requirement class. The ACP is designed to be higher than the cost of other compliance options.
MI	10% by 2015, with specific new capacity goals for utilities that serve more than 1 million customers	Solar, wind, hydro, biomass, LFG/MSW, geothermal electric, anaerobic digestion, and marine	CHP, coal with carbon capture and sequestration, and energy efficiency measures for up to 10% of a utility's sales obligation	Credit trading is allowed. Solar power receives a credit multiplier; other generation and equipment features—such as peak generation, storage, and use of equipment manufactured in-state—can earn bonus credits.
MN	31.5% by 2020 (Xcel), 26.5% by 2025(other investor-owned utilities), or 25% by 2025 (other utilities)	Solar, wind, hydro, biomass, LFG/MSW, and anaerobic digestion	Cofiring, hydrogen	Credit trading is allowed. Target includes 1.5% solar standard for investor-owned utilities; Xcel's target also includes 25% of sales specifically from wind and solar (with a 1% maximum for solar). State regulators can penalize noncompliance at the estimated cost of compliance.
MO	15% by 2021	Solar, wind, hydro, biomass, LFG/MSW, anaerobic digestion, and ethanol	Fuel cells	Credit trading is allowed. Noncompliance payments are set at double the market rate for renewable.
MT	15% by 2015	Solar, wind, hydro, geothermal, biomass, and LFG	Compressed air energy storage	Credit trading is allowed, with a price cap of $10 per MWh. There are specific targets for community-based projects.

(continued on page LR-14)

Table LR6-1. Renewable portfolio standards in the 29 states and District of Columbia with current mandates *(cont.)*

State	Renewable target for total electricity sales	Qualifying renewables	Qualifying other (thermal, efficiency, nonrenewable, distributed generation, etc.)	Compliance mechanisms
NV	25% by 2025	Solar, wind, hydro, geothermal, biomass, and LFG/MSW	Waste tires, direct use of solar and geothermal heat, efficiency measures (which can account for one-quarter of the target in any given year)	Credit trading is allowed. Solar PV receives a credit premium, with an additional premium for customer-sited systems.
NH	24.8% by 2025	Solar, wind, small hydro, marine, and LFG	Fuel cells, CHP, microturbines, direct use of solar heat, ground-source heat pumps	Credit trading is allowed, and utilities may pay into a fund in lieu of holding credits. The target has four separate compliance classes, by technology type.
NJ	20.38% by 2021 with an additional 4.1% solar by 2027	Solar, wind, hydro, geothermal, LFG/MSW, and marine	None	Credit trading is allowed, with an alternative compliance payment set by state regulators. Solar and offshore wind are subject to separate requirements and have separate enforcement provisions.
NM	20% by 2020 for investor-owned utilities, 10% by 2020 for cooperatives	Solar, wind, hydro, geothermal, and LFG	Zero-emission technology, not including nuclear	Credit trading is allowed. The program cannot increase consumer costs beyond a threshold amount, increasing to 3% of annual costs by 2015. Technology minimums are established for wind, solar, and certain other resources.
NY	29% by 2015[a]	Solar, wind, hydro, geothermal, biomass, LFG, anaerobic digestion, certain biofuels, and marine	Direct use of solar heat, CHP, and fuel cells	Credit trading is not allowed. Compliance is achieved through purchases by state authorities, funded by a surcharge on investor-owned utilities. Government-owned utilities may have their own, similar programs.
NC	12.5% by 2021 for investor-owned utilities, 10% by 2018 for municipal and cooperative utilities	Solar, wind, small hydro, biomass, geothermal, LFG, and marine	Direct use of solar heat, CHP, hydrogen, and demand reduction	Credit trading is allowed. Impacts on customer costs are capped at specified levels. There are specific targets for solar and certain animal waste projects.
OH	12.5% renewable energy resources by 2026, 12.5% advanced energy resources by 2026	Solar, wind, hydro, biomass, geothermal, and LFG/MSW	Energy storage, fuel cells, and a separate 12.5% target for advanced energy technologies, including coal mine methane, advanced nuclear, and efficiency; microturbines	Credit trading is allowed. Alternative compliance payments are set by law and adjusted annually. There is a separate target for solar electricity generation.
OR	5% by 2025 for utilities with less than 1.5% of total sales; 10% by 2025 for utilities with less than 3% of total sales; 25% by 2025 for all others	Solar, wind, hydro, biomass, geothermal, LFG/MSW, anaerobic digestion, and marine	Hydrogen	Credit trading is allowed, with an alternative compliance payment and a limit on expenditures of 4% of annual revenue. Solar receives a credit multiplier.
PA	18% by 2020	Solar, wind, hydro, biomass, geothermal, and LFG/MSW	CHP, certain advanced coal technologies, certain energy efficiency technologies, fuel cells, direct use of solar heat, ground-source heat pumps	Credit trading is allowed, with an alternative compliance payment. Separate targets are set for solar and two different combinations of renewable, fossil, and efficiency technologies.

[a]On November 2, 2015, the Governor of New York directed the Public Service Department to develop rules for a new renewable portfolio standard requiring of 50% renewable generation by 2030. The new standard is expected to be available by July 2016 and was not available for inclusion in AEO2016.

(continued on page LR-15)

Table LR6-1. Renewable portfolio standards in the 29 states and District of Columbia with current mandates *(cont.)*

State	Renewable target for total electricity sales	Qualifying renewables	Qualifying other (thermal, efficiency, nonrenewable, distributed generation, etc.)	Compliance mechanisms
RI	16% by 2019	Solar, wind, hydro, biomass, geothermal, anaerobic digestion, LFG, biodiesel, and marine	Fuel cells	Credit trading is allowed, with an alternative compliance payment. There is a separate target for 90 MW of new renewable capacity.
TX	5,880 MW by 2018	Solar, wind, hydro, biomass, geothermal, LFG, and marine	Direct use of solar heat, ground-source heat pumps	Credit trading is allowed, with capacity targets converted to generation equivalents. State regulators may cap credit prices. 500 MW must be from resources other than wind.
VT	75% by 2032	Geothermal, solar, wind, biomass, hydro, LFG, marine, anaerobic digestion, and fuel cells using renewable fuels	Ground-source heat pumps, CHP	Generation of electricity from eligible renewable sources with environmental attributes attached, the purchase of RECs from plants whose energy is capable of delivery within New England, or a combination of the two; or alternative compliance payment of $0.01/kWh.
WA	15% by 2020	Solar, wind, hydro, biomass, geothermal, LFG, anaerobic digestion, biodiesel, and marine	CHP	Credit trading is allowed, with an administrative penalty for noncompliance.
WI	10% by 2015	Solar, wind, hydro, biomass, geothermal, LFG/MSW, small hydro, anaerobic digestion, and marine	CHP, pyrolysis, synthetic gas, direct use of solar or biomass heat, ground-source heat pumps, and fuel cells	Credit trading is allowed.

Hawaii

Hawaii became the first state to establish a 100% RPS. Hawaii House Bill 623 (HB623) [*53*] mandates that Hawaii's three major electrical utilities achieve 100% of sales from renewable generation by 2045. The law also specifies interim goals: 15% by 2015, 30% by 2020, 40% by 2030, and 70% by 2040. Currently, petroleum provides 68% of Hawaii's electricity (73% of retail electricity sales). In 2014, renewable electricity accounted for 12.7% of total generation from the state's three utilities, or 14.1% of sales. However, 12% of Hawaiian houses have rooftop PV installations, and distributed generation provided an additional 5.2% of 2014 utility-scale generation, displacing 5.6% of sales. Hawaii has severely restricted new rooftop installations because of the potential impacts of high levels of distributed generation on local distribution grids.

Kansas

Kansas converted its binding 2009 RPS into a nonmandatory goal in 2015, with the passage of Senate Bill 91 (SB91) [*54*]. Kansas had approved House Bill 2369 (HB2369) in 2009 [*55*], requiring the state's investor-owned utilities and electric cooperatives to generate or purchase at least 20% of their peak demand from renewable resources for each calendar year beginning in 2020.

Wind supplied about 22% of Kansas' net electricity generation in 2014. SB91 also provides new renewable energy facilities with a 10-year property tax exemption (assuming the facilities are not located behind the customer's utility meter) and making it easier for utilities to recover costs associated with meeting the previous mandate.

Ohio

Ohio decided in June 2014 to freeze for two years the progress toward its RPS 2024 mandate of 12.5%. Senate Bill 310 (SB310) [*56*] also includes renewable electricity imported from other states in its RPS determination. Current targets are for 12.5% by 2026. In-state renewables provide Ohio with less than 2% of its electricity sales.

Vermont

On June 11, 2015, Vermont passed House Bill 40 (HB40) [*57*], creating a requirement that 75% of retail electricity sales come from qualifying renewable generation by 2032. In doing so, it became the first state to establish a new mandatory RPS since 2009. Previously, Vermont had a nonmandatory goal of 20% by 2017. HB40 established an interim target of 55% by 2017.

With the closure of the Vermont Yankee nuclear generating station in 2014, more than 90% of Vermont's 2015 in-state generation is expected to be renewable. However, the state now imports about half of its 5.6 billion kWh in total sales. Vermont is a major port-of-entry for hydroelectric and other generation from Canada, with gross imports of nearly 11 billion kWh in 2014. Currently, much of that generation is passed through Vermont to other states.

West Virginia

In February 2015, West Virginia's House Bill 2001 (HB2001) [*58*] repealed the Advanced Energy Standard, eliminating the requirement that West Virginia obtain 25% of its electricity from renewable or other advanced energy sources, such as high-efficiency fossil generators. However, the state's House Bill 2201 retains net metering for distributed solar projects. Previously, EIA did not model the Advanced Energy Standard, because the standard could be met substantively with nonrenewable generation; therefore, its repeal is not incorporated in AEO2016.

LR7. State energy efficiency resource standards and goals through January 2016

In January 2016, 32 states had current or pending efficiency targets, including 22 states that would require utilities (electric, natural gas, or both) or third-party administrators to meet energy reduction targets over time. Efficiency policies for utilities complement efficiency gained from structural changes, federal appliance standards, and enhanced building codes. The extent of changes in demand varies by region and by sector. This section describes policies in states with electricity savings targets that were in effect at the end of January 2016 [*59*]. An energy efficiency resource standard (EERS), or energy efficiency portfolio standard (EEPS), is mandatory, sets long-term reduction targets (at least three years), is sufficiently funded to allow covered entities to meet their targets, uses financial incentives or nonperformance penalties, and usually (but not always) increases over time [*60*]. Both state legislatures and public utility commissions (PUC) have created energy efficiency (EE) policies. Savings targets may be set as reductions from a single base year or from an average of prior years; as a cumulative reduction over a compliance period; or as a percentage of projected electricity sales.

In AEO2016, EIA has explicitly incorporated rebates or incentives offered by utilities to residential and commercial customers to encourage the purchase of more-efficient equipment, which helps meet the goals of the CPP [*61*]. AEO2016 is the first time the projection has included incentives by technology and sector at a Census division level. AEO2016 also incorporates related efficiency policies, such as federal equipment standards and adoption of residential and commercial building codes, which reduce demand for energy.

The jurisdictional utilities covered by EERS vary by state. Some states cover only investor-owned utilities (IOUs). Other states use tiered savings targets by utility size, or between IOUs and publicly owned utilities (POUs). Table LR7-1 compares the targets and characteristics of states with statewide EE policies as of January 2016. States with large nonjurisdictional POUs often encourage them to set similar standards [*62*]. In 7 states the EERS apply to electricity savings only; 15 states set EERS targets for both electric and natural gas utilities [*63*]. Those differences account for variations in the percentage of retail sales covered by the different state EERS (Table LR7-1).

Texas established the first EERS in 1997 as part of its electricity restructuring. There was a great deal of activity between 2004 and 2010, and by 2010, 24 states had adopted mandatory EE targets or goals for utilities. Between 2005 and 2008, California and four New England states (Vermont, Rhode Island, Connecticut, and Massachusetts) began to adopt all cost-effective energy efficiency policies [*64*]. If states with such efficiency policies also fund mandatory, multi-year programs sufficiently, they are included as states with EERS. Some states—including Vermont and Oregon—later changed EE goals to long-term requirements.

No states added EE goals or mandates between 2010 and 2014. Moreover, the direction of adoption shifted in 2013, perhaps because of the recession or to strengthen renewable policies, rather than efficiency policies [*65*]. New Mexico lowered its final target in 2013, and Nevada began to phase EE out of its RPS. In 2014 and 2015, 4 states acted to slow or stop compliance with an EERS [*66*], and 11 states enhanced existing EERS, either by extending their time horizons or increasing savings targets. Two states opened regulatory proceedings either to adopt EERS or to promulgate EERS regulations, and one state started a pilot EE program [*67*]. As of January 2016, 22 states had adopted EERS. Six states without EERS have savings targets, including nonbinding efficiency goals, efficiency as a compliance mechanism in an RPS, or EE pilots [*68*] (Figure LR7-1).

Since the beginning of 2014, 18 states have made changes to their EERS or efficiency goals, including 14 states that have increased existing savings targets, extended the end years for energy reductions, or established regulations for an EEPS. In addition, four states eliminated, froze, or defunded existing targets. Key changes since January 2014 are summarized below.

Arkansas

In December 2015, the Arkansas Public Service Commission extended a 0.9% EERS savings target from the 2015–16 to the 2017–18 program-year, and it raised targets to 1% of 2015 sales in 2019 [*69*]. The General Assembly passed Act 78 in 2015, which limits the extent to which large customers can opt-out of EERS targets [*70*].

California

California has an all cost-effective energy efficiency requirement [*71*]. In October 2014, the PUC updated EERS funding and established 2015 portfolios [*72*]. In September 2015, the legislature enacted Senate Bill 15-350 [*73*], which requires establishing annual targets for statewide energy efficiency savings to achieve a cumulative doubling of statewide energy efficiency by January 1, 2030, and includes energy efficiency reductions in existing residential and nonresidential buildings.

Table LR7-1. Characteristics of state efficiency mandates or goals as of January 2016

State	Type[a]	Targeted electricity savings (mandates and goals)[b]	Percentage of state sales[c]	Current savings period (from-to)		Reported 2014 savings[d]	
						Megawatthours	Percent
AR	E&G	0.9% annual reduction from 2014 sales	53	2015	2016	249,303	0.53
AZ	E&G	2.5% annual saving; lower for co-ops	59	2016	2020	1,190,123	1.57
CA	E&G	Varies by utility; 16,298 gigawatthours by 2020	78	2012	2020	4,082,256	1.58
CO	E&G	5% of 2006 sales by 2018, rising incrementally	57	2007	2019	472,000	0.88
CT	E&G	1.51% reduction from 2015 base	94	2016	2018	369,686	1.26
DC	E&G	Sustainable Energy Utility has program goals	--[e]	--[e]	--[e]	59,105	0.53
DE	Elec	Proceeding to establish regulations and funding	TBD[f]	TBD	TBD	8,606	0.08
HI	Elec	Approximately 1.4% incremental savings by 2030, from 2009	100	2009	2030	144,240	1.53
IA	E&G	1.2% of sales	75	2014	2018	550,035	1.17
IL	E&G	2% of delivered energy; prior year as base	88	2016	No end	1,513,045	1.08
LA	Elec	Quick Start EE Pilot	76	2015	2016	48,226	0.05
MA	E&G	2.93% of forecasted 2016–2018 sales	86	2016	2018	1,351,105	2.48
MD	Elec	2% of sales by 2020 in 0.2% annual increments	99	2015	2017	817,906	1.33
ME	E&G	Approximately 1.6% of electric sales by 2016; 30% by 2020	100	2014	2016	161,571	1.36
MI	E&G	Approximately 1.0% of prior-year's sales	100	2012	No end	1,386,912	1.35
MN	E&G	1.5% of prior 3-years' weather-normalized average	100	2010	No end	824,756	1.22
MO	Elec	9.9% cumulative annual savings by 2020	70	2016	2018	431,218	0.52
MS	Elec	Quick Start EE program	74	2014	2016	75,815	0.15
NC	Elec	5% of 2021 sales from 2008 base; EE is an eligible RPS resource	100	2009	2021	854,582	0.64
NH	E&G	Docketed proceeding to establish an EERS	TBD	TBD	TBD	63,383	0.58
NM	Elec	Cumulative 8% reduction from 2005 sales	68	2014	2020	123,919	0.54
NV	Elec	Up to 20% of RPS may be met with EE measures	62	2015	2019	194,861	0.57
NY	E&G	Extend funding and 15% reductions under REV[g]	100	2016	TBD	1,421,287	0.96
OH	Elec	1% EE target frozen, 2015–16	89	2015	2016	1,565,049	1.05
OR	E&G	240 average megawatts over four years[h]	70	2015	2019	595,548	1.27
PA	Elec	Varies by utility; 2.6%–5.0%, average 3.7%	93	2016	2021	1,019,155	0.70
RI	E&G	2.5% relative to 2012 sales	99	2015	2017	268,468	3.51
TX	Elec	30% reduction in demand growth (~0.1%)	73	2013	No end	728,047	0.19
VA	Elec	Goal: 10% by 2022 relative to 2006 sales	100	2007	2022	102,770	1.85
VT	Elec	2.1% of sales; EE utility	100	2015	2017	96,557	1.73
WA	Elec	Varies by utility; approximately 1.2% for IOUs	81	2016	2017	946,565	1.02
WI	E&G	Varies by utility; 0.77% of annual sales	100	2015	2018	527,283	0.76

[a]If an energy efficiency resource standard (EERS) covers electric utilities only, the type is shown as *Elec*. If it covers both electric and natural gas utilities, the type is abbreviated as *E&G*.
[b]Sales reductions refer to reductions in retail sales of electricity. Unless otherwise noted, they are incremental annual reductions, rather than cumulative savings. Base year indicates year (or average of prior years) against which targeted savings are measured.
[c]American Council for an Energy-Efficient Economy, "The 2015 State Energy Efficiency Scorecard, Report U1509" (ACEEE2015), Appendix D, pp. 128–133, http://aceee.org/research-report/u1509. The percentage of affected retail sales in an EERS depends on what entities are covered by an EERS; this differs by state. EIA calculated percentages for states not included in ACEEE2015 (LA, MS, MO, VA), using state EE filings and U.S. Energy Information Administration, "2014 Utility Bundled Retail Sales–Total," http://www.eia.gov/electricity/sales_revenue_price/pdf/table10.pdf.
[d]Incremental electricity savings reported to state PUCs for 2014, reported in both MWh and as percent of retail sales. **Sources:** ACEEE2015, p. 18; and Northeast Energy Efficiency Partnerships, *The Regional Roundup of Energy Efficiency Policy: Next Generation Energy Efficiency* (NEEP2016), pp. 31–42, http://www.neep.org/sites/default/files/resources/2016%20Regional%20Roundup-FINAL_1.pdf. NEEP2016 is the source for 2014 program year savings for the six New England states, five Middle Atlantic states (DE, MD, NY, NJ, PA), and the District of Columbia. Those jurisdictions report EE savings, expressed in net annual terms, to NEEP's Regional Energy Efficiency Database (REED).
[e]Not applicable.
[f]TBD: The percentage and the savings period remain *to be determined* within the setting of the regulatory proceeding.
[g]New York extended its earlier EERS goals while its *Reforming the Energy Vision* (REV) proceedings are underway.
[h]Oregon's efficiency targets are expressed in average megawatts (aMW) of electricity and annual therms (MMth) of natural gas saved. Energy Trust of Oregon, "2015–2019 Strategic Plan," page 5, http://energytrust.org/library/plans/2015-2019_Strategic_ Plan0.pdf.

Connecticut

Connecticut has an all cost-effective energy efficiency requirement. In December 2015, the state's Department of Energy & Environmental Protection approved, with conditions, the 2016–18 triennial Conservation and Load Management Plan [*74*]. The plan increased investor-owned electric utility (IOU) targets from 1.4% of electric sales (2013–15) to 1.51%. Connecticut also eliminated EE as a means to fulfill its RPS, which could strengthen EE as a separate resource [*75*].

Delaware

Delaware has an all cost-effective energy efficiency requirement. The PUC had not established EE regulations or funding for an EERS enacted in 2009 [*76*]. In 2014, the legislature directed the state's Sustainable Energy Utility (SEU) to provide utilities with cost-effective EE programs, established an advisory council to help develop financing mechanisms, and directed the Department of Natural Resources to establish energy measurement and verification (EM&V) regulations [*77*]. Utilities committed to submitting plans in 2016 and beginning programs in 2017.

Indiana

In 2014, Indiana suspended its Energizing Indiana EERS, which had targeted a 2% savings by 2019, relative to 2009 sales [*78*]. In 2015, the legislature replaced the EERS with a law that allows voluntary programs and directs utilities to file triennial energy efficiency and demand response plans with the Indiana Utility Regulatory Commission [*79*].

Louisiana

In November 2014, the Louisiana PUC implemented Phase I of its voluntary Energy Efficiency Quick Start program [*80*]. Four IOUs offered programs across all sectors that could be implemented quickly and economically. Because each utility hired the same third-party administrator and evaluator, they offer similar programs and use a standardized reporting software package and EM&V.

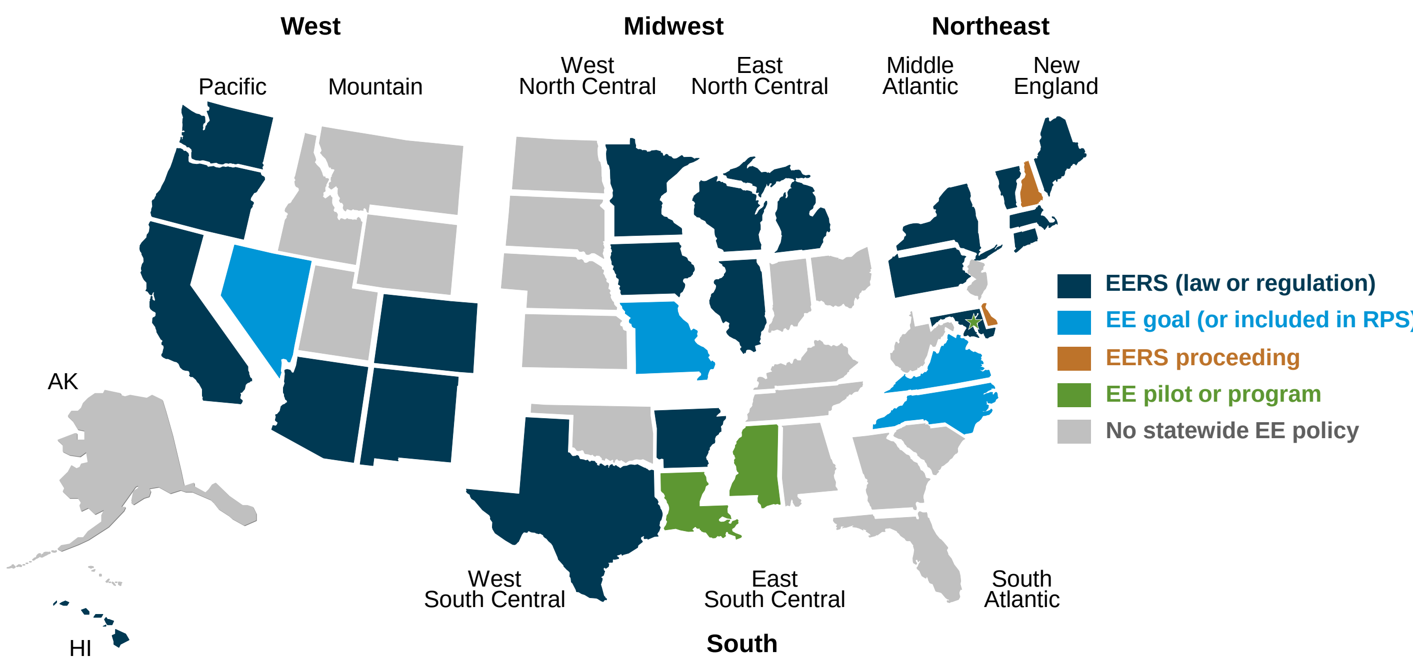
Maryland

In 2015, the Maryland PUC revised its EERS from one based on per capita reductions to savings based on a percentage of retail sales. The new EERS targets a 2% reduction in electricity sales from 2013 weather-normalized gross retail sales by 2020 for five large IOUs, in 0.2% annual increments. The previous EERS, EmPOWER Maryland, had a target of a 15% reduction in electricity use per capita by 2015 [*81*].

Massachusetts

Massachusetts has an all cost-effective energy efficiency requirement. In January 2016, its Department of Public Utilities approved the utilities' 2016–18 plans, developed in conjunction with the state Energy Efficiency Advisory Council [*82*]. The new plans raise energy savings targets for electric utilities from 2.6% in the 2013–15 plan cycle to 2.93% of projected sales. This plan also recognizes the role of demand response for peak load reductions. With the increase, Massachusetts set the highest electricity demand reduction target among all the states with EERS.

Figure LR7-1. States with energy efficiency resources standards (EERS) or energy efficiency (EE) goals that target savings in electricity use as of January 2016



Nevada

In 2013, Nevada's legislature voted to phase out EE requirements from its revised Energy Portfolio Standard. EE reductions can satisfy no more than 20% of compliance in the 2015–19 period, and they will not be an eligible resource after 2024 [*83*]. The Nevada legislature did not pass a bill for a separate EERS introduced in the 2015 legislative session.

New Hampshire

New Hampshire's PUC opened a docket in 2015 to establish an EERS [*84*]. The proceeding seeks input on appropriate goals, financing, cost recovery, incentives and penalties, and measurement and evaluation metrics. The regional energy efficiency organization, Northeast Energy Efficiency Partnership, has provided assistance to the PUC and stakeholders based on its experience with existing regional policies and with EM&V.

New York

In December 2015, the New York Department of Public Service extended energy savings targets under the state's EERS—which requires a 15% reduction below forecasted sales by 2015—and allocated funds from its Clean Energy Fund. New EE targets will be established along with revised cost-benefit tests under the Reforming the Energy Vision (REV) proceeding. The REV proceeding was opened in 2014 to transform the retail electricity market and overhaul the existing RPS and EERS [*85*].

Ohio

In 2014, Ohio froze its RPS and EERS for 2015 and 2016 and changed a number of other requirements for EE savings and peak demand reductions [*86*]. Established in 2008, the EERS had created annual targets leading to cumulative electricity savings of 22% by the end of 2025 compared with 2009 sales.

Pennsylvania

In 2015, Pennsylvania's PUC approved Phase III EERS targets for 2016–21. The targets, which vary by utility, range from 2.6% to 5% relative to the load forecast completed in 2010. The PUC also set utility-specific peak demand reduction requirements for utilities with at least 100,000 customers [*87*].

Rhode Island

Rhode Island has an all cost-effective energy efficiency requirement. The PUC increased the efficiency savings target in the 2015–17 triennial plan to an annual average of 2.5%, from 2.1% in the 2012–14 plan [*88*]. An Executive Order in December 2015 also directed state agencies to reduce energy consumption by at least 10% from fiscal year 2014 levels by 2019, and to establish a stretch (aspirational) energy efficiency building code [*89*].

Vermont

Vermont has an all cost-effective energy efficiency requirement. In 2015, the Vermont Public Service Board approved 2015–17 triennial plans both for Efficiency Vermont and for the City of Burlington Electric Department [*90*]. The plans include annual incremental kilowatthour (kWh) savings as well as summer and winter peak reduction targets. Efficiency Vermont is a statewide energy efficiency utility operated by the Vermont Energy Investment Corporation.

Washington

Washington's "Energy Independence Act," requires utilities with more than 25,000 customers to set biennial targets for all cost-effective, reliable, and feasible conservation [*91*]. In December 2015 and January 2016, the state Utilities and Transportation Commission approved 2016–17 plans for three large IOUs, and the Department of Commerce approved plans for 14 publicly owned utilities.

West Virginia

In 2015, West Virginia repealed its Alternative Renewable Energy Portfolio Act, under which energy efficiency had been eligible to earn credits. The Governor's statement indicated that changing economic factors had made the act no longer beneficial to the state [*92*].

LR8. Impacts on marine fuel choice from enforcement of Emissions Control Areas in North America and U.S. Caribbean Sea waters under the International Convention for the Prevention of Pollution from Ships (MARPOL)

Around the world, legislation and regulations mandating decreased emissions and lower levels of airborne pollutants have been put into place [*93*]. The implementation of regulations controlling emissions from the consumption of marine fuel in ocean-going vessels is one example. In March 2010, the International Maritime Organization (IMO) amended the International Convention for the Prevention of Pollution from Ships (MARPOL) to designate specific portions of the United States, Canada, and French waters as Emission Control Areas (ECAs) [*94*]. The area of the North American ECA includes waters adjacent to the Pacific coast, the Atlantic coast, and the Gulf coast, and the eight main Hawaiian Islands [*95*]. The ECAs extend up to 200 nautical miles from coasts of the United States, Canada, and the French territories but does not extend into marine areas subject to the sovereignty or jurisdiction of other countries. Compliance with the North American ECA became enforceable in August 2012 [*96*].

Emission Control Area Standards

The addition of ECAs to the international MARPOL treaty took effect in May 2005 and was amended in October 2008, when the member states of IMO [*97*]agreed to amend MARPOL Annex VI to establish new tiers or limits with progressive reductions of nitrogen oxide (NOx) and sulfur oxide (SOx) emissions from ship exhausts. The most stringent of the new international emission standards apply to ships (i.e., large ships and ocean vessels [*98*]) operating in designated ECAs, including the newly designated North American and Caribbean Sea ECA. Figure LR8-1 summarizes the Annex VI low-sulfur standards that apply globally (non-ECA) and within ECAs. AEO2016 considers the demands within North American and Caribbean ECAs, excluding energy demands occurring from shipping activity in non-ECA international waters.

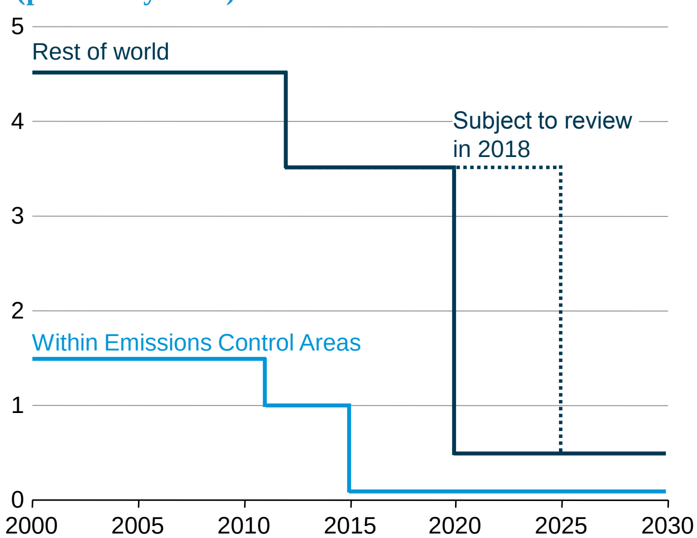
Although the start date for the new sulfur regulation is January 1, 2020, the plan will be reviewed to check the availability of the required fuel oil, because continued global investment by refiners probably will be needed to meet required emissions reductions. Depending on the outcome of that review, the startup date of new non-ECA sulfur regulations could be postponed until at least 2025, as indicated in Figure LR8-1 [*99*]. The original MARPOL Annex VI introduced global limits on sulfur content per gallon of bunker fuel at 4.5% by mass or 45,000 parts per million (ppm), with the levels within ECAs set at 1.5% by mass or 15,000 ppm.

The Tier I nitrogen oxides (NOx) standards for ships with engines built before 2000 range from 9.8 grams per kWh to 17.0 grams per kWh, depending on engine speed. The Tier II standards represent a 20% reduction from Tier I, and the Tier III standards represent an 80% reduction from Tier I. Tier III NOx limits will apply to all ships constructed on or after January 1, 2016, that operate inside a NOx ECA area with engines larger than 130 kilowatts.

NEMS is the primary source for EIA's analysis of recent history and AEO2016 projections of domestic energy markets. For AEO2016, the Freight Transportation Submodule of the NEMS Transportation Demand Module handles marine fuel choices and demand for ships operating within the North American and Caribbean ECA.

Compliance options associated with marine travel in the ECAs for both new and retrofitted vessels include the use of exhaust controls (e.g., scrubbers and selective catalytic reduction), changing fuels to marine gas oil (MGO) or liquefied natural gas (LNG), and installing engine-based controls (e.g., exhaust gas recirculation). Other technologies (e.g., biofuels and water injection), which are under development but have not yet reached wide-scale adoption, may provide additional options in the future. Ship efficiency improvements, shipping demand changes, and fuel price fluctuations also are considered in the Transportation Demand Module projections for international shipping fuel consumption within the North American and U.S. Caribbean ECAs [*100*].

Figure LR8-1. Current and proposed MARPOL regulations on sulfur content of fuel, 2000–2030 (percent by mass)



For marine travel within the North American and Caribbean ECA, AEO2016 assumes that consumption of distillate fuel oil, as the first and most widely used compliance solution, will rise rapidly between 2015 and 2019, then decline and level off after 2020, as fuel choices are affected by global emissions and fuel standards for ships. Although the long-term future of international marine fuel choice is unclear given current low and volatile prices for crude oil, it is likely that ship operators will invest in CO2 scrubbers in order to remain globally competitive, as refiners market heavy fuel oil (i.e., intermediate and residual fuel oils) at a significant discount relative to distillate fuel oil. In addition, for some types of oceangoing vessels, the use of LNG may begin to penetrate bunker fuel markets to some extent.

On July 24, 2008, the California Air Resources Board (CARB) adopted the regulation titled, Fuel Sulfur and Other Operation Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline [*101*].

Endnotes for legislation and regulations

Links current as of July 2016

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12. As indicated above, the EPA provided an option for certain new and reconstructed baseload CTs to elect between gross output-based and net output-based standards. For existing sources, EPA elected to specify a net generation basis for the standard.
13. U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), Section IV.B.1 under Table 11, p. 64812, https://www.federalregister.gov/articles/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.
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33. U.S. Internal Revenue Service, Title 26–Internal Revenue Code, pp. 215–225, Subtitle A, Chapter 1, Subchapter A, Part IV, Subpart D, Section 45, "Electricity produced from certain renewable resources, etc.)," https://www.gpo.gov/fdsys/pkg/USCODE-2014-title26/pdf/USCODE-2014-title26-subtitleA-chap1-subchapA-partIV-subpartD-sec45.pdf.

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35. United States Internal Revenue Code, Title 26, Subtitle A, Chapter 1, Subchapter A, Part IV, Subpart A, Section 25D, "Residential energy efficient property," https://www.gpo.gov/fdsys/pkg/USCODE-2014-title26/pdf/USCODE-2014-title26-subtitleA-chap1-subchapA-partIV-subpartA-sec25D.pdf.

36. United States Internal Revenue Code, Title 26, Subtitle A, Chapter 1, Subchapter A, Part IV, Subpart E, Section 48, "Energy credit," https://www.gpo.gov/fdsys/pkg/USCODE-2014-title26/pdf/USCODE-2014-title26-subtitleA-chap1-subchapA-partIV-subpartE-sec48.pdf .

37. Congress.gov, Public Law 109-58, "Energy Policy Act of 2005" (Washington, DC: August 8, 2005), https://www.congress.gov/109/plaws/publ58/PLAW-109publ58.pdf.

38. Congress.gov, Public Law 110-343, "Emergency Economic Stabilization Act of 2008" (Washington, DC: October 3, 2008), https://www.congress.gov/110/plaws/publ343/PLAW-110publ343.pdf.

39. U.S. Senate and House of Representatives, "Public Law 94-163, 94th Congress, Energy Policy and Conservation Act" (Washington, DC: December 22, 1975), https://www.gpo.gov/fdsys/pkg/STATUTE-89/pdf/STATUTE-89-Pg871.pdf.

40. U.S. Senate and House of Representatives, "National Appliance Energy Conservation Act of 1987" (Washington, DC: March 17, 1987), https://www.gpo.gov/fdsys/pkg/STATUTE-101/pdf/STATUTE-101-Pg103.pdf.

41. Key legislation addressing energy conservation standards for residential and commercial equipment includes the National Appliance Energy Conservation Act of 1987, the Energy Policy Act of 1992, the Energy Policy Act of 2005, and the Energy independence and Security Act of 2007.

42. U.S. Senate and House of Representatives, "H.R. 6, Energy Independence and Security Act of 2007" (Washington, DC: January 4, 2007), https://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf.

43. California Air Resources Board, "Zero-Emission Vehicle Standards for 2018 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" (Sacramento, CA: August 10, 2014), http://www.arb.ca.gov/msprog/zevprog/zevregs/1962.2_Clean.pdf.

44. California Air Resources Board, *California Exhaust Emission Standards and Test Procedures for 2018 and Subsequent Model Zero-Emission Vehicles and Hybrid Electric Vehicles, in the Passenger Car, Light-Duty Truck and Medium-Duty Vehicle Classes* (Sacramento, CA: March 22, 2012; Amended December 6, 2012, May 30, 2014, September 2, 2015, and September 3, 2015), http://www.arb.ca.gov/msprog/levprog/cleandoc/2018+%20my%20hevtps_clean%20complete_1-16.pdf.

45. For information about the Database of State Incentives for Renewables & Efficiency (DSIRE), see DSIRE, "Database of State Incentives for Renewables & Efficiency" (Raleigh, NC: not dated), http://www.dsireusa.org.

46. G. Barbose, "U.S. Renewables Portfolio Standards: Overview of Status and Key Trends" (Berkeley, CA: November 2015), https://emp.lbl.gov/sites/all/files/2015%20National%20RPS%20Summit%20Barbose.pdf.

47. U.S. Environmental Protection Agency, "Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015) https://www.federalregister.gov/articles/2015/10/23/2015-22837/standards-of-performance-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed-stationary; and U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.

48. Enumerations of state RPS policies may vary from source to source. The policies vary significantly from state to state, with no universal definition. Previous discussion of state RPS policies by EIA have included a policy in West Virginia that allowed for several types of fossil-fueled generators to be built instead of renewable generators to meet the portfolio requirement. That policy is not included as an RPS in AEO2016.

49. Eligible technologies, and even the definitions of technologies or fuel categories, vary by state. For example, one state's definition of renewables may include hydropower, while another's may not. Table LR6-1 provides more detail on how the technology or fuel category is defined by each state.

50. Colorado State University, Center for the New Energy Economy, "Summary of State Renewable Portfolio Standard Legislation in 2014" (Fort Collins, CO: August 2014), http://www.aeltracker.org/graphics/uploads/CNEE-2014-State-RPS-Legislation-Analysis.pdf.

51. Colorado State University, Center for the New Energy Economy, "Summary of State Renewable Portfolio Standard Legislation in 2015" (Fort Collins, CO: April 2015), http://www.aeltracker.org/graphics/uploads/2015-Trends-in-Renewable-Portfolio-Standard-Legislation_4_15.pdf.

52. California Legislative Information, "SB-350 Clean Energy and Pollution Reduction Act of 2015" (Sacramento, CA: October 7, 2015), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.

53. LegiScan, "Hawaii House Bill 623" (Honolulu, HI: June 10, 2015), https://legiscan.com/HI/text/HB623/2015.
54. Legislature of the State of Kansas, "House Substitute for Senate Bill No. 91: Renewable energy standards act and property tax exemptions for renewable energy resources" (May 28, 2015), http://www.kslegislature.org/li/b2015_16/measures/documents/sb91_enrolled.pdf.
55. Legislature of the State of Kansas, "Senate Substitute for House Bill No. 2369: Energy, generation, transmission, and efficiency" (May 22, 2009), http://www.kansas.gov/government/legislative/bills/2010/2369.pdf.
56. M. McClelland, Ohio Legislative Service Commission, "Sub. S.B. 310, Bill Summary, Renewable energy and advanced energy requirements" (May 7, 2014), http://www.lsc.ohio.gov/analyses130/s0310-rh-130.pdf.
57. Vermont General Assembly, "H.40, An act relating to establishing a renewable energy standard and energy transformation program" (May 15, 2015), http://legislature.vermont.gov/bill/status/2016/h.40.
58. West Virginia Legislature, "H.B. 2001, Article 2F. Alternative and Renewable Energy Portfolio Standard" (Charleston, WV: January 14, 2015), http://www.legis.state.wv.us/Bill_Status/bills_text.cfm?billdoc=hb2001%20intr.htm&yr=2015&sesstype=RS&i=2001.
59. This discussion focuses on electricity targets only, because of the range of electricity end uses in the AEO residential and commercial projections.
60. Different organizations may use different definitions. This is the definition adopted by EIA. Sources consulted included American Council for an Energy-Efficient Economy (ACEEE), Northeast Energy Efficiency Partnerships (NEEP2016), and the U.S. Environmental Protection Agency (EPA).
61. U.S. Environmental Protection Agency, "Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22837/standards-of-performance-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed-stationary; and U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.
62. For example, the New York Power Authority (NYPA) and Long Island Power Authority (LIPA) in New York and the Los Angeles Department of Water and Power (LADWP) in California set separate targets from those required for investor-owned utilities (IOUs).
63. U.S. Environmental Protection Agency, "Climate and Energy Resources for State, Local, and Tribal Governments" (Washington, DC: May 6, 2016), https://www3.epa.gov/statelocalclimate/resources/action-guide.html.
64. See A. Gilleo, "Picking All the Fruit: All Cost-Effective Energy Efficiency Mandates" (Washington, DC: American Council for an Energy-Efficient Economy, 2014), http://aceee.org/files/proceedings/2014/data/papers/8-377.pdf.
65. Citations of the laws and regulations mentioned in this paragraph from 2014 forward are contained under the individual state descriptions following Table LR7-1, "Characteristics of state efficiency mandates or goals."
66. Energy efficiency resource standards have been suspended (Indiana, March 2014), frozen at current levels (Ohio, June 2014), defunded (Florida, November 2014), or repealed (West Virginia, March 2015).
67. States that enhanced existing EERS include Arkansas, California, Connecticut, Massachusetts, Maryland, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington. Delaware and New Hampshire opened EERS dockets. Louisiana began an EE pilot. The changes are described in detail in the state section following the table.
68. EIA confirmed each state's requirements through original legislative or regulatory documentation, discussions with Public Utility Commission (PUC) staff, consultations with regional energy efficiency organizations such as the Northeast Energy Efficiency Partnerships (NEEP), and referring to the Database of State Incentives for Renewables & Efficiency, at http://www.dsireusa.org.
69. Arkansas Public Service Commission, Docket No. 13-002-U, Order No. 31, "In the Matter of the Continuation, Expansion, and Enhancement of Public Utility Energy Efficiency Programs in Arkansas" (Little Rock, AR: December 17, 2015), http://www.apscservices.info/pdf/13/13-002-U_226_1.pdf.
70. State of Arkansas, 90th General Assembly, Regular Session, 2015, Act 78 of the Regular Session, House Bill 1191, "An Act to Clarify the Regulation of Rates and Charges Under the Energy Conservation Endorsement Act Of 1977" (Little Rock, AR: January 13, 2015), ftp://www.arkleg.state.ar.us/acts/2015/Public/ACT78.pdf.
71. See A. Gilleo, "Picking All the Fruit: All Cost-Effective Energy Efficiency Mandates" (Washington, DC: American Council for an Energy-Efficient Economy, 2014), http://aceee.org/files/proceedings/2014/data/papers/8-377.pdf.

72. California Public Utility Commission, Decision 14-10-046, "Decision Establishing Energy Efficiency Savings Goals and Approving 2015 Energy Efficiency Programs and Budgets" (Sacramento, CA: October 16, 2014), http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M129/K228/129228024.pdf.

73. California Legislature, "Senate Bill No. 350, Chapter 547: Clean Energy and Pollution Reduction Act of 2015" (Sacramento, CA: October 7, 2015), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.

74. Connecticut Department of Energy & Environmental Protection, "Approval with Conditions of the Connecticut Energy Efficiency Fund's Electric and Natural Gas Conservation and Load Management Plan for 2016 through 2018" (Hartford, CT: December 31, 2015), http://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/DEEP_Approval_with_Conditions_of_2016-2018_C&LM_Plan_with_Attachment_A_12-31-15.pdf.

75. Connecticut General Assembly, Public Act No. 13-303, "An Act Concerning Connecticut's Clean Energy Goals" (Hartford, CT: June 5, 2013), https://www.cga.ct.gov/2013/ACT/PA/2013PA-00303-R00SB-01138-PA.htm.

76. State of Delaware, "Title 26, Public Utilities, Chapter 15. Energy Efficiency Resource Standards" (Dover, DE: July 27, 2009), http://delcode.delaware.gov/title26/c015/index.shtml.

77. Delaware General Assembly, 147th General Assembly, "Senate Bill #150: An Act to Amend Title 29 of the Delaware Code Relating to Sustainable Energy Utility" (Dover, DE: August 6, 2014), http://legis.delaware.gov/LIS/lis147.nsf/vwLegislation/SB+150?Opendocument.

78. Indiana Senate Enrolled Act 340 (March 27, 2014) prohibited the Utility Regulatory Commission (U.R.C) from establishing an EERS or requiring an electricity supplier to meet such a target after December 31, 2014. (See http://iga.in.gov/static-documents/a/4/c/2/a4c2943f/SB0340.06.ENRS.pdf.)

79. Indiana's Senate Enrolled Act No. 412 (May 6, 2015) allowed utilities to set individual voluntary efficiency programs. See http://in.proxy.openstates.org/2015/bills/sb0412/versions/sb0412.05.enrs.

80. Louisiana Public Service Commission, Docket No. R-31106, "Statewide Energy Efficiency Program" (October 9, 2014), http://lpscstar.louisiana.gov/star/ViewFile.aspx?Id=8a69809f-a6c1-44c0-b326-ccf42f41869e, and "Comments of LPSC Staff" (April 1, 2016), http://lpscstar.louisiana.gov/star/ViewFile.aspx?Id=0fca1fdd-4b65-4a77-b314-77a1d8282493.

81. Maryland Public Service Commission, "EmPOWER Maryland Energy Efficiency Act of 2008" (April 24, 2008); Public Service Commission of Maryland, Order No. 87082, Case 9153, "In the Matter of [six utilities] Energy Efficiency, Conservation and Demand Response Programs Pursuant to the EmPOWER Maryland Energy Efficiency Act of 2008" (July 16, 2015), http://www.psc.state.md.us/wp-content/uploads/Order-No.-87082-Case-Nos.-9153-9157-9362-EmPOWER-MD-Energy-Efficiency-Goal-Allocating-and-Cost-Effectiveness.pdf.

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83. State of Nevada, "Senate Bill No. 252—Committee on Commerce, Labor and Energy" (Carson City, NV: March 13, 2013), https://www.leg.state.nv.us/Session/77th2013/Bills/SB/SB252.pdf.

84. New Hampshire Public Utilities Commission, Docket No. DE 15-137, "Gas and Electric Utilities, Energy Efficiency Resource Standard" (Concord, NH: May 8, 2015), http://www.puc.state.nh.us/Regulatory/Docketbk/2015/15-137.html. In this Order of Notice, the PUC noted its statutory authority to advance a policy of energy efficiency as a least-cost supply option. The proposal covers electric and/or natural gas utilities, with a proposed 2014 baseline.

85. New York State Department of Public Service, "Reforming the Energy Vision (REV)" (Albany, NY: April 2014), http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument; and http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=15-M-0252&submit=Search+by+Case+Number. The original EERS required a reduction of 2015 sales based on the forecast done in 2008.

86. State of Ohio, S.B. 310 (Columbus, OH: June 13, 2014), http://archives.legislature.state.oh.us/BillText130/130_SB_310_EN_N.pdf; and S.B. 221 (May 1, 2008), http://archives.legislature.state.oh.us/bills.cfm?ID=127_SB_221 (initial legislation).

87. Pennsylvania Public Utility Commission, "Energy Efficiency and Conservation (EE&C) Program, Phase III, Final Implementation Order" (Philadelphia, PA: June 19, 2015), and Phase III Clarification Order (August 20, 2015), http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/energy_efficiency_and_conservation_ee_c_program.aspx.

88. State of Rhode Island and Providence Plantations Public Utilities Commission, "Energy Efficiency Program Plan for 2016: Settlement of the Parties" (Providence, RI: October 15, 2015), http://www.ripuc.org/eventsactions/docket/4580-NGrid-2016-EEPP(10-15-15).pdf.

89. State of Rhode Island and Providence Plantations, Executive Order 15-17, "State Agencies to Lead by Example in Energy Efficiency and Clean Energy" (Providence, RI: December 8, 2015), http://www.governor.ri.gov/documents/orders/ExecOrder15-17.pdf.

90. Vermont Energy Investment Corporation, *Triennial Plan 2015–2017* (prepared for the Vermont Public Service Board) (Burlington, VT: December 1, 2014), http://psb.vermont.gov/utilityindustries/eeu/generalinfo/oversightactivities; City of Burlington Electric Department, "2015–2017 Triennial Energy Efficiency Plan" (prepared for the Vermont Public Service Board, December 1, 2014), http://psb.vermont.gov/sites/psb/files/EEU/BED2015-17Triennialplan.pdf; State of Vermont, Order under Docket EEU-2014-7, "Triennial Plans for 2015–2017 of Efficiency Vermont and City of Burlington Electric Department" (February 13, 2015); and "Oversight Activities Regarding the Energy Efficiency Utility" (not dated), http://psb.vermont.gov/utilityindustries/eeu/generalinfo/oversightactivities.

91. State of Washington, Department of Commerce, "Energy Independence Act (EIA or I-937)," http://www.commerce.wa.gov/Programs/Energy/Office/EIA/Pages/default.aspx. The UTC approved 2016–17 biennial conservation plans and targets under Docket Nos. UE-152076 (Avista), UE-152072 (Pacific Power & Light), and UE-152058 (Puget Sound Energy).

92. West Virginia, Office of the Governor, "Governor Tomblin Approves Repeal of Alternative Renewable Energy Portfolio Act" (Press Release, February 3, 2015), http://www.governor.wv.gov/media/pressreleases/2015/Pages/GOVERNOR-TOMBLIN-APPROVES-REPEAL-OF-ALTERNATIVE-RENEWABLE-ENERGY-PORTFOLIO-ACT.aspx.

93. U.S. Energy Information Administration, "Large reduction in distillate fuel sulfur content has only minor effect on energy content" (Today in Energy, February 24, 2015), http://www.eia.gov/todayinenergy/detail.cfm?id=20092.

94. U.S. Environmental Protection Agency, "MARPOL Annex VI" (Washington, DC: January 14, 2015), http://www2.epa.gov/enforcement/marpol-annex-vi.

95. The North American ECA does not include the Pacific U.S. territories, smaller Hawaiian Islands, the Aleutian Islands and Western Alaska, and the U.S. and Canadian Arctic waters. The U.S. Caribbean ECA includes the waters adjacent to the Commonwealth of Puerto Rico and the U.S. Virgin Islands out to approximately 50 nautical miles from the coastline.

96. On June 27, 2011, the U.S. Environmental Protection Agency and U.S. Coast Guard entered into a Memorandum of Understanding (MOU) to enforce Annex VI MARPOL.

97. International Maritime Organization (IMO), "Member States" (2016), http://www.imo.org/en/About/Membership/Pages/MemberStates.aspx. IMO currently has 171 Member States and three Associate Members. The United States became a signatory in 1950.

98. Ships propelled by Category 3 (C3) marine vessels or diesel engines are included. Marine engine and Category 3 have the same meanings given under 40 CFR 94.2. Category 3 marine vessels, for the purposes of 40 CFR Part 80, are vessels that are propelled by engines meeting the definition of "Category 3" in 40 CFR Part 1042.901. Source: IMO, Marine Environment Protection Committee (MEPC), 68th Session (May 11–15, 2015.

99. IMO, Marine Environment Protection Committee (MEPC), 68th session, 11 to 15 May 2015, http://www.imo.org/en/MediaCentre/MeetingSummaries/MEPC/Pages/MEPC-68th-session.aspx.

100. MARPOL Annex VI, Chapter 4, introduces two mandatory mechanisms intended to ensure an energy efficiency standard for ships: (1) the Energy Efficiency Design Index (EEDI), for new ships; and (2) the Ship Energy Efficiency Management Plan (SEEMP) for all ships. The regulations apply to all ships of and above 400 gross tonnage and entered into force on January 1, 2013. See International Maritime Organization, "Prevention of Air Pollution from Ships" (not dated), http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx.

101. Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline, Title 13, California Code of Regulations (CCR) §2299.2 and Title 17, CCR §93118.2. The California OGV Fuel Regulation requires that the fuel must not only have a per-gallon sulfur content of 0.10% or lower, but must also meet the specifications for distillates (marine gas oil or marine diesel oil). Therefore, vessels using new hybrid fuels to comply with the Annex VI ECA-SOx regulations do not automatically comply with the OGV Regulation; to do so they must obtain a "Temporary Experimental" or "Research Exemption" from CARB.

Figure and table sources for legislation and regulations

Links current as of July 2016

Table LR3-1. Production tax credits and investment tax credits included in the AEO2016 Reference case, 2015–23: U.S. Government Printing Office, "H.R.2029 - Consolidated Appropriations Act, 2016, Public Law 114-113" (Washington, DC: December 18, 2015), https://www.congress.gov/bill/114th-congress/house-bill/2029/text.

Table LR4-1. Effective dates of initial and current appliance efficiency standards for selected equipment: U.S. Energy Information Administration, Office of Energy Analysis. Based on U.S. Department of Energy, Building Technologies Office, http://energy.gov/eere/buildings/standards-and-test-procedures.

Figure LR5-1. ZEV credit percentage requirements, model years 2018–25: California Air Resources Board, "Zero-Emission Vehicle Standards for 2018 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" (Sacramento, CA: August 10, 2014), http://www.arb.ca.gov/msprog/zevprog/zevregs/1962.2_Clean.pdf.

Figure LR6-1. Total qualifying renewable generation required for combined state renewable portfolio standards and projected total achieved, 2012–40: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Table LR6-1. Renewable portfolio standards in the 29 states and District of Columbia with current mandates: U.S. Energy Information Administration, Office of Energy Analysis. Based on a review of enabling legislations and regulatory actions from the various States on policies enacted prior to December 31, 2015, identified by the database of State Incentives for Renewables & Efficiency (as of March 24, 2016), website www.dsireusa.org.

Table LR7-1. Characteristics of state efficiency mandates or goals as of January 2016: U.S. Energy Information Administration, Office of Energy Analysis. Based on a review of each state's enabling legislations, implementing regulations, and annual efficiency achievement reports, as cited in the notes to Table LR7-1 and citations for the descriptions of individual states' policies.

Figure LR7-1. States with energy efficiency resources standards (EERS) or energy efficiency (EE) goals that target savings in electricity use as of January 2016: U.S. Energy Information Administration, Office of Energy Analysis. Based on an analysis of states with statewide efficiency policies as identified either in the Database of State Incentives for Renewables & Efficiency (DSIRE), http://programs.dsireusa.org/system/program/tables, or in the American Council for an Energy Efficiency Economy's (ACEEE) State and Local Policy Database, http://aceee.org/sector/state-policy.

Figure LR8-1. Current and proposed MARPOL regulations on sulfur content of fuel, 2000–2030: U.S. Energy Information Administration, based on International Convention of Pollution from Ships (MARPOL), http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.

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Issues in focus

Introduction

The "Issues in focus" section of the *Annual Energy Outlook* (AEO) provides in-depth discussions on topics of special interest, including possible changes in policies and developments in technologies and resources for energy production and consumption. Selected topics from recent AEOs are listed in Table IF1. Quantitative results from the issues discussed in AEO2016 are available in Appendix D.

Topics discussed in this section include:

- The Clean Power Plan, including analysis of alternative implementation approaches and the possible adoption of a more stringent Clean Power Plan program beyond 2030
- Proposed Phase 2 fuel consumption and greenhouse gas emissions standards for medium- and heavy-duty vehicles, which could significantly affect transportation fuel use
- An Extended Policies case that starts from current laws and regulations, which are the basis for the Reference case, and assumes future extensions of some major energy policies, including various energy tax credits, fuel economy regulations for light-duty and heavy-duty vehicles, and carbon dioxide emissions standards for existing power plants
- Growth in hydrocarbon gas liquids production and related developments in the industrial sector
- Sensitivity of the steel industry's energy consumption sensitivity to technology choices, and fuel and carbon prices in the AEO2016 Industrial Demand Module.

IF1. Effects of the Clean Power Plan

The Clean Power Plan (CPP) [*1*] rule, issued under Section 111(d) of the Clean Air Act, is the U.S. Environmental Protection Agency (EPA) program to regulate carbon dioxide (CO2) emissions at existing fossil-fired electric power plants. EPA estimates that the CPP will reduce CO2 emissions from the power sector by 32% from 2005 levels by 2030. As described in the *Annual Energy Outlook 2016* (AEO2016) Legislation and Regulations section, the CPP rule allows states to choose either mass-based or rate-based emissions targets. A mass-based target simply specifies an annual limit on the amount of CO2 that can be emitted by states from the affected sources. A rate-based target requires states to meet an annual adjusted emission rate (lbs CO2/MWh) based on emissions from affected sources divided by generation from affected sources, which for this calculation includes new non-emitting sources, such as nuclear and renewable capacity, and incremental energy efficiency. The rule also provides flexibility in other areas, such as regional cooperation through trading.

The final rule incorporated in the AEO2016 is a revision to the initial proposal [*2*] that U.S. Energy Information (EIA) analyzed in May 2015. [*3*] The final rule differs from the initial proposal in several ways, including:

Table IF1. "Issues in focus" analyses included in recent AEOs

AEO2014	AEO2013	AEO2012
U.S. tight oil production: Alternative supply projections and an overview of EIA's analysis of well-level data aggregated to the county level	U.S. reliance on imported liquid fuels in alternative scenarios	Potential efficiency improvements and their impacts on end-use energy demand
Potential of liquefied natural gas as a freight locomotive fuel	Competition between coal and natural gas in the electric power sector	Energy impacts of proposed CAFE standards for light-duty vehicles, model years 2017 to 2025
Light-duty vehicle energy demand: demographics and travel behavior	Nuclear power in AEO2013	Impacts of a breakthrough in battery vehicle technology
Effects of lower natural gas prices on projected industrial production	Effect of natural gas liquids growth	Heavy-duty natural gas vehicles
Implications of accelerated power plant retirements		Changing structure of the refining industry
Renewable electricity projections show growth under alternative assumptions in AEO2014		Changing environment for fuel use in electricity generation
Implications of low electricity demand growth		Nuclear power in AEO2012

Sources: U.S. Energy Information Administration, *Annual Energy Outlook 2014*, DOE/EIA-0383(2014) (Washington, DC: April 2014); U.S. Energy Information Administration, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); and U.S. Energy Information Administration, *Annual Energy Outlook 2012*, DOE/EIA-0383(2012) (Washington, DC: June 2012). The *Annual Energy Outlook 2015*, which was a shorter edition of the AEO, did not include an "Issues in focus" section.

- The compliance start date has been delayed from 2020 to 2022, and the reductions are phased in between 2022 and 2030 using 3 sets of multi-year, interim goals instead of one interim period
- Demand-side energy efficiency was not used in setting rate-based targets although it still may be used for compliance
- The variations between state targets have been reduced by using source-specific rates for fossil fuel steam and natural gas-fired combined-cycle generation at the interconnection level, rather than individual state emission rates
- Compliance calculations for rate-based targets have been limited to capacity additions since 2012, rather than also including pre-existing renewable capacity and at-risk nuclear plants
- Greater detail is provided for mass-based implementation approaches and emissions credit trading.

In comparison with the EIA's analysis of the preliminary CPP rule, which was based on the *Annual Energy Outlook 2015* (AEO2015) Reference case, the analysis described here includes other differences in underlying trends that are unrelated to the CPP but influence compliance decisions. These differences include lower natural gas prices, lower capital costs for renewable electricity generation plants, and extension of renewable tax credits.

In February 2016, the U.S. Supreme Court issued a stay of enforcement of the existing plant rule [*4*], pending resolution of legal challenges from the states and the affected industries. The AEO2016 Reference case assumes that the CPP will proceed as currently promulgated, and that all states will implement it by using a mass-based standard that caps emissions from both existing and new power plants, with allowance revenues rebated to ratepayers [*5*]. Alternative cases consider how outcomes could change with different implementation approaches, without the rule in place, and in a scenario with tighter standards beyond 2030.

Reductions in CO2 emissions can be achieved by switching from carbon-intensive fuels (such as coal) to less carbon-intensive natural gas-fired power plants or to zero-carbon technologies (such as renewables and nuclear power). Other options to reduce CO2 emissions include improving plant efficiency to reduce fuel use and increasing energy efficiency to reduce energy demand. Compliance decisions made by the states, as well as any future court decision regarding the rule, would have implications for plant retirements, capacity additions, generation by fuel type, demand, and prices.

Alternative Clean Power Plan cases

As described in the *Legislation and regulations* section below, the AEO2016 Reference case assumes that the CPP is upheld, and that all states choose to meet a mass-based standard to cover both existing and new sources. Using the standard that includes new sources ensures that *leakage* (which would represent a shift of emissions from existing sources to new natural gas-fired sources not covered by the CPP) does not occur. Because EIA's model is not developed at the state level, and because some level of trading is likely to happen among states with the mass-based approach, the Reference case assumes compliance at the same level in the 22 electricity regions included in the Electricity Market Model (EMM) [*6*]. An aggregate cap is calculated for each region, with the implicit assumption that carbon allowance trading can occur within the region. The Reference case also assumes that the allowances are allocated to load-serving entities, which provide the revenue back to consumers through lower distribution prices. The cap is specified for 2022 through 2030, based on EPA specifications, and remains flat at 2030 levels thereafter.

No CPP case

The No CPP case assumes that the final CPP rule is permanently voided and is not replaced by other controls on power sector CO2 emissions. States have no federal requirement to reduce CO2 emissions from existing power plants, but other programs remain in place, including the Regional Greenhouse Gas Initiative (RGGI) [*7*], the California Assembly Bill 32 (AB 32), and the Global Warming Solutions Act of 2006 [*8*]. Also, state and regional renewable portfolio standard programs remain in place, as described in the *Legislation and regulations* section, and may have an indirect impact on CO2 emissions.

CPP Rate case

The CPP provides state-specific, rate-based targets as an option for compliance. The affected electricity generation used in the rate calculation includes existing fossil steam and natural gas-fired combined-cycle units, incremental renewable generation added since January 2012, incremental nuclear generation, and incremental energy efficiency. Renewable capacity added in the end-use sectors also can be used to offset the affected emissions in the rate calculation. The CPP Rate case assumes that all regions (even those currently under mass-based programs such as in the Northeast and California) choose to comply with the CPP by meeting average rate-based targets—calculated as pounds of CO2 per megawatthour (lb/MWh)—in each EMM region. The rates are based on a weighted average of the state targets, specified by year from 2022 to 2030 as provided in the CPP. After 2030, the average emission rates for each region remain constant through 2040, implying that total emissions can increase after 2030 as electricity generation increases.

CPP Interregional Trading case

The EPA allows trading of carbon allowances among states, as long as the states involved use the mass-based compliance option. The CPP Interregional Trading case assumes that all regions choose to meet mass-based targets, covering existing and new sources (as in the AEO2016 Reference case), but with trading of carbon allowances between regions within the Eastern Interconnection and within the Western Interconnection. In the CPP Interregional Trading case, regions that reduce emissions by more than is needed to meet their own regional caps may trade their excess allowances, enabling the purchasing regions to exceed their nominal emissions caps.

CPP Extended case

The CPP Extended case further reduces the CO2 targets after 2030 instead of maintaining a constant standard, as specified in the CPP. This case assumes that the mass-based limits in 2030, which result in power sector CO2 emissions that are about 35% below 2005 levels, continue to decline linearly to achieve a 45% reduction below 2005 levels in 2040. The post-2030 reductions are applied using the same rate of decline for each state.

CPP Hybrid case

Unlike the CPP Rate case, the CPP Hybrid case assumes that regions in which existing programs enforce carbon caps (RGGI in the Northeast [9] and AB 32 in California) comply with the CPP through a mass-based target (considered more likely given their public comments on the rule). The CPP Hybrid case also assumes that states in other regions implement the CPP using a rate-based approach. This case assumes no interregional trading for CPP compliance. Because the RGGI and AB 32 constraints already are reducing emissions in these regions, the RGGI states and California tend to overcomply with their CPP requirements, whether implemented as a mass-based or rate-based standard. Consequently, the results of the CPP Hybrid case are similar to those of the CPP Rate case, because these regions do not need to behave differently to comply with either a mass-based or rate-based standard. The remaining regions are assumed to have rate-based standards in both cases. Because the results are indistinguishable, the following discussion of the case results does not include the CPP Hybrid case.

CPP Allocation to Generators case

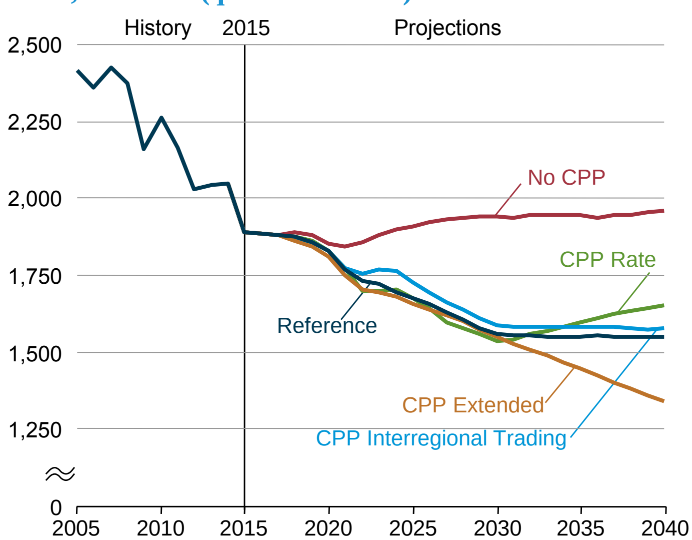
The CPP Allocation to Generators case assumes that (as in the Reference case) all regions meet mass-based caps that include new sources; however, the case also assumes that the carbon allowances are allocated to electricity generators rather than to load-serving entities. The CPP Allocation to Generators case also assumes that generators in competitive regions will continue to include the value of their carbon allowances in their operating costs. As a result, marginal generation costs will reflect the costs of allowances. The Reference case assumes that allowances are allocated to load-serving entities, which then refund the revenue from allowance sales to consumers through lower distribution prices. In the CPP Allocation to Generators case, retail electricity prices are higher than in the Reference case because there is no reduction of distribution costs, showing the impact of allowance allocation alternatives on retail prices. Because the impact of the CPP Allocation to Generators case is primarily on retail prices—and not on changes in how compliance is achieved, so that capacity and generation mix results are close to those in the Reference case—this case is discussed primarily in terms of pricing impacts.

Results

CO2 Emissions

cIn the Reference case, which assumes that states comply with mass-based CPP requirements, total CO2 emissions from the U.S. electric power sector in 2030 are 35% below their 2005 level. Emissions from the electric power sector, which have historically been the largest source of energy-related CO2 emissions in the United States, fall below those in the transportation sector by 2020 and throughout the remainder of the projection. After 2030, with the carbon cap assumed to remain flat and binding in almost all regions, emissions remain constant through 2040 (Figure IF1-1). Roughly the same reduction is seen in 2030 in the CPP Rate case, consistent with EPA's intent to develop equivalent measures for the alternate programs. After 2030, emissions increase in the CPP Rate case, and in 2040 they are only 32% below the 2005 total, because a constant emission rate standard can result in increasing emissions when overall generation is growing. Relative to the No CPP case, the power-sector CO2 emissions are 18% to 21% lower in 2030 across the cases that include the CPP and 16% to 21% lower in 2040 in all CPP cases except the CPP Extended case. The CPP Extended case assumes that further CO2 emissions reductions, beyond those currently specified in the CPP, are required after 2030, to 45% below 2005 levels in 2040, or 32% below the 2040 emissions total in the No CPP case.

Figure IF1-1. Total energy consumption in three cases, 2005–40 (quadrillion Btu)



In the CPP Interregional Trading case, emissions are slightly higher than in the Reference case because several regions overcomply, emitting less than their caps. This is typically because of enforcement of other state- or region-specific programs to reduce emissions or encourage renewables. In the CPP Interregional Trading case, where a market exists for those regions to sell their excess allowances, enabling other regions to emit above their caps. As a result, overall U.S. electricity-related CO2 emissions in the 2030–40 projection period are approximately 2% higher in the CPP Interregional Trading case than in the Reference case.

Capacity expansion and retirements

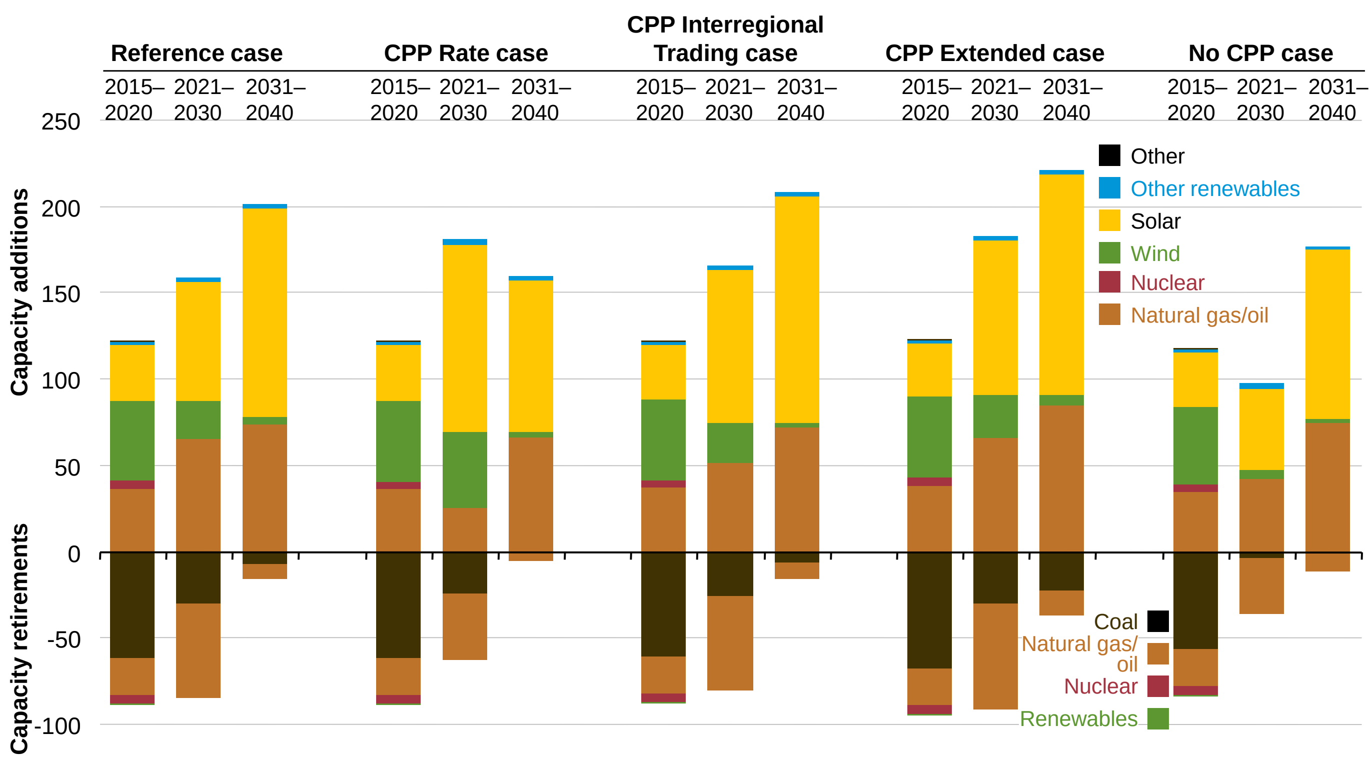
Relative to the No CPP case, the AEO2016 Reference case and the other CPP cases all result in more retirements of coal-fired and other fossil-fired steam plant capacity and increases in total renewable capacity additions, as regions reduce emissions to comply with mass-based or rate-based CO2 emissions standards (Figure IF1-2). The impact on natural gas-fired capacity varies somewhat with the CPP implementation decisions. Natural gas-fired plants produce less CO2 per kilowatthour (kWh) of electricity generated than is produced by coal-fired plants. However, replacement of coal plants with new natural gas plants does not reduce emissions to the same extent as replacement with new renewable plants.

Of the cases that maintain the final CPP target beyond 2030, the AEO2016 Reference case (which includes the mass-based approach) has the highest level of fossil-fired capacity retirements and the most new natural gas-fired capacity additions. To comply by EMM region using a mass-based standard, the EMM regions choose to replace existing fossil-fired plants with both new renewable generating capacity and new, more efficient, natural gas-fired combined-cycle plants. In the CPP Rate case, zero-emitting generation can help meet the rate standard both by offsetting emissions and by providing additional affected generation used to calculate the rate. As a result, more new renewable capacity is added than in the Reference case. Natural gas-fired combined-cycle capacity additions are 48 gigawatts (GW) lower than in the Reference case, and fossil-fired capacity retirements are 33 GW lower.

Because the rate standard allows new renewable generation to be included in the base of the rate calculation, additional incentive exists to meet incremental load growth with renewable capacity rather than with natural gas-fired capacity. Consequently, more existing fossil-fired capacity continues to operate. In the CPP Rate case, significantly more wind and solar capacity is added by 2030 than in the Reference case, but less is added after 2030. In the CPP Rate case, less incremental change is required after 2030 to maintain the emission rate standard than is required to maintain the mass-based cap in the Reference case as electricity demand increases.

In the CPP Interregional Trading case, a shift from natural gas-fired additions to renewable additions also occurs. Although regions are still required to meet a mass-based standard in the CPP Interregional Trading case, the ability to trade allowances provides regions that have cheaper renewable sources an incentive to exceed the required standards so they have excess allowances to sell. The availability and costs of renewable energy resources can vary significantly across the country. Broader allowance trading can allow for more economical means to achieve compliance overall. Regions that are best able to lower their emissions can sell allowances to regions that have fewer options to reduce emissions. In the CPP Interregional Trading case, solar capacity additions increase by 31 GW and natural gas-fired additions decrease by 15 GW from the 2040 totals in the Reference case. Also, 5 GW less capacity is retired as more existing capacity remains online in regions that purchase allowances.

Figure IF1-2. Cumulative additions and retirements of generating capacity in five cases, 2015–40 (gigawatts)



In the CPP Extended case, the mix of compliance actions is similar to that of the Reference case, but larger shifts are needed after 2030. From 2015 to 2030, plans for future declines in emissions targets will result in changes to the generation capacity mix, retiring an additional 12 GW of fossil-fired capacity and adding 20 GW of solar capacity beyond the Reference case totals. After 2030, the differences are more significant, with another 21 GW of incremental retirements of fossil-fired capacity in the CPP Extended case beyond those in the Reference case and additional solar (7 GW) and natural gas-fired (11 GW) capacity.

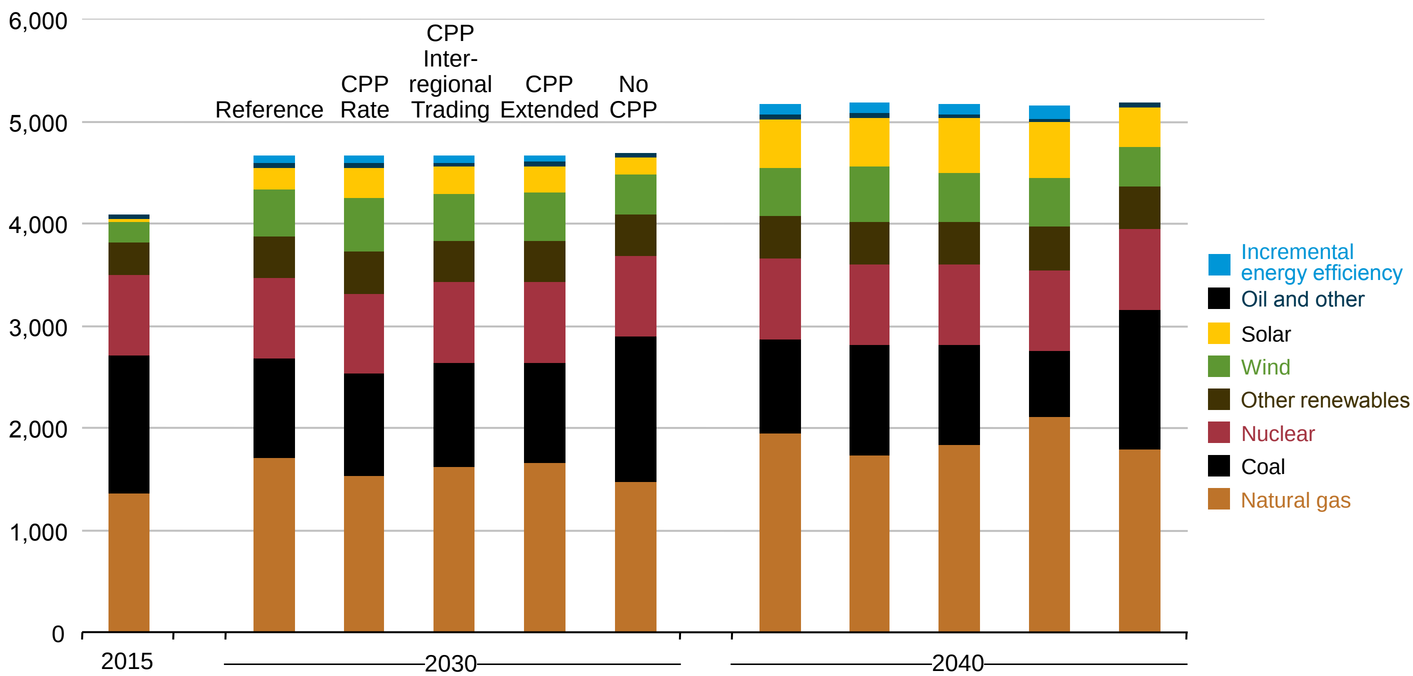
Generation fuel mix

Across the AEO2016 Reference case and CPP cases, shifts in the generation fuel mix reduce coal-fired generation by between 24% and 28% from 2015 to 2030 (Figure IF1-3). The declines from 2015 to 2040 vary across the cases, ranging from 20% to 32% across the cases that keep the CPP target constant after 2030. The rate-based case allows some increase in coal generation in the later years as long as sufficient renewable generation is available to offset it. The mass-based case continues to reduce coal generation and uses lower-emitting sources to meet new demand and maintain the same emission cap. In the CPP Extended case, which assumes that CO2 emissions target continues to decline after 2030, coal generation in 2040 is 52% below 2015 levels. In the No CPP case, coal electricity generation increases slightly from 2015 levels, as natural gas prices increase and as existing coal units are used at higher levels than in 2015, but remains relatively flat after 2020. Most growth in electricity demand is met by generation with natural gas and renewable capacity, which are more economic to build to meet new demand even without the CPP in place.

The tradeoff between natural gas and renewable capacity for compliance in the AEO2016 Reference case versus the CPP Rate case similarly affects the electricity generation mix across the cases. The natural gas share of total electricity generation grows from 33% in 2015 to 37% in 2030 in the Reference case and remains at 33% in the CPP Rate case, while the renewable share grows from 13% in 2015 to 24% in the Reference case and to 27% in the CPP Rate case. The CPP Interregional Trading case provides regions with more flexibility by allowing them to purchase allowances and reduce their own emissions, resulting in more renewable generation and less replacement of coal-fired generation with natural gas-fired generation than in the Reference case. Incremental demand-side energy efficiency (EE), measured as additional to what occurs without the CPP in place, lowers electricity demand by 73 billion kWh to 76 billion kWh in 2030 across the Reference, CPP Rate and CPP Interregional Trading cases. The additional EE impacts the calculation of the achieved emissions rate for a region, as the kWh are included in the denominator of the calculation. However, incremental EE can also help in meeting a mass-based target by reducing the need for additional fossil-fired generation by reducing electricity demand.

The CPP Extended case requires further shifts beyond 2030, resulting in a significant drop in coal's share of generation, from 33% in 2015 to 21% in 2030 and to 13% in 2040. In 2040, both the renewable share and the natural gas share, at 29% and 42% of total electricity generation, respectively, are higher than those in the Reference case. Incremental EE is also 21 billion kWh higher in the CPP Extended case compared with the Reference case. In 2030, natural gas-fired generation in the CPP Extended case is slightly lower than in the Reference case, as more early development of renewable capacity occurs in anticipation of the declining target.

Figure IF1-3. Electricity generation by fuel in five cases, 2015, 2030, and 2040 (billion kilowatthours)



Electricity prices

Retail electricity prices are higher when the CPP is in place than when it is not, as the fuel and capital costs of complying with the rule by shifting to natural gas-fired generation, or by building new renewable capacity, are passed through to retail prices. Price impacts are similar in the Reference and the CPP Rate cases, with constant dollar retail prices increasing by 1% to 5% above prices in the No CPP case over the 2022–30 CPP compliance period (Figure IF1-4). Prices remain, on average, 3% higher in constant dollars in the Reference and the CPP Rate case than in the No CPP case after 2030. In the CPP Extended case, average electricity prices are slightly lower than in the Reference case through 2030, as additional renewable capacity is added and as less natural gas-fired capacity is used for generation, with less impact on natural gas prices. Delivered natural gas prices in 2030 are 4% lower in the CPP Extended case than in the Reference case; but after 2030, the CPP Extended case requires further emissions reductions and more natural gas use. In the Reference case, electricity prices decline after 2030. In the CPP Extended case, incremental compliance costs keep electricity prices higher, and in 2040 they are 3% and 6% higher than in the Reference and No CPP cases, respectively.

Under a mass-based standard, states have options for the allocation of carbon allowances, with implications for electricity prices. The AEO2016 Reference case assumes that allowances will be allocated to load-serving entities, which will pass along the revenues from allowance sales to consumers in the form of rebates to lessen the price effects of CPP compliance. This rebate is reflected through lower electric distribution system costs. The CPP Allocation to Generators case assumes that allowances are distributed to generators. As a result, retail prices in competitive regions are higher, and average electricity prices from 2022 to 2040 in the CPP Allocation to Generators case are 1% higher than in the Reference case and 4% higher than in the No CPP case.

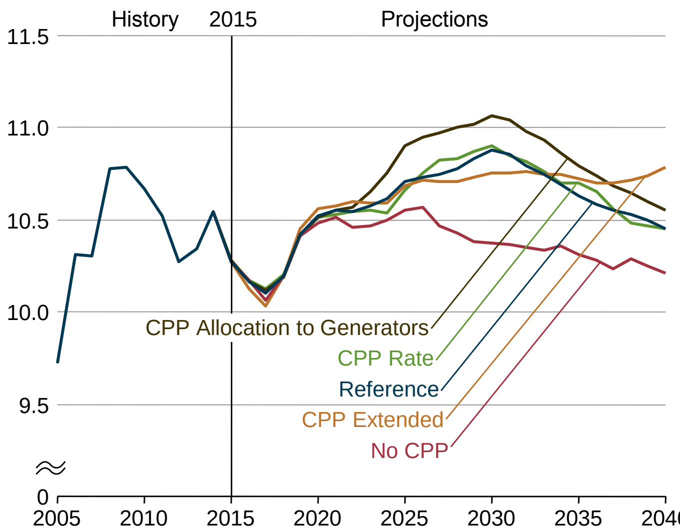
Regional Impacts

Although the targets in the final Clean Power Plan rule have less variability across the states than those in the proposed rule, different reduction levels still are required across the country, and compliance impacts differ among regions. As described earlier, EIA's modeling assumes that the CPP targets are implemented at the level of the electricity model regions [*10*] (see Appendix F). To permit a more concise display of the results in the following discussion of regional impacts, these 22 regions are grouped into 9 larger regions, with groupings of neighboring regions that have similar generation profiles and tend to use similar measures for CPP compliance (Table IF1-1 and Figure IF1-5). Detailed results for the 22 EMM regions are available on EIA's website at http://www.eia.gov/forecasts/aeo/data/browser/.

The current mix of generation types across the regions varies considerably. The Northern Plains, Midwest/Mid-Atlantic, and Southwest/Rockies regions rely the most on coal-fired generation (Table IF1-2 and Table IF1-3). Texas, the Southern Plains, and the Southeast have coal-fired generation in their mixes, along with nuclear and renewables, but these regions rely most heavily on natural gas-fired generation. The Northeast and California have almost no coal-fired generation, and their electricity is generated primarily from natural gas, along with renewables in California and a mix of nuclear and renewables in the Northeast. The Northwest has some coal-fired generation but relies predominantly on hydroelectric and other renewable electricity generation, with a relatively small share of natural gas-fired generation.

Even without the CPP (No CPP case), renewable electricity generation increases from 2015 to 2030 in all regions, with the largest increases in the Southeast, California, and the Northern Plains regions. Strong renewable electricity generation growth occurs as a result of the combination of extended tax credits, renewable portfolio standards in many regions, and declining construction costs. The Midwest/Mid-Atlantic region also experiences additional growth in natural gas-fired generation to replace generation from nuclear and coal-fired units that are retired during the 15-year period. Although these trends limit emissions growth, they do not result in the declines required by the CPP. In the No CPP case, total U.S. coal-fired generation grows slightly from the level in 2015, when low natural gas prices increased utilization rates for natural gas-fired plants and lowered utilization rates for coal-fired plants.

Figure IF1-4. Renewable electricity generation in three cases, 2012, 2020, 2030, and 2040 (billion kilowatthours)



In the Reference case, the regions that currently have the highest levels of coal-fired generation make the largest shifts in generation mix to comply with the CPP. The Midwest/Mid-Atlantic region retires additional coal-fired capacity and increases natural gas use, in addition to reducing its required electricity generation by importing more power from neighboring regions—which also reduces the region's direct CO_2 emissions in the Reference case. The EPA allows the states to determine how they will account for emissions in power trades, and EIA assumes that emissions counted against each region's target are based solely on electricity

Figure IF1-5. Change in emissions in the CPP Interregional Trading case relative to the Reference case, 2030

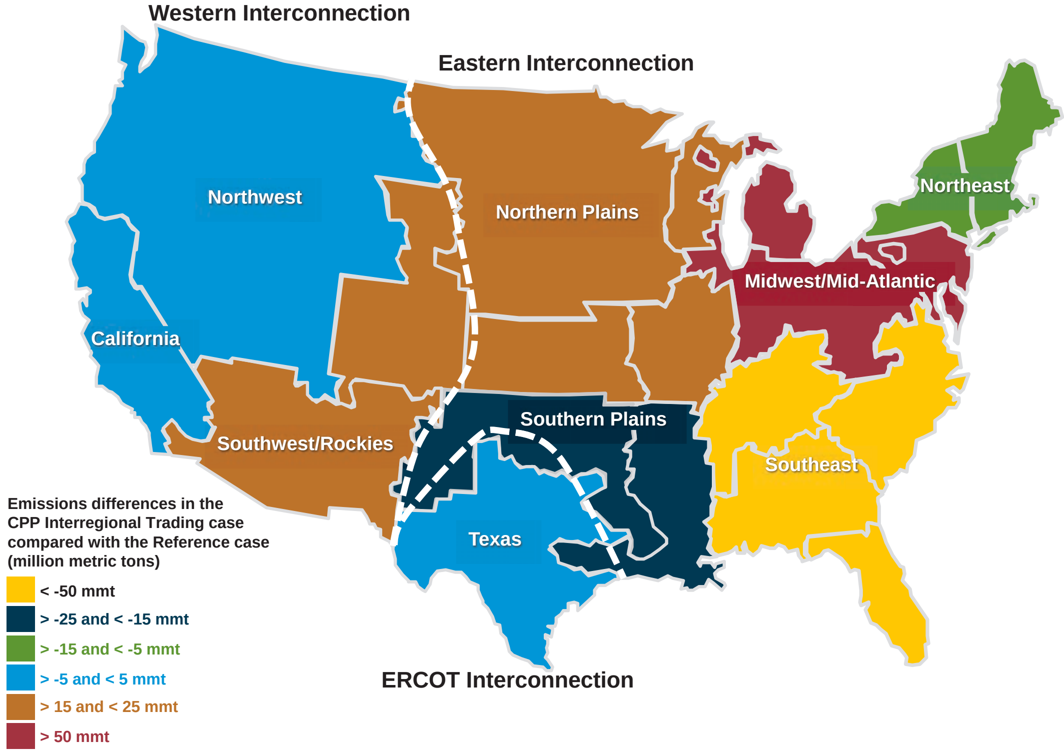


Table IF1-1. Mapping for aggregated electricity regions

Aggregate region	EMM regions included in aggregate region		
Northeast	5	NEWE	Northeast Power Coordinating Council (NPCC) / New England
Northeast	6	NYCW	NPCC / New York City-Westchester
Northeast	7	NYLI	NPCC/ Long Island
Northeast	8	NYUP	NPCC/ Upstate New York
Midwest/Mid-Atlantic	9	RFCE	ReliabilityFirst Corporation–East
Midwest/Mid-Atlantic	10	RFCM	ReliabilityFirst Corporation–Michigan
Midwest/Mid-Atlantic	11	RFCW	ReliabilityFirst Corporation–West
Southeast	2	FRCC	Florida Reliability Coordinating Council
Southeast	14	SRSE	SERC Reliability Corporation (SERC)/Southeastern
Southeast	15	SRCE	SERC/ Central
Southeast	16	SRVC	SERC/ Virginia-Carolina
Southern Plains	12	SRDA	SERC/ Delta
Southern Plains	18	SPSO	Southwest Power Pool Regional Entity / South
Texas	1	ERCT	Texas Reliability Entity
Southwest/Rockies	19	AZNM	Western Electricity Coordinating Council (WECC)/Arizona New Mexico
Southwest/Rockies	22	RMPA	WECC/ Rockies
California	20	CAMX	WECC/ California
Northwest	21	NWPP	WECC/ Northwest Power Pool Area
Northern Plains	3	MROE	Midwest Reliability Organization–East
Northern Plains	4	MROW	Midwest Reliability Organization–West
Northern Plains	13	SRGW	SERC/ Gateway
Northern Plains	17	SPNO	Southwest Power Pool Regional Entity / North

Notes: Names of grouped regions are intended to be approximately descriptive of location. Exact regional boundaries do not necessarily correspond to state borders or to other regional naming conventions. Aggregate region data are summed or averaged over the electricity model regions listed.

Table IF1-2. Electricity generation by region and fuel type in four cases, 2015 and 2030 (billion kilowatthours)

			2030			
Region	Fuel type	2015	Reference	CPP Rate	CPP Interregional Trading	No CPP
Northeast	Nuclear	76	63	63	63	63
	Coal	7	7	6	1	6
	Natural gas	130	150	134	135	137
	Wind/solar	9	25	24	24	25
	Other	45	51	51	51	51
Midwest/Mid Atlantic	Nuclear	275	242	242	242	242
	Coal	467	270	270	374	445
	Natural gas	177	377	308	317	265
	Wind/solar	25	50	145	50	46
	Other	27	32	33	32	32
Southeast	Nuclear	253	291	291	291	291
	Coal	230	232	248	165	333
	Natural gas	418	480	438	466	395
	Wind/solar	3	79	112	133	64
	Other	60	66	66	66	66
Southern Plains	Nuclear	41	40	40	40	40
	Coal	108	69	81	53	99
	Natural gas	173	221	176	217	177
	Wind/solar	25	67	81	71	69
	Other	20	21	21	21	21
Texas	Nuclear	40	40	40	40	40
	Coal	84	73	90	73	115
	Natural gas	214	230	195	231	230
	Wind/solar	36	97	111	99	60
	Other	3	4	4	4	4
Southwest/Rockies	Nuclear	32	32	32	32	32
	Coal	112	74	73	93	99
	Natural gas	62	60	84	63	67
	Wind/solar	19	87	70	75	71
	Other	18	21	21	21	21
California	Nuclear	18	18	18	18	18
	Coal	9	1	1	1	1
	Natural gas	116	116	113	110	122
	Wind/solar	32	83	75	82	75
	Other	42	68	67	67	67
Northwest	Nuclear	9	9	9	9	9
	Coal	73	52	56	55	56
	Natural gas	47	41	45	41	49
	Wind/solar	24	56	53	56	44
	Other	121	148	151	148	148

See notes at end of table.

(continued on page IF-10)

generation within the region, including generation exported to other regions. The Southeast region and the Southern Plains region also increase natural gas use considerably to comply with the CPP. In the Southeast region, where natural gas prices generally are relatively low, the available natural gas-fired, combined-cycle capacity is sufficient to support higher utilization levels.

The largest regional change in the increase in renewable electricity generation from 2015 to 2030 in the Reference case relative to the No CPP case is projected to be in Texas. The Northern Plains region also relies on increased wind generation and reduced coal-

Table IF1-2. Electricity generation by region and fuel type in four cases, 2015 and 2030 (billion kilowatthours) *(continued)*

			2030			
Region	Fuel type	2015	Reference	CPP Rate	CPP Interregional Trading	No CPP
Northern Plains	Nuclear	53	54	54	54	54
	Coal	261	194	169	213	266
	Natural gas	10	22	33	23	24
	Wind/solar	54	135	155	133	115
	Other	18	22	22	22	22
U.S. Total	Nuclear	798	798	789	789	789
	Coal	1,355	972	995	1,029	1,422
	Natural gas	1,348	1,702	1,531	1,607	1,471
	Wind/solar	227	683	830	727	571
	Other	362	443	446	442	442

Notes: Names of grouped regions are intended to be approximately descriptive of location. Exact regional boundaries do not necessarily correspond to state borders or to other regional naming conventions. Aggregate data for each region are summed or averaged over the electricity model regions listed. United States totals include estimated projections for Alaska and Hawaii, which are not included within any listed region.

Table IF1-3. Electricity generation shares by region and fuel type in four cases, 2015 and 2030 (percent of region total)

			2030			
Region	Fuel type	2015	Reference	CPP Rate	CPP Interregional Trading	No CPP
Northeast	Nuclear	29%	21%	23%	23%	22%
	Coal	3%	2%	2%	1%	2%
	Natural gas	49%	51%	48%	49%	49%
	Wind/solar	3%	8%	8%	9%	9%
	Other	17%	17%	18%	19%	18%
Midwest/Mid Atlantic	Nuclear	28%	25%	24%	24%	23%
	Coal	48%	28%	27%	37%	43%
	Natural gas	18%	39%	31%	31%	26%
	Wind/solar	3%	5%	15%	5%	4%
	Other	3%	3%	3%	3%	3%
Southeast	Nuclear	26%	25%	25%	26%	25%
	Coal	24%	20%	21%	15%	29%
	Natural gas	43%	42%	38%	42%	34%
	Wind/solar	0%	7%	10%	12%	6%
	Other	6%	6%	6%	6%	6%
Southern Plains	Nuclear	11%	10%	10%	10%	10%
	Coal	30%	16%	20%	13%	24%
	Natural gas	47%	53%	44%	54%	44%
	Wind/solar	7%	16%	20%	18%	17%
	Other	6%	5%	5%	5%	5%

See notes at end of table.

(continued on page IF-11)

fired generation to meet the CPP targets. The Southwest/Rockies region decreases coal-fired generation and more than triples solar electricity generation between 2015 and 2030 in the No CPP case. In the Reference case, solar electric power provides the region's most economical option for CPP compliance.

California and the Northeast regions have existing regional programs that are already reducing emissions. As a result, emissions tend to be below the emission caps that are applied with a mass-based implementation of the CPP in these regions. However, minor shifts in the generation mix occur relative to the No CPP case as both regions reduce their levels of imports in the Reference case, because compliance costs in neighboring regions affect the costs and relative economics of these imports.

The electricity price effects of the CPP vary across the regions, depending on the magnitude of changes required in each region's generation mix and the method of compliance (Table IF1-4). The Northeast region experiences larger price impacts, even though emissions are below the CPP cap in both the No CPP case and Reference case because the region relies heavily on natural gas-fired generation. The Northeast is also a competitive pricing market where the marginal cost of generation sets the wholesale power

Table IF1-3. Electricity generation shares by region and fuel type in four cases, 2015 and 2030 (percent of region total) *(continued)*

			2030			
Region	Fuel type	2015	Reference	CPP Rate	CPP Interregional Trading	No CPP
Texas	Nuclear	11%	9%	9%	9%	9%
	Coal	22%	16%	20%	16%	26%
	Natural gas	57%	52%	44%	52%	51%
	Wind/solar	9%	22%	25%	22%	13%
	Other	1%	1%	1%	1%	1%
Southwest/Rockies	Nuclear	13%	12%	11%	11%	11%
	Coal	46%	27%	26%	33%	34%
	Natural gas	25%	22%	30%	22%	23%
	Wind/solar	8%	32%	25%	26%	25%
	Other	7%	8%	8%	7%	7%
California	Nuclear	8%	6%	7%	6%	6%
	Coal	4%	0%	0%	0%	0%
	Natural gas	53%	41%	41%	40%	43%
	Wind/solar	15%	29%	27%	30%	27%
	Other	19%	24%	24%	24%	24%
Northwest	Nuclear	3%	3%	3%	3%	3%
	Coal	27%	17%	18%	18%	18%
	Natural gas	17%	13%	14%	13%	16%
	Wind/solar	9%	18%	17%	18%	14%
	Other	44%	48%	48%	48%	48%
Northern Plains	Nuclear	13%	13%	12%	12%	11%
	Coal	66%	45%	39%	48%	55%
	Natural gas	3%	5%	8%	5%	5%
	Wind/solar	14%	31%	36%	30%	24%
	Other	5%	5%	5%	5%	5%
U.S. Total	Nuclear	20%	17%	17%	17%	17%
	Coal	33%	21%	22%	22%	30%
	Natural gas	33%	37%	33%	35%	31%
	Wind/solar	6%	15%	18%	16%	12%
	Other	9%	10%	10%	10%	9%

Notes: Names of grouped regions are intended to be approximately descriptive of location. Exact regional boundaries do not necessarily correspond to state borders or to other regional naming conventions. Aggregate data for each region are summed or averaged over the electricity model regions listed. United States totals include estimated projections for Alaska and Hawaii, which are not included within any listed region.

price that, added to distribution charges, sets the retail price. Natural gas prices are higher in the Reference case compared to the No CPP case in all regions of the country, as a result of increased consumption, and thus result in higher marginal costs. The Midwest/Mid-Atlantic and Southeast regions also shift to greater natural gas use and see relatively larger price impacts. California and the Northwest, which have large shares of low-cost renewable generation, have smaller price impacts. Texas has an early price reduction because the region adds a large amount of wind capacity in the early years of the projection period to take advantage of available federal tax credits. Initially, this extra capacity with low operating costs lowers electricity prices. In the longer term, the price increases in Texas are consistent with those in other regions.

CPP Interregional Trading case

In the CPP Interregional Trading case, the EMM regions can trade carbon allowances within the Eastern Interconnection and within the Western Interconnection [*11*]. This trading allows emissions to be above an individual region's cap, as long as that region holds allowances from another region with total emissions that are below its limit. In the CPP Interregional Trading case, emissions are higher than their Reference case levels in the Eastern Interconnection's Midwest/Mid-Atlantic region and in the Northern Plains region, and emissions are lower in the Northeast, Southeast, and Southern Plains regions, indicating the directions of allowance trading (see Figure IF1-5). Trading is not limited to contiguous regions, and transactions can occur between any of the EMM regions within a given interconnect.

The generation mix in the regions changes as a result of emissions trading (see Tables IF1-2 and IF1-3). The Midwest/Mid-Atlantic region, which has the most purchases of allowances, retains more of its coal-fired generation and reduces the shift to natural gas use. The Southeast region, which has the most allowance sales, further reduces coal use and expands renewable electricity generation, as it has more favorable solar resources than the Midwest/Mid-Atlantic region. The shifts in power sales in those regions in the Reference case do not occur in the CPP Interregional Trading case, where the Midwest/Mid-Atlantic region can increase its electricity generation from lower cost, fossil fuel-fired generation and purchase allowances to cover excess emissions. The Northeast also reduces emissions in the CPP Interregional Trading case relative to the Reference case and provides allowances to the Midwest/Mid-Atlantic region.

In the middle of the country, shifts in emissions and allowance trading are not as large as in other regions, although some changes do occur. The Southern Plains region reduces emissions and sells allowances, and the Northern Plains region purchases allowances to increase its emissions. The Northern Plains region has coal-fired generation capacity that continues to operate when allowances are available at costs lower than the cost of developing less carbon-intensive generation facilities. The Southern Plains region has economically viable wind and solar potential.

Although the California region does not reduce emissions significantly from the Reference case, the Western Interconnection region is well below its CPP emissions cap in all CPP cases. In the Interregional Trading case, California provides more than 20 million allowances to other regions, primarily to the Southwest/Rockies region. As a result, a slight increase occurs in total national emissions in the CPP Interregional Trading case compared with the Reference case.

The interplay of interregional power trade and compliance occurs in several areas. The Southern Plains region increases exports to the Northern Plains and Southwest/Rockies regions in the Reference case, but reduces exports when allowance trading is permitted. Regions that purchase allowances can meet their own generation needs more economically by increasing generation with fossil fuels.

Table IF1-4. Differences in average electricity prices in the Reference case from the No CPP case by region, 2025, 2030, 2035, and 2040 (percent)

Region	2025	2030	2035	2040
Northeast	4%	7%	4%	3%
Midwest/Mid-Atlantic	0%	6%	3%	2%
Southeast	4%	6%	4%	3%
Southern Plains	0%	4%	3%	3%
Texas	-7%	4%	2%	0%
Southwest/Rockies	4%	5%	3%	3%
California	1%	2%	2%	2%
Northwest	2%	2%	2%	2%
Northern Plains	3%	4%	4%	4%
U.S.	1%	5%	3%	2%

Note: Differences are based on aggregate region averaged prices weighted by regional sales.

CPP Rate case

On a national level, power sector emissions in 2030 in the CPP Rate case are slightly lower than in the Reference case. However, regional emission reductions are more variable in the CPP rate case. The largest changes in emissions relative to the Reference case occur in the Midwest/Mid-Atlantic and Northern Plains regions, which reduce emissions by 5% and 10%, respectively, from their Reference case levels in 2030, and in the Texas region and the Southwest/Rockies region, which increase emissions by 6% and 9%, respectively, from Reference case levels. Total emissions with the rate-based target can vary by region, depending on the generation mix and total generation. New renewable sources also play a larger role in meeting the rate-based target, which allows for shifts in the mix of existing fossil-fired generation versus generation from new energy sources. Incremental EE can also be counted as affected generation in the rate-based calculation. After 2030, total U.S. emissions increase in the CPP Rate case. With an increase in electricity generation, total emissions can increase while the emission rate is maintained with the rate-based target. Total emissions increase in the CPP Rate case after 2030 in most regions; however, in California and the Northeast, where state and regional caps remain in place, emissions remain relatively constant through 2040.

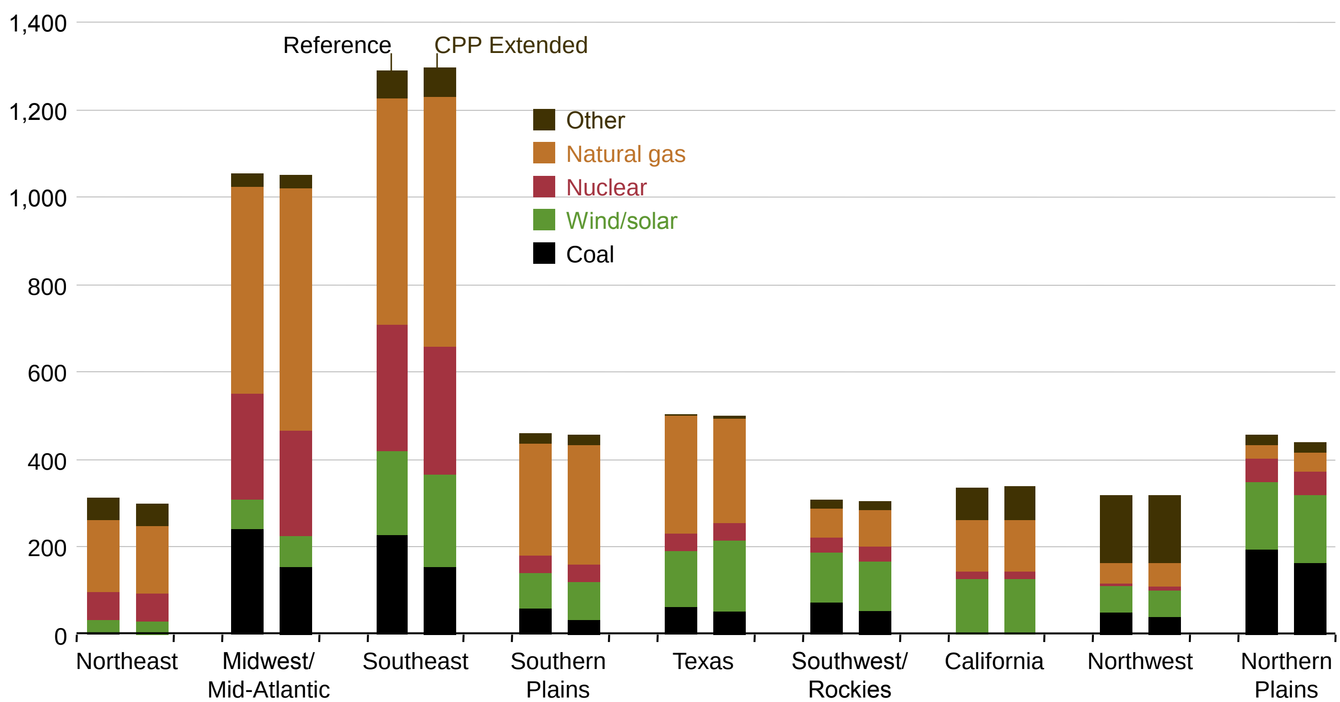
In most regions, new renewable electricity generation shifts occur in the CPP Rate case (Table IF1-2 and Table IF1-3), because the calculation of the emission rate includes generation from renewable sources in the denominator of the rate calculation. This is an added benefit from increasing renewable generation with the rate-based standard, in addition to simply offsetting emissions from fossil-fired generation. In the Midwest/Mid-Atlantic region, an additional 95 billion kWh of generation from wind and solar capacity occurs in 2030 in the CPP Rate case, relative to the Reference case, with a decline in natural gas-fired generation of 69 billion kWh compared with the Reference case. The new wind and solar capacity is added relatively early, before the production and investment tax credits are phased out, and this capacity provides a steady source of carbon-free electricity generation through 2030. However, coal-fired generation is reduced over time as the standard tightens. The patterns are similar in the Southeast, Southern Plains, and Texas regions, where generation from wind and solar energy sources in 2030 is higher than in the Reference case, and natural gas-fired generation is lower. (Coal-fired generation also increases slightly from the Reference case levels in these three regions.) In the Northern Plains region, which has little natural gas-fired capacity, electricity generation from wind and solar resources increases and coal use declines in the CPP Rate case.

CPP Extended case

In the CPP Extended case, the CPP emission targets continue to decline after 2030, and coal-fired electricity generation declines in all regions (Figure IF1-6). The most significant changes relative to the Reference case occur in the Midwest/Mid-Atlantic and Southeast regions. In the Midwest/Mid-Atlantic region, the additional emission reductions result primarily from switching to natural gas-fired generation from coal. In the Southeast region, both natural gas-fired generation and renewable electricity generation are higher in 2040 in the CPP Extended case than in the Reference case. In the Northwest and the Southern Plains regions, electricity generation from natural gas and from renewables in 2040 is higher than in the Reference case, as coal-fired generation declines. In the Southwest Rockies and Northern Plains regions, natural gas-fired generation is higher in 2040 to make up for the decline in coal consumption.

In Texas, coal-fired and natural gas-fired generation are lower in 2040 in the CPP Extended case than in the Reference case, as fossil fuel consumption is reduced to meet the declining emissions target, and large amounts of new solar capacity are added after 2035. In the Northeast region, as emissions targets are lowered in the CPP Extended case, the CPP target eventually becomes more stringent than the regional program (RGGI) that is in place, and natural gas use in 2040 is lower than in the Reference case. In contrast, California's AB 32 program continues to result in emissions below the 2040 targets in the CPP Extended case, and the generation mix is unchanged from that in the Reference case.

Figure IF1-6. Electricity generation in 2040 by region and fuel in the Reference and CPP Extended cases (billion kilowatthours)



Endnotes for IF1

Links current as of July 2016

1. U.S. Environmental Protection Agency, "Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22837/standards-of-performance-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed-stationary; and U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.
2. U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Proposed Rule), 79 Fed. Reg. 34,830 (June 18, 2014).
3. U.S. Energy Information Administration, *Analysis of the Impacts of the Clean Power Plan* (Washington, DC: May 2015), http://www.eia.gov/analysis/requests/powerplants/cleanplan/pdf/powerplant.pdf.
4. L. Deniston, "Carbon pollution controls put on hold" (Washington, DC: February 9, 2016), http://www.scotusblog.com/2016/02/carbon-pollution-controls-put-on-hold/.
5. For a more detailed discussion of the status of the rule and its implementation in the Reference case, see "Legislation and regulations."
6. See map of EMM regions in Appendix F. Because they represent a single state, EIA groups Regions 6, 7, and 8 (New York City, Long Island, and Upstate New York) into a single CPP compliance region.
7. RGGI, Inc., "Regional Greenhouse Gas Initiative," http://rggi.org/.
8. California Environmental Protection Agency, Air Resources Board, "Assembly Bill 32 Overview" (Sacramento, CA: August 5, 2014), http://www.arb.ca.gov/cc/ab32/ab32.htm.
9. The CPP Hybrid case assumes that the New York and New England electricity regions use mass-based compliance. Although Delaware and Maryland also are members of RGGI, they are part of a larger electricity modeling region that includes states that are not part of RGGI, and they represent a relatively small share of the region's total emissions. Because CPP compliance is modeled by electricity model regions, not by state, the CPP Hybrid case assumes that the region including Delaware and Maryland complies by using a rate-based approach.
10. The three New York regions are modeled as one compliance region.
11. The Electric Reliability Council of Texas (ERCOT) is located entirely within Texas, so there is no opportunity for trade between states as in the other interconnections.

Figure and table sources for IF1

Links current as of July 2016

Figure IF1-1. CO2 emissions from the electric power sector in five cases, 2005–40: History: U.S. Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2016/04) (Washington, DC: April 2016). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, REF_RATE.D032416A, REF_TRADE.D032416A, and REF_EXTEND.D050416A.

Figure IF1-2. Cumulative additions and retirements of generating capacity in five cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, REF_RATE.D032416A, REF_TRADE.D032416A, and REF_EXTEND.D050416A.

Figure IF1-3. Electricity generation by fuel in five cases, 2015, 2030, and 2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2016/04) (Washington, DC: April 2016). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, REF_RATE.D032416A, REF_TRADE.D032416A, and REF_EXTEND.D050416A.

Figure IF1-4. Average retail electricity prices in five cases, 2005–40: History: U.S. Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035 (2016/04) (Washington, DC: April 2016). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, REF_RATE.D032416A, REF_EXTEND.D050416A, and REF_ALLOW_GEN.D032416A.

Table IF1-1. Mapping for aggregated electricity regions: U.S. Energy Information Administration.

Figure IF1-5. Change in emissions in the CPP Interregional Trading case relative to the Reference case, 2030: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_TRADE.D032416A.

Table IF1-2. Electricity generation by region and fuel type in four cases, 2015 and 2030: AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, REF_TRADE.D032416A, and REF_RATE.D032416A.

Table IF1-3. Electricity generation shares by region and fuel type in four cases, 2015 and 2030: AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, REF_TRADE.D032416A, and REF_RATE.D032416A.

Table IF1-4. Differences in average electricity prices in the Reference case from the No CPP case by region, 2025, 2030, 2035, and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure IF1-6. Electricity generation in 2040 by region and fuel in the Reference and CPP Extended cases: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_EXTEND.D050416A.

IF2. Fuel consumption and greenhouse gas emissions Phase 2 standards for medium- and heavy-duty vehicles

The transportation sector is the second-largest consumer of energy in the United States, accounting for more than 70% of U.S. petroleum consumption and thus playing a significant role in projections of energy demand. The *Annual Energy Outlook 2016* (AEO2016) Reference case reflects the effects of existing laws and regulations on the fuel consumption and greenhouse gas (GHG) emissions of medium- and heavy-duty vehicles, which in 2015 accounted for 20% of total energy consumption in the transportation sector and 60% of total delivered distillate fuel consumption.

EIA has produced a separate case—the Phase 2 Standards case—to analyze the impacts of a proposed rulemaking jointly issued by the U.S. Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) in July 2015 [*1*]. The proposed standards build on the Phase 1 GHG emissions standards for medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs) that were implemented starting in model year (MY) 2014. The proposed Phase 2 rulemaking establishes a second round of standards for GHG emissions and fuel consumption by medium- and heavy-duty trucks. The Phase 1 standards extend through MY 2018. The proposed Phase 2 standards take effect in MY 2021 (or MY 2018 for trailers) and increase in stringency through MY 2027.

In the AEO2016 Phase 2 Standards case, average fuel economy increases for all new vehicles covered by the standards. In 2040, total MDV and HDV energy consumption, which is 3.4 million barrels per day oil equivalent in the AEO2016 Reference case, is 2.6 million barrels per day oil equivalent in the Phase 2 Standards case, or 22% lower. Total MDV and HDV diesel fuel use in 2040 is 18% lower than in the Reference case. With higher on-road fuel economy of the truck stock in the Phase 2 Standards case, total delivered energy consumption in the transportation sector is 6% lower in 2040 than in the Reference case. As the average fuel economy of conventional vehicles increases in the Phase 2 Standards case, there is less also incentive to pay high capital costs for natural gas and propane vehicles despite their lower fuel costs, and there is a shift away from natural gas and propane toward conventional diesel and gasoline fuels.

The proposed Phase 2 standards address specific vehicle categories, including combination tractors, trailers, heavy-duty (HD) pickup trucks and vans, and vocational vehicles (Table IF2-1). For combination tractors, standards are proposed by cab, roof, and fuel type. In addition, for the first time, standards are proposed for heavy-haul tractors [*2*] and for trailers pulled by Class 7 and Class 8 tractors. The proposed standards for trailers vary in stringency, depending on the type of trailer. For HD pickups and vans, the proposed standards are categorized by diesel or gasoline engine and are set as total gallons consumed per 100 miles or as grams per mile. For heavy-duty pickups and vans, the proposed standards consider a vehicle's work factor—the weighted average of payload and towing capacity. For vocational vehicles, the proposed standards are based on chassis type, gross vehicle weight rating (GVWR), engine type, and drive cycle.

The AEO2016 Phase 2 Standards case analyzes the estimated effects of the proposed regulations on fuel consumption and GHG emissions. The requirements for each of the vehicle categories are derived from U.S. Energy Information Administration projected sales, distributed into the size classes according to data from Polk Automotive [*3*] and the U.S. Census Bureau's Vehicle Inventory and Use Survey (VIUS) [*4*].

Heavy-duty pickups and vans

The proposed standards for heavy-duty pickups and vans in Class 2b (GVWR between 8,501 and 10,000 pounds) and Class 3 (GVWR between 10,001 and 14,000 pounds) are phased in from MY 2021 to MY 2027. Although heavy-duty pickups and vans often use efficiency improvements similar to those for light-duty pickup trucks and vans, the standards are based on a work-based metric rather than on the footprint metric used for light-duty vehicles. The work factor incorporates towing and payload capacity as well as four-wheel drive capability in determining minimum fuel efficiency requirements.

The proposed standards include an annual 2.5%/year reduction in allowable emissions from MY 2021 to MY 2027, an approximate 16% increase from the standards set by Phase 1 for MY 2018. Standards are set individually for vehicles with spark ignition engines

Table IF2-1. Types of vehicles regulated by the proposed Phase 2 standards

Vehicle category	Description	Truck classes covered
Combination tractors	Semi-trucks that typically pull trailers	Class 7 and Class 8 (GVWR 26,001 pounds and above)
Heavy-duty pickups and vans	Pickup trucks and vans, such as 3/4-ton or 1-ton pickups for example used on construction sites or 12- to 15-person passenger vans	Class 2b and Class 3 (GVWR 8,501 to 14,000 pounds)
Vocational vehicles	Wide range of truck configurations, such as delivery, refuse, utility, dump, cement, school bus, ambulance, and tow trucks. For purposes of the rulemaking, vocational vehicles are defined as all heavy-duty trucks that are not combination tractors or heavy-duty pickups or vans	Class 2b through Class 8 (GVWR 8,501 pounds and above)

and vehicles with compression ignition engines, but the standards are expected to improve at the same rate. Compliance test procedures for heavy-duty pickups and vans employ the same EPA drive cycles used to determine light-duty vehicle compliance, and manufacturer compliance retains the same Phase 1 production-weighted fleet average to determine compliance.

Combination tractor cabs

The proposed Phase 2 standards continue the attribute-based classification of combination tractor cabs from Phase 1—by Classes 7 and 8, day and sleeper cabs, and roof height (low, mid, high). In addition, a specific set of vocational tractors, heavy-haul tractors, are subject to a specific standard to reflect their unique powertrains. The proposed standards would require reductions in carbon dioxide (CO2) emissions and fuel consumption of up to 24% compared to the MY 2017 baseline [5]. They are based on expected technology improvements for engines, transmissions, drivelines, aerodynamics, tires, accessories, and extended idle reduction technologies. Tractors are certified with the Greenhouse Gas Emissions Model (GEM) [6].

Trailers

The contributions of trailers to fuel efficiency improvement are not regulated in Phase 1. The proposed Phase 2 standards apply to trailers pulled by Classes 7 and 8 tractors coupled to the fifth wheel. The most comprehensive requirements are applicable to traditional long-box trailers, both refrigerated and dry, which typically are pulled by high-roof cab tractors. The proposed changes center on improving aerodynamics and reducing rolling resistance. Compliance is determined with a version of GEM. The standards are less stringent for trailer categories with shorter boxes or trailers with aerodynamic limitations. Non-box trailers and non-aerodynamic box vans are required to adopt specific tire technologies to comply. In total, there are 10 separate categories:

- Long-box dry vans (longer than 50 feet)
- Long-box refrigerated vans (longer than 50 feet)
- Short-box dry vans (50 feet and shorter)
- Short-box refrigerated vans (50 feet and shorter)
- Partial-aero long-box dry vans
- Partial-aero long-box refrigerated vans
- Partial-aero short-box dry vans
- Partial-aero short-box refrigerated vans
- Non-aero box vans (all lengths of dry and refrigerated vans)
- Non-box trailers (tanker, platform, container chassis, and all other types of highway trailers that are not box trailers).

With the exception of refrigerated units, trailers typically do not directly emit GHGs. However, the proposed standards assign required levels of emissions and fuel consumption as if the trailers were pulled by a standard reference tractor [7]. The standards require reductions of 3% to 8% from MY 2021 to MY 2027 in fuel consumption and CO2 emissions, depending on the trailer type. Certain trailers are exempt, including those that operate only at low speed and those that are used for logging and mining. Trailers are also certified with GEM.

Vocational vehicles

Vocational vehicles are separated into three class groups: light heavy-duty (Classes 2b–5), medium heavy-duty (Classes 6–7), and heavy heavy-duty (Class 8). Each class group is separated by engine type (compression or spark ignition) and a duty cycle that captures expected vehicle usage and energy consumption. The three available duty cycles are urban, multi-purpose, and regional. Because power requirements for vocational vehicles vary widely, multiple baseline drivelines are available in the Phase 2 standards for calculating fuel efficiency and GHG emission improvements. Standards are set at increments starting in MY 2021, with updates in MY 2024 and MY 2027.

In comparison with MY 2017 baseline vehicles, the proposed standards require a 16% reduction in CO2 emissions and fuel consumption for all vehicles across all weight classes powered by compression ignition (primarily diesel) engines. Vocational vehicles powered by spark ignition engines are subject to emission and fuel-use reductions by MY 2027 of 12% for light heavy-duty, 13% for medium heavy-duty, and 12% for heavy heavy-duty. Like combination tractors and trailers, vocational vehicles are certified with GEM.

Certification for combination tractors, trailers, and vocational vehicles

As in Phase 1, compliance for tractors and vocational vehicles is certified in Phase 2 using an updated version of GEM that incorporates some fixed input values, such as payload and trailer weights, to determine fuel efficiency performance by drive cycle. Compliance can be achieved through adoption of various technology combinations. Improving on Phase 1, the Phase 2 GEM incorporates several changes to more accurately reflect the effects of technology adoption on fuel efficiency performance. These changes include road grade, an additional averaged aerodynamic drag coefficient, and improved simulation of engines and transmissions. Ultimately, the changes mean that a vehicle evaluated with the Phase 2 GEM would have higher CO2 emissions and fuel consumption than if evaluated with the Phase 1 GEM. Consequently, results from the two standards are not directly comparable. Trailers are modeled in GEM with attribute inputs for aerodynamics, tires, weight characteristics, and performance.

Results

The Phase 2 Standards case estimates fuel efficiency improvement and fuel consumption based on the proposed requirements for combination tractors, HD pickups and vans, and vocational vehicles. Trailer stocks are not explicitly modeled, because there are limited data on trailer inventories and usage; however, efficiency improvements as a result of the adoption of limited trailer improvements are included in the model. Between MY 2017 and MY 2027, the Phase 2 Standards case indicates that the proposed standards lead to the adoption of technologies to improve fuel economy that otherwise would not have been purchased. Although the standards do not start until MY 2021, manufacturers are expected to begin adoption beforehand to ensure initial compliance by MY 2021. Fuel economy and energy usage reports combine vocational and nonvocational vehicles for Classes 3, 4–6, and 7–8.

New vehicle average fuel economy increases for all size classes in the Phase 2 Standards case. From 2017 to 2027, new vehicle average fuel economy (combined Classes 3–8) rises by 28% in the Phase 2 Standards case compared to the Reference case. After 2027 the standards are held constant, but technology adoption continues as new technologies become available. In 2040, new vehicle fuel efficiency averages 10.6 miles per gallon gasoline equivalent in the Phase 2 Standards case, representing a 33% improvement compared to the Reference case. The improvements represent overcompliance as the model continues to adopt cost-effective technologies beyond 2027.

The increase in fuel economy of the entire vehicle stock is lagged, reflecting slow turnover in the stock of Classes 2b–8 trucks, which have a median lifetime of 12 years [8]. As new medium- and heavy-duty trucks are added to the total stock, and older trucks with lower fuel economy are removed from service, the average on-road fuel economy for the total stock of heavy-duty trucks increases in the Phase 2 Standards case (Figure IF2-1).

In comparison with the AEO2016 Reference case, differences in total vehicle sales and stocks are negligible in the Phase 2 Standards case. Between 2017 and 2040, new MDV and HDV sales per year are equal to about 5% of the total truck stock, ranging from about 660,000 to 790,000 new MDV and HDV sales per year out of a total stock that grows from 11.7 million in 2017 to 17.2 million in 2040. However, there is a shift away from natural gas and propane toward conventional diesel and gasoline in the Phase 2 Standards case. As the average fuel economy of conventional vehicles increases, there is less incentive to pay high capital costs for natural gas and propane vehicles, despite their lower fuel costs.

The most significant effect of Phase 2 is a reduction of diesel consumption—the most commonly used fuel—in medium- and heavy-duty vehicles. In the Reference case, MDV and HDV diesel consumption increases steadily through 2040, as industrial output grows (Figure IF2-2). In the Phase 2 Standards case, diesel consumption decreases from 2015 to 2033 as gains in fuel economy more than offset growth in transport requirements. After 2033, diesel consumption increases slowly without continued enhancement of the standard, but in 2040 it still is 18% lower in the Phase 2 Standards case than in the Reference case. Cumulative MDV and HDV consumption of diesel fuel from 2021 to 2040 in the Phase 2 Standards case is 2.5 billion barrels lower than in the Reference case.

The reduction in diesel consumption in the Phase 2 Standards case has significant implications for the mix, as well as the amount, of petroleum products consumed in the United States. Implications for refiners would depend on the extent to which similar

Figure IF2-1. Average on-road fuel economy of vehicles by weight class, 2005–40 (miles per gallon gasoline equivalent)

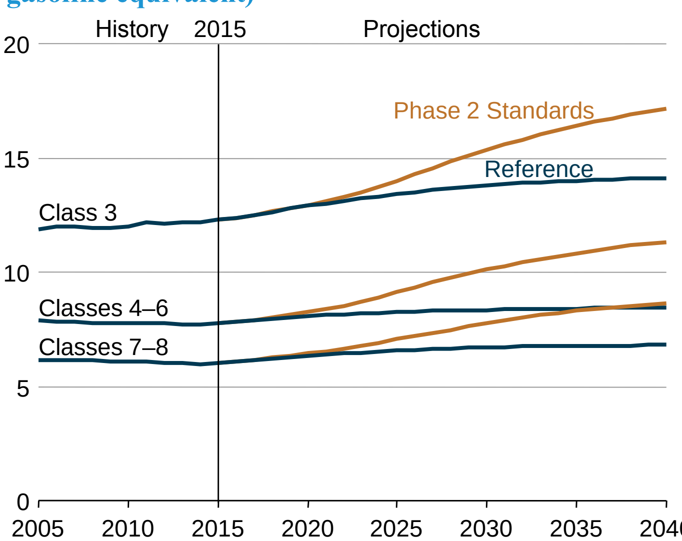
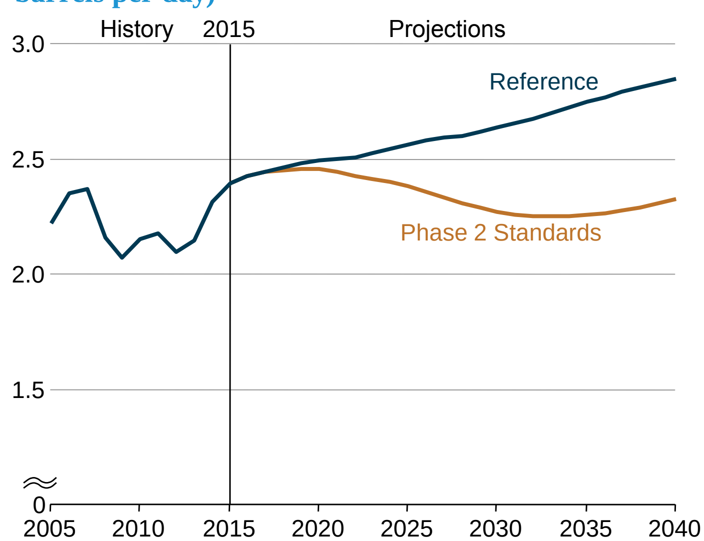


Figure IF2-2. Diesel fuel consumption by large trucks, Classes 3–8, in two cases, 2005–40 (million barrels per day)



standards were adopted in other countries with significant trucking activity, because diesel and other petroleum products are widely traded in global markets.

Consumption of other fuels by MDVs and HDVs—including gasoline, propane, liquefied natural gas (LNG), and compressed natural gas (CNG)—is lower in the Phase 2 Standards case than in the Reference case (Figure IF2-3). In the Phase 2 Standards case, diesel fuel consumption accounts for 90% of all fuel consumption by MDVs and HDVs in 2040, with the remainder consisting primarily of gasoline and a small amount of natural gas. The higher diesel share in the Phase 2 Standards case reflects a shift away from alternative fuels as improved fuel economy reduces the incentive to pay high capital costs for natural gas and propane vehicles despite their lower fuel costs.

In the Phase 2 Standards case, higher on-road fuel economy of the truck stock reduces total delivered energy consumption in the transportation sector. From 2021 to 2040, cumulative delivered energy consumption in the transportation sector is 3% lower in the Phase 2 Standards case than in the Reference case, and total transportation sector energy consumption in 2040 is about 750,000 barrels per day oil equivalent (22%) lower than in the Reference case (Figure IF2-4). Cumulative CO2 emissions from

Figure IF2-3. Fuel consumption by large trucks, Classes 3–8, in two cases, 2005–40 (million barrels oil equivalent per day)

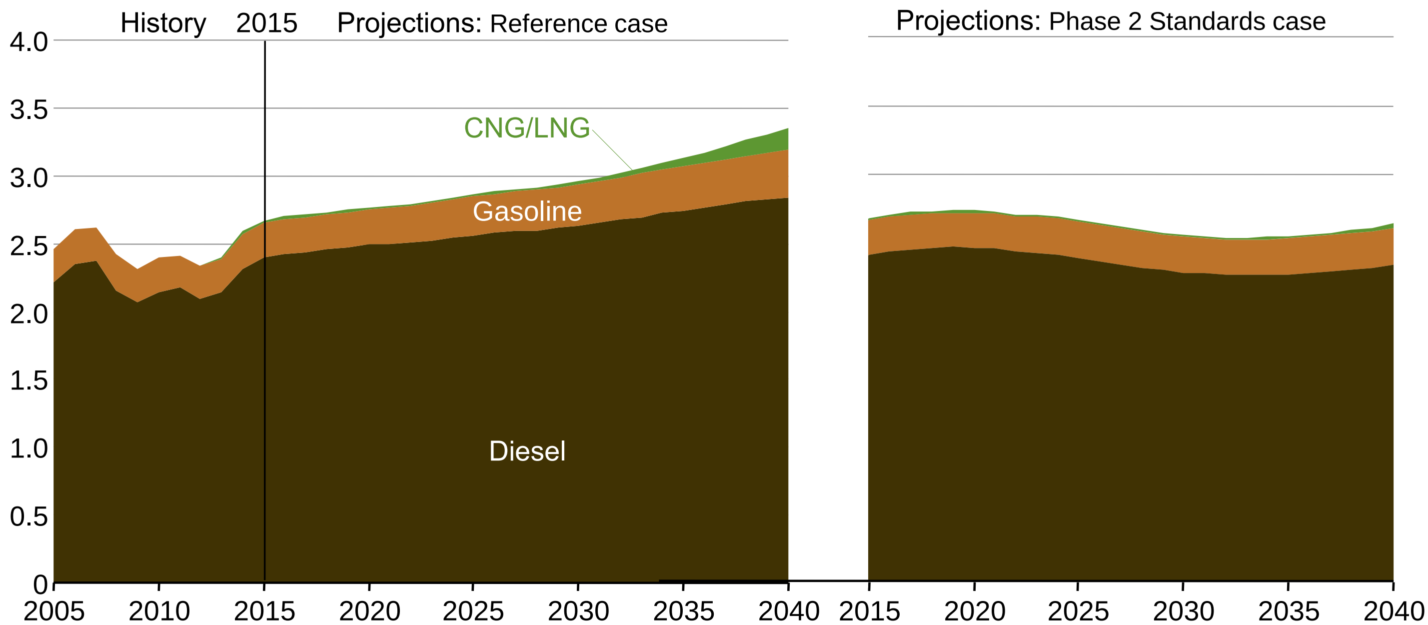
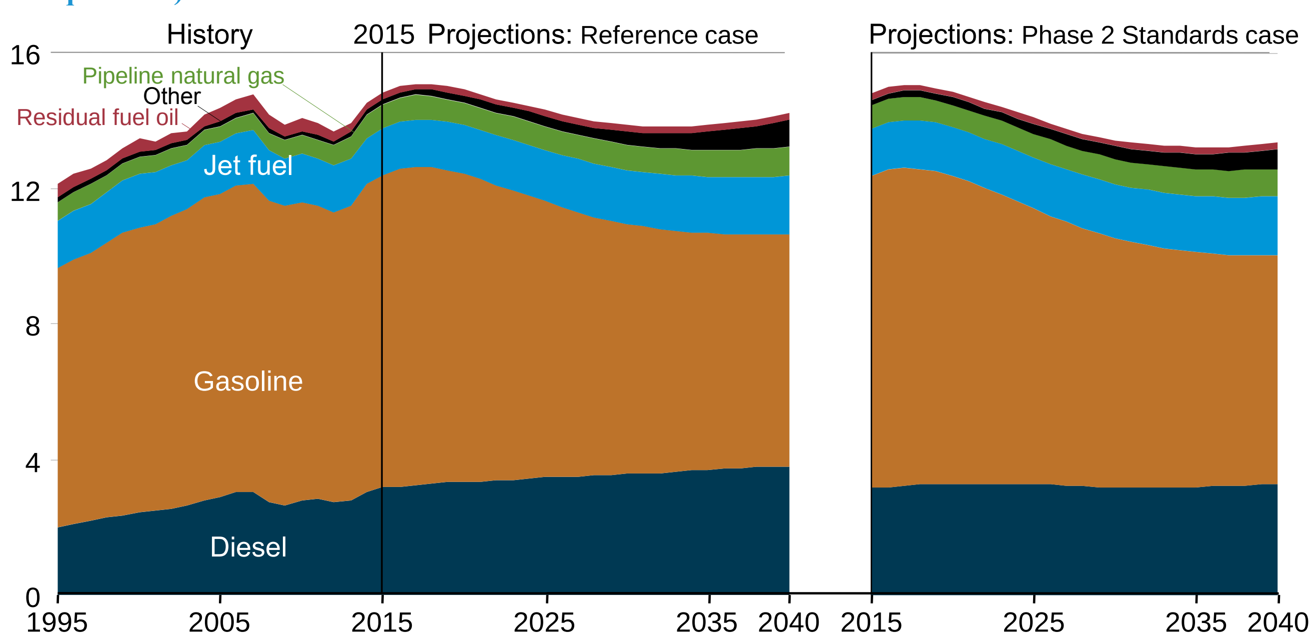


Figure IF2-4. Transportation sector energy consumption by fuel in two cases, 1995–2040 (million barrels per day oil equivalent)

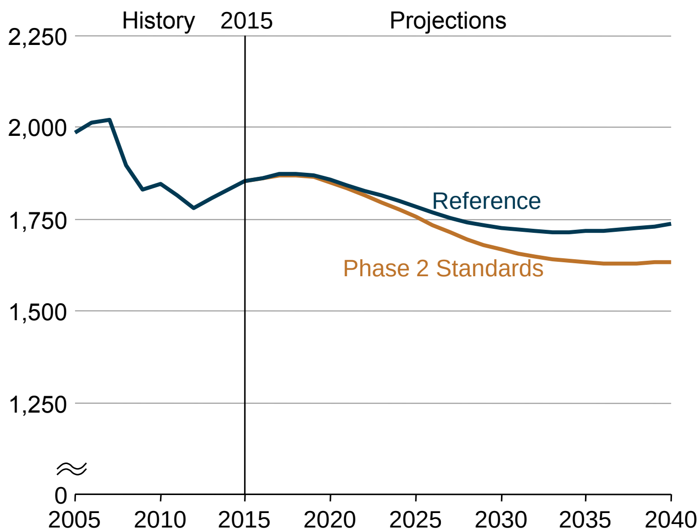


2021 to 2040 in the transportation sector are 1,200 million metric tons (3%) lower in the Phase 2 Standards case than in the AEO2016 Reference case. In 2040, total transportation sector CO2 emissions are 6% lower in the Phase 2 Standards case than in the AEO2016 Reference case (Figure IF2-5).

Regulatory and data issues

- Although Class 2b pickup trucks and vans are included in the Phase 2 Standards case, their fuel economy and consumption are not reported individually. However, the effects of Class 2b are included in total transportation fuel consumption and emissions data.
- The Phase 2 Standards case approximates the proposed rulemaking by disaggregating Class 7 and Class 8 tractor vehicle body types (based on data from the VIUS survey [9], which has not been updated since 2002). As a result, there may be significant differences between the tractor market today and more than a decade ago. Further, there are data uncertainties associated with vehicle usage reported in the VIUS survey. Nevertheless, the data were used because VIUS is the only source of information on tractor type.
- Trailers were not explicitly modeled in this study, because there are limited data on trailer inventories and usage. There are more registered trailers than tractors, and an understanding of usage logistics is critical to evaluating the adoption and overall results of improving trailer technology.
- Despite improvements since the start of Phase 1, there are still limits on data about the technologies used to meet the Phase 1 compliance standards. Consequently, it is difficult to estimate the energy outcomes that could be expected as medium- and heavy-duty trucks begin to comply with the new Phase 2 standards. Without better data, it is difficult to analyze the composition of the truck market at the level of diversity included in the proposed standards, or the efficiency and fuel economy metrics associated with each classification in the standards.
- A critical issue is the limited availability of information that would provide a baseline from which to measure improvement. The lack of baseline data is a result of the previously discussed data limitations, as well as operational changes in Phase 2 compared with Phase 1. Although many improvements have been made in GEM, the changes evaluation methods for the different technology categories make it difficult to map Phase 1 compliance to Phase 2. The baseline for Phase 2 (MY 2017) assumes compliance with Phase 1 at that time, and it is evaluated differently. As a result, it is not known whether Phase 1 compliant vehicles in MY 2017 accurately represent the proposed Phase 2 baseline.

Figure IF2-5. Transportation sector carbon dioxide emissions in two cases, 2005–40 (million metric tons)



- Continuing issues from Phase 1 include how compliance will be measured and how well compliance testing procedures will replicate the average real-world performance of combination tractors, heavy-duty pickups and vans, vocational vehicles, and trailers. Phase 2 has three vocational drive cycles that can be used for compliance (urban, multi-purpose, and regional). Only the multi-purpose cycle is used in the AEO2016 Phase 2 Standards case. GEM has many new categories and improvements compared with Phase 1, but many of the categories are simplified to Yes or No responses, rather than to custom inputs. Some inputs, including payload and trailer weights, are fixed.
- Compliance for heavy-duty pickups and vans will be determined by a vehicle test procedure similar to that used in the national program for light-duty vehicles, including the highway fuel economy test and the federal test procedure for city driving, weighted 45% and 55%, respectively. Heavy-duty pickups and vans are assumed to be loaded to one-half of their payload capacity.

Endnotes for IF2

Links current as of July 2016

1. U.S. Environmental Protection Agency and National Highway Traffic Safety Administration, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2" (Washington, DC: June 19, 2015), http://www.nhtsa.gov/fuel-economy.
2. Heavy-haul tractors have a gross combined weight rating of more than 120,000 pounds.
3. IHS-Polk Automotive, unpublished data (Southfield, MI: 2014).
4. Microdata available online at U.S. Department of Commerce, U.S. Census Bureau, "2002 Vehicle Inventory and Use Survey," https://www.census.gov/svsd/www/vius/2002.html.
5. U.S. Environmental Protection Agency and National Highway Traffic Safety Administration, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2" (Washington, DC: June 19, 2015), http://www.nhtsa.gov/fuel-economy.
6. The GEM model is a MATLAB/Simulink based model with a spreadsheet interface that determines compliance based on set factors and user inputs (such as vehicle class, engine data, transmission type, aerodynamics, technology adoption, etc.) with variations for the different vehicle types. U.S. Environmental Protection Agency, "Greenhouse Gas Emissions Model (GEM) for Medium- and Heavy-Duty Vehicle Compliance," https://www3.epa.gov/otaq/climate/gem.htm.
7. U.S. Environmental Protection Agency and National Highway Traffic Safety Administration, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2" (Washington, DC: June 19, 2015), http://www.nhtsa.gov/fuel-economy.
8. IHS-Polk Automotive, unpublished data (Southfield, MI: 2014).
9. Microdata available online at U.S. Department of Commerce, Bureau of the Census, "2002 Vehicle Inventory and Use Survey," https://www.census.gov/svsd/www/vius/2002.html.

Figure and table sources for IF2

Links current as of July 2016

Table IF2-1. Types of vehicles regulated by the proposed Phase 2 standards: U.S. Environmental Protection Agency and National Highway Traffic Safety Administration, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2" (Washington, DC: June 19, 2015), http://www.nhtsa.gov/fuel-economy.

Figure IF2-1. Average on-road fuel economy of all motor vehicles by weight class, 2005–40: AEO2016 National Energy Modeling System, runs REF2016.D0324A and PHASEII.D041316A.

Figure IF2-2. Diesel fuel consumption by large trucks, Classes 3–8, in two cases, 2005–40: History: U.S. Energy Information Administration, *Monthly Energy Review*, February 2016, DOE/EIA-0035(2016/02), http://www.eia.gov/totalenergy/data/monthly/archive/00351602.pdf. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D0324A and PHASEII.D041316A.

Figure IF2-3. Fuel consumption by large trucks, Classes 3–8, in two cases, 2005–40: History: U.S. Energy Information Administration, *Monthly Energy Review*, February 2016, DOE/EIA-0035(2016/02), http://www.eia.gov/totalenergy/data/monthly/archive/00351602.pdf. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D0324A and PHASEII.D041316A.

Figure IF2-4. Transportation sector energy consumption by fuel in two cases, 1995–2040: History: U.S. Energy Information Administration, *Monthly Energy Review*, February 2016, DOE/EIA-0035(2016/02), http://www.eia.gov/totalenergy/data/monthly/archive/00351602.pdf. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D0324A and PHASEII.D041316A.

Figure IF2-5. Transportation sector carbon dioxide emissions in two cases, 2005–40: History: U.S. Energy Information Administration, *Monthly Energy Review*, February 2016, DOE/EIA-0035(2016/02), http://www.eia.gov/totalenergy/data/monthly/archive/00351602.pdf. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D0324A and PHASEII.D041316A.

IF3. Extended Policies case

The *Annual Energy Outlook 2016* (AEO2016) Extended Policies case includes selected policies that go beyond current laws and regulations. Existing tax credits that have scheduled reductions and sunset dates are assumed to remain unchanged through 2040. Other efficiency policies, including corporate average fuel economy standards, appliance standards, and building codes, are expanded beyond current provisions; and the U.S. Environmental Protection Agency (EPA) Clean Power Plan (CPP) [*1*] regulations that reduce carbon dioxide emissions from electric power generation are tightened after 2030.

No attempt is made to cover the full range of possible uncertainties, and the policy assumptions used in the Extended Policies case should not be construed as a U.S. Energy Information Administration (EIA) opinion regarding how laws or regulations should, or are likely to, be changed. The Extended Policies case includes only federal laws and regulations and does not include state laws or regulations. In general, the Extended Polices case leads to lower estimates for overall delivered energy consumption, increased use of renewable fuels (particularly for electricity generation), reduced energy-related carbon dioxide (CO2) emissions, lower energy prices, and higher government tax expenditures.

Background

The AEO2016 Reference case is best described as a current laws and regulations case, because it generally assumes that existing laws and regulations remain unchanged throughout the projection period, except for those current laws or regulations that include sunset dates or specific changes over time. The Reference case serves as a starting point for analysis of proposed changes in legislation or regulations. The Extended Policies case assumes updates or extensions of current laws and regulations, including:

- Laws or regulations that have a history of being extended beyond their legislated sunset dates. Examples include the various tax credits for renewable fuels and technologies, which have been extended with or without modifications several times since their initial implementation.
- Laws or regulations that call for periodic updating of initial specifications. Examples include appliance efficiency standards issued by the U.S. Department of Energy (DOE) and Corporate Average Fuel Economy (CAFE) and greenhouse gas (GHG) emissions standards for vehicles issued by the National Highway Traffic Safety Administration (NHTSA) and EPA.
- Laws or regulations that allow or require regulatory agencies to issue new or revised regulations under certain conditions. Examples include many provisions of the Clean Air Act that require EPA to issue or revise regulations if it finds that an environmental quality goal is not being met.

Extended Policies case

The Extended Policies case adopts the following assumptions:

- Electricity generation technologies eligible for the Production Tax Credit (PTC) retain their full credit value through 2040, as opposed to declining in value starting in 2017 (wind) or expiring at the end of 2016 (other PTC-eligible technologies, including geothermal and hydroelectric).
- For solar power, the full Investment Tax Credit (ITC) value of 30% remains in effect through 2040 for the residential, commercial, and electric power sectors, whereas in the Reference case, the value of the ITC begins to decline in 2020.
- In the buildings sector, tax credits for the purchase of energy-efficient and renewable equipment are assumed to be extended indefinitely at their current levels. For the residential sector, the extensions include personal tax credits for solar photovoltaic (PV) installations, solar water heaters, small wind turbines, fuel cells, and geothermal heat pumps. For the commercial sector, the extensions include the business ITC for solar PV, solar water heaters, small wind turbines, fuel cells, microturbines, geothermal heat pumps, and conventional combined heat and power (CHP). The ITC for solar PV and solar water heaters is assumed to remain at 30%, rather than being phased out in 2022 (residential systems) or declining to 10% (commercial systems).
- Standards for residential and commercial equipment are assumed to be updated as prescribed by the timeline in the DOE multi-year plan, at levels based on ENERGY STAR™ specifications or on Federal Energy Management Program purchasing guidelines for federal agencies, as applicable. Standards also are updated for products that currently are not subject to federal efficiency standards but are covered by voluntary industry agreements or by prevailing state standards.
- Federal energy codes for residential and commercial buildings are assumed to be updated twice over the projection, with implementation beginning in 2025 and in 2034, each phased in over nine years. The updates provide additional improvements to new construction. The equipment standards and building codes assumed for the Extended Policies case are meant to illustrate the potential effects of those policies on energy consumption for buildings. No cost-benefit analysis or evaluation of impacts on consumer welfare was completed in developing the assumptions. Likewise, no technical feasibility analysis was conducted, although standards were not allowed to exceed the maximum technologically feasible levels described in DOE's technical support documents.
- The Reference case and the Extended Policies case include the joint attribute-based CAFE and vehicle greenhouse gas (GHG) emissions standards for model years (MY) 2012 to 2025 for light-duty vehicles (LDV). In the Reference case, the CAFE standards are assumed to remain constant at MY 2025 levels in subsequent model years, although the fuel economy of new

LDVs continues to rise modestly over time. The Extended Policies case assumes continued increases in CAFE standards at an annual average rate of 1.4% for new LDVs after MY 2025.

- The Reference case and the Extended Policies case include the medium-duty vehicle (MDV) and heavy-duty vehicle (HDV) fuel consumption and GHG emissions standards for MY 2014 to MY 2018. In the Reference case, the standards are held constant at MY 2018 levels in subsequent model years, although the fuel economy of HDVs continues to rise modestly. The Extended Policies case includes tighter standards for fuel consumption and GHG emissions for MDVs and HDVs, as proposed in the Phase 2 standards jointly issued by EPA and NHTSA in July 2015 [*2*].
- The Reference case includes the CPP, which under current regulations is phased in over the 2022–30 period, and assumes that states comply by setting mass-based compliance strategies that cover both existing and new electric generators. The Extended Policies case assumes a further reduction in the CO2 targets after 2030. The mass-based limits, which in the Reference case result in power sector CO2 emissions that in 2030 are about 35% below 2005 levels, are assumed to continue to decline linearly to 45% below 2005 emission levels in 2040 in the Extended Policies case.
- In the industrial sector, the 10% ITC for combined heat and power (CHP), which in the Reference case ends in 2016 [*3*], continues through 2040. Also, the ITC is modified to increase the size limit for eligible CHP units from 15 megawatts (MW) to 25 MW. The ITC for CHP is extended to cover all properties with CHP, no matter the powerplant size, instead of being limited to properties with plants smaller than 50 MW as in the Reference case [*4*]. These extensions are consistent with previously proposed legislation.

Analysis results

In general, estimates for overall delivered energy consumption are lower in the Extended Policies case than in the Reference case, with renewable fuels providing an increasing share of U.S. electricity generation and total energy-related CO2 emissions declining. Average electricity prices are marginally affected, leading to small declines in 2040 relative to the Reference case. Energy expenditures are lower in the Extended Policies case than in the Reference case, because the assumed tax credits and efficiency standards lead to lower energy demand. Appliance purchase costs also are affected, and government tax expenditures generally are higher as consumers and businesses take advantage of the tax credits.

Energy consumption

Total energy consumption in the Extended Policies case is lower than in the AEO2016 Reference case throughout the projection period (Figure IF3-1) as a result of improvements in energy efficiency. In 2040, total energy consumption in the Extended Policies case is 4% lower than in the Reference case, as the combination of the extension of tax credits and other policies reduces overall demand even after taking price declines into account.

Buildings sector energy consumption

In the Extended Policies case, delivered energy consumption in the buildings sector falls below its 2015 level from 2022 to 2034 (Figure IF3-2), with renewable distributed generation (DG) technologies (PV systems and small wind turbines) providing much of the energy savings. With the continuation of tax credits spurring wider adoption of DG systems, onsite electricity generation from renewable DG increases to 90 billion kilowatthours (kWh) in 2025, compared with 61 billion kWh in the Reference case. In 2040, onsite electricity generation from renewable sources totals 249 billion kWh in the Extended Policies case—nearly double the Reference case total.

Figure IF3-1. Total energy consumption in two cases, 2000–2040 (quadrillion Btu)

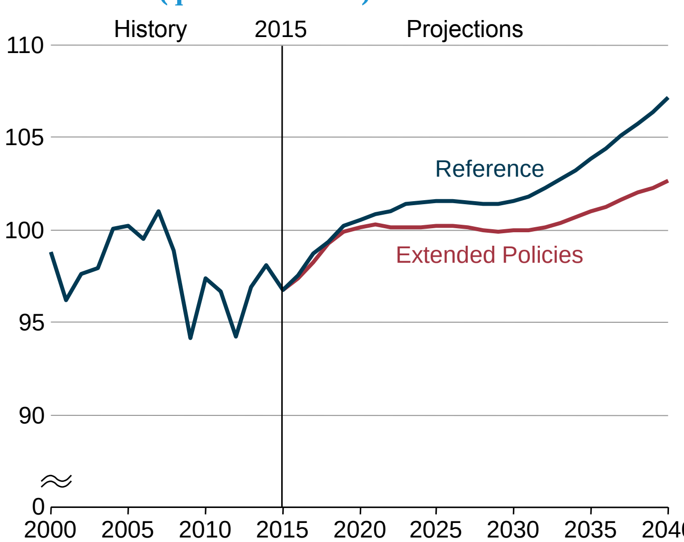
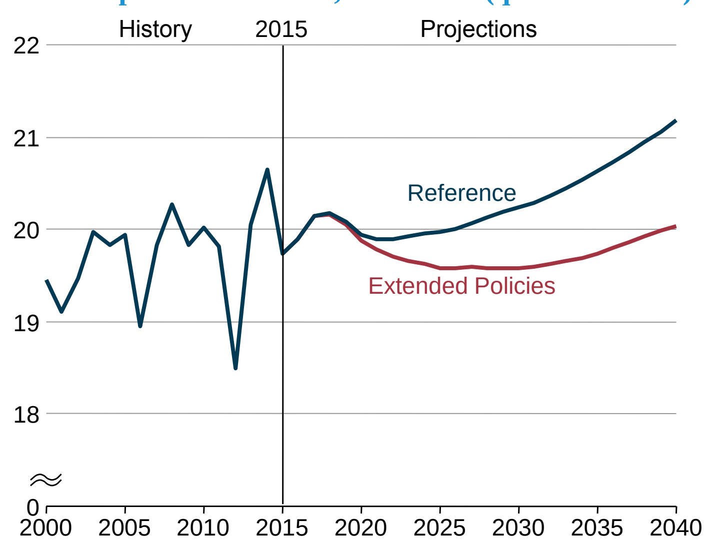


Figure IF3-2. Buildings sector delivered energy consumption in two cases, 2000–2040 (quadrillion Btu)



Efficiency gains from assumed future standards and more stringent building codes further reduce delivered energy use in the buildings sectors in the Extended Policies case. Including savings from distributed generation, delivered energy use in the buildings sector in the Extended Policies case is 1.9%, or 0.4 quadrillion British thermal units (Btu), lower than in the Reference case in 2025 and 5.4%, or 1.1 quadrillion Btu, lower than in the Reference case in 2040.

Among delivered energy sources, electricity is the buildings fuel source most affected in the Extended Policies case. Efficiency standards and buildings codes affect appliances that run on all fuels, but distributed generation has a larger impact on electricity purchases than other fuel purchases. In comparison with the Reference case, building sector electricity purchases are 2.6% lower in the Extended Policies case in 2025 and 7.4% lower in 2040, and natural gas and distillate fuel oil purchases are 3.7% and 1.6% lower, respectively, in 2040.

Energy consumption levels for all end uses are lower in the Extended Policies case than in the Reference case (Figure IF3-3), with space heating, cooling, and ventilation accounting for almost 50% of the reduction. Delivered energy consumption continues to grow for many end uses in the buildings sector, as commercial floorspace and the number of households continue to expand. In particular, energy consumption for laundry and other uses, which includes small devices and other miscellaneous uses that typically are not covered by efficiency standards.

Industrial sector energy consumption

In the industrial sector, the 10% ITC for CHP is extended to 2040 in the Extended Policies case, the maximum size of individual generating units eligible for the ITC is increased from 15 MW to 25 MW, and there is no ITC cap on total plant size (compared with a cap of 50 MW in the Reference case). Although most CHP units are smaller than 15 MW, approximately 15% of operable industrial CHP units as of 2014 were between 15 MW (the unit size cap in the Reference case) and 25 MW (the unit size cap in the Extended Policies case). In addition to the tax credit extension, the higher size cap also has an effect, given that 30% of operable CHP plants in 2014 exceeded the Reference case cap of 50 MW [5]. In 2040, industrial CHP capacity is 8% higher in the Extended Policies case than in the Reference case (Figure IF3-4), and delivered energy intensity is slightly lower.

Transportation sector energy consumption

The Extended Policies case differs from the AEO2016 Reference case in assuming that the joint CAFE and GHG emissions standards promulgated by EPA and NHTSA for MY 2012–25 are extended through 2040 with an average annual increase of 1.4%. Sales of LDVs that do not rely solely on gasoline internal combustion engines for power (including those that use diesel, alternative fuels, or hybrid electric systems) play a substantial role in meeting the higher fuel economy standards after 2025, growing to 80% of new LDV sales in the Extended Policies case, compared with 61% in the Reference case, in 2040.

In the Reference case, LDV energy consumption declines from 15.9 quadrillion Btu, or 8.6 million barrels per day (b/d) oil equivalent, in 2015 to 14.1 quadrillion Btu (7.7 million b/d oil equivalent) in 2025 as a result of more stringent CAFE standards. Extension of the CAFE standards in the Extended Policies case further reduces LDV energy consumption, to 11.0 quadrillion Btu (6.0 million b/d oil equivalent) in 2040, or 7% lower than in the Reference case.

The Extended Policies case includes the proposed Phase 2 standards for MDVs and HDVs. The average fuel economy of new MDVs and HDVs increases from a combined 7.4 miles per gallon (mpg) in 2017 to 10.8 mpg in 2040 in the Extended Policies case. MDV and HDV annual energy consumption falls from 5.6 quadrillion Btu (2.7 million b/d oil equivalent) in 2015 to 5.4 quadrillion Btu

Figure IF3-3. Changes in buildings sector delivered energy consumption by end use in two cases, 2015–40 (percent)

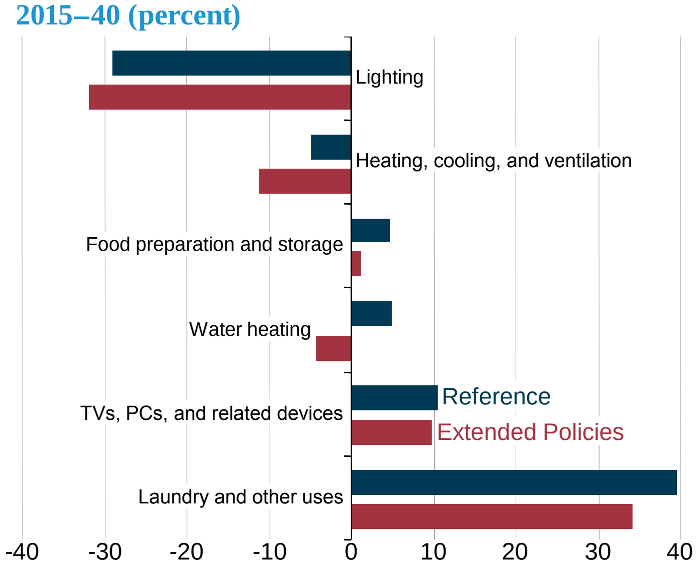
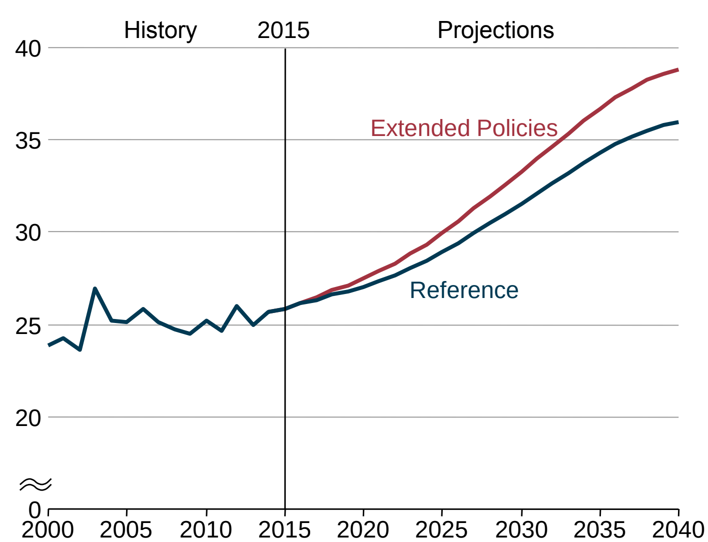


Figure IF3-4. Industrial sector combined heat and power capacity in two cases, 2000–2040 (megawatts)



(2.6 million b/d oil equivalent) in 2040 in the Extended Policies case. In 2040, MDV and HDV fuel consumption is 1.6 quadrillion Btu (0.8 million b/d oil equivalent), or 23%, lower than in the Reference case. Consumption of petroleum and other liquids in the transportation sector declines in the Extended Policies case from 14.3 million b/d oil equivalent in 2017 to 11.6 million b/d oil equivalent in 2040, compared with 12.7 million b/d oil equivalent in 2040 in the Reference case (Figure IF3-5).

Electricity generation

The Extended Policies case assumes that the value of the tax credits for eligible renewable electricity generation sources as of 2016 is extended through 2040, and that the stringency of the CPP increases from 2030–40, requiring emissions in 2040 to be 45% below the 2005 total. As a result, coal-fired generation declines to 779 billion kWh in 2040 in the Extended Policies case, compared with 919 billion kWh in the Reference case (Figure IF3-6). Generation from oil and natural gas in 2040 also is lower in the Extended Policies case, at 1,686 billion kWh, compared with 1,952 billion kWh in the Reference case. Generation from renewable technologies in 2040 is higher in the Extended Policies case, at 1,663 billion kWh, than in the Reference case (1,374 billion kWh), and nuclear power generation is virtually the same in the two cases.

The Extended Policies case includes energy efficiency measures that result in slower load growth and lower demand for new generating capacity. Because of those measures, differences in renewable technology trends between the Extended Policies case and the Reference case can be seen in the mix of energy sources for electricity generation. As a result of the PTC extension for wind energy in the Extended Policies case, the share of electricity generation from wind resources declines from Reference case levels in the near term. Wind projects built in anticipation of expiring tax credits in the Reference case are built later in the projection period in the Extended Policies case, at a time when electricity demand and economic conditions are more favorable. In 2040, the share of electricity generation from wind energy resources is larger in the Extended Policies case than in the Reference case (Figure IF3-7).

In the Extended Policies case, the share of total electricity generation from wind resources more than doubles, from 5% in 2015 to 13% in 2040, as compared with 9% in 2040 in the Reference case. In the Extended Policies case, extension of the PTC through 2040 makes wind projects more attractive throughout the projection. In the Reference case, the value of the PTC starts to decline in 2017 and expires in 2020, and as a result, more wind capacity is added earlier in the projection

Figure IF3-5. Transportation sector petroleum and other liquids demand in two cases, 2000–2040 (million barrels per day)

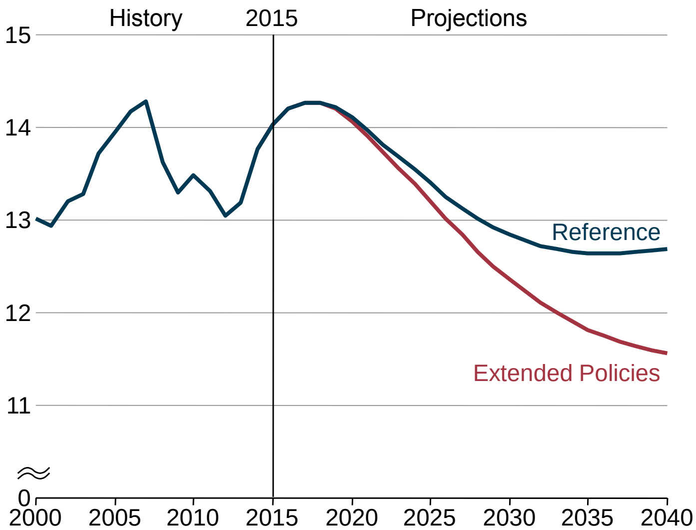
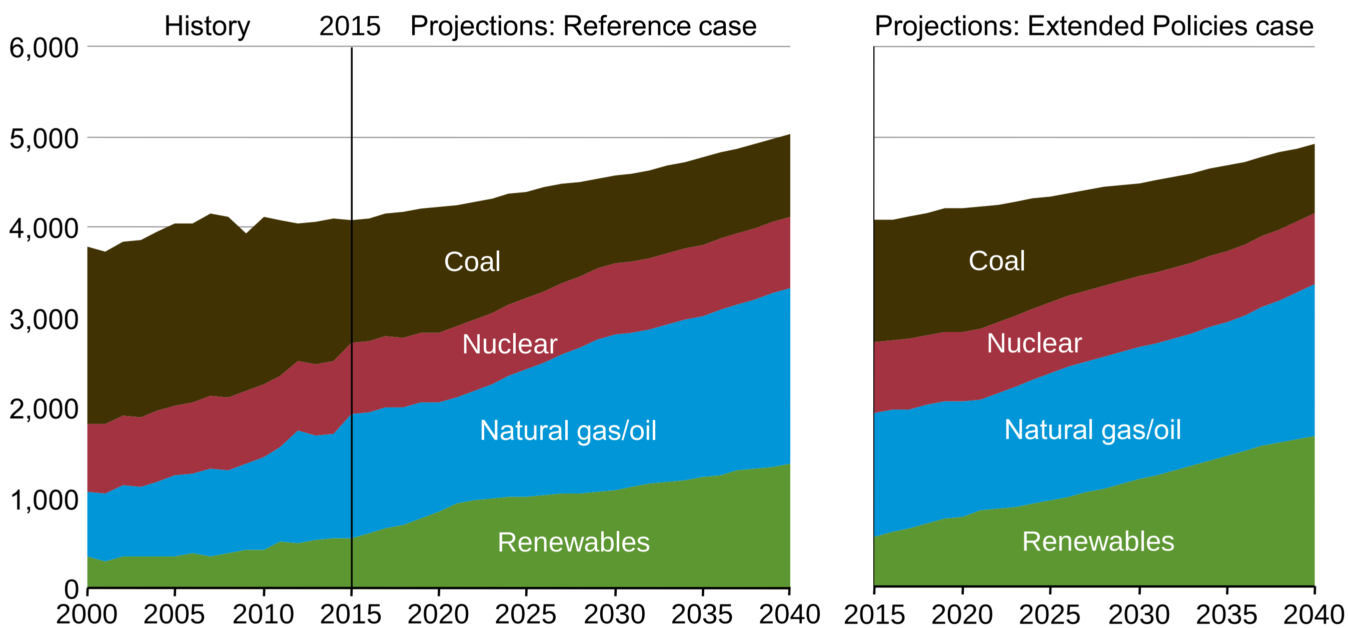


Figure IF3-6. Electricity generation by fuel in the Reference and Extended Policies cases, 2000–2040 (billion kilowatthours)



period. In the Extended Policies case, more capacity is added after 2020, and more electricity is generated from wind installations, than in the Reference case.

The solar ITC for utility-scale projects in the Reference case decreases gradually from 30% in 2019 to 10% by 2022. In the Extended Policies case, the value of the ITC remains at 30% through 2040, and as a result, the share of total electricity generation from utility-scale solar PV increases from 0.5% in 2015 to 8.0% in 2040, compared with 6.8% in 2040 in the Reference case.

While tax credits for residential projects expire in the Reference case, and those for commercial projects decline to 10% starting in 2022, the solar ITC continues through 2040 in the Extended Policies case. As a result, electricity generation from solar PV in the end-use sector grows more rapidly in the Extended Policies case than in the Reference case, by an average of 10.6%/year from 2015 to 2040, compared with 8.4%/year in the Reference case—as a result of the extension of the solar ITC through 2040 in the Extended Policies case, while tax credits for residential projects expire and those for commercial projects decline to 10% starting in 2022 in the Reference case. The effects of tax credit extensions on other eligible renewable generation technologies, including hydropower, biomass, and geothermal, are minimal in comparison.

Energy-related CO2 emissions

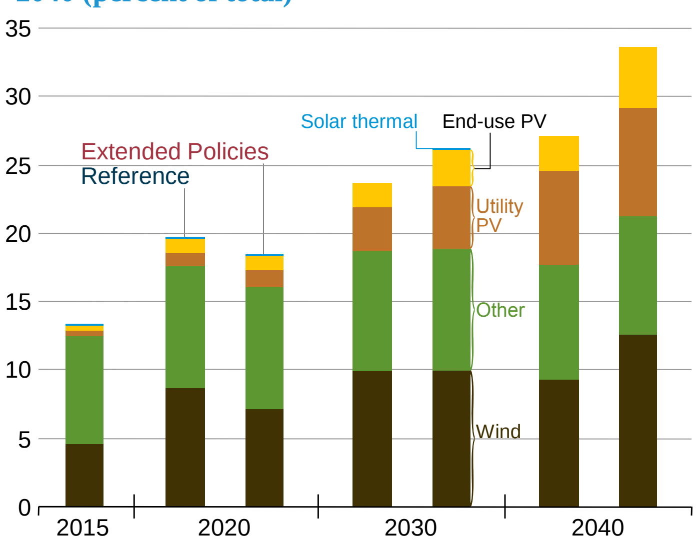
In the Extended Policies case, lower overall demand for fossil energy results in lower energy-related CO2 emissions than in the Reference case (Figure IF3-8). From 2015 to 2040, energy-related CO2 emissions are reduced by a cumulative total of 3.2 billion metric tons (or 2.4%) in the Extended Policies case compared with the Reference case. Electric power sector emissions also differ significantly between the two cases after 2030, reflecting the impact of more stringent CPP requirements over the 2030–40 period. With the CPP becoming more stringent after 2030, cumulative power sector CO2 emissions are reduced by 1.3 billion metric tons (or 3.0%) from 2015 to 2040 in the Extended Policies case compared with the Reference case. The increase in fuel economy standards for new LDVs, MDVs, and HDVs in the Extended Policies case accounts for 50% of the total cumulative reduction in CO2 emissions from 2015 to 2040 in comparison with the Reference case. The rest of the increase results from greater improvement in appliance efficiencies and increased penetration of renewable electricity generation.

Because the effects of the Extended Policies case on energy use and CO2 emissions increase over time, the maximum percentage difference in projected emissions between the Reference case and the Extended Policies case occurs in 2040 (8.4% lower in the Extended Policies case than in the Reference case). In the Extended Policies case, space cooling, water heating, and small devices and miscellaneous end uses together account for most of the emissions reductions from Reference case levels in the buildings sector, and lower petroleum use accounts for most of the emissions reductions in the industrial sector.

Energy prices and tax credit payments

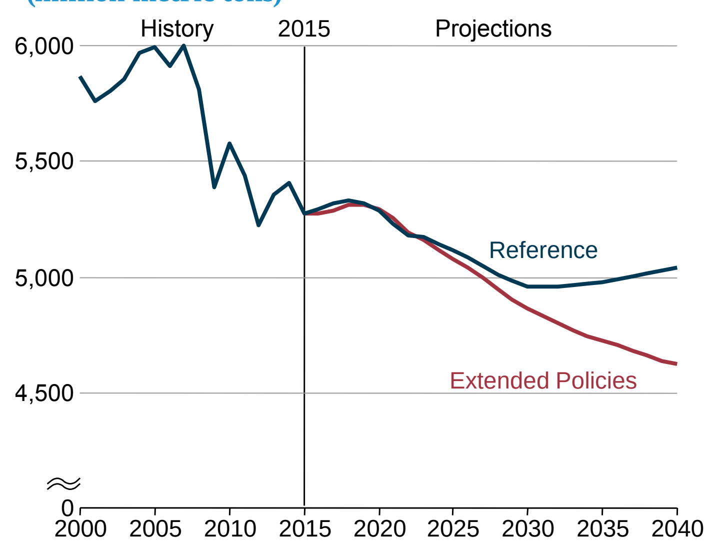
Average electricity prices in both the Reference case and Extended Policies case remain in a relatively tight range between 10.1 cents/kWh and 10.9 cents/kWh (2015 dollars) through 2040 (Figure IF3-9). Electricity prices in the near term are higher in the Extended Policies case than in the Reference case. With the certainty of continued tax credits in the Extended Policies case, renewable capacity—particularly wind—is added later than in the Reference case, resulting in more electricity generation from natural gas, which increases fuel costs and electricity prices. As more renewable capacity is added later in the Extended Policies

Figure IF3-7. Renewable electricity generation by energy source in two cases, 2015, 2020, 2030, and 2040 (percent of total)



Note: "Other" includes generation from hydroelectric, geothermal, and biomass sources.

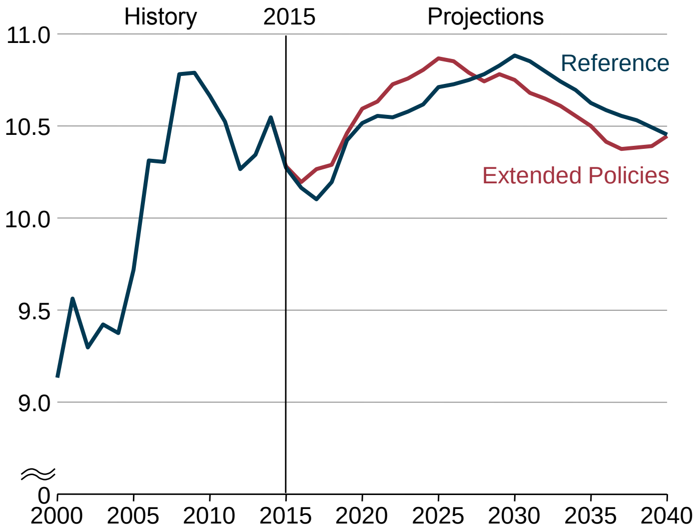
Figure IF3-8. Energy-related carbon dioxide emissions in two cases, 2000–2040 (million metric tons)



case, electric power sector fuel costs decline, leading to lower electricity prices. Increased energy efficiency expenditures in the Extended Policies case bring electricity prices back to levels close to those in the Reference case in 2040.

The reductions in delivered energy consumption and CO2 emissions in the Extended Policies case are accompanied by higher equipment costs for consumers and increased tax expenditures that reduce tax revenue for the U.S. government. In comparison with the AEO2016 Reference case, residential and commercial consumers in the Extended Policies case pay an extra $15.6 billion/year (2015 dollars) on average from 2015 to 2040 for end-use equipment, residential building shell improvements, and additional distributed generation systems. The government pays an extra $7.3 billion/year on average in tax credits to consumers (or, from the government's perspective, net revenues are reduced by that amount) in the buildings sector. The additional investments by consumers in the Extended Policies case are offset, however, by savings on energy purchases as a result of efficiency improvements and increases in distributed generation. Compared with the Reference case, consumers in the residential and commercial sectors save an average of $14.9 billion (2015 dollars) in annual energy costs from 2015 to 2040 in the Extended Policies case.

Figure IF3-9. U.S. average electricity prices in two cases, 2000–2040 (2015 cents per kilowatthour)



In the electric power sector, the extension of the PTC in the Extended Policies case increases government tax expenditures by approximately $4.1 billion/year from 2015 to 2040, compared with $2.0 billion/year in the Reference case. Most of the change in tax expenditures between the two cases is attributable to additional generation from wind energy. Over the 2015–40 period, the ITC increases government tax expenditures in the electric power sector by approximately $3.6 billion/year in the Extended Policies case, compared with $1.6 billion/year in the Reference case, primarily as a result of additional credits for utility-scale PV in the Extended Policies case. For all sectors combined, tax credit extensions in the Extended Policies case over the 2015–40 period have an average aggregate value of $16.4 billion/year, or more than three times the average of $5.1 billion/year in the Reference case.

Endnotes for IF3

Links current as of July 2016

1. U.S. Environmental Protection Agency, "Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22837/standards-of-performance-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed-stationary; and U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.
2. U.S. Environmental Protection Agency and National Highway Traffic Safety Administration, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2" (Washington, DC: June 19, 2015), http://www.nhtsa.gov/fuel-economy.
3. United States Internal Revenue Code, Title 26, Subtitle A—Income Taxes, §48(a)(2)(A)(ii), https://www.gpo.gov/fdsys/pkg/USCODE-2011-title26/pdf/USCODE-2011-title26-subtitleA-chap1-subchapA-partIV-subpartE-sec48.pdf.
4. United States Internal Revenue Code, Title 26, Subtitle A—Income Taxes, §48(c)(3)(B)(iii), https://www.gpo.gov/fdsys/pkg/USCODE-2011-title26/pdf/USCODE-2011-title26-subtitleA-chap1-subchapA-partIV-subpartE-sec48.pdf.
5. U.S. Energy Information Administration, Form 860, 2014 data (Washington, DC: October 21, 2015; corrected February 21, 2016): https://www.eia.gov/electricity/data/eia860/.

Figure sources for IF3

Links current as of July 2016

Figure IF3-1. Total energy consumption in two cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2016/02) (Washington, DC: February 2016). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-2. Buildings sector delivered energy consumption in two cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2016/02) (Washington, DC: February 2016). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-3. Changes in buildings sector delivered energy consumption by end use in two cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-4. Industrial sector combined heat and power capacity in two cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2016/02) (Washington, DC: February 2016). Projections: AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-5. Transportation sector petroleum and other liquids demand in two cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2016/02) (Washington, DC: February 2016. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-6. Electricity generation by fuel in the Reference and Extended Policies cases, 2000–2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-7. Renewable electricity generation by energy source in two cases, 2015, 2020, 2030, and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-8. Energy-related carbon dioxide emissions in two cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2016/02) (Washington, DC: February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

Figure IF3-9. U.S. average electricity prices in two cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2016/02) (Washington, DC: February 2016). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D051216A.

IF4. Hydrocarbon gas liquids production and related industrial development

Hydrocarbon gas liquids (HGL) are produced at refineries from crude oil and at natural gas processing plants from unprocessed natural gas. From 2010 to 2015, total HGL production increased by 42%. Natural gas processing plants accounted for all the increase, with recovered natural gas plant liquids (NGPL)—light hydrocarbon gases such as propane—rising by 58%, from 2.07 million barrels per day (b/d) in 2010 to 3.27 million b/d in 2015, while refinery output of HGL declined by 7%. The rapid increase in NGPL output was the result of rapid growth in natural gas production, as production shifted to tight gas and shale gas resources, and as producers targeted formations likely to yield natural gas with high liquids content.

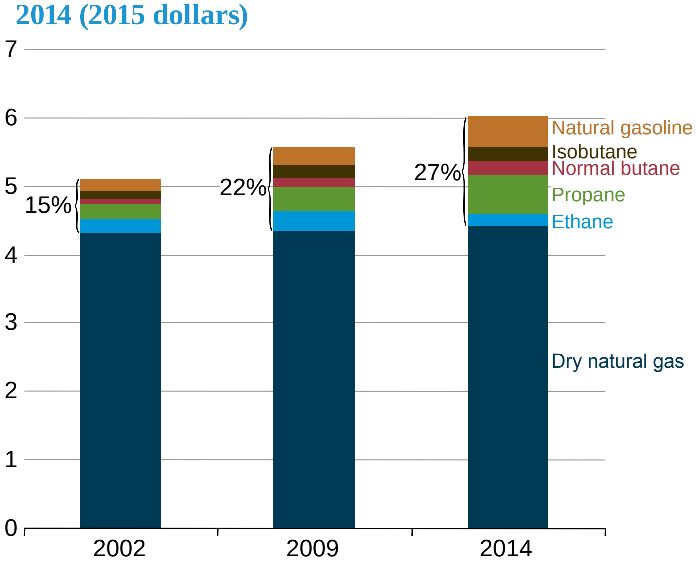
NGPL, contained in the unprocessed natural gas stream, are recovered from natural gas at gas processing plants, yielding a stream of liquids that is then separated at fractionation plants into ethane, propane, normal butane, isobutane, and natural gasoline, as well as dry natural gas (or residue gas), which is moved to markets. On an energy content basis, NGPL prices historically have been close to the prices of petroleum products and are generally well above the price of natural gas. This premium on the recovered NGPL portion of the unprocessed natural gas stream generates additional revenue beyond what is achievable from the sale of unprocessed natural gas at the dry natural gas prices alone.

The additional revenue from NGPL sales can vary significantly, depending on the relative prices of NGPL and natural gas (Figure IF4-1). NGPL prices are linked to both crude oil prices and natural gas prices. In 2002, 2009, and 2014, Henry Hub spot natural gas prices averaged between $4.33 and $4.44 per million British thermal units (Btu), while North Sea Brent crude oil prices averaged $5.63 per million Btu ($32.33/barrel (b)) in 2002, $11.81 per million Btu ($67.82/b) in 2009, and $17.40 per million Btu ($99.92/b) in 2014 (all prices in 2015 dollars).

Changes in industry practice, combined with the increasing premium generated by the NGPL component of the unprocessed natural gas stream relative to dry natural gas, resulted in both an increasing share of Btu coming from NGPL, relative to dry natural gas, and rapid growth in the value generated by those liquids, relative to the dry natural gas component of the unprocessed natural gas. Consequently, although the NGPL contribution to the total Btu value of natural gas produced increased only marginally, from 11.6% in 2002 to 13.4% in 2014, its contribution to the total value of natural gas produced nearly doubled, from 15.1% in 2002 to 26.7% in 2014 (Figure IF4-2).

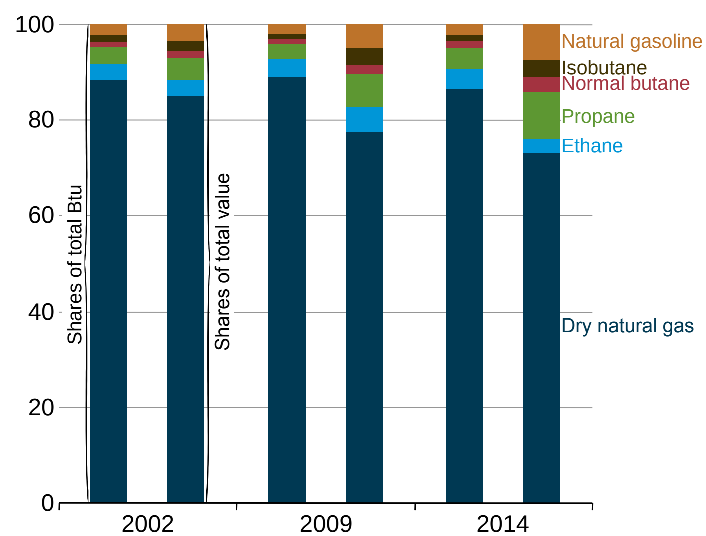
Natural gas production from tight and shale gas formations has grown rapidly in recent years. From 2010 to 2015, total U.S. gross withdrawals, the broadest measure of total wellhead flows, increased by 23%, from 73.5 billion cubic feet per day (Bcf/d) to 90.1 Bcf/d. The geography of natural gas production has also changed over this period, with the northeastern United States (previously a net recipient of large amounts of natural gas from the rest of the country and abroad) now producing more natural gas than it uses. The Marcellus Formation, which underlies much of West Virginia, Pennsylvania, and other states in the northern Appalachian region, has become the most prolific natural gas-producing formation in the country. The presence of the Utica Formation, which overlaps but is deeper than the Marcellus Formation, bolsters production in the Northeast and improves the economics for producers, adding to their return on investment.

Figure IF4-1. U.S. revenue per million Btu of unprocessed natural gas generated by natural gas plant liquids and dry natural gas, 2002, 2009, and 2014 (2015 dollars)



Note: Values are U.S. averages based on natural gas prices reported at the Henry Hub natural gas plant liquid prices at Mont Belvieu, Texas.

Figure IF4-2. Relative heat contents and values of natural gas plants liquids, 2002, 2009, and 2014 (percent of total)



Changes accompanying the rapid shift of natural gas production, both geographically and geologically, have required all segments of the oil and gas industry to adapt: producers have moved personnel and equipment to the locations of the new resources; midstream companies have started building additional natural gas processing and pipeline capacity; and consuming industries such as power producers and petrochemicals have invested in new plants and related infrastructure.

The recent surge in natural gas production, together with several mild winters that lower natural gas demand, resulted in a decline in U.S. natural gas prices (as reported at the Henry Hub natural gas trading hub) from $6.33/million Btu in January 2010 to $2.23/million Btu in January 2016 (2015 dollars). The increasing spread between spot natural gas prices and Brent crude oil prices, on which NGPL prices are largely based, spurred producers to explore for and develop natural gas resources that yield a higher share of NGPL. When crude oil prices started falling in late 2014, the premium commanded by NGPL over dry natural gas diminished, and producers began to shift activity out of areas with high liquids yield to resources yielding higher quantities of pipeline-ready natural gas at the lowest net production cost.

Activity in the Rocky Mountains region (Petroleum Administration for Defense District 4 [PADD 4]) illustrates the shift from development of dry natural gas resources to wet natural gas resources as the ratio of crude oil prices to natural gas prices increases. Historically, Wyoming has accounted for most of the natural gas production in PADD 4. In January 2010, more than 7 Bcf/d of natural gas was produced in Wyoming, accounting for 56% of the PADD 4 total. Natural gas produced in Wyoming is generally considered dry. The U.S. Geological Survey has reported that natural gas produced from coalbed resources in the Powder River Basin, which underlies eastern Wyoming and Montana, contains "trace amounts (0.005 to 0.97 parts per million) of [other] hydrocarbons (for example, propane, isobutane, butane, isopentane, and pentane)" [*1*]. Composition of the unprocessed natural gas produced from the considerably wetter Jonah field in western Wyoming (Table IF4-1) includes 16.4% hydrocarbons, and the gas produced has a heat content of 1,215 Btu per standard cubic foot (Btu/scf)—well above the heat content of 1,010 Btu/scf for dry natural gas consisting of 100% methane.

Unprocessed natural gas produced from the Niobrara Formation [*2*], located predominantly in Colorado, has an even higher heat content of 1,350 Btu/scf and an NGPL content of 22.6%. The natural gas comes out of a lease separator at the wellhead and requires further processing to remove impurities and to separate out the NGPL before the dry natural gas is suitable for transport via interstate pipelines. In the Niobrara Formation, significant quantities of liquids, classified as crude oil, also are recovered at the lease separator. Because of the high ratio of crude oil to natural gas volumes produced from the Niobrara Formation, it is considered a crude oil resource, and activity in the field is determined more by the economics of crude oil and NGPL than by the economics of natural gas.

The shift of production in PADD 4 from Wyoming to Colorado since 2009 reflects a broader shift of natural gas production from dry to wet resources, in part because of consistently high crude oil prices from 2011 through the third quarter of 2014. After reaching more than 7 Bcf/d in January 2010 (56% of PADD 4 production), natural gas production in Wyoming declined by 1.9 Bcf/d (25% of PADD 4 production) to 5.0 Bcf/d in January 2016 (46% of PADD 4 production). Natural gas production in Colorado increased from

Table IF4-1. Composition of oil and natural gas produced from the Niobrara formation in Colorado and the Jonah field in Wyoming

Key characteristics	Niobrara Formation	Jonah Field
Crude oil		
Crude oil to natural gas (barrels per million cubic feet)	86.4	9.5
Crude oil heat content (million Btu/barrel)[a]	5.570	4.980
Share of Btu from crude oil	26%	4%
Wet natural gas		
Heat content (Btu/standard cubic foot)[b]	1,350	1,215
Composition (percent of total)		
Methane	76.2%	77.9%
Ethane	13.7%	8.7%
Propane	5.5%	4.2%
Butane	2.6%	2.5%
Pentane plus	0.8%	3.2%
Inert gases	1.2%	3.5%

[a]Heat content of oil barrel calculated by U.S. Energy Information Administration based on reported API gravity and/or reported composition of crude oil.

[b]Heat content for Niobrara Formation is as reported; heat content for Jonah field is estimated based on gas composition.

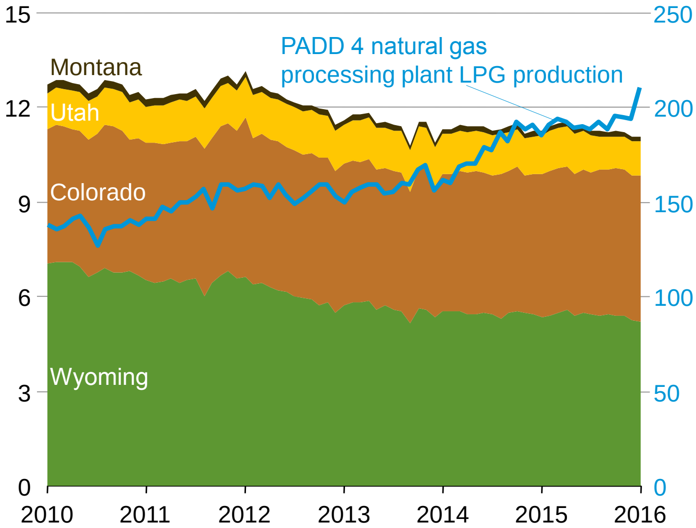
4.2 Bcf/d in 2010 (33% of PADD 4 production) to 4.6 Bcf/d in January 2016 (42% of PADD 4 natural gas production), approaching the production levels in Wyoming.

The focus of producers on crude oil resources and natural gas that is rich in NGPL has led to more production of liquids in PADD 4, even as natural gas output has declined (Figure IF4-3). From January 2010 to January 2016, PADD 4 production of propane and butanes increased by 52%, from 138 thousand b/d to 210 thousand b/d [3], while gross withdrawals of natural gas declined by 13%, from 12.7 Bcf/d in January 2010 to 10.9 Bcf/d in January 2016.

The increase in PADD 4 propane and butanes production, at a time when natural gas production growth is stagnant or falling and when crude oil production is declining, mirrors trends in NGPL production nationwide. Even the reduction of activity in the wettest areas over the past year or so has not slowed the growth of NGPL production, which has exceeded the growth of dry natural gas production (Figure IF4-4).

The growth of NGPL output since 2010–11 has outpaced the growth of domestic demand. The resulting market imbalance has spurred investment in midstream and downstream capacity to process, transport, store, consume, and export increasing quantities of HGL. For example, projects either completed since 2013 or currently under construction will increase the capacity to produce ethylene from ethane by 31%—from 29 million metric tons (mmt)/year to 38 million mmt/year. Investments made in propane dehydrogenation (PDH) capacity, which converts propane to propylene) [4], have increased total PDH capacity more than threefold—from 0.66 mmt/year to 2.16 mmt/year. U.S. capacity to export HGL also has undergone significant expansion since 2013. Capacity to ship propane and butane overseas has grown by more than 550%—from 0.2 million b/d in 2013 to 1.32 million b/d in 2017, and capacity for marine exports of ethane, which only five years ago were not considered viable, have increased from zero to 0.28 million b/d [5]. EIA estimates total investment in these projects at approximately $33 billion, and more projects have been proposed with completion dates in 2018 and beyond [6].

Figure IF4-3. Rocky Mountain region (PADD 4) total natural gas processing plant liquids production (thousand barrels per day) and natural gas production by state (billion cubic feet per day), 2010–16



NGPL production in AEO2016

The future production profile for NGPL will be determined to a large extent not only by the natural resources endowment but also by production economics, which are influenced primarily by natural gas and crude oil prices and the spread between their prices on an energy-equivalent basis. In the Annual Energy Outlook 2016 (AEO2016), the High Oil and Gas Resource and Technology case and the Low Oil and Gas Resource and Technology case, as well as the High Oil Price case and the Low Oil Price case (Figure IF4-5), reflect different possible futures for U.S. NGPL production. The High and Low

Figure IF4-4. U.S. total natural gas and natural gas plant liquids production, 2010–16 (index, January 2010 = 1.00)

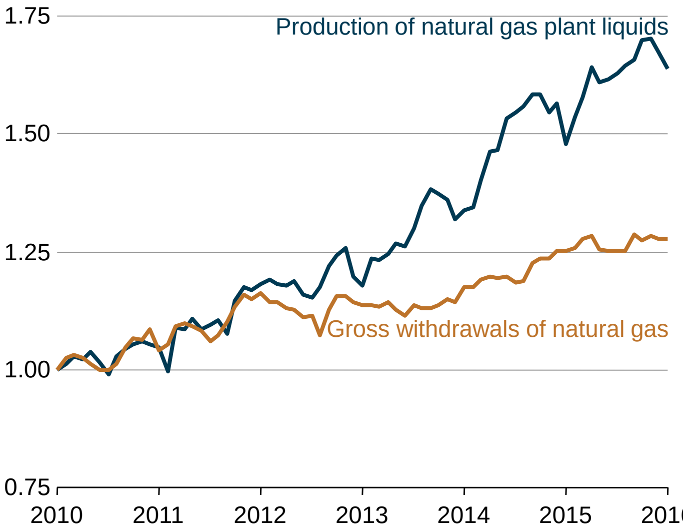
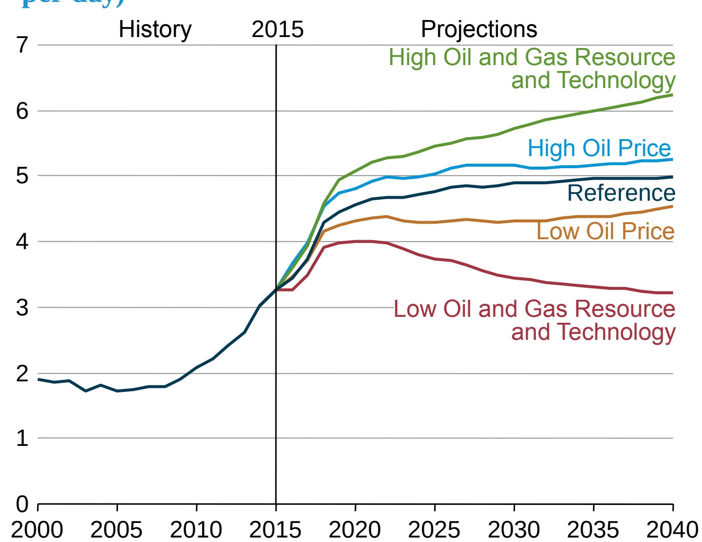


Figure IF4-5. U.S. total natural gas plant liquids production in five cases, 2000–2040 (million barrels per day)



Oil and Gas Resource and Technology cases have a more significant effect on NGPL output because of changes in natural gas and crude oil production. In the High and Low Oil Price cases, production levels are influenced by the changes in value resulting from increases or decreases in the amount of NGPL contained in the unprocessed natural gas.

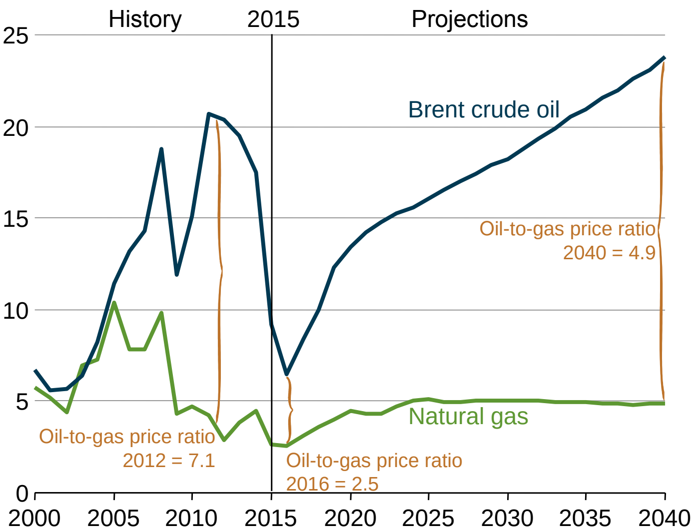
As in the 2010–14 period, when a high premium for liquids led to a shift in natural gas production to those areas where natural gas yielded higher shares of NGPL relative to dry natural gas, the AEO2016 results suggest varying rates of NGPL production growth, depending on relative crude oil and natural gas prices. Until crude oil prices began their sustained decline in the fourth quarter of 2014, natural gas producers generally had chosen wet gas production over dry natural gas production. That choice required some tradeoffs: wet gas needs to be processed before it can be injected into interstate natural gas pipelines for delivery as dry natural gas to consumers, and wells drilled in formations that yield wet natural gas generally have lower initial production rates. However, the extra revenue generated by the liquids can improve the economics of natural gas production and create an incentive to focus drilling on wet natural gas resources.

In the AEO2016 Reference case, with Brent crude oil prices rising from an average of $37/b in 2016 to $136/b in 2040 (2015 dollars), the oil-to-gas price ratio (2015 dollars/million Btu) increases from 2.5 in 2016 to 5.0 in 2040 (Figure IF4-6). Total U.S. NGPL production increases from 3.5 million b/d in 2016 to 4.8 million b/d in 2025 and to almost 5 million b/d in the late 2030s. In the Low Oil Price case, with oil prices remaining below $40/b until 2022 and then increasing to $73/b in 2040, NGPL production averages between 4.3 million b/d and 4.5 million b/d from 2020 to 2040, even as natural gas production grows from 75 Bcf/d in 2016 to 115 Bcf/d in 2040. In the High Oil Price case, natural gas production increases at a slightly higher rate, to 127 Bcf/d in 2040, and NGPL production increases rapidly to 5.0 million b/d in 2025 and then levels off at about 5.2 million b/d from 2025–40. The additional revenue from NGPL sales also shifts production to other regions of the country, resulting in a decrease in PADD 4 natural gas output, where unprocessed natural gas is generally drier, and an increase in production from the Bakken Formation (primarily associated with oil production) and parts of the Marcellus Formation, centered around western Pennsylvania and the West Virginia panhandle, where the unprocessed natural gas has a relatively high liquids content.

Downstream development

Since 2012, when NGPL production started to increase, the U.S. industry has responded with an aggressive build-out of capacity to consume or export the liquids. Operators of petrochemical crackers (plants designed to convert ethane, propane, and normal butane, as well as naphtha, to ethylene, propylene, and other building blocks of the petrochemical industry) announced plans to expand their facilities to take advantage of the rising availability of feedstock, particularly NGPL. In the first wave of projects in the United States from 2012 to 2015, an additional 300,000 b/d of feedstock demand, primarily for ethane, was developed through plant expansions and restarts of mothballed facilities. In the second wave from 2016 to 2018, large established petrochemical companies, including Dow Chemical, Chevron Phillips Chemical, and ExxonMobil, have announced plans for new large-scale ethylene crackers and propane dehydrogenation facilities that would increase demand for ethane feedstock by up to 0.5 million b/d and for propane feedstock by an additional 0.15 million b/d by 2018. In the third wave from 2019 onwards, a further 0.37 million b/d expansion of ethane and propane feedstock demand has been proposed. In addition, midstream companies brought more than 0.97 million b/d of propane and butane export capacity into service by the end of 2015, with another 0.2 million b/d of propane and butane capacity and nearly 0.2 million b/d of marine ethane export capacity slated to come online by the end of 2018.

Figure IF4-6. Brent crude oil and Henry Hub natural gas spot prices in the Reference case, 2000–2040 (2015 dollars per million Btu)



In the AEO2016 Oil and Gas Resource and Technology cases and Oil Price cases, the significant commitment of capital to projects in the first and second waves of petrochemical industry expansion, as well as most of the export capacity expansion, results in completion of the projects. However, later waves of petrochemical projects, as well as any further expansion of U.S. HGL export capacity, have different outcomes across those cases.

The primary motivation for the buildout of U.S. industrial and export HGL capacity is the impact of the wide price spread between U.S. natural gas prices and international crude oil prices on NGPL production, which creates a price advantage for U.S. producers relative to producers in other countries. As such, any narrowing of the price spread would reduce the competitive advantage and reduce opportunities for exports of U.S. NGPL to international destinations, possibly to the point of making exports of spot cargoes unprofitable. However, for many countries seeking to diversify sources of supply for strategic reasons, the United States may still have an advantage in long-term contracts. The price spread has narrowed recently, and sponsors of major petrochemical projects in the United States have announced postponements of some investment decisions, pushed back completion dates, and scaled down the scopes of some projects.

In the High Oil Price case, U.S. natural gas producers are projected to target formations with the highest liquids content, resulting in greater supply of NGPL to the U.S. market. In addition, the High Oil Price case provides U.S.-based petrochemical plants with a cost advantage relative to their international peers, resulting in better opportunities for U.S. exporters in international markets. With an estimated $33 billion in projects between 2013 and 2017 directly tied to the growing availability of HGL feedstock, and billions more in associated upstream and downstream activities, HGL-related economic activity has become a major factor in the U.S. economy. Depending on future prices, developments in the U.S. petrochemical industry may provide either further growth in this segment of the U.S. economy or a slowdown from recent high activity levels.

Endnotes for IF4

Links current as of July 2016

1. R.M. Flores, *Coalbed Methane in the Powder River Basin, Wyoming and Montana: An Assessment of the Tertiary-Upper Cretaceous Coalbed Methane Total Petroleum System*, Version 1.0 (Denver, CO: U.S. Geological Survey, Information Services, 2004), p. 14, http://pubs.usgs.gov/dds/dds-069/dds-069-c/REPORTS/Chapter_2.pdf.
2. U.S. Energy Information Administration, "Niobrara Region Drilling Productivity Report" (Washington, DC: May 2016), http://www.eia.gov/petroleum/drilling/pdf/niobrara.pdf.
3. Ethane, an NGPL that may be recovered or left in pipeline natural gas, depending on gas processing economics, is not included in the total.
4. U.S. Energy Information Administration, "Today in Energy: Growing U.S. HGL production spurs petrochemical industry investment" (Washington, DC: January 29, 2015), https://www.eia.gov/todayinenergy/detail.cfm?id=19771.
5. U.S. Energy Information Administration, "Short-Term Outlook for Hydrocarbon Gas Liquids," Appendix, pp. 21–22 (Washington, DC: March 2016), http://www.eia.gov/forecasts/steo/special/supplements/2016/hgl/pdf/2016_sp_01.pdf.
6. Based on publicly available data from company announcements and SEC filings, EIA estimates average investment requirements of $2.8 billion per million metric tons per year of ethylene capacity, $2 billion per million metric tons per year of PDH capacity, $0.2 billion per 0.1 million barrels per day of propane and butane export capacity, and $0.6 billion per 0.1 million barrels per day of marine ethane export capacity.

Figure and table sources for IF4

Links current as of July 2016

Figure IF4-1. U.S. revenue per million Btu of unprocessed natural gas generated by natural gas plant liquids and dry natural gas, 2002, 2009, and 2014: U.S. Energy Information Administration, "Petroleum & Other Liquids: Natural Gas Plant Field Production," http://www.eia.gov/dnav/pet/pet_pnp_gp_dc_nus_mbbl_m.htm; "Natural Gas: Natural Gas Gross Withdrawals and Production," http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_m.htm; "Natural Gas: Heat Content of Natural Gas Consumed," http://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm; and "Natural Gas: Natural Gas Spot and Futures Prices (NYMEX)," http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm. **NGL prices:** Bloomberg Markets, Energy: Crude Oil & Natural Gas, http://www.bloomberg.com/energy (subscription site).

Figure IF4-2. Relative heat contents and values of natural gas plants liquids, 2002, 2009, and 2014: U.S Energy Information Administration, "Petroleum & Other Liquids: Natural Gas Plant Field Production," http://www.eia.gov/dnav/pet/pet_pnp_gp_dc_nus_mbbl_m.htm; "Petroleum & Other Liquids: Natural Gas Plant Field Production," http://www.eia.gov/dnav/pet/pet_pnp_gp_dc_nus_mbbl_m.htm; "Natural Gas: Natural Gas Gross Withdrawals and Production," http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_m.htm; "Natural Gas: Heat Content of Natural Gas Consumed," http://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm; and "Natural Gas: Natural Gas Spot and Futures Prices (NYMEX)," http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm. **NGL prices:** Bloomberg Markets, Energy: Crude Oil & Natural Gas, http://www.bloomberg.com/energy (subscription site).

Table IF4-1. Composition of oil and natural gas produced from the Niobrara formation in Colorado and the Jonah field in Wyoming: *Niobrara:* D.K. Higley and D.O. Cox, "Oil and Gas Exploration and Development along the Front Range in the Denver Basin of Colorado, Nebraska, and Wyoming" (Reston, VA: U.S. Geological Survey, 2007), Chapter 2, p. 15, https://pubs.usgs.gov/dds/dds-069/dds-069-p/REPORTS/69_P_CH_2.pdf. *Jonah: Final Environmental Impact Statement, Jonah Infill Drilling Project, Sublette Country, Wyoming*, Appendix DP-B, "Reclamation Plan, Jonah Infill Drilling Project" (Cheyenne, WY: Bureau of Land Management, January 2006), http://www.blm.gov/style/medialib/blm/wy/information/NEPA/pfodocs/jonah.Par.6420.File.dat/17B.pdf.

Figure IF4-3. Rocky Mountain region (PADD 4) total natural gas plant liquids production and natural gas production by state, 2010–16: U.S Energy Information Administration, "Petroleum & Other Liquids: Natural Gas Plant Field Production," http://www.eia.gov/dnav/pet/pet_pnp_gp_dc_nus_mbbl_m.htm; and "Natural Gas: Natural Gas Gross Withdrawals and Production," http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_m.htm.

Figure IF4-4. Annual changes in U.S. total natural gas and natural gas plant liquids production, 2010–16: U.S Energy Information Administration, "Petroleum & Other Liquids: Natural Gas Plant Field Production," http://www.eia.gov/dnav/pet/pet_pnp_gp_dc_nus_mbbl_m.htm; and "Natural Gas: Natural Gas Gross Withdrawals and Production," http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_m.htm.

Figure IF4-5. U.S. total natural gas plant liquids production in five cases, 2000–2040: History: U.S Energy Information Administration, "Petroleum & Other Liquids: Natural Gas Plant Field Production," http://www.eia.gov/dnav/pet/pet_pnp_gp_dc_nus_mbbl_m.htm. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWPRICE.D041916A, HIGHPRICE.D041916A, LOWRT.D032516A, and HIGHRT.D032516A.

Figure IF4-6. Comparison of Brent crude oil and Henry Hub natural gas spot prices in the Reference case, 2000–2040: History: U.S Energy Information Administration, "Petroleum & Other Liquids: Spot Prices," http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm; and "Natural Gas: Natural Gas Spot and Futures Prices (NYMEX)," http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm. **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

IF5. Steel industry energy consumption: Sensitivity to technology choices, fuel prices, and carbon prices in the AEO2016 Industrial Demand Module

The manufacture of steel and related products is an energy-intensive process. According to the U.S. Energy Information Administration's (EIA) Manufacturing Energy Consumption Survey (MECS), steel industry energy consumption in 2010 totaled 1,158 trillion British thermal units (Btu), representing 8% of total manufacturing energy consumption [*1*]. Energy consumption in the steel industry is largely for crude steel production using basic oxygen furnace (BOF) and electric arc furnace (EAF) technologies. Overall energy intensity in EAF, used primarily to melt scrap steel, is significantly lower than in BOF, which is used to create virgin steel by reducing (i.e., removing oxygen from) iron ore [*2*]. In 2014, BOF technology accounted for 37% of total U.S. steel production, and EAF accounted for 63% of the total [*3*]. Over the past two decades, a shift from BOF to EAF has contributed to a substantial reduction in the energy intensity of the U.S. steel industry. From 1991 to 2010, the EAF share of total U.S. steel production in physical units increased from 38% to 61%, and the overall energy intensity of crude steel production in Btu per metric ton decreased by 37% [*4*].

The basic process choice for crude steel production is not the only factor affecting energy intensity in the steel industry. Technology choices are based on product specifications, demand, fuel prices, and environmental policies. Technology advances in both BOF and EAF crude steel production processes—including blast furnace gas recovery, pulverized coal injection, and scrap preheating—as well as advances in rolling and casting processes have continued to lower the energy intensity of the overall manufacturing processes for steel and finished steel products. For example, direct reduced iron (DRI), a newer technology used only recently in the United States [*5*], is now commercially available and growing, accounting for 8 million tons (9%) of iron production in 2015. DRI involves the direct conversion of iron ore using a reducing gas (usually natural gas). The resulting sponge iron is readily used as feed in the EAF process. The DRI process performs the same function as a blast furnace, in that it converts iron ore to iron, but it does not involve the use of coke (produced by anaerobic baking of metallurgical coal). The DRI process converts iron ore to iron using less energy and with a lower capital cost than the blast furnace process. In addition, DRI plants in the United States are able to take advantage of relatively low natural gas prices [*6*].

In the future, steelmaking processes and technologies will continue to evolve in response to commodity prices for iron ore and scrap steel, investment in energy efficiency, product-specification demand, environmental regulations, and fuel prices. Differences in those factors can change the processes (BOF or EAF) and technologies used for each process, which in turn can lead to differences in energy intensity and fuel mix. However, because capital investments in particular technologies last for many years, energy use does not react quickly to price changes. To explore how such conditions affect steel technology choice and energy intensity, this article compares the *Annual Energy Outlook 2016* (AEO2016) Reference case with three alternative cases, two of which include demand-side energy efficiency incentives and one that assumes more rapid adoption of energy-efficient technologies. Although fuel intensity and some technology choices vary across the AEO2016 Reference case and alternative cases, the major choice in 2040 remains either BOF or EAF. New or revolutionary technological breakthroughs are not assumed for this analysis.

Energy use in steelmaking depends on both the technology chosen for a process step and the energy intensity of the different technologies. In the steelmaking process, technology choices may be available in some but not all of the following process steps. Iron production has two alternative technologies: blast furnace (BF) and DRI. The BF process reduces iron ore, using a mixture of iron ore, coking coal, and limestone. The BF output is further processed in a BOF to produce steel. DRI reduces iron, which can then be fed into either a BOF or an EAF to produce crude steel. A BOF receives iron either from a BF or from the DRI process and uses oxygen to remove impurities. An EAF melts down steel scrap to produce steel and can also use DRI. Continuous casting can then be used to produce slabs of molten steel for further processing, and hot rolling can be used to further process the cast steel into intermediate and final products.

Alternative cases

In two of the AEO2016 alternative cases, CO2 fees are used as a proxy for demand-side energy efficiency incentives. A third case assumes that more efficient technology is available, and that new, more energy-efficient capacity will be available sooner than in the Reference case. These alternative cases assume that technology and process choices achieve more energy efficiency than in the AEO2016 Reference case, as existing steelmaking capacity is retired and new capacity is brought online to meet the projected growth in industry shipments [*7*].

Industrial Efficiency Incentive Low (Low Incentive) case

In the Low Incentive case, a CO2 fee is used as a proxy for demand-side energy efficiency incentives. The fee increases gradually from zero in 2017 to $12.50 (2015 dollars) per metric ton (mt) of CO2 in 2023. After 2023 the CO2 fee increases by 5%/year, to approximately $29/mt CO2 in 2040.

Industrial Efficiency Incentive High (High Incentive) case

The High Incentive case also uses a CO2 fee as a proxy for demand-side energy efficiency incentives. In this case, the fee increases gradually from zero in 2017 to $35/mt CO2 (2015 dollars) in 2023. Thereafter, the CO2 fee increases by 5%/year, to approximately $80/mt CO2 in 2040.

Energy Efficiency for Manufacturing Industries with Technical Choice (Energy-Efficient Technology) case

The Energy-Efficient Technology case assumes the deployment of more energy-efficient technologies over time than in the AEO2016 Reference case in five industries—aluminum, cement and lime, glass, iron and steel, and paper—with no demand-side efficiency incentives. Existing technologies are retired sooner, and new technologies have shorter lifespans than in the AEO2016 Reference case, providing more opportunities for deployment of energy-efficient technologies. In addition, new technologies penetrate the industry more rapidly than in the Reference case.

The CO2 fee paths in the Low Incentive and High Incentive cases (Figure IF5-1) translate to higher fuel prices for metallurgical coal, natural gas, and electricity than in the AEO2016 Reference case, with the impacts differing for each fuel. The largest price impact is on metallurgical coal, the smallest price impact is on electricity, and the price impact on natural gas falls between the two.

Results

Technology choice

In the High Incentive and Low Incentive cases, differences in the prices of metallurgical coal, natural gas, and electricity that result from the inclusion of demand-side energy efficiency incentives favor technology choices that use less metallurgical coal and more natural gas and electricity than in the Reference case. The metallurgical coal price is 20% higher in the Low Incentive case than in the Reference case and 56% higher in the High Incentive case than in the Reference case in 2025, and the price differences continue to increase through 2040. Similarly, natural gas prices in 2025 are 10% higher in the Low Incentive case than in the Reference case and 38% higher in the High Incentive case than in the Reference case. The smallest effects are on electricity prices; the electricity price is 8% higher in the Low Incentive case than in the AEO2016 Reference case and 23% higher in the High Incentive case in 2025 than in the AEO2016 Reference case.

Changes in the alternative case assumptions affect both the process choice and technology choice. In terms of process, the selection of BOF or EAF for crude steel production results in the largest energy consumption difference. Over the projection period, across all cases, most of the growth in steel output is in EAF. As a result, crude steel production uses relatively more natural gas over time, and its energy intensity declines.

In the AEO2016 Reference case, BOF output increases by 1.3%/year on average from 2015 to 2025 (Figure IF5-2), while EAF output grows at more than twice that rate. Between 2025 and 2040, total steel output growth slows. BOF output in the Reference case increases by 0.4%/year, and EAF output increases by 1.6%/year. As a result of more rapid EAF growth, the EAF output share increases from 62% in 2015 to 69% in 2040. The increasing EAF output share in the Reference case continues the long-term trend toward more EAF steel production in the United States.

In the Low Incentive case, coal prices are higher than in the Reference case, and the difference between metallurgical coal prices and electricity prices is generally greater than in the Reference case. As a result, in the Low Incentive case BOF production of crude steel increases by 0.4%/year on average from 2015 to 2025 and by 0.5%/year from 2025 to 2040, while EAF output grows by 2.9%/year from 2015 to 2025 and by 1.8%/year from 2025 to 2040. Because metallurgical coal is more expensive in the Low Incentive case than in the Reference case, the BOF output share declines more rapidly than in the Reference case (Table IF5-1).

Figure IF5-1. Carbon dioxide proxy prices in two cases, 2015–40 (2015 dollars per metric ton)

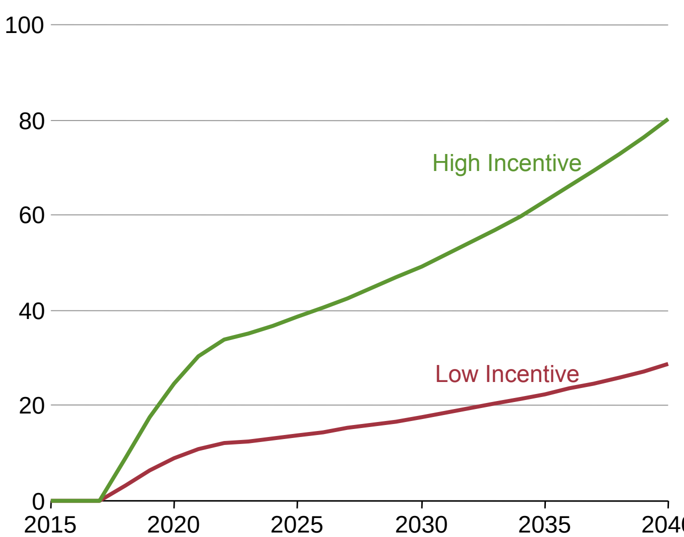
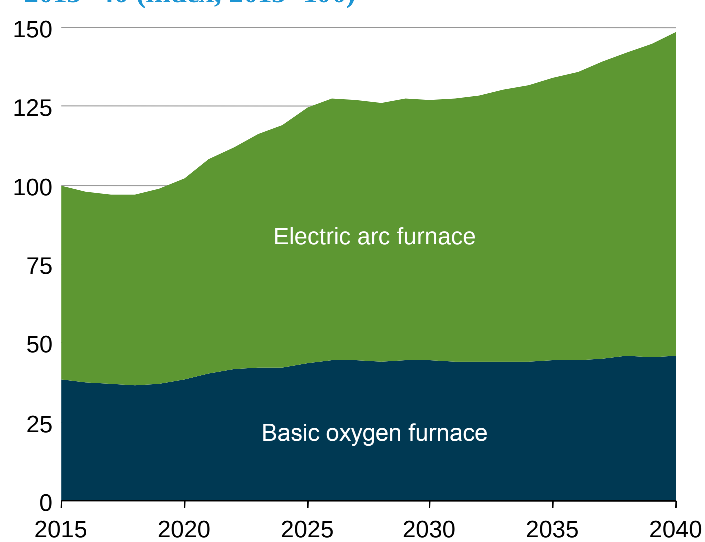


Figure IF5-2. Changes in U.S. total crude steel production by technology in the Reference case, 2015–40 (index, 2015=100)



In the High Incentive case, the difference between metallurgical coal prices and electricity prices also is greater than in the AEO2016 Reference case, by an even a larger amount, and the prices are much higher than in the Reference case. As a result, BOF output declines by 1.5%/year on average from 2015 to 2025 and increases by 1.7%/year from 2025 to 2040, while EAF output increases by 2.1%/year from 2015 to 2025 period and by 2.5%/year from 2025 to 2040. In response to increasing CO2 prices in the High Incentive case, the BOF output share declines by 8 percentage points from 2015 to 2025 and by a more moderate 2 percentage points from 2025 to 2040 as BOF output increases.

In the Energy-Efficient Technology case, BOF output grows by an average of 0.2%/year from 2015 to 2025, similar to the growth rate in the Reference case, because prices are the same as in the Reference case and there is no additional incentive for innovation. From 2025 to 2040, BOF output grows by 0.7%/year in the Energy-Efficient Technology case. EAF output grows much more rapidly than BOF output in the Energy-Efficient Technology case, by averages of 3.4%/year from 2015 to 2025 and 1.4%/year from 2025 to 2040, as the new technology is adopted more rapidly than in the Reference case.

In 2015, BOF accounted for approximately 38% of total steel output. In 2040, it accounts for about 30% of the total in all the AEO2016 cases for three reasons. First, the BF process uses significant amounts of "off-gas" to provide waste heat for the smelting process, displacing fuel use that would otherwise be needed in the smelting process, and thereby mitigating CO2 emissions. EAFs do not have this feature. Second, as DRI production increases with EAF use, it is available as a less CO2-intensive feedstock for BOF as well. Finally, there will always be a need for steel made using BOF, because BOF-produced steel is better suited for products that require formability, such as automobile body panels [*8*].

In the Low Incentive and High Incentive cases, DRI accounts for a larger share of BOF iron input than in the Reference case (Figure IF5-3). DRI is less carbon-intensive than BF, because DRI uses natural gas to reduce iron, whereas BF relies on metallurgical coal that has been coked, and the coking process is carbon-intensive. Also, DRI is less energy-intensive than BF because the DRI process does not involve melting iron and thus operates at lower temperatures [*9*].

In the Low Incentive case and the High Incentive case, greater demand-side energy efficiency incentives result in a shift to more energy-efficient technologies, leading to more use of high-technology plasma torches (a plasma torch delivers an electric charge to the metal for heating [*10*]) in the BOF process than occurs in the Reference case [*11*]. For continuous casting of steel, greater demand-side incentives increase the use of electric ladles (a ladle transfers molten steel from the furnace to a continuous casting process). In the Energy-Efficient Technology case, higher CO2 fees encourage the use of more efficient natural gas-based technologies than in the Reference case, including natural gas ladles. In the Low Incentive case and the High Incentive case, higher CO2 emissions fees reduce the use of more energy-intensive alternative ironmaking technologies [*12*].

Fuel use and energy intensity

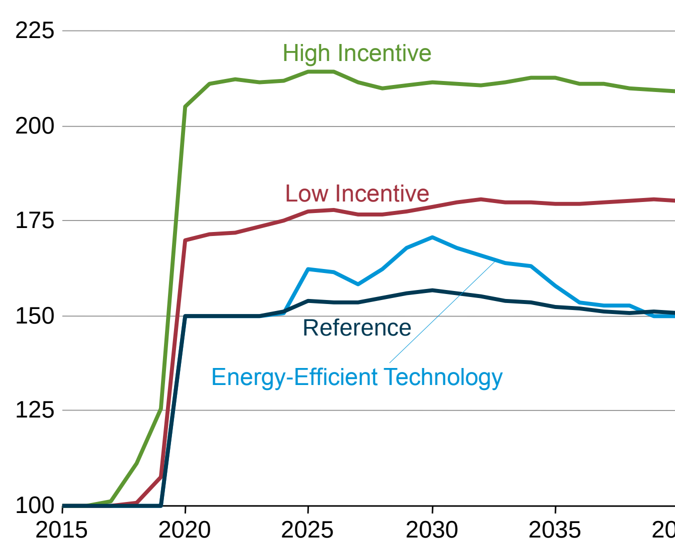
The total energy intensity of U.S. steelmaking declines from 2015 to 2040 in all the AEO2016 cases (Figure IF5-4), with the smallest decline in the Reference case (27%) and the largest decline in the Energy-Efficient Technology case (32%). The decline in steelmaking energy intensity in the Reference case is greater than the average decline of 18% projected in the Reference case for all other energy-intensive industries from 2015 to 2040, primarily as a result of the shift toward greater use of more energy-efficient steelmaking technologies, with EAF increasing at a much faster rate than BOF, and DRI increasing at a faster rate than BF.

Natural gas is used in DRI production in electric arc furnaces, and is also used extensively in continuous casting and hot rolling. In the Reference case, the overall natural gas intensity of U.S. steelmaking declines by a total of 25% from 2015 to 2040, with the

Table IF5-1. BOF and EAF shares of total crude steel production in four cases, 2015–40 (percent)

AEO case and type of production	2015	2025	2040
Reference case			
Basic oxygen furnace	38%	35%	31%
Electric arc furnace	62%	65%	69%
Low Incentive case			
Basic oxygen furnace	38%	33%	29%
Electric arc furnace	62%	67%	71%
High Incentive case			
Basic oxygen furnace	38%	30%	28%
Electric arc furnace	62%	70%	72%
Energy-Efficient Technology case			
Basic oxygen furnace	39%	32%	30%
Electric arc furnace	61%	68%	70%

Figure IF5-3. U.S. direct reduced iron (DRI) production in four cases, 2015–40 (index, 2015=100)



declines spread evenly over the period. Although natural gas-intensive technologies are more widely used, new technologies and efficiency gains outweigh the use of natural gas-intensive technologies. In the Low Incentive and High Incentive cases, natural gas consumption intensity declines by just over 20%—slightly less than in the Reference case, because technologies that use more natural gas, including DRI and EAF, are more widely employed. In the Energy-Efficient Technology case, natural gas intensity declines more rapidly than in the Reference case, by a total of slightly more than 30% from 2015 to 2040, because many steelmaking processes, including continuous casting and hot rolling, use natural gas more efficiently than in the Reference case (Figure IF5-5). Approximately 50% of the Reference case decline in energy intensity occurs from 2015 to 2025. Although natural gas-intensive technologies are more likely to be selected in the Energy-Efficient Technology case, overall levels of natural gas consumption also decline in this case, because gains in energy efficiency outweigh the impact of fuel switching to natural gas.

Figure IF5-4. Total energy intensity of U.S. steel production in four cases, 2015–40 (thousand Btu per 2009 dollar of shipments)

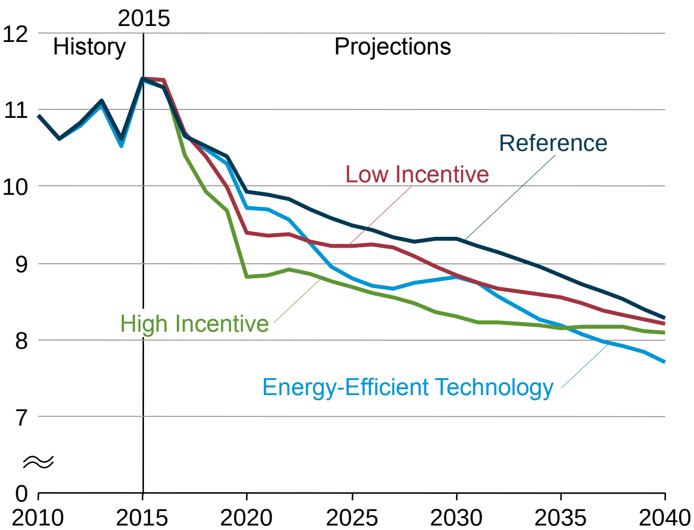
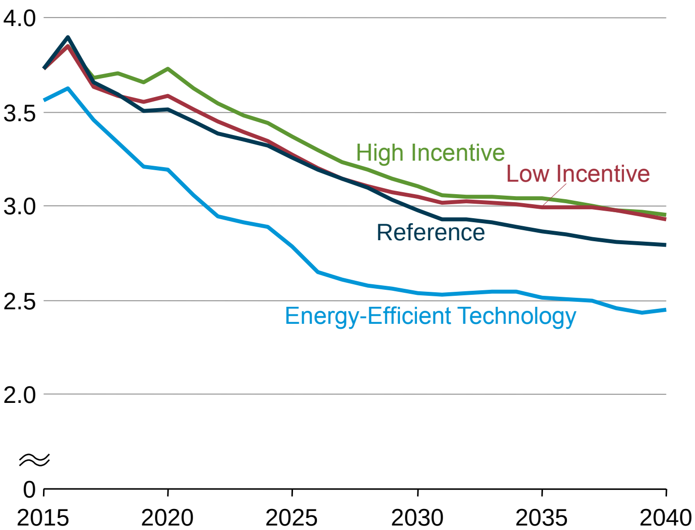


Figure IF5-5. Natural gas intensity of U.S. steel production in four cases, 2015–40 (thousand Btu per 2009 dollar of shipments)



Endnotes for IF5

Links current as of July 2016

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Figure and table sources for IF5

Links current as of July 2016

Figure IF5-1. Carbon dioxide proxy prices in two cases, 2015–40: AEO2016 National Energy Modeling System, runs LOWINNOVATE.D032516A and HIGHINNOVATE.D032516A.

Figure IF5-2. Changes in U.S. total crude steel production by technology in the Reference case, 2015–40: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Table IF5-1. BOF and EAF shares of total crude steel production in four cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWINNOVATE.D032516A, HIGHINNOVATE.D032516A, and EFFICIENTTECH.D032516A.

Figure IF5-3. U.S. direct reduced iron (DRI) production in four cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWINNOVATE.D032516A, HIGHINNOVATE.D032516A, and EFFICIENTTECH.D032516A.

Figure IF5-4. Total energy intensity of U.S. steel production in four cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWINNOVATE.D032516A, HIGHINNOVATE.D032516A, and EFFICIENTTECH.D032516A.

Figure IF5-5. Natural gas intensity of U.S. steel production in four cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWINNOVATE.D032516A, HIGHINNOVATE.D032516A, and EFFICIENTTECH.D032516A.

Market trends

Projections by the U.S. Energy Information Administration (EIA) are not statements of what will happen but of what might happen, given the assumptions and methodologies used for any particular case. The Reference case projection is a business-as-usual estimate, given known market, demographic, and technological trends. Most cases in the *Annual Energy Outlook 2016* (AEO2016) generally assume that current laws and regulations are maintained throughout the projections. Such projections provide a baseline starting point that can be used to analyze policy initiatives. EIA explores the impacts of alternative assumptions in other cases with different macroeconomic growth rates, world oil prices, rates of technological progress, and policy changes.

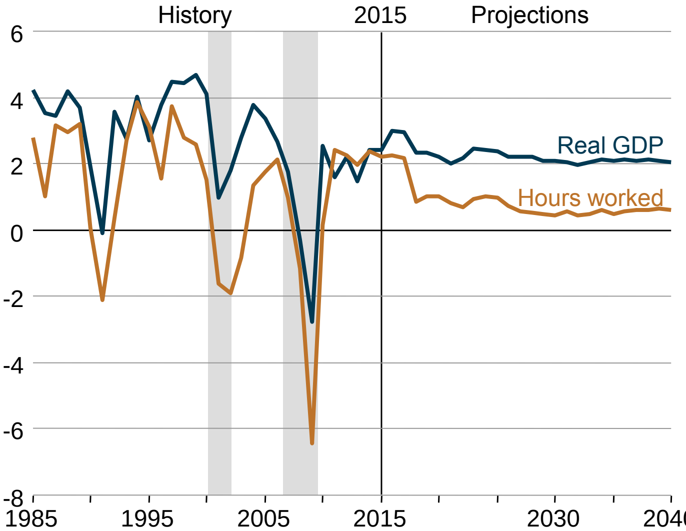
While energy markets are complex, energy models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. Behavioral characteristics are indicative of real-world tendencies rather than representations of specific outcomes.

Energy market projections are subject to much uncertainty. Many of the events that shape energy markets are random and cannot be anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Many key uncertainties in the AEO2014 projections are addressed through alternative cases.

EIA has tried to make these projections as objective, reliable, and useful as possible. However, they should serve as an adjunct to, not as a substitute for, a complete and focused analysis of public policy initiatives.

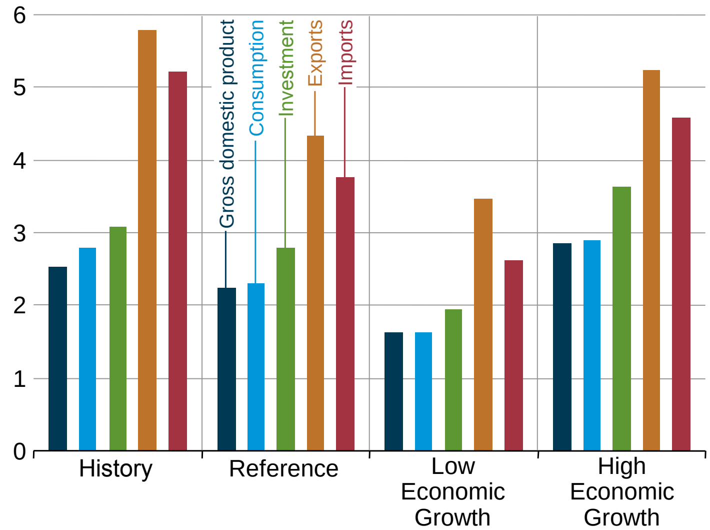
With lower labor productivity growth, investment is key to improving living standards

Figure MT-1. Growth of real gross domestic product and hours worked in the Reference case, 1985–2040 (annual percent)



Three economic growth cases show a range of possible future trends in economic growth

Figure MT-2. Average annual growth rates for real gross domestic product and its major components in three cases, 2015–40 (percent per year)



Growth in labor productivity is an important determinant of economic growth [*1*]. Since the end of the latest U.S. recession in June 2009 [*2*], labor productivity has been slow to recover. From 1987–2014, U.S. labor productivity growth averaged 1.9%/year [*3*]. The average rate of growth in the previous expansion (2001–07) was 2.6%, compared with 1.3%/year in the current expansion (2009–15). In the AEO2016 Reference case, labor productivity growth averages 1.7%/year from 2015–40. From 2009–15, the number of hours worked by private, nonfarm workers has increased by an average of 0.7%/year, compared with 0.3%/year from 2001–07. This difference implies that growth of output has not kept pace with growth of hours worked. In the AEO2016 Reference case, the number of hours worked grows by an average of 0.9%/year from 2015–40, compared with the historical average of 1.2%/year from 1987–2014, and real GDP grows by an average of 2.2%/year from 2015–40, which is below the historical average of 2.6%/year from 1987–2014 (Figure MT-1).

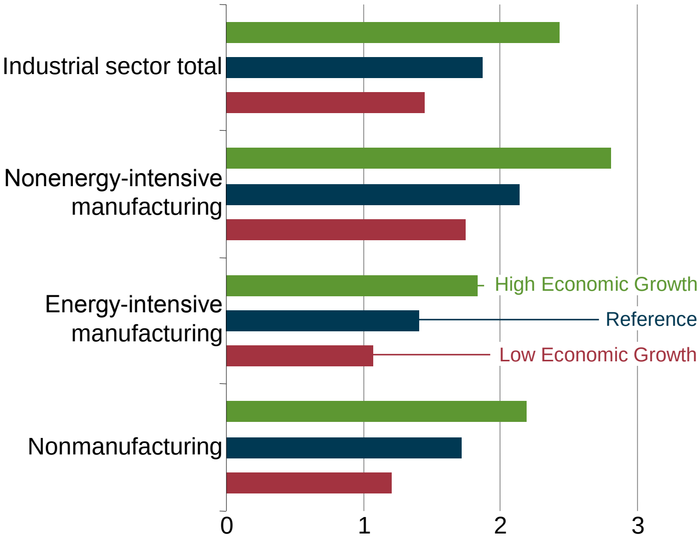
Many economists attribute the current slump in labor productivity to the slow recovery of capital spending. Businesses servicing excessive debt after the financial crisis have delayed investment spending until they can restore their financial positions, and lower capital investment leads to higher costs of production and distribution of all goods and services. Investment spending as a share of GDP from 2001–07 was 12.6%, compared with 12.1% from 2009–15. In the AEO2016 Reference case, investment spending averages 14.4% of GDP from 2015–40, compared with the historical average of 12.5% from 1987–2014.

The AEO2016 Reference, High Economic Growth, and Low Economic Growth cases illustrate three possible paths for U.S. economic growth from 2015 to 2040 (Figure MT-2). The High Economic Growth case assumes higher growth and lower inflation than in the Reference case, and the Low Economic Growth case assumes lower growth and higher inflation. In each case, the short-term outlook (five years) represents different IHS Global Insights scenarios [*4*] of economic activity in the United States and the rest of the world, the impacts of fiscal and monetary policies, and potential risks that could affect U.S. economic activity.

Beyond five years, all three cases assume smooth economic growth and no shocks to the economy. Differences among the AEO2016 Reference, High Economic Growth, and Low Economic Growth cases reflect different expectations for growth in population (specifically, net immigration), labor force, capital stock, and productivity. The projections are above trend in the High Economic Growth case and below trend in the Low Economic Growth case. The average annual growth rate for real gross domestic product from 2015 to 2040 in the Reference case is 2.2%, compared with 2.8% in the High Economic Growth case and 1.6% in the Low Economic Growth case (Figure MT-2). Compared with the 1987–2014 period, both the Reference and Low Economic Growth cases show lower growth for all components of the U.S. economy over the projection period, and the High Economic Growth case shows higher growth for all components of the economy, except for trade.

Industrial sector output growth highly dependent on trade

Figure MT-3. Average annual growth rates of shipments from the U.S. industrial sector and its components in three cases, 2015–40 (percent per year)



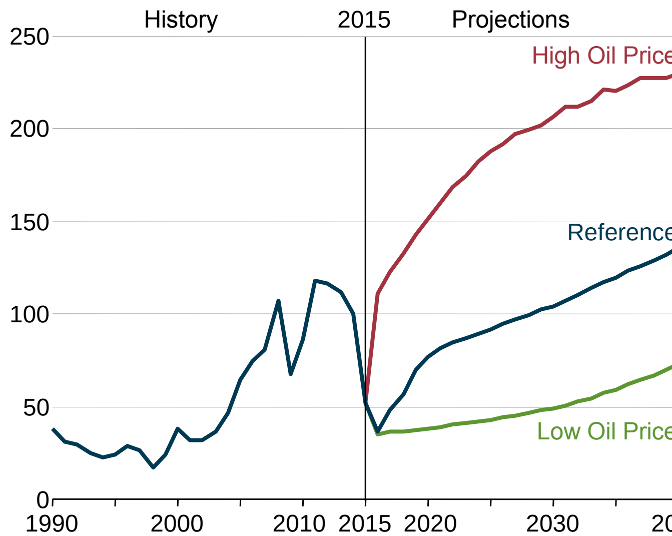
In the future, growth of the U.S. industrial sector [5] contributes to overall economic growth, led by growth in the production of manufactured goods, which in 2015 accounted for 17% of the total real value of shipments of all goods and services in 2015 [6]. In the AEO2016 Reference case, manufacturing shipments grow by 1.9%/year from 2015 to 2040, compared with overall industrial sector growth of 1.9%/year and 1.7%/year growth in nonmanufacturing shipments (Figure MT-3). In the first 5 years of the projection, industry growth rates vary in response to changes in economic factors, such as a strong dollar or low energy prices, but by 2025 growth becomes consistently positive across all industries. In the last decade of the projection, however, growth slows in certain industries (for example, pulp and paper and bulk chemicals) and increases in other industries (for example, primary metals and metal-based durables) in response to changes in U.S. net exports.

In the Low and High Economic Growth cases, industry growth rates generally mirror changes in the rate of GDP growth. However, in the final decade of the projection period, growth rates for the bulk chemical industry are slower in the High Economic Growth Case than in the Reference case, because appreciating exchange rates reduce net U.S. exports of industrial supplies. For the other energy-intensive industries, growth rates in the High Economic Growth case are higher than in the Reference case, as a result of increasing net exports of labor-intensive consumer and capital goods.

Industrial production growth is strongly linked to trade, along with consumer demand and investment. In the Reference case, declining exchange rates and modest growth in labor costs lead to increased U.S. exports. From 2015 to 2040, real exports of goods and services increase by 4.3%/year on average in the Reference case, compared with average increases of 3.8%/year for real imports of goods and services. The growth rate for net exports of industrial supplies is strongest in the first 10 years of the projection period, and the growth rate for net exports of capital and consumer goods is strongest in the last 10–15 years of the projection.

Range of oil price cases represents uncertainty in world oil markets

Figure MT-4. North Sea Brent crude oil spot prices in three cases, 1990–2040 (2015 dollars per barrel)

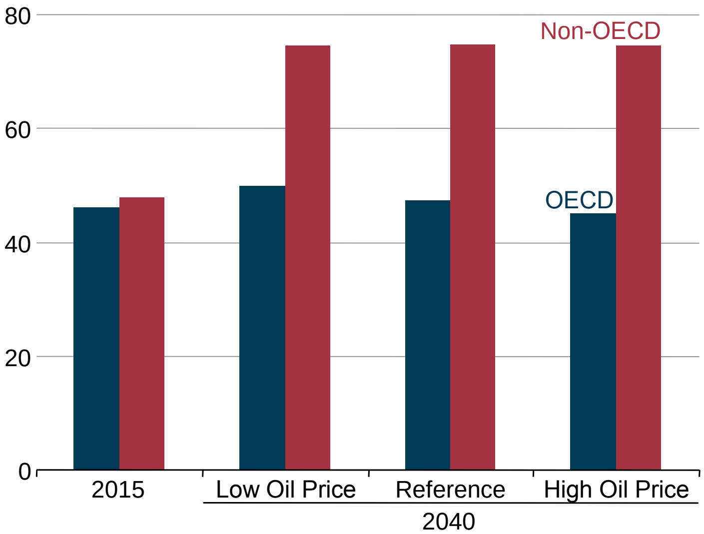


In AEO2016, the North Sea Brent crude oil price is the main benchmark for world oil prices. Three oil price cases—Reference, High Oil Price, and Low Oil Price—examine the potential effects of alternative price paths on energy markets (Figure MT-4). In the Low Oil Price case, global demand for liquids is assumed to be relatively low, and supply is relatively high; in the High Oil Price case demand is high and supply is low. Crude oil prices begin rising early in the High Oil Price case and continue on an upward trend throughout the projection. The oil price cases illustrate offsetting shifts in global supply and demand that keep liquids consumption close to the Reference case levels even though prices are substantially different. In all three cases, non-Organization for Economic Cooperation and Development (non-OECD) countries account for about 60% (roughly 75 million barrels/day) of world liquids use in 2040.

The AEO2016 price cases include different assumptions about investment and production decisions by the Organization of the Petroleum Exporting Countries (OPEC) as well as non-OPEC countries; about the pace of development of tight and shale oil resources in non-OPEC countries (including the United States); and about demand growth in China, the Middle East, and other non-OECD countries. In the Low Oil Price case, which assumes lower demand for liquids in non-OECD regions and more abundant supply than in the Reference case, OPEC supplies 47% of the world's liquid fuels in 2040, compared with 42% in the Reference case. In the High Oil Price case, the OPEC share of world liquids production never exceeds the 41% level reached in 2012.

Prices, policies, technologies, and economic growth rates influence demand for liquids

Figure MT-5. World petroleum and other liquids consumption by region in three cases, 2015 and 2040 (million barrels per day)



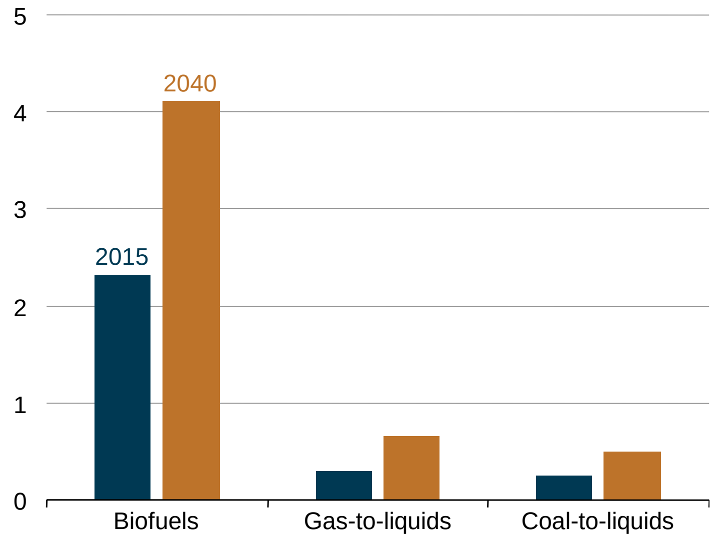
In the AEO2016 Reference, High Oil Price, and Low Oil Price cases, total world consumption of petroleum and other liquids in 2040 ranges from 119 million barrels/day (b/d) to 124 million b/d (Figure MT-5). The alternative oil price cases illustrate the effects of supply differences from the Reference case that lead to substantial differences in prices while consumption remains relatively close to demand in the Reference case. Variations in liquids consumption levels among the Organization for Economic Cooperation and Development (OECD) countries are influenced primarily by oil prices. On the other hand, consumption levels in the non-OECD countries are influenced by prices, technologies, policies, and economic growth rates, resulting in nearly identical demand in the three oil price cases in 2040, at about 75 million b/d, or 60% of world liquids consumption.

In the AEO2016 High Oil Price case, stronger economic growth in the non-OECD nations leads to increased demand for liquid fuels, greater demand for personal travel, and more consumption of goods in the industrial sector. In addition, liquid fuels continue to provide the energy needed to meet growing demand in the nonmanufacturing sector, and national policies favor the use of liquids over coal for chemical feedstocks.

In the Low Oil Price case, world economic growth is slower than in the Reference case, and demand for liquid fuels is lower. OECD countries reduce energy consumption through the use of more-efficient technologies, extended corporate average fuel economy standards, less travel demand, and/or more use of natural gas or electricity in the transportation sector. In the non-OECD countries, demand for liquids in the Low Oil Price case remains relatively strong as low oil prices result in more consumption of liquid fuels relative to other energy sources.

World production of liquid fuels from biomass, coal, and natural gas increases

Figure MT-6. World production of nonpetroleum liquids by type in the Reference case, 2015 and 2040 (million barrels per day)



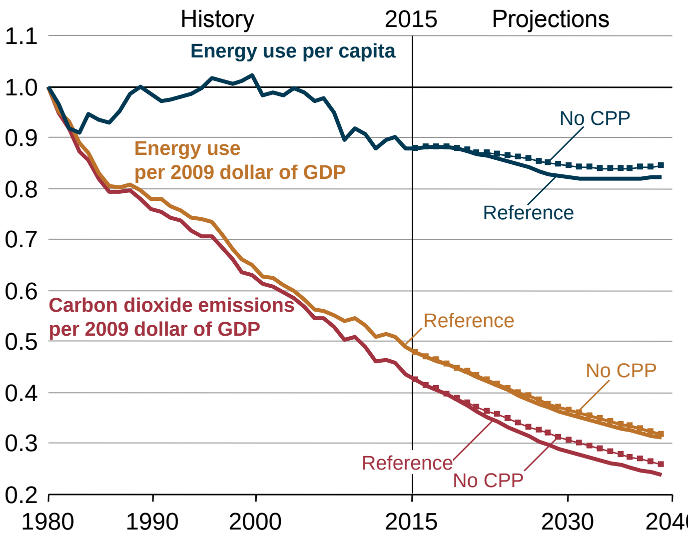
Nonpetroleum fuels are a small but increasing source of total liquids supply in the AEO2016 Reference case. Combined world production of biofuels, coal-to-liquids (CTL), and gas-to-liquids (GTL) totaled 2.9 million barrels per day (b/d) or 3% of total world liquids production in 2015. In 2040, synthetic fuels production in the Reference case totals 5.3 million b/d, or 4% of total world liquids production (Figure MT-6). Production of these fuels is supported by high oil prices, but in the United States high prices alone are not sufficient to increase domestic production of nonpetroleum liquids. As a result, the United States produces no CTL or GTL in the Reference case. Biofuels production grows only slightly, from 1.0 million b/d in 2015 to 1.1 million b/d in 2040, and the U.S. share of world biofuels production falls from 44% in 2015 to 26% in 2040.

Biofuels development relies heavily on country-specific programs or mandates and outlooks for consumption of transportation fuels. U.S. demand for transportation fuels declines in the Reference case, and without significant additional market penetration of fuels with high-percentage ethanol blends or of drop-in fuels [7], the possibilities for expanded biofuel production are limited.

Biofuels production accounts for the largest share of total world nonpetroleum liquid fuels production throughout the projection, although its share falls from 81% in 2015 to 78% in 2040. In 2040, world biofuels production of 4.1 million b/d is more than 250% greater than world production of CTL and GTL combined.

Energy use per capita continues to decline in the Reference and No CPP cases

Figure MT-7. Energy use per capita and per dollar of gross domestic product and carbon dioxide emissions per dollar of gross domestic product in two cases, 1980–2040 (index, 1980 = 1)



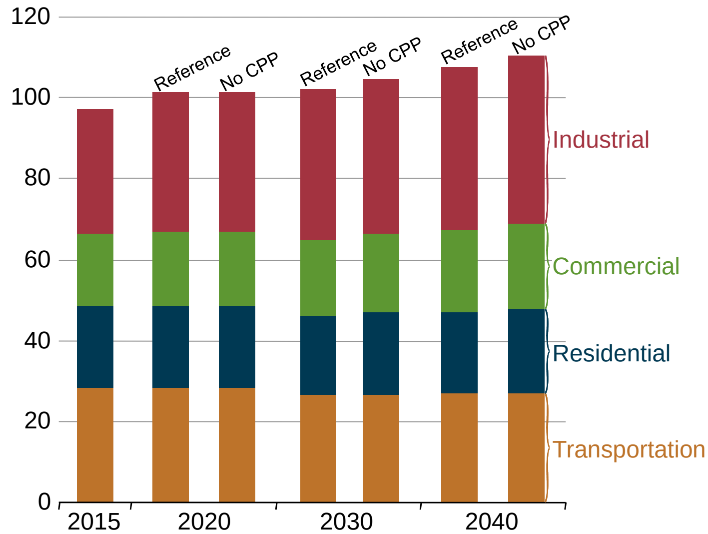
Population growth affects energy use through increases in housing, commercial floorspace, transportation, and economic activity. In the AEO2016 Reference case, which includes the U.S. Environmental Protection Agency's Clean Power Plan (CPP), the U.S. population grows by 0.7%/year from 2015 to 2040; the national economy, as measured by gross domestic product (GDP), grows by an average of 2.2%/year; and total energy consumption increases by 0.4%/year. In the No CPP case, which excludes the CPP, total energy consumption grows at a faster rate of 0.5%/year. Energy intensity, measured both as energy use per capita and as energy use per dollar of GDP, declines (Figure MT-7).

The structure and efficiency of the U.S. economy are changing in ways that can lower total energy use and energy use per dollar of GDP. The service industry share of total shipments remains at or just below 77% through 2040 in the Reference case, and in the manufacturing sector output continues to shift from energy-intensive industries to nonenergy-intensive industries. In the No CPP case, the manufacturing output and energy-intensive manufacturing output shares of total shipments are slightly higher than in the Reference case.

Changes in consumer behavior also affect energy consumption. The Reference case decline in energy use per capita results largely from gains in appliance efficiency, a shift in population from cooler to warmer regions, and an increase in vehicle efficiency standards combined with modest growth in travel per licensed driver. From 1970 through 2008, energy use dipped below 320 million British thermal units (Btu) per person for only a few years in the 1980s. In 2012, energy use per capita was about 300 million Btu, the lowest level since 1967; however, it has increased slightly since 2012. In the Reference case, energy use per capita in 2020 is below the 2012 level, and in 2040 it is 281 million Btu per capita. Efficiency gains in appliances reduce demand for electricity, and efficiency gains in the electric power sector also reduce overall energy intensity, as older, less-efficient generators are retired as a result of slower growth in electricity demand, changing dispatch economics related to rising fuel prices, and stricter environmental regulations.

Industrial and commercial sectors lead U.S. growth in primary energy use

Figure MT-8. Primary energy consumption by end-use sector in two cases, 2015–40 (quadrillion Btu)



Total energy consumption increases by an average of 0.4%/year, reaching 107.1 quadrillion British thermal units (Btu) in 2040 in the AEO2016 Reference case, and at a somewhat faster 0.5%/year in the No CPP case, to 109.9 quadrillion Btu in 2040 (Figure MT-8). Energy consumption declines over the 2015–40 period in the transportation and residential sectors and increases in the commercial and industrial sectors. The decline in transportation sector energy consumption would be even greater with the Phase 2 standards for medium- and heavy-duty vehicles proposed jointly by the National Highway Traffic Safety Administration and the U.S. Environmental Protection Agency, which are not considered in the Reference case. Feedstock use in the chemical industry accounts for approximately 40% of the 9.6 quadrillion Btu increase in total industrial sector energy consumption in the Reference case and almost 40% of the 10.4 quadrillion Btu increase in the No CPP case. Increases in non-feedstock industrial natural gas use account for slightly more than 25% of the sector's increase in the Reference case, more than half of which results from the use of natural gas as lease and plant fuel and to liquefy natural gas for export.

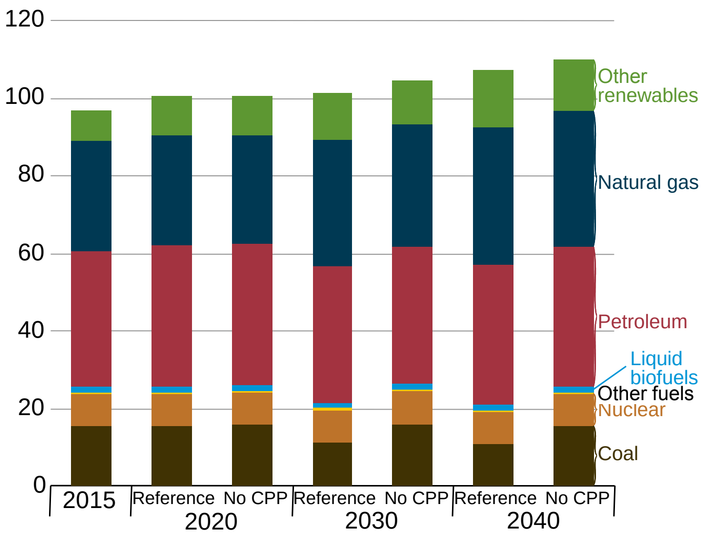
Energy use in the commercial sector increases by about 2.2 quadrillion Btu from 2015 to 2040 in the Reference case, with most of the increase attributable to electricity consumption despite increases in efficiency that reduce energy use for space heating, lighting, refrigeration, and personal computers. In the No CPP case, energy use in the commercial sector increases by 3.3 quadrillion Btu from 2015 to 2040.

U.S. energy demand

In both the residential and transportation sectors, energy use in the AEO2016 Reference case declines from 2015 through the early 2030s before it begins to increase again. Energy use in the transportation sector is affected less by the CPP than the other end-use sectors, as the CPP has no direct effect on transportation sector energy consumption. In the Phase 2 Standards case, transportation sector energy consumption is more than 1.5 quadrillion Btu lower in 2040 compared with the Reference case. In the Reference case, energy use in the residential sector declines despite population growth, as the efficiency of space heating and lighting improves. For the residential and transportation sectors combined, energy use declines by 1.6 quadrillion Btu from 2015 to 2040 in the Reference case, as compared with a decline of 0.7 quadrillion Btu in the No CPP case.

Renewables and natural gas lead rise in primary energy consumption

Figure MT-9. Primary energy use by fuel in two cases, 2015, 2020, 2030, and 2040 (quadrillion Btu)



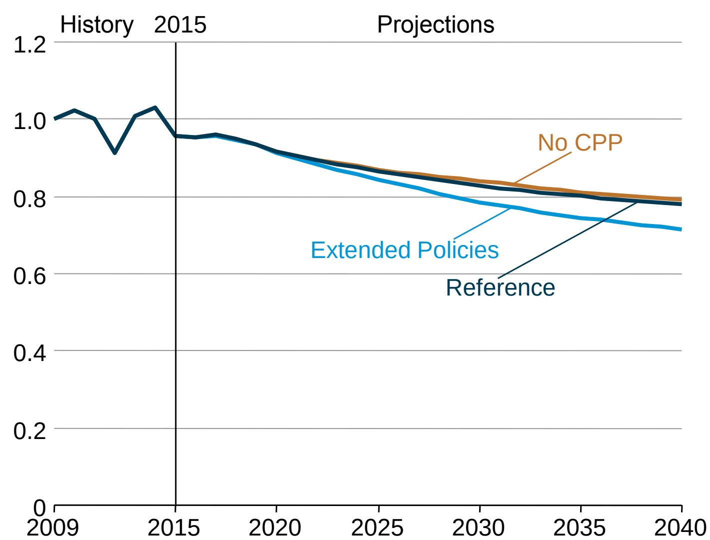
The fossil fuel share of total energy use declines in the Reference case from 82% in 2015 to 77% in 2040, while renewable energy use grows (Figure MT-9). The renewable share of total energy use (including liquid biofuels) increases from 9% in 2015 to 15% in 2040 in response to the Clean Power Plan (CPP), availability of federal tax credits for renewable electricity generation and capacity during the early years of the projection, and state renewable portfolio standard programs.

Natural gas consumption grows by about 0.9%/year from 2015–40, led by increases in natural gas use for electricity generation and in the industrial sector. Growing production from tight shale keeps the price of natural gas to end users below 2009–10 levels through 2040. Increases in vehicle fuel economy offset growth in transportation and industrial fuel use, resulting in a decline in total consumption of petroleum and other liquids from 2020–30. After 2030, petroleum and other liquids consumption rises through 2040 but does not return to the 2020 peak level. With the proposed medium- and heavy-duty vehicle Phase 2 standards for fuel consumption and greenhouse gas emissions in effect, consumption of petroleum and other liquids would be 1.5 quadrillion British thermal units (Btu) lower in 2040 than in the Reference case, or about equal to 2014 levels.

Coal consumption declines by an average of 1.4%/year from 2015–40, with most of the reduction occurring from 2015–30. A small amount of coal-fired power plant capacity is added through 2040, including a total of 0.3 gigawatts (GW) currently under construction and another 0.2 GW (with carbon sequestration capability) added after 2016. Consumption of renewable energy surpasses the use of energy from coal-fired generation in 2026. Energy consumption—both the total and the mix—in the No CPP case is different from that in the Reference. Total energy consumption in 2040 is about 2.7 quadrillion Btu higher in the No CPP case, with about 4.7 quadrillion Btu more coal consumption, 1.6 quadrillion Btu less renewable energy consumption, and 0.6 quadrillion Btu less natural gas consumption than in the Reference case.

Residential energy intensity declines across a range of policy assumptions

Figure MT-10. Residential delivered energy intensity in three cases, 2009–40 (index, 2009 = 1)

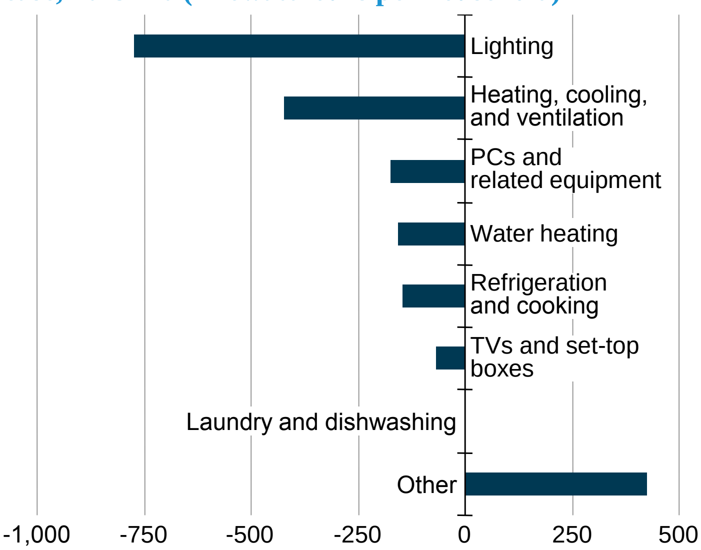


The intensity of residential energy demand, defined as annual delivered energy use per household, declines by 18% from 2015–40 in the Reference case (Figure MT-10). The major factors leading to the decline include energy efficiency policies and standards and population shifts to warmer climates in the south and west. Space heating and water heating account for almost 74% of the reduction in energy intensity and lighting for about 15%, primarily as a result of the phasing in of the light bulb efficiency standards mandated by the Energy Independence and Security Act of 2007 [*8*]. The continued growth of renewable capacity in the residential sector, such as rooftop solar photovoltaic panels, also reduces delivered energy intensity, given that solar panels are considered to be a distributed generation source rather than delivered energy purchased from a centrally located utility or energy provider.

The AEO2016 Reference case includes all current laws and regulations, including the Clean Power Plan (CPP) [*9*]. Alternative cases model the effects of different policy assumptions on residential energy intensity. In the No CPP case, which assumes no implementation of the CPP, there are fewer rebates and subsidies for efficient end-use equipment. In the Extended Policies case, there are additional rounds of appliance standards and building codes, as well as the extension of tax credits for efficient equipment and distributed generation technologies, including solar photovoltaics and wind. As a result, household energy intensity declines by 18% from 2015 to 2040 in the No CPP case and by 25% in the Extended Policies case. The CPP assumptions in the Reference case lead to additional efficiency improvements for electricity end uses, particularly lighting and electric heating, ventilation, and air conditioning (HVAC) appliances. Assumptions in the Extended Policies case lead to lower consumption as a result of efficiency gains in all residential fuels (particularly fuels used for HVAC and water heating), including electricity, and an increase in distributed generation.

Electricity use per household declines in the Reference case

Figure MT-11. Change in residential electricity consumption for selected end uses in the Reference case, 2015–40 (kilowatthours per household)

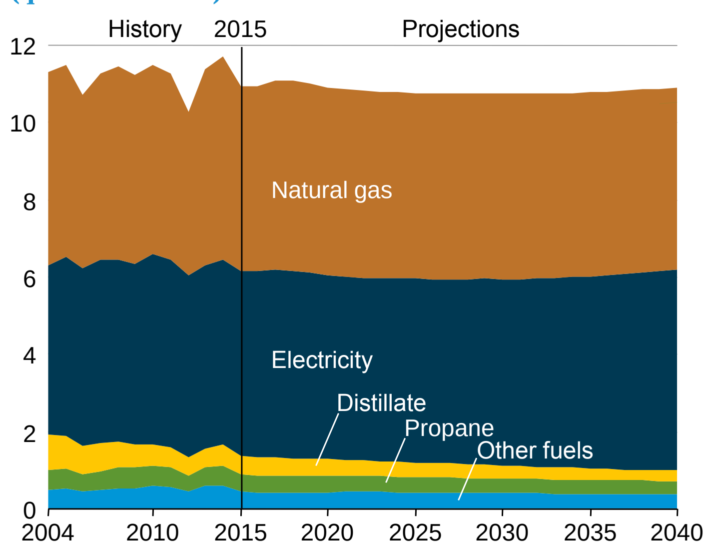


Annual electricity demand for the average household declines by 11% in the Reference case, from 12.1 megawatthours (MWh) in 2015 to 10.8 MWh in 2040. In 2015, the largest uses of electricity at the household level are space cooling, small devices and other minor electric end uses, and lighting. In 2040, electricity consumed for small devices and other minor electric end uses per household is 13% higher, and electricity use for lighting and space cooling per household is 62% lower and 9% lower, respectively (Figure MT-11). The growth in electricity use per household for small devices and other minor appliances results from the continued proliferation of appliances available and adopted by consumers. Regulations implementing the lighting efficiency standards in the Energy Independence and Security Act of 2007 are a major factor in the replacement of incandescent bulbs with more efficient lighting technologies, including light-emitting diode lamps and compact fluorescent lighting, which results in the decrease in electricity use for lighting. Space cooling energy use per household declines as efficiency improvement more than offsets the increased load due to the shift of population to warmer climates. Also contributing to the decline is increased distributed generation, particularly rooftop solar, that offsets purchased electricity sales.

Although electricity consumption for most end uses declines from 2015–40 on a per-household basis, electricity consumption for the residential sector as a whole increases as a result of growth in the U.S. population and number of households. Most of the increase results from market penetration of smaller electric devices, most of which are not covered by efficiency standards, and from growing demand for space cooling as the U.S. population shifts to warmer climates in the South and West. Overall, residential electricity use grows by 9% from 2015–40, as the fuel mix in the residential sector moves increasingly toward electricity. Petroleum and other liquids lose fuel share for almost every residential end-use service, particularly for space heating, where both electricity and natural gas gain share. Natural gas loses fuel share in every end-use service except space heating and water heating but continues to account for more than 50% of the fuel consumed for space heating, water heating, and cooking. In 2040, total natural gas use in the residential sector is 1% lower, and petroleum and other liquids use is 34% lower, than in 2015.

Residential sector energy consumption shows little change from 2015 to 2040

Figure MT-12. Residential sector delivered energy consumption by fuel in the Reference case, 2004–40 (quadrillion Btu)



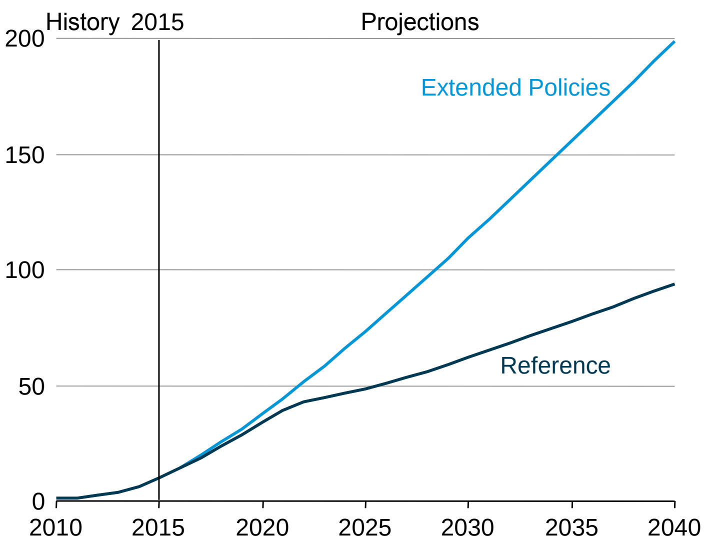
In the Reference case, total delivered energy use in the residential sector is virtually unchanged from 2015–40 (Figure MT-12), while the number of households grows by 0.8%/year. As a result, residential sector energy intensity declines [*10*]. Over the same period, consumption of purchased electricity increases by

0.3%/year. Although demand for electricity is affected more than other fuels by the adoption of new uses, consumption of electricity for residential lighting declines in the Reference case. The use of natural gas for residential space heating and water heating remains nearly flat over the 2015–40 period.

Residential distillate fuel consumption declines by an average of 2.4%/year in the Reference case, as a result of decreasing use of distillate fuel for space and water heating. The price of distillate fuel rises relative to the prices of natural gas and electricity. Similarly, propane consumption in the residential sector falls by an average of 0.9%/year as its use for home and water heating continues to decline. The cost of propane remains lower than the cost of electricity for residential uses but increases relative to the cost of natural gas over the projection period.

Investment tax credit extension increases adoption of renewable energy sources

Figure MT-13. Residential distributed electricity generation in two cases, 2010–40 (billion kilowatthours)



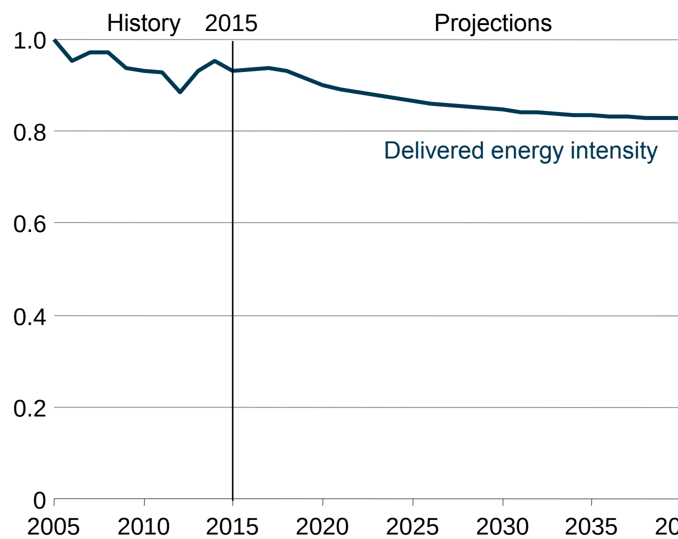
Distributed electricity generation in the residential sector, including solar photovoltaic (PV) and wind technologies, increased tenfold from 2010–15. In the Reference case, it more than triples from 2015–20, in part as a result of financial incentives for residential distributed generation. The 30% federal investment tax credit (ITC) for solar technologies that was slated to expire at the end of 2016 has been extended through 2019 and currently is scheduled to be phased out gradually from 2020–21. In the Extended Policies case, the 30% ITC continues indefinitely.

The Extended Policies case represents a more optimistic future for the growth of distributed generation in the residential sector, based on the tax credits available for installations of solar and other distributed generation technologies. With the ITC extended beyond its currently legislated 2016 expiration date for wind and a 2022 phaseout date for solar, residential generation doubles in the Extended Policies case from 2021–28 and more than doubles from 2028–40. Residential distributed generation, including solar and wind, totals 199 billion kilowatthours (kWh) in 2040, compared with 10 billion kWh in 2015 (Figure MT-13).

The effects of the ITC on installation costs for residential distributed generation systems are significant. For example, solar PV installation costs (excluding tax credits and other financial incentives) fall in the Reference case from $4,042 per kilowatt (kW) of capacity in 2015 to $2,387 per kW in 2025 and to $2,170 per kW in 2040. Along with declining installation costs, the 30% tax credit in the Extended Policies case increases the adoption of renewable electricity generation technologies in the residential sector.

Commercial sector energy intensity continues to decline

Figure MT-14. Commercial sector delivered energy intensity in the Reference case, 2005–40 (energy use per square foot, index, 2005 = 1.0)



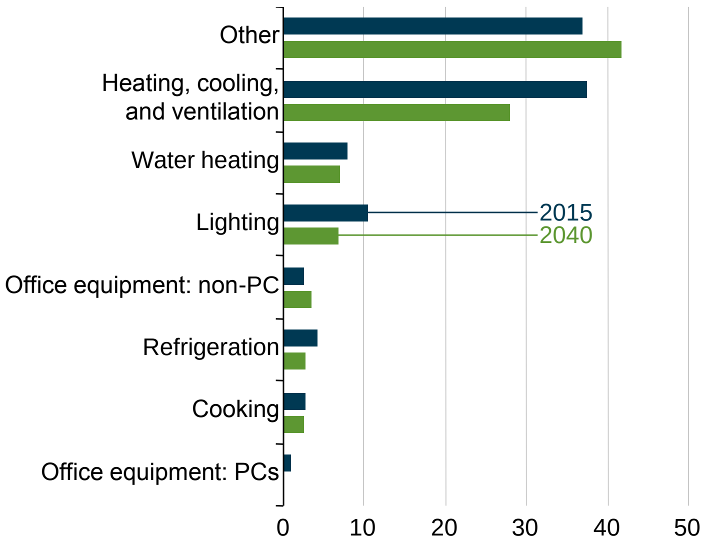
In the AEO2016 Reference case, commercial sector energy intensity, defined as delivered energy consumption per square foot of commercial floorspace, declines by an average 0.5%/year from 2015–40 (Figure MT-14). While commercial buildings energy intensity decreases, delivered energy consumption grows by 0.6%/year, and commercial floorspace grows by 1.1%/year.

In the commercial sector, delivered electricity consumption grows faster than natural gas consumption in the Reference case. As a result, natural gas intensity declines by an average of 0.5%/year from 2015–40, compared with an average decline of 0.3%/year in commercial sector electricity intensity. The natural gas share of total delivered energy use in the commercial sector declines from 38% in 2015 to 37% in 2040 in the Reference case, while the electricity share of total delivered energy use increases from 53% in 2015 to 55% in 2040.

The continued decline in energy intensity of commercial buildings is explained in part by improvements in the energy efficiency of lighting, heating, cooling, and ventilation systems, as well as more stringent building codes. Improvements in the efficiency of major end-use equipment help to slow the growth of delivered energy consumption in the commercial sector. In the Extended Policies case, which assumes the issuance of more stringent efficiency standards for end-use equipment in the future, overall energy intensity is lower than in the AEO2016 Reference case. In 2040, total commercial sector energy per square foot in the Extended Policies case is more than 2% lower than in the Reference case.

Federal efficiency standards reduce commercial sector energy intensity

Figure MT-15. Energy intensity of selected commercial end uses in the Reference case, 2015 and 2040 (thousand Btu per square foot)

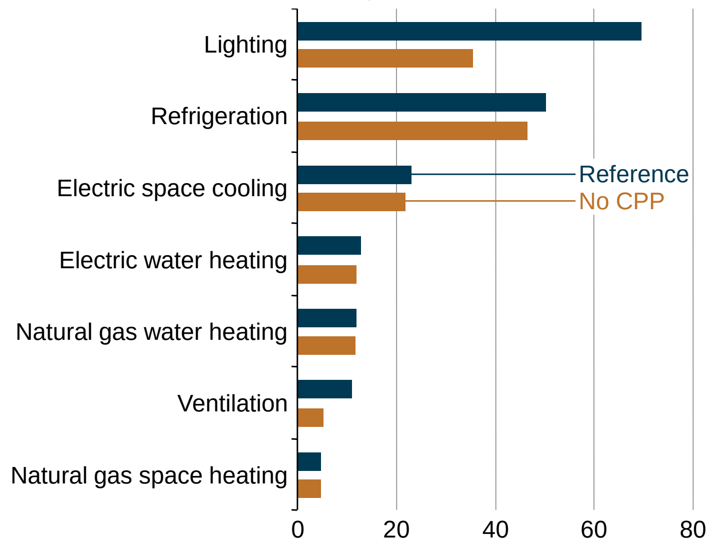


While commercial floorspace grows by an average of 1.1%/year from 2015–40 in the AEO2016 Reference case, delivered energy consumption for many commercial end uses decreases or grows more slowly than floorspace, resulting in declines in commercial sector energy intensity (the ratio of energy consumption to commercial floorspace) (Figure MT-15). Virtually every major use of energy in commercial buildings, including space heating and cooling, water heating, lighting, and refrigeration, is covered by some sort of federal energy efficiency standard. The U.S. Department of Energy is required by law to investigate whether updated standards are technologically feasible and economically justified and to work with stakeholders to develop updated standards as appropriate. As a result, energy intensity decreases in the Reference case by 1.7%/year from 2015–40 for lighting and refrigeration and by 1.2%/year for space heating, cooling, and ventilation.

The energy intensity of miscellaneous electric loads in commercial buildings—equipment ranging from large medical imaging equipment to video displays and other electric devices—increases by a total of 11.5% from 2015–40. While voluntary efficiency programs such as ENERGY STAR may help to reduce energy use for some devices and appliances, many other devices and appliances are not covered by federal efficiency standards. In large part, the growth of energy use for commercial non-PC office equipment results from new data centers for web- and network-based services and connectivity, with energy intensity increasing by 1.1%/year in the AEO2016 Reference case. For commercial PC office equipment, energy intensity decreases by 5.9%/year as users shift from desktop computers to more efficient laptops and mobile computing devices. Although no national standard exists, a growing number of states and municipalities continue to adopt more stringent building energy codes, often aligning with newer versions of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 90.1. Improvements in building shells, including tighter air sealing, more efficient windows, and more insulation, also reduce energy use for heating and cooling of buildings.

Efficiency gains for advanced technologies reduce commercial energy consumption growth

Figure MT-16. Efficiency gains for selected commercial equipment in two cases, 2015–40 (percent change from 2015 installed stock efficiency)



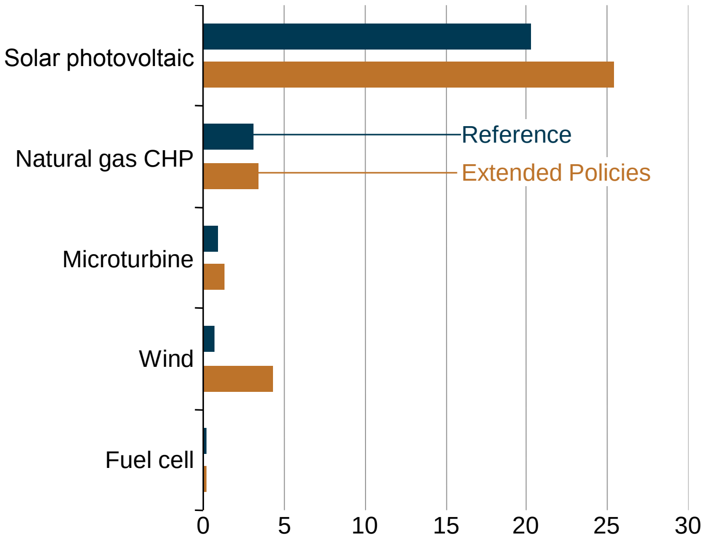
In the commercial sector, the largest efficiency gains in the AEO2016 Reference case are for lighting. Lighting efficiency, or efficacy (light output per unit of energy consumed, measured in lumens per watt), increases by 70% from 2015–40 in the Reference case with continued improvements as a result of federal standards and the increasing penetration of light-emitting diode lighting technologies. Refrigeration and electric space cooling also show significant efficiency gains (Figure MT-16).

The largest impacts of the Clean Power Plan (CPP) on efficiency in the commercial sector are on lighting and ventilation. Efficiency gains from 2015–40 in the Reference case are about twice those in the No CPP case for both end uses. Rebates offered in support of the CPP in the Reference case make efficient technology purchases more attractive to consumers.

Total commercial energy demand increases by an average of 0.5%/year from 2015–40 in the Reference case. However, energy use for office equipment other than personal computers increases by 1.9%/year as local servers are replaced by central data storage and network computing. Energy use for nonbuilding services and miscellaneous electric loads (such as portable and plug-in devices) increases by an average of 1.4%/year. The AEO2016 Reference case reflects the efficiency effects of federal equipment standards, technology advances, and efficiency rebates and incentives offered in support of the CPP.

Extended investment tax credits result in more additions to renewable distributed generation capacity

Figure MT-17. Additions to commercial sector electricity generation capacity in two cases, 2015–40 (gigawatts)



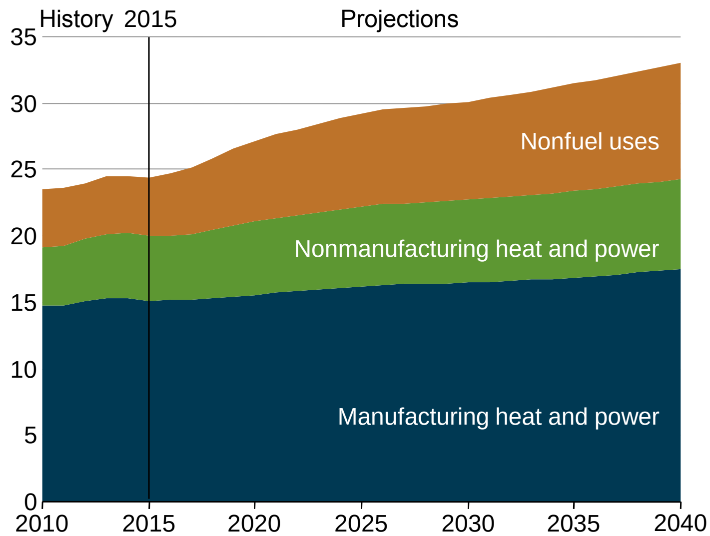
Solar photovoltaic (PV) capacity for electricity generation accounts for nearly 78% of the 33.3 gigawatts (GW) of commercial sector distributed generation (DG) capacity in 2040 in the Reference case. The costs of PV inverters, solar panels, and equipment installation continue to decline, while state and utility rebates and extensions of federal investment tax credits contribute to the growth of installed PV capacity. In the Reference case, solar PV capacity increases by more than 6%/year on average, from 5.6 GW in 2015 to 25.8 GW in 2040.

Federal business investment tax credits for solar technologies, including PV, which were set to expire after 2016, have been extended. The 30% credit will continue through 2019, then decrease to 26% in 2020, 22% in 2021, and 10% in 2022 and after. Tax credits for combined heat and power (CHP) and small wind generators will expire after 2016. The Extended Policies case assumes that the CHP and wind tax credits do not expire. As a result, in the Extended Policies case, commercial wind capacity increases by 16%/year from 2015–40, compared with more than 8%/year in the Reference case (Figure MT-17), and accounts for 10% of the 42.8 GW of total commercial distributed generation capacity in 2040, compared with 72% for PV.

Use of natural gas-fired CHP continues to grow in the commercial sector, with conventional natural gas-fired CHP capacity—including reciprocating engines and turbines—growing by more than 4%/year and accounting for 14% of commercial DG capacity in 2040 in the Reference case. The total capacity of natural gas microturbines grows by almost 8%/year and accounts for more than 3% of commercial DG capacity in 2040, while the total capacity of fuel cells grows by 7%/year and accounts for almost 1% of commercial DG capacity in 2040. Higher commercial electricity prices as a result of the CPP also contribute to the increased use of DG technologies.

Industrial shipments grow more rapidly than energy consumption

Figure MT-18. Industrial energy consumption by application in the Reference case, 2010–40 (quadrillion Btu)



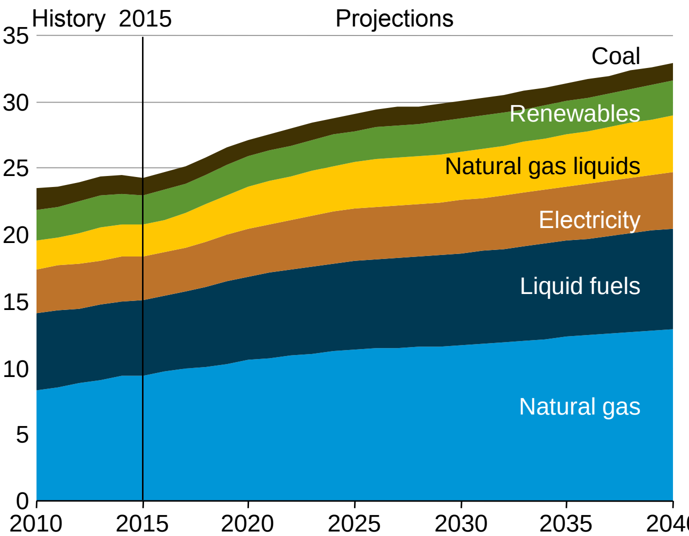
In the AEO2016 Reference case, manufacturing shipments increase by more than 60% from 2015–40, while delivered energy consumption for heat and power in the manufacturing sector increases by 16%. The continued decline in energy intensity of manufacturing results in part from continued improvement in the efficiency of industrial equipment, as well as a shift in the share of shipments from energy-intensive manufacturing industries to nonenergy-intensive industries. With lower fuel prices, shipments and energy use in many energy-intensive industries (bulk chemicals, petroleum refineries, iron and steel, and aluminum) continue to increase throughout the projection, but shipments in less energy-intensive manufacturing industries (plastics, metal-based durables) grow more rapidly.

With lower prices for natural gas and hydrocarbon gas liquids, shipments in the bulk chemical industry expand faster than those in other energy-intensive industries. Shipments in the bulk chemical industry increase by 4.8%/year from 2015–25, then slow to 1.4%/year growth from 2025–40. Energy use increases by 4.3%/year from 2015–25 and 1.1%/year from 2025–40, when energy use for bulk chemicals exceeds 10 quadrillion Btu and accounts for more than 31% of total industrial sector energy consumption. In the nonmanufacturing industries (agriculture, mining, and construction), energy intensity declines from 2015–40, as shipments increase by 53% and total delivered energy consumption increases by 30%. The overall decline in energy intensity is limited by the mining industry, where energy intensity increases as resource extraction moves into less-productive areas.

In the manufacturing sector, energy consumption for heat and power grows steadily in the Reference case, averaging 0.5%/year growth from 2015–40 (Figure MT-18). Nonmanufacturing energy consumption grows by an average of 2.2%/year from 2015–25, then slows to 0.8%/year from 2025–40. Nonfuel energy use (principally used for bulk chemical feedstocks and asphalt) grows by 4.7%/year from 2015–25, largely as a result of an increase in shipments of bulk chemicals. After 2025, nonfuel energy use grows by 1.5%/year in parallel with bulk chemical shipments.

Reliance on natural gas, natural gas liquids, and renewables rises as industrial energy use grows

Figure MT-19. Industrial sector energy consumption by fuel in the Reference case, 2010–40 (quadrillion Btu)



Total delivered energy consumption in the industrial sector increases in the Reference case by 35%—8.6 quadrillion British thermal units (Btu)—from 2015–40 (Figure MT-19). As a result of relatively low prices, natural gas use accounts for 41% of the total increase. The mix of industrial energy sources stays relatively constant, however, reflecting limited capability for switching from other fuels to natural gas in most industries.

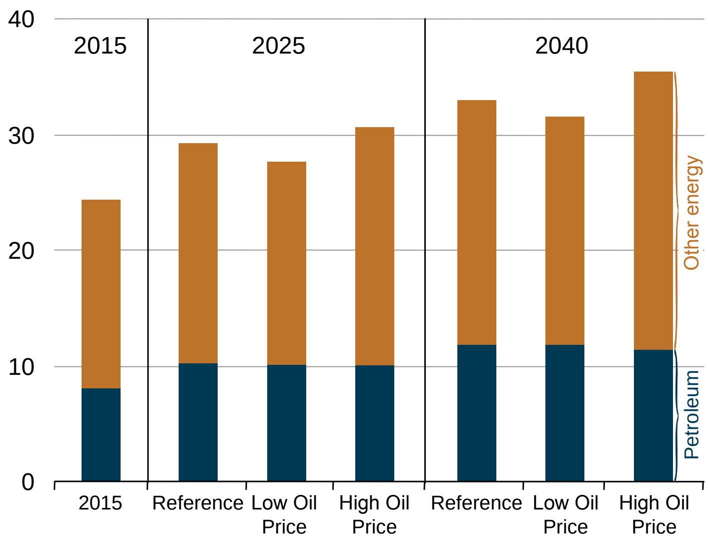
Consumption of renewable fuels (including biofuels heat and coproducts) increases by 16% from 2015–40 and accounts for a 5% share of total delivered energy consumption in 2040. The paper industry continues to be the predominant user of renewable energy, at 41% of the industrial sector total in 2040.

Industrial consumption of liquefied petroleum gases (LPG) increases by 47% from 2015–25 and by 21% from 2025–40. LPG are consumed predominantly as feedstocks in the bulk chemicals industry, with smaller amounts (mostly propane) consumed for process heat in other industries. Coal is the only industrial fuel whose share declines consistently over the projection, from 6% of the total in 2015 to 4% in 2040 as coal consumption remains relatively constant while total industrial energy use grows.

Low natural gas prices contribute to increasing use of combined heat and power (CHP) generation in the industrial sector, which grows by 48%, from 139 billion kilowatthours (kWh) in 2015 to 206 billion kWh in 2040. CHP is used primarily in the bulk chemicals, paper, and refining industries. Smaller amounts are used in the iron and steel industry and the food industry.

Petroleum share of industrial sector energy use increases in all oil price cases

Figure MT-20. Industrial consumption of petroleum and other energy in three cases, 2015, 2025, and 2040 (quadrillion Btu)



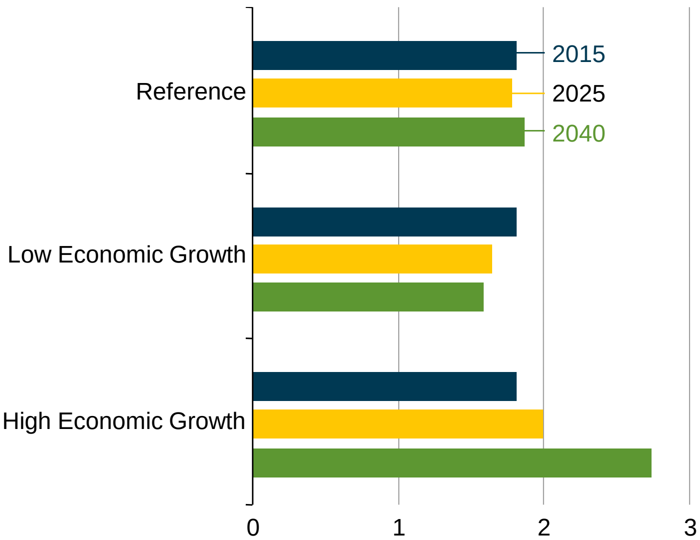
Because there are few substitutes for petroleum in construction, mining, agriculture, and manufacturing applications, industrial petroleum use varies only modestly across alternative oil price cases. In the Reference case, the petroleum share of total industrial energy use grows from 33% in 2015 to 36% in 2040. Industrial petroleum consumption increases by 46%, from 8.1 quadrillion British thermal units (Btu) in 2015 to 11.8 quadrillion Btu in 2040, compared with a 30% increase for all other energy sources.

While petroleum consumption in the industrial sector in 2040 is similar in the AEO2016 Reference and Low Oil Price cases, consumption of other fuels grows by 30% in the Reference case and 21% in the Low Oil Price case from 2015–40. The petroleum share of total consumption in 2040 in the Low Oil Price case is slightly higher than in the Reference case as a result of increased shipments from petroleum refineries. Lower oil prices create less incentive for improving the efficiency of petroleum consumption.

In the High Oil Price case, petroleum consumption in the industrial sector increases by 40% over 2015–40, reaching 11.3 quadrillion Btu in 2040. With a lower petroleum-intensive manufacturing share of shipments, including bulk chemicals and refining, petroleum intensity is slightly lower than in the Reference case. Consumption of other fuels, particularly natural gas, increases by 48% from 2015–40 in the High Oil Price case. The increase in natural gas consumption in the High Oil Price case is a result of higher levels of gas-to-liquids (GTL) production and more exports of liquefied natural gas, which consumes natural gas in liquefaction, than in the Reference case. GTL production is economical only in the High Oil Price case.

Energy use in the pulp and paper industry depends on technology choices

Figure MT-21. Energy consumption for pulp and paper production in three cases, 2015, 2025, and 2040 (quadrillion Btu)

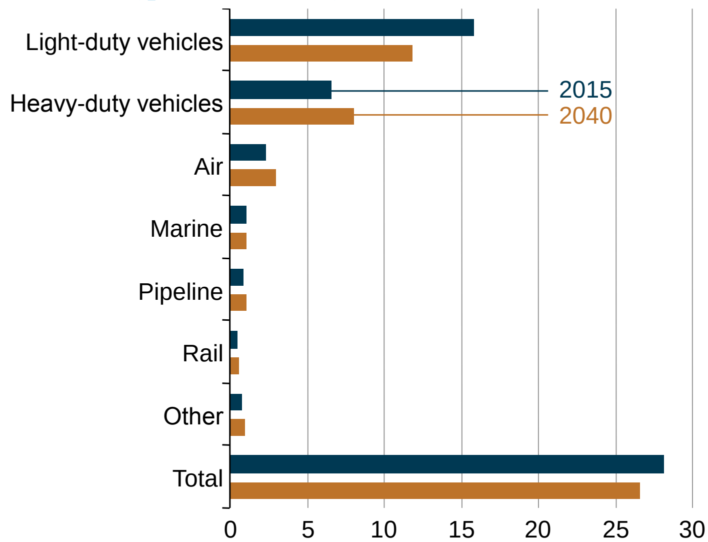


Energy use in the pulp and paper industry, which is closely related to shipment volumes, differs significantly in the AEO2016 Reference, Low Economic Growth, and High Economic Growth cases (Figure MT-21). Most of the energy consumed in the industry is from renewable sources. In the Reference case, the renewable share of total energy consumption in the pulp and paper industry grows from 55% in 2015 to 58% in 2040. The amount of energy used in the industry also depends on the technologies chosen for each process step, with the choices generally based on capital costs, operation and maintenance costs, fuel costs, and emissions. Some technologies use recycled products and waste, including recycled paper for pulp, wood waste for fuel, and chemical recovery (such as black liquor from the Kraft pulping process) for combined heat and power.

In the AEO2016 Reference and Low Economic Growth cases, slow growth in shipments and the adoption of more-energy-efficient technologies result in declines in energy consumption over the first 10 years of the projection. In the Reference case, pulp and paper industry shipments increase by 3%, while energy consumption declines by 1% from 2015–25. From 2025–40, with an 8% increase in pulp and paper industry shipments, energy consumption increases by 4%. In the Low Economic Growth case, with a 4% decline in pulp and paper industry shipments, energy consumption declines by 9% from 2015–25. From 2025–40, with a 2% increase in pulp and paper industry shipments, energy consumption declines by a smaller 3%. In the High Economic Growth case, with more rapid 13% growth in pulp and paper industry shipments from 2015–25, energy consumption increases by 10%, and from 2025–40 both pulp and paper industry shipments and energy consumption increase by about 37%. Although energy efficiency improves in the 2025–40 period, more rapid growth in combined heat and power generation results in a higher rate of increase in energy consumption.

Higher light-duty vehicle fuel economy reduces transportation energy consumption after 2018

Figure MT-22. Delivered energy consumption for transportation by mode in the Reference case, 2015 and 2040 (quadrillion Btu)



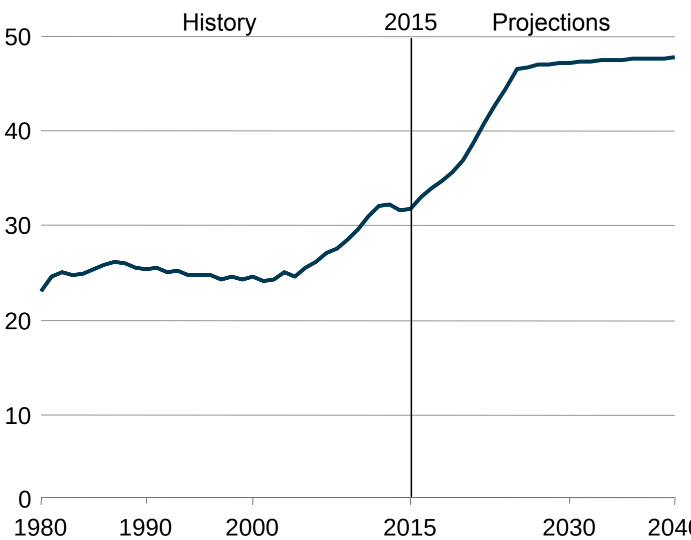
In the Reference case, transportation sector delivered energy consumption increases from 28.1 quadrillion British thermal units (Btu) in 2015 to 28.6 quadrillion Btu in 2017, declines to 26.1 quadrillion Btu in 2033, then rises to 26.6 quadrillion Btu in 2040. Transportation energy consumption increased by 1.6%/year on average from 1995 to 2007 (to 28.6 quadrillion Btu), then fell to 26.0 quadrillion Btu in 2012 as economic recession reduced demand for freight and passenger transportation. After 2012, growth in demand for transportation services offset efficiency improvements. The decline after 2017 in the Reference case results from a drop in light-duty vehicle (LDV) energy use with the implementation of new corporate average fuel economy standards, more than offsetting increases in energy use for heavy-duty vehicles (HDVs), aircraft, marine vessels, pipelines, and rail. The Reference case does not include the proposed Phase 2 standards for trucks (see discussion in the AEO2016 Issues in focus section), which if finalized would further reduce transportation energy use.

LDV energy demand falls sharply in the Reference case, from 15.9 quadrillion Btu in 2015 to 11.8 quadrillion Btu in 2040, as higher fuel economy more than offsets increases in LDV travel. Although new fuel efficiency and greenhouse gas emissions standards for HDVs took effect in 2014, energy use by HDVs (including tractor trailers, buses, vocational vehicles, and heavy-duty pickup trucks and vans) grows from 6.6 quadrillion Btu in 2015 to 8.1 quadrillion Btu in 2040 in the Reference case, as travel demand increases with economic growth.

Because growth in personal air travel is not fully offset by increases in aircraft fuel efficiency, aircraft energy consumption increases at a faster rate than other transportation modes, from 2.4 quadrillion Btu in 2015 to 3.0 quadrillion Btu in 2040s. Energy consumption by marine vessels also grows, as increased international trade boosts demand for shipping (despite a modest decline in domestic shipping), and rising incomes increase demand for recreational boating. Pipeline energy use is tempered as more natural gas is produced closer to end-use markets. With travel demand growing more rapidly than efficiency improvements, energy consumption for freight and passenger rail travel also increases slightly.

Corporate average fuel economy and greenhouse gas emissions standards boost light-duty vehicle fuel economy

Figure MT-23. Average fuel economy of new light-duty vehicles in the Reference case, 1980–2040 (miles per gallon)



In the Reference case, transportation sector delivered energy consumption increases from 28.1 quadrillion British thermal units (Btu) in 2015 to 28.6 quadrillion Btu in 2017, declines to 26.1 quadrillion Btu in 2033, then rises to 26.6 quadrillion Btu in 2040. Transportation energy consumption increased by 1.6%/year on average from 1995 to 2007 (to 28.6 quadrillion Btu), then fell to 26.0 quadrillion Btu in 2012 as economic recession reduced demand for freight and passenger transportation. After 2012, growth in demand for transportation services offset efficiency improvements. The decline after 2017 in the Reference case results from a drop in light-duty vehicle (LDV) energy use with the implementation of new corporate average fuel economy standards, more than offsetting increases in energy use for heavy-duty vehicles (HDVs), aircraft, marine vessels, pipelines, and rail. The Reference case does not include the proposed Phase 2 standards for trucks (see discussion in the AEO2016 Issues in focus section), which if finalized would further reduce transportation energy use.

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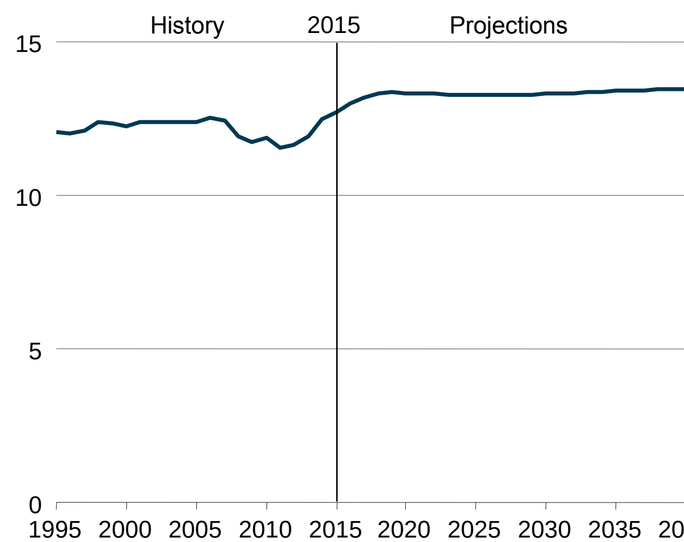
Miles traveled per licensed driver grows through 2018 and then levels off

Figure MT-24. Vehicle miles traveled per licensed driver in the Reference case, 1995–2040 (thousand miles)



Demand for personal vehicle travel, measured as annual vehicle miles traveled (VMT) per licensed driver, continues to grow beyond 2015 levels in the AEO2016 Reference case, from 12,700 miles in 2015 to 13,300 miles in 2018, remains at about 13,300 until 2033, and then increases again to 13,500 in 2040 (Figure MT-24). The major factors influencing personal vehicle travel include motor gasoline prices, personal income, vehicle fuel efficiency, travel patterns, driving population, and employment rates.

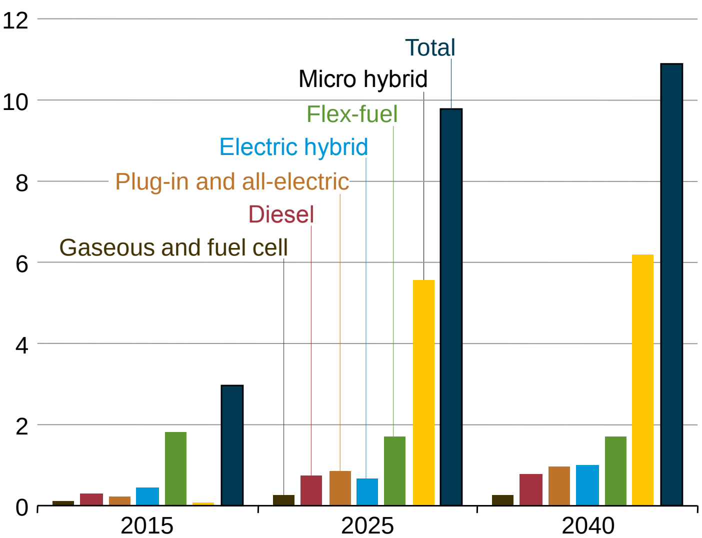
Transportation sector energy demand

The number of licensed drivers grows by an average of 0.7%/year from 2015–40, as the employment rate of the licensed driver population (the employed, nonfarm population ages 16 and over) increases by an average of 0.7%/yr from 2015–40. Total light-duty VMT increases in the Reference case to 3.4 trillion in 2040—a 25% increase from 2015—partly as a result of 18% overall growth in the number of licensed drivers, from 217 million in 2015 to 255 million in 2040.

Although vehicle sales decline between 2017 and 2022 before generally increasing through 2040, the number of vehicles per licensed driver stays constant at 1.1 from 2015–40. Motor gasoline prices fall from 2015 levels and do not exceed that level again until 2019, while real personal disposable income per licensed driver increases by 47% from 2015–40. Income growth and lower motor gasoline prices, combined with increasing fuel economy for both light-duty cars and light trucks, contribute to the increase in VMT per licensed driver throughout the projection.

Sales of vehicles using nongasoline technologies triple from 2015 to 2040

Figure MT-25. Sales of light-duty vehicles capable of using nongasoline technologies by type in the Reference case, 2015, 2025, and 2040 (million vehicles sold)



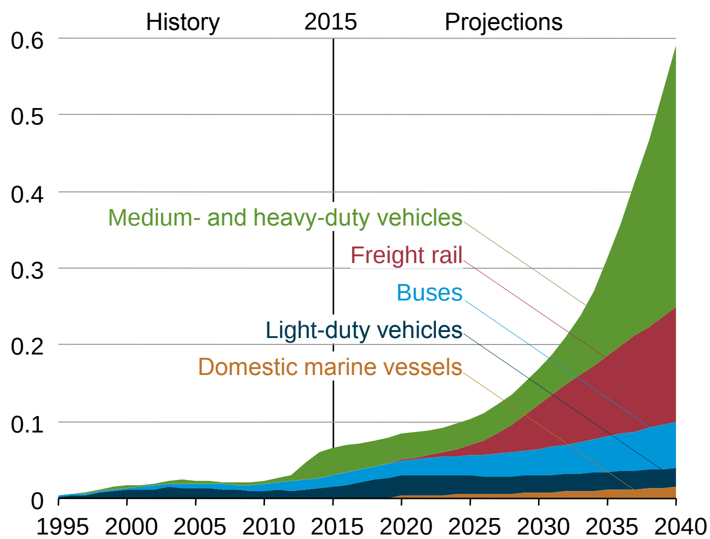
Light-duty vehicles (LDVs) that use diesel, alternative-fuel, hybrid-electric, or all-electric systems play a significant role in meeting more stringent greenhouse gas emissions and corporate average fuel economy (CAFE) standards in the AEO2016 Reference case, with sales increasing from 18% of all new LDV sales in 2015 to 61% in 2040. Micro hybrid vehicles, defined here as conventional gasoline internal combustion engine vehicles with micro hybrid systems that manage engine operation at idle, represent 34% of new LDV sales in 2040 (Figure MT-25). Flex-fuel vehicles (FFVs), which can use blends of up to 85% ethanol, represent about 10% of all new LDV sales in 2040. Current incentives for manufacturers selling FFVs, which are available in the form of fuel economy credits earned for CAFE compliance, expire at the end of 2019. As a result, the FFV share of LDV sales rises through 2019 and then remains flat through the rest of the projection.

Sales of hybrid electric and all-electric vehicles that use stored electric energy for motive power grow substantially in the Reference case. Gasoline- and diesel-electric hybrid vehicles account for 5% of total LDV sales in 2040. Plug-in hybrid and all-electric vehicles account for 5% of total LDV sales and 9% of total sales of vehicles using diesel, alternative-fuel, hybrid, or all-electric systems in 2040.

The diesel vehicle share of total LDV sales increases slightly from 2015–40 in the Reference case, from 2% to 4%. Light-duty gaseous and fuel cell vehicles account for less than 2% of new vehicle sales because of limited fueling infrastructure and the high incremental costs of the vehicles.

Natural gas use for transportation increases but remains a small share of total transportation energy

Figure MT-26. Transportation sector natural gas consumption by vehicle type in the Reference case, 1995–2040 (quadrillion Btu)



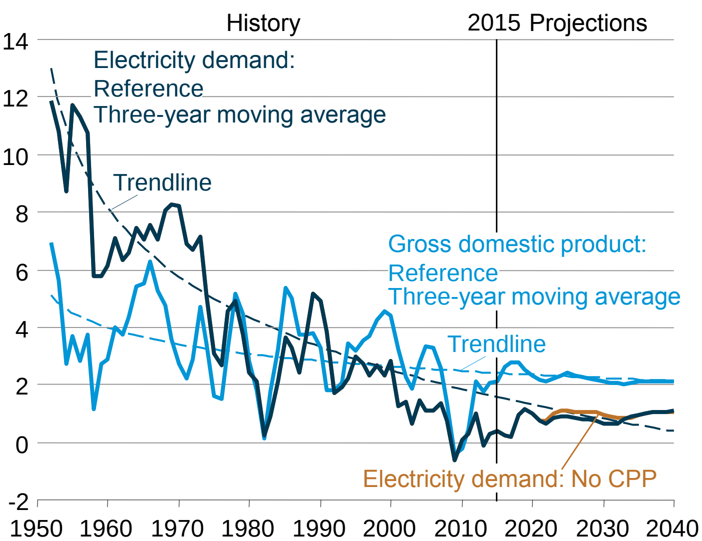
Unlike natural gas applications in other demand sectors, consumption of natural gas by rail, marine, and road vehicles in the transportation sector—in both dedicated and dual-fueled engines—generally requires additional processing to meet energy storage requirements on vehicles, either as compressed natural gas (CNG) or liquefied natural gas (LNG). In the AEO2016 Reference case, demand for natural gas in the transportation sector grows from 66 trillion British thermal units (Btu) in 2015 to 591 trillion Btu in 2040 (Figure MT-26). However, natural gas still accounts for just 2% of the sector's total delivered energy consumption in 2040, or slightly more than half of the 1,069 trillion Btu of natural gas consumed in pipeline transport operations in 2040.

Medium-duty and heavy-duty vehicles—including tractor trailers, vocational vehicles, pickups, and vans with gross vehicle weight rating of 10,001 pounds or more—become the largest consumers of CNG and LNG in the Reference case, increasing from 35 trillion Btu in 2015 to 342 trillion Btu in 2040. Most of the increase occurs after 2025, when natural gas is marketed at a steadily increasing discount compared to petroleum fuels. Initially, natural gas is used primarily as CNG in medium-duty trucks, but over time it is used increasingly as LNG to fuel heavy-duty trucks (primarily tractor trailers)—a relatively energy-dense storage, high-mileage application in which the fuel cost savings of LNG offset the significant incremental capital costs of LNG vehicles.

LNG energy consumption by freight rail locomotives grows to 150 trillion Btu in 2040, when it accounts for 30% of total freight rail energy consumption, with natural gas fuel cost savings offsetting the incremental capital costs of LNG locomotives. CNG and LNG energy demand for transit, intercity, and school buses also grows, from 16 trillion Btu in 2015 to 60 trillion Btu in 2040, primarily as a result of high CNG adoption rates for transit buses, which account for 95% (57 trillion Btu) of the natural gas used by buses in 2040. Use of CNG in light-duty vehicles and LNG in marine vessels remains relatively minor, at 24 trillion Btu and 15 trillion Btu in 2040, or 0.2% and 2.0% of each mode's energy consumption, respectively.

Growth in electricity use from 2015 to 2040 slows to 24% with Clean Power Plan (CPP) and to 27% with no CPP

Figure MT-27. U.S. gross domestic product growth and electricity demand growth rates, 1950–2040 (percent, three-year moving average)

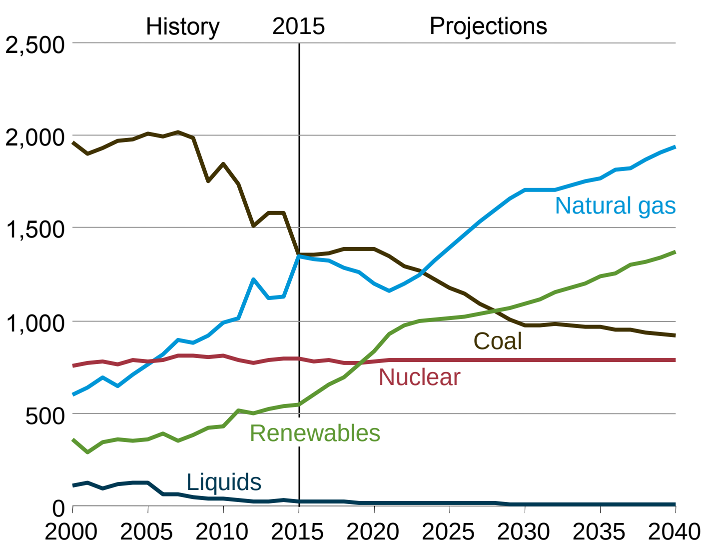


Electricity demand growth (including retail sales and direct use) has slowed in every decade since the 1950s, from 9.8%/year from 1949–59 to 0.5%/year from 2000–2015. In the AEO2016 Reference case and No CPP case, electricity demand growth remains relatively slow, as rising demand for electric services is offset by efficiency gains from new appliance standards and investments in energy-efficient equipment. Total electricity demand grows by 24% (0.9%/year) from 2015–40 in the Reference case, which includes the effects of the Clean Power Plan (CPP). In the No CPP case, demand increases by 27% from 2015–40 (1.0%/year). U.S. electricity demand is affected primarily by population growth and economic activity. However, electricity demand growth has been significantly slower than gross domestic product (GDP) growth in recent years and continues to be slower in the projections (Figure MT-27).

Electricity sales grow at a slower rate than electricity use, given the increasing role of self-generation in all end-use sectors. Total retail electricity sales increase by 20% (0.7%/year) from 2015–40 in the Reference case and by 23% (0.8%/year) in the No CPP case. Population shifts to warmer regions increase cooling requirements, which affects both residential and commercial electricity sales. In the residential sector, electricity sales grow by 9% and 11% from 2015–40 in the Reference case and No CPP case, respectively. The increasing energy efficiency of residential appliances and consumer electronics offsets some of the growth in electricity demand that would otherwise have occurred as a result of the increasing availability and sales of electronic devices. In the commercial sector, electricity demand grows by 21% in the Reference case and by 26% in the No CPP case from 2015–40, as demand for electrical devices and equipment continues to rise. In the industrial sector, electricity demand grows by 30% in the Reference case and by 32% in No CPP case from 2015–40, initially as a result of increasing sales in the primary metals, bulk chemical, and food industries, and later as a result of growth in the construction and metal-based durables industries. However, while demand increases for most industrial uses, total electricity use per unit of output declines in both the Reference case and No CPP case as energy efficiency increases.

Clean Power Plan accelerates shift from coal to natural gas and renewables

Figure MT-28. Net electricity generation by fuel in the Reference case, 2000–2040 (billion kilowatthours)



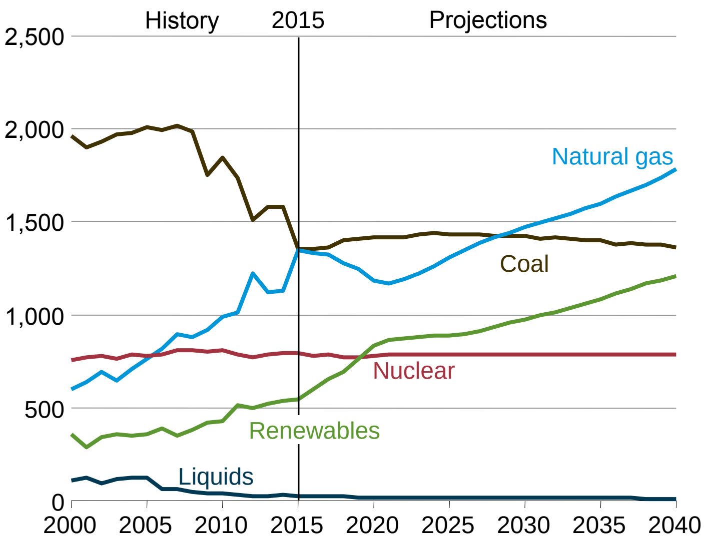
The Clean Power Plan (CPP) requires states to develop plans to reduce carbon dioxide (CO_2) emissions from existing fossil-fired electric generating units. The AEO2016 Reference case assumes that states will choose to cooperate with each other at the regional level [*11*], using a mass-based (cap-and-trade) program that allocates allowances to load-serving entities to reduce the potential impacts of higher rates on consumers.

If the CPP emerges intact from legal challenges, it is expected to reinforce the trend toward less carbon-intensive generation by accelerating the shift away from coal to natural gas and renewables, and toward increased energy efficiency. In the Reference case, coal use for electricity generation is overtaken by natural gas in 2024 and by renewables in 2028.

In the Reference case, higher electricity prices and the push for greater energy efficiency slows the 2015–30 growth rate of U.S. total electricity sales, from 1%/year from 2015–30 in the No CPP case to 0.8%/year in the Reference case. In addition, the higher cost associated with CO2 emissions under the CPP contributes to a 1.5% annual decline in electricity generated from coal, which drops from 1,355 billion kilowatthours (kWh) (a 33% share) in 2015 to 919 billion kWh (18%) in 2040. Retirements of coal-fired generators by 2030, increase from 60 gigawatts (GW) in the No CPP case to 92 GW in the Reference case, or about one-third of current capacity (Figure MT-28). Growth in generation from renewable energy sources also accelerates from 3.2%/year in the No CPP case to 3.8%/year in the Reference case, as total renewable generation increases from 546 billion kWh (13% of current generation) to 1,374 billion kWh (27% of 2040 generation in the Reference case). The average growth rate of nonhydropower renewable generation from 2015–40 increases from 4.5%/year in the No CPP case to 5.3%/year in the Reference case.

With no Clean Power Plan (CPP), coal-fired generation shows little change from 2015 level

Figure MT-29. Net electricity generation by fuel in the No CPP case, 2000–2040 (billion kilowatthours)



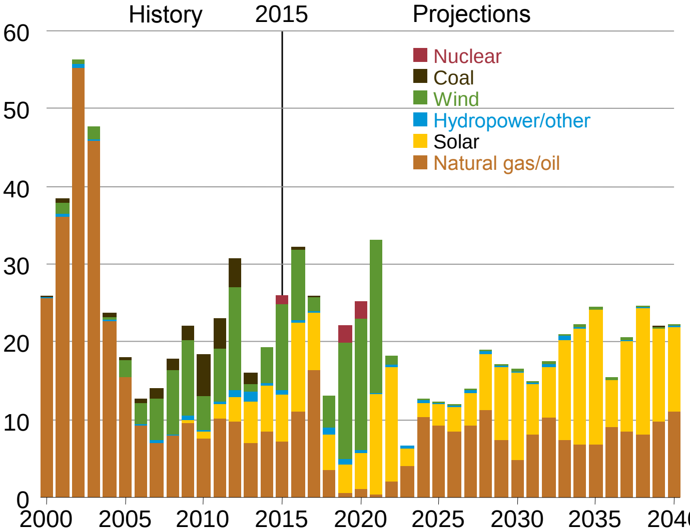
The decline in natural gas prices since 2009 has threatened the cost competitiveness of existing U.S. coal-fired generators, resulting in a 25% reduction in coal-fired generation in 2015 from its level in the mid-2000s. In the No CPP case, natural gas-fired generation roughly equals coal generation in the United States on an annual basis in 2016. After declining somewhat from 2016–20 with strong renewable growth as a result of tax credits, the natural gas share increases steadily in the No CPP case, overtaking the coal share in 2029 as the predominant fuel for electricity generation. In 2040, the natural gas share of total generation is 34% in the No CPP case.

Recent policy and technology developments, including the extension of production and investment tax credits for renewable generation technologies enacted in December 2015, as well as reduced capital costs for solar photovoltaic systems, are further increasing the pressure on coal. In the No CPP case, renewables generation increases at 3.2%/year from 546 billion kilowatthours (kWh) (a 13% share) in 2015 to 1,204 billion kWh (a 23% share) in 2040 (Figure MT-29). Nonhydro renewables generation grows at the fastest rate through 2040, increasing at 4.5%/year, from 252 billion kWh in 2015 to 750 billion kWh in 2040. Over the same period, hydroelectric generation grows at 0.7%/year, from 245 billion kWh in 2015 to 294 billion kWh in 2040.

The coal share of total electricity generation falls from 48% in 2008 to 31% in 2029, when the natural gas share surpasses it, and then continues to decline, falling to a 26% share in 2040. Coal generation is essentially flat from 2015 to 2040 in the No CPP case. A large portion of the decline in coal generation is attributable to the retirement of coal generating capacity in the No CPP case. The No CPP case has 60 gigawatts of cumulative coal capacity retirements between 2016 and 2030. Nuclear generating capacity remains virtually unchanged over the projection in the No CPP case, as additions are more than offset by retirements. Total nuclear generation is flat at about 789 billion kWh, accounting for a 20% share in 2015 and a 15% share in 2040. Coal and nuclear generation, which together satisfied 70% of U.S. generation requirements as recently as 2005, fall to a 47% share of total generation in 2030 and a 42% share in 2040 in the No CPP case.

Renewables and natural gas lead capacity additions through 2040 in the Reference case

Figure MT-30. Additions to electricity generation capacity by fuel in the Reference case, 2000–2040 (gigawatts)

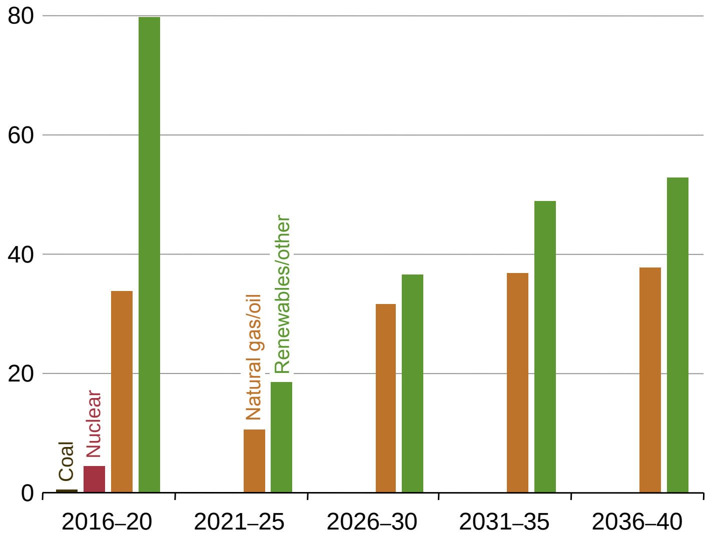


In the AEO2016 Reference case, two developments significantly improve the prospects for renewable capacity: extension of favorable federal tax treatment for renewable generators, and continued dramatic reductions in the capital cost of solar photovoltaic (PV) systems. In the Reference case, cumulative additions to U.S. generating capacity from 2016–40 total 483 gigawatts (GW) for all technologies, including 302 GW of renewable technology additions (63% of the total), both power-sector and end-use generators (Figure MT-30). Renewable generation capacity additions consist primarily of wind (73 GW) and solar (221 GW) technologies, including 77 GW of solar PV installations in the end-use sectors.

The increase in renewable capacity additions helps offset the retirement of 100 GW of coal-fired capacity as a result of environmental legislation, including implementation of the Clean Power Plan. Relatively low natural gas prices from 2016–40 also lead to a significant increase in natural gas-fired capacity, with 175 GW of gas-fired capacity additions accounting for 36% of the total increase. Total renewable capacity additions average 16 GW/year through 2024. From 2025–40, renewable capacity additions slow to 10 GW/year, as electricity demand growth slows. Virtually all capacity additions after 2025 in the Reference case are solar PV and natural gas, which account for 53% and 43% of total additions, respectively, over the 2025–40 period. Among fossil fuel generating technologies, natural gas-fired combined-cycle plants remain the least-cost option for new capacity additions, and they generally are more efficient to operate than existing steam plants fueled with natural gas, oil, or coal.

In the No CPP case, most new electricity generation capacity uses natural gas and renewables

Figure MT-31. Cumulative additions to electricity generation capacity by fuel in the No CPP case by period (gigawatts)



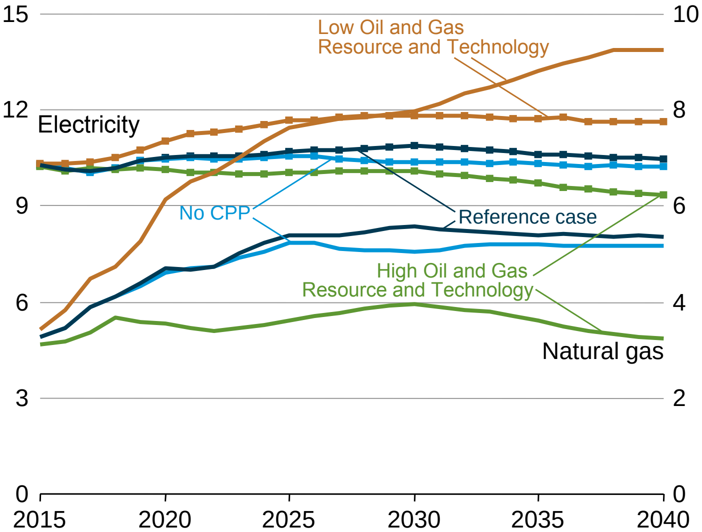
In the No CPP case, additions to electricity generation capacity—including those in the end-use sectors—total 392 gigawatts (GW) from 2016–40 (Figure MT-31). Capacity additions in the near term replace retiring coal-fired plants, which are the result of low natural gas prices and implementation of the Mercury Air Toxic Standards. Coal-fired capacity declines from 284 GW in 2015 to 215 GW in 2040, with much of that capacity retired by 2025. A total of 60 GW of coal-fired capacity is retired from 2016–25 in the No CPP case, including both announced retirements and those projected on the basis of market factors. Total capacity additions average 16 GW/year from 2016–40, with 97 GW of renewable capacity additions from 2016–25 and 44 GW of natural gas additions over the same period.

Renewable additions in the No CPP case benefit from the extension of the federal tax credit in the near term and from declining costs in the long term. Renewable additions total 236 GW from 2016–40, primarily solar (178 GW) and wind (52 GW). The solar capacity additions include 74 GW of rooftop and other distributed solar generation installations in the end-use sectors. Most of the wind capacity is added before 2025 to take advantage of the production tax credit, which is available only to projects beginning substantive development before 2020. Solar capacity is added steadily through 2040, as it becomes more cost-competitive as a result of declining capital cost and the investment tax credit. The tax credit phases down from 30% in 2016 to 10% in 2022 and then remains at that level for utility and commercially operated solar projects but ends for residential solar projects.

In the No CPP case, natural gas accounts for 38% (150 GW) of cumulative capacity additions from 2016–40. The relatively steady growth of natural gas capacity, which helps to maintain baseload generation and provide grid reliability services, also results from continued low natural gas prices.

Electricity prices rise and fall with natural gas availability and prices

Figure MT-32. Electricity prices and natural gas prices to electricity generators in four cases, 2015–40 (left axis, 2015 cents per kilowatthour; right axis, 2015 dollars per million Btu)



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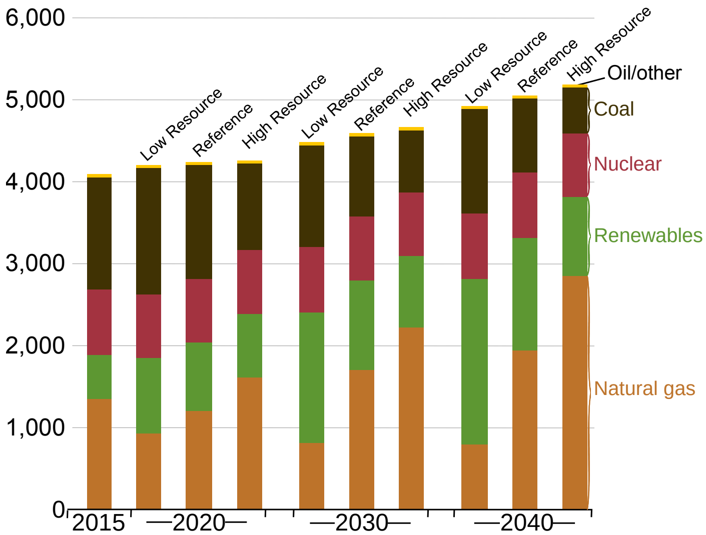
Electricity generation mix responds significantly to natural gas prices

Figure MT-33. Electricity generation by fuel in three cases, 2015, 2020, 2030, and 2040 (billion kilowatthours)



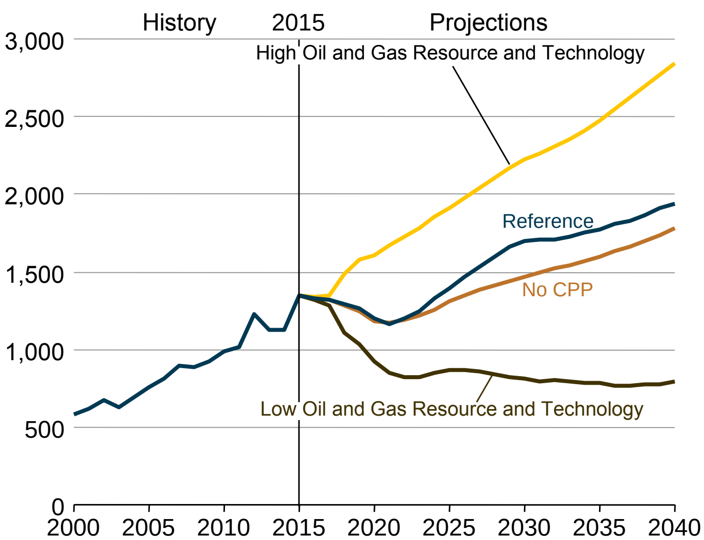
Recent low natural gas prices have led to a shift from coal to natural gas for electricity generation. In addition, favorable federal and state policies have supported increases in renewable capacity. The future generation mix will depend to significant extent on future natural gas prices, as existing natural gas plants compete with coal for dispatch decisions in the short term, and natural gas combined-cycle capacity competes with wind and solar capacity in the longer term. The AEO2016 Low and High Oil and Gas Resource and Technology cases provide a range of potential future natural gas price paths that could affect the mix of fuels used for electricity generation. In the High Oil and Gas Resource and Technology case, delivered natural gas prices remain below $4/million British thermal units (Btu) through 2040. In the Low Oil and Gas Resource and Technology case, delivered natural gas prices rise steadily, to $8/million Btu in 2030 and more than $9/million Btu in 2040.

Lower natural gas prices in the High Resource and Technology case lead to a 48% natural gas share of total generation in 2030—compared with 37% in the Reference case—and a 55% share in 2040 (Figure MT-33). An additional 39 gigawatts of coal-fired capacity is retired by 2040, and the coal share of total generation falls from 33% in 2015 to 17% in 2030 and to 11% in 2040. Renewable capacity additions in the same case are less than half of those in the Reference case, and the overall renewable share of total generation is 18% in 2030 and 19% in 2040, compared with 24% and 27%, respectively, in the Reference case.

In the Low Oil and Gas Resource and Technology case, higher natural gas prices reduce the natural gas share of total electricity generation from 33% in 2015 to 18% in 2030 and to 16% in 2040. Fewer coal plants are retired, allowing for higher levels of coal-fired generation than in the Reference case. More new renewable generation reduces the share of more expensive natural gas-fired generation needed to meet the growth in demand for electricity.

Resource availability has more effect than the Clean Power Plan on natural gas-fired generation

Figure MT-34. Natural gas-fired electricity generation in four cases, 2000–2040 (billion kilowatthours)



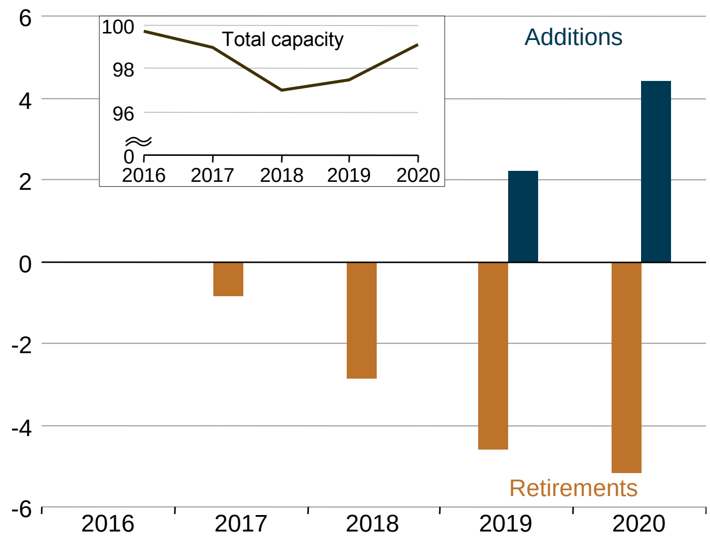
In the No CPP case, additions to electricity generation capacity—including those in the end-use sectors—total 392 gigawatts (GW) from 2016–40 (Figure MT-31). Capacity additions in the near term replace retiring coal-fired plants, which are the result of low natural gas prices and implementation of the Mercury Air Toxic Standards. Coal-fired capacity declines from 284 GW in 2015 to 215 GW in 2040, with much of that capacity retired by 2025. A total of 60 GW of coal-fired capacity is retired from 2016–25 in the No CPP case, including both announced retirements and those projected on the basis of market factors. Total capacity additions average 16 GW/year from 2016–40, with 97 GW of renewable capacity additions from 2016–25 and 44 GW of natural gas additions over the same period.

Renewable additions in the No CPP case benefit from the extension of the federal tax credit in the near term and from declining costs in the long term. Renewable additions total 236 GW from 2016–40, primarily solar (178 GW) and wind (52 GW). The solar capacity additions include 74 GW of rooftop and other distributed solar generation installations in the end-use sectors. Most of the wind capacity is added before 2025 to take advantage of the production tax credit, which is available only to projects beginning substantive development before 2020. Solar capacity is added steadily through 2040, as it becomes more cost-competitive as a result of declining capital cost and the investment tax credit. The tax credit phases down from 30% in 2016 to 10% in 2022 and then remains at that level for utility and commercially operated solar projects but ends for residential solar projects.

In the No CPP case, natural gas accounts for 38% (150 GW) of cumulative capacity additions from 2016–40. The relatively steady growth of natural gas capacity, which helps to maintain baseload generation and provide grid reliability services, also results from continued low natural gas prices.

Nuclear power generation faces competition from natural gas and renewables

Figure MT-35. Cumulative nuclear generation capacity additions and retirements, 2016–20 (gigawatts)



Decisions to build new nuclear capacity, uprate existing reactors, or extend their operating lifetimes depend on the cost-competitiveness of nuclear generation in electric power markets. Independent power producers [*12*] have faced financial losses in recent years on their nuclear capacity as a result of competition from lower-cost energy sources—including natural gas and wind—and declining electricity demand and reduced capacity payments in some regions [*13*].

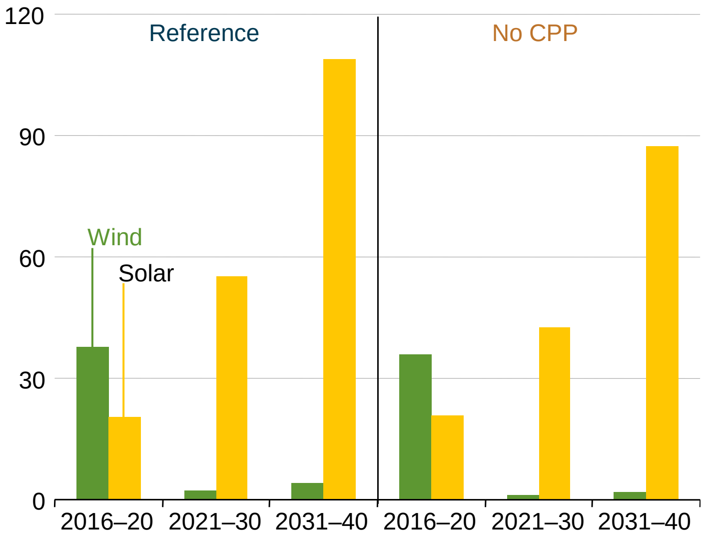
Low natural gas prices reduce the competiveness of newly built nuclear capacity relative to natural gas-fired combined-cycle plants, and they reduce wholesale market prices for electricity from existing nuclear power plants. As a result, no uprates or new builds of nuclear capacity beyond those already underway occur in any of the AEO2016 cases.

The Reference case incorporates 2,139 megawatts (MW) of planned and announced nuclear plant retirements (Figure MT-35), including FitzPatrick (852 MW) in 2016, and Pilgrim (678 MW) and Oyster Creek (610 MW) in 2019. The Reference case also assumes early retirement of 3 gigawatts (GW) of nuclear capacity, modeled as derates in competitive regions, based on an assessment of market uncertainties. These retirements represent a total reduction in nuclear capacity of 5.1 GW from the existing nuclear fleet. Market uncertainties and regulatory issues have led to recent announcements of reactor retirements that are not reflected in the Reference case: Clinton (1,065 MW), Quad Cities Units 1 and 2 (1,819 MW), Fort Calhoun (479

MW), and Diablo Canyon Units 1 and 2 (2,240 MW). These reecent announcements represent an additional incremental reduction of 2.6 gigawatts of retirements not reflected in the Reference case. The Reference case addresses near-term accelerated nuclear retirements but assumes that subsequent license renewals will allow for long-term operation up to 80 years. Future AEOs will discuss the ability of nuclear power stations to achieve long-term operation beyond 60 years.

Renewable capacity additions are dominated by solar photovoltaics

Figure MT-36. Wind and solar electricity generation capacity additions in all sectors by energy source in two cases, 2016–20, 2021–30, and 2031–40 (gigawatts)



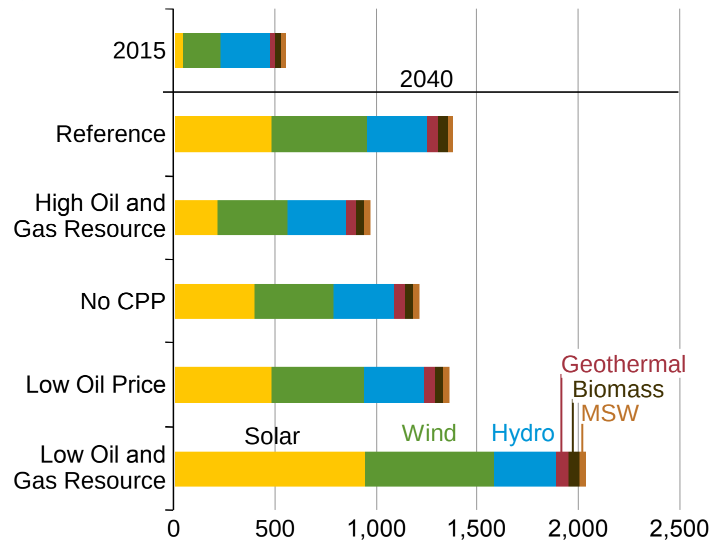
In the AEO2016 Reference case, total wind and solar electricity generation capacity grows by 5%/year from 2016–40, adding more than 294 gigawatts (GW) to provide 80% of total renewables capacity in 2040 (Figure MT-36). In the No CPP case, which assumes that the Clean Power Plan (CPP) is not implemented, wind and solar capacity together increase by more than 4%/year, adding almost 230 GW of generating capacity over the 2016–40 period. Wind and solar capacity increases by 10%/year from 2016–20 and then slows to 3%/year from 2021–40 in both the Reference and No CPP cases.

Solar power provides the largest increase in renewable capacity, from 25 GW in 2015 to more than 246 GW in 2040 in the Reference case and more than 202 GW in the No CPP case. The increases in wind capacity are much smaller, at 73 GW in the Reference case and less than 52 GW in the No CPP case from 2016–40. Solar installations have benefitted from significant reductions in technology costs in recent years, while wind capacity is hampered by the need to access wind sites farther from existing transmission lines or with less favorable development characteristics. Wind capacity additions are particularly slow between 2030–40, at slightly more than 4 GW in the Reference case and 2 GW in the No CPP case. With slow growth in wind capacity additions and continued fast growth in solar additions, solar capacity surpasses wind capacity in 2032 in the Reference case and in 2033 in the No CPP case.

Renewable capacity growth is supported by a variety of federal and state policies. The recent five-year extension of production tax credits and investment tax credits supports the growth of new renewable capacity through 2022. The CPP policy takes effect in 2022, providing additional incentives for renewable capacity additions to meet CO2 emissions targets from 2022–29. Although the targets remain flat after the interim period, additions of renewable capacity continue in order to meet CO2 emissions targets while satisfying demand for new generation.

Renewable electricity generation sensitive to government policies and natural gas prices

Figure MT-37. Renewable electricity generation by fuel type in all sectors in five cases, 2015 and 2040 (billion kilowatthours)



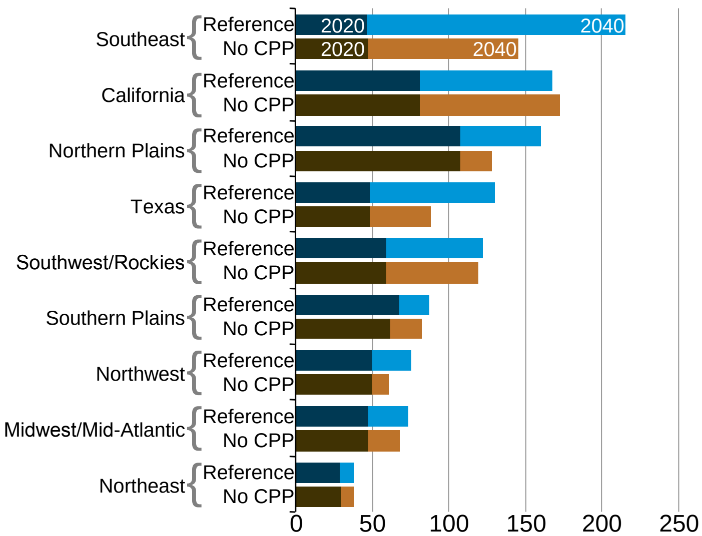
Total renewable electricity generation increases in the Reference case by more than 150%, from 546 billion kilowatthours (kWh) in 2015 to 1,374 billion kWh in 2040 (Figure MT-37). The total varies in the alternative cases with different price, resource, and policy assumptions, ranging from a 76% increase in the High Oil and Gas Resource and Technology case to a 271% increase in the Low Oil and Gas Resource and Technology case. Generation from wind and solar resources represents the largest share of the increase in renewable generation. In the Reference case, solar generation increases by an average of 11%/year, from 38 billion kWh in 2015 to 477 billion kWh in 2040, and wind generation increases by an average of 4%/year, from 190 billion kWh in 2015 to 473 billion kWh in 2040. Solar power provides about 35% of total renewable electricity generation in 2040 in the Reference case, up from 7% in 2015.

In the Low Oil and Gas Resource and Technology case, which has the highest natural gas prices among all the AEO2016 cases, renewable generation increases to 2,030 billion kWh in 2040, with approximately 46% of the total coming from solar generation, 31% from wind, and 15% from hydropower. Because natural gas often is the marginal fuel in determining wholesale electricity prices, higher natural gas prices tend to make renewable generation more competitive. Solar generation, which is available during the day to meet peak demand and can displace natural gas-fired generation, serves 19% of total load in 2040.

In the High Oil and Gas Resource and Technology case, low natural gas prices reduce growth in total renewable generation, which increases to only 961 billion kWh in 2040. Lower natural gas prices increase the cost-effectiveness of natural gas-fired power plants and make renewable generation less competitive.

Southeast region leads growth in non-hydropower renewable electricity generation

Figure MT-38. Nonhydropower renewable electricity generation in all sectors in two cases, 2020 and 2040 (billion kilowatthours)



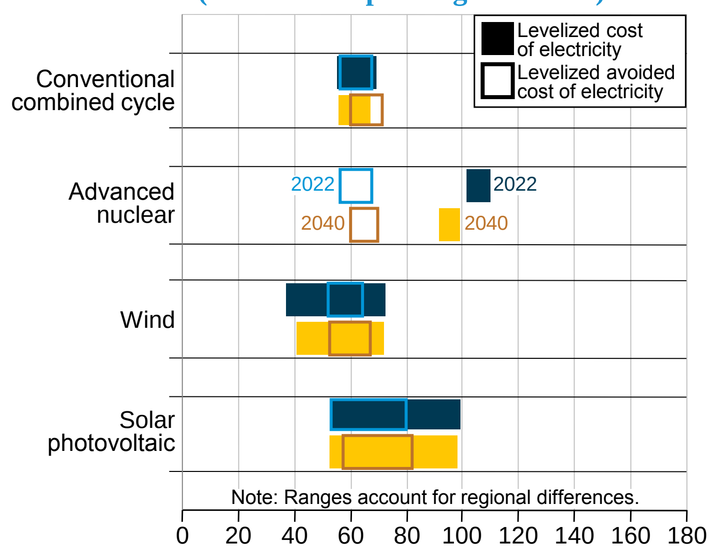
In the AEO2016 Reference case and the No CPP case, nonhydropower renewable generation increases from 2020 to 2040 in all the electricity regions. (For a map of regions, see Appendix F.) Regional growth in renewable generation is determined by four factors: implementation of the Clean Power Plan (CPP), state renewable portfolio standards (RPS), availability of renewable energy resources, and cost competition with fossil fuel technologies. Factors such as electricity demand growth, non-RPS policies (such as net metering), and electricity prices also affect regional growth rates.

From 2020–40, the Southeast region experiences the largest increases in nonhydropower renewable electricity generation both in the Reference case (360%) and in the No CPP case (206%), with growth led by utility-scale solar and wind capacity additions in the Tennessee Valley and in Florida (Figure MT-38). In the Reference case, which includes the CPP, nonhydropower renewable generation in the Southeast in 2040 is the largest among all regions and is 48%, or 70 billion kilowatthours (kWh), greater than in the No CPP case. In the California and Southwest/Rockies regions, generation from nonhydropower renewables doubles from 2020–40 in both the Reference and No CPP cases, partly as a result of mandatory RPS policies. Solar power leads the growth in nonhydropower renewable generation in California, making up more than 65% of the growth from 2020–40 in both the Reference and No CPP cases. Solar makes up more than 80% of the growth in the Southwest/Rockies region in both cases. In Texas, nonhydropower renewable electricity generation in 2040 in the Reference case is approximately 165% higher than in 2020 (an increase of more than 80 billion kWh). The growth over the same period in the No CPP case is 80% (an increase of nearly 39 billion kWh).

Nonhydropower renewable generation growth is generally higher with the carbon emission restrictions of the CPP in the Reference case than without the restrictions. However, both the growth and the resulting generation mix vary substantially among regions, depending on the cost and availability of resources and state policies.

Levelized generation and avoided costs influence the economics of new technologies

Figure MT-39. Levelized electricity costs with tax credits for new power plants in the Reference case, 2022 and 2040 (2015 dollars per megawatthour)



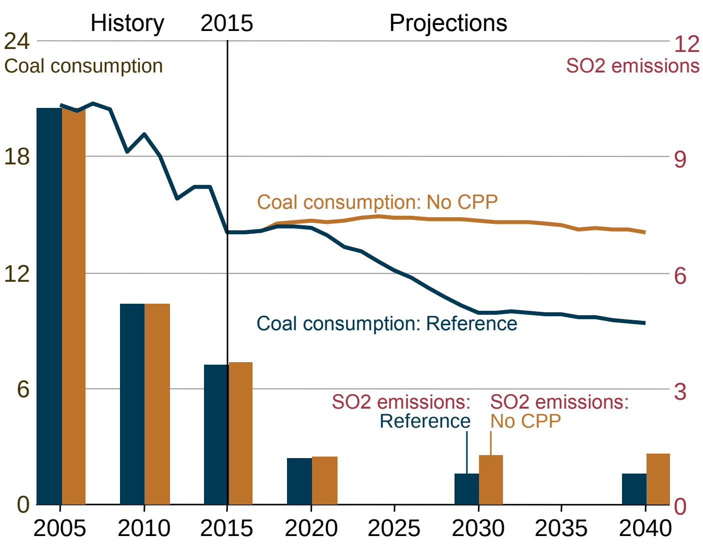
Factors that influence technology choices for new generating capacity are difficult to compare. Different technologies can have vastly different costs (capital, fuel, maintenance, financing), utilization rates, fuel resources, and value to the grid. The levelized cost of electricity (LCOE) is often used to compare costs among technologies with similar operating characteristics; the levelized avoided cost of electricity (LACE) is used to compare value across technologies with different duty cycles (Figure MT-39). LCOE—which represents the costs of building and operating a plant per kilowatthour of output over an assumed financial life and activity level (e.g., baseload, peaking, seasonal)—can vary significantly across regions and over time. Because solar photovoltaic (PV) and wind generation have no fuel costs and relatively small variable operation and maintenance costs, their LCOE is determined mostly by capital and financing costs. LACE, which represents the per-kilowatthour value of generation to the electric grid, reflects the cost of the electricity displaced by the new technology. A technology is generally considered economically competitive when its LACE exceeds its LCOE.

Emissions from electricity generation

In comparisons of two new plants using different technologies, LCOE may not account for differences in the grid services each is providing. For example, nuclear plants and natural gas combined-cycle plants both provide baseload services to the grid and thus have similar LACE values, even if their LCOE values differ. By 2040, the LACE range for most technologies is expected to shift upward, indicating the increasing value of new generation to the grid as demand for new sources grows. Wind plants have increased generation during the night (when the demand for and value of electricity typically are low) and thus provide a limited contribution to system reliability reserves. Solar PV plants produce most of their energy during the middle of the day, when higher demand increases the value of electricity. Consequently, in 2040, the upper bound of LACE for solar PV generation, at 55.7–80.3 dollars/megawatthour (MWh), is higher than the upper bound of LACE for wind (50.6–65.3 dollars/MWh). In 2022, the lower bound of LCOE without tax credits for solar PV generation (not shown) is generally much higher than the lower bound for generation with tax credits, although available tax credits close the gap in some regions. In 2040, the LCOE and LACE ranges for solar PV are overlapping, even without the 10% investment tax credit that, under current law, would be available for solar PV in 2040.

With Clean Power Plan, power plant coal use and sulfur dioxide emissions decline in the Reference case

Figure MT-40. Coal consumption (quadrillion Btu) and sulfur dioxide emissions (million short tons) in the Reference and No CPP cases, 2005–40



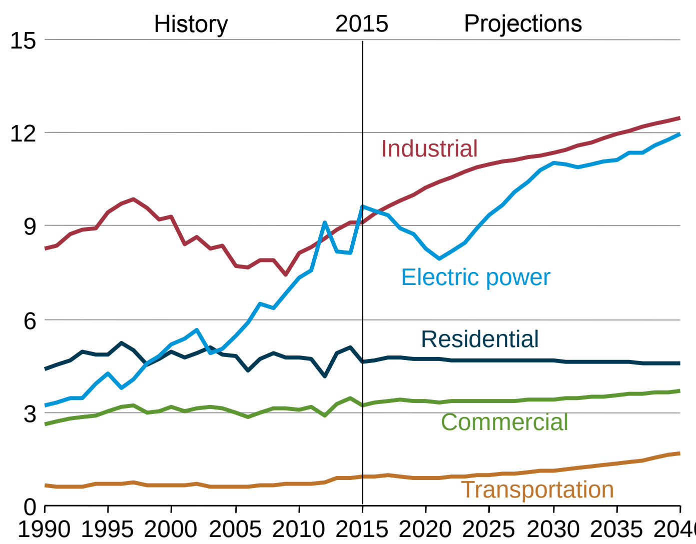
Sulfur dioxide (SO2) emissions from electricity generation have declined with reduced coal use. In 2016, SO2 emissions are expected to fall by nearly two-thirds from 2015 levels with the lapse of extended deadlines for compliance with the Mercury and Air Toxics Standards (MATS) for almost all generating units in April 2016. The MATS rule requires that any coal-fired power plant in operation after the deadline must be retrofitted to control mercury and acid gases with either dry sorbent injection or flue-gas desulfurization (scrubbing) equipment, which also removes 70%–90% of SO2 emissions. Although the Cross-State Air Pollution Rule (CSAPR) is still in effect and covers SO2 emissions from these units, the more stringent reduction requirements under MATS render CSAPR irrelevant.

For some generators, the prospect of meeting MATS compliance requirements is uneconomical, based on cost recovery with likely lower operating rates for retrofitted coal units in a market driven by lower natural gas prices. Even in the No CPP case, a cumulative total of 40 gigawatts (GW) of coal-fired capacity is retired by 2016 and 57 GW by 2020. Utility sector coal use increases slightly from 2016–20 with increased utilization, but SO2 emissions are largely unchanged as a result of high levels of SO2 removal with newly installed retrofits and remain at about the same level through 2040.

In the AEO2016 Reference case, which includes the requirement for power plants in each state to lower CO2 emissions beginning in 2022, retirements continue to a cumulative total of 92 GW in 2030 and to nearly 100 GW in 2040. As a result, utility coal consumption in the Reference Case falls by approximately 35%, from 14.3 quadrillion Btu in 2020 to 9.4 quadrillion Btu in 2040 (Figure MT-40). SO2 emissions also fall by about one-third, from 1.2 million tons in 2020 to 0.8 million tons in 2040.

Electric power sector accounts for 35% of U.S. natural gas consumption in 2040

Figure MT-41. Natural gas consumption by sector in the Reference case, 1990–2040 (trillion cubic feet)



Total U.S. natural gas consumption grows from 27.5 trillion cubic feet (Tcf) in 2015 to 34.4 Tcf in 2040 in the AEO2016 Reference case (Figure MT-41). Consumption of natural gas for electric power generation increases by 2.4 Tcf, accounting for 34% of the total increase. Natural gas consumption was at a record high in 2015, which resulted primarily from low natural gas prices and the retirement of coal-fired capacity. In the Reference case, natural gas use for electricity generation declines from 2015–21 as a result of rising natural gas prices and increasing use of renewable fuels. With implementation of the Clean Power Plan starting in 2022, as well as the reduction or phasing out of some renewable tax credits, and relatively low natural gas prices, natural gas use for electric power generation grows by an average of approximately 4%/year from 2021–30 and continues to increase at a more modest pace of just under 1%/year from 2031–40.

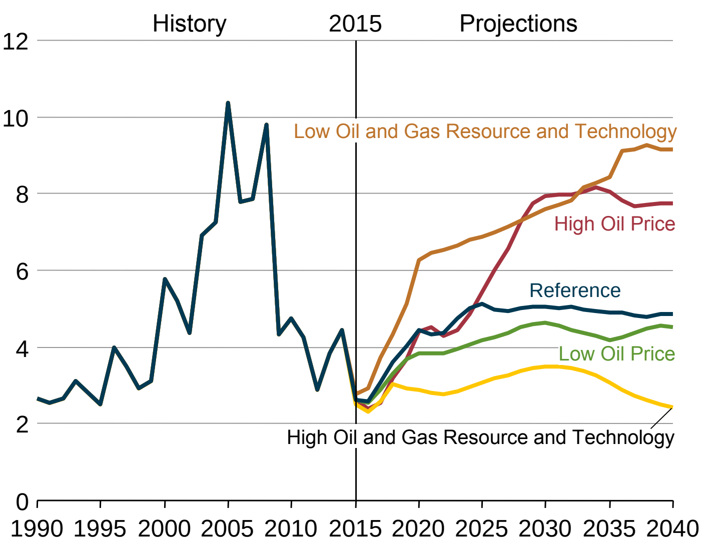
Natural gas consumption in the industrial sector, which includes the use of natural gas for lease and plant fuel and liquefaction of natural gas for export, increases by 3.4 Tcf from 2015–40, an average increase of 1.3%/year. Energy-intensive industries and those that use natural gas as a feedstock, such as bulk chemicals, benefit from relatively low natural gas prices throughout the projection. Increasing use of lease and plant fuel, which is correlated with natural gas production, and fuel used for the production of liquefied natural gas for export also contribute to the growth of natural gas consumption in the industrial sector.

Natural gas use in vehicles currently accounts for only a small portion of U.S. total natural gas use, but it grows rapidly from 64 billion cubic feet (Bcf) in 2015 to 658 Bcf in 2040. Heavy-duty vehicles and freight rail account for 33% of the natural gas used in the transportation sector in 2040 in the Reference case, and pipeline compressor stations account for most of the remainder.

In the residential sector, natural gas use for space heating declines, partially as a result of improvements in energy efficiency and population shifts to warmer regions. In the commercial sector, where growth in commercial floor space more than offsets improvements in energy efficiency, natural gas use rises gradually over the projection period.

Natural gas prices depend on oil prices, technology improvement, and resource recovery rates

Figure MT-42. Annual average Henry Hub natural gas spot market prices in five cases, 1990–2040 (2015 dollars per million Btu)



Across the AEO2016 cases, the average annual Henry Hub spot price for natural gas in 2040 (Figure MT-42) ranges from $2.40–$9.20/million British thermal units (Btu). In the Reference case, average annual U.S. natural gas prices at the Henry Hub remain at about $5.00/million Btu in 2015 dollars through 2040. Crude oil prices affect natural gas prices through changes in consumption and exports, although changes on the supply side, such as increased production of associated-dissolved gas, balance out those factors.

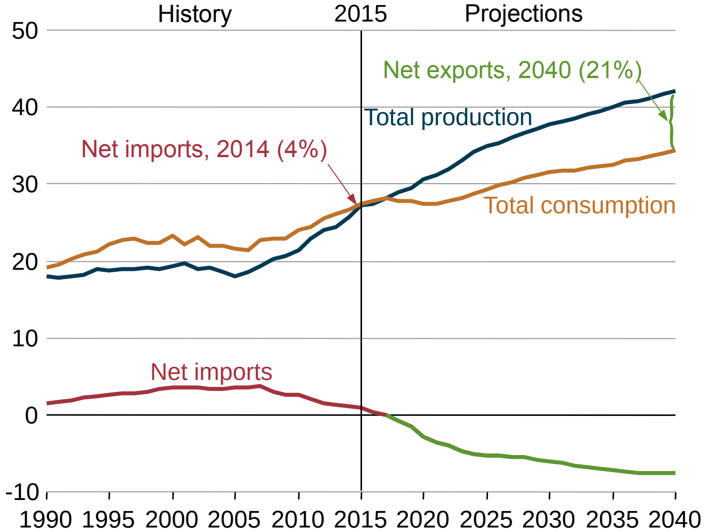
In the High Oil Price case, U.S. exports of liquefied natural gas (LNG) begin to exceed the Reference case total in 2024, and in 2030 they total 8.5 Tcf, or 3.3 Tcf more than in the Reference case. In response, the Henry Hub spot price begins to rise above Reference case levels in 2025, from more than $5.40/million Btu in 2025 to about $7.90/million Btu in 2030. The higher prices are sustained by increased consumption in the transportation sector, where a high price differential between oil and natural gas favors the use of natural gas over diesel. Natural gas use for gas-to-liquids production also increases over the projection period.

In the Low Oil Price case, the Henry Hub spot price averages about $0.50/million Btu lower than in the Reference case throughout the projection. Because of the relatively small price differential between crude oil and natural gas in the Low Oil Price case, U.S. exports of LNG from 2025–40 are about 50% lower in the Low Oil Price case than in the Reference case, and natural gas consumption is lower in both the industrial and transportation sectors.

Natural gas prices are affected by rates of resource recovery from oil and natural gas wells and by technology improvements, which affect total natural gas production and the associated costs. In the High Oil and Gas Resource and Technology case, with higher initial estimated ultimate recovery per well and more rapid technology improvements, total dry natural gas production in 2040 is 32% higher than in the Reference case. In the Low Oil and Gas Resource and Technology case, with slower rates of resource recovery and technology improvement, total dry natural gas production in 2040 is 37% less than in the Reference case. As a result, U.S. natural gas prices are lowest in the High Oil and Gas Resource and Technology case, ranging from about $2.45 to $3.50/million Btu over the projection period, and highest in the Low Oil and Gas Resource and Technology case, where prices rise quickly to more than $6.25/million Btu in 2020 and to just under $9.20/million Btu in 2040.

Ample natural gas supply is adequate to meet growth in both export and domestic markets

Figure MT-43. Natural gas production, consumption, and net imports and exports in the Reference case, 1990–2040 (trillion cubic feet)

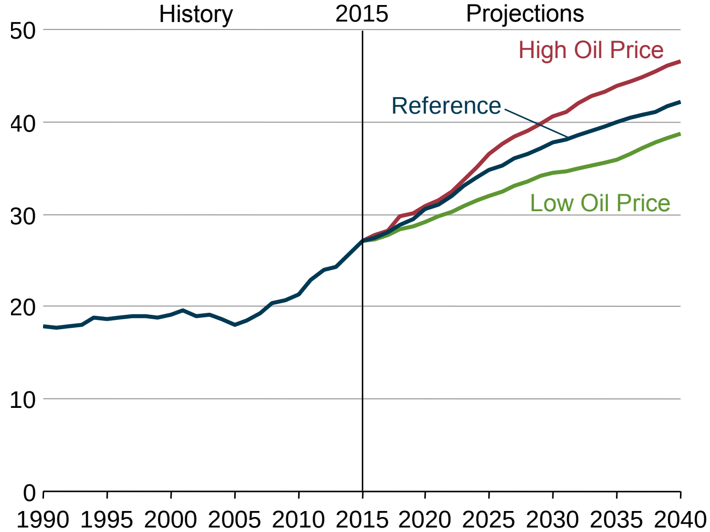


In the Reference case, U.S. natural gas production is sufficient to meet increases in demand for both domestic consumption and net exports through 2040, and Henry Hub spot prices remain relatively low (Figure MT-43). The United States transitions from being a net importer of 1.0 trillion cubic feet (Tcf) of natural gas in 2015, or 3% of U.S. total natural gas supply, to a net exporter in 2018. In 2040, net U.S. exports of natural gas total 7.5 Tcf, or 18% of dry natural gas production. Almost 50% (3.6 Tcf) of the growth in net exports occurs by 2021, as liquefied natural gas (LNG). Most of the LNG export capacity is already under construction. After 2021, U.S. net exports grow at a more moderate average rate of 4%/year.

Total U.S. natural gas consumption grows by 0.9%/year from 2015–40. After falling from 2017–21 as consumption in the electric power sector drops by 1.4 Tcf, total natural gas consumption rises steadily to 34.4 Tcf in 2040. Natural gas production increases in the reference case by an average of 1.8%/year, from 27.2 Tcf in 2015 to 42.1 Tcf in 2040. Technology improvements in the development of shale gas resources continue, which results in higher rates of recovery at lower costs. Production growth holds down natural gas prices, stimulating demand for U.S. natural gas in the United States (particularly in the electric power sector) and in overseas markets. Most U.S. natural gas exports to overseas markets are delivered as LNG. Through 2020, Mexico is also a rapidly growing market for U.S. natural gas. Canada continues to be a modest net exporter to the United States throughout the projection.

U.S. natural gas production, use, and exports are affected by oil prices

Figure MT-44. Natural gas production in three cases, 1990–2040 (trillion cubic feet)



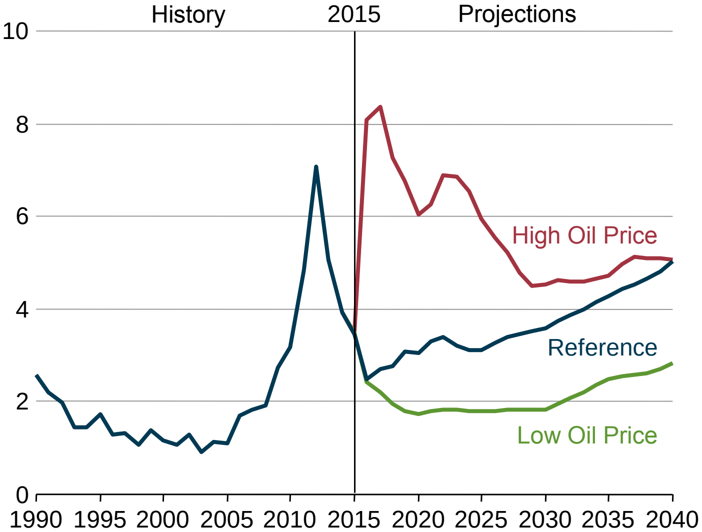
Crude oil prices affect U.S. natural gas production primarily through changes in natural gas consumption and exports. In 2040, total natural gas production varies by 7.8 trillion cubic feet (Tcf) across the oil price cases (Figure MT-44), liquefied natural gas (LNG) exports vary by 6.3 Tcf (plus 0.6 Tcf used for liquefaction), and natural gas use in the transportation sector varies by 1.4 Tcf.

In the High Oil Price case, the difference between the crude oil price and the natural gas price in 2022 is about $25/million British thermal unit (Btu), compared with $10/million Btu in the Reference case. The larger difference in the High Oil Price case creates more incentive for direct use of natural gas in transportation, and for conversion to LNG for export, than in the Reference case. The opposite occurs in the Low Oil Price case: the difference between the crude oil price and the natural gas price in 2033 is about $5/million Btu, and the smaller price difference results in virtually no incentive for additional natural gas consumption in the transportation sector or for more LNG exports.

Natural gas production levels are similar in the Reference and High Oil Price cases from 2015–23. In both cases, most LNG exports come from liquefaction plants currently under construction. Outside the United States—particularly in Australia—significant liquefaction capacity is coming online or is under construction. The near-term increase in LNG supply is expected to weaken the relationship between international oil and natural gas prices. As world demand for LNG grows, the economics of LNG exports from the United States are expected to improve in the Reference case. That transition is projected to occur more quickly in the High Oil Price case. In the Low Oil Price case, continued low oil prices act to hold down international natural gas prices, limiting U.S. LNG export capacity to the total under construction before 2035 and also limiting the utilization of existing capacity.

In all the AEO2016 cases, oil prices are higher than natural gas prices through 2040

Figure MT-45. Ratio of crude oil prices to U.S. natural gas prices on an energy-equivalent basis in three cases, 1990–2040



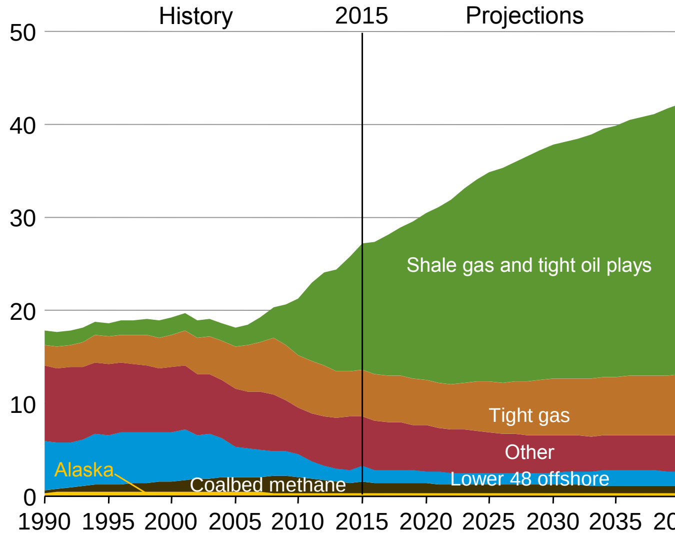
The oil-to-gas price ratio, on an energy-equivalent basis, is used as an indicator of the extent to which oil competes with natural gas in most applications. From 1990–2005, the downward trend in the oil-to-gas price ratio reflected declining crude oil prices and a gradual rise in natural gas prices. Natural gas use for electric power generation nearly doubled over that period. With stagnant domestic natural gas production, all incremental natural gas supply to the U.S. market came from imports. From 1995–2005, real prices for natural gas at the Henry Hub quadrupled.

After 2008, changes in the U.S. natural gas market resulted in a rapid and long-lasting decoupling of domestic crude oil prices from natural gas prices. As oil prices fell from their 2008 highs, natural gas prices declined even faster. When crude oil prices began to rise again, natural gas prices continued to decline, averaging about $2.85/million British thermal units (Btu) in 2012 compared with average crude oil prices at $20.10/million Btu. At that point, the oil-to-gas price ratio was 7.1 (Figure MT-45).

In the AEO2016 Reference case, the prices of liquid fuels continue to exceed natural gas prices from 2015–40. The disparity between Brent crude oil prices and Henry Hub natural gas prices on an energy-equivalent basis leads to a gradual increase in the oil-to-gas price ratio, from 3.5 in 2015 to 5.0 in 2040. In the High Oil Price case, the oil-to-gas price ratio grows to 8.3 in 2017 before declining gradually to 5.1 in 2040, as high oil prices spur U.S. crude oil development, which increases associated natural gas production and depresses natural gas prices in the short to medium term. Crude oil prices do not rebound in the Low Oil Price case but instead increase at a rate close to the inflation rate.

Natural gas production from shale gas and tight oil plays leads growth in U.S. natural gas supply

Figure MT-46. U.S. dry natural gas production by source in the Reference case, 1990–2040 (trillion cubic feet)



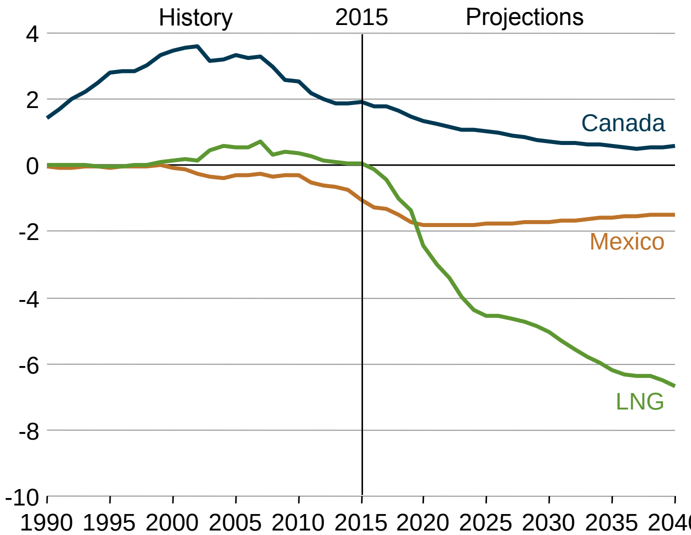
The 55% increase in dry natural gas production from 2015–40 in the AEO2016 Reference case results from increased development of shale gas and tight oil plays, tight gas, and offshore natural gas resources (Figure MT-46). Production from shale gas and tight oil plays is the largest contributor, growing by more than 15 trillion cubic feet (Tcf), from 13.6 Tcf in 2015 to 29.0 Tcf in 2040. The shale gas and tight oil play share of total U.S. dry natural gas production increases from 50% in 2015 to 69% in 2040. Although tight gas production increases by 31% from 2015 to 2040, its share of total production remains nearly constant.

Tight gas production is the second-largest source of domestic natural gas supply in the Reference case, providing 18% of total supply in 2015 and 16% of total supply in 2040. Lower 48 onshore production from all sources other than tight and shale gas formations declines from 6.6 Tcf in 2015 to 4.6 Tcf in 2040, when it accounts for about 11% of total domestic production, down from 24% in 2015.

Offshore natural gas production in the United States averages about 1.4 Tcf/year from 2015–20 before declining to 1.2 Tcf in 2027, reflecting declines in production from legacy offshore fields. Production of coalbed methane also declines. Offshore natural gas production increases to 1.7 Tcf in 2040 as new discoveries offset declines in legacy fields. Alaska's natural gas production remains relatively constant throughout the projection period, averaging 0.3 Tcf/year.

U.S. exports of liquefied natural gas increase to 4.6 trillion cubic feet in 2025 and to 6.7 trillion cubic feet in 2040

Figure MT-47. U.S. net imports of natural gas by source in the Reference case, 1990–2040 (trillion cubic feet)



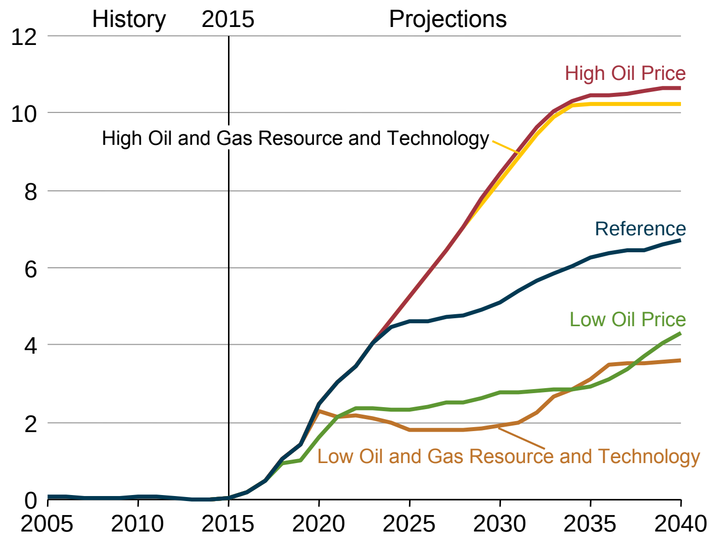
In the AEO2016 Reference case, the United States becomes a net exporter of natural gas in 2018, with net exports of 5.3 trillion cubic feet (Tcf) in 2025 and 7.5 Tcf in 2040. Liquefied natural gas (LNG) exports from the United States account for most of the growth (Figure MT-47). With the first LNG export terminal in the United States opening in 2016, LNG exports grow to 2.5 Tcf in 2020, 4.6 Tcf in 2025, and 6.7 Tcf in 2040. Although the five LNG export projects currently under construction in the Mid-Atlantic and Gulf Coast regions will provide total export capacity of 2.9 Tcf/year, additional capacity will be needed to meet the Reference case projection. U.S. natural gas is competitive in international markets, because Henry Hub spot natural gas prices are relatively low in comparison to international prices. However, the U.S. competitive advantage will also depend on world oil prices, growth of global LNG supply, international natural gas production, and international demand for natural gas, particularly in China and other key markets.

Natural gas pipeline exports from the United States to Mexico continue to increase in the near term in the Reference case, from 1.0 Tcf in 2015 to 1.8 Tcf in 2020. Although Mexico's domestic natural gas production is declining, its consumption is increasing, particularly in the electric power sector. Several pipeline projects currently under construction in Mexico are expected to come online between 2016 and 2018, opening new regional markets for natural gas use. After 2020, U.S. natural gas pipeline exports to Mexico decrease gradually to 1.5 Tcf in 2040, reflecting new oil and natural gas production projects and increases in the use of renewable energy for electric power generation in Mexico.

Net imports from Canada to the United States continue to decline in the Reference case, from 1.9 Tcf in 2015 to 0.6 Tcf in 2040. The United States maintains its current export volume of 0.7 Tcf, largely into eastern Canada, through 2040. Natural gas imports from western Canada to the United States decline in the Reference case as relatively low U.S. natural gas prices and Canada's proximity to major U.S. markets make natural gas produced in the United States more competitive.

Liquefied natural gas export growth depends on oil price and productivity assumptions

Figure MT-48. U.S. exports of liquefied natural gas in five cases, 2005–40 (trillion cubic feet)



In the AEO2016 Reference case, growing natural gas production from shale gas and tight oil formations at relatively low prices supports an increase in U.S. liquefied natural gas (LNG) exports of 6.7 trillion cubic feet (Tcf) from 2015–40, representing 93% of the total increase in U.S. natural gas exports over the period. In the United States, LNG exports surpass LNG imports beginning in 2016 and continue to increase through 2040. Prices increase rapidly until 2020 as the liquefaction facilities currently under construction begin operation, allowing rapid growth in natural gas exports, but the rate of increase slows somewhat from 2021–26 and more rapidly thereafter as growing LNG exports from the United States cause natural gas prices to decrease in the rest of the world.

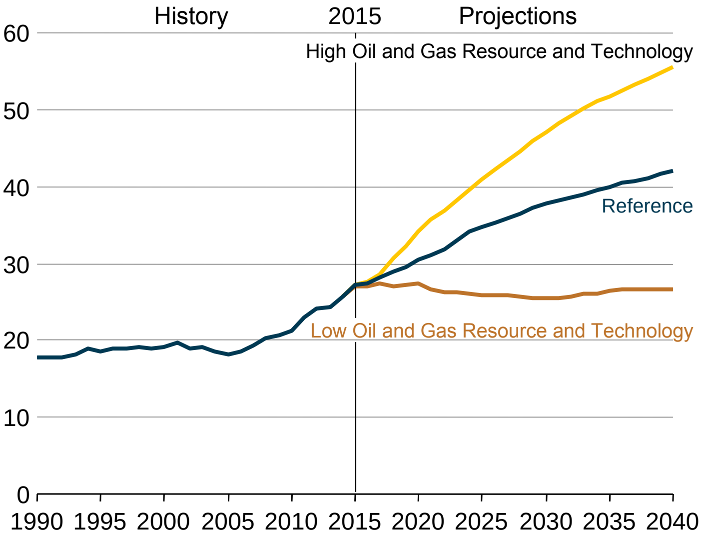
Exports of LNG from the United States vary significantly among the AEO2016 cases. In the High Oil Price case, both global LNG demand and LNG prices are higher than in the Reference case, and LNG exports from the United States increase to 10.5 Tcf in 2035 and remain near that level through 2040 (Figure MT-48). In the Low Oil Price case, gross LNG exports from the United States increase to 2.2 Tcf in 2021, remain above the export levels in the Low Oil and Gas Resource and Technology case through 2034, and then increase to 4.3 Tcf in 2040. In general, low oil prices reduce the incentive for expanding natural gas markets and result in decreasing global LNG prices; however, rising oil prices in the Low Oil Price case contribute to an eventual increase in LNG exports.

In the High Oil and Gas Resource and Technology case, large production increases at low costs result in decreasing U.S. natural gas prices, and LNG exports grow to 10.3 Tcf in 2035.

In the Low Oil and Gas Resource and Technology case, limited technology improvement results in lower natural gas production and higher domestic natural gas prices. Gross LNG exports increase to 2.3 Tcf in 2020 in the Low Oil and Gas Resource and Technology case but remain below export levels in the Low Oil Price case until 2035.

Natural gas production rates depend on resource availability and production costs

Figure MT-49. U.S. dry natural gas production in three cases, 1990–2040 (trillion cubic feet per year)

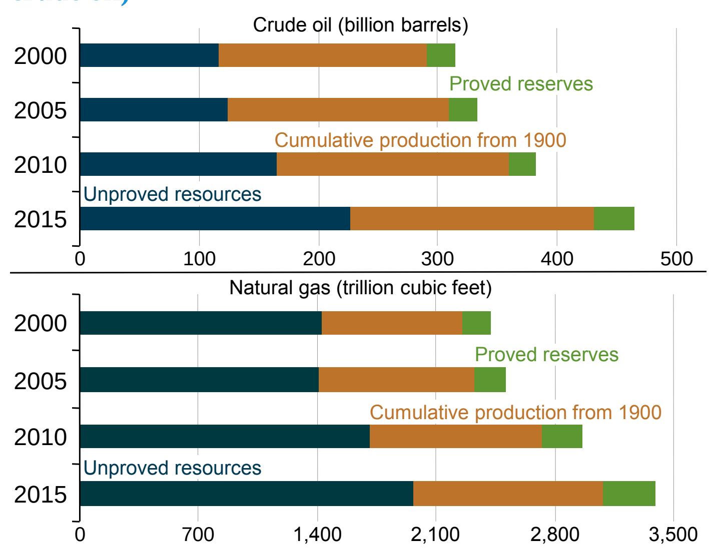


Prospects for natural gas production from tight oil and shale gas resources are uncertain because large portions of the formations have little or no production history and because future technology could increase well productivity while reducing costs. The High and Low Oil and Gas Resource and Technology cases illustrate potential impacts of changes in Reference case assumptions about technology advances and resource size and quality on natural gas demand, imports, and prices. These cases do not represent lower or upper bounds for production and do not have associated probabilities of occurrence.

The High Oil and Gas Resource and Technology case assumes higher estimates of unproved Alaska resources, offshore lower 48 resources, and onshore lower 48 tight oil, tight gas, and shale gas resources than in the Reference case. These assumptions are based on higher initial estimated ultimate recovery per well, larger volumes of onshore lower 48 tight oil and shale gas resources, and higher rates of long-term technology improvement that lead to reductions in drilling and operating costs and higher production levels. Higher well productivity reduces development and production costs per unit, resulting in more resource development than in the Reference case. With more abundant shale gas resources at lower costs, cumulative dry gas production is 1,115 trillion cubic feet (Tcf) from 2015–40, compared with 920 Tcf in the Reference case. In the High Oil and Gas Resource and Technology case, dry natural gas production is nearly 56 Tcf in 2040, compared with 42 Tcf in the Reference case (Figure MT-49). In the Low Oil and Gas Resource and Technology case, which assumes lower tight oil, tight gas, and shale gas estimated ultimate recoveries (EURs) per well and lower rates of technology improvement than in the Reference case, total production of dry natural gas remains between 25 and 27 Tcf per year through 2040, while shale gas production increases to 15 Tcf in 2040 from 13.3 Tcf in 2015, and cumulative shale gas production is 383 Tcf over the 2015–40 period.

Crude oil and natural gas supply reflects new representation of technology advancement

Figure MT-50. Crude oil and natural gas resources and cumulative production by *Annual Energy Outlook* year (trillion cubic feet of natural gas, billion barrels of crude oil)



Note: U.S. technically recoverable resources and cumulative production are, as of January 1, two years before the "edition year" of the AEO (e.g., AEO2015 is as of 1/1/2013).

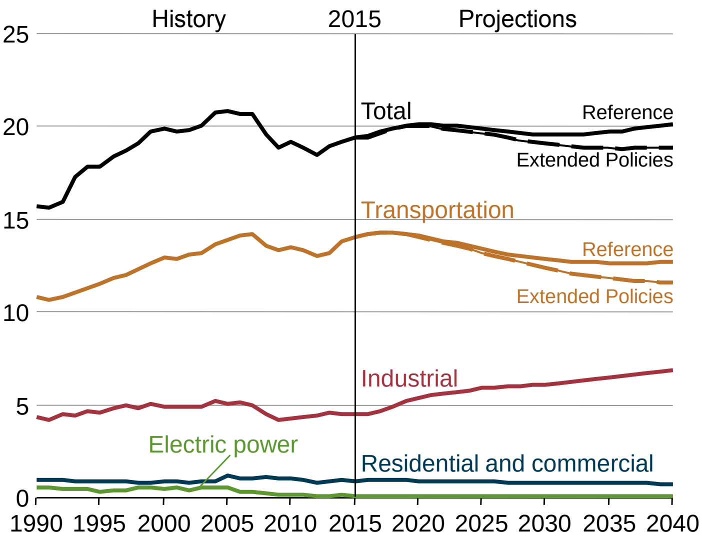
The AEO2016 Reference case uses a simplified approach to model the impacts of technology advances on U.S. oil and natural gas production. The Reference case includes assumptions about ongoing innovation in upstream technologies and reflects the average annual growth rate between AEO2000 and AEO2015 in natural gas and oil resources and the cumulative production from 1900 (Figure MT-50). The new representation of technology advances divides areas in tight oil, tight gas, and shale gas plays into two tiers with different technology change rate assumptions. Tier 1 encompasses areas within these plays that are under active development. The EUR per well for Tier 1 areas have a 1% annual growth rate. Tier 2 encompasses areas not yet developed and includes, for example, large areas of the Utica Shale in the Northeast. The EUR per well in Tier 2 areas has a 3% annual growth rate until development begins. Once development begins, the Tier 2 areas revert to a 1% annual EUR growth rate. These assumptions reflect the combined effects of diminishing returns per well from decreasing well spacing as development progresses, market penetration of technologies, and application of industry practices and technologies at the time of development.

Liquid fuels consumption

Annual EUR growth rates for conventional, enhanced oil recovery, and coalbed methane sources are 0.25%. Technology improvements also affect drilling and operating costs. Both Tier 1 and Tier 2 areas are assumed to have 1% annual declines in drilling costs and 0.5% annual declines in operating costs as a result of advances in technology and industry practices. Conventional oil recovery, enhanced oil recovery, and coalbed methane sources are assumed to have 0.25% annual declines in drilling costs and operating costs.

Petroleum and other liquids consumption is relatively level through 2040

Figure MT-51. U.S. consumption of petroleum and other liquids by sector in two cases, 1990–2040 (million barrels per day)

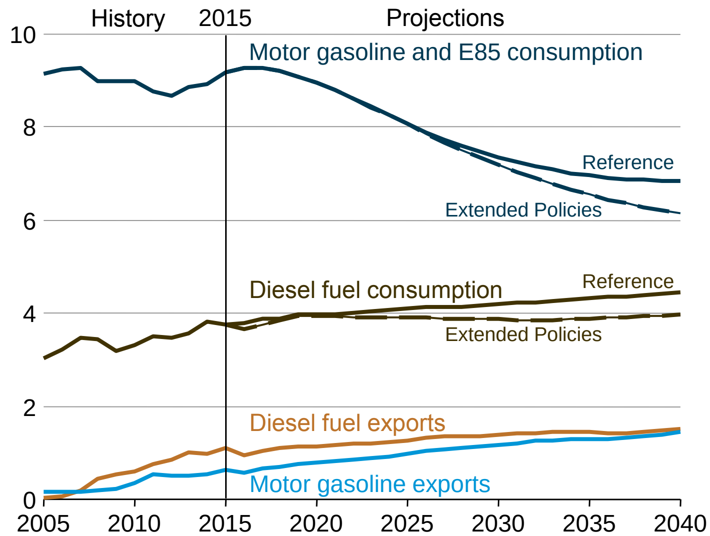


Total consumption of petroleum and other liquids in the AEO2016 Reference case remains relatively level through 2040, with decreases in transportation consumption offsetting increases in industrial consumption. The transportation sector continues to account for the largest share of total liquids consumption (Figure MT-51). However, with improvements in vehicle efficiency following incorporation of corporate average fuel economy standards for both light-duty vehicles and heavy-duty vehicles, the transportation share declines from 72% in 2015 to 63% in 2040. In the industrial sector, consumption of light chemical feedstocks—natural gas liquids and refinery olefins—increases by 1.5 million barrels/day (b/d) from 2015–40, largely as a result of increased supplies of hydrocarbon gas liquids from natural gas and crude oil production [*14*]. Transportation fuels—primarily motor gasoline, ultra-low-sulfur diesel fuel, and jet fuel—can also include biofuels in their compositions.

Total motor gasoline consumption decreases by approximately 2.3 million b/d from 2015–40 in the Reference case, while total diesel fuel consumption grows by 0.7 million b/d from 2015–40. Ethanol consumption in both low-blend and high-blend gasoline is essentially flat throughout the projection, as gasoline consumption declines and the penetration of flex-fuel vehicles is limited.

Fuel consumption shares shift from motor gasoline toward diesel fuel in the Reference case

Figure MT-52. Consumption and gross exports of motor gasoline and diesel fuel in the Reference and Extended Policies cases, 2005–40 (million barrels per day)

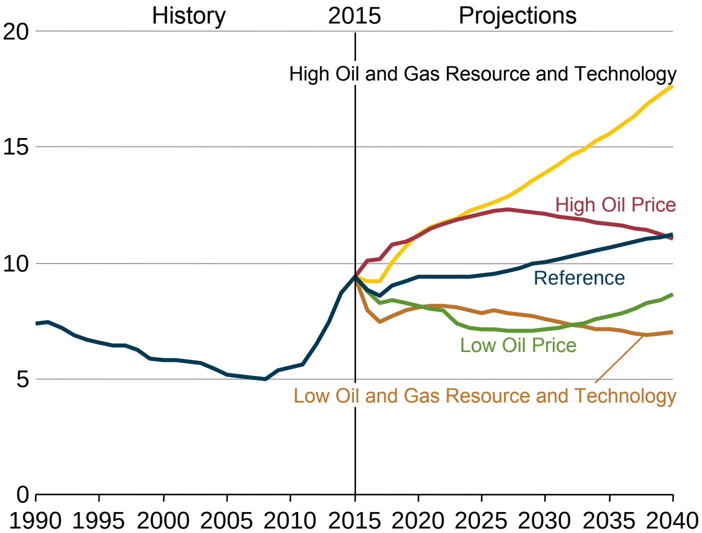


With corporate average fuel economy (CAFE) and greenhouse gas (GHG) emissions standards included in the Reference case, new light-duty vehicles (LDV) average 47 miles per gallon in 2025. The improvement in vehicle efficiency more than offsets an increase in total LDV vehicle miles traveled (VMT), which leads to a decline in motor gasoline consumption. In contrast, diesel fuel consumption continues to grow as VMT increases because of a smaller fuel efficiency improvement in freight trucks than in LDVs. Consumption of diesel fuel grows by about 0.7 million barrels per day (b/d) from 2015–40, while motor gasoline consumption falls by 2.3 million b/d (Figure MT-52). With motor gasoline and diesel fuel consumption trending in opposite directions, new refinery investment projects focus on shifting production from gasoline to distillate fuels. The Extended Policies case, which extends the CAFE and GHG emissions standards through 2040, results in higher average fuel efficiency for new LDVs and freight trucks, lower domestic consumption of motor gasoline and diesel fuel, and higher demand for electric and hybrid vehicles in 2040 compared with the Reference case.

As a result of refinery economics and slower growth in domestic demand, no new U.S. petroleum refinery crude-unit capacity is built in the Reference case, except for plants already under construction in 2015. Refineries continue to export finished products to international markets. Gross exports of total finished petroleum products, excluding hydrocarbon gas liquids, increase from 3.2 million b/d in 2015 to 5.2 million b/d in 2040 in the Reference case. Gasoline and diesel exports constitute about 74% of the increase. The United States became a net exporter of finished petroleum products in 2011 and remains a net exporter through 2040 in the Reference case. In the Extended Policies case, gross exports of total finished petroleum products remain near the same level as in the Reference case. However, in response to reduced domestic consumption of motor gasoline and diesel fuel, U.S. refinery utilization drops to 85% (reflected in a reduction of gross imports of crude oil).

U.S. crude oil production depends on market prices, resource availability, and production costs

Figure MT-53. Total U.S. crude oil production in five cases, 1990–2040 (million barrels per day)



Projections of U.S. tight oil production are uncertain because large portions of the known formations have little or no production history and because technology improvements could increase well productivity while reducing drilling, completion, and production costs. The High and Low Oil and Gas Resource and Technology cases apply different assumptions regarding technology advances, prices, and resource size and quality than used in the Reference case to examine the effects of higher and lower domestic supply on energy demand, imports, and prices.

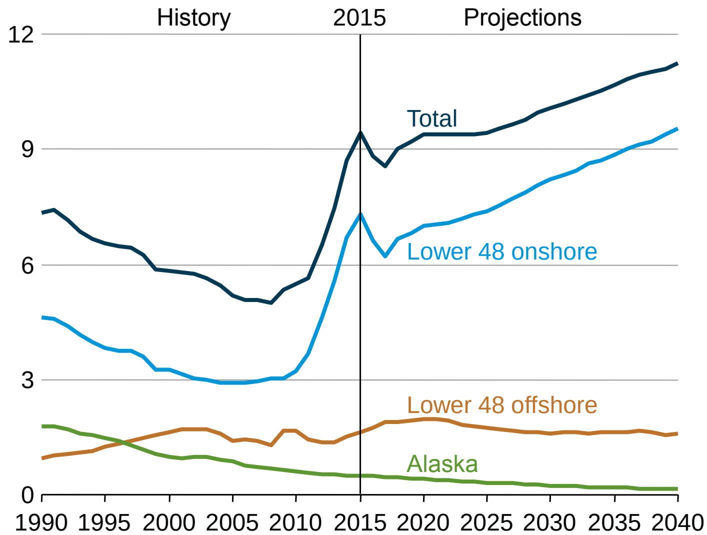
In the High Oil and Gas Resource and Technology case, higher well productivity and rates of technological progress reduce development and production costs per unit. The lower costs result in more and earlier development of oil and natural gas resources than in the Reference case (Figure MT-53), even after considering the effects that additional production would have on world markets for crude oil. U.S. crude oil production in this case increases to 17.7 million barrels per day (b/d) in 2040, compared with 11.3 million b/d in the Reference case, and cumulative production from 2015–40 is 126 billion barrels—about 32 billion barrels more than in the Reference case. In the Low Oil and Gas Resource and Technology case, U.S. crude oil production declines from 9.4 million b/d in 2015 to 7.0 million b/d in 2040, compared with 11.3 million b/d in the Reference case. Cumulative crude oil production from 2015–40 is 73 billion barrels, or about 21 billion barrels less than in the Reference case.

In the High Oil Price case, domestic crude oil production declines from 12.3 million b/d in 2027 to 11.0 million b/d in 2040. Cumulative production from 2015–40 is 109 billion barrels, compared with 94 billion barrels in the Reference case.

In the Low Oil Price case, production falls to 7.0 million b/d in 2028 and then increases to 8.6 million b/d in 2040. Cumulative production from 2015–40 is 74 billion barrels in the Low Oil Price case.

Lower 48 states onshore tight oil development increases U.S. crude oil production

Figure MT-54. Domestic crude oil production by source in the Reference case, 1990–2040 (million barrels per day)



In the Reference case, total U.S. crude oil production declines from 9.4 million barrels per day (b/d) in 2015 to 8.6 million b/d in 2017, then increases steadily to 11.3 million b/d in 2040 (Figure MT-54). With the average wellhead price of oil below $50 per barrel from 2015–17, lower 48 onshore production declines to 6.2 million b/d in 2017. After 2017, as crude oil prices rise, onshore crude oil production in the Lower 48 states increases to about 9.5 million b/d in 2040. The trend in Lower 48 states onshore crude oil production reflects the continued development of tight oil resources in the Bakken, the Western Gulf Basin (including the Eagle Ford play), and the Permian Basin. Tight oil production decreases to 4.2 million b/d in 2017 before increasing to 7.1 million b/d in 2040. The increase is primarily a result of higher oil prices and exploration and development programs that expand operator knowledge about producing reservoirs and lead to the identification of additional tight oil resources and development of new technologies that reduce costs and increase recovery.

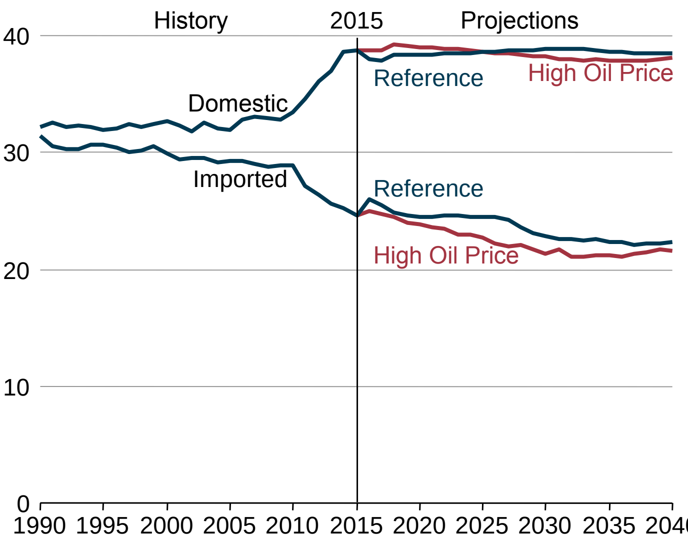
Offshore production in the Lower 48 states is less sensitive than onshore production to short-term price movements. With the startup and development of deepwater projects in the Gulf of Mexico—including the Heidelberg and Appomattox fields starting in 2016 and 2017—lower 48 offshore crude oil production increases to 2.0 million b/d in 2021 in the Reference case, declines to 1.6 million b/d in 2030, and continues at about the 2030 level through 2040, as production from newly developed fields is offset by declines in production from legacy fields.

Crude oil supply

Lower 48 onshore crude oil production that uses carbon dioxide-enhanced oil recovery increases from 0.3 million b/d in 2017 to 0.7 million b/d in 2040, as oil prices rise and affordable anthropogenic sources of carbon dioxide become available. In Alaska, production (both onshore and offshore) declines from nearly 0.5 million b/d in 2015 to less than 0.2 million b/d in 2040.

Domestic production of tight oil reduces imports of light sweet crude oil

Figure MT-55. Average API gravity of U.S. domestic and imported crude oil supplies in two cases, 1990–2040 (degrees API)



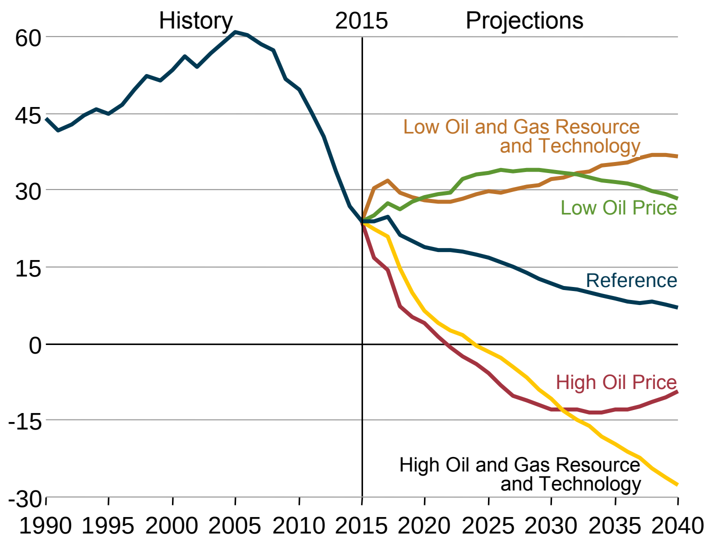
API gravity, as defined by the American Petroleum Institute (API), is a measure of the specific gravity, or relative density, of a liquid, expressed in degrees, with higher numbers indicating lower densities. Refineries generally process a mix of crude oils with a range of API gravities to optimize refinery operations. Over the past 15 years, the API gravity of crude oil processed in U.S. refineries has averaged between 30 and 32 degrees. As U.S. refiners run more domestic light crude oil produced from tight formations, they need less imported light crude to maintain an optimal API gravity. With increasing U.S. production of light crude oil in the AEO2016 Reference case, the average API gravity of crude oil imports declines from 24.6 degrees in 2015 to 22.3 degrees in 2040 (Figure MT-55).

With total crude oil imports declining in the Reference case, imports of light crude oil are reduced further, resulting in a heavier slate of imported crude oil. The share of heavier crude oil imports grows through 2030 before stabilizing. The increase in demand for diesel fuel in the Reference case, from 3.8 million barrels/day (b/d) in 2015 to 4.4 million b/d in 2040, combined with a steady increase in exports of distillate fuel oil, from 1.2 million b/d in 2015 to 1.8 million b/d in 2040, strains the ability of refiners to switch from gasoline to distillate. As a result, distillate prices remain higher than gasoline prices through 2040.

In the High Oil Price case, domestic light crude oil production is higher than in the Reference case. With increased supplies of light crude oil available in domestic markets, light crude oil imports decline, and heavier crude oil imports become a larger share of total crude oil imports. As a result of the greater heavy crude oil share of total imports, the API gravity of crude oil imports is lower in the High Oil Price case than in the Reference case.

Increasing U.S. oil supply reduces net imports of petroleum and other liquid fuels

Figure MT-56. Net import share of U.S. petroleum and other liquid fuels consumption in five cases, 1990–2040 (percent)



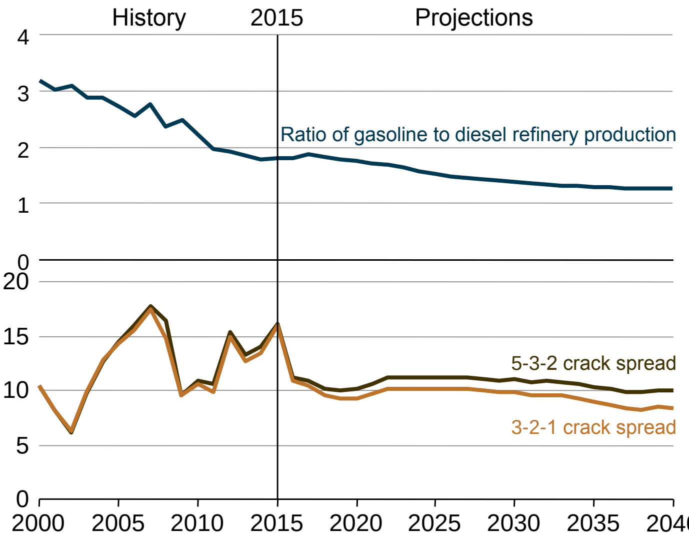
From the mid-1980s to 2005, the net crude oil and product imports share of U.S. petroleum and other liquid fuels consumption grew, and then from 2005–15 it fell steadily (Figure MT-56). In the Reference case, as tight oil production declines from 2015–17, the net import share of U.S. petroleum and other liquids consumption increases before resuming its decline to 7.4% in 2040, when U.S. net imports total 1.4 million barrels per day (b/d).

The outlook for net petroleum and other liquid fuel imports in the High and Low Oil Price and High and Low Oil and Gas Resource and Technology cases depends on U.S. oil production levels. Higher oil prices reduce consumption and encourage development of oil resources. In the High Oil Price case, with domestic liquids production rising and consumption declining, the United States becomes a net exporter of petroleum and other liquids. Total net exports in the High Oil Price case reach 2.4 million b/d in 2033 before declining to 1.7 million b/d in 2040. In the Low Oil Price case, the net import share of domestic consumption rises to 33.8% (6.0 million b/d) in 2028 before declining to 28.3% (6.1 million b/d) in 2040.

In the High Oil and Gas Resource and Technology case, with improvements in oil production technology beyond those in the Reference case and estimated ultimate recovery (EUR) 50% higher than in the Reference case, U.S. crude oil production increases to 17.7 million b/d in 2040. The United States transitions from a net importer of crude oil and petroleum products to a net exporter of 5.6 million b/d in 2040 in the High Oil and Gas Resource and Technology case. In the Low Oil and Gas Resource and Technology case, which assumes slower advances in production technology and a 50% lower EUR than in the Reference case, the net import share of U.S. crude oil and petroleum product consumption falls to 27.6% (5.5 million b/d) in 2022 before beginning a steady increase to 37.3% (7.4 million b/d) in 2040.

Petroleum refinery yields and crack spreads shift with changes in liquid fuels demand

Figure MT-57. U.S. refinery gasoline-to-diesel production ratio and crack spreads (dollars per barrel) in the Reference case, 2000–2040

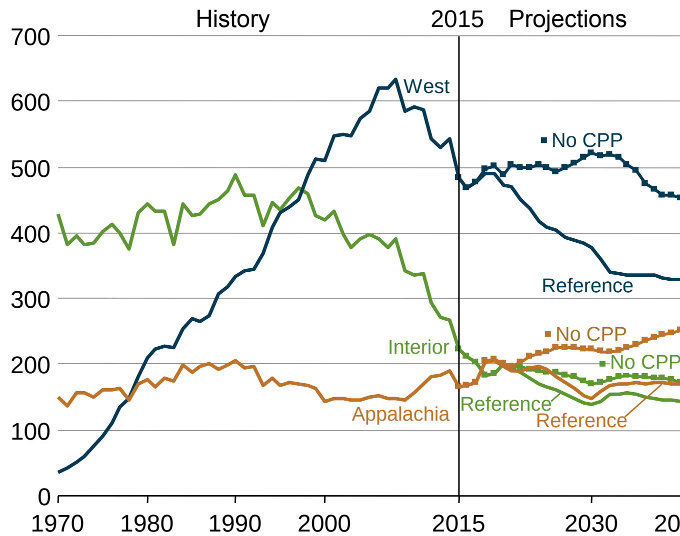


The transition to lower gasoline and higher diesel fuel production has a significant effect on petroleum refinery operations in the AEO2016 Reference case, with the ratio of gasoline to diesel production declining from 1.8 in 2015 to below 1.3 in 2040 (Figure MT-57, top). In response to the drop in gasoline demand, refinery utilization of fluid catalytic cracking (FCC) units falls. In contrast, with diesel production increasing, installed distillate and gas oil hydrocracking calendar day capacity grows from 2.1 million barrels per day (b/d) in 2015 to 2.6 million b/d in 2040, indicating a shift from FCC to hydrocrackers to maximize diesel production.

Refinery profitability is affected by crude oil input costs, processing costs, and market prices for the end products. Profitability often is estimated from the crack spread, which is the difference between the price of crude oil and the price of finished products—typically, gasoline and distillate fuel. The 3-2-1 crack spread estimates the profitability of processing three barrels of crude oil to produce two barrels of gasoline and one barrel of distillate. In the Reference case, the 3-2-1 crack spread (based on Brent crude oil prices) declines from $16/barrel in 2015 to $8/barrel in 2040 (2015 dollars) (Figure MT-57, bottom). A 5-3-2 crack spread, which estimates the profitability of processing five barrels of crude oil to produce three barrels of gasoline and two barrels of distillate, is more representative of the trend toward higher distillate production to meet market demands.

Western coal supply shows largest decline among regions with Clean Power Plan in effect

Figure MT-58. Coal production by region in the Reference and No CPP cases, 1970–2040 (million short tons)



In the AEO2016 Reference case, total coal production decreases from 873 million short tons (MMst) in 2015 to 827 MMst in 2022 when the Clean Power Plan (CPP) takes effect, and to 643 MMst in 2040. The CPP affects coal supply differently in the West, Interior, and Appalachia regions because of differences in coal quality and markets served (Figure MT-58). Compared with the No CPP case, the West region accounts for the largest share of the decline in total coal production in the Reference case because its share of total domestic coal production is larger than in the other regions (about 55% in 2015), and most western coal is consumed in the electric power sector, which is subject to the CPP. The strongest markets for western coal (about 75% from the Wyoming Powder River basin) are in states where it was more economical to switch to low-sulfur western coal than to retrofit power plants to control sulfur emissions. In both the Reference and No CPP cases, competition from natural gas and renewables, coal plant retirements, and equipment retrofits early in the projection reduce consumption of western coal in those states.

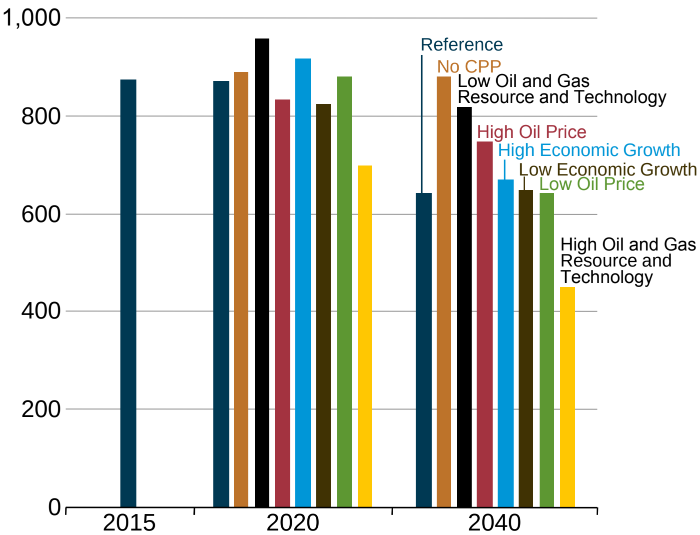
Reduced coal demand in the Reference case delays expansion of coal production in the Interior region, with production in the Interior region declining by 0.7%/year from 2015–30. Starting in 2030, coal production in the Interior region grows before flattening out from 2033–40. In the No CPP case, coal production increases throughout the projection period, by 2.0%/year from 2015–30 and 1.2%/year from 2030–40, because power plants that were recently retrofitted with sulfur emission control equipment to comply with the Mercury and Air Toxics Standards (MATS) that took effect in 2015–16 can use higher sulfur Interior coal.

Coal production

In the Appalachian region, the effects of the CPP in 2040 are less pronounced than in other regions because major cuts in coal production occurred over the past decade, and further cuts are expected to result from MATS and from fuel competition. In addition, exports and domestic metallurgical coal use, which together represented about 34% of Appalachia's coal production in 2015, are not directly affected by the CPP. As U.S. steam coal use declines, Appalachia's coal producers depend increasingly on exports and on domestic demand for metallurgical coal, which together account for 50% of the region's total coal production in 2040 in the Reference case.

Coal production falls in all AEO2016 cases except No CPP

Figure MT-59. U.S. coal production in eight cases, 2015, 2020, and 2040 (million short tons)

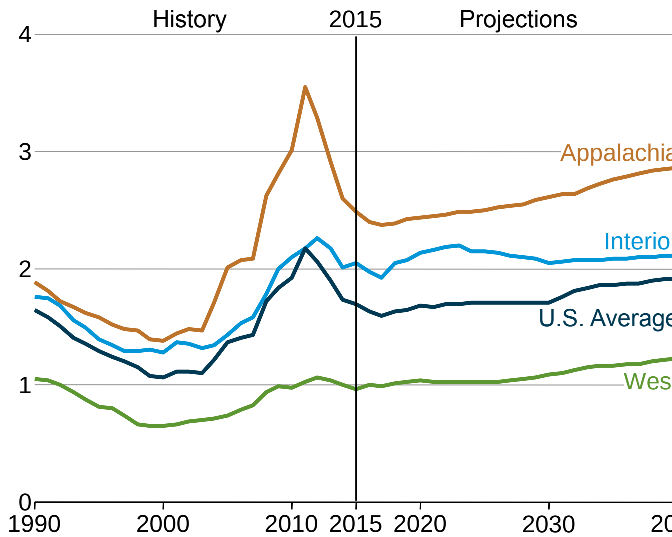


The No CPP case is the only AEO2016 case in which coal production in 2040 is higher than it was in 2015. Competition from natural gas and renewables, compliance with the Mercury Air Toxics Standard [*15*], and declining worldwide demand for coal contribute to lower production. In the No CPP case, as natural gas prices, electricity demand, and global coal demand rise, coal production increases from 873 million short tons (MMst) in 2015 to 890 MMst in 2020. After 2020, coal production stabilizes but declines slightly to 877 MMst in 2040 (compared with 643 MMst in 2040 in the Reference case). Production in the other cases varies between 192 MMst lower and 175 MMst higher in 2040 than in the Reference case. Among the cases shown in Figure MT-59, the Low Oil and Gas Resource and Technology case has the second-highest coal production in 2040 (818 MMst) because of higher natural gas prices. Before the Clean Power Plan (CPP) is implemented in 2022, coal production in the Low Oil and Gas Resource and Technology case is higher than in the No CPP case. After 2022, production declines, but it is still 175 MMst higher in 2040 than in the AEO2016 Reference case. The lowest level of coal production in 2040, at 450 MMst (about 52% of 2015 production), is in the High Oil and Gas Resource and Technology case, which has the lowest natural gas prices.

In the High Oil Price case, coal production in 2040 is 105 MMst higher than in the Reference case. In the High Oil Price case, beginning in 2025, rising demand at coal-to-liquids facilities contributes to higher levels of coal production. In the Low Oil Price case, coal production in 2040 varies little from the Reference case because electric power plants have limited ability to substitute oil for coal in electric power production. In the High and Low Economic Growth cases, coal production in 2020 is higher and lower, respectively, than in the Reference case. However, after implementation of the CPP, coal production in the Low Economic Growth case is nearly the same as in the Reference case because lower electricity sales deter investment in new generating capacity fueled by other energy sources, and existing coal plants in some regions are used to meet relatively low growth in demand for electric power. As a result, coal production in 2040 is slightly higher in both the High and Low Economic Growth cases than in the Reference case.

With declines in mining productivity, average minemouth coal prices increase

Figure MT-60. Average annual minemouth coal prices by region in the Reference case, 1990–2040 (2015 dollars per million Btu)



Average U.S. minemouth coal prices decline in the Reference case from 2015–17 as demand declines and less efficient higher-cost mines are closed. From 2017–30, the average minemouth coal price increases by 0.5%/year, as declines in coal mine productivity, which increase production costs, more than offset declines in coal demand, which reduce prices. Most of the production decline occurs before 2030, with domestic coal demand falling by 1.9%/year from 2015–30, and a smaller 0.7%/year from 2030–40. From 2030–40, the average minemouth coal price rises by 1.1%/year as average mine productivity continues to decline (Figure MT-60).

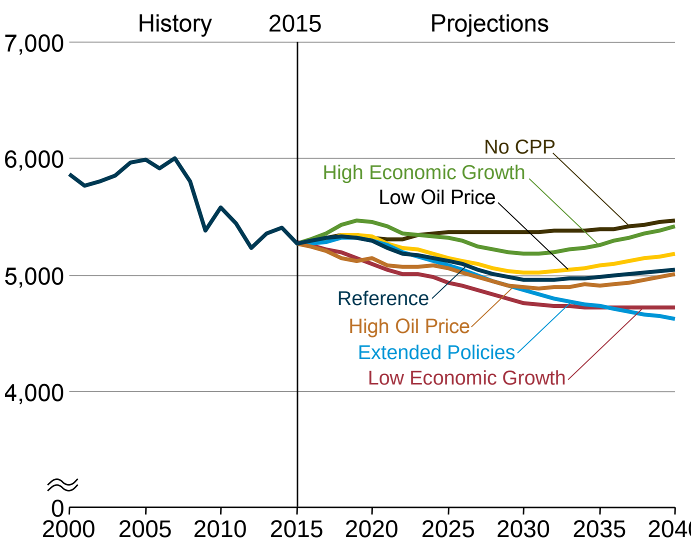
In the Appalachian region, average minemouth coal prices increase by 0.5%/year from 2015–40 as mine productivity declines. Appalachia's high-value coking coal continues to account for most of the coal supplied to U.S. steelmakers and exporters of coking coal. Coking coal is priced significantly higher than steam coal, and the price increases over the projection period. Appalachian coking coal provides 36% of the region's total production volume in 2040, compared with 29% in 2015, which contributes to a higher average coal price for the entire Appalachian region.

In the Interior region, previously unmarketable, but geologically favorable, high-sulfur coal reserves often can be mined with highly productive longwall equipment. While Interior region coal production and prices increase slowly from 2015 to about 2025 in the Reference case, Interior region coal production remains relatively constant over the entire projection period from 2015–40, and prices increase by an average of only 0.2%/year from 2015–40.

The West region has higher productivity improvement and lower mine costs than the other regions, but its productivity declines as Powder River Basin producers move to more westward reserves with thinner seams and thicker overburdens. As a result, the region's average minemouth coal price increases by an average of 1.3%/year from 2030–40 (compared with 0.1%/year from 2015–30). Powder River Basin coal production accounts for about 40% of total U.S. coal production over the 2030–40 period.

Energy-related carbon dioxide emissions projections depend on assumptions about economic growth, energy prices, resource availability, and policies

Figure MT-61. Energy-related carbon dioxide emissions in seven cases, 2000–2040 (million metric tons)



The AEO2016 Reference case assumes that current laws and regulations remain in effect through 2040. However, the status of the Clean Power Plan (CPP), which is on hold pending judicial review, is uncertain. The Reference case assumes implementation of the CPP as scheduled and uses mass-based standards that impose limits on carbon dioxide (CO_2) emissions from fossil fuel-fired generators. The No CPP case assumes that no federal carbon reduction program is implemented. The No CPP case represents the upper end of the range of CO_2 emissions (5,468 million metric tons) in 2040, but the range of projected energy-related CO_2 emissions in 2040 is more than 800 million metric tons across the alternative cases included in AEO2016 (Figure MT-61). Projected emissions vary, depending on assumptions about economic growth, energy prices, and policies. In the High Economic Growth case, emissions in 2040 are close to emissions in the No CPP case—even though the High Economic Growth case includes the CPP—because emissions increase outside the electric power sector in response to higher economic growth.

The Extended Policies case represents the lower end of the emissions range, with CO_2 emissions falling to 4,623 million metric tons in 2040, 23% below the 2005 level. The Extended Policies case assumes that existing policies and regulations remain in effect, or are extended beyond sunset dates specified in current regulation, and that existing tax credits that have scheduled reductions and sunset dates remain unchanged through 2040. Efficiency policies, including corporate average fuel economy standards, appliance standards, and building codes, are expanded beyond current provisions, and the CPP regulations that reduce CO_2 emissions from electric power generation are tightened after 2030. The result is that, by 2040, energy-related CO_2 emissions are 846 million metric tons lower in the Extended Policies case than in the No CPP case.

Variations in natural gas prices have less impact than the CPP requirements on total CO_2 emissions. Because the limit that the CPP imposes on CO_2 emissions in the electric power sector is met in all cases, differences in energy-related emissions occur only in the end-use sectors. As a result, CO_2 emissions in 2040 in the Low Oil Price and High Oil Price cases fall within the range of emissions created by the No CPP and Extended Policies cases.

Endnotes for market trends

Links current as of July 2016

1. Labor productivity is measured as output per hour in private, nonfarm business.
2. As determined by the Business Cycle Dating Committee of the National Bureau of Economic Research, the most recent U.S. business contraction was from December 2007 to June 2009, the previous business expansion was from November 2001 to December 2007, and the current business expansion began in June 2009. See National Bureau of Economic Research, "US Business Cycle Expansions and Contractions," http://www.nber.org/cycles.html.
3. See U.S. Department of Labor, Bureau of Labor Statistics, "Multifactor Productivity Trends News Release" (Washington, DC: June 23, 2015), http://www.bls.gov/news.release/archives/prod3_06232015.htm.
4. Modified for EIA's energy prices and other key assumptions.
5. The industrial sector includes manufacturing, agriculture, construction, and mining. The energy-intensive manufacturing sectors include food, paper, bulk chemicals, petroleum refining, glass, cement, steel, and aluminum.
6. Value of shipments includes both final and intermediate products.
7. Drop-in fuels are those renewable fuels which can be blended with petroleum products, such as gasoline, and utilized in the current infrastructure of pumps, pipelines, and other existing equipment.
8. U.S. Senate and House of Representatives, "H.R. 6, Energy Independence and Security Act of 2007" (Washington, DC: January 4, 2007), https://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf, p. 86.
9. U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units" (Washington, DC: October 23, 2015), https://www.federalregister.gov/articles/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.
10. The AEO2016 Reference case includes only existing and announced standards and codes.
11. The NEMS Electricity Market Model regions are designed to replicate the power trading patterns in each market (see map in Appendix F).
12. Independent power producers are also known as nongovernment utilities and merchant generators. In 1978, the U.S. Congress passed the U.S. Public Utility Regulatory Policies Act, which established a class of nonutility generators called Qualifying Facilities permitted to produce power for resale.
13. W. Barber, "More nuclear power plant retirements forecast," Electric Light and Power (September 28, 2015), http://www.elp.com/articles/2015/09/more-nuclear-power-plant-retirements-forecast.html.
14. Hydrocarbon gas liquids include liquids produced from natural gas processing plants and fractionators and liquefied gases from crude oil refineries.
15. U.S. Environmental Protection Agency, "Mercury and Air Toxics Standards (MATS)" (Washington, DC: June 8, 2016), https://www.epa.gov/mats.

Figure sources for market trends

Links current as of July 2016

Figure MT-1. Growth of real gross domestic product and hours worked in the Reference case, 1985–2040: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-2. Average annual growth rates for real gross domestic product and its major components in three cases, 2015–40: History: Bureau of Economic Analysis. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWMACRO.D032516A, and HIGHMACRO.D032516A.

Figure MT-3. Average annual growth rates of shipments from the U.S. industrial sector and its components in three cases, 2015–40: Projections: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWMACRO.D032516A, and HIGHMACRO.D032516A.

Figure MT-4. North Sea Brent crude oil spot prices in three cases, 1990–2040: History: U.S. Energy Information Administration, Petroleum & Other Liquids, Europe Bent Spot Price FOB, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=D. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-5. World petroleum and other liquids consumption by region in three cases, 2015 and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-6. World production of nonpetroleum liquids by type in the Reference case, 2015 and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-7. Energy use per capita and per dollar of gross domestic product and carbon dioxide emissions per dollar of gross domestic product in two cases, 1980–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-8. Primary energy consumption by end-use sector in two cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-9. Primary energy use by fuel in two cases, 2015, 2020, 2030, and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-10. Residential delivered energy intensity in three cases, 2009–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, and TAXTENDED.D050216A.

Figure MT-11. Change in residential electricity consumption for selected end uses in the Reference case, 2015–40: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-12. Residential sector delivered energy consumption by fuel in the Reference case, 2004–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-13. Residential distributed electricity generation in two cases, 2010–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D050216A.

Figure MT-14. Commercial delivered energy intensity in the Reference case, 2005–40: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-15. Energy intensity of selected commercial end uses in the Reference case, 2015 and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-16. Efficiency gains for selected commercial equipment in two cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-17. Additions to commercial sector electricity generation capacity in two cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D050216A.

Figure MT-18. Industrial energy consumption by application in the Reference case, 2010–40: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-19. Industrial sector energy consumption by fuel in the Reference case, 2010–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-20. Industrial consumption of petroleum and other energy in three cases, 2015, 2025, and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-21. Energy Consumption for pulp and paper production in three cases, 2015, 2025, and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWMACRO.D032516A, and HIGHMACRO.D032516A.

Figure MT-22. Delivered energy consumption for transportation by mode in the Reference case, 2015 and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-23. Average fuel economy of new light-duty vehicles in the Reference case, 1980–2040: History: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Summary of Fuel Economy Performance* (Washington, DC: January 2016), http://www.nhtsa.gov/CAFE_PIC/CAFE_PIC_fleet_LIVE.html. **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-24. Vehicle miles traveled per licensed driver in the Reference case, 1995–2040: History: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2014* (Washington, DC: 2015), http://www.fhwa.dot.gov/policyinformation/statistics/2014/. **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-25. Sales of light-duty vehicles capable of using nongasoline technologies by type in the Reference case, 2015, 2025, and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-26. Transportation sector natural gas consumption by vehicle type in the Reference case, 1995–2040: Projections: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-27. U.S. gross domestic product growth and electricity demand growth rates, 1950–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-28. Net electricity generation by fuel in the Reference case, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-29. Net electricity generation by fuel in the No CPP case, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF_NO_CPP.D032316A.

Figure MT-30. Additions to electricity generation capacity by fuel in the Reference case, 2000–2040: History: Energy Information Administration, Form-860, "Annual Electric Generator Report." **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-31. Cumulative additions to electricity generation capacity by fuel in the No CPP case by period: AEO2016 National Energy Modeling System, run REF_NO_CPP.D032316A.

Figure MT-32. Electricity prices and natural gas prices to electricity generators in four cases, 2015–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, LOWRT.D032516A, and HIGHRT.D032516A.

Figure MT-33. Electricity generation by fuel in three cases, 2015, 2020, 2030 and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWRT.D032516A, and HIGHRT.D032516A.

Figure MT-34. Natural gas-fired electricity generation in four cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, LOWRT.D032516A, and HIGHRT.D032516A.

Figure MT-35. Cumulative nuclear generation capacity additions and retirements, 2016–20: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-36. Wind and solar electricity generation capacity additions in all sectors by energy source in two cases, 2016–20, 2021–30, and 2031–40: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-37. Renewable electricity generation by fuel type in all sectors in five cases, 2015 and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, LOWRT.D032516A, HIGHRT.D032516A, and LOWPRICE.D041916A.

Figure MT-38. Nonhydropower renewable electricity generation in all sectors in two cases, 2020 and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-39. Levelized electricity costs with tax credits for new power plants in the Reference case, 2022 and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-40. Coal consumption and sulfur dioxide emissions in the Reference and No CPP cases, 2005–40: History: U.S. Environmental Protection Agency, Clean Air Markets Database, http://ampd.epa.gov/ampd/. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A.

Figure MT-41. Natural gas consumption by sector in the Reference case, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-42. Annual average Henry Hub natural gas spot market prices in five cases, 1990–2040: History: U.S. Energy Information Administration, *Natural Gas Annual 2014,* DOE/EIA-0131(2014) (Washington, DC: September 2015). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWRT.D032516A, HIGHRT.D032516A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-43. Natural gas production, consumption, and net imports and exports in the Reference case, 1990–2040: History, 1990–2014: U.S. Energy Information Administration, *Natural Gas Annual 2014,* DOE/EIA-0131(2014) (Washington, DC: September 2015). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-44. U.S. natural gas production in three cases, 1990–2040: History, 1990–2014: U.S. Energy Information Administration, *Natural Gas Annual 2014,* DOE/EIA-0131(2014) (Washington, DC: September 2015). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-45. Ratio of crude oil prices to U.S. natural gas prices on an energy-equivalent basis in three cases, 1990–2040: History, 1990–2014: U.S. Energy Information Administration, *Natural Gas Annual 2014,* DOE/EIA-0131(2014) (Washington, DC: September 2015). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-46. U.S. dry natural gas production by source in the Reference case, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-47. U.S. net imports of natural gas by source in the Reference case, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-48. U.S. exports of liquefied natural gas in five cases, 2005–40: History: 2005–14, U.S. Energy Information Administration, *Natural Gas Annual 2014,* DOE/EIA-0131(2014) (Washington, DC: September 2015). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWRT.D032516A, HIGHRT.D032516A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-49. U.S. dry natural gas production in three cases, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWRT.D032516A, and HIGHRT.D032516A.

Figure MT-50. Crude oil and natural gas resources and cumulative production by *Annual Energy Outlook* year: Projections: AEO2000 National Energy Modeling System, run REF2K.D100199A; AEO2005 National Energy Modeling System, run REF2005.D102004A; AEO2010 National Energy Modeling System, run REF2010.D111809A; and AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-51. U.S. consumption of petroleum and other liquids by sector in two cases, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D050216A.

Figure MT-52. Consumption and gross exports of motor gasoline and diesel fuel in the Reference case and Extended Policies cases, 2005–40: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and TAXTENDED.D050216A.

Figure MT-53. Total U.S. crude oil production in five cases, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWRT.D032516A, HIGHRT.D032516A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-54. Domestic crude oil production by source in the Reference case, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-55. Average API gravity of U.S. domestic and imported crude oil supplies in two cases, 1990–2040: History: U.S. Energy Information Administration, Crude Oil Input Qualities and Company Level Imports Archives, http://www.eia.gov/petroleum/imports/companylevel/archive/. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and HIGHPRICE.D041916A.

Figure MT-56. Net import share of U.S. petroleum and other liquid fuels consumption in five cases, 1990–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, LOWRT.D032516A, HIGHRT.D032516A, LOWPRICE.D041916A, and HIGHPRICE.D041916A.

Figure MT-57. U.S. refinery gasoline-to-diesel production ratio and crack spreads in the Reference case, 2000–2040: History: Crack spread calculated from national average New York Harbor (NYH) RBOB prices and ULSD spot prices (2006–15) and No. 2 heating oil spot prices (2000–05), http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm. Gasoline and diesel refinery production calculated from finished gasoline, motor gasoline blend components (net), and distillate fuel oil (15 ppm and 15–500 ppm), http://www.eia.gov/dnav/pet/pet_pnp_refp2_dc_nus_mbblpd_a.htm and http://www.eia.gov/dnav/pet/pet_pnp_intp2_dc_nus_mbblpd_a.htm. **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A.

Figure MT-58. Coal production by region in the Reference and No CPP cases, 1970–2040: History: 1970–90: U.S. Energy Information Administration, *The U.S. Coal Industry, 1970–1990: Two Decades of Change,* DOE/EIA-0559 (Washington, DC: November 2002). **1991–2000:** U.S. Energy Information Administration, *Coal Industry Annual,* DOE/EIA-0584 (various years). **2001–14:** U.S. Energy Information Administration, *Annual Coal Report 2014,* DOE/EIA-0584(2014) (Washington, DC: March 2016) and previous issues. **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A and REF_NO_CPP.D032316A. Note: For 1989–2040, coal production includes waste coal.

Figure MT-59. U.S. coal production in eight cases, 2015, 2020, and 2040: AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, LOWRT.D032516A, HIGHPRICE.D041916A, HIGHMACRO.D032516A, LOWMACRO.D032516A, LOWPRICE.D041916A, and HIGHRT.D032516A. **Note:** Coal production includes waste coal.

Figure MT-60. Average annual minemouth coal prices by region in the Reference case, 1990–2040: History (dollars per short ton): 1990–2000: U.S. Energy Information Administration, *Coal Industry Annual,* DOE/EIA-0584 (various years). **2001–14:** U.S. Energy Information Administration, *Annual Coal Report 2014,* DOE/EIA-0584(2014) (Washington, DC: March 2016), and previous issues. **History (conversion to dollars per million Btu): 1970–2014:** *Estimation Procedure:* Estimates of average heat content by region and year based on coal quality data collected through various energy surveys (see sources) and national-level estimates of U.S. coal production by year in units of quadrillion Btu published in EIA's *Monthly Energy Review*. *Sources:* U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02), Table 1.2; Form EIA-3, "Quarterly Coal Consumption and Quality Report, Manufacturing and Transformation/Processing Coal Plants and Commercial and Institutional Coal Users"; Form EIA-5, "Quarterly Coal Consumption and Quality Report, Coke Plants"; Form EIA-6A, "Coal Distribution Report"; Form EIA-7A, "Coal Production and Preparation Report"; Form EIA-423, "Monthly Cost and Quality of Fuels for Electric Plants Report"; Form EIA-906, "Power Plant Report"; Form EIA-920, "Combined Heat and Power Plant Report"; Form EIA-923, "Power Plant Operations Report"; U.S. Department of Commerce, Bureau of the Census, "Monthly Report EM 545"; and Federal Energy Regulatory Commission, Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants." **Projections:** AEO2016 National Energy Modeling System, run REF2016.D032416A. Note: Includes reported prices for both open-market and captive mines.

Figure MT-61. Energy-related carbon dioxide emissions in seven cases, 2000–2040: History: U.S. Energy Information Administration, *Monthly Energy Review,* February 2016, DOE/EIA-0035(2016/02). **Projections:** AEO2016 National Energy Modeling System, runs REF2016.D032416A, REF_NO_CPP.D032316A, LOWPRICE.D041916A, HIGHPRICE.D041916A, LOWMACRO.D032516A, HIGHMACRO.D032516A, and TAXTENDED.D050216A.

Comparison with other projections

Energy Information Administration (EIA) and other contributors have endeavored to make these projections as objective, reliable, and useful as possible; however, they should serve as an adjunct to, not a substitute for, a complete and focused analysis of public policy initiatives. None of the EIA or any of the other contributors shall be responsible for any loss sustained due to reliance on the information included in this report.

Few organizations produce energy projections with details and time horizons comparable with those in the *Annual Energy Outlook 2016* (AEO2016). Other organizations do, however, address one or more aspects of the U.S. energy market. Projections from other organizations, which tend to focus on selected areas—such as economic growth, international oil prices, energy consumption, electricity, natural gas, petroleum, and coal—are compared with the AEO2016 Reference case in the following sections.

CP1. Economic growth

The range of projected economic growth rates in the outlooks included in this comparison tends to be wider over the first 3 years of the projection than over longer periods because the group of variables that influence long-run economic growth—such as population, productivity, and labor force growth—is smaller than the group of variables that affect projections of short-run growth. The 5-year average annual growth rate of real gross domestic product (GDP) from 2015–20 ranges from 2.0% to 3.1% (Table CP1), and the 11-year average annual growth rate from 2015–26 ranges from 1.9% to 2.7%.

From 2015–20, real GDP growth averages 2.6%/year in the AEO2016 Reference case, lower than projected by the Social Security Administration (SSA) in *The 2015 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds* and by ExxonMobil, but higher than projected by IHS Global Insight (IHSGI), the Congressional Budget Office (CBO), the Office of Management and Budget (OMB), the Interindustry Forecasting Project at the University of Maryland (INFORUM), Energy Ventures Analysis (EVA), the International Energy Agency (IEA) in its November 2015 *World Energy Outlook* Current Policies Scenario, and the Oxford Economics Group (OEG).

The average annual GDP growth of 2.4% in the AEO2016 Reference case from 2015–26 is identical to the mid-range of the outlooks, with IHSGI and CBO projecting 2.4% average growth; SSA and Exxon Mobil projecting higher average growth (2.7%/year and 2.6%/year, respectively); and OEG, OMB, INFORUM, and EVA projecting lower average growth (2.0%/year, 2.1%/year, 2.2%/year, and 1.9%/year, respectively).

There are few public or private projections of GDP growth for the United States that extend to 2040. The AEO2016 Reference case projects 2.2% average annual GDP growth from 2015–2040, consistent with trends in labor force and productivity growth. OEG, IEA, INFORUM, and EVA project lower GDP growth than in the AEO2016 Reference case, averaging 1.9%/year, 2.1%/year, 2.1%/year, and 2.0%/year, respectively. Exxon Mobil and SSA project higher GDP growth from 2015–40, both averaging 2.4%/year. IHSGI projects the same growth rate, at 2.2%/year, as in the AEO2016 Reference case.

CP2. Oil prices

In the AEO2016 Reference case, crude oil prices are represented by spot prices for North Sea Brent (Brent) crude oil and West Texas Intermediate (WTI) crude oil price, and by the imported U.S. refiner acquisition cost for crude oil (IRAC). The WTI price generally is lower than the North Sea Brent price. The historical record shows substantial variability in crude oil prices, and there is arguably even more uncertainty about prices in the long term. AEO2016 considers three crude oil price cases (Reference, Low Oil Price, and High Oil Price) to allow assessment of alternative views on the future course of crude oil prices (Table CP2).

In AEO2016, the North Sea Brent spot crude oil price is tracked as the main benchmark for world crude oil prices, because it better reflects the marginal price paid by refineries for imported light, sweet crude oil (used to produce petroleum products for

Table CP1. Comparisons of average annual economic growth projections, 2015–40

	Average annual percentage growth			
Projection	2015-20	2015-26	2026-40	2015-40
AEO2015 (Reference case)	2.6	2.5	2.3	2.4
AEO2016 (Reference case)	2.6	2.4	2.1	2.2
IHSGI (February 2016)	2.5	2.4	2.2	2.2
OMB (January 2016)[a]	2.2	2.1	--	--
CBO (January 2016)[a]	2.5	2.4	--	--
INFORUM (Spring 2016)	2.3	2.2	2.1	2.1
Social Security Administration (August 2015)	3.1	2.7	2.1	2.4
IEA (2015)[b]	2.5	--	2.0	2.1
Oxford Economics Group (February 2016)	2.2	2.0	1.9	1.9
ExxonMobil (growth calculated from 2014)[c]	2.7	2.6	2.3	2.4
EVA (growth calculated from 2014)[c]	2.0	1.9	2.0	2.0

-- = not reported or not applicable.
[a]OMB and CBO projections end in 2026, and growth rates cited are for 2015–26. AEO projections end in 2040.
[b]IEA publishes U.S. growth rates for certain intervals: 2013–20 growth is 2.5%, 2020–40 growth is 2.0%, and 2013–40 growth is 2.1%.
[c]ExxonMobil and EVA projections are calculated from 2014–20, 2014–25, 2025–40, and 2014–40.

consumers) than the West Texas Intermediate (WTI) crude oil price does. The WTI price has continued to trade at a discount relative to other world crude oil prices. In 2015, the WTI and North Sea Brent crude oil prices differed by $4 per barrel ($4/b). In the AEO2016 Reference case, the discount grows to $7/ b in 2040.

Spot crude oil prices in the other outlooks used in the comparison are based on either Brent, WTI, or IRAC prices, except for prices from the IEA, which are based on the average of crude oil import prices paid by members of the Organization for Economic Cooperation and Development (OECD) and prices from the Organization of Petroleum Exporting Countries (OPEC), which reflect the average price of a basket of crude oil sold by OPEC member countries.

The range of oil price projections in both the near term and the long term reflects current market conditions, including low prices due to crude oversupply in the near term and different assumptions about the future of the world economy. The wide range of the projections underscores the inherent uncertainty associated with future crude oil prices. With the exception of Strategic Energy & Economic Research (SEER)—which projects Brent prices remaining between $40/b and $45/b (2015 dollars)—the projections show crude oil prices rising over the entire projection period. On the other hand, the spread of the projections (again with the exception of SEER) is encompassed by the AEO2016 Low and High Oil Price cases, ranging from $49/b to $207/b for Brent in 2030 and from $73/b to $230/b in 2040. However, except for IEA (in 2030 and 2040) and IHSGI (in 2025), all the other projections in this comparison show lower crude oil prices than those in the AEO2016 Reference case for every year of the projection.

CP3. Total energy consumption

Three other organizations—ExxonMobil, BP, and IEA—provide projections of energy consumption by sector. IHSGI provides a projection of total primary energy consumption (but not consumption by sector) and projections of electricity sales, petroleum, and natural gas demand by end-use sector. To allow comparisons with the BP and IEA projections, AEO2016 Reference case projections for the residential and commercial sectors have been combined to produce a buildings sector projection (Table CP3). The IEA projections have a base year of 2013. ExxonMobil did not provide data for a base year. The BP projection extends through 2035, with a base year of 2014. The AEO2016 Reference case includes an unspecified sector, which has been combined with transportation for this comparison, in order to make it comparable with other projections.

Both IEA and ExxonMobil account for electricity generation from renewable energy sources at a conversion rate of 3,412 British thermal units (Btu) per kilowatthour (kWh) rather than a heat rate for displaced fossil fuel, as is used in the AEO2016 and other projections. As a result, their estimates for total energy consumption are lower. The BP projection appears to include the Clean Power Plan (CPP), with coal use for electricity generation showing the largest drop from 2020–25, as well as smaller declines in all other 5-year periods. The ExxonMobil projection does not include the CPP but assumes the implementation of unspecified environmental regulations related to carbon dioxide (CO_2) emissions, which reduce demand for coal, particularly after 2030, whereas the CPP has a larger impact before 2030. Although the IEA New Policies Scenario includes the CPP, it is not included in

Table CP2. Comparisons of oil price projections, 2025, 2030, 2035, and 2040 (2015 dollars per barrel)

			Projections							
	2015		2025		2030		2035		2040	
	WTI	Brent	WTI	Brent	WTI	Brent	WTI	Brent	WTI	Brent
AEO2016 (Reference case)	48.67	52.32	85.41	91.59	97.06	104.00	112.45	119.64	129.11	136.21
AEO2016 (Low Oil Price case)	48.67	52.32	36.57	43.09	42.38	48.94	53.02	59.23	67.00	72.99
AEO2016 (High Oil Price case)	48.67	52.32	180.49	187.69	197.83	206.75	211.77	220.71	222.27	229.91
AEO2015 (Reference case)	54.58	57.58	88.02	94.34	102.98	109.37	120.34	126.51	140.45	146.26
ArrowHead Economics	58.00	58.00	66.00	66.00	68.00	69.00	71.00	73.00	75.00	77.00
Strategic Energy & Economic Research (SEER)[a]	--	--	--	40.40	--	40.40	--	43.44	--	45.46
Energy Security Analysis (ESAI)	--	52.45	--	80.00	--	80.00	--	87.10	--	94.10
IHS Global Insight (GI)[b]	48.83	-	95.41	--	96.26	-	95.62	--	95.15	--
ICF[a]	--	--	--	75.61	--	75.76	--	75.76	--	--
Energy Ventures Analysis (EVA)[a]	--	--	--	64.59	--	65.84	--	67.09	--	--
IEA (Current Policies Scenario)[c]	--	--	--	--	--	130.00	--	--	--	150.00
OPEC Reference Basket[d]	--	--	--	--	--	88.41	--	--	--	95.00

-- = No data reported.
[a]Inflated from 2014 to 2015 dollars using GDP chain-type price index from the AEO2016 Reference case.
[b]Deflated from nominal dollars using IHS Global Insight deflator.
[c]IEA mixed crude oil import prices are based on OECD member country reporting.
[d]OPEC uses a basket of crudes reflecting the mix of the crude markers of its member exporting countries.

this comparison because it assumes other new policies that are difficult to compare with the AEO2016 Reference case. IEA also includes scenarios that do not anticipate policies. The IEA Current Policies Scenario, which does not include the CPP and assumes that no new policies are added to those in place in mid-2015, is used for this comparison.

For all the years shown, ExxonMobil and IEA project lower total energy consumption than in the AEO2016 Reference case. Total energy consumption is higher in all years of the IHSGI projection than in the AEO2016 Reference case. IHSGI projects significantly higher total electricity sales than in the AEO2016 Reference case, which helps to explain much of the difference in total energy consumption between the two projections.

The use of unspecified CO2 emissions regulations instead of the CPP in the ExxonMobil projections results in a different path for energy use and lower total energy use in 2040 in the electric power sector than in the other projections. The AEO2016 Reference case shows switching from coal to natural gas and renewables in the electric power sector from 2020–25, with the CPP beginning in 2022. With the assumption of more general CO2 emissions regulations in the ExxonMobil projection, the transition away from coal begins in the 2030s and occurs more gradually. Both the AEO2016 Reference case and ExxonMobil projections show residential energy consumption slightly lower in 2040, commercial consumption growing slowly, and transportation consumption lower in 2040. Industrial consumption increases through 2040 in the AEO2016 Reference case, while ExxonMobil shows industrial consumption declining from 2030–40. The direction of the trends is relatively consistent, if not the timing, even with different assumptions for the timing of environmental regulations.

Table CP3. Comparisons of energy consumption projections by sector, 2015, 2020, 2030, 2035, and 2040 (quadrillion Btu)

Sector	AEO2016 Reference	ExxonMobil	BP[a]	IHSGI	IEA[a]
	2015 (except where noted)				
Residential	10.9	--	--	--	--
Commercial	8.8	--	--	--	--
Buildings Sector	***19.7***	**--**	***21.2[b]***	**--**	***19.3[c]***
Industrial	24.3	--	23.8[b]	--	23.0[c]
Transportation and unspecified[d]	27.6	--	23.8[b]	--	24.1[c]
Electric Power	37.8	--	37.5[b]	--	35.6[c]
Less: electricity demand[e]	12.7	--	15.1[b]	--	14.8[c]
Total primary energy	**96.7**	**--**	**91.2[b]**	**99.1**	**86.7[c]**
	2020				
Residential	10.9	10.6	--	--	--
Commercial	9.0	8.7	--	--	--
Buildings sector	***19.9***	***19.3***	***20.9***	**--**	***20.2***
Industrial	27.1	26.6	26.0	--	25.6
Transportation and unspecified[d]	27.7	27.8	24.5	--	24.4
Electric power	38.9	36.1	39.0	--	37.1
Less: electricity demand[e]	13.1	14.2	16.1	--	16.1
Total primary energy	**100.5**	**95.6**	**94.3**	**105.5**	**90.7**
	2030				
Residential	10.7	10.4	--	--	--
Commercial	9.5	8.9	--	--	--
Buildings sector	***20.2***	***19.3***	***21.4***	**--**	***21.5***
Industrial	30.1	29.2	26.9	--	25.9
Transportation and unspecified[d]	25.8	26.3	23.0	--	23.7
Electric power	39.4	36.5	39.6	--	39.0
Less: electricity demand[e]	14.0	15.5	16.7	--	17.5
Total primary energy	**101.5**	**95.9**	**94.1**	**109.8**	**92.2**

-- = No data reported.
See notes at end of table.

(continued on page CP-5)

The base year consumption figures used by BP are lower than the AEO2016 base year data, with most of the difference in transportation consumption. Part of the difference is that AEO2016 uses 2015 as a base year and BP uses 2014, but that does not account for all the difference. Base year consumption in the BP projection is about 7 quadrillion Btu less than in the AEO2016 Reference case, and the BP projections are about 10 quadrillion Btu lower in 2035. The gap widens in the 2030–35 period, due mainly to transportation consumption (which declines by a little more than 1 quadrillion Btu in the BP projection) and electric power consumption. Over the same period, transportation consumption remains relatively constant, and electric power consumption increase by about 1 quadrillion Btu, in the AEO2016 Reference case. The difference in accounting for renewable electricity generation could explain the variation in the electric power sector.

Total energy consumption in the IEA projection is higher in 2040 than in 2013 as a result of an increase of 3.5 quadrillion Btu in buildings sector energy consumption, including a 3.0 quadrillion Btu increase in buildings electricity use. IEA projects a small increase in energy use in the industrial sector of 0.4 quadrillion Btu from 2020–40 after a 10% increase from 2013–20. The increase through 2020 is similar to that in the AEO2016 Reference case, and it continues to grow through 2040 but at a slower rate than in the AEO2016 Reference case.

CP4. Electricity

Table CP4 compares AEO2016 Reference case projections for electricity with those from IEA, NREL, and EVA. The IEA and NREL projections for total electricity generation are similar to the AEO2016 Reference case projections for 2025, 2035, and 2040, whereas the EVA projections for total electricity generation are significantly higher than those of the other projections across all years. The AEO2016 Reference case projects total U.S. generation of 4,420 billion kWh in 2025, as compared with the EVA projection of 5,361 billion kWh, which is about 20% higher than AEO2016 and the highest among all of the projections compared. The EVA projection appears to be based on policy assumptions that are similar to those in the AEO2016 Reference case, including the CPP.

In the AEO2016 Reference case, as a result of the CPP, total generation from coal-fired power plants in 2025 is 217 billion kWh lower than generation from natural gas-fired plants. In the NREL projection, total coal-fired generation is 558 billion kWh higher

Table CP3. Comparisons of energy consumption projections by sector, 2015, 2020, 2030, 2035, and 2040 (quadrillion Btu) *(continued)*

Sector	AEO2016 Reference	ExxonMobil	BP[a]	IHSGI	IEA[a]
			2035		
Residential	10.8	10.3	--	--	--
Commercial	9.9	8.9	--	--	--
Buildings sector	***20.6***	***19.2***	***21.5***	**--**	**--**
Industrial	31.4	28.9	27.6	--	--
Transportation and unspecified[d]	25.7	25.2	21.7	--	--
Electric power	40.6	36.4	39.6	--	--
Less: electricity demand[e]	14.5	15.9	16.9	--	--
Total primary energy	**103.9**	**93.9**	**93.4**	**111.2**	**--**
			2040		
Residential	10.9	10.2	--	--	--
Commercial	10.3	9.0	--	--	--
Buildings sector	***21.2***	***19.2***	**--**	**--**	***22.7***
Industrial	32.9	28.2	--	--	26.1
Transportation and unspecified[d]	26.2	24.5	--	--	23.6
Electric power	42.0	36.1	--	--	40.5
Less: electricity demand[e]	15.2	16.2	--	--	18.8
Total primary energy	**107.1**	**91.8**	**--**	**112.5**	**93.8**

-- = No data reported.
[a]Converted from million tons oil equivalent (mtoe), assuming 1 mtoe equals 0.03968 quadrillion Btu.
[b]BP data are for 2014.
[c]IEA data are for 2013.
[d]Unspecified sector consumption is that not attributed to the sectors listed.
[e]Energy consumption in the sectors includes electricity demand purchases from the electric power sector, which are subtracted to avoid double counting in deriving total primary energy consumption.

than natural gas-fired generation in 2025, even with the assumed implementation of both carbon taxes and carbon pollution standards for new power plants. The NREL projection shows a decline in total electricity generation from natural gas-fired power plants over the projection. In IEA's Current Policies scenario, which is based on current laws and regulations (excluding the CPP), electricity generation from natural gas-fired power plants does not surpass generation from coal-fired power plants until the later part of the 2030s. The EVA projection shows total natural gas-fired generation surpassing coal-fired generation in the early 2030s. One possible cause for the variation in projected timing of the transition (although no cause was suggested) may be differences in the IEA and EVA trends for natural gas and coal prices.

Electricity generation from U.S. nuclear power plants varies widely among the projections. In the AEO2016 Reference and No CPP cases, nuclear generation declines from 798 billion kWh in 2015 to 770 billion kWh in 2019 before rebounding to 789 billion kWh/year from 2022–40. In the IEA projection, nuclear generation grows by 5% (39 billion kWh) from 2013–20 and remains nearly constant through 2040. In the NREL projection, nuclear generation falls steadily, with an accelerated decline after 2025.

Table CP4. Comparisons of electricity projections, 2025, 2035, and 2040 (billion kilowatthours, except where noted)

Sector	2015	AEO2016 Reference	AEO2016 No CPP	IEA[h]	NREL	EVA
				2025		
Average end-use price (2015 cents per kilowatthour)[a]	10.3	10.7	10.6	--	--	--
Residential	12.4	13.2	13.1	--	--	--
Commercial	10.5	10.9	10.8	--	--	--
Industrial	6.9	7.3	7.2	--	--	--
Total generation plus net imports	**4,090**	**4,420**	**4,461**	**4,665**	**4,217**	**5,361**
Coal	1,355	1,179	1,432	1,692	1,425	1,433
Petroleum	26	13	14	24	0	0
Natural gas[b]	1,348	1,396	1,307	1,361	867	1,183
Nuclear	798	789	789	861	780	839
Hydroelectric/other[c]	336	419	417	413	431	325
Solar	38	170	113	68	163	71
Wind	190	453	388	247	551	372
Electricity sales	**3,729**	**3,986**	**4,025**	**--**	**--**	**--**
Residential	1,402	1,393	1,406	--	--	--
Commercial/other[d]	1,368	1,448	1,462	--	--	--
Industrial	959	1,145	1,156	--	--	--
Capacity, including CHP (gigawatts)[e]	**1,082**	**1,144**	**1,112**	**1,192**	**1,151**	**--**
Coal	284	196	215	281	249	--
Oil and natural gas	477	485	479	539	433	--
Nuclear	100	99	99	107	99	--
Hydroelectric/other[f]	120	124	124	130	122	--
Solar	25	96	70	44	96	--
Wind	76	144	125	91	151	--
Cumulative capacity retirements from 2016 (gigawatts)[g]	**--**	**145**	**116**	**--**	**--**	**--**
Coal	--	80	60	--	--	--
Oil and natural gas	--	60	50	--	--	--
Nuclear	--	5	5	--	--	--
Hydroelectric/other[f]	--	0	0	--	--	--

-- = No data reported.
See notes at end of table.

(continued on page CP-7)

EVA projects rising nuclear generation through 2025, followed by a decline. Across the projections, nuclear electricity generation in 2025 ranges from a low of 789 billion kWh in the AEO2016 Reference case to a high of 861 billion kWh in the IEA projection.

Generation from nonhydroelectric renewable resources accounts for a significant portion of the total increase in electricity generation, but its share of total generation varies across the projections. In the AEO2016 Reference case, wind and solar provide 10% and 4%, respectively, of total generation in 2025, compared with 9% and 3%, respectively, in the No CPP case. In the EVA projection, wind and solar energy provide the smallest share of total generation in 2025, 2035, and 2040. In the NREL projection, wind and solar have the largest shares of total generation in 2025, 2035, and 2040 of the projections compared. Differences among the projections may result from different assumptions about technology costs and performance or from different treatments of federal and state policies for renewable electricity generation (i.e., production tax credits, investment tax credits, renewable fuel standards, etc.).

Table CP4. Comparisons of electricity projections, 2025, 2035, and 2040 (billion kilowatthours, except where noted) *(continued)*

Sector	2015	AEO2016 Reference	AEO2016 No CPP	IEA[h]	NREL	EVA
				2035		
Average end-use price (2015 cents per kilowatthour)[a]	10.3	10.6	10.3	--	--	--
Residential	12.4	13.2	12.8	--	--	--
Commercial	10.5	10.7	10.4	--	--	--
Industrial	6.9	7.3	7.1	--	--	--
Total generation plus net imports	**4,090**	**4,795**	**4,910**	**5,065**	**4,477**	**5,943**
Coal	1,355	962	1,398	1,769	1,292	1,396
Petroleum	26	10	12	20	0	0
Natural gas[b]	1,348	1,768	1,599	1,496	820	1,500
Nuclear	798	789	789	864	581	704
Hydroelectric/other[c]	336	441	436	470	442	343
Solar	38	364	281	117	486	128
Wind	190	460	394	328	856	472
Electricity sales	**3,729**	**4,256**	**4,369**	**--**	**--**	**--**
Residential	1,402	1,457	1,494	--	--	--
Commercial/other[d]	1,368	1,601	1,657	--	--	--
Industrial	959	1,197	1,218	--	--	--
Capacity, including CHP (gigawatts)[e]	**1,082**	**1,277**	**1,254**	**1,281**	**1,388**	**--**
Coal	284	179	215	281	205	--
Oil and natural gas	477	536	536	560	483	--
Nuclear	100	99	99	107	74	--
Hydroelectric/other[f]	120	127	126	142	128	--
Solar	25	192	152	74	288	--
Wind	76	145	126	118	210	--
Cumulative capacity retirements from 2016 (gigawatts)[g]	**--**	**183**	**128**	**--**	**--**	**--**
Coal	--	97	60	--	--	--
Oil and natural gas	--	81	62	--	--	--
Nuclear	--	5	5	--	--	--
Hydroelectric/other[f]	--	0	0	--	--	--

-- = No data reported.
See notes at end of table.

(continued on page CP-8)

Total generating capacity (including combined heat and power) is similar across the projections, ranging from 1,112 gigawatts (GW) in 2025 in the AEO2016 No CPP case to 1,144 GW in the AEO2016 Reference case and 1,192 GW in the IEA projection. NREL projects slightly more growth in total generating capacity, corresponding to a higher projection of total generation from nonhydroelectric renewables, despite having the lowest projections for total generation in 2025, 2035, and 2040.

Table CP4. Comparisons of electricity projections, 2025, 2035, and 2040 (billion kilowatthours, except where noted) *(continued)*

Sector	2015	AEO2016 Reference	AEO2016 No CPP	IEA[a]	NREL	EVA
		2040				
Average end-use price (2015 cents per kilowatthour)[b]	10.3	10.5	10.2	--	--	--
Residential	12.4	13.0	12.7	--	--	--
Commercial	10.5	10.5	10.2	--	--	--
Industrial	6.9	7.2	7.1	--	--	--
Total generation plus net imports	**4,090**	**5,060**	**5,180**	**5,451**	**4,638**	**6,416**
Coal	1,355	919	1,364	1,710	1,318	1,236
Petroleum	26	9	11	10	0	0
Natural gas[c]	1,348	1,942	1,784	1,752	763	1,785
Nuclear	798	789	789	865	461	679
Hydroelectric/other[d]	336	451	444	537	443	353
Solar	38	477	389	169	635	168
Wind	190	473	399	409	1,019	530
Electricity sales	**3,729**	**4,464**	**4,587**	**--**	**--**	**--**
Residential	1,402	1,523	1,557	--	--	--
Commercial/other[e]	1,368	1,692	1,761	--	--	--
Industrial	959	1,249	1,269	--	--	--
Capacity, including CHP (gigawatts)[f]	**1,082**	**1,374**	**1,342**	**1,343**	**1,539**	**--**
Coal	284	176	215	271	192	--
Oil and natural gas	477	576	570	572	534	--
Nuclear	100	99	99	107	58	--
Hydroelectric/other[g]	120	128	127	155	128	--
Solar	25	246	203	100	379	--
Wind	76	149	128	138	247	--
Cumulative capacity retirements from 2016 (gigawatts)[h]	**--**	**190**	**132**	**--**	**--**	**--**
Coal	--	100	60	--	--	--
Oil and natural gas	--	85	66	--	--	--
Nuclear	--	5	5	--	--	--
Hydroelectric/other[g]	--	0	0	--	--	--

-- = No data reported.
[a]Projections from IEA in the 2025 and 2035 comparison tables are in fact for 2020 and 2030 respectively. Since projections for year 2025 and 2035 under IEA WEO 2015 Current Policies Scenario (CPS) are not provided, projections from the closest years, 2020 and 2030, were used instead.
[b]Average end-use price includes the transportation sector.
[c]Includes supplemental gaseous fuels. For EVA, represents total oil and natural gas.
[d]Other includes conventional hydroelectric, pumped storage, geothermal, wood, wood waste, municipal waste, other biomass, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, petroleum coke, and miscellaneous technologies.
[e]Other includes sales of electricity to government and other transportation services.
[f]EIA capacity is net summer capability, including CHP plants and end-use generators.
[g]Other includes conventional hydroelectric, geothermal, wood, wood waste, all municipal waste, landfill gas, other biomass, pumped storage, other gaseous fuels, refinery gas, still gas, and fuel cells.
[h]Retirements for AEO2016 reflect the electric power sector only.

The implied capacity utilization rate for coal-fired power plants in the AEO2016 Reference case (calculated from total coal-fired capacity and generation) is about 60% in both 2035 and 2040, which is lower than for any other projection. In comparison, IEA and NREL project more than 70% utilization of total U.S. coal-fired capacity in 2035 and 2040. For oil/natural gas, hydroelectric/other, and solar energy, however, the AEO2016 Reference case has the highest utilization rates among the projections, at about 38% for oil/natural gas, 40% for hydroelectric/other, and 22% for solar in 2035 and 2040. NREL projects the highest utilization rate for wind capacity in 2035 and 2040 (47%) and the lowest utilization rates for oil, natural gas, and nuclear capacity in the same years. IEA projects the highest utilization rate for nuclear capacity in 2035 and 2040 (92%) and the lowest for wind in both years. IEA also has the lowest utilization rates for hydroelectric/other and solar capacity in 2035, but the utilization rates for hydroelectric/other in 2040 are similar in all of the projections. IEA's utilization rate for solar in 2040 is lower than in the AEO2016 Reference case but similar to NREL's projection.

CP5. Natural gas

Projections for natural gas consumption, production, imports, and prices (Table CP5) differ significantly, largely as a result of different assumptions. For example, the AEO2016 Reference case assumes that current laws and regulations generally remain unchanged from 2015–40, whereas other projections may include assumptions about policy developments over the period. In particular, the AEO2016 Reference case does not incorporate any future changes in policies affecting carbon emissions or other environmental issues.

Production

All the outlooks shown in Table CP5 (with the exception of IHSGI, which did not provide production data) project increases in natural gas production from 2015, when production totaled 27.2 trillion cubic feet (Tcf). BP projects the largest production increase, to 42.0 Tcf in 2035, or 54% more than the 2015 level. BP is followed closely by ExxonMobil, which projects 40.8 Tcf of natural gas production in 2035 and 41.4 Tcf in 2040, or 50% and 53% above 2015 levels, respectively.

The AEO2016 Reference case, ICF, BP, and ExxonMobil all project larger increases in natural gas production before 2025 than in the later years. In the AEO2016 Reference case, natural gas production increases by 28% from 2015–25 and by 15% from 2025–35. ICF, BP, and ExxonMobil project production increases of more than 30% from 2015–25 and less than 20% from 2025–35. EVA projects roughly equal growth rates for natural gas production from 2015–25 and 2025–35. EVA projects production increases of 23% (to 33.4 Tcf) from 2015–25 and 22% (to 40.6 Tcf) from 2025–35.

Net imports/exports

The AEO2016 Reference case projection for growth in U.S. natural gas exports from 2015–40 is the largest among those reviewed here, from net imports of 1.0 Tcf in 2015 to net exports in 2018. U.S. export growth to 7.6 Tcf in 2040 consists mostly of liquefied natural gas (LNG) exports, along with a smaller increase in net pipeline exports to Mexico through 2020 and a reduction in net pipeline imports from Canada through 2040, which offsets a gradual decline in net pipeline exports to Mexico after 2020.

EVA, ICF, and BP also provide projections for net imports of natural gas that show the United States becoming a net exporter by 2020, but they differ from the AEO2016 Reference case in terms of export levels. ICF shows net exports growing early in the projection but declining through 2035, when net exports of 3.4 Tcf are less than one-half of those in the AEO2016 Reference case (7.2 Tcf). The decline of net natural gas exports in the ICF projection results from a decrease in net LNG exports, from 3.2 Tcf in 2025 to 2.6 Tcf in 2035. EVA and BP show continued growth in net exports, to 4.7 Tcf and 7.6 Tcf in 2035, respectively. The BP projection of 7.6 Tcf of net natural gas exports in 2035 is fairly close to the AEO2016 Reference case projection of 7.2 Tcf in 2035. EVA projects net pipeline imports of natural gas into the United States after 2020, rather than net pipeline exports, with U.S. gross pipeline imports of natural gas more than doubling from 2025–35.

Consumption

In the AEO2016 Reference case, total domestic natural gas consumption increases by 19% from 2015–35 and by 25% from 2015–40 to a total of 34.4 Tcf in 2040. The 5.1 Tcf increase in total domestic consumption in the AEO2016 Reference case from 2020–35 is 0.8 Tcf larger than the projected increase in net natural gas exports (4.3 Tcf). The domestic consumption share of total U.S. natural gas production declines in the Reference case from 90% in 2020 to 82% in 2035 and 2040. From 2015–35, natural gas consumption in the electric power sector grows by 16%, to a total of 11.1 Tcf, as compared with a 22% increase in the industrial sector, to 9.2 Tcf, and a 10% increase in the commercial sector, to 3.6 Tcf in 2035. In the residential sector, natural gas consumption remains constant at 4.6 Tcf from 2015 to 2035 in the Reference case.

EVA, ICF, BP, and ExxonMobil provided outlooks for domestic natural gas consumption at different levels of detail, with the ICF projections being the most comprehensive. BP provided separate projections for consumption in the industrial and electric power sectors—projections of residential and commercial sector consumption are included with projections of consumption in the transportation sector, for lease and plant operations, for liquefaction to LNG for export and for pipeline fuel. BP consistently shows higher projections than those in the AEO2016 Reference case for total natural gas consumption. BP shows increasing consumption of natural gas in all domestic sectors, led by consumption in the electric power sector, with ICF showing a greater increase than BP in electric power sector consumption from 2020–35. ICF projects 63% growth in power sector natural gas use, to 16.3 Tcf in 2035, which is higher than projected in the AEO2016 Reference case and the other outlooks. The AEO2016 projection for natural gas consumption in the electric power sector is lower than the others, and its projection for industrial sector natural gas consumption in 2035 is lower than the EVA, BP, and ExxonMobil projections.

Table CP5. Comparisons of natural gas projections, 2025, 2035, and 2040 (trillion cubic feet, except where noted)

Projection	2015	AEO2016 Reference	IHSGI	EVA	ICF	BP	ExxonMobil
		2025					
Dry gas production	**27.19**	**34.81**	**--**	**33.37**	**35.70**	**36.18**	**35.51**
Net imports	**0.95**	**-5.32**	**--**	**-2.86**	**-3.55**	**-4.42**	**--**
Pipeline	0.89	-0.76	--	0.16	-0.37	--	--
LNG	0.06	-4.56	--	-3.02	-3.18	--	--
Consumption	**27.47**	**29.35**	**--**	**28.19**	**31.70**	**31.75**	**--**
Residential	4.62	4.67	--	4.68	5.15	--	6.82[a]
Commercial	3.22	3.35	--	3.53	3.36	--	--
Industrial[b]	7.51	8.65	--	10.15	8.08	11.25	10.72
Electricity generation[c]	9.61	9.33	--	9.74	12.06	12.17	10.72
Other[d]	2.51	3.34	--	0.08[e]	3.04	8.34	--
Henry Hub spot market price (2012 dollars per million Btu)	**2.62**	**5.12**	**4.40[f]**	**4.70[g]**	**4.19[g]**	**--**	**--**
End-use prices (2012 dollars per thousand cubic feet)							
Residential	10.40	11.99	--	--	--	--	--
Commercial	7.92	10.39	--	--	--	--	--
Industrial	3.84	6.15	--	--	--	--	--
Electricity generation	3.35	5.55	--	--	--	--	--
		2035					
Dry gas production	**27.19**	**39.92**	**--**	**40.65**	**39.89**	**42.02**	**40.84**
Net imports	**0.95**	**-7.18**	**--**	**-4.70**	**-3.38**	**-7.61**	**--**
Pipeline	0.89	-0.99	--	0.51	-0.77	--	--
LNG	0.06	-6.19	--	-5.22	-2.61	--	--
Consumption	**27.47**	**32.59**	**--**	**31.02**	**36.15**	**34.41**	**--**
Residential	4.62	4.62	--	4.67	5.16	--	6.82[a]
Commercial	3.22	3.55	--	3.58	3.17	--	--
Industrial[b]	7.51	9.19	--	10.81	8.24	11.76	10.72
Electricity generation[c]	9.61	11.13	--	11.86	16.29	13.32	13.65
Other[d]	2.51	4.09	--	0.10[e]	3.28	9.33	1.00
Henry Hub spot market price (2012 dollars per million Btu)	**2.62**	**4.91**	**5.73[f]**	**5.93[g]**	**5.20[g]**	**--**	**--**
End-use prices (2012 dollars per thousand cubic feet)							
Residential	10.40	12.50	--	--	--	--	--
Commercial	7.92	10.66	--	--	--	--	--
Industrial	3.84	5.95	--	--	--	--	--
Electricity generation	3.35	5.54	--	--	--	--	--

-- = No data reported.
See notes at end of table.

(continued on page CP-11)

ICF shows the U.S. domestic sector consuming a steady share of U.S. natural gas production from 2020–35, varying from 89% to 92%. BP shows the share of production consumed in the United States declining from 88% in 2020 to 82% to 2035. In the AEO2016 Reference case, the share of production consumed in domestic markets falls from 90% in 2020 to 82% in 2035.

Although the EVA and ExxonMobil projections show lower volumes of natural gas consumption, they are not comparable with the other outlooks. EVA does not include natural gas consumed for lease and plant operations, liquefaction for export, or pipeline fuel. ExxonMobil does not include natural gas consumed in the commercial sector for transportation, lease and plant operations, liquefaction for export, and pipeline fuel. Also, ExxonMobil provides a combined projection for residential and commercial natural gas consumption. EVA differs from ExxonMobil in that it shows industrial consumption growing to 10.8 Tcf in 2035 (the second highest level among the projections), whereas ExxonMobil shows relatively flat consumption in the industrial sector. The ExxonMobil projections for total domestic consumption of natural gas through 2035 are higher than the EVA projections but lower than the AEO2016 Reference case projections.

Prices

Only IHSGI, EVA, and ICF provide projections for Henry Hub natural gas spot prices. All the price projections, including those in the AEO2016 Reference case, are in real 2015 dollars. Prices in the IHSGI, EVA, and ICF outlooks are lower than those in the AEO2016 Reference case from 2015–30. After 2030, the EVA, IHSGI, and ICF prices are above $5.00, in million British thermal unit (MMBtu), while, with the exception of 2031 and 2032, the price in the AEO2016 Reference case remains below $5.00/MMBtu throughout the projection period. EVA projects the highest Henry Hub prices through 2035, followed closely by IHSGI, with EVA having a projected 2035 spot natural gas price of $5.93/MMBtu, IHGSI $5.73/MMBtu, and ICF $5.20/MMBtu, all in real 2015

Table CP5. Comparisons of natural gas projections, 2025, 2035, and 2040 (trillion cubic feet, except where noted) *(continued)*

Projection	2015	AEO2016 Reference	IHSGI	EVA	ICF	BP	ExxonMobil
		2040					
Dry gas production	**27.19**	**42.12**	**--**	**--**	**--**	**--**	**41.39**
Net imports	**0.95**	**-7.55**	**--**	**--**	**--**	**--**	**--**
Pipeline	0.89	-0.89	--	--	--	--	--
LNG	0.06	-6.66	--	--	--	--	--
Consumption	**27.47**	**34.42**	**--**	**--**	**--**	**--**	**--**
Residential	4.62	4.58	--	--	--	--	6.82[a]
Commercial	3.22	3.69	--	--	--	--	--
Industrial[b]	7.51	9.58	--	--	--	--	9.75
Electricity generation[c]	9.61	11.96	--	--	--	--	13.65
Other[d]	2.51	4.60	--	--	--	--	--
Henry Hub spot market price (2012 dollars per million Btu)	**2.62**	**4.86**	**6.82[f]**	**--**	**--**	**--**	**--**
End-use prices (2012 dollars per thousand cubic feet)							
Residential	10.40	12.74	--	--	--	--	--
Commercial	7.92	10.73	--	--	--	--	--
Industrial	3.84	5.89	--	--	--	--	--
Electricity generation	3.35	5.52	--	--	--	--	--
Electricity generation	3.35	5.54	--	--	--	--	--

-- = No data reported.
[a]Natural gas consumed in the residential and commercial sectors.
[b]Includes consumption for industrial CHP plants and a small number of industrial electricity-only plants, and natural gas-to-liquids heat/power and production; excludes consumption by nonutility generators.
[c]Includes consumption of energy by electricity-only and CHP plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes electric utilities, small power producers, and exempt wholesale generators.
[d]Includes lease, plant, and pipeline fuel, fuel consumed in natural gas vehicles, and fuel consumed in liquefaction for export.
[e]Does not include lease, plant, and pipeline fuel, and fuel consumed in liquefaction for export.
[f]Converted to 2015 dollars using IHS's GDP deflator for the IHS Reference case.
[g]Converted to 2015 dollars using EIA's GDP deflator.

dollars. IHSGI is the only other outlook that provides a projection in 2040, with a projected spot price of $6.82/MMBtu in 2040, 40% higher than projected in the AEO2016 Reference case.

In the AEO2016 Reference case, residential natural gas prices rise to $12.74/thousand cubic feet (Mcf) in real 2015 dollars in 2040. Commercial natural gas prices rise to $10.72/Mcf in 2030, and remain between $10.66 and $10.73/Mcf through 2040. Electric power and industrial natural gas prices rise to $6.15/Mcf in 2025 and $5.74/Mcf in 2030 in real 2015 dollars, respectively, before gradually declining to $5.52/Mcf and $5.89/Mcf, respectively, in 2040. EVA, and ICF did not project natural gas prices by sector.

Table CP6. Comparisons of petroleum and other liquids projections, 2025, 2035, and 2040 (million barrels per day, except where noted)

Projection	2015	AEO2016 Reference	BP	EVA	ICF	IEA	ExxonMobil[a]	IHSGI[b]
					2025			
U.S. refiner imported acquisition cost of crude oil (2015 dollars per barrel)	46.42	83.45	--	--	75.63	--	--	87.35
Brent spot price (2015 dollars per barrel)	52.32	91.59	--	64.59	--	--	--	--
U.S. WTI crude oil price (2015 dollars per barrel)	48.67	85.41	--	64.61	--	--	--	95.41
Domestic production	**12.68**	**14.20**	**15.90**	**--**	**13.96**	**--**	**18.70**	**--**
Crude oil	9.42	9.43	10.20	--	8.88	12.00	--	--
Alaska	0.48	0.32	--	--	0.40	--	--	--
Natural gas liquids	3.25	4.77	5.70	--	5.08	--	11.00	--
Total net imports	**4.64**	**3.27**	**1.20**	**--**	**--**	**--**	**--**	**--**
Crude oil	6.88	6.95	--	--	--	--	--	--
Products	-2.24	-3.69	--	--	--	--	--	--
Petroleum and other liquids consumption	19.42	19.90	19.50	--	--	16.50	20.02	--
Net petroleum import share of liquids supplied (percent)	24.00	16.50	6.00	--	--	--	--	--
Biofuel production	1.01	1.02	1.20	--	--	--	--	--
					2035			
U.S. refiner imported acquisition cost of crude oil (2015 dollars per barrel)	46.42	109.70	--	--	75.78	--	--	91.00
Brent spot price (2015 dollars per barrel)	52.32	119.64	--	67.09	--	--	--	--
U.S. WTI crude oil price (2015 dollars per barrel)	48.67	112.45	--	67.29	--	--	--	95.62
Domestic production	**12.68**	**15.62**	**17.30**	**--**	**13.99**	**--**	**19.10**	**--**
Crude oil	9.42	10.66	10.50	--	8.52	11.40	--	--
Alaska	0.48	0.19	--	--	0.38	--	--	--
Natural gas liquids	3.25	4.95	6.90	--	5.47	--	--	--
Total net imports	**4.64**	**1.72**	**-1.90**	**--**	**--**	**--**	**--**	**--**
Crude oil	6.88	6.24	--	--	--	--	--	--
Products	-2.24	-4.52	--	--	--	--	--	--
Petroleum and other liquids consumption	19.42	19.69	18.10	--	--	14.20	19.09	--
Net petroleum import share of liquids supplied (percent)	24.00	9.00	-9.00	--	--	--	--	--
Biofuel production	1.01	1.03	1.40	--	--	--	--	--

-- = No data reported.
See notes at end of table.

(continued on page CP-13)

CP6. Petroleum and other liquid fuels

In the AEO2016 Reference case, the North Sea Brent spot crude oil price (in 2015 dollars) increases from about $52/barrel (b) in 2015 to $92/b in 2025 and then continues rising to $120/b in 2035 and $136/b in 2040 (Table CP6). North Sea Brent spot crude oil prices are relatively flat in the Energy Ventures Analysis (EVA) projection, rising from $65/b in 2025 to $67/b in 2035. In the AEO2016 projection, the U.S. imported refiner acquisition cost (IRAC) of crude oil (in 2015 dollars) increases from $46/b in 2015 to about $83/b in 2025, and then increases to $110/b in 2035 and $126/b in 2040. IRAC prices in the International Energy Agency (IEA) projection are similar but rise faster, increasing from $46/b in 2015 to $152/b in 2040, while IHS-Global Insight (IHSGI) project that IRAC prices will increase from $46/b in 2015 to $87/b in 2025 and then gradually to $91/b in 2035 and $93/b in 2040. IRAC prices in the ICF projection are relatively flat after increasing from 2015 levels, averaging $76/b in both 2025 and 2035. BP and ExxonMobil did not report projections of North Sea Brent or IRAC crude oil prices.

In the AEO2016 Reference Case, domestic crude oil production decreases from about 9.4 million barrels/day (b/d) in 2015 to 8.6 million b/d in 2017, before growing to 9.4 million b/d in 2025, 10.7 million b/d in 2035, and 11.3 million b/d by 2040. Overall, the production level in 2040 is about 20% higher than in 2015. Production in the BP projection grows from 9.4 million b/d in 2015 to 10.2 million b/d in 2025 and then grows modestly to 10.5 million b/d in 2035. The ICF projection shows production falling from the 9.4 million b/d produced in 2015 to 8.9 million b/d in 2025 and to 8.5 million b/d in 2035. Production increases from 2015 levels in the IEA projection to 12.0 million b/d in 2025 before falling to 10.6 million b/d in 2040. The ExxonMobil projection includes only total domestic production of crude oil and natural gas liquids, which is higher than in the AEO2016 Reference Case. Total production in the ExxonMobil projection increases from 2015 levels of 12.7 million b/d to 18.7 million b/d in 2025 before increasing to 19.1 million b/d in 2035, and then falling again to 18.0 million b/d in 2040. These levels are all higher than in the AEO2016 projection where production falls to 14.2 million b/d in 2025 before rising to 15.6 million b/d in 2035 and 16.3 million b/d in 2040.

With rapid growth in U.S. crude oil production, net imports fall in the AEO2016 Reference case and other projections. In the Reference case, total net imports of crude oil and products fall from 4.6 million b/d in 2015 to 3.3 million b/d in 2025, 1.7 million b/d in 2035, and 1.4 million b/d in 2040. In the BP projection, total net imports are even lower than in the AEO2016 Reference Case, falling to 1.2 million b/d in 2025. By 2035, the United States is a net exporter of 1.9 million b/d of crude oil and products.

Biofuel production increases to about 1.0 million b/d in 2025 and remains at roughly that level through 2040 in the AEO2016 Reference case. In the BP projection, biofuel production on an energy-equivalent basis increases to 1.2 million b/d in 2025 and 1.4 million b/d in 2035. Biofuels production is not explicitly included in the EVA, ICF, IEA, ExxonMobil, and IHSGI projections.

Table CP6. Comparisons of petroleum and other liquids projections, 2025, 2035, and 2040 (million barrels per day, except where noted) *(continued)*

Projection	2015	AEO2016 Reference	BP	EVA	ICF	IEA	ExxonMobil[a]	IHSGI[b]
		2040						
U.S. refiner imported acquisition cost of crude oil (2015 dollars per barrel)	46.42	125.93	--	--	--	151.57	--	92.53
Brent spot price (2015 dollars per barrel)	52.32	136.21	--	--	--	--	--	--
U.S. WTI crude oil price (2015 dollars per barrel)	48.67	129.11	--	--	--	--	--	95.15
Domestic production	**12.68**	**16.25**	**--**	**--**	**--**	**--**	**18.00**	**--**
Crude oil	9.42	11.26	--	--	--	10.60	--	--
Alaska	0.48	0.15	--	--	--	--	--	--
Natural gas liquids	3.25	4.99	--	--	--	--	--	--
Total net imports	**4.64**	**1.44**	**--**	**--**	**--**	**--**	**--**	**--**
Crude oil	6.88	6.10	--	--	--	--	--	--
Products	-2.24	-4.66	--	--	--	--	--	--
Petroleum and other liquids consumption	19.42	20.14	--	--	--	17.30	18.43	--
Net petroleum import share of liquids supplied (percent)	24.00	7.00	--	--	--	--	--	--
Biofuel production	1.01	1.06	--	--	--	--	--	--

-- = No data reported.
[a]ExxonMobil liquids demand data converted from quadrillion Btu to barrels assuming 187.9 million barrels per quadrillion Btu.
[b]Deflated from nominal dollars using IHS Global Insight deflator.
Note: 2014 dollars per barrel converted to 2015 dollars per barrel using the AEO2016 Reference case GDP Chain-type price deflator.

CP7. Coal

Projections for U.S. coal production, consumption, exports, and prices vary widely in the AEO2016 Reference case and the projections from EVA, Wood Mackenzie (WoodMac), SNL Energy, IEA, and BP (Table CP7). The range of projections implies significant differences in analysts' views on how CO2 emissions and other environmental regulations will be implemented and how U.S. coal mining regions will compete with each other, with alternative energy sources, and with coal from other parts of the world. Most of the projections point to an overall downward trend for total coal consumption and production; however, the size and pace of the expected declines in coal consumption and production, as well as expectations for coal imports, vary even among projections with similar regulatory assumptions.

The projections generally noted the environmental regulations or programs considered; however, the respondents did not provide details for how the environmental regulations and programs were implemented in the projections, such as the assumed start dates for rules currently in litigation. WoodMac incorporated the CPP, Carbon Pollution Standards for new plants, regional carbon programs that constrain CO2 emissions, and rules that limit conventional air emissions. EVA and SNL Energy excluded the CPP but included everything else mentioned above, including CO2 emissions standards for new coal-fired power plants. IEA's Current Policies Scenario took into account only policies formally enacted as of mid-2015, implying that it excludes regulations that would limit coal use the most, such as the CPP [*1*].

Collectively, the projections demonstrate the profound impact of the CPP on coal consumption in the electricity sector. Compared with 2015, coal consumption is projected to decline by 13% in 2025 and 30% in 2035 in the AEO2016 Reference case, as compared with 17% in 2025 and 42% in 2035 in the WoodMac projection [*2*]. BP projects the most significant drop from 2015 levels with

Table CP7. Comparisons of coal projections, 2025, 2035, and 2040 (million short tons, except where noted)

		AEO2016 Reference case		Other projections				
				EVA[a]	Wood Mackenzie[b]	SNL Energy[c]	IEA[d]	BP[e]
Projection	2015	(million short tons)	(quadrillion Btu)	(million short tons)			(quadrillion Btu)	
		2025						
Production	**873**	**766**	**15.35**	**921**	**713**	**857**	**--**	**16.37**
Appalachia	223	165	--	232	104	173	--	--
Interior	165	193	--	200	143	194	--	--
West	484	408	--	489	465	490	--	--
Consumption								
Electric power	739	643	12.12	812	612	742	--	10.90
Coke plants	19	16	0.45	15	--	16	--	--
Coal-to-liquids	--	--	--	--	--	--	--	--
Other industrial/buildings	40	44	1.37[f]	40	--	34	--	--
Total consumption (quadrillion Btu)	**15.48**	**--**	**13.49**	**--**	**--**	**--**	**--**	**12.00**
Total consumption (million short tons)	**801**	**705**	**--**	**867**	**--**	**792**	**--**	**--**
Net coal exports (million short tons)	**63**	**70**	**1.80**	**72**	**103**	**65**	**--**	**4.37[g]**
Exports	75[h]	70	--	82	105	72	--	--
Imports	11	0	--	10	2	7	--	--
Minemouth price								
2015 dollars per ton	33.80	33.99	--	--	--	26.95[i]	--	--
2015 dollars per Btu	1.69	1.71	--	--	--	1.32[i]	--	--
Average delivered price to electricity generators								
2015 dollars per ton	41.62	42.69	--	--	--	40.43[i]	--	--
2015 dollars per Btu	2.19	2.26	--	--	--	1.98[i]	--	--

-- = No data reported.
See notes at end of table.

(continued on page CP-15)

coal consumption falling by 7.4 quadrillion Btu by 2035, compared with a 4.3 quadrillion Btu decline in the AEO2016 Reference case [*3*]. In the EVA projection, consumption declines between 2014 and 2020, recovers in the following five years, and then drops by 12% from 2025–40 [*4*]. Coal consumption for electricity generation in 2025 is slightly higher in the SNL Energy projection and remains nearly constant before 2030 in the IEA Current Policies Scenario. The EVA, SNL Energy, and IEA projections do not include the CPP.

The key difference among the projections for end-use (residential, commercial, industrial, and transportation sectors) coal use is in the other industrial/buildings sector. In the AEO2016 Reference case, the largest share of coal use in the other industrial/buildings sector is in combined heat and power plants and small on-site generating plants. Coal consumption in those applications increases throughout the 2015–40 projection period in the AEO2016 Reference case. Coking plants account for the remaining coal consumption. Only EVA and SNL Energy provide projections for coal consumption at coking plants, and both projections are largely in line with the AEO2016 Reference case, with coal use at coking plants declining steadily throughout the projection. Total end-use coal consumption, including coal use in the other industrial/buildings sector and at coking plants, remains largely constant through 2040 in the AEO2016 Reference case, while all the other projections show steady declines in end-use coal consumption resulting from declines in both the other industrial/building sector and at coking plants. The decline in total domestic coal consumption through 2040 significantly outweighs the impact of any changes in net coal exports, resulting in declines in total coal production in all of the projections. From 2015–35, the reductions in coal production range from 24% (EIA) to 31% (WoodMac), based on tonnage, and from 22% (EIA) to 34% (BP), based on energy content.

Table CP7. Comparisons of coal projections, 2025, 2035, and 2040 (million short tons, except where noted) *(continued)*

Projection	2015	AEO2016 Reference case (million short tons)	AEO2016 Reference case (quadrillion Btu)	Other projections: EVA[a] (million short tons)	Wood Mackenzie[b] (million short tons)	SNL Energy[c] (million short tons)	IEA[d] (quadrillion Btu)	BP[e] (quadrillion Btu)
		2035						
Production	**873**	**661**	**13.44**	**890**	**606**	**--**	**--**	**12.10**
Appalachia	223	154	--	226	83	--	--	--
Interior	165	172	--	195	150	--	--	--
West	484	335	--	469	373	--	--	--
Consumption								
Electric power	739	520	9.82	787	432	--	--	7.65
Coke plants	19	15	0	14	--	--	--	--
Coal-to-liquids	--	--	--	--	--	--	--	--
Other industrial/buildings	40	45	1.38	37	--	--	--	--
Total consumption (quadrillion Btu)	**15.48**	**--**	**11.21**	**--**	**--**	**--**	**--**	**8.60**
Total consumption (million short tons)	**801**	**583**	**--**	**838**	**--**	**--**	**--**	**--**
Net coal exports (million short tons)	**63**	**87**	**2.19**	**69**	**189**	**--**	**--**	**3.50[g]**
Exports	75[h]	87	--	79	191	--	--	--
Imports	11	0	--	10	2	--	--	--
Minemouth price								
2015 dollars per ton	33.80	37.58	--	--	--	--	--	--
2015 dollars per Btu	1.69	1.86	--	--	--	--	--	--
Average delivered price to electricity generators								
2015 dollars per ton	41.62	43.79	--	--	--	--	--	--
2015 dollars per Btu	2.19	2.32	--	--	--	--	--	--

-- = No data reported.
See notes at end of table.

(continued on page CP-16)

Table CP7. Comparisons of coal projections, 2025, 2035, and 2040 (million short tons, except where noted) *(continued)*

		AEO2016 Reference case		Other projections				
				EVA[a]	Wood Mackenzie[b]	SNL Energy[c]	IEA[d]	BP[e]
Projection	2015	(million short tons)	(quadrillion Btu)	(million short tons)			(quadrillion Btu)	
		2040						
Production	**873**	**643**	**13.11**	**814**	**--**	**--**	**--**	**--**
Appalachia	223	144	--	187	--	--	--	--
Interior	165	170	--	182	--	--	--	--
West	484	329	--	445	--	--	--	--
Consumption								
Electric power	739	494	9.36	711	--	--	14.64	--
Coke plants	19	14	0.40	14	--	--	--	--
Coal-to-liquids	--	--	--	--	--	--	--	--
Other industrial/buildings	40	47	1.38f	36	--	--	0.74	--
Total consumption (quadrillion Btu)	**15.48**	**--**	**10.75**	**--**	**--**	**--**	**16.30**	**--**
Total consumption (million short tons)	**801**	**557**	**--**	**761**	**--**	**--**	**--**	**--**
Net coal exports (million short tons)	**63**	**94**	**2.32**	**69**	**--**	**--**	**--**	**--**
Exports	75[h]	94	--	78	--	--	--	--
Imports	11	0	--	9	--	--	--	--
Minemouth price								
2015 dollars per ton	33.80	38.68	--	--	--	--	--	--
2015 dollars per Btu	1.69	1.91	--	--	--	--	--	--
Average delivered price to electricity generators								
2015 dollars per ton	41.62	45.17	--	--	--	--	--	--
2015 dollars per Btu	2.19	2.38	--	--	--	--	--	--

-- = No data reported.

[a]Regulations known to be accounted for in the EVA projections include the Carbon Pollution Standard for new plants, Regional Greenhouse Gas Initiative (RGGI), California carbon tax (California AB32), Cross-State Air Pollution Rule (CSAPR, with allowances reaching zero between the mid- and late 2020s), regulations for cooling water intake structures under Section 316(b) of the Clean Water Act (all plants must achieve compliance by 2018), regulations for coal combustion residuals under authority of the Resource Conservation and Recovery Act (compliance by 2022), Regional Haze Program, and Effluent Limitation Guidelines (compliance by 2022).

[b]Regulations known to be accounted for in the Wood Mackenzie projections include interconnect-level, mass-based CPP with new source complement, Carbon Pollution Standards for new plants, RGGI, California AB32, CSAPR, MATS, regulations for cooling water intake structures under Section 316(b) of the Clean Water Act, and regulations for coal combustion residuals under authority of the Resource Conservation and Recovery Act and the Regional Haze Program.

[c]Regulations known to be accounted for in the SNL Energy projections include RGGI, California AB32, Carbon Pollution Standards for new plants, CSAPR (with Phase I budgets applied through the end of 2016 and Phase II budgets starting in 2017), MATS, California cooling water regulations and ban on once-through cooling, and Regional Haze Program.

[d]International Energy Agency, *World Energy Outlook 2015,* Current Policies Scenario.

[e]BP generally assumes continued evolution of policies and regulations that constrain CO2 emissions and support renewables (the CPP is included in the *BP Energy Outlook,* 2016 edition). Values were converted from million metric tons oil equivalent to quadrillion Btu, using a conversion factor of 39.653 million Btu per metric ton oil equivalent.

[f]Represents coal consumed in both the other industrial/buildings sector and at coke plants, to facilitate comparison of the AEO2016 and IEA projections, because IEA provided projections for total end-use coal consumption with no breakout for coke plants.

[g]Net coal exports in the BP projection are calculated as production minus consumption.

[h]Preliminary estimate. Finalized as 74 million tons in EIA's *Quarterly Coal Report – October-December 2015,* https://www.eia.gov/coal/production/quarterly/pdf/t7p01p1.pdf.

[i]Converted from 2014 dollars to 2015 dollars using an inflator of 1.0322.

There are also differences among the projections of coal production by region, especially for the Appalachian and West regions. All of the projections suggest that Appalachian coal production will be lower in 2040 than in 2015. In the AEO2016 Reference case and WoodMac projections most of the decline occurs before 2030, compared with after 2035 in the EVA projection. The projections also disagree on how much the Appalachian region's production will shrink, with WoodMac projecting a decline to 83 million tons in 2035, compared with 154 million tons in the AEO2016 Reference case. Coal production in the West region declines rapidly in the AEO2016 Reference case, beginning in 2020, and falls to 335 million tons in 2035. In the WoodMac projection, coal production declines rapidly from 2025–2030 before leveling off at about 373 million tons through 2040. EVA projects only moderate declines before 2035, with 2040 production at approximately 445 million tons. Compared with Appalachia and the West, production in the Interior region is relatively flat in all of the projections, ranging from about 150 million tons (WoodMac) to 200 million tons (EVA). Production in the AEO2016 Reference case falls within that range.

Coal exports increase from 75 million tons in 2015 to 94 million tons in 2040 in the AEO2016 Reference case. In comparison, WoodMac projects a more substantial increase in coal exports, to 191 million tons in 2035. EVA projects an increase to 82 million tons in 2025, followed by a decline to 78 million tons in 2040. BP does not project coal exports and imports separately, but the difference between its projections for production and consumption suggests a significant increase in net exports from 2015–25, by 2.1 quadrillion Btu, compared with an increase of 0.1 quadrillion Btu over the same period in the AEO2016 Reference case. Net exports decline in the BP projection by 0.9 quadrillion Btu from 2025–35, as compared with an increase of 0.4 quadrillion Btu from 2025–35 in the AEO2016 Reference case.

All the projections show coal imports declining over time. The largest reduction is in the AEO2016 Reference case, with imports declining from 11 million tons in 2015 to 55,000 tons in 2020 and remaining at that level through 2040. EVA projects that imports will remain at a level of about 10 million tons through 2040, and SNL projects that imports will remain at about 7 million tons from 2020–25. In the WoodMac projection, imports decline to 6 million tons in 2020, then drop to 2 million tons in 2025 and remain at that level through 2040.

The only projection for coal prices that can be compared with the EIA projections is from SNL Energy, which shows coal prices declining from 2015–20 and remaining relatively flat from 2020–25. In the AEO2016 Reference case, both minemouth prices and delivered prices to power plants increase moderately from 2015–40.

Endnotes for comparisons with other projections

Links current as of July 2016

1. International Energy Agency, *World Energy Outlook 2015*, http://www.worldenergyoutlook.org/weo2015/.
2. The ranges of percentages are based on the tonnage of coal.
3. BP, *Energy Outlook 2016*, http://www.bp.com/en/global/corporate/energy-economics/energy-outlook-2035/energy-outlook-downloads.html.
4. All changes over time in this section are calculated based on projections provided to EIA starting 2020 and in 5-year increments. Values for 2020 and 2030 are not shown in Table CP7. When values for 2015 are available in a projection provided to EIA, they are used in calculations for the projection but not shown in Table CP7; when they are not available, EIA data for 2015 are used to calculation changes from 2015.

Table sources for comparisons with other projections

Links current as of July 2016

Table CP1. Comparisons of average annual economic growth projections, 2015–40: AEO2016 (Reference case): AEO2016 National Energy Modeling System, run REF2016.D032416A. **AEO2015 (Reference case):** AEO2015 National Energy Modeling System, run REF2015.D021915A. **IHSGI:** IHS Global Insight, 30-year U.S. Economic Forecast (Lexington, MA: February 2016), http://www.ihs.com/products/global-insight/index.aspx (subscription site). **OMB:** Office of Management and Budget, *Fiscal Year 2017 Budget of the U.S. Government* (Washington, DC: January 2016), http://www.whitehouse.gov/sites/default/files/omb/budget/fy2017/assets/budget.pdf. **CBO:** Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2016 to 2026* (Washington, DC: February 2016), http://www.cbo.gov/publication/51129. **INFORUM:** "INFORUM Spring 2016 Reference Case, Lift (Long-term Interindustry Forecasting Tool) Model" (College Park, MD: February 2016), http://inforumweb.umd.edu/services/models/lift.html. **SSA:** Social Security Administration, *The 2015 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds* (Washington, DC: U.S. Government Printing Office, August 2015), http://www.ssa.gov/oact/tr/2015/2015_Long-Range_Economic_Assumptions.pdf. **IEA (New Policies Scenario):** International Energy Agency, *World Energy Outlook 2015* (Paris, France: November 2015), http://www.worldenergyoutlook.org/weo2015/. **Oxford Economics Group:** Oxford Economics, Ltd., *2016 Long Term Forecast* (Oxford, United Kingdom: February 2016), http://www.OxfordEconomics.com (subscription site). **ExxonMobil:** ExxonMobil Corporation, *The Outlook for Energy: A View to 2040* (Irving, TX: 2016), http://www.exxonmobil.com/Corporate/energy_outlook.aspx. **EVA:** Energy Ventures Analysis, Inc., email from Wes Mitchell (April 12, 2016).

Table CP2. Comparisons of oil price projections, 2025, 2030, 2035, and 2040: AEO2016 (Reference case): AEO2016 National Energy Modeling System, run REF2016.D032416A. **AEO2016 (Low Oil Price case):** AEO2016 National Energy Modeling System, run LOWPRICE.D041916A. **AEO2016 (High Oil Price case):** AEO2016 National Energy Modeling System, run HIGHPRICE.D041916A. **AEO2015 (Reference case):** AEO2015 National Energy Modeling System, run REF2015.D021915A. **Arrowhead:** ArrowHead Economics LLC, email from Dale Nesbitt (March 17, 2016). **SEER:** Strategic Energy & Economic Research, email from Michael Lynch (March 14, 2016). **ESAI:** Energy Security Analysis, Inc., "ESAI Energy 2016 Long Term Crude Price Forecast," email from Sarah Emerson (March 17, 2016). **IHSGI:** IHS Global Insight, 30-year U.S. Economic Forecast (Lexington, MA: February 2016), http://www.ihs.com/products/global-insight/index.aspx (subscription site). **ICF:** ICForecast Natural Gas Strategic Outlook (Fairfax, VA: 1st Quarter 2016), email from Hua Fang (March 28, 2016). **EVA:** Energy Ventures Analysis, Inc., email from Wes Mitchell (April 12, 2016). **IEA (New Policies Scenario):** International Energy Agency, *World Energy Outlook 2015* (Paris, France: November 2015), http://www.worldenergyoutlook.org/weo2015/. **OPEC:** Organization of the Petroleum Exporting Countries, *2015 World Oil Outlook* (Vienna, Austria: October 2015), http://woo.opec.org/images/woo/WOO_2015.pdf.

Table CP3. Comparisons of energy consumption projections by sector, 2015, 2020, 2035, and 2040: AEO2016 (Reference case): AEO2016 National Energy Modeling System, run REF2016.D032416A.AEO2016. **AEO2016 (No CPP case):** AEO2016 National Energy Modeling System, run REF_NO_CPP.D032316A. **ExxonMobil:** ExxonMobil Corporation, *The Outlook for Energy: A View to 2040* (Irving, TX: 2016), http://www.exxonmobil.com/Corporate/energy_outlook.aspx. **BP:** BP p.l.c., *BP Energy Outlook 2035* (London, United Kingdom: February 2015), http://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2015/bp-energy-outlook-2035-booklet.pdf. **IHSGI:** IHS Global Insight, "30-year U.S. Economic Forecast" (Lexington, MA: February 2016), http://www.ihs.com/products/global-insight/index.aspx (subscription site). **IEA:** International Energy Agency, *World Energy Outlook 2015* (Paris, France: November 2015), http://www.worldenergyoutlook.org/weo2015/.

Table CP4. Comparisons of electricity projections, 2025, 2035, and 2040: AEO2016 (Reference case): AEO2016 National Energy Modeling System, run REF2016.D032416A. **AEO2016 (No CPP case):** AEO2016 National Energy Modeling System, run REF_NO_CPP.D032316A. **IEA (New Policies Scenario):** International Energy Agency, *World Energy Outlook 2015* (Paris, France: November 2015), http://www.worldenergyoutlook.org/weo2015/. **NREL (Regional Energy Deployment System model reference case):** T. Mai, W. Cole, E. Lantz, C. Marcy, and B. Sigrin, *Impacts of Federal Tax Credit Extensions on Renewable Deployment and Power Sector Emissions,* NREL/TP-6A20-65571 (Golden, CO: National Renewable Energy Laboratory, February 2016), http://www.nrel.gov/docs/fy16osti/65571.pdf. **EVA:** Energy Ventures Analysis, Inc., email from Wes Mitchell (April 12, 2016).

Table CP5. Comparisons of natural gas projections, 2025, 2035, and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A. **IHSGI:** IHS Global Insight, "30-year U.S. Economic Forecast" (Lexington, MA: February 2016), http://www.ihs.com/products/global-insight/index.aspx (subscription site). **EVA:** Energy Ventures Analysis, Inc., email from Wes Mitchell (April 12, 2016). **ICF:** ICForecast Natural Gas Strategic Outlook (Fairfax, VA: 1st Quarter 2016), email from Hua Fang (March 28, 2016). **ExxonMobil:** ExxonMobil Corporation, *The Outlook for Energy: A View to 2040* (Irving, TX: 2016), http://www.exxonmobil.com/Corporate/energy_outlook.aspx.

Table CP6. Comparisons of petroleum and other liquids projections, 2025, 2035, and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A. **BP:** BP p.l.c., *BP Energy Outlook 2035* (London, United Kingdom: February 2015), http://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2015/bp-energy-outlook-2035-booklet.pdf. **EVA:** Energy Ventures Analysis, Inc., email from Wes Mitchell (April 12, 2016). **ICF:** ICForecast Natural Gas Strategic Outlook (Fairfax, VA: 1st Quarter 2016), email from Hua Fang (March 28, 2016). **IEA (New Policies Scenario):** International Energy Agency, *World Energy Outlook 2015* (Paris, France: November 2015), http://www.worldenergyoutlook.org/weo2015/. **ExxonMobil:** ExxonMobil Corporation, *The Outlook for Energy: A View to 2040* (Irving, TX: 2016), http://www.exxonmobil.com/Corporate/energy_outlook.aspx. **IHSGI:** IHS Global Insight, "30-year U.S. Economic Forecast" (Lexington, MA: February 2016), http://www.ihs.com/products/global-insight/index.aspx (subscription site).

Table CP7. Comparisons of coal projections, 2025, 2035, and 2040: AEO2016 National Energy Modeling System, run REF2016.D032416A. **EVA:** Energy Ventures Analysis, Inc., email from Wes Mitchell (April 12, 2016). **Wood Mackenzie:** Wood Mackenzie, Inc., email from Shane Mathers (April 22, 2016). **SNL Energy:** S&P Global Market Intelligence, email from Steve Piper (March 29, 2016). **IEA (New Policies Scenario):** International Energy Agency, *World Energy Outlook 2015* (Paris, France: November 2015), http://www.worldenergyoutlook.org/weo2015/. **BP:** BP p.l.c., *BP Energy Outlook 2035* (London, United Kingdom: February 2015), http://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2015/bp-energy-outlook-2035-booklet.pdf.

List of acronyms

AB 32	California Assembly Bill 32, the Global Warming Solutions Act of 2006
ACEEE	American Council for an Energy-Efficient Economy
ACP	alternative compliance payment
AEO	Annual Energy Outlook
AEO2016	Annual Energy Outlook 2016
ACU	atmospheric cracking unit
API	American Petroleum Institute
ARRA	American Recovery and Reinvestment Act
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ATPZEV	advanced technology partial zero-emission vehicle
b	barrel
b/d	barrels per day
BAT	best available technology
Bcf	billion cubic feet
Bcf/d	billion cubic feet per day
BF	blast furnace
BOF	basic oxygen furnace
BSER	best system of emission reduction
BTL	biomass-to-liquids
Btu	British thermal unit
Btu/scf	Btu per standard cubic foot
CAA	Clean Air Act
CAFE	Corporate Average Fuel Economy
CAIR	Clean Air Interstate Rule
CARB	California Air Resource Board
CBTL	coal-and-biomass-to-liquids
CCR	Coal Combustion Residual rule
CCS	carbon capture and storage
CHP	combined heat and power
CMM	Coal Market Module
CNG	compressed natural gas
CO2	carbon dioxide
CPP	Clean Power Plan
CSAPR	Cross State Air Pollution Rule
CT	combustion turbine
CTL	coal-to-liquids
CWA	Clean Water Act
DG	distributed generation
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
DRI	direct reduced iron
DSI	dry sorbent injection
DSIRE	Database of State Incentives for Renewables & Efficiency
EAER	equivalent all-electric range
EAF	electric arc furnace
ECAs	U.S. Emission Control Areas
ECP	Electricity Capacity Planning
EE	energy efficiency
EEPS	energy efficiency portfolio standard
EERS	energy efficiency resource standard
EFD	Electricity Fuel Dispatch
EG	Steam Electric Power Generating Effluent Guidelines and Standards
EGUs	electric generating units
EIA	U.S. Energy Information Administration
EIEA2008	Energy Improvement and Extension Act of 2008
EISA	Energy Independence and Security Act of 2007
EMM	Electricity Market Module
EM&V	energy measurement and verification
EPA	U.S. Environmental Protection Agency
EPACT2005	Energy Policy Act of 2005
ERCOT	Electric Reliability Council of Texas
EUR	estimated ultimate recovery
FCC	fluid catalytic cracking
FHWA	Federal Highway Administration
GDP	gross domestic product
GEM	Greenhouse Gas Emissions Model
GHG	greenhouse gas
GTL	gas-to-liquids
GVWR	gross vehicle weight rating
GW	gigawatt
HB2001	West Virginia House Bill 2001
HB40	Vermont House Bill 40
HB623	Hawaii House Bill 623
HD	heavy-duty
HDV	heavy-duty vehicle
HGL	hydrocarbon gas liquids
HVAC	heating, ventilation, and air conditioning
IDM	Industrial Demand Module
IEM	International Energy Module
IMO	International Maritime Organization
IOU	investor-owned utility
ITC	investment tax credit
kWh	kilowatthour
LACE	levelized avoided cost of electricity
LADWP	Los Angeles Department of Water and Power
LCFS	Low Carbon Fuel Standard
LCOE	levelized cost of electricity
LDV	light-duty vehicle
LFG	landfill gas
LFMM	Liquid Fuels Market Module
LIPA	Long Island Power Authority
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MAM	Macroeconomic Activity Module
MARPOL	International Convention for the Prevention of Pollution from Ships

MATS	Mercury Air Toxics Standard
MDV	medium-duty vehicle
MECS	Manufacturing Energy Consumption Survey
MGO	marine gas oil
MMST	million metric short tons
MMT	million metric tons
MOU	memorandum of understanding
mpg	miles per gallon
MSW	municipal solid waste
MT	metric ton
MW	megawatt
MWh	megawatthour
MY	model year
NAICS	North American Industry Classification System
NEEP	Northeast Energy Efficiency Partnerships
NEMS	National Energy Modeling System
NGPL	natural gas plant liquids
NGTDM	Natural Gas Transmission and Distribution Module
NHTSA	U.S. National Highway Traffic Safety Administration
NOx	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NSPS	new source performance standards
NYPA	New York Power Authority
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of the Petroleum Exporting Countries
PADD	Petroleum Administration for Defense District
PM2.5	fine particulate matter
POU	publicly owned utility
PRB	Wyoming Powder River Basin
PTC	production tax credit
PUC	public utility commission
PV	solar photovoltaic
PZEV	partial zero-emission vehicle
RECs	Renewable Energy Certificates
RFM	Renewable Fuels Module
RFS	Renewable Fuels Standard
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standards
SB91	Kansas Senate Bill 91
SB310	Ohio Senate Bill 310
SB350	California Senate Bill 350
SEU	Sustainable Energy Utility
SOx	sulfur oxide
SO2	sulfur dioxide
SPR	Strategic Petroleum Reserve
SPR	Stream Protection Rule
STEO	Short-Term Energy Outlook
Tcf	trillion cubic feet
TZEV	transitional zero-emission vehicle
VIUS	Vehicle Inventory and Use Survey
VMT	vehicle miles traveled
WTI	West Texas Intermediate
ZEV	zero-emission vehicle

Table A1. Total energy supply, disposition, and price summary
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Production								
Crude oil and lease condensate	18.4	19.7	19.6	19.7	21.0	22.3	23.5	0.7%
Natural gas plant liquids	4.1	4.4	6.1	6.4	6.5	6.6	6.7	1.6%
Dry natural gas	26.5	28.0	31.4	35.9	38.9	41.2	43.4	1.8%
Coal[1]	20.6	17.2	17.5	15.4	13.3	13.4	13.1	-1.1%
Nuclear / uranium[2]	8.3	8.3	8.1	8.2	8.2	8.2	8.2	0.0%
Conventional hydroelectric power	2.5	2.3	2.8	2.8	2.8	2.8	2.8	0.8%
Biomass[3]	4.4	4.1	4.2	4.3	4.4	4.4	4.6	0.4%
Other renewable energy[4]	2.5	2.6	4.6	6.1	6.6	7.8	8.8	5.0%
Other[5]	1.0	0.5	0.9	1.0	0.9	0.9	1.0	2.8%
Total	**88.4**	**87.3**	**95.4**	**99.8**	**102.7**	**107.7**	**112.2**	**1.0%**
Imports								
Crude oil	16.3	16.1	16.8	16.8	16.0	15.8	15.9	-0.1%
Petroleum and other liquids[6]	3.9	3.9	4.5	4.5	4.3	4.2	4.3	0.4%
Natural gas[7]	2.8	2.8	2.1	1.8	1.6	1.4	1.4	-2.6%
Other imports[8]	0.4	0.4	0.2	0.2	0.2	0.2	0.2	-3.9%
Total	**23.3**	**23.2**	**23.6**	**23.2**	**22.0**	**21.5**	**21.8**	**-0.3%**
Exports								
Petroleum and other liquids[9]	8.2	9.0	11.6	12.5	13.5	14.4	15.2	2.1%
Natural gas[10]	1.5	1.8	5.0	7.1	7.6	8.6	9.0	6.7%
Coal	2.5	2.0	1.9	1.8	1.9	2.2	2.3	0.7%
Total	**12.2**	**12.8**	**18.5**	**21.4**	**23.0**	**25.2**	**26.6**	**3.0%**
Discrepancy[11]	**1.4**	**1.0**	**0.0**	**0.1**	**0.1**	**0.2**	**0.3**	**- -**
Consumption								
Petroleum and other liquids[12]	36.0	36.5	37.8	37.3	36.6	36.8	37.5	0.1%
Natural gas	27.5	28.3	28.3	30.2	32.5	33.5	35.4	0.9%
Coal[13]	17.9	15.5	15.6	13.5	11.3	11.2	10.7	-1.4%
Nuclear / uranium[2]	8.3	8.3	8.1	8.2	8.2	8.2	8.2	0.0%
Conventional hydroelectric power	2.5	2.3	2.8	2.8	2.8	2.8	2.8	0.8%
Biomass[14]	3.0	2.8	2.8	2.9	3.0	3.0	3.1	0.5%
Other renewable energy[4]	2.5	2.6	4.6	6.1	6.6	7.8	8.8	5.0%
Other[15]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.1%
Total	**98.1**	**96.7**	**100.5**	**101.6**	**101.5**	**103.9**	**107.1**	**0.4%**
Prices (2015 dollars per unit)								
Crude oil spot prices (dollars per barrel)								
Brent	100	52	77	92	104	120	136	3.9%
West Texas Intermediate	94	49	71	85	97	112	129	4.0%
Natural gas at Henry Hub (dollars per million Btu)	4.44	2.62	4.43	5.12	5.06	4.91	4.86	2.5%
Coal (dollars per ton)								
at the minemouth[16]	35.2	33.8	33.6	34.0	33.8	37.6	38.7	0.5%
Coal (dollars per million Btu)								
at the minemouth[16]	1.73	1.69	1.68	1.71	1.71	1.86	1.91	0.5%
Average end-use[17]	2.52	2.37	2.43	2.49	2.55	2.61	2.68	0.5%
Average electricity (cents per kilowatthour)	10.5	10.3	10.5	10.7	10.9	10.6	10.5	0.1%

Table A1. Total energy supply, disposition, and price summary *(continued)*

(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Prices (nominal dollars per unit)								
Crude oil spot prices (dollars per barrel)								
Brent	99	52	85	112	141	181	229	6.1%
West Texas Intermediate	93	49	79	105	131	170	217	6.2%
Natural gas at Henry Hub (dollars per million Btu)	4.39	2.62	4.90	6.27	6.84	7.42	8.17	4.7%
Coal (dollars per ton)								
at the minemouth[16]	34.9	33.8	37.1	41.6	45.8	56.8	65.1	2.7%
Coal (dollars per million Btu)								
at the minemouth[16]	1.71	1.69	1.86	2.09	2.31	2.81	3.21	2.6%
Average end-use[17]	2.49	2.37	2.69	3.05	3.45	3.94	4.50	2.6%
Average electricity (cents per kilowatthour)	10.4	10.3	11.6	13.1	14.7	16.1	17.6	2.2%

[1]Includes waste coal.
[2]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[3]Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table A17 for details.
[4]Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table A17 for selected nonmarketed residential and commercial renewable energy data.
[5]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.
[6]Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.
[7]Includes imports of liquefied natural gas that are later re-exported.
[8]Includes coal, coal coke (net), and electricity (net). Excludes imports of fuel used in nuclear power plants.
[9]Includes crude oil, petroleum products, ethanol, and biodiesel.
[10]Includes re-exported liquefied natural gas.
[11]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[12]Estimated consumption. Includes petroleum-derived fuels and non-petroleum derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel. Refer to Table A17 for detailed renewable liquid fuels consumption.
[13]Excludes coal converted to coal-based synthetic liquids and natural gas.
[14]Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.
[15]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[16]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[17]Prices weighted by consumption; weighted average excludes export free-alongside-ship (f.a.s.) prices.
Btu = British thermal unit.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 natural gas supply values: EIA, *Natural Gas Monthly*, July 2015. 2014 coal minemouth and delivered coal prices: EIA, *Annual Coal Report 2013*. 2014 petroleum supply values: EIA, *Petroleum Supply Annual 2014*. 2014 crude oil spot prices and natural gas spot price at Henry Hub: Thomson Reuters. Other 2014 coal values: *Quarterly Coal Report, October-December 2014*. Other 2014: EIA, *Monthly Energy Review*, February 2016. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A2. Energy consumption by sector and source
(quadrillion Btu per year, unless otherwise noted)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Energy consumption								
Residential								
Propane	0.50	0.43	0.42	0.40	0.38	0.36	0.34	-0.9%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-2.6%
Distillate fuel oil	0.55	0.50	0.43	0.38	0.34	0.30	0.27	-2.4%
Petroleum and other liquids subtotal	1.05	0.93	0.86	0.78	0.72	0.66	0.61	-1.7%
Natural gas	5.25	4.77	4.87	4.82	4.80	4.77	4.73	0.0%
Renewable energy[1]	0.59	0.44	0.42	0.41	0.39	0.38	0.37	-0.7%
Electricity	4.80	4.78	4.76	4.75	4.83	4.97	5.20	0.3%
Delivered energy	**11.70**	**10.92**	**10.90**	**10.77**	**10.74**	**10.78**	**10.91**	**0.0%**
Electricity related losses	9.72	9.44	9.37	9.03	8.77	8.93	9.15	-0.1%
Total	**21.42**	**20.37**	**20.27**	**19.79**	**19.50**	**19.71**	**20.05**	**-0.1%**
Commercial								
Propane	0.15	0.17	0.18	0.19	0.19	0.20	0.20	0.7%
Motor gasoline[2]	0.04	0.04	0.06	0.06	0.06	0.07	0.07	2.1%
Kerosene	0.00	0.00	0.00	0.00	0.01	0.01	0.01	5.0%
Distillate fuel oil	0.36	0.37	0.36	0.34	0.32	0.30	0.29	-1.0%
Residual fuel oil	0.02	0.07	0.11	0.10	0.10	0.10	0.10	1.2%
Petroleum and other liquids subtotal	0.57	0.66	0.70	0.69	0.68	0.67	0.67	0.1%
Natural gas	3.58	3.32	3.45	3.46	3.53	3.66	3.81	0.5%
Coal	0.05	0.06	0.05	0.05	0.05	0.05	0.05	-0.4%
Renewable energy[3]	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.0%
Electricity	4.61	4.64	4.69	4.86	5.09	5.33	5.62	0.8%
Delivered energy	**8.95**	**8.81**	**9.03**	**9.20**	**9.49**	**9.86**	**10.28**	**0.6%**
Electricity related losses	9.34	9.16	9.23	9.23	9.23	9.57	9.89	0.3%
Total	**18.29**	**17.97**	**18.26**	**18.43**	**18.72**	**19.43**	**20.17**	**0.5%**
Industrial[4]								
Liquefied petroleum gases and other[5]	2.44	2.38	3.10	3.50	3.66	3.92	4.22	2.3%
Motor gasoline[2]	0.27	0.27	0.28	0.27	0.27	0.27	0.27	0.0%
Distillate fuel oil	1.36	1.34	1.44	1.45	1.44	1.45	1.47	0.4%
Residual fuel oil	0.03	0.04	0.04	0.06	0.06	0.05	0.05	1.6%
Petrochemical feedstocks	0.70	0.66	0.96	1.21	1.31	1.47	1.66	3.8%
Other petroleum[6]	3.19	3.38	3.59	3.71	3.82	3.95	4.15	0.8%
Petroleum and other liquids subtotal	7.99	8.07	9.40	10.19	10.55	11.13	11.82	1.5%
Natural gas	7.84	7.75	8.55	8.93	9.13	9.49	9.89	1.0%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[7]	1.55	1.63	1.76	1.94	2.06	2.19	2.31	1.4%
Natural gas liquefaction for export[8]	0.00	0.00	0.26	0.48	0.53	0.64	0.69	- -
Natural gas subtotal	9.40	9.38	10.57	11.34	11.72	12.32	12.89	1.3%
Metallurgical coal	0.58	0.54	0.41	0.45	0.47	0.43	0.40	-1.2%
Other industrial coal	0.87	0.82	0.82	0.86	0.88	0.89	0.93	0.5%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Net coal coke imports	-0.02	-0.02	-0.01	0.00	0.00	0.01	0.01	- -
Coal subtotal	1.43	1.34	1.23	1.31	1.35	1.33	1.34	0.0%
Biofuels heat and coproducts	0.75	0.78	0.83	0.80	0.81	0.81	0.84	0.3%
Renewable energy[9]	1.52	1.48	1.48	1.59	1.67	1.70	1.79	0.8%
Electricity	3.40	3.27	3.61	3.91	3.98	4.08	4.26	1.1%
Delivered energy	**24.49**	**24.33**	**27.11**	**29.14**	**30.07**	**31.38**	**32.94**	**1.2%**
Electricity related losses	6.89	6.46	7.11	7.42	7.22	7.34	7.50	0.6%
Total	**31.38**	**30.79**	**34.22**	**36.56**	**37.29**	**38.72**	**40.44**	**1.1%**

Table A2. Energy consumption by sector and source *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Transportation								
Propane	0.01	0.01	0.01	0.01	0.01	0.01	0.02	3.3%
Motor gasoline[2]	16.78	17.01	16.79	15.05	13.62	12.84	12.55	-1.2%
of which: E85[10]	0.03	0.05	0.04	0.12	0.22	0.27	0.28	7.3%
Jet fuel[11]	2.82	2.84	2.99	3.14	3.32	3.46	3.56	0.9%
Distillate fuel oil[12]	6.40	6.67	6.99	7.28	7.49	7.77	8.01	0.7%
Residual fuel oil	0.44	0.45	0.37	0.40	0.42	0.44	0.45	0.1%
Other petroleum[13]	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.1%
Petroleum and other liquids subtotal	26.61	27.14	27.32	26.04	25.01	24.68	24.75	-0.4%
Pipeline fuel natural gas	0.87	0.89	0.83	0.89	0.94	1.00	1.07	0.7%
Compressed / liquefied natural gas	0.06	0.07	0.08	0.10	0.17	0.31	0.59	9.2%
Liquid hydrogen	0.00	0.00	0.01	0.03	0.04	0.05	0.06	22.9%
Electricity	0.03	0.03	0.05	0.08	0.11	0.14	0.15	6.7%
Delivered energy	**27.56**	**28.13**	**28.29**	**27.13**	**26.28**	**26.18**	**26.63**	**-0.2%**
Electricity related losses	0.05	0.06	0.09	0.15	0.20	0.24	0.27	6.2%
Total	**27.61**	**28.19**	**28.38**	**27.28**	**26.48**	**26.42**	**26.90**	**-0.2%**
Unspecified sector[14]	**-0.57**	**-0.58**	**-0.58**	**-0.52**	**-0.46**	**-0.43**	**-0.42**	**-1.3%**
Delivered energy consumption for all sectors								
Liquefied petroleum gases and other[5]	3.09	2.99	3.71	4.09	4.24	4.49	4.79	1.9%
Motor gasoline[2]	16.51	16.96	16.55	14.87	13.49	12.74	12.47	-1.2%
of which: E85[10]	0.03	0.05	0.04	0.12	0.22	0.27	0.28	7.3%
Jet fuel[11]	3.04	3.18	3.22	3.38	3.58	3.72	3.83	0.7%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.3%
Distillate fuel oil	8.45	8.33	8.98	9.19	9.33	9.56	9.77	0.6%
Residual fuel oil	0.50	0.56	0.52	0.56	0.57	0.59	0.60	0.3%
Petrochemical feedstocks	0.70	0.66	0.96	1.21	1.31	1.47	1.66	3.8%
Other petroleum[15]	3.35	3.54	3.75	3.87	3.98	4.12	4.31	0.8%
Petroleum and other liquids subtotal	35.65	36.23	37.70	37.18	36.51	36.71	37.44	0.1%
Natural gas	16.73	15.90	16.95	17.31	17.63	18.23	19.02	0.7%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[7]	1.55	1.63	1.76	1.94	2.06	2.19	2.31	1.4%
Natural gas liquefaction for export[8]	0.00	0.00	0.26	0.48	0.53	0.64	0.69	- -
Pipeline fuel natural gas	0.87	0.89	0.83	0.89	0.94	1.00	1.07	0.7%
Natural gas subtotal	19.15	18.43	19.80	20.61	21.16	22.06	23.09	0.9%
Metallurgical coal	0.58	0.54	0.41	0.45	0.47	0.43	0.40	-1.2%
Other coal	0.92	0.88	0.88	0.92	0.93	0.95	0.98	0.5%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Net coal coke imports	-0.02	-0.02	-0.01	0.00	0.00	0.01	0.01	- -
Coal subtotal	1.48	1.40	1.28	1.36	1.40	1.39	1.39	0.0%
Biofuels heat and coproducts	0.75	0.78	0.83	0.80	0.81	0.81	0.84	0.3%
Renewable energy[16]	2.24	2.06	2.03	2.13	2.19	2.22	2.29	0.4%
Liquid hydrogen	0.00	0.00	0.01	0.03	0.04	0.05	0.06	22.9%
Electricity	12.84	12.72	13.11	13.60	14.01	14.52	15.23	0.7%
Delivered energy	**72.12**	**71.62**	**74.75**	**75.73**	**76.12**	**77.77**	**80.34**	**0.5%**
Electricity related losses	26.01	25.12	25.80	25.83	25.41	26.09	26.81	0.3%
Total	**98.13**	**96.74**	**100.55**	**101.56**	**101.54**	**103.85**	**107.15**	**0.4%**
Electric power[17]								
Distillate fuel oil	0.09	0.09	0.09	0.08	0.06	0.06	0.05	-2.0%
Residual fuel oil	0.22	0.17	0.06	0.05	0.04	0.04	0.03	-6.6%
Petroleum and other liquids subtotal	0.31	0.26	0.15	0.13	0.11	0.10	0.09	-4.4%
Natural gas	8.38	9.89	8.50	9.60	11.34	11.46	12.31	0.9%
Steam coal	16.42	14.08	14.34	12.12	9.92	9.82	9.36	-1.6%
Nuclear / uranium[18]	8.33	8.34	8.12	8.25	8.25	8.25	8.25	0.0%
Renewable energy[19]	5.01	4.86	7.37	8.91	9.41	10.60	11.67	3.6%
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.0%
Electricity imports	0.18	0.19	0.19	0.20	0.17	0.16	0.15	-1.1%
Total	**38.86**	**37.85**	**38.90**	**39.43**	**39.42**	**40.61**	**42.04**	**0.4%**

Table A2. Energy consumption by sector and source *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Total energy consumption								
Liquefied petroleum gases and other[5]	3.09	2.99	3.71	4.09	4.24	4.49	4.79	1.9%
Motor gasoline[2]	16.51	16.96	16.55	14.87	13.49	12.74	12.47	-1.2%
of which: E85[10]	0.03	0.05	0.04	0.12	0.22	0.27	0.28	7.3%
Jet fuel[11]	3.04	3.18	3.22	3.38	3.58	3.72	3.83	0.7%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.3%
Distillate fuel oil	8.54	8.42	9.07	9.27	9.40	9.62	9.82	0.6%
Residual fuel oil	0.72	0.73	0.58	0.61	0.62	0.63	0.64	-0.5%
Petrochemical feedstocks	0.70	0.66	0.96	1.21	1.31	1.47	1.66	3.8%
Other petroleum[15]	3.35	3.54	3.75	3.87	3.98	4.12	4.31	0.8%
Petroleum and other liquids subtotal	35.96	36.49	37.85	37.31	36.62	36.81	37.52	0.1%
Natural gas	25.11	25.79	25.45	26.91	28.97	29.69	31.33	0.8%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[7]	1.55	1.63	1.76	1.94	2.06	2.19	2.31	1.4%
Natural gas liquefaction for export[8]	0.00	0.00	0.26	0.48	0.53	0.64	0.69	- -
Pipeline fuel natural gas	0.87	0.89	0.83	0.89	0.94	1.00	1.07	0.7%
Natural gas subtotal	27.53	28.31	28.30	30.22	32.51	33.52	35.39	0.9%
Metallurgical coal	0.58	0.54	0.41	0.45	0.47	0.43	0.40	-1.2%
Other coal	17.34	14.96	15.22	13.04	10.86	10.77	10.34	-1.5%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Net coal coke imports	-0.02	-0.02	-0.01	0.00	0.00	0.01	0.01	- -
Coal subtotal	17.90	15.48	15.62	13.49	11.32	11.21	10.75	-1.4%
Nuclear / uranium[18]	8.33	8.34	8.12	8.25	8.25	8.25	8.25	0.0%
Biofuels heat and coproducts	0.75	0.78	0.83	0.80	0.81	0.81	0.84	0.3%
Renewable energy[20]	7.26	6.92	9.40	11.04	11.60	12.82	13.96	2.8%
Liquid hydrogen	0.00	0.00	0.01	0.03	0.04	0.05	0.06	22.9%
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.0%
Electricity imports	0.18	0.19	0.19	0.20	0.17	0.16	0.15	-1.1%
Total	**98.13**	**96.74**	**100.55**	**101.56**	**101.54**	**103.85**	**107.15**	**0.4%**
Energy use and related statistics								
Delivered energy use	72.12	71.62	74.75	75.73	76.12	77.77	80.34	0.5%
Total energy use	98.13	96.74	100.55	101.56	101.54	103.85	107.15	0.4%
Ethanol consumed in motor gasoline and E85	1.14	1.18	1.19	1.13	1.12	1.14	1.24	0.2%
Population (millions)	319	322	335	348	360	371	381	0.7%
Gross domestic product (billion 2009 dollars)	15,962	16,349	18,555	20,765	23,113	25,598	28,397	2.2%
Carbon dioxide emissions (million metric tons)	5,406	5,273	5,289	5,115	4,961	4,980	5,044	-0.2%

[1]Includes wood used for residential heating. See Table A4 and/or Table A17 for estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal water heating, and electricity generation from wind and solar photovoltaic sources.
[2]Includes ethanol and ethers blended into gasoline.
[3]Excludes ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. See Table A5 and/or Table A17 for estimates of nonmarketed renewable energy consumption for solar thermal water heating and electricity generation from wind and solar photovoltaic sources.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[5]Includes ethane, natural gasoline, and refinery olefins.
[6]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Represents natural gas used in well, field, and lease operations, and in natural gas processing plant machinery.
[8]Fuel used in facilities that liquefy natural gas for export.
[9]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Diesel fuel for on- and off- road use.
[13]Includes aviation gasoline and lubricants.
[14]Represents consumption unattributed to the sectors above.
[15]Includes aviation gasoline, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[16]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[17]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[18]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[19]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[20]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
Btu = British thermal unit.
- - = Not applicable.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 consumption, carbon dioxide emissions, and emission factors based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. 2014 population and gross domestic product: IHS Economics, Industry and Employment models, November 2015. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A3. Energy prices by sector and source

(2015 dollars per million Btu, unless otherwise noted)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Residential								
Propane	23.3	16.9	20.2	21.4	22.4	24.0	25.6	1.7%
Distillate fuel oil	26.9	19.3	22.4	25.5	27.8	30.8	33.8	2.3%
Natural gas	10.7	10.1	10.7	11.6	12.0	12.1	12.3	0.8%
Electricity	37.1	36.3	37.7	38.8	39.4	38.7	38.1	0.2%
Commercial								
Propane	20.6	15.1	17.9	18.9	19.8	21.2	22.5	1.6%
Distillate fuel oil	26.4	17.0	19.7	22.2	24.4	27.4	30.5	2.4%
Residual fuel oil	16.7	6.9	11.0	13.5	15.3	17.6	19.9	4.3%
Natural gas	9.0	7.7	9.3	10.1	10.4	10.3	10.4	1.2%
Electricity	31.8	30.6	31.5	32.0	32.3	31.4	30.7	0.0%
Industrial[1]								
Propane	18.8	12.2	15.6	16.8	17.8	19.5	21.1	2.2%
Distillate fuel oil	27.1	17.0	19.7	22.2	24.4	27.4	30.5	2.4%
Residual fuel oil	15.0	6.8	11.3	14.2	15.9	18.2	20.6	4.6%
Natural gas[2]	5.4	3.7	5.4	6.0	6.0	5.8	5.7	1.7%
Metallurgical coal	5.3	5.4	6.0	6.5	7.0	7.2	7.3	1.2%
Other industrial coal	3.2	3.4	3.4	3.4	3.4	3.5	3.6	0.2%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	21.0	20.3	20.9	21.5	22.1	21.5	21.2	0.2%
Transportation								
Propane	24.4	18.0	21.2	22.4	23.4	25.0	26.6	1.6%
E85[3]	33.3	23.3	32.0	31.2	30.8	32.3	35.0	1.6%
Motor gasoline[4]	28.4	20.9	22.7	24.7	26.5	28.9	31.8	1.7%
Jet fuel[5]	20.8	12.0	16.2	19.0	21.3	24.5	27.7	3.4%
Diesel fuel (distillate fuel oil)[6]	27.8	19.8	23.1	25.8	28.0	31.0	34.1	2.2%
Residual fuel oil	14.6	8.1	11.7	13.4	15.0	17.0	19.2	3.5%
Natural gas[7]	18.4	16.6	16.6	16.4	15.5	15.4	15.9	-0.2%
Electricity	32.2	29.5	33.0	36.0	37.4	36.4	35.5	0.7%
Electric power[8]								
Distillate fuel oil	23.8	15.0	18.4	21.2	23.5	26.4	29.4	2.7%
Residual fuel oil	18.3	10.2	13.8	16.3	18.1	20.2	22.4	3.2%
Natural gas	5.1	3.3	4.7	5.4	5.6	5.4	5.4	2.0%
Steam coal	2.4	2.2	2.3	2.3	2.3	2.3	2.4	0.3%
Average price to all users[9]								
Propane	21.2	14.9	18.0	19.2	20.1	21.6	23.2	1.8%
E85[3]	33.3	23.3	32.0	31.2	30.8	32.3	35.0	1.6%
Motor gasoline[4]	28.4	20.9	22.7	24.7	26.5	28.9	31.8	1.7%
Jet fuel[5]	20.8	12.0	16.2	19.0	21.3	24.5	27.7	3.4%
Distillate fuel oil	27.5	19.1	22.3	25.1	27.3	30.3	33.3	2.2%
Residual fuel oil	15.8	8.4	11.7	13.8	15.4	17.4	19.6	3.4%
Natural gas	6.9	5.3	6.7	7.4	7.4	7.3	7.4	1.4%
Metallurgical coal	5.3	5.4	6.0	6.5	7.0	7.2	7.3	1.2%
Other coal	2.4	2.3	2.3	2.4	2.4	2.4	2.5	0.4%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	30.9	30.1	30.8	31.4	31.9	31.2	30.6	0.1%
Non-renewable energy expenditures by sector (billion 2015 dollars)								
Residential	261	239	250	259	266	268	274	0.6%
Commercial	193	178	193	205	216	221	230	1.0%
Industrial[1]	231	168	232	276	301	330	369	3.2%
Transportation	707	514	586	615	640	698	777	1.7%
Total non-renewable expenditures	1,391	1,099	1,260	1,355	1,423	1,517	1,650	1.6%
Transportation renewable expenditures	1	1	1	4	7	9	10	9.1%
Total expenditures	**1,393**	**1,100**	**1,262**	**1,359**	**1,430**	**1,526**	**1,660**	**1.7%**

Table A3. Energy prices by sector and source *(continued)*
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Residential								
Propane	23.1	16.9	22.3	26.2	30.3	36.2	43.0	3.8%
Distillate fuel oil	26.7	19.3	24.7	31.2	37.6	46.5	56.9	4.4%
Natural gas	10.6	10.1	11.9	14.2	16.3	18.3	20.8	2.9%
Electricity	36.7	36.3	41.7	47.5	53.3	58.4	64.2	2.3%
Commercial								
Propane	20.4	15.1	19.8	23.2	26.8	31.9	37.9	3.8%
Distillate fuel oil	26.1	17.0	21.8	27.2	33.1	41.4	51.2	4.5%
Residual fuel oil	16.5	6.9	12.1	16.5	20.7	26.5	33.6	6.5%
Natural gas	8.9	7.7	10.3	12.3	14.1	15.6	17.5	3.4%
Electricity	31.5	30.6	34.8	39.2	43.7	47.4	51.7	2.1%
Industrial[1]								
Propane	18.7	12.2	17.2	20.6	24.1	29.4	35.6	4.4%
Distillate fuel oil	26.8	17.0	21.8	27.2	33.1	41.4	51.3	4.5%
Residual fuel oil	14.8	6.8	12.4	17.4	21.6	27.5	34.7	6.8%
Natural gas[2]	5.3	3.7	5.9	7.3	8.1	8.7	9.6	3.9%
Metallurgical coal	5.3	5.4	6.7	8.0	9.4	10.9	12.2	3.3%
Other industrial coal	3.2	3.4	3.7	4.2	4.6	5.2	6.0	2.4%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	20.8	20.3	23.1	26.3	29.9	32.5	35.7	2.3%
Transportation								
Propane	24.1	18.0	23.4	27.5	31.7	37.8	44.8	3.7%
E85[3]	32.9	23.3	35.4	38.2	41.7	48.8	58.8	3.8%
Motor gasoline[4]	28.1	20.9	25.1	30.2	35.9	43.7	53.6	3.8%
Jet fuel[5]	20.6	12.0	17.9	23.2	28.8	37.0	46.6	5.6%
Diesel fuel (distillate fuel oil)[6]	27.5	19.8	25.5	31.6	37.9	46.7	57.3	4.3%
Residual fuel oil	14.5	8.1	12.9	16.5	20.3	25.7	32.3	5.7%
Natural gas[7]	18.2	16.6	18.4	20.0	21.0	23.2	26.7	1.9%
Electricity	31.8	29.5	36.5	44.1	50.5	55.0	59.8	2.9%
Electric power[8]								
Distillate fuel oil	23.5	15.0	20.4	26.0	31.8	39.9	49.4	4.9%
Residual fuel oil	18.1	10.2	15.2	19.9	24.4	30.5	37.8	5.4%
Natural gas	5.0	3.3	5.2	6.6	7.5	8.1	9.0	4.2%
Steam coal	2.4	2.2	2.5	2.8	3.1	3.5	4.0	2.5%

Table A3. Energy prices by sector and source *(continued)*
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Average price to all users[9]								
Propane	21.0	14.9	19.9	23.5	27.2	32.6	39.0	3.9%
E85[3]	32.9	23.3	35.4	38.2	41.7	48.8	58.8	3.8%
Motor gasoline[4]	28.1	20.9	25.1	30.2	35.9	43.7	53.6	3.8%
Jet fuel[5]	20.6	12.0	17.9	23.2	28.8	37.0	46.6	5.6%
Distillate fuel oil	27.2	19.1	24.7	30.7	36.9	45.7	56.1	4.4%
Residual fuel oil	15.7	8.4	13.0	16.8	20.8	26.2	32.9	5.6%
Natural gas	6.9	5.3	7.4	9.0	10.0	11.1	12.4	3.5%
Metallurgical coal	5.3	5.4	6.7	8.0	9.4	10.9	12.2	3.3%
Other coal	2.4	2.3	2.6	2.9	3.2	3.7	4.2	2.5%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	30.6	30.1	34.1	38.4	43.1	47.0	51.6	2.2%
Non-renewable energy expenditures by sector (billion nominal dollars)								
Residential	258	239	276	317	360	405	462	2.7%
Commercial	191	178	213	251	292	334	387	3.2%
Industrial[1]	229	168	256	338	407	498	620	5.4%
Transportation	699	514	647	753	866	1,054	1,307	3.8%
Total non-renewable expenditures	1,377	1,099	1,392	1,659	1,925	2,291	2,776	3.8%
Transportation renewable expenditures	1	1	1	5	9	13	17	11.4%
Total expenditures	**1,378**	**1,100**	**1,394**	**1,663**	**1,934**	**2,304**	**2,793**	**3.8%**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Excludes use for lease and plant fuel.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Kerosene-type jet fuel. Includes Federal and State taxes while excluding county and local taxes.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Natural gas used as fuel in motor vehicles, trains, and ships. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[8]Includes electricity-only and combined heat and power plants that have a regulatory status.
[9]Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
- - = Not applicable.
Note: Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 prices for motor gasoline, distillate fuel oil, and jet fuel are based on prices in the U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, January 2105-December 2015. 2014 residential, commercial, and industrial natural gas delivered prices: EIA, *Natural Gas Monthly*, July 2015. 2015 transportation sector natural gas delivered prices derived from: U.S. Department of Energy, Clean Cities Alternative Fuel Price Report. 2014 electric power sector distillate and residual fuel oil prices: EIA, *Monthly Energy Review*, February 2016. 2014 electric power sector natural gas prices: EIA, *Electric Power Monthly*, April 2014 and April 2015, Table 4.2, and EIA, *State Energy Data Report 2013*. 2014 coal prices based on: EIA, *Quarterly Coal Report, October-December 2014* and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. 2014 electricity prices: EIA, *Monthly Energy Review*, February 2016. 2014 E85 prices derived from: U.S. Department of Energy, Clean Cities Alternative Fuel Price Report. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A4. Residential sector key indicators and consumption
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Key indicators								
Households (millions)								
Single-family	80.1	80.6	84.4	88.5	92.2	95.5	99.0	0.8%
Multifamily	28.6	28.9	30.5	32.3	34.0	35.8	37.5	1.1%
Mobile homes	6.1	6.0	5.5	5.3	5.1	4.9	4.8	-0.9%
Total	**114.8**	**115.4**	**120.4**	**126.0**	**131.3**	**136.3**	**141.4**	**0.8%**
Average house square footage	**1,686**	**1,694**	**1,733**	**1,768**	**1,799**	**1,828**	**1,857**	**0.4%**
Energy intensity								
(million Btu per household)								
Delivered energy consumption	101.9	94.6	90.5	85.4	81.8	79.1	77.1	-0.8%
Total energy consumption	186.6	176.5	168.3	157.1	148.5	144.6	141.8	-0.9%
(thousand Btu per square foot)								
Delivered energy consumption	60.4	55.9	52.3	48.3	45.5	43.2	41.6	-1.2%
Total energy consumption	110.7	104.2	97.1	88.9	82.6	79.1	76.4	-1.2%
Delivered energy consumption by fuel								
Purchased electricity								
Space heating	0.43	0.33	0.36	0.35	0.34	0.34	0.33	0.0%
Space cooling	0.65	0.80	0.74	0.75	0.79	0.84	0.89	0.4%
Water heating	0.45	0.45	0.46	0.47	0.47	0.48	0.48	0.2%
Refrigeration	0.36	0.36	0.34	0.33	0.33	0.34	0.36	0.0%
Cooking	0.11	0.11	0.11	0.12	0.13	0.14	0.14	1.1%
Clothes dryers	0.20	0.21	0.21	0.22	0.23	0.24	0.26	0.9%
Freezers	0.08	0.08	0.07	0.07	0.07	0.06	0.06	-0.7%
Lighting	0.51	0.50	0.43	0.37	0.30	0.25	0.23	-3.0%
Clothes washers[1]	0.03	0.03	0.02	0.02	0.02	0.02	0.02	-2.0%
Dishwashers[1]	0.09	0.09	0.10	0.10	0.11	0.12	0.13	1.2%
Televisions and related equipment[2]	0.30	0.29	0.26	0.25	0.26	0.29	0.32	0.4%
Computers and related equipment[3]	0.11	0.11	0.09	0.08	0.07	0.06	0.05	-3.0%
Furnace fans and boiler circulation pumps	0.14	0.11	0.12	0.12	0.11	0.11	0.10	-0.5%
Other uses[4]	1.34	1.32	1.43	1.50	1.60	1.70	1.82	1.3%
Delivered energy	**4.80**	**4.78**	**4.76**	**4.75**	**4.83**	**4.97**	**5.20**	**0.3%**
Natural gas								
Space heating	3.52	3.03	3.11	3.04	3.01	2.98	2.95	-0.1%
Space cooling	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.9%
Water heating	1.21	1.21	1.23	1.25	1.27	1.27	1.25	0.1%
Cooking	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.3%
Clothes dryers	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.7%
Other uses[5]	0.25	0.25	0.24	0.24	0.23	0.23	0.22	-0.5%
Delivered energy	**5.25**	**4.77**	**4.87**	**4.82**	**4.80**	**4.77**	**4.73**	**0.0%**
Distillate fuel oil								
Space heating	0.49	0.45	0.40	0.35	0.31	0.28	0.25	-2.3%
Water heating	0.05	0.04	0.03	0.02	0.02	0.02	0.01	-4.7%
Other uses[6]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.6%
Delivered energy	**0.55**	**0.50**	**0.43**	**0.38**	**0.34**	**0.30**	**0.27**	**-2.4%**
Propane								
Space heating	0.37	0.29	0.30	0.27	0.26	0.24	0.22	-1.1%
Water heating	0.06	0.06	0.05	0.05	0.04	0.03	0.03	-2.7%
Cooking	0.03	0.03	0.03	0.03	0.02	0.02	0.02	-0.8%
Other uses[6]	0.04	0.04	0.05	0.05	0.05	0.06	0.06	1.4%
Delivered energy	**0.50**	**0.43**	**0.42**	**0.40**	**0.38**	**0.36**	**0.34**	**-0.9%**
Marketed renewables (wood)[7]	0.59	0.44	0.42	0.41	0.39	0.38	0.37	-0.7%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-2.6%

Table A4. Residential sector key indicators and consumption *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Delivered energy consumption by end use								
Space heating	5.40	4.55	4.58	4.43	4.31	4.22	4.13	-0.4%
Space cooling	0.67	0.83	0.76	0.77	0.81	0.86	0.91	0.4%
Water heating	1.76	1.77	1.78	1.79	1.81	1.79	1.78	0.0%
Refrigeration	0.36	0.36	0.34	0.33	0.33	0.34	0.36	0.0%
Cooking	0.34	0.34	0.35	0.36	0.37	0.38	0.39	0.5%
Clothes dryers	0.25	0.26	0.27	0.28	0.29	0.30	0.32	0.9%
Freezers	0.08	0.08	0.07	0.07	0.07	0.06	0.06	-0.7%
Lighting	0.51	0.50	0.43	0.37	0.30	0.25	0.23	-3.0%
Clothes washers[1]	0.03	0.03	0.02	0.02	0.02	0.02	0.02	-2.0%
Dishwashers[1]	0.09	0.09	0.10	0.10	0.11	0.12	0.13	1.2%
Televisions and related equipment[2]	0.30	0.29	0.26	0.25	0.26	0.29	0.32	0.4%
Computers and related equipment[3]	0.11	0.11	0.09	0.08	0.07	0.06	0.05	-3.0%
Furnace fans and boiler circulation pumps	0.14	0.11	0.12	0.12	0.11	0.11	0.10	-0.5%
Other uses[8]	1.64	1.62	1.73	1.80	1.89	1.99	2.11	1.1%
Delivered energy	**11.70**	**10.92**	**10.90**	**10.77**	**10.74**	**10.78**	**10.91**	**0.0%**
Electricity related losses	**9.72**	**9.44**	**9.37**	**9.03**	**8.77**	**8.93**	**9.15**	**-0.1%**
Total energy consumption by end use								
Space heating	6.27	5.20	5.29	5.10	4.94	4.83	4.72	-0.4%
Space cooling	1.98	2.41	2.21	2.20	2.24	2.36	2.48	0.1%
Water heating	2.67	2.66	2.69	2.69	2.67	2.65	2.62	-0.1%
Refrigeration	1.09	1.06	1.01	0.96	0.93	0.95	0.98	-0.3%
Cooking	0.56	0.56	0.58	0.59	0.60	0.62	0.64	0.5%
Clothes dryers	0.67	0.66	0.69	0.70	0.71	0.74	0.77	0.6%
Freezers	0.23	0.22	0.21	0.20	0.18	0.18	0.18	-1.0%
Lighting	1.54	1.47	1.29	1.07	0.85	0.69	0.64	-3.3%
Clothes washers[1]	0.08	0.08	0.07	0.05	0.05	0.04	0.05	-2.3%
Dishwashers[1]	0.29	0.28	0.29	0.29	0.31	0.33	0.35	0.9%
Televisions and related equipment[2]	0.91	0.85	0.77	0.73	0.74	0.81	0.88	0.1%
Computers and related equipment[3]	0.35	0.33	0.28	0.23	0.20	0.17	0.14	-3.3%
Furnace fans and boiler circulation pumps	0.43	0.34	0.36	0.34	0.31	0.29	0.28	-0.8%
Other uses[8]	4.36	4.23	4.55	4.65	4.79	5.05	5.32	0.9%
Total	**21.42**	**20.37**	**20.27**	**19.79**	**19.50**	**19.71**	**20.05**	**-0.1%**
Nonmarketed renewables[9]								
Geothermal heat pumps	0.01	0.01	0.02	0.02	0.02	0.02	0.02	2.8%
Solar hot water heating	0.01	0.01	0.01	0.02	0.02	0.02	0.02	3.4%
Solar photovoltaic	0.05	0.08	0.30	0.43	0.57	0.71	0.86	10.2%
Wind	0.01	0.02	0.03	0.03	0.03	0.03	0.03	2.0%
Total	**0.08**	**0.11**	**0.35**	**0.50**	**0.63**	**0.78**	**0.94**	**8.8%**
Heating degree days[10]	**4,549**	**4,084**	**4,173**	**4,106**	**4,041**	**3,977**	**3,914**	**-0.2%**
Cooling degree days[10]	**1,299**	**1,488**	**1,456**	**1,503**	**1,551**	**1,599**	**1,648**	**0.4%**

[1]Does not include water heating portion of load.
[2]Includes televisions, set-top boxes, home theater systems, DVD players, and video game consoles.
[3]Includes desktop and laptop computers, monitors, and networking equipment.
[4]Includes small electric devices, heating elements, and motors not listed above. Electric vehicles are included in the transportation sector.
[5]Includes such appliances as outdoor grills, exterior lights, pool heaters, spa heaters, and backup electricity generators.
[6]Includes such appliances as pool heaters, spa heaters, and backup electricity generators.
[7]Includes wood used for primary and secondary heating in wood stoves or fireplaces as reported in the *Residential Energy Consumption Survey 2009*.
[8]Includes small electric devices, heating elements, outdoor grills, exterior lights, pool heaters, spa heaters, backup electricity generators, and motors not listed above. Electric vehicles are included in the transportation sector.
[9]Consumption determined by using the fossil fuel equivalent of 9,541 Btu per kilowatthour.
[10]See Table A5 for regional detail.
Btu = British thermal unit.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. 2014 degree days based on state-level data from the National Oceanic and Atmospheric Administration's Climatic Data Center and Climate Prediction Center. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A5. Commercial sector key indicators and consumption
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Key indicators								
Total floorspace (billion square feet)								
Surviving	81.6	82.2	86.7	91.9	97.1	102.3	107.5	1.1%
New additions	1.5	1.7	2.1	2.1	2.2	2.3	2.3	1.4%
Total	**83.1**	**83.8**	**88.7**	**94.0**	**99.3**	**104.6**	**109.8**	**1.1%**
Energy consumption intensity (thousand Btu per square foot)								
Delivered energy consumption	107.6	105.1	101.8	97.8	95.6	94.3	93.6	-0.5%
Electricity related losses	112.4	109.3	104.0	98.2	92.9	91.5	90.0	-0.8%
Total energy consumption	220.0	214.3	205.8	196.0	188.5	185.8	183.7	-0.6%
Delivered energy consumption by fuel								
Purchased electricity								
Space heating[1]	0.16	0.14	0.14	0.13	0.13	0.13	0.13	-0.4%
Space cooling[1]	0.48	0.55	0.52	0.52	0.53	0.55	0.57	0.1%
Water heating[1]	0.09	0.09	0.09	0.09	0.09	0.08	0.08	-0.3%
Ventilation	0.51	0.52	0.54	0.56	0.57	0.58	0.61	0.6%
Cooking	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.1%
Lighting	0.89	0.88	0.87	0.83	0.81	0.76	0.74	-0.7%
Refrigeration	0.37	0.36	0.33	0.31	0.30	0.30	0.31	-0.6%
Office equipment (PC)	0.09	0.08	0.06	0.05	0.04	0.03	0.02	-4.8%
Office equipment (non-PC)	0.22	0.22	0.24	0.26	0.30	0.34	0.38	2.2%
Other uses[2]	1.79	1.76	1.88	2.08	2.30	2.53	2.76	1.8%
Delivered energy	**4.61**	**4.64**	**4.69**	**4.86**	**5.09**	**5.33**	**5.62**	**0.8%**
Natural gas								
Space heating[1]	1.92	1.74	1.75	1.70	1.66	1.64	1.62	-0.3%
Space cooling[1]	0.03	0.04	0.04	0.04	0.04	0.04	0.04	-0.6%
Water heating[1]	0.54	0.55	0.56	0.57	0.60	0.63	0.66	0.8%
Cooking	0.20	0.21	0.22	0.22	0.23	0.25	0.26	0.9%
Other uses[3]	0.89	0.79	0.89	0.93	1.01	1.11	1.22	1.8%
Delivered energy	**3.58**	**3.32**	**3.45**	**3.46**	**3.53**	**3.66**	**3.81**	**0.5%**
Distillate fuel oil								
Space heating[1]	0.16	0.16	0.15	0.14	0.13	0.11	0.10	-1.6%
Water heating[1]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.1%
Other uses[4]	0.18	0.19	0.18	0.18	0.18	0.17	0.17	-0.6%
Delivered energy	**0.36**	**0.37**	**0.36**	**0.34**	**0.32**	**0.30**	**0.29**	**-1.0%**
Marketed renewables (biomass)	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.0%
Other fuels[5]	0.26	0.34	0.40	0.41	0.42	0.42	0.43	0.9%
Delivered energy consumption by end use								
Space heating[1]	2.24	2.03	2.04	1.97	1.92	1.89	1.85	-0.4%
Space cooling[1]	0.51	0.60	0.56	0.56	0.57	0.58	0.60	0.0%
Water heating[1]	0.64	0.66	0.67	0.68	0.70	0.73	0.77	0.6%
Ventilation	0.51	0.52	0.54	0.56	0.57	0.58	0.61	0.6%
Cooking	0.23	0.23	0.24	0.25	0.26	0.27	0.28	0.8%
Lighting	0.89	0.88	0.87	0.83	0.81	0.76	0.74	-0.7%
Refrigeration	0.37	0.36	0.33	0.31	0.30	0.30	0.31	-0.6%
Office equipment (PC)	0.09	0.08	0.06	0.05	0.04	0.03	0.02	-4.8%
Office equipment (non-PC)	0.22	0.22	0.24	0.26	0.30	0.34	0.38	2.2%
Other uses[6]	3.26	3.23	3.49	3.74	4.03	4.36	4.72	1.5%
Delivered energy	**8.95**	**8.81**	**9.03**	**9.20**	**9.49**	**9.86**	**10.28**	**0.6%**

Table A5. Commercial sector key indicators and consumption *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Key indicators and consumption	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Electricity related losses	**9.34**	**9.16**	**9.23**	**9.23**	**9.23**	**9.57**	**9.89**	**0.3%**
Total energy consumption by end use								
Space heating[1]	2.57	2.32	2.32	2.22	2.16	2.12	2.08	-0.4%
Space cooling[1]	1.47	1.69	1.59	1.56	1.53	1.57	1.60	-0.2%
Water heating[1]	0.83	0.83	0.84	0.84	0.86	0.89	0.91	0.4%
Ventilation	1.55	1.54	1.61	1.62	1.60	1.63	1.67	0.3%
Cooking	0.27	0.28	0.28	0.29	0.30	0.31	0.32	0.6%
Lighting	2.68	2.62	2.58	2.41	2.27	2.12	2.04	-1.0%
Refrigeration	1.11	1.08	0.97	0.89	0.84	0.85	0.85	-0.9%
Office equipment (PC)	0.27	0.25	0.18	0.14	0.10	0.08	0.07	-5.1%
Office equipment (non-PC)	0.65	0.65	0.70	0.76	0.85	0.96	1.05	1.9%
Other uses[6]	6.88	6.71	7.19	7.70	8.20	8.90	9.57	1.4%
Total	**18.29**	**17.97**	**18.26**	**18.43**	**18.72**	**19.43**	**20.17**	**0.5%**
Nonmarketed renewable fuels[7]								
Solar thermal	0.08	0.09	0.09	0.10	0.10	0.11	0.11	1.0%
Solar photovoltaic	0.06	0.07	0.09	0.12	0.19	0.27	0.35	6.5%
Wind	0.00	0.00	0.00	0.00	0.00	0.01	0.01	9.0%
Total	**0.15**	**0.16**	**0.18**	**0.22**	**0.29**	**0.38**	**0.47**	**4.4%**
Heating degree days								
New England	6,674	6,526	6,099	6,004	5,909	5,813	5,716	-0.5%
Middle Atlantic	6,203	5,781	5,533	5,459	5,385	5,312	5,240	-0.4%
East North Central	7,194	6,168	6,207	6,182	6,158	6,133	6,109	0.0%
West North Central	7,304	6,090	6,521	6,508	6,492	6,476	6,459	0.2%
South Atlantic	2,952	2,492	2,628	2,593	2,559	2,526	2,494	0.0%
East South Central	3,931	3,227	3,440	3,433	3,426	3,419	3,411	0.2%
West South Central	2,422	2,087	2,031	1,995	1,959	1,923	1,888	-0.4%
Mountain	4,742	4,593	4,877	4,819	4,757	4,691	4,622	0.0%
Pacific	2,772	2,867	3,366	3,334	3,302	3,271	3,240	0.5%
United States	**4,549**	**4,084**	**4,173**	**4,106**	**4,041**	**3,977**	**3,914**	**-0.2%**
Cooling degree days								
New England	419	557	561	589	618	647	676	0.8%
Middle Atlantic	596	799	778	810	843	875	906	0.5%
East North Central	610	728	790	804	818	832	846	0.6%
West North Central	814	942	985	999	1,014	1,028	1,043	0.4%
South Atlantic	2,008	2,390	2,169	2,205	2,241	2,278	2,313	-0.1%
East South Central	1,493	1,717	1,686	1,709	1,731	1,754	1,777	0.1%
West South Central	2,474	2,741	2,809	2,875	2,941	3,007	3,073	0.5%
Mountain	1,432	1,484	1,547	1,594	1,644	1,697	1,751	0.7%
Pacific	1,068	1,095	956	994	1,032	1,069	1,107	0.0%
United States	**1,299**	**1,488**	**1,456**	**1,503**	**1,551**	**1,599**	**1,648**	**0.4%**

[1]Includes fuel consumption for district services.
[2]Includes (but is not limited to) miscellaneous uses such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, and water services.
[3]Includes miscellaneous uses, such as emergency generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings.
[4]Includes miscellaneous uses, such as cooking, emergency generators, and combined heat and power in commercial buildings.
[5]Includes residual fuel oil, propane, coal, motor gasoline, and kerosene.
[6]Includes (but is not limited to) miscellaneous uses such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, water services, emergency generators, combined heat and power in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, propane, coal, motor gasoline, kerosene, and marketed renewable fuels (biomass).
[7]Consumption determined by using the fossil fuel equivalent of 9,541 Btu per kilowatthour.
Btu = British thermal unit.
PC = Personal computer.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 consumption based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. 2014 degree days based on state-level data from the National Oceanic and Atmospheric Administration's Climatic Data Center and Climate Prediction Center. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A6. Industrial sector key indicators and consumption

Shipments, prices, and consumption	Reference case 2014	2015	2020	2025	2030	2035	2040	Annual growth 2015-2040 (percent)
Key indicators								
Value of shipments (billion 2009 dollars)								
Manufacturing	5,208	5,299	5,858	6,527	7,066	7,734	8,528	1.9%
Agriculture, mining, and construction	1,957	1,931	2,493	2,620	2,710	2,828	2,955	1.7%
Total	**7,165**	**7,229**	**8,351**	**9,146**	**9,776**	**10,562**	**11,483**	**1.9%**
Energy prices								
(2015 dollars per million Btu)								
Propane	18.8	12.2	15.6	16.8	17.8	19.5	21.1	2.2%
Motor gasoline	27.5	20.4	22.5	24.7	26.6	28.9	31.8	1.8%
Distillate fuel oil	27.1	17.0	19.7	22.2	24.4	27.4	30.5	2.4%
Residual fuel oil	15.0	6.8	11.3	14.2	15.9	18.2	20.6	4.6%
Asphalt and road oil	9.0	3.3	7.7	10.3	11.7	13.5	15.3	6.3%
Natural gas heat and power	5.2	3.5	5.2	5.8	5.8	5.6	5.6	1.8%
Natural gas feedstocks	5.6	3.9	5.5	6.1	6.1	5.9	5.8	1.6%
Metallurgical coal	5.3	5.4	6.0	6.5	7.0	7.2	7.3	1.2%
Other industrial coal	3.2	3.4	3.4	3.4	3.4	3.5	3.6	0.2%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	21.0	20.3	20.9	21.5	22.1	21.5	21.2	0.2%
(nominal dollars per million Btu)								
Propane	18.7	12.2	17.2	20.6	24.1	29.4	35.6	4.4%
Motor gasoline	27.2	20.4	24.9	30.2	35.9	43.7	53.6	3.9%
Distillate fuel oil	26.8	17.0	21.8	27.2	33.1	41.4	51.3	4.5%
Residual fuel oil	14.8	6.8	12.4	17.4	21.6	27.5	34.7	6.8%
Asphalt and road oil	8.9	3.3	8.5	12.6	15.9	20.4	25.8	8.5%
Natural gas heat and power	5.1	3.5	5.7	7.1	7.8	8.5	9.4	4.0%
Natural gas feedstocks	5.5	3.9	6.1	7.5	8.2	8.9	9.8	3.8%
Metallurgical coal	5.3	5.4	6.7	8.0	9.4	10.9	12.2	3.3%
Other industrial coal	3.2	3.4	3.7	4.2	4.6	5.2	6.0	2.4%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	20.8	20.3	23.1	26.3	29.9	32.5	35.7	2.3%
Energy consumption (quadrillion Btu)[1]								
Industrial consumption excluding refining								
Propane heat and power	0.42	0.35	0.37	0.38	0.37	0.37	0.38	0.3%
Liquefied petroleum gas and other feedstocks[2]	2.00	2.02	2.73	3.13	3.29	3.55	3.85	2.6%
Motor gasoline	0.27	0.27	0.28	0.27	0.27	0.27	0.27	0.0%
Distillate fuel oil	1.36	1.34	1.44	1.45	1.44	1.45	1.47	0.4%
Residual fuel oil	0.03	0.03	0.04	0.06	0.06	0.05	0.05	1.9%
Petrochemical feedstocks	0.70	0.66	0.96	1.21	1.31	1.47	1.66	3.8%
Petroleum coke	0.12	0.16	0.22	0.23	0.23	0.23	0.23	1.4%
Asphalt and road oil	0.79	0.83	0.89	0.93	1.05	1.18	1.31	1.8%
Miscellaneous petroleum[3]	0.30	0.40	0.42	0.50	0.52	0.53	0.55	1.3%
Petroleum and other liquids subtotal	5.99	6.08	7.34	8.15	8.53	9.11	9.76	1.9%
Natural gas heat and power	5.74	5.61	5.94	6.19	6.33	6.59	6.87	0.8%
Natural gas feedstocks	0.63	0.68	1.22	1.41	1.45	1.52	1.59	3.5%
Lease and plant fuel[4]	1.55	1.63	1.76	1.94	2.06	2.19	2.31	1.4%
Natural gas liquefaction for export[5]	0.00	0.00	0.26	0.48	0.53	0.64	0.69	- -
Natural gas subtotal	7.92	7.92	9.17	10.01	10.38	10.94	11.45	1.5%
Metallurgical coal and coke[6]	0.56	0.52	0.40	0.45	0.47	0.44	0.41	-1.0%
Other industrial coal	0.85	0.79	0.82	0.86	0.88	0.89	0.93	0.6%
Coal subtotal	1.41	1.31	1.23	1.31	1.35	1.33	1.34	0.1%
Renewables[7]	1.52	1.48	1.48	1.59	1.67	1.70	1.79	0.8%
Purchased electricity	3.21	3.07	3.42	3.73	3.81	3.91	4.08	1.1%
Delivered energy	**20.04**	**19.87**	**22.65**	**24.79**	**25.73**	**26.99**	**28.42**	**1.4%**
Electricity related losses	6.49	6.07	6.74	7.09	6.91	7.03	7.18	0.7%
Total	**26.53**	**25.94**	**29.38**	**31.87**	**32.64**	**34.02**	**35.60**	**1.3%**

Table A6. Industrial sector key indicators and consumption *(continued)*

Shipments, prices, and consumption	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Refining consumption								
Liquefied petroleum gas heat and power[2]	0.01	0.01	0.00	0.00	0.00	0.00	0.00	- -
Distillate fuel oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Residual fuel oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Petroleum coke	0.53	0.50	0.36	0.36	0.35	0.35	0.36	-1.3%
Still gas	1.45	1.48	1.70	1.68	1.67	1.67	1.69	0.6%
Miscellaneous petroleum[3]	0.01	0.01	0.00	0.00	0.00	0.00	0.01	1.9%
Petroleum and other liquids subtotal	2.00	2.00	2.06	2.04	2.02	2.02	2.06	0.1%
Natural gas heat and power	1.29	1.25	1.09	1.04	1.04	1.06	1.10	-0.5%
Natural gas feedstocks	0.19	0.22	0.31	0.30	0.31	0.32	0.34	1.8%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Natural gas subtotal	1.48	1.46	1.39	1.33	1.35	1.39	1.44	-0.1%
Other industrial coal	0.02	0.02	0.00	0.00	0.00	0.00	0.00	- -
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Coal subtotal	0.02	0.02	0.00	0.00	0.00	0.00	0.00	- -
Biofuels heat and coproducts	0.75	0.78	0.83	0.80	0.81	0.81	0.84	0.3%
Purchased electricity	0.20	0.20	0.19	0.18	0.17	0.17	0.18	-0.4%
Delivered energy	**4.45**	**4.47**	**4.46**	**4.36**	**4.34**	**4.39**	**4.52**	**0.0%**
Electricity related losses	0.40	0.39	0.37	0.33	0.31	0.31	0.32	-0.8%
Total	**4.85**	**4.86**	**4.84**	**4.69**	**4.65**	**4.70**	**4.84**	**0.0%**
Total industrial sector consumption								
Liquefied petroleum gas heat and power[2]	0.43	0.36	0.37	0.38	0.37	0.37	0.38	0.2%
Liquefied petroleum gas and other feedstocks[2]	2.00	2.02	2.73	3.13	3.29	3.55	3.85	2.6%
Motor gasoline	0.27	0.27	0.28	0.27	0.27	0.27	0.27	0.0%
Distillate fuel oil	1.36	1.34	1.44	1.45	1.44	1.45	1.47	0.4%
Residual fuel oil	0.03	0.04	0.04	0.06	0.06	0.05	0.05	1.6%
Petrochemical feedstocks	0.70	0.66	0.96	1.21	1.31	1.47	1.66	3.8%
Petroleum coke	0.65	0.67	0.57	0.59	0.58	0.58	0.59	-0.5%
Asphalt and road oil	0.79	0.83	0.89	0.93	1.05	1.18	1.31	1.8%
Still gas	1.45	1.48	1.70	1.68	1.67	1.67	1.69	0.6%
Miscellaneous petroleum[3]	0.30	0.41	0.42	0.50	0.52	0.53	0.56	1.3%
Petroleum and other liquids subtotal	7.99	8.07	9.40	10.19	10.55	11.13	11.82	1.5%
Natural gas heat and power	7.03	6.85	7.03	7.23	7.37	7.65	7.96	0.6%
Natural gas feedstocks	0.81	0.90	1.52	1.70	1.76	1.84	1.93	3.1%
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and plant fuel[4]	1.55	1.63	1.76	1.94	2.06	2.19	2.31	1.4%
Natural gas liquefaction for export[5]	0.00	0.00	0.26	0.48	0.53	0.64	0.69	- -
Natural gas subtotal	9.40	9.38	10.57	11.34	11.72	12.32	12.89	1.3%
Metallurgical coal and coke[6]	0.56	0.52	0.40	0.45	0.47	0.44	0.41	-1.0%
Other industrial coal	0.87	0.82	0.82	0.86	0.88	0.89	0.93	0.5%
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Coal subtotal	1.43	1.34	1.23	1.31	1.35	1.33	1.34	0.0%
Biofuels heat and coproducts	0.75	0.78	0.83	0.80	0.81	0.81	0.84	0.3%
Renewables[7]	1.52	1.48	1.48	1.59	1.67	1.70	1.79	0.8%
Purchased electricity	3.40	3.27	3.61	3.91	3.98	4.08	4.26	1.1%
Delivered energy	**24.49**	**24.33**	**27.11**	**29.14**	**30.07**	**31.38**	**32.94**	**1.2%**
Electricity related losses	6.89	6.46	7.11	7.42	7.22	7.34	7.50	0.6%
Total	**31.38**	**30.79**	**34.22**	**36.56**	**37.29**	**38.72**	**40.44**	**1.1%**

Table A6. Industrial sector key indicators and consumption *(continued)*

Key indicators and consumption	Reference case 2014	2015	2020	2025	2030	2035	2040	Annual growth 2015-2040 (percent)
Energy consumption per dollar of shipments (thousand Btu per 2009 dollar)								
Petroleum and other liquids	1.12	1.12	1.13	1.11	1.08	1.05	1.03	-0.3%
Natural gas	1.31	1.30	1.27	1.24	1.20	1.17	1.12	-0.6%
Coal	0.20	0.19	0.15	0.14	0.14	0.13	0.12	-1.8%
Renewable fuels[7]	0.32	0.31	0.28	0.26	0.25	0.24	0.23	-1.2%
Purchased electricity	0.48	0.45	0.43	0.43	0.41	0.39	0.37	-0.8%
Delivered energy	**3.42**	**3.37**	**3.25**	**3.19**	**3.08**	**2.97**	**2.87**	**-0.6%**
Industrial combined heat and power[1]								
Capacity (gigawatts)	25.7	25.8	27.0	28.9	31.5	34.3	36.0	1.3%
Generation (billion kilowatthours)	138	139	158	168	182	196	206	1.6%

[1]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Includes ethane, natural gasoline, and refinery olefins.
[3]Includes lubricants and miscellaneous petroleum products.
[4]Represents natural gas used in well, field, and lease operations, and in natural gas processing plant machinery.
[5]Fuel used in facilities that liquefy natural gas for export.
[6]Includes net coal coke imports.
[7]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources.
Btu = British thermal unit.
- - = Not applicable.

Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.

Sources: 2014 prices for motor gasoline and distillate fuel oil are based on: U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, January 2105-December 2015. 2014 petrochemical feedstock and asphalt and road oil prices are based on: EIA, *State Energy Data Report 2013*. 2014 coal prices are based on: EIA, *Quarterly Coal Report, October-December 2014* and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. 2014 electricity prices: EIA, *Monthly Energy Review*, February 2016. 2014 natural gas prices: *Natural Gas Monthly*, July 2015. 2014 refining consumption based on: *Petroleum Supply Annual 2014*. Other 2014 consumption values are based on: EIA, *Monthly Energy Review*, February 2016. 2014 shipments: IHS Economics, Industry model, November 2015. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A7. Transportation sector key indicators and delivered energy consumption

Key indicators and consumption	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Key indicators								
Travel indicators								
(billion vehicle miles traveled)								
Light-duty vehicles less than 8,501 pounds	2,665	2,752	3,031	3,126	3,232	3,336	3,438	0.9%
Commercial light trucks[1]	94	96	110	118	125	133	143	1.6%
Freight trucks greater than 10,000 pounds	270	280	304	329	349	375	407	1.5%
(billion seat miles available)								
Air	1,053	1,070	1,168	1,261	1,364	1,452	1,531	1.4%
(billion ton miles traveled)								
Rail	1,690	1,690	1,810	1,956	2,006	2,054	2,128	0.9%
Domestic shipping	497	482	453	423	404	402	407	-0.7%
Energy efficiency indicators								
(miles per gallon)								
New light-duty vehicle CAFE standard[2]	30.9	31.5	36.2	46.1	46.4	46.6	46.9	1.6%
New car[2]	34.9	36.0	43.7	54.3	54.3	54.3	54.3	1.7%
New light truck[2]	26.9	27.9	30.9	39.5	39.5	39.5	39.5	1.4%
Compliance new light-duty vehicle[3]	31.6	31.7	37.0	46.5	47.2	47.6	47.8	1.7%
New car[3]	36.0	36.3	44.2	54.6	55.1	55.2	55.1	1.7%
New light truck[3]	27.3	28.0	31.8	40.1	40.4	40.5	40.4	1.5%
Tested new light-duty vehicle[4]	30.8	30.9	36.9	46.5	47.2	47.6	47.8	1.8%
New car[4]	35.6	35.9	44.2	54.6	55.1	55.2	55.1	1.7%
New light truck[4]	26.1	27.0	31.7	40.0	40.4	40.5	40.4	1.6%
On-road new light-duty vehicle[5]	24.9	25.0	29.8	37.6	38.2	38.5	38.6	1.8%
New car[5]	29.1	29.3	36.1	44.6	45.0	45.1	45.0	1.7%
New light truck[5]	20.9	21.6	25.4	32.1	32.3	32.4	32.3	1.6%
Light-duty stock[6]	21.4	21.7	24.1	27.6	31.5	34.4	36.3	2.1%
New commercial light truck[1]	17.0	17.3	19.5	23.7	24.0	24.1	24.0	1.3%
Stock commercial light truck[1]	14.8	15.0	16.6	18.7	20.8	22.2	23.2	1.7%
Freight truck	6.9	6.9	7.3	7.6	7.8	7.9	8.0	0.6%
(seat miles per gallon)								
Aircraft	65.9	66.1	67.5	68.7	70.1	71.9	74.1	0.5%
(ton miles per thousand Btu)								
Rail	3.5	3.5	3.6	3.8	3.9	4.1	4.2	0.7%
Domestic shipping	4.8	4.8	5.0	5.2	5.4	5.6	5.8	0.8%
Energy use by mode (quadrillion Btu)								
Light-duty vehicles	15.60	15.86	15.73	14.12	12.82	12.10	11.83	-1.2%
Commercial light trucks[1]	0.80	0.80	0.82	0.79	0.75	0.75	0.77	-0.1%
Bus transportation	0.26	0.26	0.27	0.28	0.29	0.30	0.31	0.6%
Freight trucks	5.39	5.57	5.76	5.96	6.16	6.52	6.98	0.9%
Rail, passenger	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.9%
Rail, freight	0.49	0.48	0.50	0.52	0.51	0.51	0.51	0.2%
Shipping, domestic	0.11	0.10	0.09	0.08	0.08	0.07	0.07	-1.4%
Shipping, international	0.64	0.73	0.64	0.68	0.70	0.73	0.74	0.1%
Recreational boats	0.24	0.25	0.27	0.28	0.29	0.29	0.30	0.8%
Air	2.35	2.37	2.52	2.66	2.82	2.93	3.00	0.9%
Military use	0.65	0.65	0.65	0.66	0.69	0.73	0.78	0.8%
Lubricants	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.2%
Pipeline fuel	0.87	0.89	0.83	0.89	0.94	1.00	1.07	0.7%
Total	**27.56**	**28.14**	**28.28**	**27.11**	**26.24**	**26.13**	**26.57**	**-0.2%**

Table A7. Transportation sector key indicators and delivered energy consumption *(continued)*

Key indicators and consumption	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Energy use by mode (million barrels per day oil equivalent)								
Light-duty vehicles	8.45	8.60	8.52	7.66	6.98	6.60	6.47	-1.1%
Commercial light trucks[1]	0.42	0.42	0.43	0.41	0.39	0.39	0.40	-0.2%
Bus transportation	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.6%
Freight trucks	2.59	2.67	2.77	2.87	2.96	3.14	3.36	0.9%
Rail, passenger	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.9%
Rail, freight	0.23	0.23	0.24	0.25	0.24	0.24	0.24	0.2%
Shipping, domestic	0.05	0.05	0.04	0.04	0.04	0.03	0.03	-1.4%
Shipping, international	0.29	0.33	0.29	0.31	0.31	0.33	0.34	0.1%
Recreational boats	0.13	0.13	0.14	0.15	0.16	0.16	0.16	0.8%
Air	1.14	1.15	1.22	1.29	1.36	1.42	1.45	0.9%
Military use	0.31	0.31	0.31	0.31	0.33	0.35	0.38	0.8%
Lubricants	0.06	0.06	0.07	0.06	0.07	0.07	0.07	0.2%
Pipeline fuel	0.41	0.42	0.39	0.42	0.44	0.47	0.51	0.7%
Total	**14.23**	**14.52**	**14.57**	**13.92**	**13.45**	**13.36**	**13.58**	**-0.3%**

[1]Commercial trucks 8,501 to 10,000 pounds gross vehicle weight rating.
[2]CAFE standard based on projected new vehicle sales.
[3]Includes CAFE credits for alternative fueled vehicle sales and credit banking.
[4]Environmental Protection Agency rated miles per gallon.
[5]Tested new vehicle efficiency revised for on-road performance.
[6]Combined"on-the-road" estimate for all cars and light trucks.
CAFE = Corporate average fuel economy.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016; EIA, Alternatives to Traditional Transportation Fuels 2009 (Part II - User and Fuel Data), April 2011; Federal Highway Administration, *Highway Statistics 2012*; Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 34*; National Highway Traffic and Safety Administration, *Summary of Fuel Economy Performance* June 2015; U.S. Department of Commerce, Bureau of the Census, "Vehicle Inventory and Use Survey," EC02TV; EIA, U.S. Department of Transportation, Research and Special Programs Administration, *Air Carrier Statistics Monthly, December 2010/2009*; and United States Department of Defense, Defense Fuel Supply Center, Factbook January, 2010. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A8. Electricity supply, disposition, prices, and emissions
(billion kilowatthours, unless otherwise noted)

Supply, disposition, prices, and emissions	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Net generation by fuel type								
Electric power sector[1]								
Power only[2]								
Coal	1,549	1,320	1,355	1,145	938	928	884	-1.6%
Petroleum	26	23	13	11	9	8	7	-4.6%
Natural gas[3]	911	1,114	947	1,129	1,412	1,460	1,618	1.5%
Nuclear power	797	798	777	789	789	789	789	0.0%
Pumped storage/other[4]	1	3	3	3	3	3	3	0.1%
Renewable sources[5]	505	493	757	918	969	1,094	1,205	3.6%
Distributed generation (natural gas)	0	0	0	1	1	1	2	- -
Total	**3,790**	**3,751**	**3,853**	**3,996**	**4,121**	**4,284**	**4,508**	**0.7%**
Combined heat and power[6]								
Coal	20	23	21	21	21	21	21	-0.4%
Petroleum	2	1	1	1	1	1	1	0.0%
Natural gas	120	136	143	143	147	142	139	0.1%
Renewable sources	4	4	4	4	4	4	4	0.1%
Total	**150**	**164**	**168**	**169**	**173**	**169**	**165**	**0.0%**
Total net electric power sector generation	**3,939**	**3,915**	**4,021**	**4,165**	**4,294**	**4,452**	**4,673**	**0.7%**
Less direct use	16	18	18	17	17	17	17	-0.1%
Net available to the grid	**3,924**	**3,897**	**4,004**	**4,148**	**4,276**	**4,435**	**4,656**	**0.7%**
End-use sector[7]								
Coal	12	12	12	13	13	13	14	0.6%
Petroleum	2	2	1	1	1	1	2	-0.4%
Natural gas	97	99	111	124	143	165	183	2.5%
Other gaseous fuels[8]	11	11	21	21	21	21	21	2.5%
Renewable sources[9]	45	49	75	93	115	139	165	5.0%
Other[10]	3	3	3	3	3	3	3	0.0%
Total end-use sector net generation	**170**	**176**	**223**	**255**	**296**	**343**	**387**	**3.2%**
Less direct use	121	127	181	210	246	286	324	3.8%
Total sales to the grid	**49**	**49**	**42**	**45**	**51**	**57**	**63**	**1.0%**
Total net electricity generation by fuel								
Coal	1,582	1,355	1,388	1,179	972	962	919	-1.5%
Petroleum	30	26	15	13	11	10	9	-4.0%
Natural gas	1,129	1,348	1,201	1,396	1,702	1,768	1,942	1.5%
Nuclear power	797	798	777	789	789	789	789	0.0%
Renewable sources[5,9]	554	546	836	1,015	1,088	1,238	1,374	3.8%
Other[11]	18	17	27	27	27	27	27	1.8%
Total net electricity generation	**4,109**	**4,090**	**4,244**	**4,420**	**4,590**	**4,795**	**5,060**	**0.9%**
Net generation to the grid	**3,972**	**3,946**	**4,046**	**4,193**	**4,327**	**4,492**	**4,719**	**0.7%**
Net imports	**52**	**57**	**57**	**58**	**50**	**46**	**43**	**-1.1%**
Electricity sales by sector								
Residential	1,407	1,402	1,395	1,393	1,416	1,457	1,523	0.3%
Commercial	1,352	1,360	1,374	1,425	1,491	1,562	1,647	0.8%
Industrial	998	959	1,059	1,145	1,166	1,197	1,249	1.1%
Transportation	8	9	13	23	32	40	45	6.7%
Total	**3,765**	**3,729**	**3,841**	**3,986**	**4,105**	**4,256**	**4,464**	**0.7%**
Direct use	137	144	199	227	263	303	341	3.5%
Total electricity use	**3,902**	**3,873**	**4,039**	**4,213**	**4,368**	**4,559**	**4,805**	**0.9%**

Table A8. Electricity supply, disposition, prices, and emissions *(continued)*
(billion kilowatthours, unless otherwise noted)

Supply, disposition, prices, and emissions	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
End-use prices								
(2015 cents per kilowatthour)								
Residential	12.7	12.4	12.9	13.2	13.4	13.2	13.0	0.2%
Commercial	10.9	10.5	10.7	10.9	11.0	10.7	10.5	0.0%
Industrial	7.2	6.9	7.1	7.3	7.5	7.3	7.2	0.2%
Transportation	11.0	10.1	11.3	12.3	12.7	12.4	12.1	0.7%
All sectors average	**10.5**	**10.3**	**10.5**	**10.7**	**10.9**	**10.6**	**10.5**	**0.1%**
(nominal cents per kilowatthour)								
Residential	12.5	12.4	14.2	16.2	18.2	19.9	21.9	2.3%
Commercial	10.7	10.5	11.9	13.4	14.9	16.2	17.6	2.1%
Industrial	7.1	6.9	7.9	9.0	10.2	11.1	12.2	2.3%
Transportation	10.9	10.1	12.5	15.1	17.2	18.8	20.4	2.9%
All sectors average	**10.4**	**10.3**	**11.6**	**13.1**	**14.7**	**16.1**	**17.6**	**2.2%**
Prices by service category								
(2015 cents per kilowatthour)								
Generation	6.8	6.4	6.4	6.8	7.3	6.8	6.6	0.1%
Transmission	1.0	1.1	1.2	1.2	1.3	1.3	1.3	0.7%
Distribution	2.7	2.8	3.0	2.7	2.3	2.6	2.6	-0.3%
(nominal cents per kilowatthour)								
Generation	6.7	6.4	7.0	8.4	9.9	10.3	11.1	2.2%
Transmission	1.0	1.1	1.3	1.5	1.7	1.9	2.2	2.8%
Distribution	2.7	2.8	3.3	3.3	3.2	3.9	4.4	1.8%
Electric power sector emissions[1]								
Sulfur dioxide (million short tons)	4.05	3.57	1.20	1.07	0.77	0.84	0.79	-5.9%
Nitrogen oxide (million short tons)	1.63	1.41	1.16	1.00	0.91	0.90	0.88	-1.9%
Mercury (short tons)	26.77	23.74	5.55	4.62	3.76	3.82	3.57	-7.3%

[1]Includes electricity-only and combined heat and power plants that have a regulatory status.
[2]Includes plants that only produce electricity and that have a regulatory status.
[3]Includes electricity generation from fuel cells.
[4]Includes non-biogenic municipal waste. The U.S. Energy Information Administration estimates that in 2015 approximately 7 billion kilowatthours of electricity were generated from a municipal waste stream containing petroleum-derived plastics and other non-renewable sources. See U.S. Energy Information Administration, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy*, (Washington, DC, May 2007).
[5]Includes conventional hydroelectric, geothermal, wood, wood waste, biogenic municipal waste, landfill gas, other biomass, solar, and wind power.
[6]Includes combined heat and power plants whose primary business is to sell electricity and heat to the public (i.e., those that report North American Industry Classification System code 22 or that have a regulatory status).
[7]Includes combined heat and power plants and electricity-only plants in the commercial and industrial sectors that have a non-regulatory status; and small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
[8]Includes refinery gas and still gas.
[9]Includes conventional hydroelectric, geothermal, wood, wood waste, all municipal waste, landfill gas, other biomass, solar, and wind power.
[10]Includes batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.
[11]Includes pumped storage, non-biogenic municipal waste, refinery gas, still gas, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 electric power sector generation; sales to the grid; net imports; electricity sales; and electricity end-use prices: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016, and supporting databases. 2014 emissions: U.S. Environmental Protection Agency, Clean Air Markets Database. 2014 electricity prices by service category: EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections**: EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A9. Electricity generating capacity
(gigawatts)

Net summer capacity[1]	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Electric power sector[2]								
Power only[3]								
Coal[4]	290.8	277.7	208.4	189.3	177.0	172.2	169.5	-2.0%
Oil and natural gas steam[4,5]	91.9	91.0	89.9	65.6	54.0	52.4	52.4	-2.2%
Combined cycle	198.1	202.3	220.6	231.5	267.7	287.9	318.7	1.8%
Combustion turbine/diesel	138.7	138.3	140.1	137.4	134.2	136.8	141.8	0.1%
Nuclear power[6]	99.1	99.8	99.1	99.1	99.1	99.1	99.1	0.0%
Pumped storage	22.6	22.6	22.6	22.6	22.6	22.6	22.6	0.0%
Fuel cells	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0%
Renewable sources[7]	162.1	176.2	237.7	287.3	304.3	356.1	398.4	3.3%
Distributed generation (natural gas)[8]	0.0	0.0	0.2	0.5	1.0	1.8	2.9	- -
Total	**1,003.4**	**1,007.8**	**1,018.7**	**1,033.4**	**1,060.0**	**1,128.9**	**1,205.3**	**0.7%**
Combined heat and power[9]								
Coal	3.8	3.7	3.3	3.3	3.3	3.3	3.3	-0.4%
Oil and natural gas steam[5]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.0%
Combined cycle	25.1	25.0	26.8	26.7	26.7	26.7	26.7	0.3%
Combustion turbine/diesel	2.9	2.9	2.9	2.9	2.9	2.9	2.9	0.0%
Renewable sources[7]	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.0%
Total	**33.1**	**32.9**	**34.4**	**34.3**	**34.3**	**34.3**	**34.3**	**0.2%**
Cumulative planned additions[10]								
Coal	- -	- -	0.3	0.3	0.3	0.3	0.3	- -
Oil and natural gas steam[5]	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Combined cycle	- -	- -	21.5	21.5	21.5	21.5	21.5	- -
Combustion turbine/diesel	- -	- -	5.0	5.0	5.0	5.0	5.0	- -
Nuclear power	- -	- -	4.4	4.4	4.4	4.4	4.4	- -
Pumped storage	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Fuel cells	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Renewable sources[7]	- -	- -	19.7	19.7	19.7	19.7	19.7	- -
Distributed generation[8]	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Total	**- -**	**- -**	**50.8**	**50.8**	**50.8**	**50.8**	**50.8**	**- -**
Cumulative unplanned additions[10]								
Coal	- -	- -	0.2	0.2	0.2	0.2	0.2	- -
Oil and natural gas steam[5]	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Combined cycle	- -	- -	5.2	26.0	63.4	85.1	117.2	- -
Combustion turbine/diesel	- -	- -	2.3	2.4	3.0	7.0	14.5	- -
Nuclear power	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Pumped storage	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Fuel cells	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Renewable sources[7]	- -	- -	42.3	91.8	108.9	160.7	203.1	- -
Distributed generation[8]	- -	- -	0.2	0.5	1.0	1.8	2.9	- -
Total	**- -**	**- -**	**50.3**	**121.0**	**176.6**	**254.8**	**337.8**	**- -**
Cumulative electric power sector additions[10]	**- -**	**- -**	**101.1**	**171.8**	**227.4**	**305.6**	**388.6**	**- -**
Cumulative retirements[11]								
Coal	- -	- -	61.6	79.7	92.1	96.9	99.6	- -
Oil and natural gas steam[5]	- -	- -	9.7	34.9	46.4	48.1	48.1	- -
Combined cycle	- -	- -	6.5	16.5	17.7	19.2	20.5	- -
Combustion turbine/diesel	- -	- -	5.5	8.3	12.2	13.5	16.0	- -
Nuclear power	- -	- -	5.2	5.2	5.2	5.2	5.2	- -
Pumped storage	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Fuel cells	- -	- -	0.0	0.0	0.0	0.0	0.0	- -
Renewable sources[7]	- -	- -	0.4	0.4	0.4	0.5	0.5	- -
Total	**- -**	**- -**	**88.9**	**144.9**	**174.0**	**183.3**	**189.8**	**- -**
Total electric power sector capacity	**1,037**	**1,041**	**1,053**	**1,068**	**1,094**	**1,163**	**1,240**	**0.7%**

Table A9. Electricity generating capacity *(continued)*
(gigawatts)

Net summer capacity[1]	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
End-use generators[12]								
Coal	2.9	2.9	2.9	3.0	3.1	3.2	3.3	0.5%
Petroleum	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.0%
Natural gas	16.2	16.5	17.4	19.7	22.9	26.6	29.5	2.4%
Other gaseous fuels[13]	2.4	2.4	3.0	3.0	3.0	3.0	3.0	1.0%
Renewable sources[7]	15.0	18.4	36.6	49.1	63.6	80.3	97.4	6.9%
Other[14]	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.0%
Total	**37.8**	**41.3**	**61.1**	**76.0**	**93.9**	**114.4**	**134.5**	**4.8%**
Cumulative capacity additions[10]	**- -**	**- -**	**21.0**	**35.9**	**53.8**	**74.2**	**94.3**	**- -**

[1]Net summer capacity is the steady hourly output that generating equipment is expected to supply to system load (exclusive of auxiliary power), as demonstrated by tests during summer peak demand.
[2]Includes electricity-only and combined heat and power plants that have a regulatory status.
[3]Includes plants that only produce electricity and that have a regulatory status. Includes capacity increases (uprates) at existing units.
[4]Total coal and oil and natural gas steam capacity account for the conversion of coal capacity to gas steam capacity, but the conversions are not included explicitly as additions or retirements. The totals reflect 8.8 gigawatts of planned conversions as well as additional model-projected conversions.
[5]Includes oil-, gas-, and dual-fired capacity.
[6]Nuclear capacity includes 0.1 gigawatts of uprates.
[7]Includes conventional hydroelectric, geothermal, wood, wood waste, all municipal waste, landfill gas, other biomass, solar, and wind power. Facilities co-firing biomass and coal are classified as coal.
[8]Primarily peak load capacity fueled by natural gas.
[9]Includes combined heat and power plants whose primary business is to sell electricity and heat to the public (i.e., those that report North American Industry Classification System code 22 or that have a regulatory status).
[10]Cumulative additions after December 31, 2015.
[11]Cumulative retirements after December 31, 2015.
[12]Includes combined heat and power plants and electricity-only plants in the commercial and industrial sectors that have a non-regulatory status; and small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
[13]Includes refinery gas and still gas.
[14]Includes batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 capacity and projected planned additions: U.S. Energy Information Administration (EIA), Form EIA-860, "Annual Electric Generator Report" (preliminary). 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A10. Electricity trade
(billion kilowatthours, unless otherwise noted)

Electricity trade	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Interregional electricity trade								
Gross domestic sales								
Firm power	105	102	95	92	73	53	49	-2.9%
Economy	165	233	216	257	239	226	222	-0.2%
Total	**271**	**336**	**311**	**349**	**312**	**278**	**270**	**-0.9%**
Gross domestic sales (million 2015 dollars)								
Firm power	6,761	6,568	6,088	5,871	4,683	3,375	3,120	-2.9%
Economy	8,385	7,704	9,139	12,921	13,756	11,896	11,460	1.6%
Total	**15,147**	**14,273**	**15,227**	**18,792**	**18,439**	**15,270**	**14,580**	**0.1%**
International electricity trade								
Imports from Canada and Mexico								
Firm power	20.3	28.3	29.5	28.5	26.6	23.2	20.2	-1.4%
Economy	45.3	37.5	41.0	43.8	37.6	36.0	35.9	-0.2%
Total	**65.6**	**65.9**	**70.5**	**72.4**	**64.2**	**59.2**	**56.1**	**-0.6%**
Exports to Canada and Mexico								
Firm power	2.6	1.8	1.8	1.8	0.9	0.0	0.0	- -
Economy	10.6	7.5	11.9	12.7	13.0	13.2	13.2	2.3%
Total	**13.3**	**9.3**	**13.7**	**14.5**	**13.9**	**13.2**	**13.2**	**1.4%**

- - = Not applicable.

Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports. Firm power sales are capacity sales, meaning the delivery of the power is scheduled as part of the normal operating conditions of the affected electric systems. Economy sales are subject to curtailment or cessation of delivery by the supplier in accordance with prior agreements or under specified conditions.

Sources: 2014 interregional firm electricity trade data: Federal Energy Regulatory Commission, Form 1, “Electric Utility Annual Report”, and 2014 seasonal reliability assessments from North American Electric Reliability Council regional entities and Independent System Operators, and Federal Energy Regulatory Commission, Form 1. 2014 interregional economy electricity trade are model results. 2014 Mexican electricity trade data: U.S. Energy Information Administration (EIA), *Electric Power Annual 2014*. 2014 Canadian international electricity trade data: National Energy Board, *Electricity Exports and Imports Statistics, 2014*. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A11. Petroleum and other liquids supply and disposition
(million barrels per day, unless otherwise noted)

Supply and disposition	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Crude oil								
Domestic crude production[1]	8.71	9.42	9.38	9.43	10.06	10.66	11.26	0.7%
Alaska	0.50	0.48	0.41	0.32	0.24	0.19	0.15	-4.7%
Lower 48 states	8.21	8.94	8.96	9.12	9.82	10.48	11.11	0.9%
Net imports	6.99	6.88	6.97	6.95	6.57	6.24	6.10	-0.5%
Gross imports	7.35	7.28	7.60	7.58	7.20	7.07	7.12	-0.1%
Exports	0.35	0.40	0.63	0.63	0.63	0.83	1.02	3.8%
Other crude supply[2]	0.15	-0.11	0.01	0.07	0.00	0.00	0.00	- -
Total crude supply	**15.85**	**16.19**	**16.36**	**16.46**	**16.63**	**16.91**	**17.36**	**0.3%**
Net product imports	-1.90	-2.24	-3.26	-3.69	-4.32	-4.52	-4.66	3.0%
Gross refined product imports[3]	0.78	0.66	1.11	1.24	1.30	1.44	1.63	3.7%
Unfinished oil imports	0.55	0.55	0.53	0.50	0.46	0.43	0.39	-1.4%
Blending component imports	0.55	0.67	0.58	0.52	0.45	0.35	0.30	-3.2%
Exports	3.76	4.12	5.48	5.95	6.52	6.74	6.98	2.1%
Refinery processing gain[4]	1.08	1.03	1.05	1.01	0.98	0.97	0.99	-0.2%
Product stock withdrawal	-0.18	0.00	0.00	0.00	0.00	0.00	0.00	- -
Natural gas plant liquids	3.02	3.25	4.57	4.77	4.90	4.95	4.99	1.7%
Supply from renewable sources	0.96	1.01	1.08	1.03	1.03	1.05	1.12	0.4%
Ethanol	0.86	0.89	0.89	0.85	0.84	0.86	0.93	0.2%
Domestic production	0.91	0.94	0.90	0.87	0.87	0.88	0.91	-0.1%
Net imports	-0.05	-0.05	-0.01	-0.03	-0.03	-0.03	0.02	- -
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Biodiesel	0.10	0.11	0.15	0.10	0.10	0.10	0.10	-0.5%
Domestic production	0.08	0.08	0.11	0.06	0.06	0.06	0.06	-1.6%
Net imports	0.02	0.03	0.04	0.04	0.04	0.04	0.04	1.7%
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Other biomass-derived liquids[5]	0.00	0.00	0.04	0.09	0.09	0.09	0.09	18.1%
Domestic production	0.00	0.00	0.04	0.09	0.09	0.09	0.09	18.1%
Net imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Liquids from gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Liquids from coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Other[6]	0.21	0.21	0.28	0.28	0.30	0.31	0.32	1.7%
Total primary supply[7]	**19.04**	**19.46**	**20.08**	**19.87**	**19.52**	**19.66**	**20.12**	**0.1%**
Product supplied								
by fuel								
Liquefied petroleum gases and other[8]	2.45	2.46	2.90	3.22	3.34	3.55	3.80	1.8%
Motor gasoline[9]	8.94	9.18	8.97	8.08	7.35	6.96	6.84	-1.2%
of which: E85[10]	0.02	0.03	0.03	0.09	0.15	0.18	0.19	7.3%
Jet fuel[11]	1.47	1.54	1.56	1.64	1.73	1.80	1.86	0.8%
Distillate fuel oil[12]	4.04	3.96	4.31	4.40	4.46	4.57	4.67	0.7%
of which: Diesel	3.83	3.76	3.97	4.10	4.19	4.32	4.43	0.7%
Residual fuel oil	0.26	0.26	0.25	0.27	0.27	0.28	0.28	0.2%
Other[13]	2.01	2.02	2.11	2.29	2.39	2.53	2.70	1.2%
by sector								
Residential and commercial	0.93	0.90	0.89	0.84	0.80	0.77	0.74	-0.8%
Industrial[14]	4.46	4.47	5.35	5.88	6.10	6.46	6.89	1.8%
Transportation	13.76	14.04	14.11	13.40	12.84	12.65	12.69	-0.4%
Electric power[15]	0.14	0.12	0.07	0.06	0.05	0.04	0.04	-4.3%
Unspecified sector[16]	-0.31	-0.30	-0.31	-0.28	-0.25	-0.23	-0.23	-1.1%
Total product supplied	**19.16**	**19.42**	**20.11**	**19.90**	**19.54**	**19.69**	**20.14**	**0.1%**
Discrepancy[17]	-0.12	0.04	-0.03	-0.03	-0.03	-0.03	-0.03	- -

Table A11. Petroleum and other liquids supply and disposition *(continued)*

(million barrels per day, unless otherwise noted)

Supply and disposition	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Domestic refinery distillation capacity[18]	17.9	18.0	19.0	19.0	19.0	19.0	19.0	0.2%
Capacity utilization rate (percent)[19]	90.4	91.1	87.7	88.2	88.9	90.2	92.5	0.1%
Net import share of product supplied (percent)	26.6	23.7	18.6	16.5	11.6	8.8	7.4	-4.5%
Net expenditures for imported crude oil and petroleum products (billion 2015 dollars)	262	128	207	250	268	303	348	4.1%

[1]Includes lease condensate.
[2]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude oil stock withdrawals.
[3]Includes other hydrocarbons and alcohols.
[4]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[5]Includes pyrolysis oils, biomass-derived Fischer-Tropsch liquids, biobutanol, and renewable feedstocks used for the on-site production of diesel and gasoline.
[6]Includes domestic sources of other blending components, other hydrocarbons, and ethers.
[7]Total crude supply, net product imports, refinery processing gain, product stock withdrawal, natural gas plant liquids, supply from renewable sources, liquids from gas, liquids from coal, and other supply.
[8]Includes ethane, natural gasoline, and refinery olefins.
[9]Includes ethanol and ethers blended into gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Includes distillate fuel oil from petroleum and biomass feedstocks.
[13]Includes kerosene, aviation gasoline, petrochemical feedstocks, lubricants, waxes, asphalt, road oil, still gas, special naphthas, petroleum coke, crude oil product supplied, methanol, and miscellaneous petroleum products.
[14]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[15]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[16]Represents consumption unattributed to the sectors above.
[17]Balancing item. Includes unaccounted for supply, losses, and gains.
[18]End-of-year operable capacity.
[19]Rate is calculated by dividing the gross annual input to atmospheric crude oil distillation units by their operable refining capacity in barrels per calendar day.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 product supplied based on: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. Other 2014 data: EIA, *Petroleum Supply Annual 2014*. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A12. Petroleum and other liquids prices
(2015 dollars per gallon, unless otherwise noted)

Sector and fuel	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Crude oil prices (2015 dollars per barrel)								
Brent spot	100	52	77	92	104	120	136	3.9%
West Texas Intermediate spot	94	49	71	85	97	112	129	4.0%
Average imported refiners acquisition cost[1]	91	46	69	83	95	110	126	4.1%
Brent / West Texas Intermediate spread	5.8	3.7	5.4	6.2	6.9	7.2	7.1	2.7%
Delivered sector product prices								
Residential								
Propane	2.13	1.55	1.84	1.95	2.04	2.19	2.33	1.7%
Distillate fuel oil	3.71	2.66	3.08	3.51	3.82	4.23	4.65	2.3%
Commercial								
Distillate fuel oil	3.63	2.34	2.71	3.05	3.36	3.77	4.19	2.4%
Residual fuel oil	2.50	1.04	1.64	2.02	2.29	2.63	2.98	4.3%
Residual fuel oil (2015 dollars per barrel)	105	44	69	85	96	110	125	4.3%
Industrial[2]								
Propane	1.72	1.12	1.42	1.54	1.63	1.78	1.93	2.2%
Distillate fuel oil	3.72	2.34	2.71	3.05	3.36	3.76	4.19	2.4%
Residual fuel oil	2.24	1.01	1.68	2.13	2.39	2.73	3.08	4.6%
Residual fuel oil (2015 dollars per barrel)	94	42	71	89	100	115	130	4.6%
Transportation								
Propane	2.23	1.64	1.94	2.05	2.14	2.28	2.43	1.6%
E85[3]	3.15	2.21	3.05	2.97	2.93	3.08	3.33	1.6%
Ethanol wholesale price	2.25	2.22	2.77	2.38	2.28	2.39	2.60	0.6%
Motor gasoline[4]	3.42	2.52	2.74	2.97	3.19	3.47	3.81	1.7%
Jet fuel[5]	2.81	1.62	2.18	2.56	2.87	3.30	3.74	3.4%
Diesel fuel (distillate fuel oil)[6]	3.82	2.72	3.18	3.55	3.85	4.25	4.68	2.2%
Residual fuel oil	2.19	1.21	1.75	2.01	2.25	2.54	2.87	3.5%
Residual fuel oil (2015 dollars per barrel)	92	51	73	85	94	107	121	3.5%
Electric power[7]								
Distillate fuel oil	3.27	2.07	2.53	2.92	3.23	3.63	4.04	2.7%
Residual fuel oil	2.73	1.53	2.06	2.43	2.70	3.03	3.36	3.2%
Residual fuel oil (2015 dollars per barrel)	115	64	87	102	114	127	141	3.2%
Average prices, all sectors[8]								
Propane	1.94	1.36	1.65	1.75	1.83	1.97	2.12	1.8%
Motor gasoline[4]	3.42	2.52	2.74	2.97	3.19	3.47	3.81	1.7%
Jet fuel[5]	2.81	1.62	2.18	2.56	2.87	3.30	3.74	3.4%
Distillate fuel oil	3.78	2.63	3.07	3.44	3.75	4.16	4.58	2.2%
Residual fuel oil	2.37	1.26	1.76	2.06	2.30	2.60	2.93	3.4%
Residual fuel oil (2015 dollars per barrel)	99	53	74	87	97	109	123	3.4%
Average	**3.12**	**2.18**	**2.44**	**2.65**	**2.85**	**3.13**	**3.42**	**1.8%**

Table A12. Petroleum and other liquids prices *(continued)*
(nominal dollars per gallon, unless otherwise noted)

Sector and fuel	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Crude oil prices (nominal dollars per barrel)								
Brent spot	99	52	85	112	141	181	229	6.1%
West Texas Intermediate spot	93	49	79	105	131	170	217	6.2%
Average imported refiners acquisition cost[1]	90	46	76	102	128	166	212	6.3%
Delivered sector product prices								
Residential								
Propane	2.11	1.55	2.03	2.39	2.76	3.30	3.93	3.8%
Distillate fuel oil	3.67	2.66	3.40	4.29	5.16	6.39	7.83	4.4%
Commercial								
Distillate fuel oil	3.59	2.34	2.99	3.74	4.54	5.69	7.04	4.5%
Residual fuel oil	2.47	1.04	1.81	2.47	3.09	3.97	5.02	6.5%
Residual fuel oil (nominal dollars per barrel)	104	44	76	104	130	167	211	6.5%
Industrial[2]								
Propane	1.70	1.12	1.57	1.88	2.20	2.69	3.25	4.4%
Distillate fuel oil	3.68	2.34	2.99	3.74	4.54	5.69	7.04	4.5%
Residual fuel oil	2.22	1.01	1.86	2.60	3.23	4.12	5.19	6.8%
Residual fuel oil (nominal dollars per barrel)	93	42	78	109	136	173	218	6.8%
Transportation								
Propane	2.21	1.64	2.14	2.51	2.89	3.45	4.09	3.7%
E85[3]	3.12	2.21	3.37	3.63	3.97	4.65	5.60	3.8%
Ethanol wholesale price	2.23	2.22	3.06	2.91	3.09	3.62	4.38	2.8%
Motor gasoline[4]	3.38	2.52	3.02	3.64	4.32	5.25	6.40	3.8%
Jet fuel[5]	2.78	1.62	2.41	3.14	3.89	4.99	6.29	5.6%
Diesel fuel (distillate fuel oil)[6]	3.78	2.72	3.51	4.34	5.21	6.43	7.88	4.3%
Residual fuel oil	2.17	1.21	1.93	2.46	3.04	3.84	4.83	5.7%
Residual fuel oil (nominal dollars per barrel)	91	51	81	103	128	161	203	5.7%
Electric power[7]								
Distillate fuel oil	3.24	2.07	2.80	3.57	4.37	5.48	6.79	4.9%
Residual fuel oil	2.71	1.53	2.28	2.98	3.66	4.57	5.65	5.4%
Residual fuel oil (nominal dollars per barrel)	114	64	96	125	154	192	237	5.4%
Average prices, all sectors[8]								
Propane	1.92	1.36	1.82	2.14	2.48	2.98	3.56	3.9%
Motor gasoline[4]	3.38	2.52	3.02	3.64	4.32	5.24	6.40	3.8%
Jet fuel[5]	2.78	1.62	2.41	3.14	3.89	4.99	6.29	5.6%
Distillate fuel oil	3.75	2.63	3.39	4.22	5.08	6.28	7.71	4.4%
Residual fuel oil	2.34	1.26	1.94	2.52	3.11	3.93	4.93	5.6%
Residual fuel oil (nominal dollars per barrel)	98	53	81	106	131	165	207	5.6%
Average	**3.09**	**2.18**	**2.70**	**3.25**	**3.86**	**4.72**	**5.76**	**4.0%**

[1]Weighted average price delivered to U.S. refiners.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Includes only kerosene type.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Includes electricity-only and combined heat and power plants that have a regulatory status.
[8]Weighted averages of end-use fuel prices are derived from the prices in each sector and the corresponding sectoral consumption.
Note: Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. 2014 average imported crude oil price: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. 2014 prices for motor gasoline, distillate fuel oil, and jet fuel are based on: EIA, *Petroleum Marketing Monthly*, January 2105-December 2015. 2014 residential, commercial, industrial, and transportation sector petroleum product prices are derived from: EIA, Form EIA-782A, "Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales Report." 2014 electric power prices based on: EIA, *Monthly Energy Review*, February 2016. 2014 E85 prices derived from: U.S. Department of Energy, Clean Cities Alternative Fuel Price Report. 2014 wholesale ethanol prices derived from Bloomberg U.S. average rack price. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.
Projections: EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A13. Natural gas supply, disposition, and prices
(trillion cubic feet, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Supply								
Dry gas production[1]	25.73	27.19	30.50	34.81	37.76	39.92	42.12	1.8%
Supplemental natural gas[2]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.3%
Net imports	1.18	0.95	-2.89	-5.32	-6.02	-7.18	-7.55	- -
Pipeline[3]	1.14	0.89	-0.48	-0.76	-0.97	-0.99	-0.89	- -
Liquefied natural gas	0.04	0.06	-2.42	-4.56	-5.06	-6.19	-6.66	- -
Total supply	**26.97**	**28.20**	**27.67**	**29.55**	**31.80**	**32.80**	**34.63**	**0.8%**
Consumption by sector								
Residential	5.09	4.62	4.71	4.67	4.65	4.62	4.58	0.0%
Commercial	3.47	3.22	3.34	3.35	3.42	3.55	3.69	0.5%
Industrial[4]	7.60	7.51	8.29	8.65	8.85	9.19	9.58	1.0%
Natural-gas-to-liquids heat and power[5]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Natural gas to liquids production[6]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Electric power[7]	8.14	9.61	8.26	9.33	11.02	11.13	11.96	0.9%
Transportation[8]	0.06	0.06	0.09	0.14	0.22	0.38	0.66	9.8%
Pipeline fuel	0.84	0.86	0.81	0.86	0.91	0.97	1.04	0.7%
Lease and plant fuel[9]	1.50	1.58	1.71	1.88	2.00	2.12	2.24	1.4%
Liquefaction for export[10]	0.00	0.00	0.25	0.46	0.51	0.63	0.67	- -
Total consumption	**26.70**	**27.47**	**27.46**	**29.35**	**31.59**	**32.59**	**34.42**	**0.9%**
Discrepancy[11]	**0.27**	**0.73**	**0.21**	**0.21**	**0.21**	**0.21**	**0.21**	**- -**
Natural gas spot price at Henry Hub								
(2015 dollars per million Btu)	**4.44**	**2.62**	**4.43**	**5.12**	**5.06**	**4.91**	**4.86**	**2.5%**
(nominal dollars per million Btu)	**4.39**	**2.62**	**4.90**	**6.27**	**6.84**	**7.42**	**8.17**	**4.7%**
Delivered prices								
(2015 dollars per thousand cubic feet)								
Residential	11.08	10.40	11.08	11.99	12.41	12.50	12.74	0.8%
Commercial	9.24	7.92	9.58	10.39	10.72	10.66	10.73	1.2%
Industrial[4]	5.57	3.84	5.53	6.15	6.14	5.95	5.89	1.7%
Electric power[7]	5.20	3.35	4.83	5.55	5.74	5.54	5.52	2.0%
Transportation[12]	19.03	17.18	17.18	16.90	16.05	15.87	16.37	-0.2%
Average[13]	**7.15**	**5.42**	**6.95**	**7.58**	**7.65**	**7.55**	**7.59**	**1.4%**
(nominal dollars per thousand cubic feet)								
Residential	10.96	10.40	12.24	14.67	16.78	18.87	21.44	2.9%
Commercial	9.15	7.92	10.59	12.72	14.51	16.09	18.05	3.4%
Industrial[4]	5.51	3.84	6.11	7.53	8.31	8.98	9.91	3.9%
Electric power[7]	5.15	3.35	5.33	6.80	7.76	8.36	9.29	4.2%
Transportation[12]	18.83	17.18	18.98	20.68	21.71	23.96	27.54	1.9%
Average[13]	**7.08**	**5.42**	**7.67**	**9.28**	**10.35**	**11.40**	**12.77**	**3.5%**

[1]Marketed production (wet) minus extraction losses.
[2]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
[3]Includes any natural gas regasified in the Bahamas and transported via pipeline to Florida, as well as gas from Canada and Mexico.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems. Excludes use for lease and plant fuel.
[5]Includes any natural gas used in the process of converting natural gas to liquid fuel that is not actually converted.
[6]Includes any natural gas converted into liquid fuel.
[7]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[8]Natural gas used as fuel in motor vehicles, trains, and ships.
[9]Represents natural gas used in well, field, and lease operations, and in natural gas processing plant machinery.
[10]Fuel used in facilities that liquefy natural gas for export.
[11]Balancing item. Natural gas lost as a result of converting flow data measured at varying temperatures and pressures to a standard temperature and pressure and the merger of different data reporting systems which vary in scope, format, definition, and respondent type. In addition, 2014 and 2015 values include net storage injections.
[12]Natural gas used as fuel in motor vehicles, trains, and ships. Price includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[13]Weighted average prices. Weights used are the sectoral consumption values excluding lease, plant, and pipeline fuel.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 supply values; lease, plant, and pipeline fuel consumption; and residential, commercial, and industrial delivered prices: U.S. Energy Information Administration (EIA), *Natural Gas Monthly*, July 2015. Other 2014 consumption based on: EIA, *Monthly Energy Review*, February 2016. 2014 natural gas spot price at Henry Hub: Thomson Reuters. 2014 electric power prices: EIA, *Electric Power Monthly*, April 2014 and April 2015, Table 4.2, and EIA, *State Energy Data Report 2013*. 2014 transportation sector delivered prices derived from: U.S. Department of Energy, Clean Cities Alternative Fuel Price Report. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A14. Oil and gas supply

Production and supply	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Crude oil								
Lower 48 average wellhead price[1] (2015 dollars per barrel)	**88**	**49**	**74**	**88**	**99**	**114**	**130**	**4.0%**
Production (million barrels per day)[2]								
United States total	8.71	9.42	9.38	9.43	10.06	10.66	11.26	0.7%
Lower 48 onshore	6.71	7.30	6.99	7.38	8.22	8.85	9.53	1.1%
Tight oil[3]	4.28	4.89	5.08	5.51	6.25	6.72	7.08	1.5%
Carbon dioxide enhanced oil recovery	0.28	0.28	0.32	0.43	0.55	0.63	0.72	3.8%
Other	2.15	2.13	1.59	1.44	1.41	1.50	1.73	-0.8%
Lower 48 offshore	1.50	1.64	1.98	1.74	1.60	1.63	1.58	-0.2%
State	0.07	0.07	0.05	0.04	0.04	0.03	0.03	-3.6%
Federal	1.43	1.57	1.92	1.69	1.57	1.60	1.55	0.0%
Alaska	0.50	0.48	0.41	0.32	0.24	0.19	0.15	-4.7%
Onshore	0.40	0.41	0.28	0.22	0.17	0.14	0.11	-5.0%
State offshore	0.10	0.07	0.13	0.10	0.07	0.05	0.03	-3.2%
Federal offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-10.7%
Natural gas plant liquids production (million barrels per day)								
United States total	3.02	3.25	4.57	4.77	4.90	4.96	4.99	1.7%
Lower 48 onshore	2.65	2.86	4.15	4.39	4.50	4.51	4.54	1.9%
Lower 48 offshore	0.34	0.37	0.40	0.36	0.39	0.44	0.44	0.8%
Alaska	0.03	0.03	0.02	0.02	0.01	0.01	0.01	-4.9%
Natural gas								
Natural gas spot price at Henry Hub (2015 dollars per million Btu)	4.44	2.62	4.43	5.12	5.06	4.91	4.86	2.5%
Dry production (trillion cubic feet)[4]								
United States total	25.73	27.19	30.50	34.81	37.76	39.92	42.12	1.8%
Lower 48 onshore	24.05	25.20	28.82	33.31	36.15	37.99	40.18	1.9%
Tight gas	4.81	5.00	4.92	5.43	6.08	6.30	6.55	1.1%
Shale gas and tight oil plays[3]	12.29	13.64	17.96	22.50	25.16	27.04	29.00	3.1%
Coalbed methane	1.16	1.24	1.04	1.02	0.94	0.85	0.78	-1.9%
Other	5.79	5.32	4.90	4.36	3.97	3.79	3.85	-1.3%
Lower 48 offshore	1.36	1.70	1.39	1.21	1.33	1.65	1.67	-0.1%
State	0.10	0.14	0.07	0.04	0.03	0.02	0.02	-7.3%
Federal	1.25	1.56	1.32	1.17	1.30	1.63	1.64	0.2%
Alaska	0.32	0.29	0.29	0.29	0.28	0.28	0.28	-0.2%
Onshore	0.32	0.29	0.29	0.29	0.28	0.28	0.28	-0.2%
State offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Federal offshore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Supplemental gas supplies (trillion cubic feet)[5]	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.3%**
Total lower 48 wells drilled (thousands)	**47.4**	**32.3**	**32.3**	**36.8**	**41.8**	**44.6**	**47.4**	**1.5%**

[1]Represents lower 48 onshore and offshore supplies.
[2]Includes lease condensate.
[3]Tight oil represents resources in low-permeability reservoirs, including shale and chalk formations. The specific plays included in the tight oil category are Bakken/Three Forks/Sanish, Eagle Ford, Woodford, Austin Chalk, Spraberry, Niobrara, Avalon/Bone Springs, and Monterey.
[4]Marketed production (wet) minus extraction losses.
[5]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 crude oil lower 48 average wellhead price: U.S. Energy Information Administration (EIA), *Petroleum Marketing Monthly*, January 2105-December 2015. 2014 lower 48 onshore, lower 48 offshore, and Alaska crude oil production: EIA, *Petroleum Supply Annual 2014*. 2014 natural gas spot price at Henry Hub: Thomson Reuters. 2014 Alaska and total natural gas production, and supplemental gas supplies: EIA, *Natural Gas Monthly*, July 2015. Other 2014: EIA, Office of Energy Analysis. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A15. Coal supply, disposition, and prices
(million short tons, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Production[1]								
Appalachia	270	223	202	165	138	154	144	-1.7%
Interior	190	165	197	193	148	172	170	0.1%
West	542	484	473	408	378	335	329	-1.5%
East of the Mississippi	413	346	351	307	243	281	276	-0.9%
West of the Mississippi	590	526	521	460	422	380	367	-1.4%
Total	**1,002**	**873**	**872**	**766**	**664**	**661**	**643**	**-1.2%**
Waste coal supplied[2]	**9**	**9**	**11**	**9**	**9**	**8**	**9**	**-0.3%**
Net imports								
Imports[3]	11	11	0	0	0	0	0	-19.2%
Exports	97	75	70	70	74	87	94	0.9%
Total	**-86**	**-63**	**-70**	**-70**	**-74**	**-87**	**-94**	**1.6%**
Total supply[4]	**925**	**819**	**813**	**705**	**599**	**583**	**557**	**-1.5%**
Consumption by sector								
Commercial and institutional	2	3	2	2	2	2	2	-0.4%
Coke plants	20	19	14	16	16	15	14	-1.2%
Other industrial[5]	43	40	42	44	45	45	47	0.6%
Coal-to-liquids heat and power	0	0	0	0	0	0	0	- -
Coal to liquids production	0	0	0	0	0	0	0	- -
Electric power[6]	852	739	754	643	536	520	494	-1.6%
Total	**917**	**801**	**813**	**705**	**599**	**583**	**557**	**-1.4%**
Discrepancy and stock change[7]	**8**	**17**	**0**	**0**	**0**	**0**	**0**	**- -**
Average minemouth price[8]								
(2015 dollars per short ton)	35.2	33.8	33.6	34.0	33.8	37.6	38.7	0.5%
(2015 dollars per million Btu)	1.73	1.69	1.68	1.71	1.71	1.86	1.91	0.5%
Delivered prices[9]								
(2015 dollars per short ton)								
Commercial and institutional	91.2	85.6	85.0	86.0	85.7	87.2	89.2	0.2%
Coke plants	153.0	153.7	173.4	186.8	200.2	207.3	208.1	1.2%
Other industrial[5]	68.9	69.7	70.6	71.5	71.2	72.3	74.9	0.3%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electric power[6]								
(2015 dollars per short ton)	46.1	41.6	43.1	42.7	41.8	43.8	45.2	0.3%
(2015 dollars per million Btu)	2.38	2.19	2.26	2.26	2.26	2.32	2.38	0.3%
Average	**49.7**	**45.8**	**47.0**	**47.8**	**48.5**	**50.4**	**51.9**	**0.5%**
Exports[10]	85.3	86.7	84.0	81.7	81.2	84.8	83.9	-0.1%

Table A15. Coal supply, disposition, and prices *(continued)*
(million short tons, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Average minemouth price[8]								
(nominal dollars per short ton)	34.9	33.8	37.1	41.6	45.8	56.8	65.1	2.7%
(nominal dollars per million Btu)	1.71	1.69	1.86	2.09	2.31	2.81	3.21	2.6%
Delivered prices[9]								
(nominal dollars per short ton)								
Commercial and institutional	90.3	85.6	93.9	105.2	116.0	131.6	150.0	2.3%
Coke plants	151.4	153.7	191.6	228.7	270.9	313.1	350.2	3.3%
Other industrial[5]	68.2	69.7	78.0	87.5	96.3	109.2	126.0	2.4%
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -
Electric power[6]								
(nominal dollars per short ton)	45.7	41.6	47.6	52.3	56.5	66.1	76.0	2.4%
(nominal dollars per million Btu)	2.35	2.19	2.50	2.77	3.05	3.50	4.01	2.5%
Average	**49.2**	**45.8**	**51.9**	**58.6**	**65.5**	**76.1**	**87.3**	**2.6%**
Exports[10]	84.4	86.7	92.8	100.0	109.8	128.0	141.2	2.0%

[1]Includes anthracite, bituminous coal, subbituminous coal, and lignite.
[2]Includes waste coal consumed by the electric power and industrial sectors. Waste coal supplied is counted as a supply-side item to balance the same amount of waste coal included in the consumption data.
[3]Excludes imports to Puerto Rico and the U.S. Virgin Islands.
[4]Production plus waste coal supplied plus net imports.
[5]Includes consumption for combined heat and power plants that have a non-regulatory status, and small on-site generating systems. Excludes all coal use in the coal-to-liquids process.
[6]Includes all electricity-only and combined heat and power plants that have a regulatory status.
[7]Balancing item: the sum of production, net imports, and waste coal supplied minus total consumption.
[8]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[9]Prices weighted by consumption; weighted average excludes commercial and institutional prices, and export free-alongside-ship prices.
[10]Free-alongside-ship price at U.S. port of exit.
- - = Not applicable.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 data based on: U.S. Energy Information Administration (EIA), *Annual Coal Report 2013*; EIA, *Quarterly Coal Report, October-December 2014*; and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A16. Renewable energy generating capacity and generation
(gigawatts, unless otherwise noted)

Net summer capacity and generation	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Electric power sector[1]								
Net summer capacity								
Conventional hydroelectric power	79.0	79.2	79.8	80.0	80.1	80.1	80.4	0.1%
Geothermal[2]	2.5	2.5	3.1	4.5	5.6	6.7	7.2	4.3%
Municipal waste[3]	3.7	3.8	3.9	3.9	3.9	3.9	3.9	0.0%
Wood and other biomass[4]	3.4	3.4	3.6	3.6	3.6	3.7	4.1	0.7%
Solar thermal	1.9	2.0	2.5	2.5	2.5	2.5	2.5	0.8%
Solar photovoltaic[5]	8.4	11.7	25.5	52.5	67.6	117.6	155.6	10.9%
Wind	64.1	74.4	120.4	141.3	142.0	142.6	145.7	2.7%
Offshore wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	- -
Total electric power sector capacity	**163.0**	**177.1**	**238.7**	**288.2**	**305.2**	**357.0**	**399.4**	**3.3%**
Generation (billion kilowatthours)								
Conventional hydroelectric power	262.3	245.5	292.7	293.7	294.2	294.8	296.3	0.8%
Geothermal[2]	15.9	16.7	21.5	32.6	42.3	51.4	55.5	4.9%
Biogenic municipal waste[6]	17.6	19.4	20.9	20.8	20.8	21.7	21.9	0.5%
Wood and other biomass	15.1	6.2	9.4	13.1	14.8	13.8	17.7	4.3%
Dedicated plants	14.0	5.4	8.7	12.4	14.1	13.1	17.0	4.7%
Cofiring	1.1	0.7	0.7	0.7	0.7	0.7	0.7	-0.3%
Solar thermal	2.5	3.3	4.5	4.6	4.6	4.7	4.8	1.5%
Solar photovoltaic[5]	15.0	18.8	47.8	107.5	143.5	256.2	345.0	12.3%
Wind	180.9	187.5	364.5	449.9	453.1	456.0	468.3	3.7%
Offshore wind	0.0	0.0	0.1	0.1	0.1	0.1	0.1	- -
Total electric power sector generation	**509.2**	**497.4**	**761.4**	**922.2**	**973.4**	**1,098.6**	**1,209.5**	**3.6%**
End-use sectors[7]								
Net summer capacity								
Conventional hydroelectric power	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0%
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	- -
Municipal waste[8]	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0%
Biomass	4.7	4.7	4.7	4.9	5.0	5.0	5.0	0.3%
Solar photovoltaic[5]	8.6	11.2	28.7	41.0	55.1	71.5	88.3	8.6%
Wind	0.9	1.6	2.3	2.4	2.6	2.9	3.2	2.8%
Total end-use sector capacity	**15.0**	**18.4**	**36.6**	**49.1**	**63.6**	**80.3**	**97.4**	**6.9%**
Generation (billion kilowatthours)								
Conventional hydroelectric power	1.3	1.3	1.3	1.3	1.3	1.3	1.3	0.0%
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	- -
Municipal waste[8]	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0%
Biomass	26.1	26.0	25.9	26.6	27.4	27.4	27.6	0.2%
Solar photovoltaic[5]	11.8	15.5	40.2	58.1	78.7	102.7	127.2	8.8%
Wind	1.2	2.1	3.1	3.1	3.5	3.9	4.3	3.0%
Total end-use sector generation	**44.5**	**49.0**	**74.6**	**93.2**	**115.0**	**139.4**	**164.6**	**5.0%**

Table A16. Renewable energy generating capacity and generation *(continued)*

(gigawatts, unless otherwise noted)

Net summer capacity and generation	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Total, all sectors								
Net summer capacity								
Conventional hydroelectric power	79.3	79.5	80.1	80.3	80.3	80.4	80.7	0.1%
Geothermal	2.5	2.5	3.1	4.5	5.6	6.7	7.2	4.3%
Municipal waste	4.3	4.4	4.4	4.4	4.4	4.4	4.4	0.0%
Wood and other biomass[4]	8.1	8.1	8.3	8.4	8.6	8.7	9.1	0.5%
Solar[5]	18.9	24.9	56.6	95.9	125.3	191.6	246.4	9.6%
Wind	65.0	76.0	122.7	143.7	144.6	145.5	149.0	2.7%
Total capacity, all sectors	**178.1**	**195.4**	**275.3**	**337.3**	**368.8**	**437.3**	**496.8**	**3.8%**
Generation (billion kilowatthours)								
Conventional hydroelectric power	263.6	246.8	294.1	295.0	295.6	296.1	297.6	0.8%
Geothermal	15.9	16.7	21.5	32.6	42.3	51.4	55.5	4.9%
Municipal waste	21.7	23.5	25.0	24.9	24.9	25.8	26.0	0.4%
Wood and other biomass	41.2	32.1	35.3	39.7	42.2	41.2	45.2	1.4%
Solar[5]	29.3	37.6	92.5	170.1	226.8	363.6	477.1	10.7%
Wind	182.1	189.6	367.6	453.2	456.7	459.9	472.8	3.7%
Total generation, all sectors	**553.7**	**546.4**	**836.0**	**1,015.5**	**1,088.4**	**1,238.1**	**1,374.1**	**3.8%**

[1]Includes electricity-only and combined heat and power plants that have a regulatory status.
[2]Includes both hydrothermal resources (hot water and steam) and near-field enhanced geothermal systems (EGS). Near-field EGS potential occurs on known hydrothermal sites, however this potential requires the addition of external fluids for electricity generation and is only available after 2025.
[3]Includes municipal waste, landfill gas, and municipal sewage sludge. Incremental growth is assumed to be for landfill gas facilities. All municipal waste is included, although a portion of the municipal waste stream contains petroleum-derived plastics and other non-renewable sources.
[4]Facilities co-firing biomass and coal are classified as coal.
[5]Does not include off-grid photovoltaics (PV). Based on annual PV shipments from 1989 through 2015, EIA estimates that as much as 274 megawatts of remote electricity generation PV applications (i.e., off-grid power systems) were in service in 2015, plus an additional 573 megawatts in communications, transportation, and assorted other non-grid-connected, specialized applications. See U.S. Energy Information Administration, *Annual Energy Review 2011*, DOE/EIA-0384(2011) (Washington, DC, September 2012), Table 10.9 (annual PV shipments, 1989-2010), and Table 12 (U.S. photovoltaic module shipments by end use, sector, and type) in U.S. Energy Information Administration, *Solar Photovoltaic Cell/Module Shipments Report, 2011* (Washington, DC, September 2012) and U.S. Energy Information Administration, *Solar Photovoltaic Cell/Module Shipments Report, 2012* (Washington, DC, December 2013). The approach used to develop the estimate, based on shipment data, provides an upper estimate of the size of the PV stock, including both grid-based and off-grid PV. It will overestimate the size of the stock, because shipments include a substantial number of units that are exported, and each year some of the PV units installed earlier will be retired from service or abandoned.
[6]Includes biogenic municipal waste, landfill gas, and municipal sewage sludge. Incremental growth is assumed to be for landfill gas facilities. Only biogenic municipal waste is included. The U.S. Energy Information Administration estimates that in 2015 approximately 7 billion kilowatthours of electricity were generated from a municipal waste stream containing petroleum-derived plastics and other non-renewable sources. See U.S. Energy Information Administration, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy* (Washington, DC, May 2007).
[7]Includes combined heat and power plants and electricity-only plants in the commercial and industrial sectors that have a non-regulatory status; and small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
[8]Includes municipal waste, landfill gas, and municipal sewage sludge. All municipal waste is included, although a portion of the municipal waste stream contains petroleum-derived plastics and other non-renewable sources.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 capacity: U.S. Energy Information Administration (EIA), Form EIA-860, "Annual Electric Generator Report" (preliminary). 2014 generation: EIA, *Monthly Energy Review*, February 2016. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A17. Renewable energy consumption by sector and source
(quadrillion Btu per year)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Marketed renewable energy[1]								
Residential (wood)	**0.59**	**0.44**	**0.42**	**0.41**	**0.39**	**0.38**	**0.37**	**-0.7%**
Commercial (biomass)	**0.14**	**0.14**	**0.14**	**0.14**	**0.14**	**0.14**	**0.14**	**0.0%**
Industrial[2]	**2.26**	**2.26**	**2.30**	**2.39**	**2.47**	**2.52**	**2.63**	**0.6%**
Conventional hydroelectric power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0%
Municipal waste[3]	0.19	0.20	0.22	0.23	0.23	0.24	0.26	1.1%
Biomass	1.32	1.29	1.25	1.35	1.43	1.46	1.53	0.7%
Biofuels heat and coproducts	0.75	0.78	0.83	0.80	0.81	0.81	0.84	0.3%
Transportation	**1.30**	**1.38**	**1.53**	**1.48**	**1.47**	**1.50**	**1.59**	**0.6%**
Ethanol used in E85[4]	0.02	0.03	0.03	0.08	0.14	0.18	0.18	7.3%
Ethanol used in gasoline blending	1.09	1.12	1.12	1.01	0.94	0.93	1.01	-0.4%
Biodiesel used in distillate blending	0.19	0.22	0.30	0.19	0.19	0.19	0.19	-0.5%
Biobutanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Liquids from biomass	0.00	0.00	0.00	0.00	0.01	0.01	0.01	- -
Renewable diesel and gasoline[5]	0.00	0.00	0.08	0.19	0.19	0.19	0.19	17.9%
Electric power[6]	**5.01**	**4.86**	**7.37**	**8.91**	**9.41**	**10.60**	**11.67**	**3.6%**
Conventional hydroelectric power	2.50	2.34	2.79	2.80	2.81	2.81	2.83	0.8%
Geothermal	0.15	0.16	0.21	0.31	0.41	0.49	0.53	4.9%
Biogenic municipal waste[7]	0.24	0.25	0.28	0.28	0.28	0.29	0.29	0.6%
Biomass	0.23	0.10	0.15	0.21	0.24	0.22	0.27	3.9%
Dedicated plants	0.15	0.06	0.09	0.13	0.15	0.14	0.18	4.7%
Cofiring	0.08	0.05	0.06	0.08	0.09	0.08	0.09	2.7%
Solar thermal	0.02	0.03	0.04	0.04	0.04	0.04	0.05	1.5%
Solar photovoltaic	0.14	0.18	0.46	1.03	1.37	2.44	3.29	12.3%
Wind	1.73	1.79	3.43	4.24	4.27	4.30	4.41	3.7%
Total marketed renewable energy	**9.31**	**9.08**	**11.76**	**13.32**	**13.88**	**15.13**	**16.40**	**2.4%**
Sources of ethanol								
from corn and other starch	1.18	1.21	1.16	1.12	1.12	1.13	1.17	-0.1%
from cellulose	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.4%
Net imports	-0.07	-0.06	-0.01	-0.04	-0.04	-0.03	0.02	- -
Total	**1.11**	**1.15**	**1.15**	**1.09**	**1.09**	**1.11**	**1.20**	**0.2%**

Table A17. Renewable energy consumption by sector and source *(continued)*

(quadrillion Btu per year)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Nonmarketed renewable energy[8]								
Selected consumption								
Residential	**0.08**	**0.11**	**0.35**	**0.50**	**0.63**	**0.78**	**0.94**	**8.8%**
Solar hot water heating	0.01	0.01	0.01	0.02	0.02	0.02	0.02	3.4%
Geothermal heat pumps	0.01	0.01	0.02	0.02	0.02	0.02	0.02	2.8%
Solar photovoltaic	0.05	0.08	0.30	0.43	0.57	0.71	0.86	10.2%
Wind	0.01	0.02	0.03	0.03	0.03	0.03	0.03	2.0%
Commercial	**0.15**	**0.16**	**0.18**	**0.22**	**0.29**	**0.38**	**0.47**	**4.4%**
Solar thermal	0.08	0.09	0.09	0.10	0.10	0.11	0.11	1.0%
Solar photovoltaic	0.06	0.07	0.09	0.12	0.19	0.27	0.35	6.5%
Wind	0.00	0.00	0.00	0.00	0.00	0.01	0.01	9.0%

[1]Includes nonelectric renewable energy groups for which the energy source is bought and sold in the marketplace, although all transactions may not necessarily be marketed, and marketed renewable energy inputs for electricity entering the marketplace on the electric power grid. Excludes electricity imports; see Table A2. Actual heat rates used to determine fuel consumption for all renewable fuels except hydroelectric, geothermal, solar, and wind. Consumption at hydroelectric, solar, and wind facilities is determined by using the fossil fuel equivalent of 9,541 Btu per kilowatthour.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]Includes municipal waste, landfill gas, and municipal sewage sludge. All municipal waste is included, although a portion of the municipal waste stream contains petroleum-derived plastics and other non-renewable sources.
[4]Excludes motor gasoline component of E85.
[5]Renewable feedstocks for the on-site production of diesel and gasoline.
[6]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[7]Includes biogenic municipal waste, landfill gas, and municipal sewage sludge. Incremental growth is assumed to be for landfill gas facilities. Only biogenic municipal waste is included. The U.S. Energy Information Administration estimates that in 2015 approximately 0.3 quadrillion Btus were consumed from a municipal waste stream containing petroleum-derived plastics and other non-renewable sources. See U.S. Energy Information Administration, *Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy* (Washington, DC, May 2007).
[8]Includes selected renewable energy consumption data for which the energy is not bought or sold, either directly or indirectly as an input to marketed energy. The U.S. Energy Information Administration does not estimate or project total consumption of nonmarketed renewable energy.
- - = Not applicable.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 ethanol: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. 2014 electric power sector: EIA, Form EIA-860, "Annual Electric Generator Report" (preliminary). Other 2014 values: EIA, Office of Energy Analysis. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A18. Energy-related carbon dioxide emissions by sector and source
(million metric tons, unless otherwise noted)

Sector and source	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Residential								
Petroleum	69	64	59	53	49	45	41	-1.7%
Natural gas	278	253	258	256	255	253	251	0.0%
Electricity[1]	765	711	664	586	538	531	529	-1.2%
Total residential	**1,112**	**1,028**	**981**	**895**	**841**	**829**	**821**	**-0.9%**
Commercial								
Petroleum	39	47	50	49	49	48	47	0.0%
Natural gas	189	176	183	184	188	194	202	0.5%
Coal	5	6	5	5	5	5	5	-0.4%
Electricity[1]	735	690	654	599	566	569	572	-0.7%
Total commercial	**968**	**918**	**893**	**836**	**807**	**817**	**826**	**-0.4%**
Industrial[2]								
Petroleum	341	378	410	431	434	443	458	0.8%
Natural gas[3]	476	478	524	560	579	609	636	1.2%
Coal	138	130	120	128	131	130	131	0.0%
Electricity[1]	542	486	504	481	443	436	434	-0.5%
Total industrial	**1,497**	**1,472**	**1,558**	**1,600**	**1,587**	**1,618**	**1,660**	**0.5%**
Transportation								
Petroleum[4]	1,777	1,800	1,802	1,720	1,652	1,629	1,628	-0.4%
Natural gas[5]	48	51	49	55	62	74	93	2.4%
Electricity[1]	4	5	6	10	12	15	16	5.1%
Total transportation	**1,829**	**1,855**	**1,857**	**1,784**	**1,726**	**1,717**	**1,737**	**-0.3%**
Electric power[6]								
Petroleum	26	20	11	10	8	7	6	-4.4%
Natural gas	444	524	451	509	602	608	653	0.9%
Coal	1,570	1,340	1,360	1,150	943	930	885	-1.6%
Other[7]	6	6	6	6	6	6	6	0.0%
Total electric power	**2,046**	**1,891**	**1,829**	**1,675**	**1,559**	**1,551**	**1,551**	**-0.8%**
Total by fuel								
Petroleum[4]	2,252	2,309	2,332	2,262	2,191	2,171	2,181	-0.2%
Natural gas	1,434	1,482	1,466	1,563	1,685	1,737	1,835	0.9%
Coal	1,713	1,476	1,485	1,283	1,079	1,065	1,021	-1.5%
Other[7]	6	6	6	6	6	6	6	0.0%
Total	**5,406**	**5,273**	**5,289**	**5,115**	**4,961**	**4,980**	**5,044**	**-0.2%**
Carbon dioxide emissions (tons per person)	**16.9**	**16.4**	**15.8**	**14.7**	**13.8**	**13.4**	**13.3**	**-0.8%**

[1]Emissions from the electric power sector are distributed to the end-use sectors.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]Includes lease and plant fuel.
[4]This includes carbon dioxide from international bunker fuels, both civilian and military, which are excluded from the accounting of carbon dioxide emissions under the United Nations convention. From 1990 through 2015, international bunker fuels accounted for 90 to 126 million metric tons annually.
[5]Includes pipeline fuel natural gas and natural gas used as fuel in motor vehicles, trains, and ships.
[6]Includes electricity-only and combined heat and power plants that have a regulatory status.
[7]Includes emissions from geothermal power and nonbiogenic emissions from municipal waste.
Note: By convention, the direct emissions from biogenic energy sources are excluded from energy-related carbon dioxide emissions. The release of carbon from these sources is assumed to be balanced by the uptake of carbon when the feedstock is grown, resulting in zero net emissions over some period of time. If, however, increased use of biomass energy results in a decline in terrestrial carbon stocks, a net positive release of carbon may occur. See Table A19, "Energy-Related Carbon Dioxide Emissions by End Use", for the emissions from biogenic energy sources as an indication of the potential net release of carbon dioxide in the absence of offsetting sequestration. Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 emissions and emission factors: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A19. Energy-related carbon dioxide emissions by end use
(million metric tons)

Sector and end use	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Residential								
Space heating	314	262	263	248	237	230	223	-0.6%
Space cooling	104	120	104	94	89	90	92	-1.1%
Water heating	143	139	136	129	124	121	118	-0.6%
Refrigeration	57	53	47	41	37	36	36	-1.5%
Cooking	30	29	29	28	27	28	28	-0.1%
Clothes dryers	35	33	33	30	29	29	29	-0.5%
Freezers	12	11	10	8	7	7	6	-2.2%
Lighting	81	74	60	45	33	26	24	-4.4%
Clothes washers[1]	4	4	3	2	2	2	2	-3.4%
Dishwashers[1]	15	14	13	12	12	13	13	-0.3%
Televisions and related equipment[2]	48	42	36	31	29	31	32	-1.1%
Computers and related equipment[3]	18	17	13	10	8	7	5	-4.4%
Furnace fans and boiler circulation pumps	23	17	17	14	12	11	10	-2.0%
Other uses[4]	230	213	216	201	194	198	202	-0.2%
Discrepancy[5]	-3	0	0	0	0	0	0	-0.9%
Total residential	**1,112**	**1,028**	**981**	**895**	**841**	**829**	**821**	**-0.9%**
Commercial								
Space heating[6]	139	125	124	117	112	109	107	-0.6%
Space cooling[6]	78	85	75	67	61	60	60	-1.4%
Water heating[6]	44	44	43	42	43	44	45	0.1%
Ventilation	82	77	76	69	63	62	62	-0.9%
Cooking	14	14	15	15	15	16	16	0.5%
Lighting	141	131	121	103	90	81	75	-2.2%
Refrigeration	58	54	46	38	33	32	32	-2.1%
Office equipment (PC)	14	12	9	6	4	3	2	-6.3%
Office equipment (non-PC)	34	33	33	32	34	37	39	0.7%
Other uses[7]	362	343	352	349	352	372	389	0.5%
Total commercial	**968**	**918**	**893**	**836**	**807**	**817**	**826**	**-0.4%**
Industrial[8]								
Manufacturing								
Refining	261	257	247	238	233	235	241	-0.3%
Food products	99	94	97	96	97	100	104	0.4%
Paper products	79	72	65	65	64	61	60	-0.7%
Bulk chemicals	249	238	300	326	325	338	351	1.6%
Glass	15	16	17	17	17	17	17	0.1%
Cement and lime	24	24	30	32	32	34	38	1.8%
Iron and steel	115	108	94	106	105	104	107	0.0%
Aluminum	42	40	44	42	40	38	35	-0.5%
Fabricated metal products	33	33	31	29	27	28	29	-0.5%
Machinery	19	19	19	21	20	21	22	0.6%
Computers and electronics	19	18	18	17	17	18	19	0.3%
Transportation equipment	40	40	38	36	34	35	36	-0.4%
Electrical equipment	9	9	10	11	11	11	11	1.0%
Wood products	14	13	15	15	14	14	15	0.5%
Plastics	34	33	34	33	31	32	32	0.0%
Balance of manufacturing	137	131	127	122	117	116	116	-0.5%
Total manufacturing	**1,190**	**1,144**	**1,186**	**1,205**	**1,186**	**1,202**	**1,233**	**0.3%**
Nonmanufacturing								
Agriculture	86	85	82	79	76	74	72	-0.7%
Construction	69	64	83	83	81	82	82	1.0%
Mining	123	111	115	115	114	117	120	0.3%
Total nonmanufacturing	**277**	**261**	**281**	**277**	**271**	**272**	**274**	**0.2%**
Discrepancy[5]	29	67	92	117	130	144	153	3.3%
Total industrial	**1,497**	**1,472**	**1,558**	**1,600**	**1,587**	**1,618**	**1,660**	**0.5%**

Table A19. Energy-related carbon dioxide emissions by end use *(continued)*
(million metric tons)

Sector and end use	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Transportation								
Light-duty vehicles	1,043	1,050	1,040	929	837	785	759	-1.3%
Commercial light trucks[9]	54	54	55	53	51	51	52	-0.2%
Bus transportation	18	18	18	18	18	18	18	0.1%
Freight trucks	379	389	396	410	424	448	477	0.8%
Rail, passenger	6	5	5	5	5	5	5	0.0%
Rail, freight	34	34	34	36	35	33	33	-0.2%
Shipping, domestic	8	7	6	6	5	5	5	-1.5%
Shipping, international	49	55	48	50	52	54	56	0.1%
Recreational boats	16	17	18	19	19	20	20	0.7%
Air	166	168	178	189	200	207	212	0.9%
Military use	46	46	46	46	49	52	56	0.8%
Lubricants	5	5	5	5	5	5	5	0.2%
Pipeline fuel	46	47	44	47	50	53	57	0.7%
Discrepancy[5]	-40	-40	-37	-30	-24	-20	-17	-3.4%
Total transportation	**1,829**	**1,855**	**1,857**	**1,784**	**1,726**	**1,717**	**1,737**	**-0.3%**
Biogenic energy combustion[10]								
Biomass	214	185	184	198	206	205	216	0.6%
Electric power sector	21	10	14	19	22	20	25	3.9%
Other sectors	193	175	169	178	184	185	191	0.3%
Biogenic waste	22	23	25	25	25	26	27	0.6%
Biofuels heat and coproducts	70	73	77	75	76	76	79	0.3%
Ethanol	76	79	79	75	74	76	82	0.2%
Biodiesel	14	16	22	14	14	14	14	-0.5%
Liquids from biomass	0	0	0	0	0	1	1	- -
Renewable diesel and gasoline	0	0	6	14	14	14	14	17.9%
Total	**396**	**376**	**393**	**401**	**409**	**413**	**432**	**0.6%**

[1]Does not include water heating portion of load.
[2]Includes televisions, set-top boxes, home theater systems, DVD players, and video game consoles.
[3]Includes desktop and laptop computers, monitors, and networking equipment.
[4]Includes small electric devices, heating elements, outdoor grills, exterior lights, pool heaters, spa heaters, backup electricity generators, and motors not listed above. Electric vehicles are included in the transportation sector.
[5]Represents differences between total emissions by end-use and total emissions by fuel as reported in Table A18. Emissions by fuel may reflect benchmarking and other modeling adjustments to energy use and the associated emissions that are not assigned to specific end uses.
[6]Includes emissions related to fuel consumption for district services.
[7]Includes emissions related to (but not limited to) miscellaneous uses such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, water services, emergency generators, combined heat and power in commercial buildings, manufacturing performed in commercial buildings, and cooking (distillate), plus residual fuel oil, propane, coal, motor gasoline, kerosene, and marketed renewable fuels (biomass).
[8]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[9]Commercial trucks 8,501 to 10,000 pounds gross vehicle weight rating.
[10]By convention, the direct emissions from biogenic energy sources are excluded from energy-related carbon dioxide emissions. The release of carbon from these sources is assumed to be balanced by the uptake of carbon when the feedstock is grown, resulting in zero net emissions over some period of time. If, however, increased use of biomass energy results in a decline in terrestrial carbon stocks, a net positive release of carbon may occur. Accordingly, the emissions from biogenic energy sources are reported here as an indication of the potential net release of carbon dioxide in the absence of offsetting sequestration.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 emissions and emission factors: U.S. Energy Information Administration (EIA), *Monthly Energy Review*, February 2016. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A20. Macroeconomic indicators
(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Real gross domestic product	**15,962**	**16,349**	**18,555**	**20,765**	**23,113**	**25,598**	**28,397**	**2.2%**
Components of real gross domestic product								
Real consumption	10,876	11,221	12,861	14,348	16,092	17,881	19,870	2.3%
Real investment	2,718	2,842	3,513	4,068	4,520	5,051	5,661	2.8%
Real government spending	2,838	2,860	2,967	3,056	3,222	3,396	3,602	0.9%
Real exports	2,086	2,119	2,615	3,374	4,178	5,105	6,113	4.3%
Real imports	2,529	2,662	3,374	4,032	4,824	5,721	6,683	3.8%
Energy intensity								
(thousand Btu per 2009 dollar of GDP)								
Delivered energy	4.52	4.38	4.03	3.65	3.29	3.04	2.83	-1.7%
Total energy	6.15	5.92	5.42	4.89	4.39	4.06	3.77	-1.8%
Price indices								
GDP chain-type price index (2009=1.000)	1.09	1.10	1.21	1.34	1.49	1.66	1.85	2.1%
Consumer price index (1982-4=1.00)								
All-urban	2.37	2.37	2.65	2.99	3.35	3.78	4.27	2.4%
Energy commodities and services	2.43	2.02	2.41	2.87	3.34	3.92	4.61	3.4%
Wholesale price index (1982=1.00)								
All commodities	2.05	1.91	2.14	2.37	2.59	2.87	3.16	2.0%
Fuel and power	2.10	1.60	2.10	2.53	2.91	3.39	3.92	3.7%
Metals and metal products	2.15	2.01	2.15	2.35	2.55	2.80	3.06	1.7%
Industrial commodities excluding energy	1.98	1.94	2.13	2.33	2.53	2.76	3.01	1.8%
Interest rates (percent, nominal)								
Federal funds rate	0.09	0.13	3.32	3.22	3.24	3.23	3.08	- -
10-year treasury note	2.54	2.14	3.83	3.66	3.77	3.82	3.72	- -
AA utility bond rate	4.19	4.01	5.87	5.41	5.73	5.85	5.71	- -
Value of shipments (billion 2009 dollars)								
Non-industrial and service sectors	23,338	24,085	26,750	29,265	32,042	34,833	37,701	1.8%
Total industrial	7,165	7,229	8,351	9,146	9,776	10,562	11,483	1.9%
Agriculture, mining, and construction	1,957	1,931	2,493	2,620	2,710	2,828	2,955	1.7%
Manufacturing	5,208	5,299	5,858	6,527	7,066	7,734	8,528	1.9%
Energy-intensive	1,718	1,704	1,892	2,046	2,147	2,267	2,417	1.4%
Non-energy-intensive	3,490	3,594	3,967	4,481	4,920	5,467	6,111	2.1%
Total shipments	**30,504**	**31,314**	**35,101**	**38,411**	**41,818**	**45,396**	**49,184**	**1.8%**
Population and employment (millions)								
Population, with armed forces overseas	319	322	335	348	360	371	381	0.7%
Population, aged 16 and over	254	257	269	281	292	302	311	0.8%
Population, aged 65 and over	46	48	57	66	74	79	82	2.2%
Employment, nonfarm	138	142	150	156	161	165	170	0.7%
Employment, manufacturing	12.2	12.5	13.1	13.4	13.0	12.6	12.3	-0.1%
Key labor indicators								
Labor force (millions)	156	157	167	171	177	183	188	0.7%
Nonfarm labor productivity (2009=1.00)	1.05	1.06	1.15	1.25	1.37	1.50	1.63	1.7%
Unemployment rate (percent)	6.15	5.31	4.72	4.90	4.78	4.76	4.78	- -
Key indicators for energy demand								
Real disposable personal income	11,836	12,225	14,197	15,888	17,826	19,689	21,789	2.3%
Housing starts (millions)	1.06	1.18	1.74	1.71	1.66	1.66	1.65	1.3%
Commercial floorspace (billion square feet)	83.1	83.8	88.7	94.0	99.3	104.6	109.8	1.1%
Unit sales of light-duty vehicles (millions)	16.4	17.4	17.1	17.3	17.7	18.2	19.0	0.4%

GDP = Gross domestic product.
Btu = British thermal unit.
- - = Not applicable.
Sources: 2014 and 2015: IHS Economics, Industry and Employment models, November 2015. **Projections:** U.S. Energy Information Administration, AEO2016 National Energy Modeling System run ref2016.d032416a.

Table A21. International petroleum and other liquids supply, disposition, and prices
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Crude oil spot prices								
(2015 dollars per barrel)								
Brent	100	52	77	92	104	120	136	3.9%
West Texas Intermediate	94	49	71	85	97	112	129	4.0%
(nominal dollars per barrel)								
Brent	99	52	85	112	141	181	229	6.1%
West Texas Intermediate	93	49	79	105	131	170	217	6.2%
Petroleum and other liquids consumption[1]								
OECD								
United States (50 states)	19.16	19.42	20.11	19.90	19.54	19.69	20.14	0.1%
United States territories	0.30	0.30	0.31	0.32	0.34	0.36	0.38	1.0%
Canada	2.41	2.39	2.39	2.38	2.39	2.44	2.51	0.2%
Mexico and Chile	2.29	2.30	2.38	2.36	2.50	2.67	2.87	0.9%
OECD Europe[2]	13.66	13.83	13.70	13.57	13.65	13.79	13.98	0.0%
Japan	4.30	4.14	3.91	3.75	3.66	3.56	3.40	-0.8%
South Korea	2.35	2.38	2.41	2.42	2.44	2.48	2.55	0.3%
Australia and New Zealand	1.24	1.28	1.35	1.39	1.41	1.45	1.53	0.7%
Total OECD consumption	**45.71**	**46.03**	**46.56**	**46.08**	**45.93**	**46.44**	**47.35**	**0.1%**
Non-OECD								
Russia	3.56	3.35	3.65	3.79	3.75	3.73	3.59	0.3%
Other Europe and Eurasia[3]	2.04	2.07	2.18	2.34	2.43	2.48	2.53	0.8%
China	10.85	11.18	12.71	13.81	14.81	15.65	16.36	1.5%
India	3.78	3.97	4.54	5.19	5.94	6.97	8.26	3.0%
Other Asia[4]	8.04	8.15	9.40	10.35	11.42	12.73	14.29	2.3%
Middle East	8.13	8.29	9.96	10.42	11.28	12.31	13.23	1.9%
Africa	3.71	3.86	4.54	5.06	5.50	6.08	6.93	2.4%
Brazil	3.15	3.15	3.41	3.74	4.06	4.39	4.71	1.6%
Other Central and South America	3.83	3.85	4.11	4.28	4.41	4.60	4.89	1.0%
Total non-OECD consumption	**47.08**	**47.87**	**54.49**	**58.99**	**63.60**	**68.93**	**74.79**	**1.8%**
Total consumption	**92.79**	**93.90**	**101.05**	**105.06**	**109.52**	**115.37**	**122.14**	**1.1%**
Petroleum and other liquids production								
OPEC[5]								
Middle East	26.66	27.76	30.87	32.33	34.29	36.87	39.38	1.4%
North Africa	2.24	2.13	1.99	2.12	2.32	2.58	2.94	1.3%
West Africa	4.18	4.21	4.35	4.41	4.58	4.72	5.07	0.8%
South America	3.24	3.24	2.96	3.10	3.33	3.60	3.88	0.7%
Total OPEC production	**36.33**	**37.33**	**40.17**	**41.96**	**44.52**	**47.75**	**51.28**	**1.3%**
Non-OPEC								
OECD								
United States (50 states)	14.01	14.95	16.33	16.52	17.26	17.93	18.62	0.9%
Canada	4.39	4.54	5.43	5.39	5.55	5.73	6.01	1.1%
Mexico and Chile	2.84	2.64	2.46	2.56	2.58	2.83	3.24	0.8%
OECD Europe[2]	3.66	3.79	3.44	3.32	3.10	2.92	2.78	-1.2%
Japan and South Korea	0.22	0.22	0.20	0.21	0.21	0.22	0.22	0.0%
Australia and New Zealand	0.52	0.51	0.66	0.63	0.61	0.69	0.76	1.7%
Total OECD production	**25.63**	**26.65**	**28.51**	**28.63**	**29.31**	**30.32**	**31.63**	**0.7%**
Non-OECD								
Russia	10.85	10.95	10.62	10.99	11.22	11.51	12.21	0.4%
Other Europe and Eurasia[3]	3.21	3.23	3.69	4.34	4.63	4.68	4.50	1.3%
China	4.60	4.69	4.90	5.23	5.44	5.91	6.24	1.1%
Other Asia[4]	3.94	4.03	3.92	3.75	3.65	3.61	3.62	-0.4%
Middle East	1.17	1.14	1.02	0.91	0.83	0.76	0.69	-2.0%
Africa	2.33	2.33	2.48	2.58	2.73	2.79	2.83	0.8%
Brazil	2.97	3.15	3.59	4.59	5.00	5.46	6.15	2.7%
Other Central and South America	2.18	2.18	2.15	2.10	2.19	2.58	2.99	1.3%
Total non-OECD production	**31.25**	**31.70**	**32.37**	**34.48**	**35.69**	**37.30**	**39.23**	**0.9%**
Total petroleum and other liquids production	**93.21**	**95.68**	**101.05**	**105.06**	**109.52**	**115.37**	**122.14**	**1.0%**
OPEC market share (percent)	39.0	39.0	39.8	39.9	40.7	41.4	42.0	- -

Table A21. International petroleum and other liquids supply, disposition, and prices *(continued)*
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	Reference case							Annual growth 2015-2040 (percent)
	2014	2015	2020	2025	2030	2035	2040	
Selected world production subtotals:								
Crude oil and equivalents[6]	77.98	80.13	82.77	85.71	89.12	93.95	99.74	0.9%
Tight oil	4.69	5.34	5.44	5.85	6.96	8.50	10.35	2.7%
Bitumen[7]	2.25	2.32	3.08	3.12	3.18	3.24	3.31	1.4%
Refinery processing gain[8]	2.50	2.45	2.53	2.62	2.73	2.84	2.94	0.7%
Natural gas plant liquids	10.07	10.37	12.32	12.88	13.24	13.58	13.88	1.2%
Liquids from renewable sources[9]	2.26	2.32	2.54	2.88	3.31	3.71	4.11	2.3%
Liquids from coal[10]	0.20	0.25	0.27	0.16	0.26	0.36	0.50	2.8%
Liquids from natural gas[11]	0.27	0.29	0.32	0.52	0.57	0.62	0.65	3.3%
Liquids from kerogen[12]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.7%
Crude oil production[6]								
OPEC[5]								
Middle East	23.32	24.38	27.07	28.31	30.10	32.42	34.74	1.4%
North Africa	1.89	1.78	1.61	1.71	1.82	1.97	2.20	0.9%
West Africa	4.16	4.19	4.28	4.34	4.51	4.64	4.99	0.7%
South America	3.06	3.05	2.75	2.85	3.09	3.35	3.64	0.7%
Total OPEC production	**32.43**	**33.40**	**35.72**	**37.22**	**39.52**	**42.38**	**45.57**	**1.3%**
Non-OPEC								
OECD								
United States (50 states)	8.71	9.42	9.38	9.43	10.06	10.66	11.26	0.7%
Canada	3.61	3.72	4.57	4.42	4.53	4.69	4.96	1.2%
Mexico and Chile	2.48	2.31	2.16	2.27	2.29	2.55	2.96	1.0%
OECD Europe[2]	2.82	2.95	2.31	2.15	1.88	1.65	1.47	-2.7%
Japan and South Korea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.2%
Australia and New Zealand	0.39	0.39	0.53	0.51	0.49	0.56	0.64	1.9%
Total OECD production	**18.01**	**18.81**	**18.96**	**18.78**	**19.24**	**20.12**	**21.29**	**0.5%**
Non-OECD								
Russia	10.11	10.17	9.84	10.23	10.49	10.81	11.53	0.5%
Other Europe and Eurasia[3]	2.99	3.00	3.43	4.07	4.36	4.40	4.23	1.4%
China	4.20	4.28	4.34	4.46	4.40	4.63	4.67	0.3%
Other Asia[4]	3.10	3.18	2.98	2.73	2.52	2.38	2.25	-1.4%
Middle East	1.14	1.11	1.00	0.89	0.81	0.74	0.67	-2.0%
Africa	1.94	1.94	2.01	2.10	2.25	2.30	2.34	0.8%
Brazil	2.25	2.43	2.77	3.58	3.78	4.07	4.67	2.7%
Other Central and South America	1.80	1.81	1.72	1.65	1.75	2.12	2.52	1.3%
Total non-OECD production	**27.54**	**27.92**	**28.09**	**29.72**	**30.36**	**31.45**	**32.87**	**0.7%**
Total crude oil production[6]	**77.98**	**80.13**	**82.77**	**85.71**	**89.12**	**93.95**	**99.74**	**0.9%**
OPEC market share (percent)	41.6	41.7	43.2	43.4	44.3	45.1	45.7	- -

[1]Estimated consumption. Includes both OPEC and non-OPEC consumers in the regional breakdown.
[2]OECD Europe = Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.
[3]Other Europe and Eurasia = Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Macedonia, Malta, Moldova, Montenegro, Romania, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
[4]Other Asia = Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), Fiji, French Polynesia, Guam, Hong Kong, India (for production), Indonesia, Kiribati, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam.
[5]OPEC = Organization of the Petroleum Exporting Countries = Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
[6]Includes crude oil, lease condensate, tight oil (shale oil), extra-heavy oil, and bitumen (oil sands).
[7]Includes diluted and upgraded/synthetic bitumen (syncrude).
[8]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[9]Includes liquids produced from energy crops.
[10]Includes liquids converted from coal via the Fischer-Tropsch coal-to-liquids process.
[11]Includes liquids converted from natural gas via the Fischer-Tropsch gas-to-liquids process.
[12]Includes liquids produced from kerogen (oil shale, not to be confused with tight oil (shale oil)).
OECD = Organization for Economic Cooperation and Development.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2014 are model results and may differ from official EIA data reports.
Sources: 2014 Brent and West Texas Intermediate crude oil spot prices: Thomson Reuters. 2015: EIA, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System run ref2016.d032416a and EIA, Generate World Oil Balance application.

Appendix B
Economic growth case comparisons

Table B1. Total energy supply, disposition, and price summary
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Production										
Crude oil and lease condensate	19.7	19.5	19.6	19.6	20.8	21.0	21.2	23.3	23.5	23.8
Natural gas plant liquids	4.4	6.0	6.1	6.2	6.4	6.5	6.5	6.5	6.7	6.7
Dry natural gas	28.0	30.9	31.4	31.7	37.9	38.9	38.8	42.5	43.4	44.0
Coal[1]	17.2	16.6	17.5	18.5	13.6	13.3	13.7	13.3	13.1	13.8
Nuclear / uranium[2]	8.3	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.2
Conventional hydroelectric power	2.3	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9
Biomass[3]	4.1	4.2	4.2	4.4	4.3	4.4	4.7	4.1	4.6	5.4
Other renewable energy[4]	2.6	4.9	4.6	4.9	5.6	6.6	9.6	6.4	8.8	13.3
Other[5]	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.1
Total	**87.3**	**93.9**	**95.4**	**97.0**	**100.4**	**102.7**	**106.5**	**107.9**	**112.2**	**119.1**
Imports										
Crude oil	16.1	16.0	16.8	17.7	14.0	16.0	18.0	12.5	15.9	18.5
Petroleum and other liquids[6]	3.9	4.5	4.5	4.6	4.2	4.3	4.4	4.1	4.3	4.7
Natural gas[7]	2.8	2.1	2.1	2.2	1.5	1.6	1.6	1.4	1.4	1.5
Other imports[8]	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2
Total	**23.2**	**22.7**	**23.6**	**24.7**	**19.8**	**22.0**	**24.2**	**18.1**	**21.8**	**24.9**
Exports										
Petroleum and other liquids[9]	9.0	11.7	11.6	11.6	13.4	13.5	13.5	15.1	15.2	15.2
Natural gas[10]	1.8	5.0	5.0	5.0	8.1	7.6	7.2	9.7	9.0	8.3
Coal	2.0	1.9	1.9	1.9	1.9	1.9	1.8	2.3	2.3	2.3
Total	**12.8**	**18.5**	**18.5**	**18.4**	**23.4**	**23.0**	**22.5**	**27.1**	**26.6**	**25.8**
Discrepancy[11]	**1.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.2**	**0.3**	**0.3**	**0.3**
Consumption										
Petroleum and other liquids[12]	36.5	36.8	37.8	39.0	34.2	36.6	39.0	33.5	37.5	41.1
Natural gas	28.3	27.7	28.3	28.6	31.0	32.5	32.8	33.7	35.4	36.8
Coal[13]	15.5	14.6	15.6	16.5	11.7	11.3	11.9	10.9	10.7	11.4
Nuclear / uranium[2]	8.3	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.2
Conventional hydroelectric power	2.3	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9
Biomass[14]	2.8	2.7	2.8	2.9	2.8	3.0	3.3	2.8	3.1	3.8
Other renewable energy[4]	2.6	4.9	4.6	4.9	5.6	6.6	9.6	6.4	8.8	13.3
Other[15]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	**96.7**	**98.1**	**100.5**	**103.3**	**96.7**	**101.5**	**108.0**	**98.7**	**107.1**	**117.9**
Prices (2015 dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	52	76	77	77	102	104	106	133	136	139
West Texas Intermediate	49	70	71	72	96	97	99	125	129	132
Natural gas at Henry Hub (dollars per million Btu)	2.62	4.24	4.43	4.58	4.70	5.06	4.96	4.54	4.86	5.04
Coal (dollars per ton) at the minemouth[16]	33.8	33.9	33.6	33.9	34.1	33.8	34.0	39.7	38.7	40.0
Coal (dollars per million Btu) at the minemouth[16]	1.69	1.70	1.68	1.69	1.73	1.71	1.71	1.95	1.91	1.96
Average end-use[17]	2.37	2.42	2.43	2.48	2.58	2.55	2.62	2.70	2.68	2.79
Average electricity (cents per kilowatthour)	10.3	10.7	10.5	10.5	10.9	10.9	10.8	10.5	10.5	10.5

Table B1. Total energy supply, disposition, and price summary *(continued)*

(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Prices (nominal dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	52	86	85	84	160	141	140	294	229	230
West Texas Intermediate	49	80	79	78	150	131	131	276	217	218
Natural gas at Henry Hub (dollars per million Btu)	2.62	4.82	4.90	4.99	7.36	6.84	6.58	10.00	8.17	8.32
Coal (dollars per ton) at the minemouth[16]	33.8	38.5	37.1	37.0	53.4	45.8	45.0	87.4	65.1	66.1
Coal (dollars per million Btu) at the minemouth[16]	1.69	1.93	1.86	1.85	2.70	2.31	2.27	4.30	3.21	3.24
Average end-use[17]	2.37	2.75	2.69	2.70	4.04	3.45	3.47	5.95	4.50	4.62
Average electricity (cents per kilowatthour)	10.3	12.1	11.6	11.5	17.1	14.7	14.3	23.2	17.6	17.3

[1]Includes waste coal.
[2]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[3]Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table A17 for details.
[4]Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table A17 for selected nonmarketed residential and commercial renewable energy data.
[5]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.
[6]Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.
[7]Includes imports of liquefied natural gas that are later re-exported.
[8]Includes coal, coal coke (net), and electricity (net). Excludes imports of fuel used in nuclear power plants.
[9]Includes crude oil, petroleum products, ethanol, and biodiesel.
[10]Includes re-exported liquefied natural gas.
[11]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[12]Estimated consumption. Includes petroleum-derived fuels and non-petroleum derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel. Refer to Table A17 for detailed renewable liquid fuels consumption.
[13]Excludes coal converted to coal-based synthetic liquids and natural gas.
[14]Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.
[15]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[16]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[17]Prices weighted by consumption; weighted average excludes export free-alongside-ship (f.a.s.) prices.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowmacro.d032516a, ref2016.d032416a, and highmacro.d032516a.

Table B2. Energy consumption by sector and source
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Energy consumption										
Residential										
Propane	0.43	0.42	0.42	0.43	0.37	0.38	0.39	0.32	0.34	0.36
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Distillate fuel oil	0.50	0.43	0.43	0.43	0.34	0.34	0.34	0.27	0.27	0.27
Petroleum and other liquids subtotal	0.93	0.86	0.86	0.87	0.71	0.72	0.73	0.59	0.61	0.64
Natural gas	4.77	4.80	4.87	4.92	4.57	4.80	5.08	4.30	4.73	5.20
Renewable energy[1]	0.44	0.41	0.42	0.42	0.38	0.39	0.40	0.35	0.37	0.38
Electricity	4.78	4.64	4.76	4.85	4.53	4.83	5.21	4.66	5.20	5.90
Delivered energy	**10.92**	**10.72**	**10.90**	**11.05**	**10.18**	**10.74**	**11.42**	**9.91**	**10.91**	**12.12**
Electricity related losses	9.44	9.14	9.37	9.56	8.44	8.77	9.50	8.38	9.15	10.44
Total	**20.37**	**19.85**	**20.27**	**20.62**	**18.62**	**19.50**	**20.92**	**18.28**	**20.05**	**22.56**
Commercial										
Propane	0.17	0.18	0.18	0.18	0.19	0.19	0.20	0.19	0.20	0.21
Motor gasoline[2]	0.04	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
Kerosene	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	0.37	0.36	0.36	0.36	0.32	0.32	0.32	0.29	0.29	0.29
Residual fuel oil	0.07	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10
Petroleum and other liquids subtotal	0.66	0.70	0.70	0.71	0.67	0.68	0.69	0.65	0.67	0.68
Natural gas	3.32	3.45	3.45	3.45	3.51	3.53	3.60	3.77	3.81	3.87
Coal	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Renewable energy[3]	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Electricity	4.64	4.65	4.69	4.71	4.96	5.09	5.19	5.41	5.62	5.80
Delivered energy	**8.81**	**8.99**	**9.03**	**9.05**	**9.34**	**9.49**	**9.67**	**10.02**	**10.28**	**10.54**
Electricity related losses	9.16	9.15	9.23	9.29	9.24	9.23	9.47	9.72	9.89	10.28
Total	**17.97**	**18.14**	**18.26**	**18.34**	**18.58**	**18.72**	**19.13**	**19.74**	**20.17**	**20.82**
Industrial[4]										
Liquefied petroleum gases and other[5]	2.38	3.00	3.10	3.21	3.46	3.66	3.80	3.96	4.22	4.22
Motor gasoline[2]	0.27	0.27	0.28	0.28	0.26	0.27	0.28	0.26	0.27	0.29
Distillate fuel oil	1.34	1.36	1.44	1.51	1.33	1.44	1.53	1.35	1.47	1.60
Residual fuel oil	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.05	0.05	0.06
Petrochemical feedstocks	0.66	0.94	0.96	1.00	1.24	1.31	1.36	1.55	1.66	1.64
Other petroleum[6]	3.38	3.39	3.59	3.78	3.45	3.82	4.15	3.59	4.15	4.63
Petroleum and other liquids subtotal	8.07	9.00	9.40	9.82	9.80	10.55	11.19	10.75	11.82	12.45
Natural gas	7.75	8.35	8.55	8.84	8.67	9.13	9.78	9.16	9.89	10.93
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.63	1.73	1.76	1.77	2.02	2.06	2.06	2.26	2.31	2.33
Natural gas liquefaction for export[8]	0.00	0.26	0.26	0.26	0.57	0.53	0.49	0.75	0.69	0.62
Natural gas subtotal	9.38	10.34	10.57	10.87	11.25	11.72	12.33	12.16	12.89	13.89
Metallurgical coal	0.54	0.39	0.41	0.52	0.47	0.47	0.60	0.37	0.40	0.59
Other industrial coal	0.82	0.79	0.82	0.87	0.81	0.88	1.00	0.82	0.93	1.16
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	-0.03	-0.01	-0.03	-0.02	0.00	-0.01	0.00	0.01	0.02
Coal subtotal	1.34	1.16	1.23	1.36	1.26	1.35	1.59	1.19	1.34	1.78
Biofuels heat and coproducts	0.78	0.81	0.83	0.83	0.81	0.81	0.82	0.74	0.84	0.90
Renewable energy[9]	1.48	1.40	1.48	1.58	1.49	1.67	1.94	1.53	1.79	2.34
Electricity	3.27	3.45	3.61	3.82	3.69	3.98	4.36	3.86	4.26	4.90
Delivered energy	**24.33**	**26.16**	**27.11**	**28.28**	**28.31**	**30.07**	**32.25**	**30.23**	**32.94**	**36.26**
Electricity related losses	6.46	6.79	7.11	7.52	6.88	7.22	7.96	6.94	7.50	8.69
Total	**30.79**	**32.95**	**34.22**	**35.80**	**35.19**	**37.29**	**40.21**	**37.17**	**40.44**	**44.95**

Table B2. Energy consumption by sector and source *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2015	Projections 2020 Low economic growth	2020 Reference	2020 High economic growth	2030 Low economic growth	2030 Reference	2030 High economic growth	2040 Low economic growth	2040 Reference	2040 High economic growth
Transportation										
Propane	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03
Motor gasoline[2]	17.01	16.52	16.79	17.05	12.65	13.62	14.35	10.57	12.55	13.77
of which: E85[10]	0.05	0.04	0.04	0.04	0.33	0.22	0.19	0.36	0.28	0.30
Jet fuel[11]	2.84	2.92	2.99	3.06	3.18	3.32	3.49	3.40	3.56	3.74
Distillate fuel oil[12]	6.67	6.66	6.99	7.38	6.93	7.49	8.28	7.21	8.01	9.54
Residual fuel oil	0.45	0.36	0.37	0.38	0.40	0.42	0.43	0.42	0.45	0.49
Other petroleum[13]	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.16	0.17
Petroleum and other liquids subtotal	27.14	26.64	27.32	28.04	23.33	25.01	26.72	21.76	24.75	27.73
Pipeline fuel natural gas	0.89	0.82	0.83	0.84	0.91	0.94	0.95	1.04	1.07	1.10
Compressed / liquefied natural gas	0.07	0.08	0.08	0.09	0.16	0.17	0.18	0.57	0.59	0.73
Liquid hydrogen	0.00	0.01	0.01	0.01	0.04	0.04	0.05	0.05	0.06	0.07
Electricity	0.03	0.05	0.05	0.05	0.10	0.11	0.12	0.13	0.15	0.17
Delivered energy	**28.13**	**27.59**	**28.29**	**29.02**	**24.54**	**26.28**	**28.01**	**23.56**	**26.63**	**29.79**
Electricity related losses	0.06	0.09	0.09	0.09	0.19	0.20	0.21	0.24	0.27	0.29
Total	**28.19**	**27.68**	**28.38**	**29.11**	**24.74**	**26.48**	**28.23**	**23.80**	**26.90**	**30.08**
Unspecified sector[14]	**-0.58**	**-0.57**	**-0.58**	**-0.60**	**-0.41**	**-0.46**	**-0.50**	**-0.33**	**-0.42**	**-0.50**
Delivered energy consumption for all sectors										
Liquefied petroleum gases and other[5]	2.99	3.61	3.71	3.83	4.03	4.24	4.40	4.49	4.79	4.82
Motor gasoline[2]	16.96	16.28	16.55	16.80	12.55	13.49	14.21	10.54	12.47	13.66
of which: E85[10]	0.05	0.04	0.04	0.04	0.33	0.22	0.19	0.36	0.28	0.30
Jet fuel[11]	3.18	3.15	3.22	3.30	3.43	3.58	3.76	3.66	3.83	4.03
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.33	8.59	8.98	9.44	8.68	9.33	10.20	8.87	9.77	11.39
Residual fuel oil	0.56	0.51	0.52	0.53	0.55	0.57	0.59	0.56	0.60	0.65
Petrochemical feedstocks	0.66	0.94	0.96	1.00	1.24	1.31	1.36	1.55	1.66	1.64
Other petroleum[15]	3.54	3.55	3.75	3.94	3.61	3.98	4.32	3.74	4.31	4.80
Petroleum and other liquids subtotal	36.23	36.63	37.70	38.84	34.10	36.51	38.84	33.43	37.44	41.00
Natural gas	15.90	16.68	16.95	17.29	16.91	17.63	18.64	17.79	19.02	20.73
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.63	1.73	1.76	1.77	2.02	2.06	2.06	2.26	2.31	2.33
Pipeline natural gas	0.00	0.26	0.26	0.26	0.57	0.53	0.49	0.75	0.69	0.62
Natural gas liquefaction for export[8]	0.89	0.82	0.83	0.84	0.91	0.94	0.95	1.04	1.07	1.10
Natural gas subtotal	18.43	19.49	19.80	20.16	20.41	21.16	22.13	21.84	23.09	24.79
Metallurgical coal	0.54	0.39	0.41	0.52	0.47	0.47	0.60	0.37	0.40	0.59
Other coal	0.88	0.84	0.88	0.93	0.86	0.93	1.05	0.88	0.98	1.22
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	-0.03	-0.01	-0.03	-0.02	0.00	-0.01	0.00	0.01	0.02
Coal subtotal	1.40	1.21	1.28	1.42	1.32	1.40	1.65	1.24	1.39	1.83
Biofuels heat and coproducts	0.78	0.81	0.83	0.83	0.81	0.81	0.82	0.74	0.84	0.90
Renewable energy[16]	2.06	1.95	2.03	2.13	2.01	2.19	2.48	2.01	2.29	2.86
Liquid hydrogen	0.00	0.01	0.01	0.01	0.04	0.04	0.05	0.05	0.06	0.07
Electricity	12.72	12.78	13.11	13.42	13.28	14.01	14.88	14.07	15.23	16.77
Delivered energy	**71.62**	**72.89**	**74.75**	**76.81**	**71.96**	**76.12**	**80.85**	**73.38**	**80.34**	**88.21**
Electricity related losses	25.12	25.17	25.80	26.46	24.76	25.41	27.14	25.28	26.81	29.70
Total	**96.74**	**98.06**	**100.55**	**103.27**	**96.72**	**101.54**	**107.99**	**98.66**	**107.15**	**117.91**
Electric power[17]										
Distillate fuel oil	0.09	0.08	0.09	0.09	0.07	0.06	0.07	0.06	0.05	0.06
Residual fuel oil	0.17	0.06	0.06	0.06	0.04	0.04	0.05	0.03	0.03	0.03
Petroleum and other liquids subtotal	0.26	0.14	0.15	0.15	0.11	0.11	0.11	0.09	0.09	0.09
Natural gas	9.89	8.18	8.50	8.44	10.56	11.34	10.70	11.85	12.31	12.01
Steam coal	14.08	13.42	14.34	15.13	10.33	9.92	10.22	9.64	9.36	9.56
Nuclear / uranium[18]	8.34	8.12	8.12	8.12	8.25	8.25	8.25	8.25	8.25	8.25
Renewable energy[19]	4.86	7.67	7.37	7.62	8.40	9.41	12.34	9.15	11.67	16.18
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.19	0.19	0.19	0.20	0.17	0.17	0.17	0.15	0.15	0.15
Total	**37.85**	**37.95**	**38.90**	**39.89**	**38.04**	**39.42**	**42.02**	**39.35**	**42.04**	**46.47**

Table B2. Energy consumption by sector and source *(continued)*

(quadrillion Btu per year, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Total energy consumption										
Liquefied petroleum gases and other[5]	2.99	3.61	3.71	3.83	4.03	4.24	4.40	4.49	4.79	4.82
Motor gasoline[2]	16.96	16.28	16.55	16.80	12.55	13.49	14.21	10.54	12.47	13.66
of which: E85[10]	0.05	0.04	0.04	0.04	0.33	0.22	0.19	0.36	0.28	0.30
Jet fuel[11]	3.18	3.15	3.22	3.30	3.43	3.58	3.76	3.66	3.83	4.03
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.42	8.67	9.07	9.53	8.75	9.40	10.26	8.93	9.82	11.44
Residual fuel oil	0.73	0.57	0.58	0.59	0.59	0.62	0.64	0.59	0.64	0.68
Petrochemical feedstocks	0.66	0.94	0.96	1.00	1.24	1.31	1.36	1.55	1.66	1.64
Other petroleum[15]	3.54	3.55	3.75	3.94	3.61	3.98	4.32	3.74	4.31	4.80
Petroleum and other liquids subtotal	36.49	36.77	37.85	38.99	34.21	36.62	38.96	33.51	37.52	41.09
Natural gas	25.79	24.87	25.45	25.73	27.47	28.97	29.33	29.64	31.33	32.74
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lease and plant fuel[7]	1.63	1.73	1.76	1.77	2.02	2.06	2.06	2.26	2.31	2.33
Natural gas liquefaction for export[8]	0.00	0.26	0.26	0.26	0.57	0.53	0.49	0.75	0.69	0.62
Pipeline natural gas	0.89	0.82	0.83	0.84	0.91	0.94	0.95	1.04	1.07	1.10
Natural gas subtotal	28.31	27.67	28.30	28.60	30.96	32.51	32.83	33.69	35.39	36.80
Metallurgical coal	0.54	0.39	0.41	0.52	0.47	0.47	0.60	0.37	0.40	0.59
Other coal	14.96	14.26	15.22	16.06	11.20	10.86	11.28	10.52	10.34	10.78
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net coal coke imports	-0.02	-0.03	-0.01	-0.03	-0.02	0.00	-0.01	0.00	0.01	0.02
Coal subtotal	15.48	14.63	15.62	16.54	11.65	11.32	11.87	10.89	10.75	11.39
Nuclear / uranium[18]	8.34	8.12	8.12	8.12	8.25	8.25	8.25	8.25	8.25	8.25
Biofuels heat and coproducts	0.78	0.81	0.83	0.83	0.81	0.81	0.82	0.74	0.84	0.90
Renewable energy[20]	6.92	9.62	9.40	9.75	10.41	11.60	14.82	11.17	13.96	19.05
Liquid hydrogen	0.00	0.01	0.01	0.01	0.04	0.04	0.05	0.05	0.06	0.07
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.19	0.19	0.19	0.20	0.17	0.17	0.17	0.15	0.15	0.15
Total	**96.74**	**98.06**	**100.55**	**103.27**	**96.72**	**101.54**	**107.99**	**98.66**	**107.15**	**117.91**
Energy use and related statistics										
Delivered energy use	71.62	72.89	74.75	76.81	71.96	76.12	80.85	73.38	80.34	88.21
Total energy use	96.74	98.06	100.55	103.27	96.72	101.54	107.99	98.66	107.15	117.91
Ethanol consumed in motor gasoline and E85	1.18	1.17	1.19	1.20	1.12	1.12	1.16	1.12	1.24	1.35
Population (millions)	322	334	335	336	355	360	364	371	381	391
Gross domestic product (billion 2009 dollars)	16,349	17,576	18,555	19,499	20,749	23,113	25,606	24,511	28,397	32,967
Carbon dioxide emissions (million metric tons)	5,273	5,098	5,289	5,458	4,762	4,961	5,176	4,720	5,044	5,417

[1]Includes wood used for residential heating. See Table A4 and/or Table A17 for estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal water heating, and electricity generation from wind and solar photovoltaic sources.
[2]Includes ethanol and ethers blended into gasoline.
[3]Excludes ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. See Table A5 and/or Table A17 for estimates of nonmarketed renewable energy consumption for solar thermal water heating and electricity generation from wind and solar photovoltaic sources.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[5]Includes ethane, natural gasoline, and refinery olefins.
[6]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Represents natural gas used in well, field, and lease operations, and in natural gas processing plant machinery.
[8]Fuel used in facilities that liquefy natural gas for export.
[9]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Diesel fuel for on- and off- road use.
[13]Includes aviation gasoline and lubricants.
[14]Represents consumption unattributed to the sectors above.
[15]Includes aviation gasoline, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[16]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[17]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[18]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[19]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[20]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
Btu = British thermal unit.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowmacro.d032516a, ref2016.d032416a, and highmacro.d032516a.

Table B3. Energy prices by sector and source
(2015 dollars per million Btu, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Residential										
Propane	16.9	20.1	20.2	20.3	22.2	22.4	22.6	25.5	25.6	26.1
Distillate fuel oil	19.3	22.2	22.4	22.6	27.3	27.8	28.3	33.0	33.8	34.6
Natural gas	10.1	10.5	10.7	11.0	11.5	12.0	12.2	11.7	12.3	13.0
Electricity	36.3	38.5	37.7	37.7	40.0	39.4	39.0	38.9	38.1	37.8
Commercial										
Propane	15.1	17.9	17.9	18.0	19.7	19.8	20.0	22.5	22.5	23.0
Distillate fuel oil	17.0	19.5	19.7	19.9	24.1	24.4	24.9	29.8	30.5	31.3
Residual fuel oil	6.9	10.8	11.0	11.1	15.0	15.3	15.6	19.4	19.9	20.4
Natural gas	7.7	9.1	9.3	9.5	10.0	10.4	10.4	9.9	10.4	10.8
Electricity	30.6	31.7	31.5	31.7	32.3	32.3	32.4	30.8	30.7	31.1
Industrial[1]										
Propane	12.2	15.5	15.6	15.7	17.7	17.8	18.1	21.1	21.1	21.7
Distillate fuel oil	17.0	19.5	19.7	19.9	24.2	24.4	24.9	29.9	30.5	31.3
Residual fuel oil	6.8	11.1	11.3	11.4	15.7	15.9	16.2	20.0	20.6	21.1
Natural gas[2]	3.7	5.2	5.4	5.5	5.6	6.0	5.9	5.4	5.7	5.9
Metallurgical coal	5.4	6.0	6.0	6.1	7.0	7.0	7.0	7.2	7.3	7.3
Other industrial coal	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.6	3.6	3.7
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	20.3	21.0	20.9	21.0	21.7	22.1	22.1	21.0	21.2	21.6
Transportation										
Propane	18.0	21.2	21.2	21.4	23.3	23.4	23.7	26.6	26.6	27.2
E85[3]	23.3	31.7	32.0	31.6	27.4	30.8	31.7	30.1	35.0	36.0
Motor gasoline[4]	20.9	22.5	22.7	22.8	26.1	26.5	26.9	30.4	31.8	32.6
Jet fuel[5]	12.0	16.0	16.2	16.4	20.9	21.3	21.9	27.2	27.7	28.4
Diesel fuel (distillate fuel oil)[6]	19.8	22.9	23.1	23.3	27.8	28.0	28.5	33.4	34.1	34.8
Residual fuel oil	8.1	11.5	11.7	11.8	14.8	15.0	15.3	18.8	19.2	19.7
Natural gas[7]	16.6	16.4	16.6	16.9	15.0	15.5	15.6	15.3	15.9	16.3
Electricity	29.5	33.3	33.0	33.2	37.1	37.4	37.0	35.4	35.5	35.6
Electric power[8]										
Distillate fuel oil	15.0	18.2	18.4	18.7	23.0	23.5	24.0	28.6	29.4	30.2
Residual fuel oil	10.2	13.6	13.8	13.9	17.8	18.1	18.4	21.8	22.4	23.0
Natural gas	3.3	4.5	4.7	4.8	5.2	5.6	5.4	5.1	5.4	5.5
Steam coal	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.4
Average price to all users[9]										
Propane	14.9	18.0	18.0	18.1	20.0	20.1	20.3	23.1	23.2	23.7
E85[3]	23.3	31.7	32.0	31.6	27.4	30.8	31.7	30.1	35.0	36.0
Motor gasoline[4]	20.9	22.5	22.7	22.8	26.1	26.5	26.9	30.4	31.8	32.6
Jet fuel[5]	12.0	16.0	16.2	16.4	20.9	21.3	21.9	27.2	27.7	28.4
Distillate fuel oil	19.1	22.1	22.3	22.5	27.1	27.3	27.8	32.8	33.3	34.2
Residual fuel oil	8.4	11.6	11.7	11.8	15.1	15.4	15.7	19.1	19.6	20.1
Natural gas	5.3	6.6	6.7	6.9	7.1	7.4	7.4	7.0	7.4	7.7
Metallurgical coal	5.4	6.0	6.0	6.1	7.0	7.0	7.0	7.2	7.3	7.3
Other coal	2.3	2.3	2.3	2.4	2.4	2.4	2.4	2.5	2.5	2.6
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	30.1	31.3	30.8	30.8	32.0	31.9	31.7	30.8	30.6	30.7
Non-renewable energy expenditures by sector (billion 2015 dollars)										
Residential	239	247	250	256	251	266	284	249	274	309
Commercial	178	192	193	195	210	216	221	221	230	241
Industrial[1]	168	220	232	247	275	301	325	332	369	411
Transportation	514	566	586	605	585	640	697	660	777	894
Total non-renewable expenditures	1,099	1,225	1,260	1,302	1,321	1,423	1,526	1,462	1,650	1,855
Transportation renewable expenditures	1	1	1	1	9	7	6	11	10	11
Total expenditures	**1,100**	**1,226**	**1,262**	**1,303**	**1,330**	**1,430**	**1,532**	**1,472**	**1,660**	**1,866**

Table B3. Energy prices by sector and source *(continued)*
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Residential										
Propane	16.9	22.8	22.3	22.2	34.8	30.3	30.0	56.3	43.0	43.1
Distillate fuel oil	19.3	25.2	24.7	24.7	42.6	37.6	37.4	72.8	56.9	57.2
Natural gas	10.1	12.0	11.9	12.0	18.0	16.3	16.1	25.7	20.8	21.4
Electricity	36.3	43.7	41.7	41.1	62.5	53.3	51.7	85.8	64.2	62.4
Commercial										
Propane	15.1	20.3	19.8	19.7	30.8	26.8	26.5	49.6	37.9	38.0
Distillate fuel oil	17.0	22.1	21.8	21.7	37.7	33.1	33.0	65.6	51.2	51.6
Residual fuel oil	6.9	12.3	12.1	12.1	23.5	20.7	20.7	42.7	33.6	33.7
Natural gas	7.7	10.4	10.3	10.4	15.6	14.1	13.8	21.9	17.5	17.8
Electricity	30.6	36.0	34.8	34.5	50.5	43.7	42.9	67.8	51.7	51.4
Industrial[1]										
Propane	12.2	17.6	17.2	17.2	27.7	24.1	24.0	46.5	35.6	35.8
Distillate fuel oil	17.0	22.1	21.8	21.7	37.8	33.1	33.0	65.8	51.3	51.6
Residual fuel oil	6.8	12.6	12.4	12.4	24.5	21.6	21.5	44.2	34.7	34.8
Natural gas[2]	3.7	5.9	5.9	6.1	8.8	8.1	7.8	11.9	9.6	9.7
Metallurgical coal	5.4	6.9	6.7	6.6	10.9	9.4	9.2	15.9	12.2	12.0
Other industrial coal	3.4	3.9	3.7	3.7	5.4	4.6	4.5	7.9	6.0	6.1
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	20.3	23.8	23.1	23.0	34.0	29.9	29.3	46.2	35.7	35.7
Transportation										
Propane	18.0	24.0	23.4	23.3	36.4	31.7	31.3	58.6	44.8	44.9
E85[3]	23.3	36.0	35.4	34.4	42.9	41.7	42.0	66.3	58.8	59.5
Motor gasoline[4]	20.9	25.6	25.1	24.8	40.8	35.9	35.6	67.1	53.6	53.9
Jet fuel[5]	12.0	18.2	17.9	17.9	32.7	28.8	29.0	59.9	46.6	46.9
Diesel fuel (distillate fuel oil)[6]	19.8	26.0	25.5	25.4	43.5	37.9	37.7	73.7	57.3	57.5
Residual fuel oil	8.1	13.1	12.9	12.8	23.2	20.3	20.3	41.4	32.3	32.5
Natural gas[7]	16.6	18.6	18.4	18.5	23.5	21.0	20.6	33.7	26.7	26.9
Electricity	29.5	37.9	36.5	36.2	58.1	50.5	49.0	78.0	59.8	58.7
Electric power[8]										
Distillate fuel oil	15.0	20.7	20.4	20.4	35.9	31.8	31.8	63.1	49.4	49.9
Residual fuel oil	10.2	15.5	15.2	15.2	27.8	24.4	24.4	48.1	37.8	37.9
Natural gas	3.3	5.1	5.2	5.3	8.1	7.5	7.2	11.2	9.0	9.2
Steam coal	2.2	2.6	2.5	2.5	3.6	3.1	3.0	5.4	4.0	4.0

Table B3. Energy prices by sector and source *(continued)*
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Average price to all users[9]										
Propane	14.9	20.5	19.9	19.8	31.3	27.2	26.9	51.0	39.0	39.1
E85[3]	23.3	36.0	35.4	34.4	42.9	41.7	42.0	66.3	58.8	59.5
Motor gasoline[4]	20.9	25.6	25.1	24.8	40.8	35.9	35.6	67.1	53.6	53.8
Jet fuel[5]	12.0	18.2	17.9	17.9	32.7	28.8	29.0	59.9	46.6	46.9
Distillate fuel oil	19.1	25.1	24.7	24.6	42.3	36.9	36.8	72.2	56.1	56.5
Residual fuel oil	8.4	13.1	13.0	12.9	23.7	20.8	20.7	42.2	32.9	33.1
Natural gas	5.3	7.4	7.4	7.6	11.1	10.0	9.8	15.4	12.4	12.7
Metallurgical coal	5.4	6.9	6.7	6.6	10.9	9.4	9.2	15.9	12.2	12.0
Other coal	2.3	2.6	2.6	2.6	3.8	3.2	3.2	5.6	4.2	4.2
Coal to liquids	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Electricity	30.1	35.5	34.1	33.6	50.1	43.1	42.0	67.9	51.6	50.7
Non-renewable energy expenditures by sector (billion nominal dollars)										
Residential	239	281	276	279	393	360	376	548	462	510
Commercial	178	217	213	213	328	292	293	487	387	398
Industrial[1]	168	250	256	269	431	407	430	732	620	678
Transportation	514	643	647	659	915	866	923	1,455	1,307	1,477
Total non-renewable expenditures	1,099	1,391	1,392	1,420	2,066	1,925	2,022	3,223	2,776	3,063
Transportation renewable expenditures	1	2	1	1	14	9	8	24	17	18
Total expenditures	**1,100**	**1,393**	**1,394**	**1,422**	**2,081**	**1,934**	**2,030**	**3,246**	**2,793**	**3,081**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Excludes use for lease and plant fuel.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Kerosene-type jet fuel. Includes Federal and State taxes while excluding county and local taxes.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Natural gas used as fuel in motor vehicles, trains, and ships. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[8]Includes electricity-only and combined heat and power plants that have a regulatory status.
[9]Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
- - = Not applicable.
Note: Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowmacro.d032516a, ref2016.d032416a, and highmacro.d032516a.

Table B4. Macroeconomic indicators
(billion 2009 chain-weighted dollars, unless otherwise noted)

Indicators	2015	Projections								
		2020			2030			2040		
		Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth	Low economic growth	Reference	High economic growth
Real gross domestic product	**16,349**	**17,576**	**18,555**	**19,499**	**20,749**	**23,113**	**25,606**	**24,511**	**28,397**	**32,967**
Components of real gross domestic product										
Real consumption	11,221	12,197	12,861	13,436	14,356	16,092	17,863	16,827	19,870	22,954
Real investment	2,842	3,094	3,513	3,939	3,758	4,520	5,283	4,591	5,661	6,935
Real government spending	2,860	2,906	2,967	3,026	3,079	3,222	3,369	3,360	3,602	3,899
Real exports	2,119	2,475	2,615	2,733	3,635	4,178	4,692	4,954	6,113	7,595
Real imports	2,662	3,069	3,374	3,602	4,013	4,824	5,499	5,070	6,683	8,171
Energy intensity (thousand Btu per 2009 dollar of GDP)										
Delivered energy	4.38	4.15	4.03	3.94	3.47	3.29	3.16	2.99	2.83	2.68
Total energy	5.92	5.58	5.42	5.30	4.66	4.39	4.22	4.02	3.77	3.58
Price indices										
GDP chain-type price index (2009=1.000)	1.10	1.25	1.21	1.20	1.72	1.49	1.45	2.42	1.85	1.81
Consumer price index (1982-4=1.00)										
All-urban	2.37	2.73	2.65	2.62	3.88	3.35	3.27	5.62	4.27	4.18
Energy commodities and services	2.02	2.48	2.41	2.39	3.83	3.34	3.29	5.93	4.61	4.61
Wholesale price index (1982=1.00)										
All commodities	1.91	2.20	2.14	2.13	3.02	2.59	2.54	4.19	3.16	3.15
Fuel and power	1.60	2.14	2.10	2.10	3.30	2.91	2.87	5.04	3.92	3.96
Metals and metal products	2.01	2.20	2.15	2.18	2.93	2.55	2.55	3.92	3.06	3.24
Industrial commodities excluding energy	1.94	2.20	2.13	2.12	2.97	2.53	2.48	4.03	3.01	2.99
Interest rates (percent, nominal)										
Federal funds rate	0.13	4.91	3.32	2.88	6.10	3.24	2.97	6.20	3.08	3.12
10-year treasury note	2.14	5.55	3.83	3.44	6.66	3.77	3.50	6.87	3.72	3.53
AA utility bond rate	4.01	7.94	5.87	5.07	9.14	5.73	5.02	9.48	5.71	4.67
Value of shipments (billion 2009 dollars)										
Non-industrial and service sectors	24,085	25,327	26,750	28,025	28,651	32,042	35,673	32,130	37,701	44,520
Total industrial	7,229	7,861	8,351	8,889	8,969	9,776	10,707	10,365	11,483	13,187
Agriculture, mining, and construction	1,931	2,270	2,493	2,715	2,408	2,710	2,970	2,604	2,955	3,320
Manufacturing	5,299	5,591	5,858	6,174	6,561	7,066	7,736	7,761	8,528	9,868
Energy-intensive	1,704	1,829	1,892	1,965	2,018	2,147	2,315	2,222	2,417	2,682
Non-energy-intensive	3,594	3,763	3,967	4,208	4,543	4,920	5,421	5,539	6,111	7,186
Total shipments	**31,314**	**33,188**	**35,101**	**36,914**	**37,620**	**41,818**	**46,380**	**42,494**	**49,184**	**57,707**
Population and employment (millions)										
Population, with armed forces overseas	322	334	335	336	355	360	364	371	381	391
Population, aged 16 and over	257	269	269	270	288	292	295	304	311	319
Population, aged 65 and over	48	57	57	57	74	74	75	83	82	84
Employment, nonfarm	142	146	150	154	154	161	168	163	170	180
Employment, manufacturing	12.5	13.0	13.1	13.5	12.2	13.0	13.2	11.2	12.3	12.7
Key labor indicators										
Labor force (millions)	157	166	167	167	174	177	180	182	188	194
Non-farm labor productivity (2009=1.00)	1.06	1.11	1.15	1.18	1.28	1.37	1.43	1.46	1.63	1.74
Unemployment rate (percent)	5.31	5.12	4.72	4.66	4.98	4.78	4.53	5.01	4.78	4.33
Key indicators for energy demand										
Real disposable personal income	12,225	13,577	14,197	14,748	16,684	17,826	19,420	20,033	21,789	24,273
Housing starts (millions)	1.18	1.24	1.74	2.34	0.97	1.66	2.50	0.85	1.65	2.77
Commercial floorspace (billion square feet)	83.8	88.1	88.7	89.3	96.8	99.3	101.4	105.5	109.8	113.6
Unit sales of light-duty vehicles (millions)	17.4	15.7	17.1	18.3	15.5	17.7	18.7	14.8	19.0	21.3

GDP = Gross domestic product.
Btu = British thermal unit.
Sources: 2015: IHS Economics, Industry and Employment models, November 2015. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowmacro.d032516a, ref2016.d032416a, and highmacro.d032516a.

Price case comparisons

Table C1. Total energy supply, disposition, and price summary
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Production										
Crude oil and lease condensate	19.7	17.0	19.6	23.3	14.8	21.0	25.4	18.0	23.5	23.1
Natural gas plant liquids	4.4	5.8	6.1	6.4	5.8	6.5	6.9	6.1	6.7	7.0
Dry natural gas	28.0	30.1	31.4	31.8	35.6	38.9	41.8	40.0	43.4	48.0
Coal[1]	17.2	17.4	17.5	17.0	13.2	13.3	15.7	13.0	13.1	15.2
Nuclear / uranium[2]	8.3	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.2
Conventional hydroelectric power	2.3	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9
Biomass[3]	4.1	4.2	4.2	4.4	4.2	4.4	4.6	4.3	4.6	4.9
Other renewable energy[4]	2.6	4.4	4.6	5.5	6.2	6.6	8.7	8.6	8.8	10.8
Other[5]	0.5	0.8	0.9	0.9	0.8	0.9	0.9	0.9	1.0	1.0
Total	**87.3**	**90.6**	**95.4**	**100.2**	**91.7**	**102.7**	**115.2**	**101.9**	**112.2**	**121.2**
Imports										
Crude oil	16.1	15.8	16.8	15.8	17.3	16.0	13.5	18.9	15.9	16.7
Petroleum and other liquids[6]	3.9	5.1	4.5	4.2	5.7	4.3	3.6	5.8	4.3	3.4
Natural gas[7]	2.8	2.0	2.1	2.1	1.5	1.6	1.8	1.3	1.4	2.1
Other imports[8]	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.5
Total	**23.2**	**23.1**	**23.6**	**22.2**	**24.6**	**22.0**	**19.0**	**26.2**	**21.8**	**22.7**
Exports										
Petroleum and other liquids[9]	9.0	7.1	11.6	16.0	7.2	13.5	19.5	10.5	15.2	21.0
Natural gas[10]	1.8	4.2	5.0	5.0	5.5	7.6	10.8	6.9	9.0	12.7
Coal	2.0	1.9	1.9	1.7	2.1	1.9	1.7	2.4	2.3	1.9
Total	**12.8**	**13.1**	**18.5**	**22.7**	**14.7**	**23.0**	**32.0**	**19.8**	**26.6**	**35.6**
Discrepancy[11]	**1.0**	**0.1**	**0.0**	**-0.1**	**0.2**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**
Consumption										
Petroleum and other liquids[12]	36.5	38.8	37.8	36.3	38.4	36.6	33.7	40.5	37.5	33.9
Natural gas	28.3	27.7	28.3	28.6	31.3	32.5	31.5	34.0	35.4	35.3
Coal[13]	15.5	15.5	15.6	15.1	11.1	11.3	13.5	10.5	10.7	13.1
Nuclear / uranium[2]	8.3	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.2
Conventional hydroelectric power	2.3	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9
Biomass[14]	2.8	2.7	2.8	2.9	2.8	3.0	3.2	2.9	3.1	3.4
Other renewable energy[4]	2.6	4.4	4.6	5.5	6.2	6.6	8.7	8.6	8.8	10.8
Other[15]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	**96.7**	**100.5**	**100.5**	**99.7**	**101.4**	**101.5**	**102.0**	**108.1**	**107.1**	**108.0**
Prices (2015 dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	52	38	77	152	49	104	207	73	136	230
West Texas Intermediate	49	32	71	145	42	97	198	67	129	222
Natural gas at Henry Hub (dollars per million Btu)	2.62	3.85	4.43	4.40	4.65	5.06	7.92	4.54	4.86	7.74
Coal (dollars per ton) at the minemouth[16]	33.8	30.8	33.6	36.7	32.3	33.8	36.8	36.3	38.7	42.0
Coal (dollars per million Btu) at the minemouth[16]	1.69	1.57	1.68	1.82	1.63	1.71	1.86	1.80	1.91	2.08
Average end-use[17]	2.37	2.31	2.43	2.62	2.34	2.55	2.78	2.45	2.68	2.85
Average electricity (cents per kilowatthour)	10.3	10.3	10.5	10.6	10.6	10.9	11.6	10.3	10.5	11.3

Table C1. Total energy supply, disposition, and price summary *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Supply, disposition, and prices	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Prices (nominal dollars per unit)										
Crude oil spot prices (dollars per barrel)										
Brent	52	42	85	166	66	141	284	121	229	397
West Texas Intermediate	49	35	79	159	58	131	272	111	217	384
Natural gas at Henry Hub										
(dollars per million Btu)	2.62	4.25	4.90	4.83	6.31	6.84	10.90	7.54	8.17	13.36
Coal (dollars per ton)										
at the minemouth[16]	33.8	34.0	37.1	40.3	43.8	45.8	50.6	60.2	65.1	72.5
Coal (dollars per million Btu)										
at the minemouth[16]	1.69	1.73	1.86	1.99	2.21	2.31	2.55	2.99	3.21	3.59
Average end-use[17]	2.37	2.55	2.69	2.87	3.18	3.45	3.82	4.06	4.50	4.92
Average electricity (cents per kilowatthour)	10.3	11.4	11.6	11.7	14.4	14.7	16.0	17.1	17.6	19.5

[1]Includes waste coal.
[2]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[3]Includes grid-connected electricity from wood and wood waste; biomass, such as corn, used for liquid fuels production; and non-electric energy demand from wood. Refer to Table A17 for details.
[4]Includes grid-connected electricity from landfill gas; biogenic municipal waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and nonmarketed renewable energy. See Table A17 for selected nonmarketed residential and commercial renewable energy data.
[5]Includes non-biogenic municipal waste, liquid hydrogen, methanol, and some domestic inputs to refineries.
[6]Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, blending components, and renewable fuels such as ethanol.
[7]Includes imports of liquefied natural gas that are later re-exported.
[8]Includes coal, coal coke (net), and electricity (net). Excludes imports of fuel used in nuclear power plants.
[9]Includes crude oil, petroleum products, ethanol, and biodiesel.
[10]Includes re-exported liquefied natural gas.
[11]Balancing item. Includes unaccounted for supply, losses, gains, and net storage withdrawals.
[12]Estimated consumption. Includes petroleum-derived fuels and non-petroleum derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are hydrocarbon gas liquids and crude oil consumed as a fuel. Refer to Table A17 for detailed renewable liquid fuels consumption.
[13]Excludes coal converted to coal-based synthetic liquids and natural gas.
[14]Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and coproducts used in the production of liquid fuels, but excludes the energy content of the liquid fuels.
[15]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[16]Includes reported prices for both open market and captive mines. Prices weighted by production, which differs from average minemouth prices published in EIA data reports where it is weighted by reported sales.
[17]Prices weighted by consumption; weighted average excludes export free-alongside-ship (f.a.s.) prices.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowprice.d041916a, ref2016.d032416a, and highprice.d041916a.

Table C2. Energy consumption by sector and source
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Energy consumption										
Residential										
Propane	0.43	0.44	0.42	0.39	0.41	0.38	0.33	0.37	0.34	0.29
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Distillate fuel oil	0.50	0.46	0.43	0.39	0.37	0.34	0.30	0.30	0.27	0.24
Petroleum and other liquids subtotal	0.93	0.91	0.86	0.79	0.78	0.72	0.63	0.67	0.61	0.54
Natural gas	4.77	4.90	4.87	4.87	4.83	4.80	4.72	4.76	4.73	4.62
Renewable energy[1]	0.44	0.34	0.42	0.54	0.30	0.39	0.51	0.29	0.37	0.45
Electricity	4.78	4.80	4.76	4.70	4.89	4.83	4.72	5.26	5.20	5.04
Delivered energy	**10.92**	**10.95**	**10.90**	**10.90**	**10.81**	**10.74**	**10.58**	**10.99**	**10.91**	**10.65**
Electricity related losses	9.44	9.43	9.37	9.27	8.85	8.77	8.93	9.25	9.15	9.32
Total	**20.37**	**20.37**	**20.27**	**20.17**	**19.66**	**19.50**	**19.50**	**20.24**	**20.05**	**19.97**
Commercial										
Propane	0.17	0.20	0.18	0.15	0.22	0.19	0.16	0.23	0.20	0.18
Motor gasoline[2]	0.04	0.07	0.06	0.05	0.08	0.06	0.05	0.08	0.07	0.06
Kerosene	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00
Distillate fuel oil	0.37	0.40	0.36	0.31	0.38	0.32	0.27	0.34	0.29	0.25
Residual fuel oil	0.07	0.17	0.11	0.07	0.16	0.10	0.07	0.13	0.10	0.08
Petroleum and other liquids subtotal	0.66	0.84	0.70	0.58	0.84	0.68	0.56	0.79	0.67	0.57
Natural gas	3.32	3.49	3.45	3.47	3.59	3.53	3.41	3.85	3.81	3.60
Coal	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Renewable energy[3]	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Electricity	4.64	4.71	4.69	4.66	5.13	5.09	4.99	5.67	5.62	5.50
Delivered energy	**8.81**	**9.23**	**9.03**	**8.91**	**9.74**	**9.49**	**9.14**	**10.51**	**10.28**	**9.86**
Electricity related losses	9.16	9.25	9.23	9.19	9.29	9.23	9.43	9.97	9.89	10.16
Total	**17.97**	**18.48**	**18.26**	**18.09**	**19.03**	**18.72**	**18.58**	**20.48**	**20.17**	**20.01**
Industrial[4]										
Liquefied petroleum gases and other[5]	2.38	3.05	3.10	3.03	3.59	3.66	3.57	4.17	4.22	4.06
Motor gasoline[2]	0.27	0.27	0.28	0.28	0.26	0.27	0.26	0.27	0.27	0.26
Distillate fuel oil	1.34	1.50	1.44	1.39	1.46	1.44	1.38	1.49	1.47	1.38
Residual fuel oil	0.04	0.08	0.04	0.03	0.09	0.06	0.05	0.07	0.05	0.05
Petrochemical feedstocks	0.66	0.92	0.96	0.94	1.28	1.31	1.28	1.63	1.66	1.59
Other petroleum[6]	3.38	3.64	3.59	3.73	3.75	3.82	3.71	4.23	4.15	3.97
Petroleum and other liquids subtotal	8.07	9.46	9.40	9.39	10.42	10.55	10.26	11.85	11.82	11.31
Natural gas	7.75	7.84	8.55	8.71	8.50	9.13	9.17	9.47	9.89	9.72
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.08	0.00	0.00	0.84	0.00	0.00	1.60
Lease and plant fuel[7]	1.63	1.69	1.76	1.79	1.87	2.06	2.21	2.11	2.31	2.54
Natural gas liquefaction for export[8]	0.00	0.17	0.26	0.26	0.29	0.53	0.87	0.45	0.69	1.10
Natural gas subtotal	9.38	9.70	10.57	10.83	10.65	11.72	13.08	12.03	12.89	14.95
Metallurgical coal	0.54	0.40	0.41	0.50	0.34	0.47	0.50	0.30	0.40	0.33
Other industrial coal	0.82	0.80	0.82	0.86	0.81	0.88	0.91	0.84	0.93	0.97
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.75
Net coal coke imports	-0.02	-0.03	-0.01	-0.03	-0.02	0.00	-0.01	-0.01	0.01	0.00
Coal subtotal	1.34	1.17	1.23	1.34	1.13	1.35	2.05	1.13	1.34	2.04
Biofuels heat and coproducts	0.78	0.84	0.83	0.82	0.80	0.81	0.83	0.81	0.84	0.92
Renewable energy[9]	1.48	1.44	1.48	1.53	1.53	1.67	1.71	1.62	1.79	1.85
Electricity	3.27	3.54	3.61	3.71	3.77	3.98	4.05	4.08	4.26	4.28
Delivered energy	**24.33**	**26.16**	**27.11**	**27.62**	**28.31**	**30.07**	**31.99**	**31.51**	**32.94**	**35.37**
Electricity related losses	6.46	6.96	7.11	7.32	6.82	7.22	7.66	7.16	7.50	7.92
Total	**30.79**	**33.12**	**34.22**	**34.94**	**35.13**	**37.29**	**39.65**	**38.67**	**40.44**	**43.28**

Table C2. Energy consumption by sector and source *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Transportation										
Propane	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Motor gasoline[2]	17.01	17.51	16.79	15.39	15.55	13.62	11.48	15.18	12.55	10.19
of which: E85[10]	0.05	0.04	0.04	0.18	0.08	0.22	0.56	0.14	0.28	0.63
Jet fuel[11]	2.84	3.02	2.99	2.95	3.34	3.32	3.28	3.58	3.56	3.53
Distillate fuel oil[12]	6.67	6.97	6.99	7.04	7.30	7.49	7.10	8.24	8.01	7.28
Residual fuel oil	0.45	0.38	0.37	0.36	0.41	0.42	0.43	0.45	0.45	0.47
Other petroleum[13]	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Petroleum and other liquids subtotal	27.14	28.05	27.32	25.91	26.77	25.01	22.46	27.64	24.75	21.66
Pipeline fuel natural gas	0.89	0.80	0.83	0.85	0.86	0.94	1.07	0.94	1.07	1.27
Compressed / liquefied natural gas	0.07	0.08	0.08	0.13	0.07	0.17	0.75	0.09	0.59	1.58
Liquid hydrogen	0.00	0.01	0.01	0.01	0.05	0.04	0.04	0.07	0.06	0.05
Electricity	0.03	0.05	0.05	0.05	0.11	0.11	0.11	0.16	0.15	0.15
Delivered energy	**28.13**	**28.98**	**28.29**	**26.95**	**27.86**	**26.28**	**24.43**	**28.90**	**26.63**	**24.72**
Electricity related losses	0.06	0.09	0.09	0.10	0.21	0.20	0.21	0.29	0.27	0.28
Total	**28.19**	**29.07**	**28.38**	**27.04**	**28.07**	**26.48**	**24.64**	**29.19**	**26.90**	**25.00**
Unspecified sector[14]	**-0.58**	**-0.60**	**-0.58**	**-0.53**	**-0.52**	**-0.46**	**-0.36**	**-0.52**	**-0.42**	**-0.30**
Delivered energy consumption for all Sectors										
Liquefied petroleum gases and other[5]	2.99	3.69	3.71	3.57	4.22	4.24	4.07	4.79	4.79	4.55
Motor gasoline[2]	16.96	17.25	16.55	15.20	15.35	13.49	11.42	15.01	12.47	10.18
of which: E85[10]	0.05	0.04	0.04	0.18	0.08	0.22	0.56	0.14	0.28	0.63
Jet fuel[11]	3.18	3.26	3.22	3.17	3.60	3.58	3.53	3.85	3.83	3.80
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.33	9.09	8.98	8.89	9.26	9.33	8.82	10.09	9.77	8.91
Residual fuel oil	0.56	0.63	0.52	0.46	0.66	0.57	0.55	0.65	0.60	0.60
Petrochemical feedstocks	0.66	0.92	0.96	0.94	1.28	1.31	1.28	1.63	1.66	1.59
Other petroleum[15]	3.54	3.81	3.75	3.88	3.91	3.98	3.87	4.39	4.31	4.13
Petroleum and other liquids subtotal	36.23	38.66	37.70	36.14	38.29	36.51	33.55	40.43	37.44	33.77
Natural gas	15.90	16.30	16.95	17.19	16.99	17.63	18.04	18.18	19.02	19.51
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.08	0.00	0.00	0.84	0.00	0.00	1.60
Lease and plant fuel[7]	1.63	1.69	1.76	1.79	1.87	2.06	2.21	2.11	2.31	2.54
Natural gas liquefaction for export[8]	0.00	0.17	0.26	0.26	0.29	0.53	0.87	0.45	0.69	1.10
Pipeline natural gas	0.89	0.80	0.83	0.85	0.86	0.94	1.07	0.94	1.07	1.27
Natural gas subtotal	18.43	18.96	19.80	20.17	20.00	21.16	23.02	21.67	23.09	26.02
Metallurgical coal	0.54	0.40	0.41	0.50	0.34	0.47	0.50	0.30	0.40	0.33
Other coal	0.88	0.85	0.88	0.91	0.86	0.93	0.97	0.90	0.98	1.02
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.75
Net coal coke imports	-0.02	-0.03	-0.01	-0.03	-0.02	0.00	-0.01	-0.01	0.01	0.00
Coal subtotal	1.40	1.23	1.28	1.39	1.18	1.40	2.11	1.19	1.39	2.10
Biofuels heat and coproducts	0.78	0.84	0.83	0.82	0.80	0.81	0.83	0.81	0.84	0.92
Renewable energy[16]	2.06	1.92	2.03	2.20	1.97	2.19	2.36	2.05	2.29	2.44
Liquid hydrogen	0.00	0.01	0.01	0.01	0.05	0.04	0.04	0.07	0.06	0.05
Electricity	12.72	13.10	13.11	13.12	13.90	14.01	13.87	15.18	15.23	14.97
Delivered energy	**71.62**	**74.73**	**74.75**	**73.85**	**76.20**	**76.12**	**75.77**	**81.40**	**80.34**	**80.28**
Electricity related losses	25.12	25.73	25.80	25.88	25.17	25.41	26.23	26.66	26.81	27.68
Total	**96.74**	**100.45**	**100.55**	**99.72**	**101.38**	**101.54**	**102.01**	**108.05**	**107.15**	**107.96**
Electric power[17]										
Distillate fuel oil	0.09	0.09	0.09	0.08	0.06	0.06	0.07	0.05	0.05	0.06
Residual fuel oil	0.17	0.06	0.06	0.06	0.04	0.04	0.04	0.03	0.03	0.03
Petroleum and other liquids subtotal	0.26	0.15	0.15	0.14	0.11	0.11	0.11	0.09	0.09	0.09
Natural gas	9.89	8.76	8.50	8.40	11.33	11.34	8.44	12.30	12.31	9.28
Steam coal	14.08	14.25	14.34	13.74	9.94	9.92	11.36	9.36	9.36	10.97
Nuclear / uranium[18]	8.34	8.12	8.12	8.12	8.25	8.25	8.25	8.25	8.25	8.25
Renewable energy[19]	4.86	7.13	7.37	8.17	9.05	9.41	11.55	11.47	11.67	13.70
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.19	0.19	0.19	0.19	0.17	0.17	0.17	0.15	0.15	0.15
Total	**37.85**	**38.83**	**38.90**	**39.00**	**39.08**	**39.42**	**40.10**	**41.84**	**42.04**	**42.65**

Table C2. Energy consumption by sector and source *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Total energy consumption										
Liquefied petroleum gases and other[5]	2.99	3.69	3.71	3.57	4.22	4.24	4.07	4.79	4.79	4.55
Motor gasoline[2]	16.96	17.25	16.55	15.20	15.35	13.49	11.42	15.01	12.47	10.18
of which: E85[10]	0.05	0.04	0.04	0.18	0.08	0.22	0.56	0.14	0.28	0.63
Jet fuel[11]	3.18	3.26	3.22	3.17	3.60	3.58	3.53	3.85	3.83	3.80
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distillate fuel oil	8.42	9.18	9.07	8.98	9.33	9.40	8.88	10.14	9.82	8.97
Residual fuel oil	0.73	0.69	0.58	0.52	0.70	0.62	0.59	0.68	0.64	0.63
Petrochemical feedstocks	0.66	0.92	0.96	0.94	1.28	1.31	1.28	1.63	1.66	1.59
Other petroleum[15]	3.54	3.81	3.75	3.88	3.91	3.98	3.87	4.39	4.31	4.13
Petroleum and other liquids subtotal	36.49	38.81	37.85	36.28	38.40	36.62	33.66	40.52	37.52	33.86
Natural gas	25.79	25.06	25.45	25.59	28.32	28.97	26.47	30.48	31.33	28.79
Natural-gas-to-liquids heat and power	0.00	0.00	0.00	0.08	0.00	0.00	0.84	0.00	0.00	1.60
Lease and plant fuel[7]	1.63	1.69	1.76	1.79	1.87	2.06	2.21	2.11	2.31	2.54
Natural gas liquefaction for export[8]	0.00	0.17	0.26	0.26	0.29	0.53	0.87	0.45	0.69	1.10
Pipeline natural gas	0.89	0.80	0.83	0.85	0.86	0.94	1.07	0.94	1.07	1.27
Natural gas subtotal	28.31	27.72	28.30	28.57	31.33	32.51	31.46	33.98	35.39	35.30
Metallurgical coal	0.54	0.40	0.41	0.50	0.34	0.47	0.50	0.30	0.40	0.33
Other coal	14.96	15.10	15.22	14.65	10.81	10.86	12.33	10.26	10.34	11.99
Coal-to-liquids heat and power	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.75
Net coal coke imports	-0.02	-0.03	-0.01	-0.03	-0.02	0.00	-0.01	-0.01	0.01	0.00
Coal subtotal	15.48	15.48	15.62	15.13	11.13	11.32	13.47	10.55	10.75	13.06
Nuclear / uranium[18]	8.34	8.12	8.12	8.12	8.25	8.25	8.25	8.25	8.25	8.25
Biofuels heat and coproducts	0.78	0.84	0.83	0.82	0.80	0.81	0.83	0.81	0.84	0.92
Renewable energy[20]	6.92	9.05	9.40	10.38	11.02	11.60	13.90	13.52	13.96	16.14
Liquid hydrogen	0.00	0.01	0.01	0.01	0.05	0.04	0.04	0.07	0.06	0.05
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Electricity imports	0.19	0.19	0.19	0.19	0.17	0.17	0.17	0.15	0.15	0.15
Total	**96.74**	**100.45**	**100.55**	**99.72**	**101.38**	**101.54**	**102.01**	**108.05**	**107.15**	**107.96**
Energy use and related statistics										
Delivered energy use	71.62	74.73	74.75	73.85	76.20	76.12	75.77	81.40	80.34	80.28
Total energy use	96.74	100.45	100.55	99.72	101.38	101.54	102.01	108.05	107.15	107.96
Ethanol consumed in motor gasoline and E85	1.18	1.22	1.19	1.18	1.13	1.12	1.17	1.14	1.24	1.06
Population (millions)	322	335	335	335	360	360	360	381	381	381
Gross domestic product (billion 2009 dollars)	16,349	18,768	18,555	18,420	23,076	23,113	23,021	28,506	28,397	28,246
Carbon dioxide emissions (million metric tons)	5,273	5,327	5,289	5,145	5,018	4,961	4,888	5,181	5,044	5,001

[1]Includes wood used for residential heating. See Table A4 and/or Table A17 for estimates of nonmarketed renewable energy consumption for geothermal heat pumps, solar thermal water heating, and electricity generation from wind and solar photovoltaic sources.
[2]Includes ethanol and ethers blended into gasoline.
[3]Excludes ethanol. Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. See Table A5 and/or Table A17 for estimates of nonmarketed renewable energy consumption for solar thermal water heating and electricity generation from wind and solar photovoltaic sources.
[4]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[5]Includes ethane, natural gasoline, and refinery olefins.
[6]Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Represents natural gas used in well, field, and lease operations, and in natural gas processing plant machinery.
[8]Fuel used in facilities that liquefy natural gas for export.
[9]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Diesel fuel for on- and off- road use.
[13]Includes aviation gasoline and lubricants.
[14]Represents consumption unattributed to the sectors above.
[15]Includes aviation gasoline, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[16]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[17]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[18]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[19]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[20]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
Btu = British thermal unit.
Note: Includes estimated consumption for petroleum and other liquids. Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowprice.d041916a, ref2016.d032416a, and highprice.d041916a.

Table C3. Energy prices by sector and source
(2012 dollars per million Btu, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil Price	Reference	High oil price
Residential										
Propane	16.9	16.1	20.2	29.2	17.0	22.4	33.6	19.4	25.6	34.5
Distillate fuel oil	19.3	14.9	22.4	36.4	17.2	27.8	46.7	21.8	33.8	50.9
Natural gas	10.1	10.3	10.7	10.6	11.6	12.0	13.6	11.9	12.3	14.4
Electricity	36.3	36.9	37.7	38.4	38.2	39.4	42.1	37.3	38.1	40.9
Commercial										
Propane	15.1	14.4	17.9	25.6	15.1	19.8	29.5	17.2	22.5	30.3
Distillate fuel oil	17.0	12.2	19.7	33.7	13.9	24.4	43.4	18.5	30.5	47.6
Residual fuel oil	6.9	4.6	11.0	21.8	6.6	15.3	30.1	10.9	19.9	33.5
Natural gas	7.7	8.9	9.3	9.1	9.9	10.4	12.0	10.0	10.4	12.4
Electricity	30.6	30.9	31.5	31.8	31.3	32.3	34.7	30.0	30.7	33.4
Industrial[1]										
Propane	12.2	11.4	15.6	24.8	12.3	17.8	29.4	14.8	21.1	30.3
Distillate fuel oil	17.0	12.2	19.7	33.6	13.9	24.4	43.4	18.5	30.5	47.6
Residual fuel oil	6.8	4.9	11.3	22.0	7.3	15.9	30.8	11.6	20.6	34.1
Natural gas[2]	3.7	5.0	5.4	5.2	5.6	6.0	7.7	5.4	5.7	7.5
Metallurgical coal	5.4	6.0	6.0	6.0	7.0	7.0	7.0	7.3	7.3	7.3
Other industrial coal	3.4	3.3	3.4	3.6	3.2	3.4	3.7	3.3	3.6	3.9
Coal to liquids	- -	- -	- -	- -	- -	- -	2.0	- -	- -	2.1
Electricity	20.3	20.5	20.9	21.1	21.4	22.1	24.0	20.8	21.2	23.5
Transportation										
Propane	18.0	17.1	21.2	30.2	18.0	23.4	34.7	20.4	26.6	35.6
E85[3]	23.3	24.1	32.0	38.1	25.4	30.8	39.3	28.5	35.0	42.2
Motor gasoline[4]	20.9	16.1	22.7	35.6	16.9	26.5	43.0	21.0	31.8	47.0
Jet fuel[5]	12.0	8.6	16.2	29.6	10.9	21.3	40.1	16.0	27.7	44.7
Diesel fuel (distillate fuel oil)[6]	19.8	15.7	23.1	37.0	17.5	28.0	46.9	22.0	34.1	51.2
Residual fuel oil	8.1	4.9	11.7	21.6	5.6	15.0	28.3	10.9	19.2	31.2
Natural gas[7]	16.6	16.4	16.6	16.4	16.1	15.5	18.8	15.5	15.9	18.5
Electricity	29.5	32.5	33.0	33.5	36.5	37.4	39.5	35.0	35.5	37.9
Electric power[8]										
Distillate fuel oil	15.0	10.9	18.4	32.4	12.9	23.5	42.5	17.4	29.4	46.6
Residual fuel oil	10.2	7.4	13.8	24.6	9.4	18.1	32.9	13.4	22.4	36.0
Natural gas	3.3	4.4	4.7	4.5	5.2	5.6	7.1	5.0	5.4	7.1
Steam coal	2.2	2.1	2.3	2.4	2.1	2.3	2.6	2.2	2.4	2.7
Average price to all users[9]										
Propane	14.9	13.9	18.0	26.9	14.8	20.1	31.1	17.1	23.2	31.9
E85[3]	23.3	24.1	32.0	38.1	25.4	30.8	39.3	28.5	35.0	42.2
Motor gasoline[4]	20.9	16.1	22.7	35.6	16.9	26.5	43.0	21.0	31.8	47.0
Jet fuel[5]	12.0	8.6	16.2	29.6	10.9	21.3	40.1	16.0	27.7	44.7
Distillate fuel oil	19.1	14.8	22.3	36.3	16.7	27.3	46.2	21.4	33.3	50.5
Residual fuel oil	8.4	5.0	11.7	22.0	6.3	15.4	29.0	11.1	19.6	31.9
Natural gas	5.3	6.4	6.7	6.6	7.0	7.4	9.4	6.9	7.4	9.6
Metallurgical coal	5.4	6.0	6.0	6.0	7.0	7.0	7.0	7.3	7.3	7.3
Other coal	2.3	2.2	2.3	2.5	2.2	2.4	2.7	2.3	2.5	2.8
Coal to liquids	- -	- -	- -	- -	- -	- -	2.0	- -	- -	2.1
Electricity	30.1	30.3	30.8	31.1	31.1	31.9	34.1	30.1	30.6	33.1
Non-renewable energy expenditures by sector (billion 2015 dollars)										
Residential	239	242	250	258	256	266	288	267	274	296
Commercial	178	186	193	198	208	216	235	223	230	251
Industrial[1]	168	184	232	309	222	301	444	275	369	509
Transportation	514	411	586	885	426	640	956	559	777	1,023
Total non-renewable expenditures	1,099	1,023	1,260	1,650	1,112	1,423	1,923	1,324	1,650	2,079
Transportation renewable expenditures	1	1	1	7	2	7	22	4	10	26
Total expenditures	**1,100**	**1,024**	**1,262**	**1,657**	**1,114**	**1,430**	**1,945**	**1,328**	**1,660**	**2,106**

Table C3. Energy prices by sector and source *(continued)*
(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Residential										
Propane	16.9	17.8	22.3	32.0	23.1	30.3	46.3	32.2	43.0	59.6
Distillate fuel oil	19.3	16.4	24.7	39.9	23.3	37.6	64.2	36.2	56.9	88.0
Natural gas	10.1	11.4	11.9	11.6	15.7	16.3	18.8	19.8	20.8	24.9
Electricity	36.3	40.7	41.7	42.1	51.8	53.3	57.9	61.9	64.2	70.7
Commercial										
Propane	15.1	15.9	19.8	28.1	20.6	26.8	40.6	28.6	37.9	52.3
Distillate fuel oil	17.0	13.5	21.8	36.9	18.8	33.1	59.7	30.7	51.2	82.2
Residual fuel oil	6.9	5.1	12.1	23.9	9.0	20.7	41.4	18.1	33.6	57.8
Natural gas	7.7	9.8	10.3	10.0	13.5	14.1	16.5	16.6	17.5	21.4
Electricity	30.6	34.1	34.8	34.9	42.5	43.7	47.7	49.9	51.7	57.6
Industrial[1]										
Propane	12.2	12.6	17.2	27.2	16.7	24.1	40.5	24.6	35.6	52.4
Distillate fuel oil	17.0	13.5	21.8	36.9	18.9	33.1	59.7	30.7	51.3	82.2
Residual fuel oil	6.8	5.4	12.4	24.1	9.9	21.6	42.3	19.2	34.7	58.9
Natural gas[2]	3.7	5.5	5.9	5.7	7.6	8.1	10.6	9.0	9.6	13.0
Metallurgical coal	5.4	6.7	6.7	6.6	9.5	9.4	9.7	12.0	12.2	12.6
Other industrial coal	3.4	3.6	3.7	4.0	4.4	4.6	5.1	5.5	6.0	6.7
Coal to liquids	- -	- -	- -	- -	- -	- -	2.8	- -	- -	3.6
Electricity	20.3	22.7	23.1	23.2	29.1	29.9	33.0	34.6	35.7	40.5
Transportation										
Propane	18.0	18.9	23.4	33.2	24.5	31.7	47.7	34.0	44.8	61.4
E85[3]	23.3	26.6	35.4	41.8	34.5	41.7	54.0	47.3	58.8	72.8
Motor gasoline[4]	20.9	17.8	25.1	39.0	23.0	35.9	59.2	34.9	53.6	81.1
Jet fuel[5]	12.0	9.5	17.9	32.5	14.8	28.8	55.1	26.5	46.6	77.2
Diesel fuel (distillate fuel oil)[6]	19.8	17.3	25.5	40.6	23.7	37.9	64.6	36.6	57.3	88.4
Residual fuel oil	8.1	5.4	12.9	23.7	7.6	20.3	38.9	18.1	32.3	53.9
Natural gas[7]	16.6	18.1	18.4	18.0	21.9	21.0	25.8	25.7	26.7	31.9
Electricity	29.5	35.9	36.5	36.8	49.6	50.5	54.4	58.2	59.8	65.5
Electric power[8]										
Distillate fuel oil	15.0	12.1	20.4	35.6	17.5	31.8	58.4	28.9	49.4	80.5
Residual fuel oil	10.2	8.2	15.2	27.0	12.7	24.4	45.2	22.2	37.8	62.1
Natural gas	3.3	4.8	5.2	4.9	7.0	7.5	9.7	8.3	9.0	12.2
Steam coal	2.2	2.4	2.5	2.7	2.8	3.1	3.5	3.7	4.0	4.7

Table C3. Energy prices by sector and source *(continued)*

(nominal dollars per million Btu, unless otherwise noted)

Sector and source	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Average price to all users[9]										
Propane	14.9	15.4	19.9	29.5	20.1	27.2	42.8	28.4	39.0	55.1
E85[3]	23.3	26.6	35.4	41.8	34.5	41.7	54.0	47.3	58.8	72.8
Motor gasoline[4]	20.9	17.8	25.1	39.0	23.0	35.9	59.2	34.9	53.6	81.1
Jet fuel[5]	12.0	9.5	17.9	32.5	14.8	28.8	55.1	26.5	46.6	77.2
Distillate fuel oil	19.1	16.4	24.7	39.8	22.7	36.9	63.6	35.5	56.1	87.2
Residual fuel oil	8.4	5.6	13.0	24.1	8.6	20.8	39.9	18.4	32.9	55.1
Natural gas	5.3	7.0	7.4	7.2	9.6	10.0	12.9	11.5	12.4	16.6
Metallurgical coal	5.4	6.7	6.7	6.6	9.5	9.4	9.7	12.0	12.2	12.6
Other coal	2.3	2.4	2.6	2.7	3.0	3.2	3.7	3.8	4.2	4.8
Coal to liquids	- -	- -	- -	- -	- -	- -	2.8	- -	- -	3.6
Electricity	30.1	33.4	34.1	34.2	42.2	43.1	47.0	50.0	51.6	57.2
Non-renewable energy expenditures by sector (billion nominal dollars)										
Residential	239	267	276	283	347	360	396	443	462	510
Commercial	178	206	213	217	282	292	323	370	387	434
Industrial[1]	168	203	256	340	301	407	611	457	620	879
Transportation	514	454	647	972	579	866	1,315	929	1,307	1,767
Total non-renewable expenditures	1,099	1,130	1,392	1,811	1,509	1,925	2,645	2,199	2,776	3,590
Transportation renewable expenditures	1	1	1	7	3	9	30	7	17	46
Total expenditures	**1,100**	**1,131**	**1,394**	**1,819**	**1,512**	**1,934**	**2,676**	**2,205**	**2,793**	**3,636**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Excludes use for lease and plant fuel.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Kerosene-type jet fuel. Includes Federal and State taxes while excluding county and local taxes.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Natural gas used as fuel in motor vehicles, trains, and ships. Includes estimated motor vehicle fuel taxes and estimated dispensing costs or charges.
[8]Includes electricity-only and combined heat and power plants that have a regulatory status.
[9]Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.
Btu = British thermal unit.
- - = Not applicable.
Note: Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowprice.d041916a, ref2016.d032416a, and highprice.d041916a.

Table C4. Petroleum and other liquids supply and disposition
(million barrels per day, unless otherwise noted)

Supply and disposition	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil										
Domestic crude production[1]	9.42	8.13	9.38	11.16	7.10	10.06	12.14	8.62	11.26	11.02
Alaska	0.48	0.41	0.41	0.41	0.00	0.24	0.24	0.00	0.15	0.15
Lower 48 states	8.94	7.72	8.96	10.75	7.09	9.82	11.90	8.61	11.11	10.88
Net imports	6.88	6.51	6.97	6.49	7.13	6.57	4.47	7.86	6.10	5.54
Gross imports	7.28	7.14	7.60	7.12	7.76	7.20	6.04	8.49	7.12	7.47
Exports	0.40	0.63	0.63	0.63	0.63	0.63	1.57	0.63	1.02	1.93
Other crude supply[2]	-0.11	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total crude supply	**16.19**	**14.65**	**16.36**	**17.66**	**14.23**	**16.63**	**16.61**	**16.48**	**17.36**	**16.56**
Net product imports	-2.24	-0.71	-3.26	-5.83	-0.28	-4.32	-6.83	-1.76	-4.66	-7.24
Gross refined product imports[3]	0.66	1.13	1.11	0.79	1.71	1.30	0.82	1.91	1.63	1.10
Unfinished oil imports	0.55	0.64	0.53	0.54	0.65	0.46	0.45	0.66	0.39	0.35
Blending component imports	0.67	0.72	0.58	0.62	0.63	0.45	0.45	0.53	0.30	0.32
Exports	4.12	3.21	5.48	7.78	3.28	6.52	8.56	4.86	6.98	9.01
Refinery processing gain[4]	1.03	0.97	1.05	1.14	0.92	0.98	0.95	1.03	0.99	0.94
Product stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas plant liquids	3.25	4.33	4.57	4.82	4.32	4.90	5.17	4.53	4.99	5.25
Supply from renewable sources	1.01	1.11	1.08	1.08	1.03	1.03	1.08	1.04	1.12	1.22
Ethanol	0.89	0.92	0.89	0.89	0.84	0.84	0.88	0.85	0.93	0.79
Domestic production	0.94	0.93	0.90	0.89	0.88	0.87	0.89	0.89	0.91	0.69
Net imports	-0.05	-0.01	-0.01	0.00	-0.04	-0.03	-0.01	-0.03	0.02	0.11
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biodiesel	0.11	0.15	0.15	0.16	0.04	0.10	0.16	0.04	0.10	0.16
Domestic production	0.08	0.11	0.11	0.12	0.00	0.06	0.12	0.00	0.06	0.12
Net imports	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other biomass-derived liquids[5]	0.00	0.04	0.04	0.04	0.14	0.09	0.04	0.14	0.09	0.27
Domestic production	0.00	0.04	0.04	0.04	0.14	0.09	0.04	0.14	0.09	0.27
Net imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liquids from gas	0.00	0.00	0.00	0.04	0.00	0.00	0.45	0.00	0.00	0.85
Liquids from coal	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.28
Other[6]	0.21	0.22	0.28	0.30	0.24	0.30	0.32	0.28	0.32	0.35
Total primary supply[7]	**19.46**	**20.56**	**20.08**	**19.22**	**20.45**	**19.52**	**17.98**	**21.60**	**20.12**	**18.21**
Product supplied										
by fuel										
Liquefied petroleum gases and other[8]	2.46	2.88	2.90	2.80	3.32	3.34	3.22	3.76	3.80	3.61
Motor gasoline[9]	9.18	9.35	8.97	8.26	8.33	7.35	6.28	8.15	6.84	5.65
of which: E85[10]	0.03	0.03	0.03	0.12	0.06	0.15	0.39	0.10	0.19	0.43
Jet fuel[11]	1.54	1.58	1.56	1.54	1.74	1.73	1.71	1.87	1.86	1.84
Distillate fuel oil[12]	3.96	4.36	4.31	4.26	4.43	4.46	4.22	4.82	4.67	4.27
of which: Diesel	3.76	3.99	3.97	3.96	4.13	4.19	3.98	4.56	4.43	4.06
Residual fuel oil	0.26	0.30	0.25	0.23	0.31	0.27	0.26	0.30	0.28	0.27
Other[13]	2.02	2.12	2.11	2.16	2.34	2.39	2.33	2.73	2.70	2.59
by sector										
Residential and commercial	0.90	0.98	0.89	0.78	0.92	0.80	0.68	0.84	0.74	0.64
Industrial[14]	4.47	5.36	5.35	5.33	6.01	6.10	5.94	6.85	6.89	6.60
Transportation	14.04	14.51	14.11	13.37	13.78	12.84	11.53	14.18	12.69	11.11
Electric power[15]	0.12	0.07	0.07	0.07	0.05	0.05	0.05	0.04	0.04	0.04
Unspecified sector[16]	-0.30	-0.32	-0.31	-0.29	-0.28	-0.25	-0.19	-0.28	-0.23	-0.16
Total product supplied	**19.42**	**20.59**	**20.11**	**19.26**	**20.47**	**19.54**	**18.01**	**21.63**	**20.14**	**18.24**
Discrepancy[17]	0.04	-0.03	-0.03	-0.03	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03

Table C4. Petroleum and other liquids supply and disposition *(continued)*
(million barrels per day, unless otherwise noted)

Supply and disposition	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Domestic refinery distillation capacity[18]	18.0	19.0	19.0	19.2	19.0	19.0	19.3	19.0	19.0	19.3
Capacity utilization rate (percent)[19]	91.1	79.2	87.7	93.8	77.0	88.9	87.5	88.8	92.5	86.9
Net import share of product supplied (percent)	23.7	28.3	18.6	3.6	33.5	11.6	-13.0	28.3	7.4	-8.5
Net expenditures for imported crude oil and petroleum products (billion 2015 dollars)	128	88	207	399	126	268	455	221	348	609

[1]Includes lease condensate.
[2]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude oil stock withdrawals.
[3]Includes other hydrocarbons and alcohols.
[4]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[5]Includes pyrolysis oils, biomass-derived Fischer-Tropsch liquids, biobutanol, and renewable feedstocks used for the on-site production of diesel and gasoline.
[6]Includes domestic sources of other blending components, other hydrocarbons, and ethers.
[7]Total crude supply, net product imports, refinery processing gain, product stock withdrawal, natural gas plant liquids, supply from renewable sources, liquids from gas, liquids from coal, and other supply.
[8]Includes ethane, natural gasoline, and refinery olefins.
[9]Includes ethanol and ethers blended into gasoline.
[10]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[11]Includes only kerosene type.
[12]Includes distillate fuel oil from petroleum and biomass feedstocks.
[13]Includes kerosene, aviation gasoline, petrochemical feedstocks, lubricants, waxes, asphalt, road oil, still gas, special naphthas, petroleum coke, crude oil product supplied, methanol, and miscellaneous petroleum products.
[14]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[15]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[16]Represents consumption unattributed to the sectors above.
[17]Balancing item. Includes unaccounted for supply, losses, and gains.
[18]End-of-year operable capacity.
[19]Rate is calculated by dividing the gross annual input to atmospheric crude oil distillation units by their operable refining capacity in barrels per calendar day.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowprice.d041916a, ref2016.d032416a, and highprice.d041916a.

Table C5. Petroleum and other liquids prices
(2015 dollars per gallon, unless otherwise noted)

Sector and fuel	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil prices (2015 dollars per barrel)										
Brent spot	52	38	77	152	49	104	207	73	136	230
West Texas Intermediate spot	49	32	71	145	42	97	198	67	129	222
Average imported refiners acquisition cost[1]	46	30	69	142	40	95	191	66	126	213
Brent / West Texas Intermediate spread	3.7	6.1	5.4	7.1	6.6	6.9	8.9	6.0	7.1	7.6
Delivered sector product prices										
Residential										
Propane	1.55	1.47	1.84	2.66	1.55	2.04	3.07	1.77	2.33	3.15
Distillate fuel oil	2.66	2.05	3.08	5.00	2.35	3.82	6.42	2.99	4.65	7.00
Commercial										
Distillate fuel oil	2.34	1.68	2.71	4.63	1.90	3.36	5.96	2.53	4.19	6.54
Residual fuel oil	1.04	0.69	1.64	3.26	0.99	2.29	4.51	1.63	2.98	5.01
Residual fuel oil (2015 dollars per barrel)	44	29	69	137	41	96	189	68	125	210
Industrial[2]										
Propane	1.12	1.04	1.42	2.27	1.12	1.63	2.69	1.35	1.93	2.77
Distillate fuel oil	2.34	1.68	2.71	4.62	1.90	3.36	5.96	2.53	4.19	6.54
Residual fuel oil	1.01	0.73	1.68	3.29	1.09	2.39	4.60	1.73	3.08	5.11
Residual fuel oil (2015 dollars per barrel)	42	31	71	138	46	100	193	73	130	214
Transportation										
Propane	1.64	1.57	1.94	2.76	1.65	2.14	3.17	1.87	2.43	3.25
E85[3]	2.21	2.30	3.05	3.62	2.42	2.93	3.74	2.71	3.33	4.01
Ethanol wholesale price	2.22	2.74	2.77	2.78	2.11	2.28	2.55	2.29	2.60	2.93
Motor gasoline[4]	2.52	1.94	2.74	4.28	2.04	3.19	5.17	2.53	3.81	5.61
Jet fuel[5]	1.62	1.16	2.18	3.99	1.47	2.87	5.41	2.15	3.74	6.04
Diesel fuel (distillate fuel oil)[6]	2.72	2.15	3.18	5.09	2.40	3.85	6.45	3.03	4.68	7.04
Residual fuel oil	1.21	0.73	1.75	3.23	0.84	2.25	4.23	1.63	2.87	4.67
Residual fuel oil (2015 dollars per barrel)	51	31	73	136	35	94	178	69	121	196
Electric power[7]										
Distillate fuel oil	2.07	1.50	2.53	4.45	1.77	3.23	5.84	2.39	4.04	6.41
Residual fuel oil	1.53	1.12	2.06	3.68	1.40	2.70	4.92	2.00	3.36	5.38
Residual fuel oil (2015 dollars per barrel)	64	47	87	154	59	114	207	84	141	226
Average prices, all sectors[8]										
Propane	1.36	1.27	1.65	2.46	1.35	1.83	2.84	1.56	2.12	2.91
Motor gasoline[4]	2.52	1.94	2.74	4.28	2.04	3.19	5.17	2.53	3.81	5.61
Jet fuel[5]	1.62	1.16	2.18	3.99	1.47	2.87	5.41	2.15	3.74	6.04
Distillate fuel oil	2.63	2.04	3.07	4.99	2.30	3.75	6.36	2.93	4.58	6.94
Residual fuel oil	1.26	0.75	1.76	3.29	0.94	2.30	4.35	1.66	2.93	4.78
Residual fuel oil (2015 dollars per barrel)	53	32	74	138	40	97	183	70	123	201
Average	**2.18**	**1.65**	**2.44**	**3.97**	**1.75**	**2.85**	**4.82**	**2.21**	**3.42**	**5.16**

Table C5. Petroleum and other liquids prices *(continued)*
(nominal dollars per gallon, unless otherwise noted)

Sector and fuel	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil prices (nominal dollars per barrel)										
Brent spot	52	42	85	166	66	141	284	121	229	397
West Texas Intermediate spot	49	35	79	159	58	131	272	111	217	384
Average imported refiners acquisition cost[1]	46	33	76	156	55	128	263	109	212	369
Delivered sector product prices										
Residential										
Propane	1.55	1.62	2.03	2.92	2.11	2.76	4.22	2.94	3.93	5.44
Distillate fuel oil	2.66	2.26	3.40	5.49	3.20	5.16	8.83	4.97	7.83	12.09
Commercial										
Distillate fuel oil	2.34	1.85	2.99	5.08	2.58	4.54	8.20	4.21	7.04	11.30
Residual fuel oil	1.04	0.76	1.81	3.58	1.34	3.09	6.20	2.70	5.02	8.65
Industrial[2]										
Propane	1.12	1.15	1.57	2.49	1.53	2.20	3.69	2.24	3.25	4.78
Distillate fuel oil	2.34	1.85	2.99	5.08	2.59	4.54	8.20	4.21	7.04	11.30
Residual fuel oil	1.01	0.81	1.86	3.61	1.49	3.23	6.33	2.88	5.19	8.82
Transportation										
Propane	1.64	1.73	2.14	3.03	2.24	2.89	4.36	3.10	4.09	5.61
E85[3]	2.21	2.53	3.37	3.98	3.28	3.97	5.14	4.51	5.60	6.93
Ethanol wholesale price	2.22	3.02	3.06	3.05	2.86	3.09	3.50	3.80	4.38	5.06
Motor gasoline[4]	2.52	2.14	3.02	4.70	2.77	4.32	7.11	4.20	6.40	9.68
Jet fuel[5]	1.62	1.28	2.41	4.38	2.00	3.89	7.44	3.58	6.29	10.42
Diesel fuel (distillate fuel oil)[6]	2.72	2.38	3.51	5.59	3.26	5.21	8.88	5.03	7.88	12.15
Residual fuel oil	1.21	0.80	1.93	3.55	1.14	3.04	5.82	2.71	4.83	8.06
Electric power[7]										
Distillate fuel oil	2.07	1.66	2.80	4.89	2.41	4.37	8.04	3.97	6.79	11.06
Residual fuel oil	1.53	1.23	2.28	4.04	1.90	3.66	6.77	3.32	5.65	9.30
Average prices, all sectors[8]										
Propane	1.36	1.40	1.82	2.70	1.83	2.48	3.91	2.60	3.56	5.03
Motor gasoline[4]	2.52	2.14	3.02	4.70	2.77	4.32	7.11	4.20	6.40	9.68
Jet fuel[5]	1.62	1.28	2.41	4.38	2.00	3.89	7.44	3.58	6.29	10.42
Distillate fuel oil	2.63	2.25	3.39	5.47	3.12	5.08	8.75	4.87	7.71	11.98
Residual fuel oil (nominal dollars per barrel)	53	35	81	152	54	131	251	116	207	347
Average	**2.18**	**1.82**	**2.70**	**4.35**	**2.37**	**3.86**	**6.64**	**3.68**	**5.76**	**8.91**

[1]Weighted average price delivered to U.S. refiners.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[4]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[5]Includes only kerosene type.
[6]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
[7]Includes electricity-only and combined heat and power plants that have a regulatory status.
[8]Weighted averages of end-use fuel prices are derived from the prices in each sector and the corresponding sectoral consumption.
Note: Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowprice.d041916a, ref2016.d032416a, and highprice.d041916a.

Table C6. International petroleum and other liquids supply, disposition, and prices
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Crude oil spot prices										
(2015 dollars per barrel)										
Brent	52	38	77	152	49	104	207	73	136	230
West Texas Intermediate	49	32	71	145	42	97	198	67	129	222
(nominal dollars per barrel)										
Brent	52	42	85	166	66	141	284	121	229	397
West Texas Intermediate	49	35	79	159	58	131	272	111	217	384
Petroleum and other liquids consumption[1]										
OECD										
United States (50 states)	19.42	20.59	20.11	19.26	20.47	19.54	18.01	21.63	20.14	18.24
United States territories	0.30	0.31	0.31	0.31	0.34	0.34	0.34	0.38	0.38	0.38
Canada	2.39	2.45	2.39	2.32	2.48	2.39	2.39	2.64	2.51	2.57
Mexico and Chile	2.30	2.48	2.38	2.27	2.61	2.50	2.44	3.05	2.87	2.84
OECD Europe[2]	13.83	13.98	13.70	13.28	13.98	13.65	13.36	14.43	13.98	13.60
Japan	4.14	4.02	3.91	3.69	3.80	3.66	3.48	3.60	3.40	3.33
South Korea	2.38	2.50	2.41	2.25	2.54	2.44	2.32	2.67	2.55	2.49
Australia and New Zealand	1.28	1.37	1.35	1.32	1.43	1.41	1.40	1.55	1.53	1.55
Total OECD consumption	**46.03**	**47.70**	**46.56**	**44.69**	**47.65**	**45.93**	**43.73**	**49.94**	**47.35**	**45.01**
Non-OECD										
Russia	3.35	3.68	3.65	3.51	3.77	3.75	3.68	3.58	3.59	3.58
Other Europe and Eurasia[3]	2.07	2.22	2.18	2.11	2.46	2.43	2.39	2.56	2.53	2.53
China	11.18	12.87	12.71	12.43	14.65	14.81	14.95	15.53	16.36	17.15
India	3.97	4.67	4.54	4.32	6.07	5.94	5.59	8.35	8.26	7.41
Other Asia[4]	8.15	9.67	9.40	9.01	11.74	11.42	10.76	14.41	14.29	13.46
Middle East	8.29	10.31	9.96	9.76	11.42	11.28	11.47	13.21	13.23	14.09
Africa	3.86	4.64	4.54	4.40	5.62	5.50	5.43	7.03	6.93	6.99
Brazil	3.15	3.52	3.41	3.24	4.14	4.06	3.93	4.80	4.71	4.58
Other Central and South America	3.85	4.23	4.11	3.98	4.57	4.41	4.18	5.00	4.89	4.65
Total non-OECD consumption	**47.87**	**55.82**	**54.49**	**52.77**	**64.43**	**63.60**	**62.38**	**74.45**	**74.79**	**74.44**
Total consumption	**93.90**	**103.51**	**101.05**	**97.46**	**112.08**	**109.52**	**106.11**	**124.39**	**122.14**	**119.44**
Petroleum and other liquids production										
OPEC[5]										
Middle East	27.76	32.44	30.87	27.42	36.70	34.29	29.33	41.63	39.38	31.71
North Africa	2.13	3.51	1.99	2.12	3.73	2.32	2.11	4.03	2.94	2.28
West Africa	4.21	4.51	4.35	4.08	5.04	4.58	3.53	6.21	5.07	3.57
South America	3.24	4.17	2.96	2.59	5.46	3.33	2.85	6.76	3.88	3.21
Total OPEC production	**37.33**	**44.63**	**40.17**	**36.21**	**50.93**	**44.52**	**37.81**	**58.63**	**51.28**	**40.77**
Non-OPEC										
OECD										
United States (50 states)	14.95	14.73	16.33	18.51	13.60	17.26	20.32	15.49	18.62	19.76
Canada	4.54	5.11	5.43	5.14	4.68	5.55	6.16	4.63	6.01	8.25
Mexico and Chile	2.64	2.54	2.46	2.75	2.69	2.58	3.35	3.11	3.24	5.06
OECD Europe[2]	3.79	3.47	3.44	3.40	3.11	3.10	3.03	2.86	2.78	2.80
Japan and South Korea	0.22	0.17	0.20	0.16	0.19	0.21	0.17	0.20	0.22	0.18
Australia and New Zealand	0.51	0.67	0.66	0.75	0.60	0.61	1.08	0.56	0.76	1.53
Total OECD production	**26.65**	**26.68**	**28.51**	**30.71**	**24.87**	**29.31**	**34.12**	**26.84**	**31.63**	**37.58**
Non-OECD										
Russia	10.95	10.44	10.62	9.68	11.75	11.22	9.80	12.56	12.21	11.17
Other Europe and Eurasia[3]	3.23	3.78	3.69	3.18	4.93	4.63	4.03	5.12	4.50	5.75
China	4.69	4.91	4.90	4.86	5.36	5.44	5.65	5.70	6.24	6.78
Other Asia[4]	4.03	3.91	3.92	3.88	3.63	3.65	3.65	3.60	3.62	3.68
Middle East	1.14	1.04	1.02	1.02	0.84	0.83	0.83	0.70	0.69	0.70
Africa	2.33	2.42	2.48	2.46	2.46	2.73	2.56	2.56	2.83	2.75
Brazil	3.15	3.57	3.59	3.21	5.25	5.00	4.73	6.45	6.15	6.03
Other Central and South America	2.18	2.14	2.15	2.25	2.06	2.19	2.93	2.22	2.99	4.24
Total non-OECD production	**31.70**	**32.20**	**32.37**	**30.55**	**36.28**	**35.69**	**34.18**	**38.92**	**39.23**	**41.09**
Total petroleum and other liquids production	**95.68**	**103.51**	**101.05**	**97.46**	**112.08**	**109.52**	**106.11**	**124.39**	**122.14**	**119.44**
OPEC market share (percent)	39.0	43.1	39.8	37.2	45.4	40.7	35.6	47.1	42.0	34.1

Table C6. International petroleum and other liquids supply, disposition, and prices *(continued)*
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	2015	Projections								
		2020			2030			2040		
		Low oil price	Reference	High oil price	Low oil price	Reference	High oil price	Low oil price	Reference	High oil price
Selected world production subtotals:										
Crude oil and equivalents[6]	80.13	86.11	82.77	78.52	93.24	89.12	83.45	103.39	99.74	92.92
Tight oil	5.34	4.19	5.44	7.73	4.17	6.96	10.17	5.55	10.35	12.84
Bitumen[7]	2.32	2.99	3.08	3.08	2.88	3.18	3.68	2.99	3.31	4.80
Refinery processing gain[8]	2.45	2.46	2.53	2.55	2.78	2.73	2.67	3.23	2.94	2.95
Natural gas plant liquids	10.37	11.74	12.32	12.87	12.67	13.24	14.34	13.82	13.88	15.69
Liquids from renewable sources[9]	2.32	2.42	2.54	2.54	2.99	3.31	3.35	3.55	4.11	4.13
Liquids from coal[10]	0.25	0.25	0.27	0.31	0.04	0.26	0.88	0.00	0.50	1.48
Liquids from natural gas[11]	0.29	0.31	0.32	0.37	0.11	0.57	1.10	0.12	0.65	1.92
Liquids from kerogen[12]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Crude oil production[6]										
OPEC[5]										
Middle East	24.38	29.14	27.07	23.60	33.28	30.10	25.10	38.06	34.74	27.03
North Africa	1.78	2.95	1.61	1.63	3.03	1.82	1.46	3.18	2.20	1.46
West Africa	4.19	4.37	4.28	3.93	4.91	4.51	3.36	6.09	4.99	3.37
South America	3.05	3.88	2.75	2.38	5.11	3.09	2.60	6.42	3.64	2.96
Total OPEC production	**33.40**	**40.34**	**35.72**	**31.54**	**46.33**	**39.52**	**32.51**	**53.75**	**45.57**	**34.83**
Non-OPEC										
OECD										
United States (50 states)	9.42	8.13	9.38	11.16	7.10	10.06	12.14	8.62	11.26	11.02
Canada	3.72	4.42	4.57	4.34	3.95	4.53	5.33	3.89	4.96	7.40
Mexico and Chile	2.31	2.19	2.16	2.46	2.35	2.29	3.07	2.77	2.96	4.78
OECD Europe[2]	2.95	2.36	2.31	2.29	1.90	1.88	1.81	1.51	1.47	1.44
Japan and South Korea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Australia and New Zealand	0.39	0.53	0.53	0.62	0.46	0.49	0.96	0.41	0.64	1.39
Total OECD production	**18.81**	**17.63**	**18.96**	**20.88**	**15.77**	**19.24**	**23.30**	**17.20**	**21.29**	**26.04**
Non-OECD										
Russia	10.17	9.84	9.84	8.79	10.90	10.49	8.51	11.28	11.53	9.21
Other Europe and Eurasia[3]	3.00	3.48	3.43	2.90	4.49	4.36	3.62	4.46	4.23	5.11
China	4.28	4.38	4.34	4.27	4.57	4.40	4.23	4.68	4.67	4.49
Other Asia[4]	3.18	3.01	2.98	2.95	2.57	2.52	2.52	2.28	2.25	2.25
Middle East	1.11	0.99	1.00	0.99	0.80	0.81	0.81	0.67	0.67	0.67
Africa	1.94	1.94	2.01	1.99	2.15	2.25	2.02	2.26	2.34	2.05
Brazil	2.43	2.80	2.77	2.39	4.07	3.78	3.46	5.08	4.67	4.52
Other Central and South America	1.81	1.69	1.72	1.80	1.58	1.75	2.46	1.73	2.52	3.75
Total non-OECD production	**27.92**	**28.15**	**28.09**	**26.10**	**31.14**	**30.36**	**27.64**	**32.44**	**32.87**	**32.05**
Total crude oil production[6]	**80.13**	**86.11**	**82.77**	**78.52**	**93.24**	**89.12**	**83.45**	**103.39**	**99.74**	**92.92**
OPEC market share (percent)	41.7	46.8	43.2	40.2	49.7	44.3	39.0	52.0	45.7	37.5

[1]Estimated consumption. Includes both OPEC and non-OPEC consumers in the regional breakdown.
[2]OECD Europe = Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.
[3]Other Europe and Eurasia = Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Macedonia, Malta, Moldova, Montenegro, Romania, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
[4]Other Asia = Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), Fiji, French Polynesia, Guam, Hong Kong, India (for production), Indonesia, Kiribati, Laos, Malaysia, Macau, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam.
[5]OPEC = Organization of the Petroleum Exporting Countries = Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
[6]Includes crude oil, lease condensate, tight oil (shale oil), extra-heavy oil, and bitumen (oil sands).
[7]Includes diluted and upgraded/synthetic bitumen (syncrude).
[8]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[9]Includes liquids produced from energy crops.
[10]Includes liquids converted from coal via the Fischer-Tropsch coal-to-liquids process.
[11]Includes liquids converted from natural gas via the Fischer-Tropsch natural-gas-to-liquids process.
[12]Includes liquids produced from kerogen (oil shale, not to be confused with tight oil (shale oil)).
OECD = Organization for Economic Cooperation and Development.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** Energy Information Administration (EIA), AEO2016 National Energy Modeling System runs lowprice.d041916a, ref2016.d032416a, and highprice.d041916a; and EIA, Generate World Oil Balance application.

Table D1. Key results for Clean Power Plan cases

Capacity, generation, prices, consumption, and emissions	2015	2020					
		Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended
Net summer capacity (gigawatts)[1]							
Capacity							
Electric power sector[2]	1,040.8	1,053.0	1,053.2	1,054.4	1,052.6	1,054.8	1,048.5
Coal[3]	281.4	211.7	211.7	212.1	211.8	212.3	205.9
Oil and natural gas steam[3,4]	91.4	90.3	90.3	91.2	90.5	91.0	90.9
Combined cycle	227.3	247.5	247.1	247.5	246.4	247.4	248.5
Combustion turbine/diesel	141.2	142.9	143.4	142.9	143.2	143.3	143.1
Nuclear power	99.8	99.1	99.1	99.1	99.1	99.1	99.1
Solar[5]	13.8	28.0	28.1	28.0	28.1	28.1	27.5
Wind	74.4	120.4	120.4	120.4	120.4	120.4	120.4
Other renewable energy[6]	89.0	90.3	90.3	90.3	90.3	90.3	90.3
Other[7]	22.6	22.9	22.9	22.9	22.9	22.9	22.9
End-use sector[8]	41.3	61.1	61.1	61.2	61.1	61.2	62.0
Total capacity	**1,082.1**	**1,114.2**	**1,114.4**	**1,115.5**	**1,113.8**	**1,115.9**	**1,110.6**
Capacity additions (gigawatts)[9]							
Electric power sector[2]	- -	101.1	101.0	101.3	101.0	101.3	102.4
Coal[3]	- -	0.5	0.5	0.5	0.5	0.5	0.5
Combined cycle	- -	26.7	26.3	26.8	26.3	26.7	28.1
Combustion turbine/diesel	- -	7.3	7.4	7.3	7.4	7.3	7.7
Nuclear power	- -	4.4	4.4	4.4	4.4	4.4	4.4
Solar[5]	- -	14.2	14.4	14.2	14.4	14.4	13.8
Wind	- -	46.1	46.1	46.1	46.1	46.1	46.1
Other renewable energy[6]	- -	1.7	1.7	1.7	1.7	1.7	1.7
Other[7]	- -	0.2	0.3	0.2	0.3	0.2	0.2
End-use sector[8]	- -	21.0	21.0	21.0	21.0	21.0	21.1
Total capacity additions	**- -**	**122.1**	**122.1**	**122.3**	**122.1**	**122.3**	**123.5**
Capacity retirements (gigawatts)[9]							
Electric power sector[2]	- -	88.9	88.6	87.7	89.2	87.4	94.7
Coal[3]	- -	61.6	61.6	61.2	61.5	61.0	67.4
Oil and natural gas steam[3,4]	- -	9.7	9.7	8.8	9.5	9.0	9.1
Combined cycle	- -	6.5	6.5	6.6	7.2	6.6	6.9
Combustion turbine/diesel	- -	5.5	5.3	5.6	5.4	5.2	5.8
Nuclear power	- -	5.2	5.2	5.2	5.2	5.2	5.2
Renewable energy[10]	- -	0.4	0.4	0.4	0.4	0.4	0.4
Fuel cells	- -	0.0	0.0	0.0	0.0	0.0	0.0
End-use sector[8]	- -	1.2	1.2	1.2	1.2	1.2	0.4
Total capacity retirements	**- -**	**90.1**	**89.9**	**89.0**	**90.5**	**88.6**	**95.1**
Total net electricity generation by fuel (billion kilowatthours)							
Coal	1,355	1,388	1,389	1,389	1,389	1,388	1,366
Petroleum	26	15	15	15	15	15	15
Natural gas	1,348	1,201	1,199	1,199	1,199	1,201	1,220
Nuclear power	798	777	777	777	777	777	777
Solar[5]	38	93	93	93	93	93	92
Wind	190	368	368	368	367	368	368
Other renewable energy[6]	319	376	375	376	375	376	376
Other[11]	17	27	27	27	27	27	27
Total net electricity generation	**4,090**	**4,244**	**4,243**	**4,244**	**4,243**	**4,245**	**4,240**
Fuel prices to the electric power sector[2] (2015 dollars per million Btu)							
Natural gas	3.26	4.69	4.69	4.68	4.69	4.68	4.76
Steam coal	2.19	2.26	2.26	2.26	2.26	2.26	2.27
Electricity prices (2015 cents per kilowatthour)							
Residential	12.4	12.9	12.9	12.9	12.9	12.9	12.9
Commercial	10.5	10.7	10.7	10.7	10.7	10.7	10.8
Industrial	6.9	7.1	7.1	7.1	7.1	7.1	7.2
Transportation	10.1	11.3	11.3	11.3	11.3	11.3	11.3
All sectors average price	**10.3**	**10.5**	**10.5**	**10.5**	**10.5**	**10.5**	**10.6**

2030						2040					
Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended	Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended
1,094.2	1,139.1	1,107.1	1,138.9	1,088.9	1,107.9	1,239.6	1,252.2	1,259.0	1,251.4	1,242.6	1,250.4
180.3	186.6	185.6	188.2	179.4	174.9	172.8	186.6	178.9	188.2	172.3	152.7
54.5	66.0	52.7	62.8	53.4	52.1	52.8	63.3	50.0	60.7	49.8	49.6
294.5	259.0	280.1	258.6	290.9	294.9	345.4	303.5	331.4	302.0	340.5	352.9
137.0	137.1	139.9	136.2	138.2	135.1	144.6	147.9	145.5	146.8	146.3	141.5
99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1
70.1	109.6	90.2	112.2	69.0	90.2	158.1	164.0	189.0	166.9	166.9	184.5
142.0	164.6	142.9	164.6	142.1	144.6	145.8	167.2	144.3	167.2	146.9	149.4
93.1	93.7	92.9	93.6	93.1	93.3	95.5	95.6	95.4	95.5	95.4	95.7
23.7	23.5	23.6	23.5	23.6	23.6	25.5	25.1	25.4	25.1	25.4	25.0
93.9	94.0	94.0	93.9	95.0	94.6	134.5	135.0	134.3	135.0	136.6	136.3
1,188.1	**1,233.1**	**1,201.0**	**1,232.8**	**1,184.0**	**1,202.5**	**1,374.1**	**1,387.2**	**1,393.2**	**1,386.4**	**1,379.2**	**1,386.6**
227.4	249.2	234.5	252.4	223.9	252.9	388.6	367.7	402.5	369.6	393.8	432.4
0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
84.9	44.3	70.2	44.6	82.4	86.1	138.6	89.8	123.6	89.1	133.6	150.4
8.0	8.0	9.1	8.2	8.0	9.5	19.5	20.3	19.2	20.3	19.9	21.6
4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
56.4	95.8	76.4	98.5	55.3	76.5	144.3	150.3	175.2	153.2	153.1	170.7
67.7	90.3	68.6	90.3	67.8	70.3	71.5	92.9	70.1	92.9	72.7	75.2
4.5	5.0	4.3	5.0	4.5	4.7	6.9	7.0	6.8	6.9	6.8	7.1
1.0	0.9	0.9	0.9	0.9	1.0	2.9	2.5	2.8	2.4	2.7	2.4
53.8	53.9	53.8	53.8	54.9	53.7	94.3	94.9	94.1	94.9	96.5	95.3
281.1	**303.1**	**288.3**	**306.2**	**278.8**	**306.5**	**482.9**	**462.6**	**496.6**	**464.6**	**490.2**	**527.7**
174.0	151.0	168.3	154.4	175.8	185.9	189.8	156.3	184.4	159.1	192.0	222.9
92.1	85.8	86.7	84.2	92.9	97.4	99.6	85.8	93.5	84.2	100.1	119.7
46.4	34.9	48.2	38.1	47.5	48.8	48.1	37.6	50.9	40.2	51.1	51.3
17.7	12.5	17.4	13.3	18.8	18.5	20.5	13.6	19.5	14.4	20.4	24.9
12.2	12.2	10.4	13.2	11.0	15.6	16.0	13.7	14.8	14.6	14.8	21.3
5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	1.2	1.2	1.2	1.2	0.4	1.2	1.2	1.2	1.2	1.2	0.4
175.2	**152.2**	**169.5**	**155.6**	**177.0**	**186.2**	**191.0**	**157.6**	**185.6**	**160.3**	**193.2**	**223.2**
972	995	1,029	997	979	987	919	1,080	980	1,081	931	653
11	11	12	11	11	11	9	10	10	10	9	8
1,702	1,531	1,607	1,524	1,680	1,650	1,942	1,723	1,829	1,712	1,896	2,097
789	789	789	789	789	789	789	789	789	789	789	789
227	302	267	306	226	266	477	482	546	491	498	538
457	528	459	528	457	466	473	541	467	540	477	487
405	407	404	407	405	405	424	422	423	421	422	427
27	27	27	27	27	27	27	27	27	27	27	27
4,590	**4,591**	**4,594**	**4,591**	**4,574**	**4,601**	**5,060**	**5,074**	**5,071**	**5,071**	**5,050**	**5,025**
5.57	5.32	5.42	5.31	5.57	5.33	5.36	5.07	5.14	5.07	5.35	5.58
2.26	2.29	2.27	2.29	2.28	2.26	2.38	2.46	2.37	2.46	2.40	2.26
13.4	13.5	13.4	13.4	13.6	13.3	13.0	13.0	12.9	13.0	13.1	13.4
11.0	11.0	11.0	11.0	11.2	10.9	10.5	10.5	10.4	10.5	10.6	10.8
7.5	7.6	7.5	7.5	7.7	7.4	7.2	7.2	7.2	7.2	7.3	7.5
12.7	12.7	12.7	12.6	13.0	12.6	12.1	12.0	12.0	12.0	12.2	12.5
10.9	**10.9**	**10.9**	**10.9**	**11.1**	**10.8**	**10.5**	**10.5**	**10.4**	**10.4**	**10.6**	**10.8**

Table D1. Key results for Clean Power Plan cases *(continued)*

Capacity, generation, prices, consumption, and emissions	2015	2020					
		Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended
Energy consumption (quadrillion Btu)							
Residential							
Petroleum and other liquids[12]	0.93	0.86	0.86	0.86	0.86	0.86	0.86
Natural gas	4.77	4.87	4.87	4.87	4.87	4.87	4.86
Renewable energy[13]	0.44	0.42	0.42	0.42	0.42	0.42	0.42
Electricity	4.78	4.76	4.76	4.76	4.76	4.76	4.76
Total residential	**10.92**	**10.90**	**10.90**	**10.90**	**10.90**	**10.90**	**10.89**
Nonmarketed residential renewable energy[14]	0.11	0.35	0.35	0.35	0.35	0.35	0.35
Commercial							
Petroleum and other liquids[15]	0.66	0.70	0.70	0.70	0.70	0.70	0.70
Natural gas	3.32	3.45	3.45	3.45	3.45	3.45	3.45
Coal	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Renewable energy[16]	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Electricity	4.64	4.69	4.69	4.69	4.69	4.69	4.68
Total commercial	**8.81**	**9.03**	**9.03**	**9.03**	**9.03**	**9.03**	**9.03**
Nonmarketed commercial renewable energy[14]	0.16	0.18	0.18	0.18	0.18	0.18	0.18
Industrial[8]							
Petroleum and other liquids[17]	8.07	9.40	9.40	9.40	9.39	9.40	9.39
Natural gas	9.38	10.57	10.57	10.57	10.57	10.57	10.56
Coal	1.34	1.23	1.23	1.23	1.23	1.23	1.22
Renewable energy[18]	2.26	2.30	2.30	2.30	2.30	2.30	2.30
Electricity	3.27	3.61	3.61	3.61	3.61	3.61	3.61
Total industrial	**24.33**	**27.11**	**27.11**	**27.10**	**27.10**	**27.11**	**27.08**
Transportation							
Petroleum and other liquids[19]	27.14	27.32	27.32	27.32	27.32	27.32	27.31
Pipeline fuel natural gas	0.89	0.83	0.83	0.83	0.83	0.83	0.83
Compressed / liquefied natural gas	0.07	0.08	0.08	0.08	0.08	0.08	0.08
Liquid hydrogen	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Electricity	0.03	0.05	0.05	0.05	0.05	0.05	0.05
Total transportation	**28.13**	**28.29**	**28.29**	**28.29**	**28.29**	**28.29**	**28.28**
Unspecified sector[20]	**-0.58**	**-0.58**	**-0.58**	**-0.58**	**-0.58**	**-0.58**	**-0.58**
Electric power[2]							
Petroleum and other liquids[21]	0.26	0.15	0.15	0.15	0.15	0.15	0.15
Natural gas	9.89	8.50	8.49	8.49	8.49	8.50	8.59
Steam coal	14.08	14.34	14.36	14.36	14.37	14.35	14.09
Nuclear / uranium[22]	8.34	8.12	8.12	8.12	8.12	8.12	8.12
Renewable energy[23]	4.86	7.37	7.34	7.37	7.36	7.37	7.36
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Net electricity imports	0.19	0.19	0.20	0.20	0.20	0.19	0.20
Total electric power	**37.85**	**38.90**	**38.89**	**38.91**	**38.91**	**38.91**	**38.73**
Total marketed energy consumption							
Petroleum and other liquids	36.49	37.85	37.85	37.85	37.85	37.85	37.83
Natural gas	28.31	28.30	28.29	28.29	28.29	28.30	28.38
Coal	15.48	15.62	15.64	15.64	15.65	15.63	15.36
Nuclear / uranium[22]	8.34	8.12	8.12	8.12	8.12	8.12	8.12
Renewable energy[24]	7.71	10.22	10.20	10.23	10.21	10.23	10.22
Other[25]	0.42	0.43	0.43	0.43	0.43	0.43	0.43
Total marketed energy consumption	**96.74**	**100.55**	**100.54**	**100.56**	**100.55**	**100.55**	**100.34**

2030						2040					
Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended	Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended
0.72	0.72	0.72	0.72	0.72	0.72	0.61	0.61	0.61	0.61	0.61	0.61
4.80	4.81	4.81	4.81	4.80	4.81	4.73	4.75	4.74	4.75	4.73	4.72
0.39	0.39	0.39	0.39	0.39	0.39	0.37	0.37	0.37	0.37	0.37	0.37
4.83	4.82	4.83	4.83	4.81	4.84	5.20	5.19	5.21	5.20	5.18	5.16
10.74	**10.74**	**10.75**	**10.75**	**10.72**	**10.76**	**10.91**	**10.92**	**10.93**	**10.93**	**10.89**	**10.86**
0.63	0.63	0.63	0.63	0.64	0.63	0.94	0.94	0.93	0.94	0.95	0.94
0.68	0.68	0.68	0.68	0.68	0.68	0.67	0.67	0.67	0.67	0.67	0.67
3.53	3.55	3.55	3.55	3.54	3.56	3.81	3.84	3.83	3.84	3.83	3.81
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
5.09	5.08	5.08	5.08	5.06	5.09	5.62	5.62	5.63	5.62	5.60	5.58
9.49	**9.50**	**9.51**	**9.51**	**9.48**	**9.53**	**10.28**	**10.31**	**10.32**	**10.32**	**10.28**	**10.25**
0.29	0.29	0.29	0.29	0.29	0.29	0.47	0.47	0.47	0.47	0.48	0.47
10.55	10.61	10.59	10.62	10.56	10.57	11.82	11.96	11.90	11.97	11.85	11.68
11.72	11.82	11.77	11.81	11.74	11.74	12.89	13.02	12.96	13.03	12.93	12.79
1.35	1.34	1.35	1.33	1.40	1.32	1.34	1.33	1.35	1.33	1.38	1.31
2.47	2.47	2.47	2.47	2.47	2.47	2.63	2.64	2.63	2.64	2.63	2.61
3.98	3.99	3.99	3.99	3.97	3.99	4.26	4.30	4.28	4.30	4.25	4.21
30.07	**30.23**	**30.18**	**30.23**	**30.13**	**30.11**	**32.94**	**33.26**	**33.13**	**33.28**	**33.04**	**32.60**
25.01	25.03	25.04	25.03	25.01	25.01	24.75	24.81	24.77	24.81	24.77	24.66
0.94	0.93	0.93	0.92	0.94	0.93	1.07	1.05	1.05	1.05	1.07	1.08
0.17	0.17	0.17	0.17	0.17	0.17	0.59	0.61	0.61	0.61	0.59	0.59
0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.06	0.06	0.06	0.06
0.11	0.11	0.11	0.11	0.11	0.11	0.15	0.15	0.15	0.15	0.15	0.15
26.28	**26.28**	**26.29**	**26.28**	**26.28**	**26.27**	**26.63**	**26.69**	**26.65**	**26.70**	**26.64**	**26.54**
-0.46	**-0.46**	**-0.46**	**-0.46**	**-0.46**	**-0.46**	**-0.42**	**-0.42**	**-0.42**	**-0.42**	**-0.42**	**-0.41**
0.11	0.11	0.11	0.11	0.11	0.11	0.09	0.09	0.09	0.09	0.09	0.07
11.34	10.52	10.76	10.46	11.18	10.89	12.31	11.20	11.60	11.12	11.98	13.27
9.92	10.12	10.56	10.14	9.99	10.07	9.36	11.03	10.06	11.04	9.48	6.60
8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25
9.41	10.74	9.81	10.79	9.39	9.85	11.67	12.25	12.29	12.34	11.86	12.36
0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
0.17	0.17	0.17	0.17	0.17	0.17	0.15	0.15	0.15	0.15	0.15	0.15
39.42	**40.13**	**39.89**	**40.15**	**39.31**	**39.56**	**42.04**	**43.19**	**42.65**	**43.20**	**42.03**	**40.93**
36.62	36.69	36.69	36.70	36.63	36.64	37.52	37.73	37.63	37.73	37.56	37.28
32.51	31.79	31.99	31.73	32.37	32.10	35.39	34.47	34.79	34.41	35.12	36.25
11.32	11.51	11.97	11.53	11.44	11.45	10.75	12.41	11.46	12.42	10.91	7.97
8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25
12.41	13.74	12.81	13.79	12.39	12.85	14.80	15.40	15.42	15.48	14.99	15.47
0.44	0.44	0.44	0.44	0.44	0.44	0.43	0.43	0.43	0.43	0.43	0.43
101.54	**102.42**	**102.14**	**102.44**	**101.51**	**101.73**	**107.15**	**108.69**	**107.98**	**108.73**	**107.27**	**105.65**

Table D1. Key results for Clean Power Plan cases *(continued)*

Capacity, generation, prices, consumption, and emissions	2015	2020					
		Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended
Carbon dioxide emissions (million metric tons)							
by sector							
Residential	1,028	981	982	982	982	981	974
Commercial	918	893	893	893	893	893	885
Industrial[8]	1,472	1,558	1,559	1,558	1,559	1,558	1,551
Transportation	1,855	1,857	1,858	1,857	1,857	1,857	1,857
Total carbon dioxide emissions	**5,273**	**5,289**	**5,291**	**5,290**	**5,291**	**5,290**	**5,267**
Electric power sector							
Petroleum	20	11	11	11	11	11	11
Natural gas	524	451	450	450	450	451	456
Coal	1,340	1,360	1,362	1,362	1,363	1,361	1,336
Other[26]	6	6	6	6	6	6	6
Total electric power sector	**1,891**	**1,829**	**1,830**	**1,830**	**1,831**	**1,829**	**1,809**

[1]Net summer capacity is the steady hourly output that generating equipment is expected to supply to system load (exclusive of auxiliary power) as demonstrated by tests during summer peak demand.
[2]Includes electricity-only and combined heat and power plants that have a regulatory status.
[3]Total coal and oil and natural gas steam capacity account for the conversion of coal capacity to gas steam capacity but the conversions are not included explicitly as additions or retirements.
[4]Includes oil-, gas-, and dual-fired capacity.
[5]Does not include off-grid photovoltaics.
[6]Includes conventional hydroelectric, geothermal, wood, wood waste, municipal waste, landfill gas, and other biomass. Facilities co-firing biomass and coal are classified as coal.
[7]Includes pumped storage, fuel cells, and distributed generation.
[8]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[9]Cumulative after December 31, 2015.
[10]Includes conventional hydroelectric, geothermal, wood, wood waste, municipal waste, landfill gas, other biomass, solar, and wind power. Facilities co-firing biomass and coal are classified as coal.
[11]Includes pumped storage, non-biogenic municipal waste, refinery gas, still gas, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.
[12]Includes propane, kerosene, and distillate fuel oil.
[13]Includes wood used for residential heating. Excludes nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[14]Includes selected renewable energy consumption data for which the energy is not bought or sold, either directly or indirectly as an input to marketed energy.
[15]Includes propane, motor gasoline (including ethanol and ethers), kerosene, distillate fuel oil, and residual fuel oil.
[16]Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. Excludes nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[17]Includes ethane, propane, butane, isobutane, natural gasoline, refinery olefins, motor gasoline (including ethanol and ethers), distillate fuel oil, residual fuel oil, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[18]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources, and all biomass input to liquid fuel conversion processes net of the liquid fuel produced.
[19]Includes propane, motor gasoline (including ethanol and ethers), jet fuel, distillate fuel oil, residual fuel oil, lubricants, and aviation gasoline.
[20]Represents consumption unattributed to the sectors above.
[21]Includes distillate fuel oil and residual fuel oil.
[22]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[23]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes net electricity imports.
[24]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources, and all biomass input to liquid fuel conversion processes net of the liquid fuel produced. Excludes net electricity imports and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[25]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[26]Includes emissions from geothermal power and non-biogenic emissions from municipal waste.
CPP = Clean Power Plan.
Btu = British thermal unit.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Source: 2015: U.S. Energy Information Administration, (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System, runs ref2016.d032416a, ref_rate.d032416A, ref_trade.d032416a, ref_hybrid.d032416a, ref_allow_gen.d032416a, and ref_extend.d050416a.

2030						2040					
Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended	Reference	CPP Rate	CPP Interregional Trading	CPP Hybrid	CPP Allocation to Generators	CPP Extended
841	833	850	832	840	838	821	855	831	854	820	750
807	799	817	799	806	805	826	864	837	863	825	749
1,587	1,586	1,599	1,585	1,593	1,583	1,660	1,700	1,674	1,700	1,665	1,586
1,726	1,726	1,728	1,726	1,726	1,726	1,737	1,742	1,738	1,742	1,738	1,728
4,961	**4,944**	**4,994**	**4,943**	**4,966**	**4,952**	**5,044**	**5,162**	**5,080**	**5,159**	**5,047**	**4,813**
8	8	8	8	8	8	6	7	7	7	6	6
602	558	571	555	593	578	653	594	615	590	636	704
943	962	1,000	965	949	958	885	1,045	949	1,045	897	623
6	6	6	6	6	6	6	6	6	6	6	6
1,559	**1,535**	**1,585**	**1,534**	**1,557**	**1,550**	**1,551**	**1,652**	**1,578**	**1,649**	**1,545**	**1,339**

Table D2. Key transportation results for the Phase 2 Standards case

Key indicators, consumption, and emissions	2015	2020		2030		2040	
		Reference	Phase 2 Standards	Reference	Phase 2 Standards	Reference	Phase 2 Standards
Average fuel efficiency of new trucks (miles per gallon)							
Light medium							
Diesel	14.3	15.5	15.6	15.6	19.0	15.7	19.2
Motor gasoline	10.4	10.8	11.5	10.8	14.3	10.9	14.7
Propane	10.0	10.3	12.3	10.9	16.2	11.0	16.3
Compressed / liquefied natural gas	9.3	9.9	11.5	10.6	15.0	10.6	14.8
Light medium average	13.4	14.4	14.7	14.5	18.0	14.5	18.3
Medium							
Diesel	8.9	9.2	10.0	9.2	12.9	9.2	13.1
Motor gasoline	6.4	6.5	7.3	6.6	9.1	6.7	9.3
Propane	6.6	6.7	6.9	7.0	8.6	7.0	8.8
Compressed / liquefied natural gas	6.5	6.6	7.2	6.6	9.1	6.7	9.3
Medium average	8.3	8.5	9.3	8.6	12.0	8.7	12.2
Heavy							
Diesel	6.3	6.8	7.2	6.9	8.8	7.0	9.1
Motor gasoline	5.7	5.9	6.5	5.9	7.8	6.1	8.0
Propane	5.2	5.4	5.5	5.5	6.7	5.8	6.9
Compressed / liquefied natural gas	5.9	6.3	6.6	6.4	8.0	6.4	8.0
Heavy average	6.3	6.8	7.2	6.9	8.8	6.9	9.0
Average new truck fuel efficiency	**7.1**	**7.7**	**8.2**	**7.9**	**10.3**	**8.0**	**10.6**
New truck sales (thousands)							
Light medium							
Diesel	136	148	148	157	157	185	186
Motor gasoline	52	54	54	54	54	63	63
Propane	0	0	0	0	0	1	1
Compressed / liquefied natural gas	0	0	0	1	1	5	4
Light medium subtotal	188	202	202	212	212	253	253
Medium							
Diesel	133	165	165	181	181	200	201
Motor gasoline	51	60	60	62	62	67	67
Propane	0	0	0	1	0	2	2
Compressed / liquefied natural gas	0	1	1	1	1	1	1
Medium subtotal	184	225	225	244	244	269	270
Heavy							
Diesel	261	242	243	226	229	219	245
Motor gasoline	11	10	10	10	10	10	11
Propane	0	0	0	0	0	1	1
Compressed / liquefied natural gas	2	2	2	4	2	35	10
Heavy subtotal	275	254	255	241	241	265	266
Total new truck sales	**647**	**681**	**682**	**697**	**698**	**787**	**790**
Freight truck stock (millions)							
Light medium	3.17	3.91	3.91	5.02	5.02	5.83	5.84
Medium	3.19	3.68	3.68	4.68	4.68	5.46	5.47
Heavy	4.58	5.19	5.19	5.60	5.60	5.91	5.92
Total freight truck stock	**10.93**	**12.77**	**12.77**	**15.29**	**15.30**	**17.20**	**17.22**
Freight truck vehicle miles traveled (billion miles)							
Light medium	49.4	52.7	52.7	64.2	64.0	78.9	78.6
Medium	47.8	54.3	54.3	75.2	75.1	91.3	91.0
Heavy	182.6	197.2	197.3	209.5	209.1	236.6	235.6
Total freight truck vehicle miles traveled	**279.8**	**304.2**	**304.4**	**348.9**	**348.2**	**406.8**	**405.1**
Freight truck fuel efficiency (miles per gallon)							
Light medium	12.3	12.9	12.9	13.8	15.3	14.1	17.2
Medium	7.8	8.1	8.2	8.4	10.1	8.5	11.3
Heavy	6.0	6.3	6.4	6.7	7.7	6.8	8.6
Total freight truck fuel efficiency	**6.9**	**7.3**	**7.4**	**7.8**	**9.0**	**8.0**	**10.2**
Freight truck fuel consumption (quadrillion Btu)							
Light medium	0.54	0.55	0.55	0.63	0.56	0.75	0.62
Medium	0.82	0.90	0.88	1.21	1.00	1.46	1.08
Heavy	4.20	4.31	4.24	4.32	3.74	4.78	3.77
Total freight truck fuel consumption	**5.57**	**5.76**	**5.67**	**6.16**	**5.30**	**6.98**	**5.46**

Table D2. Key transportation results for the Phase 2 Standards case *(continued)*

Key indicators, consumption, and emissions	2015	2020		2030		2040	
		Reference	Phase 2 Standards	Reference	Phase 2 Standards	Reference	Phase 2 Standards
Fuel consumption (quadrillion Btu)							
Transportation sector	**28.13**	**28.29**	**28.21**	**26.28**	**25.43**	**26.63**	**25.08**
Propane	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Motor gasoline	17.01	16.79	16.79	13.62	13.55	12.55	12.40
of which: ethanol	1.18	1.19	1.19	1.12	1.12	1.24	1.23
Jet fuel[1]	2.84	2.99	2.99	3.32	3.32	3.56	3.56
Distillate fuel oil[2]	6.67	6.99	6.91	7.49	6.73	8.01	6.92
Other petroleum[3]	0.60	0.53	0.53	0.58	0.58	0.62	0.62
Petroleum and other liquids subtotal	27.14	27.32	27.24	25.01	24.18	24.75	23.52
Pipeline fuel natural gas	0.89	0.83	0.83	0.94	0.94	1.07	1.03
Compressed / liquefied natural gas	0.07	0.08	0.08	0.17	0.15	0.59	0.31
Liquid hydrogen	0.00	0.01	0.01	0.04	0.04	0.06	0.06
Electricity	0.03	0.05	0.05	0.11	0.11	0.15	0.15
Total energy consumption	**96.7**	**100.5**	**100.5**	**101.5**	**100.5**	**107.1**	**105.2**
Petroleum and other liquids	36.5	37.8	37.8	36.6	35.6	37.5	36.0
Natural gas	28.3	28.3	28.2	32.5	32.4	35.4	34.9
Coal	15.5	15.6	15.8	11.3	11.4	10.7	10.8
Nuclear / uranium[4]	8.3	8.1	8.1	8.2	8.2	8.2	8.2
Renewable energy[5]	7.7	10.2	10.1	12.4	12.4	14.8	14.8
Other[6]	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Carbon dioxide emissions (million metric tons)							
Transportation sector	**1,851**	**1,851**	**1,845**	**1,714**	**1,655**	**1,721**	**1,618**
Petroleum[7]	1,800	1,802	1,796	1,652	1,594	1,628	1,542
Natural gas[8]	51	49	49	62	61	93	76
Total carbon dioxide emissions	**5,273**	**5,289**	**5,295**	**4,961**	**4,894**	**5,044**	**4,929**
Petroleum[7]	2,309	2,332	2,325	2,191	2,127	2,181	2,085
Natural gas	1,482	1,466	1,463	1,685	1,677	1,835	1,809
Coal	1,476	1,485	1,501	1,079	1,083	1,021	1,028
Other[9]	6	6	6	6	6	6	6

[1]Includes only kerosene type.
[2]Diesel fuel for on- and off- road use.
[3]Includes residual fuel oil, aviation gasoline and lubricants.
[4]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[5]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, solar photovoltaic, and solar thermal sources, and all biomass input to liquid fuel conversion processes net of the liquid fuel produced. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[6]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[7]This includes carbon dioxide from international bunker fuels, both civilian and military, which are excluded from the accounting of carbon dioxide emissions under the United Nations convention. From 1990 through 2015, international bunker fuels accounted for 90 to 126 million metric tons annually.
[8]Includes emissions from pipeline fuel natural gas and from natural gas used as fuel in motor vehicles, trains, and ships.
[9]Includes emissions from geothermal power and non-biogenic emissions from municipal waste.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Source: 2015: U.S. Energy Information Administration, (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs ref2016.d032416a, and phaseii.d041316a.

Table D3. Key results for extended policies case

Consumption, emissions, electricity generating capacity and generation, and prices	2015	2020		2030		2040	
		Reference	Extended Policies	Reference	Extended Policies	Reference	Extended Policies
Energy consumption (quadrillion Btu)							
Residential							
Liquid fuels and other petroleum[1]	0.93	0.86	0.86	0.72	0.70	0.61	0.59
Natural gas	4.77	4.87	4.85	4.80	4.63	4.73	4.43
Renewable energy[2]	0.44	0.42	0.41	0.39	0.39	0.37	0.36
Electricity	4.78	4.76	4.73	4.83	4.45	5.20	4.60
Total residential	**10.92**	**10.90**	**10.86**	**10.74**	**10.17**	**10.91**	**9.98**
Commercial							
Liquid fuels and other petroleum[3]	0.66	0.70	0.70	0.68	0.68	0.67	0.67
Natural gas	3.32	3.45	3.44	3.53	3.56	3.81	3.79
Coal	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Renewable energy[4]	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Electricity	4.64	4.69	4.68	5.09	4.98	5.62	5.42
Total commercial	**8.81**	**9.03**	**9.01**	**9.49**	**9.41**	**10.28**	**10.07**
Industrial[5]							
Liquid fuels and other petroleum[6]	8.07	9.40	9.37	10.55	10.42	11.82	11.42
Natural gas	9.38	10.57	10.57	11.72	11.90	12.89	13.06
Coal	1.34	1.23	1.21	1.35	1.36	1.34	1.33
Renewable energy[7]	2.26	2.30	2.30	2.47	2.48	2.63	2.60
Electricity	3.27	3.61	3.60	3.98	3.99	4.26	4.22
Total industrial	**24.33**	**27.11**	**27.04**	**30.07**	**30.15**	**32.94**	**32.63**
Transportation							
Liquid fuels and other petroleum[8]	27.14	27.32	27.23	25.01	24.04	24.75	22.56
Pipeline fuel natural gas	0.89	0.83	0.84	0.94	0.91	1.07	1.01
Compressed / liquefied natural gas	0.07	0.08	0.08	0.17	0.14	0.59	0.32
Liquid hydrogen	0.00	0.01	0.01	0.04	0.04	0.06	0.06
Electricity	0.03	0.05	0.05	0.11	0.12	0.15	0.22
Total transportation	**28.13**	**28.29**	**28.20**	**26.28**	**25.26**	**26.63**	**24.16**
Unspecified sector[9]	**-0.58**	**-0.58**	**-0.58**	**-0.46**	**-0.42**	**-0.42**	**-0.34**
Electric power[10]							
Distillate and residual fuel oil	0.26	0.15	0.15	0.11	0.11	0.09	0.08
Natural gas	9.89	8.50	8.86	11.34	9.77	12.31	10.75
Steam coal	14.08	14.34	14.27	9.92	10.62	9.36	7.88
Nuclear / uranium[11]	8.34	8.12	8.12	8.25	8.25	8.25	8.25
Renewable energy[12]	4.86	7.37	6.82	9.41	9.78	11.67	13.32
Non-biogenic municipal waste	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Net electricity imports	0.19	0.19	0.20	0.17	0.17	0.15	0.15
Total electric power	**37.85**	**38.90**	**38.64**	**39.42**	**38.92**	**42.04**	**40.64**
Total energy consumption							
Liquid fuels and other petroleum	36.49	37.85	37.73	36.62	35.54	37.52	34.97
Natural gas	28.31	28.30	28.64	32.51	30.91	35.39	33.35
Steam coal	15.48	15.62	15.54	11.32	12.03	10.75	9.26
Nuclear / uranium[11]	8.34	8.12	8.12	8.25	8.25	8.25	8.25
Renewable energy[13]	7.71	10.22	9.67	12.41	12.78	14.80	16.42
Other[14]	0.42	0.43	0.43	0.44	0.44	0.43	0.43
Total energy consumption	**96.74**	**100.55**	**100.13**	**101.54**	**99.95**	**107.15**	**102.67**
Carbon dioxide emissions (million metric tons)							
by sector							
Residential	317	317	316	303	293	292	275
Commercial	228	238	238	241	242	254	253
Industrial[5]	986	1,054	1,052	1,144	1,145	1,226	1,210
Transportation	1,851	1,851	1,845	1,714	1,643	1,721	1,557
Electric power[10]	1,891	1,829	1,841	1,559	1,542	1,551	1,327
by fuel							
Petroleum[15]	2,309	2,332	2,325	2,191	2,115	2,181	2,011
Natural gas	1,482	1,466	1,484	1,685	1,599	1,835	1,725
Coal	1,476	1,485	1,477	1,079	1,146	1,021	879
Other[16]	6	6	6	6	6	6	6
Total carbon dioxide emissions	**5,273**	**5,289**	**5,292**	**4,961**	**4,867**	**5,044**	**4,623**

Table D3. Key results for extended policies case *(continued)*

Consumption, emissions, electricity generating capacity and generation, and prices	2015	2020		2030		2040	
		Reference	Extended Policies	Reference	Extended Policies	Reference	Extended Policies
Electricity generating capacity (gigawatts)	**1,082.1**	**1,114.2**	**1,093.9**	**1,188.1**	**1,207.0**	**1,374.1**	**1,410.3**
Electric power sector[10]	1,040.8	1,053.0	1,029.1	1,094.2	1,069.4	1,239.6	1,188.6
Coal	281.4	211.7	206.0	180.3	183.2	172.8	166.6
Oil and natural gas steam	91.4	90.3	91.9	54.5	47.7	52.8	39.2
Combined-cycle	227.3	247.5	246.4	294.5	260.0	345.4	280.1
Combustion turbine / diesel	141.2	142.9	141.8	137.0	127.5	144.6	121.5
Nuclear / uranium	99.8	99.1	99.1	99.1	99.1	99.1	99.1
Pumped storage	22.6	22.6	22.6	22.6	22.6	22.6	22.6
Renewable sources	177.1	238.7	221.1	305.2	328.8	399.4	458.2
of which: Solar	13.8	28.0	31.2	70.1	101.3	158.1	181.1
of which: Wind	74.4	120.4	99.9	142.0	134.5	145.8	181.2
Distributed generation	0.0	0.2	0.2	1.0	0.4	2.9	1.2
Residential and commercial sectors	15.2	33.8	37.1	62.0	104.0	98.2	182.6
of which: Natural gas	1.8	2.2	2.5	3.6	4.1	6.0	6.8
of which: Solar photovoltaic	11.2	28.7	28.8	55.1	84.9	88.3	149.5
of which: Wind	1.6	2.3	5.1	2.6	14.3	3.2	25.7
Industrial sector[5]	26.1	27.3	27.8	31.8	33.6	36.3	39.1
of which: Natural gas	14.7	15.2	15.7	19.2	20.9	23.5	26.2
Cumulative capacity additions (gigawatts)[17]	- -	122.1	108.3	281.1	311.7	482.9	557.7
Cumulative capacity retirements (gigawatts)[17]	- -	90.1	96.6	175.2	186.9	191.0	229.5
Generation by fuel (billion kilowatthours)	**4,090**	**4,244**	**4,234**	**4,590**	**4,511**	**5,060**	**4,943**
Electric power sector[10]	3,915	4,021	4,003	4,294	4,144	4,673	4,418
Coal	1,343	1,376	1,371	959	1,027	905	764
Petroleum	24	14	14	10	10	8	7
Natural gas	1,250	1,090	1,137	1,558	1,304	1,757	1,474
Nuclear / uranium	798	777	777	789	789	789	789
Pumped storage / other	3	3	3	3	3	3	3
Renewable sources	497	761	700	973	1,011	1,210	1,381
of which: Solar	22	52	59	148	213	350	400
of which: Wind	188	365	296	453	428	468	587
Distributed generation	0	0	0	1	0	2	1
Residential and commercial sectors	35	64	70	113	175	180	303
of which: Natural gas	13	16	18	27	30	44	49
of which: Solar photovoltaic	15	40	40	79	121	127	215
of which: Wind	2	3	7	3	19	4	34
Industrial sector[5]	140	159	161	183	192	207	222
of which: Natural gas	86	96	98	116	125	139	154
Delivered natural gas prices (2015 dollars per thousand cubic feet)							
Residential	10.40	11.08	11.37	12.41	12.12	12.74	12.75
Commercial	7.92	9.58	9.86	10.72	10.28	10.73	10.47
Industrial[5]	3.84	5.53	5.81	6.14	5.71	5.89	5.64
Electric power[10]	3.35	4.83	5.10	5.74	5.23	5.52	5.23
Average electricity price (2015 cents per kilowatthour)	10.3	10.5	10.6	10.9	10.8	10.5	10.4

[1]Includes propane, kerosene, and distillate fuel oil.
[2]Includes wood used for residential heating. Excludes nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[3]Includes propane, motor gasoline (including ethanol and ethers), kerosene, distillate fuel oil, and residual fuel oil.
[4]Includes commercial sector consumption of wood and wood waste, landfill gas, municipal waste, and other biomass for combined heat and power. Excludes nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[5]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[6]Includes motor gasoline (including ethanol and ethers), residual fuel oil, petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
[7]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol.
[8]Includes propane, motor gasoline, ethanol and ethers, jet fuel, distillate fuel oil, residual fuel oil, aviation gasoline, and lubricants.
[9]Represents consumption unattributed to the sectors above.
[10]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[11]These values represent the energy obtained from uranium when it is used in light water reactors. The total energy content of uranium is much larger, but alternative processes are required to take advantage of it.
[12]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources.
[13]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal waste, other biomass, wind, photovoltaic, and solar thermal sources. Excludes ethanol, net electricity imports, and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[14]Includes non-biogenic municipal waste, liquid hydrogen, and net electricity imports.
[15]This includes carbon dioxide from international bunker fuels, both civilian and military, which are excluded from the accounting of carbon dioxide emissions under the United Nations convention. From 1990 through 2012, international bunker fuels accounted for 90 to 126 million metric tons annually.
[16]Includes emissions from geothermal power and emissions from non-biogenic municipal waste.
[17]Cumulative after December 31, 2015.
Btu = British thermal unit.
- - = Not applicable.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Source: 2015: U.S. Energy Information Administration, (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections**: EIA, AEO2016 National Energy Modeling System, runs ref2016.d032416a, and extended.d051216a.

Table D4. Natural gas supply and disposition, oil and gas resource and technology cases
(trillion cubic feet per year, unless otherwise noted)

Supply, disposition, and prices	2015	2020			2030			2040		
		Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology	Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology	Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology
Henry Hub spot price										
(2015 dollars per million Btu)	2.62	6.27	4.43	2.89	7.61	5.06	3.50	9.17	4.86	2.43
(nominal dollars per million Btu)	2.62	6.97	4.90	3.18	10.60	6.84	4.64	16.15	8.17	3.95
Dry gas production[1]	**27.19**	**27.35**	**30.50**	**34.19**	**25.50**	**37.76**	**47.14**	**26.68**	**42.12**	**55.53**
Lower 48 onshore	25.20	25.82	28.82	32.41	24.29	36.15	45.44	24.30	40.18	53.35
Tight gas	5.00	4.81	4.92	5.11	4.37	6.08	7.02	4.50	6.55	8.00
Shale gas and tight oil plays[2]	13.64	14.91	17.96	21.57	14.84	25.16	33.66	15.03	29.00	41.02
Coalbed methane	1.24	1.18	1.04	0.96	1.10	0.94	0.82	0.97	0.78	0.63
Other	5.32	4.92	4.90	4.78	3.98	3.97	3.95	3.80	3.85	3.70
Lower 48 offshore	1.70	1.23	1.39	1.48	0.93	1.33	1.39	1.15	1.67	1.84
Alaska	0.29	0.29	0.29	0.29	0.28	0.28	0.31	1.23	0.28	0.34
Supplemental natural gas[3]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Net imports	**0.95**	**-2.37**	**-2.89**	**-3.22**	**-1.59**	**-6.02**	**-10.21**	**-1.90**	**-7.55**	**-13.00**
Pipeline[4]	0.89	-0.14	-0.48	-0.80	0.25	-0.97	-2.02	1.62	-0.89	-2.81
Liquefied natural gas	0.06	-2.22	-2.42	-2.42	-1.84	-5.06	-8.19	-3.52	-6.66	-10.19
Total supply	**28.20**	**25.04**	**27.67**	**31.03**	**23.98**	**31.80**	**36.99**	**24.84**	**34.63**	**42.59**
Consumption by sector										
Residential	4.62	4.62	4.71	4.80	4.44	4.65	4.79	4.30	4.58	4.76
Commercial	3.22	3.20	3.34	3.47	3.14	3.42	3.65	3.23	3.69	4.02
Industrial[5]	7.51	8.14	8.29	8.33	8.62	8.85	9.12	9.26	9.58	9.89
Electric power[6]	9.61	6.29	8.26	11.10	5.12	11.02	14.60	4.76	11.96	17.94
Transportation[7]	0.06	0.09	0.09	0.09	0.16	0.22	0.23	0.47	0.66	0.52
Pipeline fuel	0.86	0.75	0.81	0.90	0.68	0.91	1.10	0.74	1.04	1.28
Lease and plant fuel[8]	1.58	1.57	1.71	1.88	1.46	2.00	2.47	1.51	2.24	2.94
Liquefaction for export[9]	0.00	0.23	0.25	0.25	0.19	0.51	0.83	0.36	0.67	1.03
Total	**27.47**	**24.89**	**27.46**	**30.83**	**23.81**	**31.59**	**36.78**	**24.64**	**34.42**	**42.38**
Discrepancy[10]	0.73	0.16	0.21	0.21	0.17	0.21	0.21	0.20	0.21	0.21

[1]Marketed production (wet) minus extraction losses.
[2]Tight oil represents resources in low-permeability reservoirs, including shale and chalk formations. The specific plays included in the tight oil category are Bakken/Three Forks/Sanish, Eagle Ford, Woodford, Austin Chalk, Spraberry, Niobrara, Avalon/Bone Springs, and Monterey.
[3]Synthetic natural gas, propane air, coke oven gas, refinery gas, biomass gas, air injected for Btu stabilization, and manufactured gas commingled and distributed with natural gas.
[4]Natural gas imported from Canada and Mexico.
[5]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems. Excludes use for lease and plant fuel.
[6]Includes consumption of energy by electricity-only and combined heat and power plants that have a regulatory status.
[7]Natural gas used as fuel in motor vehicles, trains, and ships.
[8]Represents natural gas used in well, field, and lease operations, and in natural gas processing plant machinery.
[9]Fuel used in facilities that liquefy natural gas for export.
[10]Balancing item. Natural gas lost as a result of converting flow data measured at varying temperatures and pressures to a standard temperature and pressure and the merger of different data reporting systems which vary in scope, format, definition, and respondent type. In addition, 2015 values include net storage injections.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration, (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowresource.d032516a, ref2016.d032416a, and highresource.d032516a.

Table D5. Liquid fuels supply and disposition, oil and gas resource and technology cases
(million barrels per day, unless otherwise noted)

Supply, disposition, and prices	2015	2020			2030			2040		
		Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology	Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology	Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology
Crude oil prices										
(2015 dollars per barrel)										
Brent spot	52	79	77	71	112	104	85	152	136	110
West Texas Intermediate spot	49	74	71	65	106	97	77	147	129	99
Imported crude oil[1]	46	71	69	63	101	95	76	139	126	95
Crude oil supply										
Domestic production[2]	9.42	8.08	9.38	11.25	7.55	10.06	13.89	7.02	11.26	17.68
Alaska	0.48	0.41	0.41	0.41	0.24	0.24	0.44	0.15	0.15	0.67
Lower 48 States	8.94	7.66	8.96	10.83	7.31	9.82	13.46	6.87	11.11	17.01
Net imports	6.88	7.19	6.97	6.48	6.92	6.57	4.15	6.81	6.10	-0.02
Gross imports	7.28	7.82	7.60	7.11	7.56	7.20	6.02	7.68	7.12	6.17
Exports	0.40	0.63	0.63	0.63	0.63	0.63	1.87	0.86	1.02	6.18
Other crude oil supply[3]	-0.11	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total crude oil supply	**16.19**	**15.28**	**16.36**	**17.74**	**14.47**	**16.63**	**18.04**	**13.83**	**17.36**	**17.67**
Net product imports	-2.24	-1.61	-3.26	-5.25	-0.71	-4.32	-6.26	0.54	-4.66	-5.59
Gross refined product imports[4]	0.66	1.18	1.11	1.07	1.46	1.30	1.11	1.96	1.63	1.27
Unfinished oil imports	0.55	0.53	0.53	0.54	0.46	0.46	0.46	0.39	0.39	0.39
Blending component imports	0.67	0.58	0.58	0.61	0.44	0.45	0.44	0.29	0.30	0.28
Exports	4.12	3.91	5.48	7.46	3.07	6.52	8.27	2.11	6.98	7.52
Refinery processing gain[5]	1.03	1.05	1.05	1.11	0.94	0.98	0.99	0.93	0.99	0.91
Natural gas plant liquids	3.25	4.01	4.57	5.09	3.45	4.90	5.72	3.21	4.99	6.24
Supply from renewable sources	1.01	1.08	1.08	1.08	1.03	1.03	1.02	1.12	1.12	1.10
Ethanol	0.89	0.89	0.89	0.89	0.84	0.84	0.84	0.92	0.93	0.91
Domestic production	0.94	0.89	0.90	0.90	0.87	0.87	0.87	0.89	0.91	0.92
Net imports	-0.05	0.00	-0.01	-0.01	-0.03	-0.03	-0.04	0.04	0.02	-0.01
Biodiesel	0.11	0.15	0.15	0.15	0.12	0.10	0.05	0.12	0.10	0.05
Domestic production	0.08	0.12	0.11	0.11	0.08	0.06	0.01	0.08	0.06	0.01
Net imports	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Other biomass-derived liquids[6]	0.00	0.04	0.04	0.04	0.08	0.09	0.14	0.08	0.09	0.14
Other[7]	0.21	0.28	0.28	0.27	0.29	0.30	0.29	0.30	0.32	0.30
Total primary supply[8]	**19.46**	**20.08**	**20.08**	**20.03**	**19.46**	**19.52**	**19.80**	**19.93**	**20.12**	**20.63**
Net import share of product supplied	23.7	28.0	18.6	6.2	32.0	11.6	-10.7	37.3	7.4	-27.0
Net expenditures for imports of crude oil & petroleum products (billion 2015 dollars)	128	220	207	179	300	268	182	412	348	231
Refined petroleum product prices to the transportation sector										
(2015 dollars per gallon)										
Propane	1.64	1.97	1.94	1.88	2.20	2.14	2.04	2.54	2.43	2.32
Ethanol (E85)[9]	2.21	3.09	3.05	2.96	3.02	2.93	2.71	3.45	3.33	3.01
Ethanol wholesale price	2.22	2.80	2.77	2.72	2.33	2.28	2.28	2.64	2.60	2.48
Motor gasoline[10]	2.52	2.81	2.74	2.64	3.37	3.19	2.78	4.10	3.81	3.13
Jet fuel[11]	1.62	2.26	2.18	2.05	3.08	2.87	2.44	4.09	3.74	2.91
Distillate fuel oil[12]	2.72	3.24	3.18	3.05	4.03	3.85	3.42	5.01	4.68	3.87
Residual fuel oil	1.21	1.77	1.75	1.64	2.40	2.25	1.80	3.13	2.87	2.14

[1]Weighted average price delivered to U.S. refiners.
[2]Includes lease condensate.
[3]Strategic petroleum reserve stock additions plus unaccounted for crude oil and crude stock withdrawals minus crude product supplied.
[4]Includes other hydrocarbons and alcohol.
[5]The volumetric amount by which total output is greater than input due to the processing of crude oil into products which, in total, have a lower specific gravity than the crude oil processed.
[6]Includes pyrolysis oils, biomass-derived Fischer-Tropsch liquids, biobutanol, and renewable feedstocks used for the on-site production of diesel and gasoline.
[7]Includes domestic sources of other blending components, other hydrocarbons, and ethers.
[8]Total crude supply, net product imports, refinery processing gain, natural gas plant liquids, supply from renewable sources, and other supply..
[9]E85 refers to a blend of 85 pecent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[10]Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
[11]Includes only kerosene-type.
[12]Diesel fuel for on-road use. Includes Federal and State taxes while excluding county and local taxes.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Sources: 2015: U.S. Energy Information Administration, (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowresource.d032516a, ref2016.d032416a, and highresource.d032516a.

Table D6. Key transportation results, oil and gas resource and technology cases

Key indicators and consumption	2015	2020			2030			2040		
		Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology	Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology	Low Oil and Gas Resource and Technology	Reference	High Oil and Gas Resource and Technology
Level of travel										
(billion vehicle miles traveled)										
Light-duty vehicles less than 8,501 lbs	2,752	3,019	3,031	3,043	3,191	3,232	3,332	3,364	3,438	3,656
Commercial light trucks[1]	96	110	110	109	124	125	127	140	143	146
Freight trucks greater than 10,000 lbs	280	303	304	304	343	349	356	395	407	417
(billion seat miles available)										
Air	1,070	1,166	1,168	1,170	1,360	1,364	1,373	1,529	1,531	1,536
(billion ton miles traveled)										
Rail	1,690	1,805	1,810	1,811	1,983	2,006	2,037	2,085	2,128	2,171
Domestic shipping	482	448	453	455	387	404	420	378	407	431
Energy efficiency indicators (miles per gallon)										
Tested new light-duty vehicle[2]	30.9	37.0	36.9	36.8	47.5	47.2	46.7	48.1	47.8	47.1
New car[2]	35.9	44.2	44.2	44.2	55.2	55.1	54.9	55.3	55.1	54.9
New light truck[2]	27.0	31.8	31.7	31.7	40.5	40.4	40.3	40.5	40.4	40.4
On-road new light-duty vehicle[3]	25.0	29.9	29.8	29.7	38.4	38.2	37.7	38.9	38.6	38.0
New car[3]	29.3	36.1	36.1	36.1	45.1	45.0	44.9	45.1	45.0	44.8
New light truck[3]	21.6	25.4	25.4	25.4	32.4	32.3	32.3	32.4	32.3	32.3
Light-duty stock[4]	21.7	24.1	24.1	24.1	31.5	31.5	31.4	36.5	36.3	36.0
New commercial light truck[1]	17.3	19.6	19.5	19.5	24.0	24.0	23.9	24.1	24.0	24.0
Stock commercial light truck[1]	15.0	16.6	16.6	16.6	20.8	20.8	20.9	23.2	23.2	23.2
Freight truck	6.9	7.3	7.3	7.3	7.8	7.8	7.8	8.0	8.0	7.9
Energy use by mode (quadrillion Btu)										
Light-duty vehicles	15.86	15.66	15.73	15.80	12.63	12.82	13.26	11.52	11.83	12.71
Commercial light trucks[1]	0.80	0.82	0.82	0.82	0.74	0.75	0.76	0.76	0.77	0.79
Bus transportation	0.26	0.27	0.27	0.27	0.29	0.29	0.29	0.31	0.31	0.31
Freight trucks	5.57	5.74	5.76	5.75	6.06	6.16	6.30	6.77	6.98	7.20
Rail, passenger	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Rail, freight	0.48	0.50	0.50	0.50	0.51	0.51	0.52	0.50	0.51	0.52
Shipping, domestic and international	0.83	0.73	0.73	0.73	0.74	0.77	0.84	0.77	0.82	0.89
Air	2.37	2.51	2.52	2.52	2.81	2.82	2.84	2.99	3.00	3.01
Other uses[4]	1.03	1.06	1.06	1.06	1.11	1.12	1.12	1.22	1.22	1.24
Pipeline fuel	0.89	0.77	0.83	0.93	0.71	0.94	1.13	0.76	1.07	1.32
Total	**28.14**	**28.12**	**28.28**	**28.44**	**25.66**	**26.24**	**27.12**	**25.65**	**26.57**	**28.04**
Energy use by fuel (quadrillion Btu)										
Propane	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Motor gasoline[5]	17.01	16.72	16.79	16.85	13.41	13.62	14.07	12.20	12.55	13.44
of which: E85[6]	0.05	0.04	0.04	0.03	0.24	0.22	0.16	0.32	0.28	0.20
Jet fuel[7]	2.84	2.99	2.99	3.00	3.31	3.32	3.34	3.55	3.56	3.57
Distillate fuel oil[8]	6.67	6.97	6.99	6.99	7.44	7.49	7.65	7.97	8.01	8.41
Residual fuel oil	0.45	0.37	0.37	0.37	0.39	0.42	0.47	0.42	0.45	0.52
Other petroleum[9]	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Liquid fuels and other petroleum	27.14	27.22	27.32	27.38	24.73	25.01	25.70	24.32	24.75	26.13
Pipeline fuel natural gas	0.89	0.77	0.83	0.93	0.71	0.94	1.13	0.76	1.07	1.32
Compressed/liquefied natural gas	0.07	0.08	0.08	0.09	0.10	0.17	0.18	0.40	0.59	0.44
Liquid hydrogen	0.00	0.01	0.01	0.01	0.04	0.04	0.04	0.06	0.06	0.06
Electricity	0.03	0.05	0.05	0.05	0.11	0.11	0.11	0.15	0.15	0.16
Delivered energy use	**28.13**	**28.13**	**28.29**	**28.45**	**25.69**	**26.28**	**27.17**	**25.70**	**26.63**	**28.12**

[1]Commercial trucks 8,501 to 10,000 pounds gross vehicle weight rating.
[2]Tested new vehicle efficiency revised for on-road performance.
[3]Combined "on-the-road" estimate for all cars and light trucks.
[4]Includes recreational boats, military use, and lubricants.
[5]Includes ethanol and ethers blended into gasoline.
[6]E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
[7]Includes only kerosene type.
[8]Diesel fuel for on- and off- road use.
[9]Includes aviation gasoline and lubricants.
Lbs = Pounds.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Source: 2015: U.S. Energy Information Administration, (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System runs lowresource.d032516a, ref2016.d032416a, and highresource.d032516a.

Table D7. Key results for industrial energy efficiency cases
(quadrillion Btu per year, unless otherwise noted)

Consumption and emissions	2015	2025				2040			
		Reference	Energy Efficiency	Low Incentive	High Incentive	Reference	Energy Efficiency	Low Incentive	High Incentive
Energy consumption									
Industrial[1]									
Cement and lime									
Petroleum and other liquids	0.04	0.09	0.10	0.09	0.09	0.14	0.13	0.14	0.14
Natural gas	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Coal	0.14	0.17	0.15	0.17	0.17	0.19	0.16	0.19	0.19
Renewable energy[2]	0.09	0.13	0.12	0.13	0.13	0.16	0.14	0.16	0.16
Electricity	0.05	0.06	0.05	0.06	0.06	0.07	0.06	0.07	0.07
Total cement and lime	**0.33**	**0.47**	**0.43**	**0.47**	**0.45**	**0.58**	**0.51**	**0.57**	**0.57**
Aluminum									
Petroleum and other liquids	0.03	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.03
Natural gas	0.11	0.13	0.11	0.14	0.15	0.13	0.11	0.14	0.14
Electricity	0.20	0.23	0.20	0.23	0.22	0.21	0.19	0.21	0.20
Total aluminum	**0.34**	**0.42**	**0.38**	**0.42**	**0.42**	**0.40**	**0.36**	**0.40**	**0.37**
Glass									
Petroleum and other liquids	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Natural gas	0.17	0.19	0.19	0.19	0.18	0.19	0.16	0.17	0.16
Electricity	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
Total glass	**0.24**	**0.27**	**0.26**	**0.27**	**0.26**	**0.27**	**0.24**	**0.25**	**0.23**
Iron and steel									
Petroleum and other liquids	0.07	0.10	0.09	0.09	0.08	0.13	0.13	0.13	0.14
Natural gas	0.40	0.43	0.37	0.42	0.39	0.45	0.40	0.48	0.49
Coal	0.56	0.50	0.47	0.45	0.33	0.47	0.44	0.43	0.41
Electricity	0.18	0.23	0.23	0.23	0.20	0.29	0.29	0.30	0.30
Total iron and steel	**1.21**	**1.26**	**1.17**	**1.20**	**1.00**	**1.34**	**1.25**	**1.34**	**1.34**
Paper									
Petroleum and other liquids	0.03	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.04
Natural gas	0.39	0.37	0.30	0.37	0.36	0.37	0.30	0.38	0.37
Coal	0.20	0.21	0.18	0.21	0.20	0.24	0.21	0.25	0.24
Renewable energy[2]	0.99	0.99	0.99	0.98	0.96	1.07	1.08	1.08	1.07
Electricity	0.20	0.18	0.14	0.17	0.16	0.15	0.13	0.14	0.13
Total paper	**1.81**	**1.79**	**1.64**	**1.77**	**1.71**	**1.87**	**1.75**	**1.88**	**1.84**
Other industries									
Petroleum and other liquids	7.86	9.87	9.86	9.73	9.38	11.42	11.41	11.10	10.77
Natural gas	8.30	10.20	10.22	10.14	9.85	11.73	11.75	11.57	11.40
Coal	0.44	0.43	0.43	0.43	0.42	0.45	0.45	0.44	0.44
Renewable energy[2]	1.18	1.27	1.27	1.26	1.25	1.39	1.39	1.37	1.37
Electricity	2.62	3.17	3.17	3.11	2.97	3.51	3.50	3.40	3.28
Total other industries	**20.40**	**24.94**	**24.95**	**24.67**	**23.87**	**28.49**	**28.50**	**27.89**	**27.27**
Total industrial sector									
Petroleum and other liquids	8.07	10.19	10.19	10.05	9.68	11.82	11.80	11.51	11.16
Natural gas	9.38	11.34	11.21	11.28	10.94	12.89	12.74	12.75	12.58
Coal	1.34	1.31	1.23	1.26	1.12	1.34	1.26	1.31	1.28
Renewable energy[2]	2.26	2.39	2.38	2.38	2.33	2.63	2.61	2.62	2.60
Electricity	3.27	3.91	3.83	3.83	3.65	4.26	4.21	4.15	4.01
Total industrial sector	**24.33**	**29.14**	**28.83**	**28.80**	**27.71**	**32.94**	**32.62**	**32.34**	**31.63**
Total delivered energy consumption									
Petroleum and other liquids	36.23	37.18	37.19	36.84	35.99	37.44	37.42	36.67	35.70
Natural gas	18.43	20.61	20.48	20.47	19.91	23.09	22.95	22.77	22.26
Coal	1.40	1.36	1.28	1.31	1.17	1.39	1.31	1.36	1.34
Renewable energy[3]	2.84	2.94	2.92	2.93	2.90	3.13	3.11	3.13	3.13
Electricity	12.72	13.60	13.53	13.37	12.95	15.23	15.19	14.82	14.38
Total	**71.62**	**75.73**	**75.44**	**74.94**	**72.95**	**80.34**	**80.04**	**78.81**	**76.87**
Electricity related losses	25.12	25.83	25.70	24.94	22.61	26.81	26.80	25.08	24.92
Total energy consumption	**96.74**	**101.56**	**101.14**	**99.89**	**95.56**	**107.15**	**106.84**	**103.88**	**101.79**

Table D7. Key results for industrial energy efficiency cases *(continued)*
(quadrillion Btu per year, unless otherwise noted)

Consumption and emissions	2015	2025				2040			
		Reference	Energy Efficiency	Low Incentive	High Incentive	Reference	Energy Efficiency	Low Incentive	High Incentive
Carbon dioxide emissions[4] (million metric tons)									
Residential	1,028	895	895	817	617	821	825	642	477
Commercial	918	836	837	756	550	826	830	632	450
Industrial[1]	1,472	1,600	1,575	1,523	1,316	1,660	1,637	1,498	1,341
Cement and lime	24	32	30	31	28	38	33	35	34
Aluminum	40	42	38	40	30	35	32	29	19
Glass	16	17	17	17	15	17	15	15	12
Iron and steel	108	106	101	98	72	107	101	97	88
Paper	72	65	53	62	52	60	52	56	51
Other industries	1,212	1,337	1,337	1,276	1,120	1,403	1,404	1,266	1,138
Transportation	1,855	1,784	1,785	1,770	1,735	1,737	1,737	1,703	1,657
Total carbon dioxide emissions	**5,273**	**5,115**	**5,092**	**4,865**	**4,217**	**5,044**	**5,029**	**4,475**	**3,925**

[1]Includes energy for combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[2]Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal waste, and other biomass sources. Excludes ethanol in motor gasoline.
[3]Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes ethanol and nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal water heaters.
[4]Emissions from the electric power sector are distributed to the end-use sectors.
Btu = British thermal unit.
Note: Totals may not equal sum of components due to independent rounding. Data for 2015 are model results and may differ from official EIA data reports.
Source: 2015: U.S. Energy Information Administration, (EIA), *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a. **Projections:** EIA, AEO2016 National Energy Modeling System, runs ref2016.d032416a, efficienttech.d032516a, lowinnovate.d032516a, and highinnovate.D032516a.

Appendix E
NEMS overview and brief description of cases

The National Energy Modeling System

Projections in the *Annual Energy Outlook 2016* (AEO2016) are generated using the National Energy Modeling System (NEMS) [*1*], developed and maintained by the Office of Energy Analysis of the U.S. Energy Information Administration (EIA). In addition to its use in developing the *Annual Energy Outlook* (AEO) projections, NEMS is used to complete analytical studies for the U.S. Congress, the Executive Office of the President, other offices within the U.S. Department of Energy, and other federal agencies. NEMS is also used by nongovernment groups, such as the Electric Power Research Institute, Duke University, and Georgia Institute of Technology. In addition, AEO projections are used by analysts and planners in other government agencies and nongovernmental organizations.

The projections in NEMS are developed with the use of a market-based approach, subject to regulations and standards. For each fuel and consuming sector, NEMS balances energy supply and demand, accounting for economic competition across the various energy fuels and sources. The time horizon of NEMS extends to 2040. To represent regional differences in energy markets, the component modules of NEMS function at the regional level: the 9 Census divisions for the end-use demand modules; production regions specific to oil, natural gas, and coal supply and distribution; 22 regions and subregions of the North American Electric Reliability Corporation for electricity; and 9 refining regions that are a subset of the 5 Petroleum Administration for Defense Districts.

NEMS is organized and implemented as a modular system. The modules represent each of the fuel supply markets, conversion sectors, and end-use consumption sectors of the energy system. The modular design also permits the use of the methodology and level of detail most appropriate for each energy sector. NEMS executes each of the component modules to solve for prices of energy delivered to end users and the quantities consumed, by product, region, and sector. The delivered fuel prices encompass all activities necessary to produce, import, and transport fuels to end users. The information flows also include such areas as economic activity, domestic production, and international petroleum supply. NEMS calls each supply, conversion, and end-use demand module in sequence until the delivered prices of energy and the quantities demanded have converged within tolerance, thereby achieving an economic equilibrium of supply and demand in the consuming sectors. A solution is reached for each year from 2015 through 2040. Other variables, such as petroleum product imports, crude oil imports, and several macroeconomic indicators, also are evaluated for convergence.

Each NEMS component represents the effects and costs of legislation and environmental regulations that affect each sector. NEMS accounts for all energy-related carbon dioxide emissions, as well as emissions of sulfur dioxide, nitrogen oxides, and mercury from the electricity generation sector.

The version of NEMS used for AEO2016 generally represents current legislation and environmental regulations, including recent government actions for which implementing regulations were available as of February 29, 2016, as discussed in the AEO2016 Legislation and Regulations section. The potential effects of proposed federal and state legislation, regulations, or standards—or of sections of legislation that have been enacted but require funds or implementing regulations that have not been provided or specified—are not reflected in NEMS. Many of the pending provisions are examined, however, in alternative cases included in AEO2016 or in other analysis completed by EIA.

In general, the historical data presented with AEO2016 projections are based on various EIA publications [*2*]; however, data also were taken from multiple non-EIA sources. Historical numbers through the year 2015 are presented for comparison only and may be estimates. Source documents should be consulted for the official data values. Footnotes to AEO2016 appendix tables indicate the definitions and sources of historical data.

Where possible, AEO2016, which was developed during the winter of 2015–16, presents information for 2015, 2016, and 2017 that is consistent with the short-term projections from EIA's February 2016 Short-Term Energy Outlook (STEO) [*3*]. EIA's views regarding energy use over the 2016 through 2017 period are reported in monthly STEO updates, which should be considered to supersede information reported for those years in AEO2016.

Component modules

The component modules of NEMS represent the individual supply, demand, and conversion sectors of domestic energy markets and also include international and macroeconomic modules. In general, the modules interact through values representing prices or expenditures for energy delivered to the consuming sectors, and the quantities of end-use energy consumption.

Macroeconomic Activity Module

The Macroeconomic Activity Module (MAM) provides a set of macroeconomic drivers to the energy modules and receives energy-related indicators from the NEMS energy components as part of the macroeconomic feedback mechanism within NEMS. Key macroeconomic variables used in the energy modules include gross domestic product, disposable income, values of industrial shipments, new housing starts, sales of new light-duty vehicles (LDVs), interest rates, and employment. Key energy indicators fed back to the MAM include aggregate energy prices and quantities. The MAM uses the following models from IHS Global Insight: Macroeconomic Model of the U.S. Economy, National Industrial Output Model, and National Employment by Industry Model.

In addition, EIA has constructed a Regional Economic, Industrial Output and Employment by Industry model to project regional economic drivers, and a Commercial Floorspace model to project growth rates in 13 floorspace types in the nine Census divisions. The accounting framework for industrial value of shipments uses the North American Industry Classification System (NAICS).

International Energy Module

The International Energy Module (IEM) uses assumptions about economic growth and expectations of future U.S. and world petroleum and other liquids production and consumption, by year, to project the interaction of U.S. and international petroleum and other liquids markets. The IEM module provides a supply curve for world crude-like liquids and generates a worldwide oil supply/demand balance for each year of the projection period. The supply-curve calculations are based on historical market data and a world oil supply/demand balance, which is developed from reduced-form models of international petroleum and other liquids supply and demand, current investment trends in exploration and development, and long-term resource economics by country and territory. The oil production estimates include both petroleum and other liquids supply recovery technologies. The IEM also provides, for each year of the projection period, endogenous assumptions about petroleum products for import and export in the United States. The IEM, through interaction with the rest of NEMS, changes North Sea Brent and West Texas Intermediate prices in response to changes in expected production and consumption of crude-like liquids and petroleum products in the United States.

Residential and Commercial Demand Modules

The Residential Demand Module projects energy consumption in the residential sector by Census division, housing type, and end use, based on delivered energy prices, the menu of equipment available, the availability of renewable sources of energy, and changes in the housing stock. The Commercial Demand Module projects energy consumption in the commercial sector by Census division, building type, and category of end use, based on delivered prices of energy, the menu of available equipment, availability of renewable sources of energy, and changes in commercial floorspace.

Both modules estimate the equipment stock for the major end-use services, incorporating assessments of advanced technologies, representations of renewable energy technologies, and the effects of both building shell and appliance standards. The modules also include projections of distributed generation. The Commercial Demand Module also incorporates combined heat and power technology. Both modules incorporate projections of heating and cooling degree-days by Census division, based on a 30-year historical trend and on state-level population projections. The Residential Demand Module projects an increase in the average square footage of both new construction and existing structures, based on trends in new construction and remodeling.

The investment tax credit (ITC) for renewable fuels, fuel cells, and combined heat and power systems is incorporated, as currently enacted, including a phaseout of the credit for solar energy technologies, followed by a permanent 10% ITC for business investment in solar energy (thermal nonpower uses as well as power uses). The module reflects the recently extended deadline and change in eligibility for the 30% ITC for eligible projects under construction before January 1, 2020. The module additionally captures the ITC phaseout—decreasing the credit for solar projects starting construction in 2020 and 2021 to 26% and 22%, respectively. Commercial projects under construction after 2021 receive a credit equivalent to 10% of capital costs. Tax credits for solar systems purchased by individual homeowners are phased out completely by 2022.

Industrial Demand Module

The Industrial Demand Module (IDM) projects the consumption of energy for heat and power, as well as the consumption of feedstocks and raw materials in each of 21 industry groups, subject to the delivered prices of energy and macroeconomic estimates of employment and the value of shipments for each industry. As noted in the description of the Macroeconomic Activity Module, the representation of industrial activity in NEMS is based on the NAICS. The industries are classified into three groups—energy-intensive manufacturing, nonenergy-intensive manufacturing, and nonmanufacturing. Seven of eight energy-intensive manufacturing industries are modeled in the IDM, including energy-consuming components for boiler/steam/cogeneration, buildings, and process/assembly use of energy. Energy demand for petroleum and other liquids refining (the other energy-intensive manufacturing industry) is modeled in the Liquid Fuels Market Module as described below, but the projected consumption is reported under the industrial totals.

There are several AEO2016 updates and upgrades in the representations of selected industries, including upgraded representations for the iron and steel and paper industries. Instead of assuming that technological development for a particular process occurs on a predetermined or exogenous path based on engineering judgment, these upgrades allow technological change in the iron and steel and paper industries to be modeled endogenously, using a more detailed representation of technology choices. The upgrade allows for explicit technological change, and therefore energy intensity, to respond to economic, regulatory, and other conditions. To model technology choices more accurately, the paper industry shipments have been broken out into pulp and paper mills, paperboard containers, and other paper. For iron and steel and for paper, steam use is modeled in the process/assembly step. All manufacturing industries except cement and lime, aluminum, and glass are benchmarked to the Manufacturing Energy Consumption Survey 2010. The combined cement and lime industries, aluminum industry, and glass industry were upgraded to technology choice models in previous editions of the *Annual Energy Outlook*.

Transportation Demand Module

The Transportation Demand Module projects consumption of energy by mode and fuel—including petroleum products, electricity, methanol, ethanol, compressed natural gas, liquefied natural gas, and hydrogen—in the transportation sector, subject to delivered energy prices, macroeconomic variables such as gross domestic product, and other factors such as technology adoption and consumer behavior. The Transportation Demand Module includes legislation and regulations—such as the Energy Policy Act of 2005 (EPACT2005), the Energy Improvement and Extension Act of 2008, and the American Recovery and Reinvestment Act of 2009—which contain tax credits for the purchase of alternatively fueled vehicles. Representations of corporate average fuel economy and greenhouse gas (GHG) emissions standards for LDVs, heavy-duty vehicle (HDV) fuel consumption and GHG emissions standards, and biofuels consumption reflect standards enacted by the National Highway Traffic Safety Administration (NHTSA) and the U.S. Environmental Protection Agency (EPA), as well as provisions in the Energy Independence and Security Act of 2007 and the California Air Resources Board Zero Emissions Vehicle Program.

The air transportation component of the Transportation Demand Module represents air travel in domestic and foreign markets and includes the industry practice of parking aircraft in both domestic and international markets to reduce operating costs, as well as the movement of aging aircraft from passenger to cargo markets. For passenger travel and air freight shipments, the module represents regional fuel use and travel demand for three aircraft types: regional, narrow-body, and wide-body. An infrastructure constraint, which is also modeled, can potentially limit overall growth in passenger and freight air travel to levels commensurate with industry-projected infrastructure expansion and capacity growth.

The Transportation Demand Module also projects energy consumption for freight and passenger rail and marine vessels by mode and fuel, subject to macroeconomic variables such as the value and type of industrial shipments. Freight ton-miles and efficiency also are projected in the model. Legislation such as the International Convention for the Prevention of Pollution from Ships is also included.

Electricity Market Module

There are three primary submodules of the Electricity Market Module (EMM)—capacity planning, fuel dispatching, and finance and pricing. The capacity expansion submodule uses the stock of existing generation capacity, known environmental regulations, the expected cost and performance of future generation capacity, expected fuel prices, expected financial parameters, and expected electricity demand to project the optimal mix of new generation capacity that should be added in future years. The fuel dispatching submodule uses the existing stock of generation equipment types, their operation and maintenance costs and performance, fuel prices to the electricity sector, electricity demand, and all applicable environmental regulations to determine the least-cost way to meet that demand. This submodule also determines interregional trading and costs of electricity generation. The finance and pricing submodule uses capital costs, fuel and operating costs, macroeconomic parameters, environmental regulations, and load shapes to estimate retail prices by sector for generation, transmission, and distribution services.

All specifically identified options promulgated by EPA for compliance with the Clean Air Act Amendments of 1990 are explicitly represented in the capacity expansion and dispatch decisions. All financial incentives for power generation expansion and dispatch specifically identified in EPACT2005 have been implemented. Several states, primarily in the Northeast, have enacted air emission regulations for carbon dioxide (CO2) that affect the electricity generation sector, and those regulations are represented in AEO2016. The AEO2016 Reference case also imposes a limit on CO2 emissions for specific covered sectors, including the electric power sector in California as represented in California Assembly Bill 32, the Global Warming Solutions Act of 2006 (AB 32). The AEO2016 Reference case includes the Cross-State Air Pollution Rule (CSAPR), using the original emissions budgets and revised implementation schedule, after the rule was reinstated in late 2014. CSAPR is intended to reduce emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx) from power plants in the eastern half of the United States by imposing state-level caps on emissions and facilitating a limited interstate cap-and-trade program. Reductions in hazardous air pollutant emissions from coal- and oil-fired steam electric power plants also are reflected through the inclusion of the Mercury and Air Toxics Standards for power plants, finalized by EPA in December 2011.

In August 2015, EPA released final rules under the Clean Air Act Sections 111(b) and 111(d) setting carbon pollution standards for new, modified, and reconstructed power plants and for existing fossil-fired plants. The requirements for new power plants are represented in the Reference case by allowing new technologies to be built only if they can meet the standards of 1,000 pounds CO2 per megawatthour (MWh) for natural gas combined cycle plants, and 1,400 pounds CO2/MWh for coal-fired plants, based on adjusted gross generation. EPA's Clean Power Plan (CPP) establishes emissions standards for existing power plants and provides many alternative ways for states to demonstrate compliance, as discussed in the AEO2016 Legislation and Regulations section. The Reference case assumes that the CPP is met through regional mass-based goals, implemented at the 22 EMM region level. The Supreme Court has stayed enforcement of the CPP pending resolution of ongoing litigation, but as of this writing no lower court has either affirmed or vacated the rule. The AEO2016 also includes a case that assumes no CPP rule is in force.

Because regulators and the investment community have continued to push energy companies to invest in technologies that are less GHG-intensive, there is considerable financial risk associated with major investments in long-lived power plants with relatively higher rates of carbon dioxide emissions. The trend is captured in the AEO2016 Reference case through a 3-percentage-point increase in the cost of capital when evaluating investments in new coal-fired power plants, new coal-to-liquids (CTL) plants without carbon capture and storage (CCS), and pollution control retrofits. Although any new coal-fired plants are assumed to be compliant with CAA 111(b), they would capture only 30% of CO2 emissions; thus, they still would be considered high emitters relative to other sources and would face potential financial risk.

Renewable Fuels Module

The Renewable Fuels Module (RFM) includes submodules representing renewable resource supply and technology input information for central-station, grid-connected electricity generation technologies, including conventional hydroelectricity, biomass (dedicated biomass plants and co-firing in existing coal plants), geothermal, landfill gas, solar thermal electricity, solar photovoltaics, and both onshore and offshore wind energy. The RFM includes renewable resource supply estimates representing the regional opportunities for renewable energy development.

The ITC for renewable fuels, as currently enacted, is incorporated in the RFM and reflect the recently extended deadline and change in eligibility for the 30% ITC for qualified projects under construction before January 1, 2020. The module additionally captures the ITC phaseout—decreasing to 26% and then 22%—for projects starting construction in 2020 and 2021, respectively. After 2021, all solar (thermal nonpower uses as well as power uses) receive a permanent credit equivalent to 10% of capital costs, regardless of the year in which their construction commenced. Tax credits pertaining to individual homeowners and businesses are reflected separately in the Residential and Commercial Demand Modules.

The recently enacted production tax credit (PTC) for wind, geothermal, biomass-fueled (open-loop biomass is assumed to be the dominant source), landfill gas, and certain types of hydroelectric plants also are represented in the RFM. For wind projects, the tax credit retains its full value of 2.3 cents/kilowatthour (kWh) through 2016. The PTC phaseout begins in January 2017 with a step-down schedule as follows:

- Wind projects under construction after 2016, but before the end of 2017, receive a credit equal to 80% of the current PTC value.
- Wind projects under construction in 2018 receive a credit equal to 60% of the current value.
- Wind projects under construction after 2018, but before the end of 2019, receive a credit equal to 40% of the current value.

Eligibility is extended for 2 years, until January 1, 2017, with no phase-down in value for other PTC-eligible technologies. Geothermal facilities receive the full 2.3 cents/kWh, while other technologies (including open-loop biomass, certain waste energy facilities, incremental hydroelectric, marine, and tidal) receive a half-value credit of 1.2 cents/kWh. The credits are adjusted annually for inflation and are claimed during the first 10 years of a plant's operation. In addition, new geothermal facilities continue to receive a 10% ITC after the PTC expires because they were previously eligible for the 10% ITC.

While current legislation allows-PTC eligible technologies the option to claim the ITC in lieu of the PTC (subject to the same PTC phaseout schedule), EIA assigns the most economically beneficial tax credit option, based on analyst judgment. AEO2016 also accounts for new renewable energy capacity resulting from state renewable portfolio standard programs, mandates, and goals, as described in *Assumptions to the Annual Energy Outlook 2016* [*4*].

Oil and Gas Supply Module

The Oil and Gas Supply Module represents domestic crude oil and natural gas supply within an integrated framework that captures the interrelationships among the various sources of supply—onshore, offshore, and Alaska—by all production techniques, including natural gas recovery from coalbeds and low-permeability geologic formations. The framework analyzes cash flow and profitability to compute investment and drilling for each of the supply sources, based on the prices for crude oil and natural gas, the domestic recoverable resource base, and the state of technology. Oil and natural gas production activities are modeled for 12 supply regions, including six onshore, three offshore, and in three Alaska regions.

The Onshore Lower 48 Oil and Gas Supply Submodule evaluates the economics of future exploration and development projects for crude oil and natural gas plays. Crude oil resources include structurally reservoired resources (i.e., conventional) as well as highly fractured continuous zones, such as the Austin Chalk and Bakken shale formations. Production potential from advanced secondary recovery techniques (such as infill drilling, horizontal continuity, and horizontal profile) and enhanced oil recovery (such as CO2 flooding, steam flooding, polymer flooding, and profile modification) are explicitly represented. Natural gas resources include high-permeability carbonate and sandstone, tight gas, shale gas, and coalbed methane.

Domestic crude oil production volumes are used as inputs to the Liquid Fuels Market Module (LFMM) for conversion and blending into refined petroleum products. Supply curves for natural gas are used as inputs to the Natural Gas Transmission and Distribution Module (NGTDM) for determining natural gas wellhead prices and domestic production.

Natural Gas Transmission and Distribution Module

The Natural Gas Transmission and Distribution Module (NGTDM) models the transmission, distribution, and pricing of natural gas, subject to end-use demand for natural gas, the availability of domestic natural gas, and natural gas traded on the international market. The module balances natural gas supply and demand, tracks the flows of natural gas, and determines the associated capacity expansion requirements in an aggregate pipeline network, connecting domestic and limited foreign supply sources with 12 regions in the Lower 48 states. The 12 regions align with the 9 Census divisions (with 3 subdivided). Alaska is handled separately.

The flow of natural gas is determined for both a peak and an off-peak period in the year, assuming a historically based seasonal distribution of natural gas demand. Key components of pipeline and distributor tariffs are included in separate pricing algorithms. The primary outputs of the module are delivered natural gas prices by region and sector, supply prices, and realized domestic natural gas production. The module also projects natural gas pipeline imports and exports to Canada and Mexico, as well as liquefied natural gas imports and exports.

Liquid Fuels Market Module

The Liquid Fuels Market Module (LFMM) projects prices of petroleum products, crude oil and product import/export activity, and domestic refinery operations, subject to demand for petroleum products, availability and price of imported petroleum, environmental regulations, and domestic production of crude oil, natural gas liquids, and biofuels—ethanol, biodiesel, biomass-to-liquids (BTL), CTL, gas-to-liquids (GTL), and coal-and-biomass-to-liquids (CBTL). Costs, performance, and first dates of commercial availability for the advanced liquid fuels technologies [5] are reviewed and updated annually.

The module represents refining activities in eight U.S. regions and a Maritime Canada/Caribbean refining region (created to represent short-haul international refineries that predominantly serve U.S. markets). For better representation of policy, import/export patterns, and biofuels production, the eight U.S. regions are defined by subdividing three of the five U.S. Petroleum Administration for Defense Districts. The nine refining regions are defined below:

Region 1. PADD I – East Coast

Region 2. PADD II – Midwest - inland

Region 3. PADD II – Midwest - lakes

Region 4. PADD III – Gulf Coast - gulf

Region 5. PADD III – Gulf Coast - inland

Region 6. PADD IV – Rocky Mountain

Region 7. PADD V – West Coast - California

Region 8. PADD V – West Coast - other

Region 9. Maritime Canada/Caribbean.

The LFMM models the costs of producing automotive fuels, such as conventional and reformulated gasoline, and includes production of biofuels for blending in gasoline and diesel. Fuel ethanol and biodiesel are included in the LFMM because they are commonly blended into petroleum products. The module allows ethanol blending into gasoline at 10% by volume, 15% by volume in states that lack explicit language capping ethanol volume or oxygen content, and up to 85% by volume for use in flex-fuel vehicles. The module also includes a 16% (by volume) biobutanol/gasoline blend. Crude oil and refinery product imports are represented by supply curves defined by the NEMS IEM. Products also can be imported from refining Region 9 (Maritime Canada/Caribbean). Refinery product exports are represented by demand curves, also provided by the IEM. Crude exports from the United States also are represented.

Capacity expansion of refinery process units and nonpetroleum liquid fuels production facilities is also modeled in the LFMM. The model uses current liquid fuels production capacity, the cost and performance of each production unit, expected fuel and feedstock costs, expected financial parameters, expected liquid fuels demand, and relevant environmental policies to project the optimal mix of new capacity that should be added in the future.

The LFMM includes representation of the Renewable Fuels Standard (RFS) specified in the Energy Independence and Security Act of 2007, which mandates the use of 36 billion gallons of ethanol equivalent renewable fuel by 2022. Both domestic and imported biofuels count toward the RFS. Domestic ethanol production is modeled for three feedstock categories: corn, cellulosic plant materials, and advanced feedstock materials. Corn ethanol plants, which are numerous (responsible for 98% of total ethanol produced in the U.S.), are based on a well-known technology that converts starch and sugar into ethanol. Ethanol from cellulosic sources is a new technology with only a few small pilot plants in operation. Ethanol from advanced feedstocks, which are produced at ethanol refineries that ferment and distill grains other than corn and reduce greenhouse gas emissions by at least 50%, is another new technology modeled in the LFMM. The LFMM also has the capability to model production of biobutanol from a retrofitted corn ethanol facility, if economically competitive.

Fuels produced by Fischer-Tropsch synthesis or through a pyrolysis process also are modeled in the LFMM, based on their economics in comparison with competing feedstocks and products. The five processes modeled are CTL, CBTL, GTL, BTL, and pyrolysis.

Two California-specific policies also are represented in the LFMM: the Low Carbon Fuel Standard (LCFS) and the Assembly Bill 32, the Global Warming Solutions Act of 2006 (AB 32), cap-and-trade program. The LCFS requires the carbon intensity of transportation fuels sold for use in California (the amount of greenhouse gases emitted per unit of energy) to decrease according to a schedule published by the California Air Resources Board. California's AB 32 cap-and-trade program is established to help California achieve its goal of reducing CO2 emissions to 1990 levels by 2020. Working with other NEMS modules (Industrial Demand Module, EMM, and Emissions Policy Module), the LFMM provides emissions allowances and actual emissions of CO2 from California refineries, and NEMS provides the mechanism (carbon price) to trade allowances such that the total CO2 emissions cap is met.

Coal Market Module

The Coal Market Module (CMM) simulates mining, transportation, and pricing of coal, subject to end-use demand for coal differentiated by heat and sulfur content. U.S. coal production is represented in the CMM by 41 separate supply curves—differentiated by region, mine type, coal rank, and sulfur content. The coal supply curves respond to mining capacity, capacity utilization of mines, labor productivity, and factor input costs (mining equipment, mining labor, and fuel requirements). Projections of U.S. coal distribution are determined by minimizing the cost of coal supplied, given coal demands by region and sector; environmental restrictions; and accounting for minemouth prices, transportation costs, and coal supply contracts. Over the projection horizon, coal transportation costs in the CMM vary in response to changes in the cost of rail investments.

The CMM produces projections of U.S. steam and metallurgical coal exports and imports in the context of world coal trade, determining the pattern of world coal trade flows that minimizes production and transportation costs while meeting a specified set of regional coal import demands, subject to constraints on export capacities and trade flows. The international coal market component of the module computes trade in two types of coal (steam and metallurgical) for 17 export regions and 20 import regions. U.S. coal production and distribution are computed for 14 supply regions and 16 demand regions.

Annual Energy Outlook 2016 cases

Table E1 provides a summary of the cases produced as part of AEO2016. For each case, the table gives the name used in AEO2016, a brief description of the major assumptions underlying the projections, and a reference to the pages in the body of the report and in this appendix where the case is discussed. The text sections following Table E1 describe the various cases in more detail. The Reference case assumptions for each sector are described in Assumptions to the *Annual Energy Outlook 2016*. Regional results and other details of the projections are available at http://www.eia.gov/forecasts/aeo/tables_ref.cfm#supplement.

Macroeconomic growth cases

In addition to the AEO2016 Reference case, Low Economic Growth and High Economic Growth cases were developed to reflect the uncertainty in projections of economic growth. The alternative cases are intended to show the effects of alternative growth assumptions on energy market projections. The cases are described as follows:

- In the Reference case, population grows by 0.7%/year, nonfarm employment by 0.7%/year, and productivity by 1.7%/ year from 2015 to 2040. Economic output as measured by real GDP increases by 2.2%/year from 2015 through 2040, and growth in real disposable income per capita averages 1.7%/year.
- The Low Economic Growth case assumes lower growth rates for population (0.6%/year) and productivity (1.3%/year), resulting in lower growth in nonfarm employment (0.6%/year), higher prices and interest rates, and lower growth in industrial output. In the Low Economic Growth case, economic output as measured by real GDP increases by 1.6%/year from 2015 through 2040, and growth in real disposable income per capita averages 1.4%/year.
- The High Economic Growth case assumes higher growth rates for population (0.8%/year) and productivity (2.0%/year), resulting in higher nonfarm employment (1.0%/year). With higher productivity gains and employment growth, inflation and interest rates are lower than in the Reference case, and consequently economic output grows at a higher rate (2.8%/year) than in the Reference case (2.2%/year). Real disposable income per capita grows by 2.0%/year.

Oil price cases

The benchmark oil price in AEO2016 is based on spot prices for North Sea Brent crude oil, which is an international standard for light sweet crude oil. The West Texas Intermediate (WTI) spot price is generally lower than the North Sea Brent price. EIA expects the price spread between Brent and WTI in the Reference, Low Oil Price, and High Oil Price cases to range between $0/b and $10/b and will continue to report WTI prices—a critical reference point for the value of growing production in the U.S. Midcontinent—as well as the imported refiner acquisition cost for crude oil. The December 2015 decision by the U.S. Congress to remove restrictions on U.S. crude oil exports also has the potential to narrow the spread between the Brent price and the price of domestic production streams under certain cases involving high levels of U.S. crude oil production [6].

The historical record shows substantial variability in oil prices, and there is arguably even more uncertainty about future prices in the long term. AEO2016 considers three oil price cases (Reference, Low Oil Price, and High Oil Price) to allow an assessment of alternative views on the future course of oil prices.

The Low and High Oil Price cases reflect a wide range of potential price paths, resulting from variation in global demand and supply of petroleum and other liquid fuels. The Low Oil Price case assumes conditions under which global liquids demand is low and supply is high; the High Oil Price case assumes the opposite. Both cases illustrate situations in which the shifts in global supply and demand are offsetting, so that liquids consumption is close to Reference case levels, but prices are substantially different.

- In the Reference case, real oil prices (2015 dollars) fall from $52/b in 2015 to a low of $37/b in 2016, before rising steadily to $136/b in 2040. The Reference case represents a trend projection for both oil supply and demand. Global supply increases

Table E1. Summary of *AEO2016* cases

Case name	Description	Reference in text	Reference in Appendix E
Reference	Real gross domestic product (GDP) grows at an average annual rate of 2.2% from 2015 to 2040. Brent crude oil prices rise to about $136/barrel (b) (2015 dollars) in 2040. Complete projection tables in Appendix A.	--	--
Low Economic Growth	Real GDP grows at an average annual rate of 1.6% from 2015 to 2040. Other energy market assumptions are the same as in the Reference case. Partial projection tables in Appendix B.	p. MT-2	p. E-6
High Economic Growth	Real GDP grows at an average annual rate of 2.8% from 2015 to 2040. Other energy market assumptions are the same as in the Reference case. Partial projection tables in Appendix B.	p. MT-2	p. E-6
Low Oil Price	Low prices result from a combination of relatively low demand for petroleum and other liquids in the non-Organization for Economic Cooperative Development (non-OECD) nations and higher global supply. Lower demand occurs as a result of several factors: economic growth that is relatively slow compared with history; reduced consumption from the adoption of more efficient technologies, extension of the corporate average fuel economy (CAFE) standards, less travel demand, and increased natural gas or electricity use; efficiency improvement in nonmanufacturing in non-OECD countries; and industrial fuel switching from liquid to natural gas feedstocks for producing methanol and ammonia. On the supply side, both Organization of the Petroleum Exporting Countries (OPEC) and non-OPEC producers face lower costs of production for both crude oil and other liquids production technologies. However, lower-cost supply from OPEC producers eventually begins to crowd out supply from relatively more expensive non-OPEC sources. OPEC's market share of liquids production rises steadily from 39% in 2015 to 43% in 2020 and 47% in 2040. Light, sweet crude oil prices fall to an average of $35/b (2015 dollars) in 2016, remain below $50/b through 2030, and stay below $75/b through 2040. Partial projection tables in Appendix C.	p. MT-3	p. E-8
High Oil Price	High prices result from a lack of global investment in the oil sector, eventually inducing higher production from non-OPEC producers relative to the Reference case. Higher prices stimulate increased supply from resource that are more expensive to produce—such as tight oil and bitumen, as well as increased production of renewable and synthetic fuels, compared with the Reference case. Increased non-OPEC production crowds out OPEC oil, and OPEC's share of world liquids production decreases, never exceeding the 41% reached in 2012 and dropping to 34% by the end of the projection. On the demand side, higher economic growth than in the Reference case, particularly in non-OECD countries, leads to increased demand: non-OECD consumers demand greater personal mobility and consumption of goods. There are also fewer efficiency gains throughout the industrial sector, and growing fuel needs in the nonmanufacturing sector continue to be met with liquid fuels, especially in response to policy shifts that force liquids to replace coal for chemical feedstock. Crude oil prices are about $230/b (2015 dollars) in 2040. Partial projection tables in Appendix C.	p. MT-3	p. E-9
Extended Policies	The Extended Policies case begins with the Reference case and assumes extension of all existing tax credits (full credit values prior to phaseout are extended where phaseouts are scheduled) and policies that contain sunset provisions, except those requiring additional funding (e.g., loan guarantee programs). It also assumes an increase in capacity limitations on the investment tax credit (ITC) for combined heat and power, and extension of the program. The case includes an additional round of efficiency standards for residential and commercial products, as well as new standards for products not yet covered; adds multiple rounds of national building codes by 2034; and increases LDV and HDV fuel economy standards in the transportation sector. This case also includes the extension of EPA's Clean Power Plan regulations that reduce carbon dioxide emissions from electric power generation after 2030. Partial projection tables in Appendix D.	p. IF-22	p. E-9

Table E1. Summary of *AEO2016* cases *(continued)*

Case name	Description	Reference in text	Reference in Appendix E
Oil and Gas: Low Oil and Gas Resource and Technology	Estimated ultimate recovery per shale gas, tight gas, and tight oil well in the United States and undiscovered resources in Alaska and the offshore lower 48 states are 50% lower than in the Reference case. Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% lower than in the Reference case. All other assumptions remain the same as in the Reference case. Partial projection tables in Appendix D.	p. MT-29	p. E-11
Oil and Gas: High Oil and Gas Resource and Technology	Estimated ultimate recovery per shale gas, tight gas, and tight oil well in the United States, and undiscovered resources in Alaska and the offshore lower 48 states, are 50% higher than in the Reference case. Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% higher than in the Reference case. In addition, tight oil and shale gas resources are added to reflect new plays or the expansion of known plays. All other assumptions remain the same as in the Reference case. Partial projection tables in Appendix D.	p. MT-29	p. E-11
Electricity: No CPP	Assumes that the Clean Power Plan (CPP) is not enforced, and that no federal requirements are in place to reduce carbon dioxide emissions from existing power plants.	p. IF-3	p. E-10
Electricity: CPP Rate	Assumes that CPP compliance is met through regional rate-based (pounds/MWh) standards that, on average, affect all generation within the region.	p. IF-3	p. E-10
Electricity: CPP Interregional Trading	Assumes that CPP compliance is met through regional mass-based caps, including new sources, and allows trading of carbon allowances between regions within the Eastern Interconnect and within the Western Interconnect.	p. IF-3	p. E-10
Electricity: CPP Extended	Assumes that the CPP CO2 emissions targets continue to decline after 2030, reaching a 45% reduction below 2005 levels in 2040.	p. IF-4	p. E-10
Electricity: CPP Hybrid	Assumes that regions can vary their CPP compliance method, with the Northeast and CA regions choosing mass-based caps and the remaining regions using average rate-based standards.	p. IF-4	p. E-10
Electricity: CPP Allocation to Generators	Assumes the same CPP compliance as in the Reference case, except that the carbon allowances are allocated to generators instead of being allocated to load entities, resulting in higher retail price impacts.	p. IF-4	p. E-10
Energy Efficiency Case for Manufacturing Industries with Technology Choice	Assuming Reference case prices and economic conditions, examines the effects of more aggressive adoption of energy-efficient technologies and rapid improvement in energy intensity on manufacturers in five industries (cement and lime, aluminum, glass, iron and steel, and paper).	p. IF-36	p. E-9
Industrial Efficiency Low Incentive	Uses a price on CO2 emissions as a proxy for higher energy costs, as a way to increase energy efficiency in all industries except refining. A CO2 price is phased in gradually, starting in 2018, reaches $12.50/metric ton in 2023, and increases by 5% per year thereafter.	p. IF-35	p. E-9
Industrial Efficiency High Incentive	As in the Industrial Efficiency Low Incentive case, with the only difference being that the CO2 price is $35.00/metric ton in 2023.	p. IF-35	p. E-9
Phase 2 Standards	Assumes improvements to medium- and heavy-duty vehicle technologies while increasing the number of technologies from 37 to 70. Restructures the current 13 vehicle size classes and incorporates an additional size class, bringing the total to 14 size classes.	p. IF-16	p. E-10

through the medium-term (although it does slow from 2020–25) and is limited by geopolitical constraints rather than by resource availability. Global petroleum and other liquids consumption increases steadily throughout the Reference case, in part because of an increase in the number of vehicles across the world, which is offset somewhat by improvements in LDV and HDV fuel economy in developing countries, as well as increased natural gas use for transportation in most regions. Economic growth is steady over the projection period, and there is some substitution away from liquids fuels in the industrial sector.

- In the Low Oil Price case, crude oil prices fall to an average of $35/b (2015 dollars) in 2016, remain below $50/b through 2030, and stay below $75/b through 2040. Relatively low demand compared to the Reference case occurs as a result of several factors: economic growth that is relatively slow compared to history; reduced consumption in developed countries resulting from the adoption of more efficient technologies, extended CAFE standards, less travel demand, and increased use of natural gas or electricity; efficiency improvement in nonmanufacturing industries in the non-OECD countries; and industrial fuel switching from liquids to natural gas feedstocks for production of methanol and ammonia. Low oil prices also result from lower costs of production and relatively abundant supply from both OPEC and non-OPEC producers. However, lower-cost supply from OPEC producers eventually begins to crowd out supply from relatively more expensive non-OPEC sources. In the Low Oil Price case, OPEC's market share of liquids production rises steadily from 39% in 2015 to 43% in 2020 and to 47% in 2040.

- In the High Oil Price case, oil prices average about $230/b (2015 dollars) in 2040. A lack of global investment in the oil sector is the primary cause of higher prices, which eventually lead to higher production from non-OPEC producers relative to the Reference case. Higher prices stimulate increased supply of more costly resources, including tight oil and bitumen, and also lead to significant increases in production of renewable liquid fuels as well as GTL and CTL compared with the Reference case. Increased non-OPEC production crowds out OPEC oil, and OPEC's share of world liquids production decreases, never exceeding the 41% share reached in 2012 and dropping to 34% in 2040. The main reason for increased demand in the High Oil Price case is higher economic growth, particularly in developing countries, than in the Reference case. In the developing countries, consumers demand greater personal mobility and more consumption of goods. There are fewer efficiency gains in the industrial sector, while growing demand for fuel in the non-manufacturing sector continues to be met with liquid fuels, and policy shifts result in the replacement of chemical feedstocks by coal.

Buildings sector cases

The Extended Policies case includes assumptions in the NEMS Residential and Commercial Demand Modules. The Extended Policies case extends federal incentives that have a specific sunset date in current law and adds an additional round of appliance standards and multiple rounds of building codes, as described below.

- The Extended Policies case assumes that selected federal policies with sunset provisions are extended indefinitely at current levels rather than being allowed to sunset as the law currently prescribes. For the residential sector, personal tax credits are extended at the 30% level through 2040 for solar photovoltaics installations, solar water heaters, small wind turbines, and geothermal heat pumps. For residential solar equipment, tax credits are extended at the 30% level instead of being phased out completely as specified by current law. For the commercial sector, the ITC for solar technologies, small wind turbines, geothermal heat pumps, and combined heat and power is extended at the 30% level through 2040. The business tax credit for solar technologies remains at the 30% level through 2040 instead of being phased down to 10%. The Extended Policies case includes updates to federal appliance standards, as prescribed by the timeline in the Department of Energy's (DOE) multiyear plan, and introduces new standards for products currently not covered by DOE. Efficiency levels for the updated residential appliance standards are based on current ENERGY STAR guidelines or "mid-level" efficiencies where ENERGY STAR guidelines are not available. End-use technologies eligible for extended incentives are not subject to new standards. Efficiency levels for updated commercial equipment standards are based on the technology menu from the AEO2016 Reference case and purchasing specifications for federal agencies designated by the Federal Energy Management Program. The Extended Policies case also adds two additional rounds of improved national building codes with implementation beginning in 2025 and 2034, each phased in over nine years.

Industrial sector cases

In addition to the AEO2016 Reference case, three technology-focused cases were developed, using the Industrial Demand Module (IDM) to examine the effects of less rapid and more rapid technology change and adoption in the industrial sector. The energy intensity changes discussed in this section exclude the refining industry, which is modeled separately from the IDM in the Liquid Fuels Market Module. The technology cases are described as follows:

- The Energy Efficiency Case for Manufacturing Industries with Technology Choice case examines the effects of efficiency improvements made over time by manufacturers in the five process flow industries (cement and lime, aluminum, glass, iron and steel, and paper), which can change the mix of technologies chosen relative to the Reference Case. Prices and economic conditions are the same as in the Reference case. The energy efficiency increases are based on research by Lawrence Berkeley National Laboratory related to best practice energy intensity [*7*], and on Bandwidth Analysis by DOE [*8*]. This case includes more aggressive adoption of energy-efficient technologies and more rapid improvement in the energy intensity of some future technology choices that currently are not being used.
- The Industrial Efficiency Low Incentive case examines the effects of a price on carbon emissions on energy efficiency in the industrial sector. This case includes all industries in the industrial sector except refining. It assumes a price on CO2 emissions, as a proxy for higher energy costs, stimulating an increase in energy efficiency. The CO2 price is phased in gradually, starting in 2018, rises to $12.50/metric ton in 2023, and thereafter increases by 5%/year through 2040. The higher energy costs create an incentive to reduce fuel costs by increasing the efficiencies of existing technologies, adopting more energy efficient technologies, and switching to less carbon-intensive fuels.
- The Industrial Efficiency High Incentive case uses the same approach as the Industrial Efficiency Low Incentive case but assumes a higher price on CO2 emissions, starting in 2018, increasing gradually to $35.00/metric ton in 2023, and increasing thereafter increases by 5%/year. The higher energy costs increase the incentive to increase efficiency and use less carbon-intensive fuels, leading to greater efficiency improvement than in the Reference and Industrial Efficiency Low Incentive cases.

- The Extended Policies case described below is a cross-cutting integrated case that involves making changes in a number of NEMS models. The Extended Policies case modifies selected industrial assumptions from the Reference case, assuming that the existing 10% Investment Tax Credit (ITC) for industrial CHP is extended through 2040, modifying capacity limitations on the ITC by increasing the cap on CHP equipment from 15 MW to 25 MW, and eliminating the system-wide cap of 50 MW. These assumptions are based on the proposals made in H.R. 2750 and H.R. 2784 of the 112th Congress.

Transportation sector cases

In addition to the AEO2016 Reference case, the NEMS Transportation Demand Module was used as part of two AEO2016 alternative cases.

In the Extended Policies case, the Transportation Demand Module was used to examine the effects of extending LDV GHG emissions and CAFE standards beyond 2025, with the joint EPA/NHTSA CAFE Standards increasing after 2025, at an average annual rate of 1.3% through 2040, to a combined average LDV fuel economy compliance of 56.8 mpg in 2040. As part of the Extended Policies case, the Transportation Demand Module was also used to examine the effects of extending the HDV fuel efficiency and GHG emissions standards to reflect requirements under the Phase 2 Standards proposal. The regulations are currently specified for model years 2014 through 2018. The Extended Policies case includes a modest increase in fuel consumption and GHG emissions standards for 13 HDV size classes.

Assumptions in the NEMS Transportation Demand Module were modified for the Phase 2 Standards case, which examines the effects of the EPA/NHTSA jointly proposed GHG emissions and fuel efficiency standards for medium- and heavy-duty vehicles. The Phase 2 Standards case includes assumptions of improved technology options for medium- and heavy-duty vehicles by replacing and increasing the number of technologies from 37 to 70. The Phase 2 Standards case also includes restructured and updated vehicle size classes that increase the size classes from 13 to 14.

Electricity sector cases

While the Reference case includes one potential implementation of the CPP, there are uncertainties related to the options that states will use to comply with the rule. The rule is also being challenged in court, and the Supreme Court has stayed enforcement of the rule until legal challenges are resolved. To date, the rule has not been vacated or affirmed by any lower court ruling. Therefore, several integrated cases assuming alternate paths to meeting the CPP were developed to support discussions in the Market Trends and Issues in Focus section of AEO2016. A case was also developed assuming that the CPP is not implemented. The Issues in Focus article, “Effects of the Clean Power Plan,” discusses the impacts of the CPP under different implementations relative to the mass-based standards assumed in the Reference case, and relative to the case without any CPP enforcement.

Clean Power Plan cases

- The No CPP case assumes that the CPP is completely vacated and is not enforced, implying that states have no federal requirement to reduce CO2 emissions from existing power plants. There are no constraints imposed in the electricity model to reach regional rate-based or mass-based carbon dioxide targets (other than programs already in place, such as the Regional Greenhouse Gas Initiative (RGGI) and AB 32. There is no incentive for incremental energy efficiency in the end-use demand modules.
- The CPP Rate case assumes that all regions choose to comply with the CPP by meeting average rate-based emissions goals (pounds/MWh) within each Electricity Market Module region, without cooperation across regions. That is, each region has a specific average emission rate that must be met by the affected generation in the region.
- The CPP Interregional Trading case assumes that all regions choose to meet mass-based goals, covering existing and new sources (as in the Reference case), but with trading of carbon allowances between regions within the Eastern and Western Interconnects. In this case, regions that reduce emissions more than needed to meet their own regional caps may trade their excess allowances with other regions, allowing those regions to emit more than their caps.
- The CPP Extended case further reduces the CO2 targets after 2030 instead of maintaining a constant standard. This case assumes that the mass-based limits in 2030, which will result in power sector CO2 emissions that are about 35% below 2005 levels, continue to decline linearly to achieve a 45% reduction below 2005 levels in 2040. The post-2030 reductions are applied using the same rate of decline for each state.
- The CPP Hybrid case assumes that regions in which programs enforcing carbon caps are already in place (RGGI in the Northeast [*9*] and AB 32 in California) comply with the CPP through a mass-based goal, but that states in other regions implement the CPP using a rate-based approach. This case assumes no interregional trading for CPP compliance.
- The CPP Allocation to Generators case assumes that all regions meet mass-based caps including new sources (as in the Reference case), but that the carbon allowances are freely allocated to generators, rather than to load-serving entities. In this case, it is assumed that generators in competitive regions will continue to include the value of allowances in their operating costs and, as a result, that marginal generation costs will reflect the costs of allowances. The Reference case assumes that the allowances are allocated to load-serving entities, which then refund the revenue from the allowance sales to consumers through lower distribution prices. The CPP Allocation to Generators case assumes no reduction in distribution costs, resulting in prices that are higher than those in the Reference case and showing the impact of allowance allocation alternatives on retail prices.

Extended Policies case

The Reference case includes the CPP, which under current regulations is phased in over the 2022–30 period, and assumes that states comply by setting mass-based compliance strategies that cover both existing and new electric generators. The Extended Policies case assumes a further reduction in CO2 targets after 2030. The mass-based limits, which in the Reference case result in power sector CO2 emissions that are 35% below 2005 levels in 2030, are assumed to continue declining linearly to 45% below 2005 levels in 2040.

Renewable fuels cases

AEO2016 also includes an Extended Policies case to examine the effects of indefinite extension of expiring federal tax credits for renewable electricity generation plants. In the Extended Policies case, the full tax credit of 2.3 cents/kWh (adjusted annually for inflation) is extended permanently beyond 2017 for new wind and geothermal generators and is available for the first 10 years of production. A tax credit of 1.1 cents/kWh, also available for the first 10 years of production, is extended indefinitely to new generators using landfill gas, certain hydroelectric technologies, and biomass fuels. (Open-loop biomass is assumed to be the predominant source of biomass fuel over the projection period.) Furthermore, this case maintains the permanent availability of the 30% ITC (the ITC's value prior to phaseout) for new generators using solar energy.

Oil and natural gas supply cases

The sensitivity of the AEO2016 projections to changes in assumptions regarding technically recoverable domestic crude oil and natural gas resources is examined in two cases. These cases do not represent a confidence interval for future domestic oil and natural gas supply, but rather provide a framework to examine the effects of higher and lower domestic supply on energy demand, imports, and prices. Assumptions associated with the two cases are described below.

- In the Low Oil and Gas Resource and Technology case, the estimated ultimate recovery per tight oil, tight gas, or shale gas well in the United States and undiscovered resources in Alaska and the offshore lower 48 states are assumed to be 50% lower than in the Reference case. Rates of technology improvement that reduce costs and increase productivity in the United States also are 50% lower than in the Reference case. These assumptions increase the per-unit cost of crude oil and natural gas development in the United States. The total unproved technically recoverable resource of crude oil is decreased to 150 billion barrels, and the natural gas resource is decreased to 1,303 trillion cubic feet (Tcf), as compared with unproved resource estimates of 238 billion barrels of crude oil and 2,136 Tcf of natural gas as of January 1, 2014, in the Reference case.
- In the High Oil and Gas Resource and Technology case, the resource assumptions are adjusted to allow a continued increase in domestic crude oil production through 2040, to 18 million barrels per day (b/d) compared with 11 million b/d in the Reference case. This case includes: (1) 50% higher estimated ultimate recovery per tight oil, tight gas, or shale gas well, as well as additional unidentified tight oil and shale gas resources to reflect the possibility that additional layers or new areas of low-permeability zones will be identified and developed; (2) diminishing returns on the estimated ultimate recovery once drilling levels in a county exceed the number of potential wells assumed in the Reference case, to reflect well interference at greater drilling density; (3) 50% higher assumed rates of technological improvement that reduce costs and increase productivity in the United States relative to the Reference case; and (4) 50% higher technically recoverable undiscovered resources in Alaska and the offshore lower 48 states than in the Reference case. The total unproved technically recoverable resource of crude oil increases to 385 billion barrels, and the natural gas resource increases to 3,109 Tcf as compared with unproved resource estimates of 238 billion barrels of crude oil and 2,136 Tcf of natural gas in the Reference case as of the start of 2014.

Extended Policies case

In addition to the AEO2016 Reference case, the AEO2016 Extended Policies case assumes the extension of all existing tax credits and policies that contain sunset provisions at current levels, except those requiring additional funding (e.g., loan guarantee programs). The Extended Policies case also assumes an increase in the capacity limitations on the ITC for CHP, and extension of the program. It includes an additional round of federal efficiency standards for residential and commercial products, as well as new standards for products not yet covered; adds multiple rounds of national building codes by 2034; and increases LDV and HDV fuel economy standards in the transportation sector. The Extended Policies case also assumes continued tightening of EPA's Clean Power Plan regulations that reduce carbon dioxide emissions from electric power generation after 2030. Specific assumptions for each end-use sector and for renewables are described in the sector-specific sections above.

Endnotes for Appendix E

Links current as of July 2016

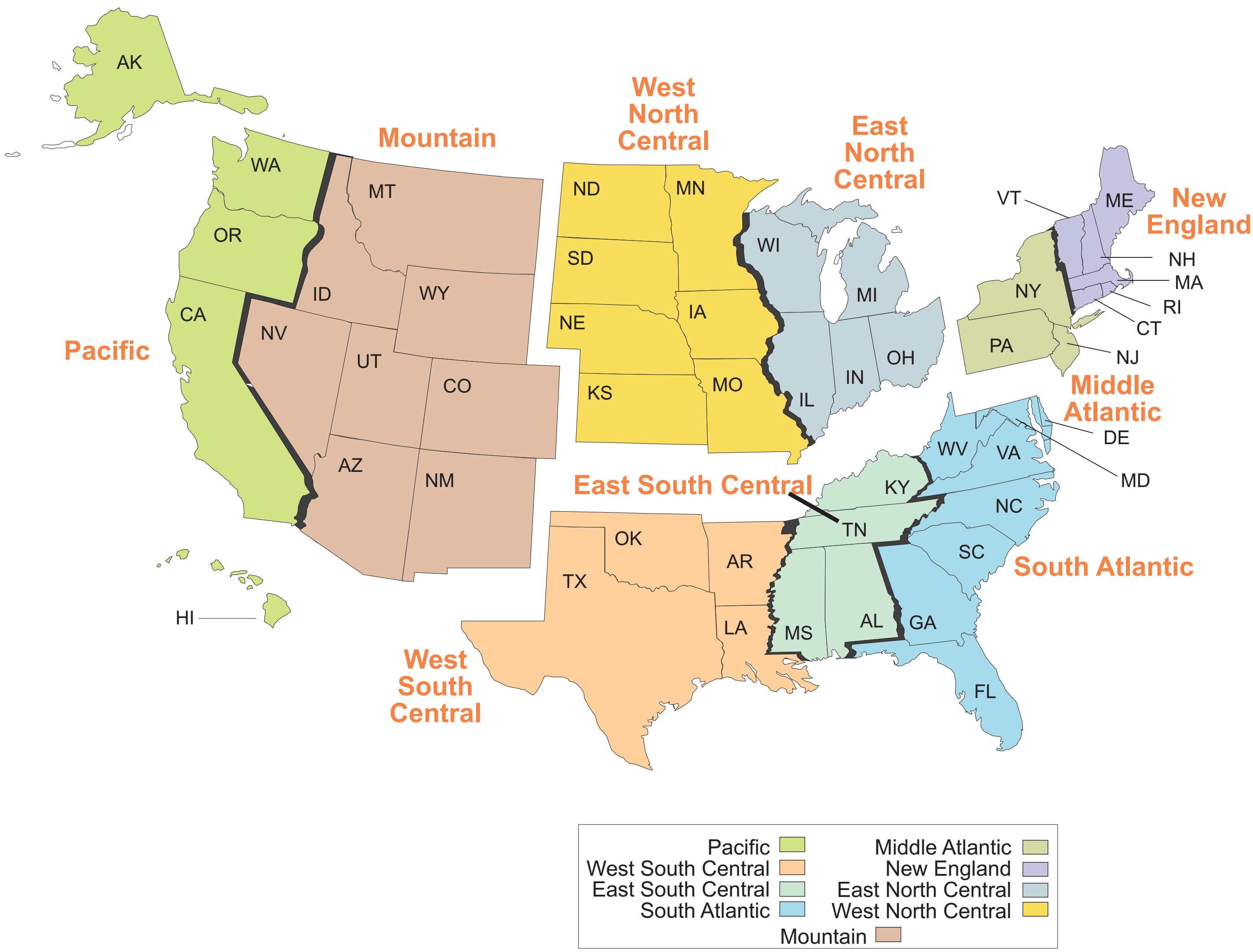
1. U.S. Energy Information Administration, *The National Energy Modeling System: An Overview 2009,* DOE/EIA-0581(2009) (Washington, DC: October 2009), http://www.eia.gov/oiaf/aeo/overview.
2. Selected EIA publications used for data sources include: *Short-Term Energy Outlook, Monthly Energy Review, Natural Gas Annual, Natural Gas Monthly, Electric Power Monthly, Electric Power Annual, Annual Coal Report, Petroleum Supply Annual,* and *Quarterly Coal Report,* as well as EIA surveys.
3. U.S. Energy Information Administration, *Short-Term Energy Outlook* (Washington, DC: February 2016), http://www.eia.gov/forecasts/steo/outlook.cfm.
4. U.S. Energy Information Administration, *Assumptions to the Annual Energy Outlook 2016,* DOE/EIA-0554(2016) (Washington, DC: forthcoming Fall 2016), http://www.eia.gov/forecasts/aeo/assumptions.
5. U.S. Energy Information Administration, *Effects of Removing Restrictions on U.S. Crude Oil Exports* (Washington, DC: September 2015), http://www.eia.gov/analysis/requests/crude-exports/.
6. U.S. Energy Information Administration, *Effects of Removing Restrictions on U.S. Crude Oil Exports* (Washington, DC: September 2015), http://www.eia.gov/analysis/requests/crude-exports/.
7. E. Worrell, L. Price, M. Neelis, C. Galitsky, and Z. Nan, *World Best Practice Energy Intensity Values for Selected Industrial Sectors,* LBNL-62806, Rev. 2 (Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA: February 2008), https://eaei.lbl.gov/sites/all/files/industrial_best_practice_en.pdf.
8. D.M. Rue, J. Servaites, and W. Wolfe, *Final Report: Industrial Glass Bandwidth Analysis* (Gas Technology Institute, Des Plains, IL: August 2007, http://www.energy.gov/sites/prod/files/2013/11/f4/industrial_bandwidth.pdf.

9. The CPP Hybrid case assumes that the New York and New England electricity regions use mass-based compliance. Delaware and Maryland are also members of RGGI; however, those states are part of a larger electricity modeling region including states that are not part of RGGI, and they represent a relatively small share of the overall region's emissions. Because CPP compliance is modeled by electricity model region, not by state, the CPP Hybrid case assumes that the region that includes Delaware and Maryland complies by using a rate-based approach.

Appendix F

Regional Maps

Figure F1. United States Census Divisions



Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F1. United States Census Divisions *(continued)*

Division 1
New England

Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Division 2
Middle Atlantic

New Jersey
New York
Pennsylvania

Division 3
East North Central

Illinois
Indiana
Michigan
Ohio
Wisconsin

Division 4
West North Central

Iowa
Kansas
Minnesota
Missouri
Nebraska
North Dakota
South Dakota

Division 5
South Atlantic

Delaware
District of Columbia
Florida
Georgia
Maryland
North Carolina
South Carolina
Virginia
West Virginia

Division 6
East South Central

Alabama
Kentucky
Mississippi
Tennessee

Division 7
West South Central

Arkansas
Louisiana
Oklahoma
Texas

Division 8
Mountain

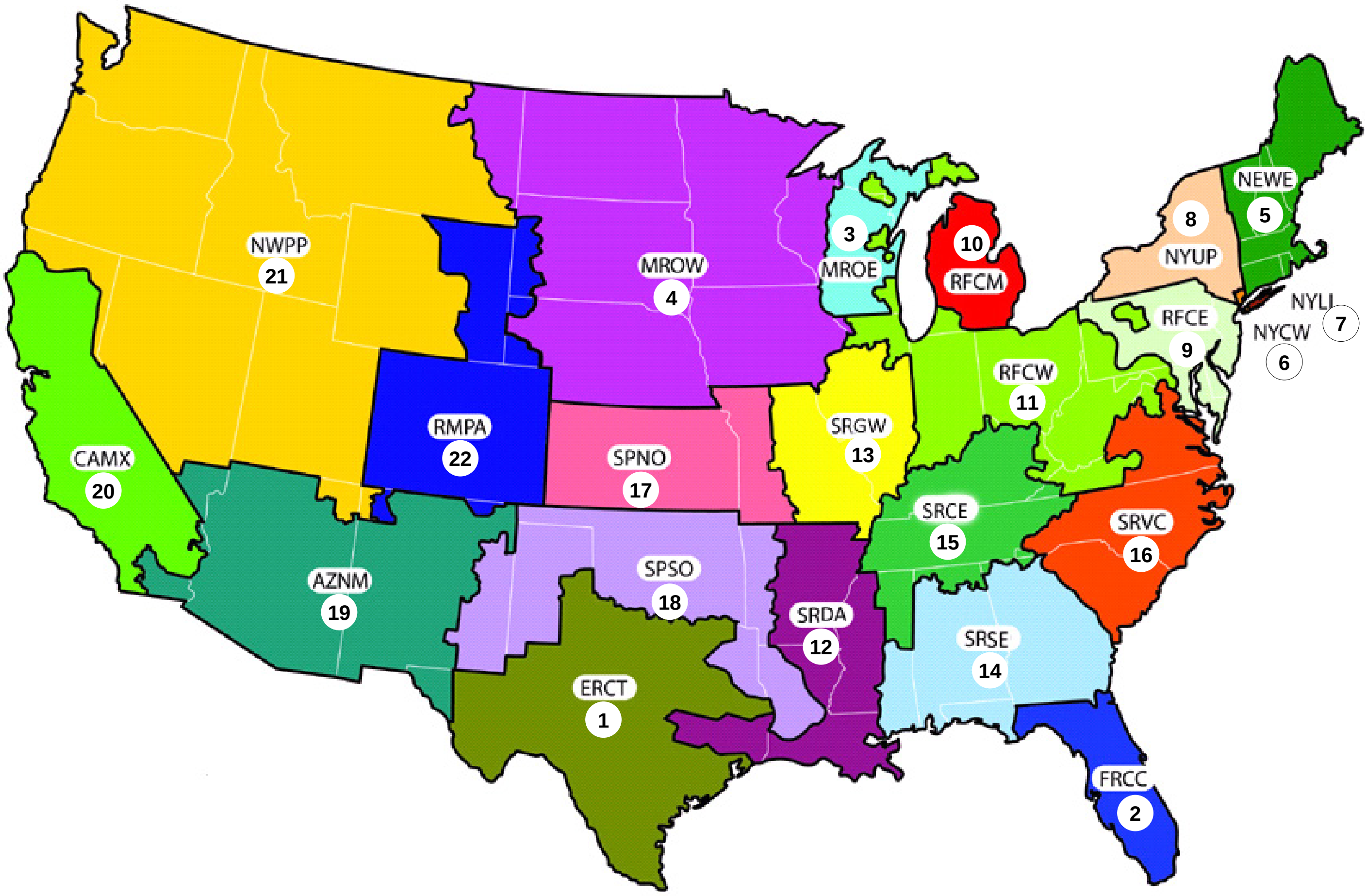
Arizona
Colorado
Idaho
Montana
Nevada
New Mexico
Utah
Wyoming

Division 9
Pacific

Alaska
California
Hawaii
Oregon
Washington

Source: U.S. Energy Information Administration, Office of Energy Analysis.

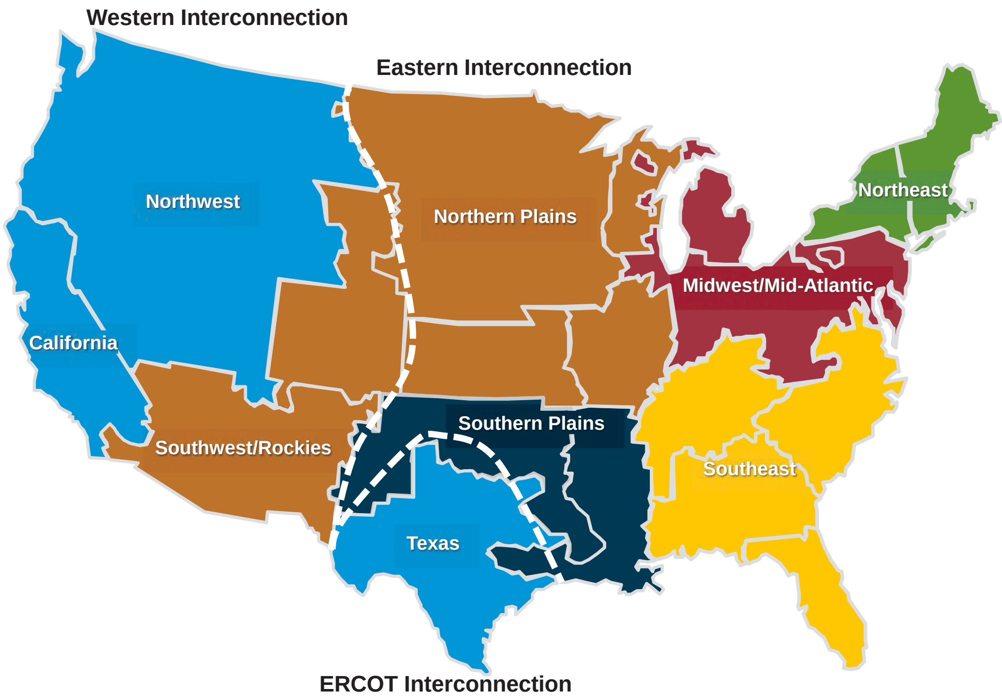
Figure F2. Electricity market module regions



1.	ERCT	TRE All	12.	SRDA	SERC Delta
2.	FRCC	FRCC All	13.	SRGW	SERC Gateway
3.	MROE	MRO East	14.	SRSE	SERC Southeastern
4.	MROW	MRO West	15.	SRCE	SERC Central
5.	NEWE	NPCC New England	16.	SRVC	SERC VACAR
6.	NYCW	NPCC NYC/Westchester	17.	SPNO	SPP North
7.	NYLI	NPCC Long Island	18.	SPSO	SPP South
8.	NYUP	NPCC Upstate NY	19.	AZNM	WECC Southwest
9.	RFCE	RFC East	20.	CAMX	WECC California
10.	RFCM	RFC Michigan	21.	NWPP	WECC Northwest
11.	RFCW	RFC West	22.	RMPA	WECC Rockies

Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F3. North American Electric Reliability Corporation regions

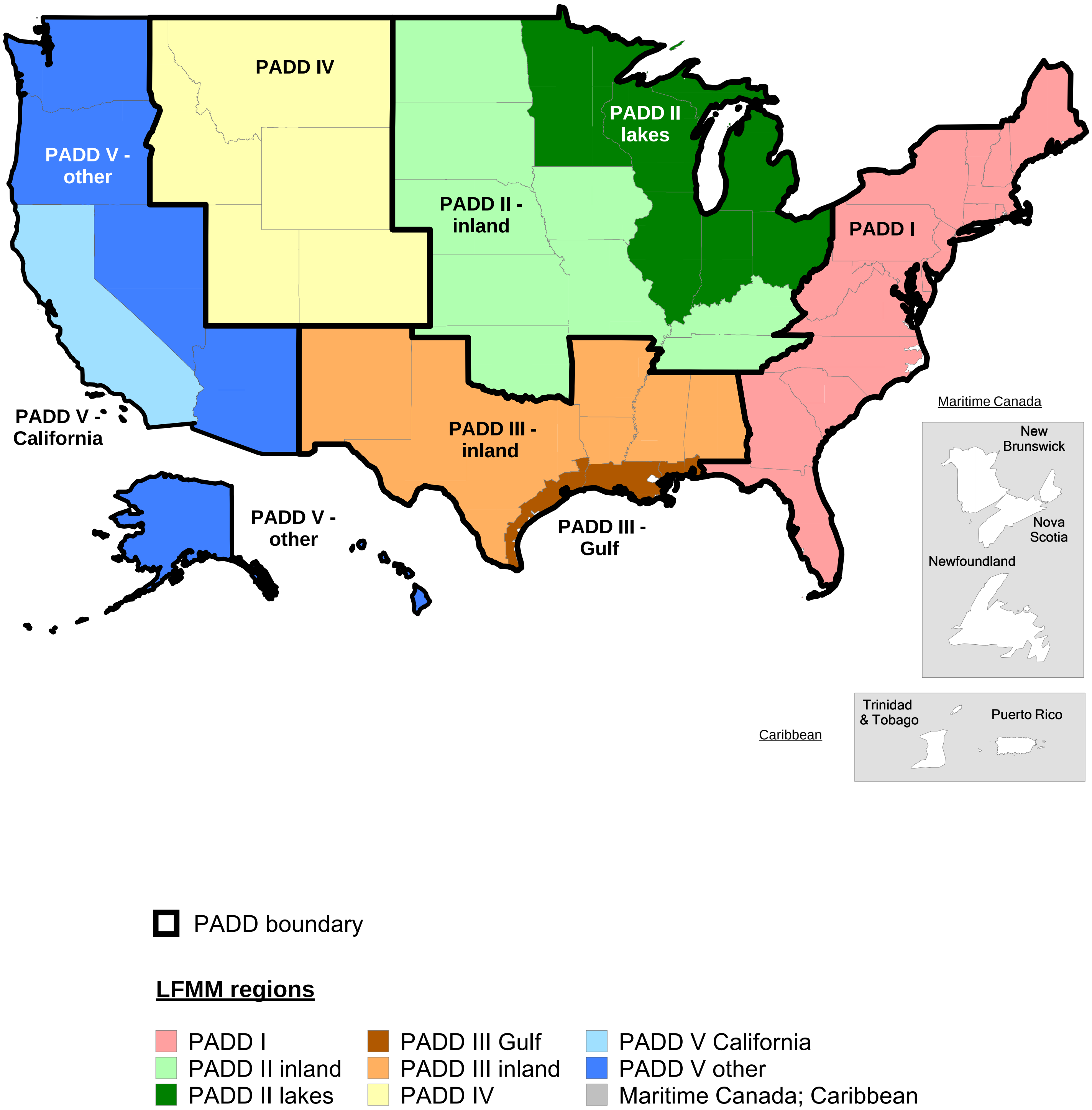


Mapping for aggregated electricity regions

Aggregate region	EMM regions included in aggregate region		
Northeast	5	NEWE	Northeast Power Coordinating Council (NPCC) / New England
Northeast	6	NYCW	NPCC / New York City-Westchester
Northeast	7	NYLI	NPCC/ Long Island
Northeast	8	NYUP	NPCC/ Upstate New York
Midwest/Mid-Atlantic	9	RFCE	ReliabilityFirst Corporation–East
Midwest/Mid-Atlantic	10	RFCM	ReliabilityFirst Corporation–Michigan
Midwest/Mid-Atlantic	11	RFCW	ReliabilityFirst Corporation–West
Southeast	2	FRCC	Florida Reliability Coordinating Council
Southeast	14	SRSE	SERC Reliability Corporation (SERC)/Southeastern
Southeast	15	SRCE	SERC/ Central
Southeast	16	SRVC	SERC/ Virginia-Carolina
Southern Plains	12	SRDA	SERC/ Delta
Southern Plains	18	SPSO	Southwest Power Pool Regional Entity / South
Texas	1	ERCT	Texas Reliability Entity
Southwest/Rockies	19	AZNM	Western Electricity Coordinating Council (WECC)/Arizona New Mexico
Southwest/Rockies	22	RMPA	WECC/ Rockies
California	20	CAMX	WECC/ California
Northwest	21	NWPP	WECC/ Northwest Power Pool Area
Northern Plains	3	MROE	Midwest Reliability Organization–East
Northern Plains	4	MROW	Midwest Reliability Organization–West
Northern Plains	13	SRGW	SERC/ Gateway
Northern Plains	17	SPNO	Southwest Power Pool Regional Entity / North

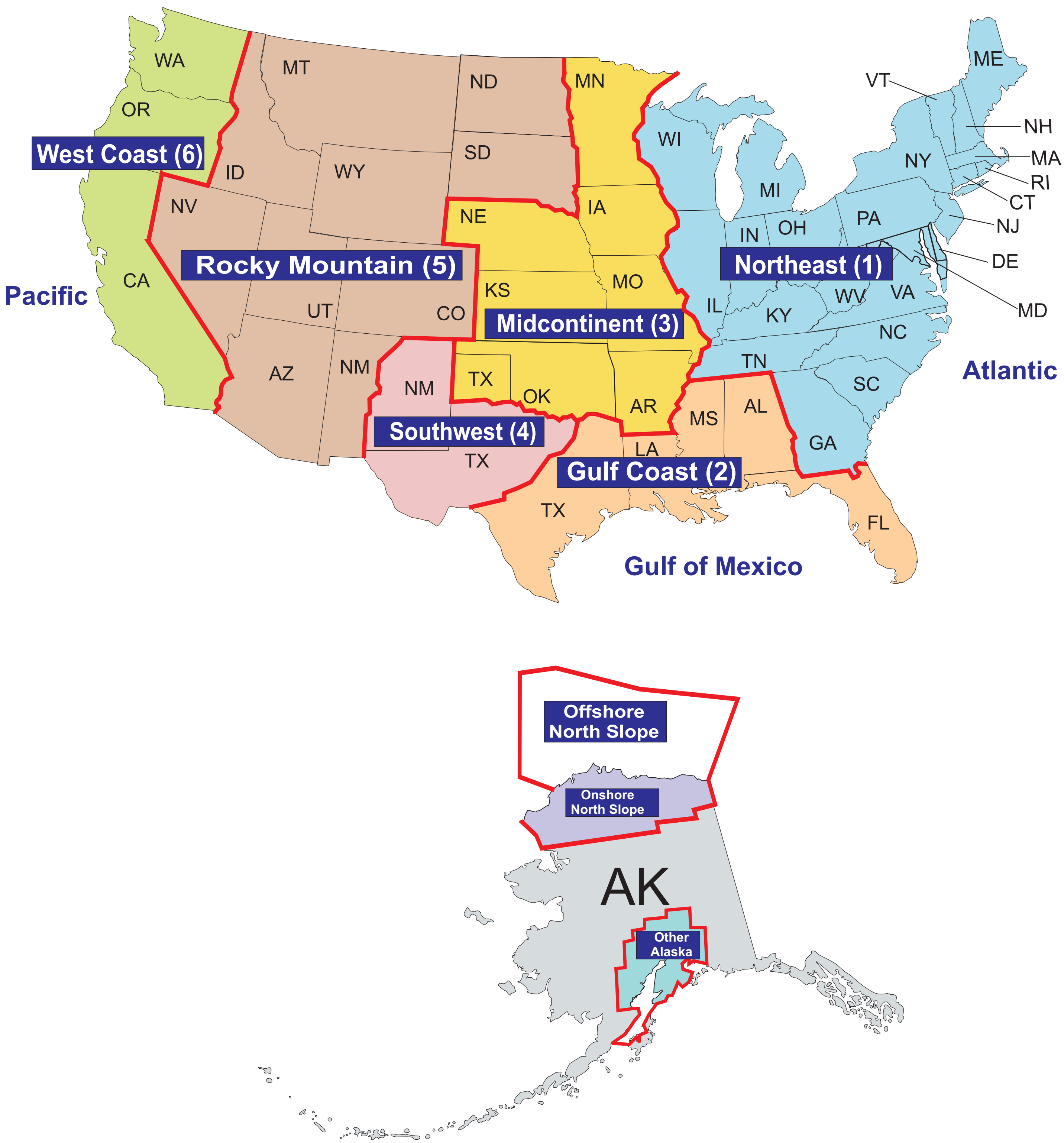
Notes: Names of grouped regions are intended to be approximately descriptive of location. Exact regional boundaries do not necessarily correspond to state borders or to other regional naming conventions. Aggregate region data are summed or averaged over the electricity model regions listed.

Figure F4. Liquid fuels market module regions



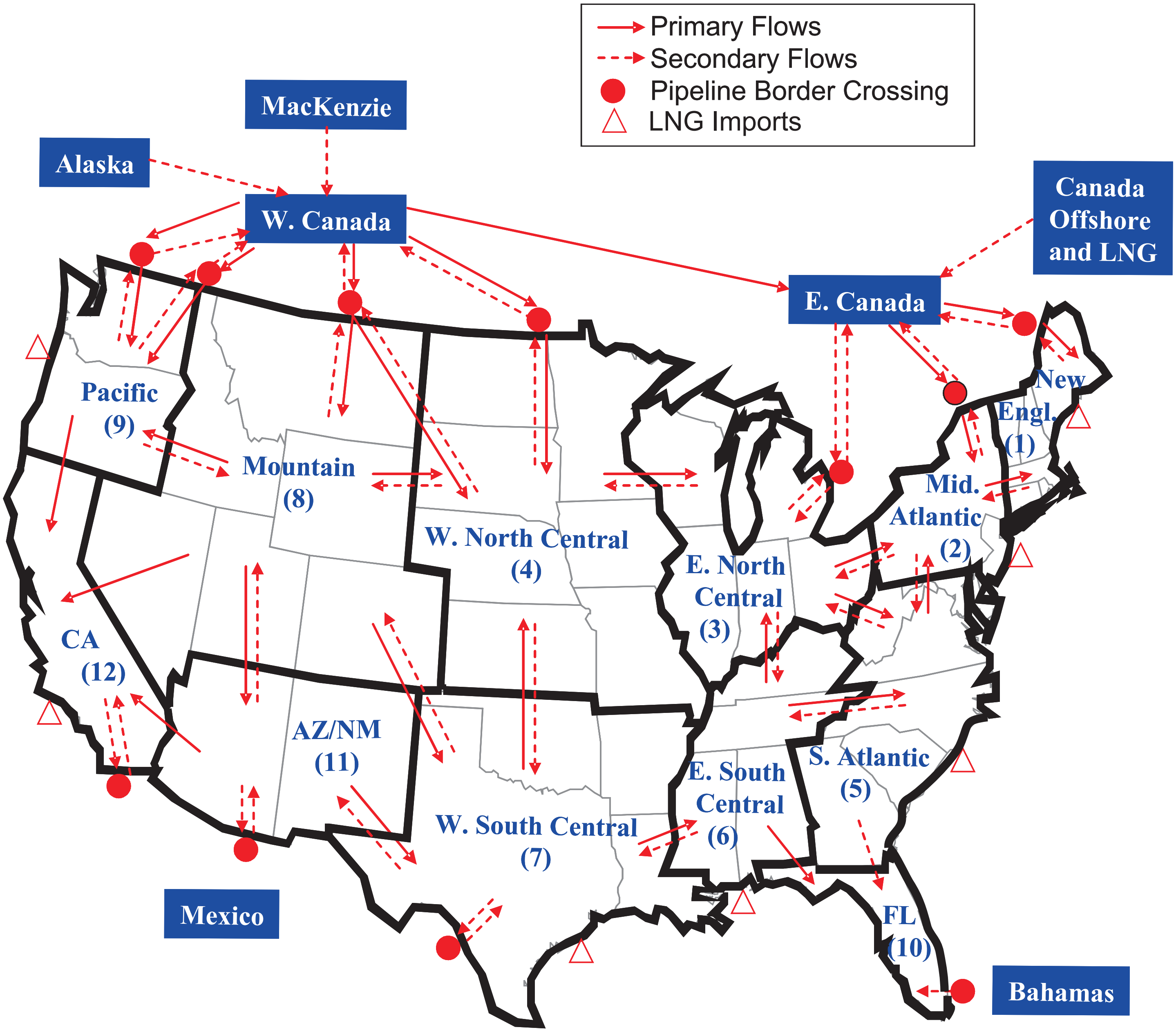
Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F5. Oil and gas supply model regions



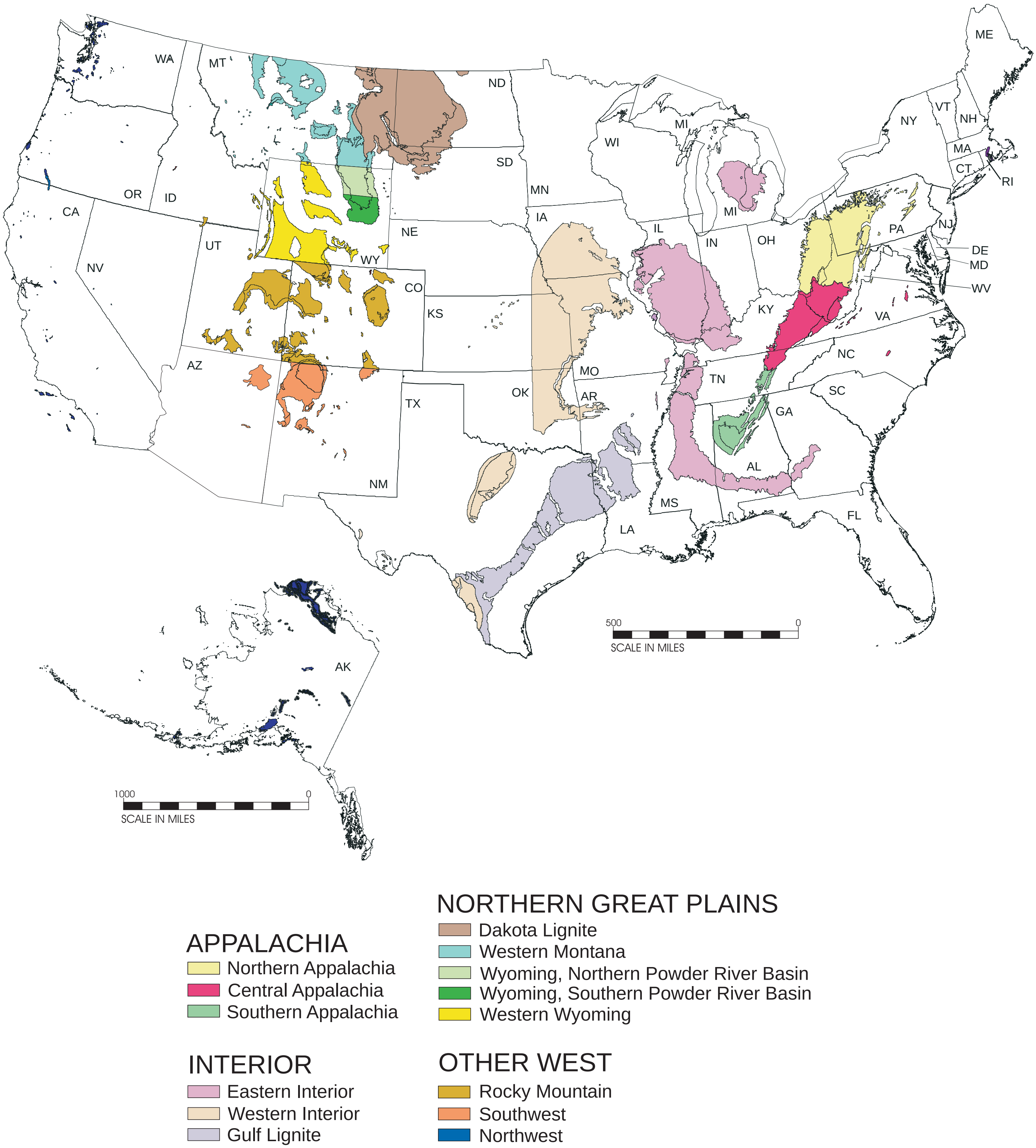
Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F6. Natural gas transmission and distribution model regions



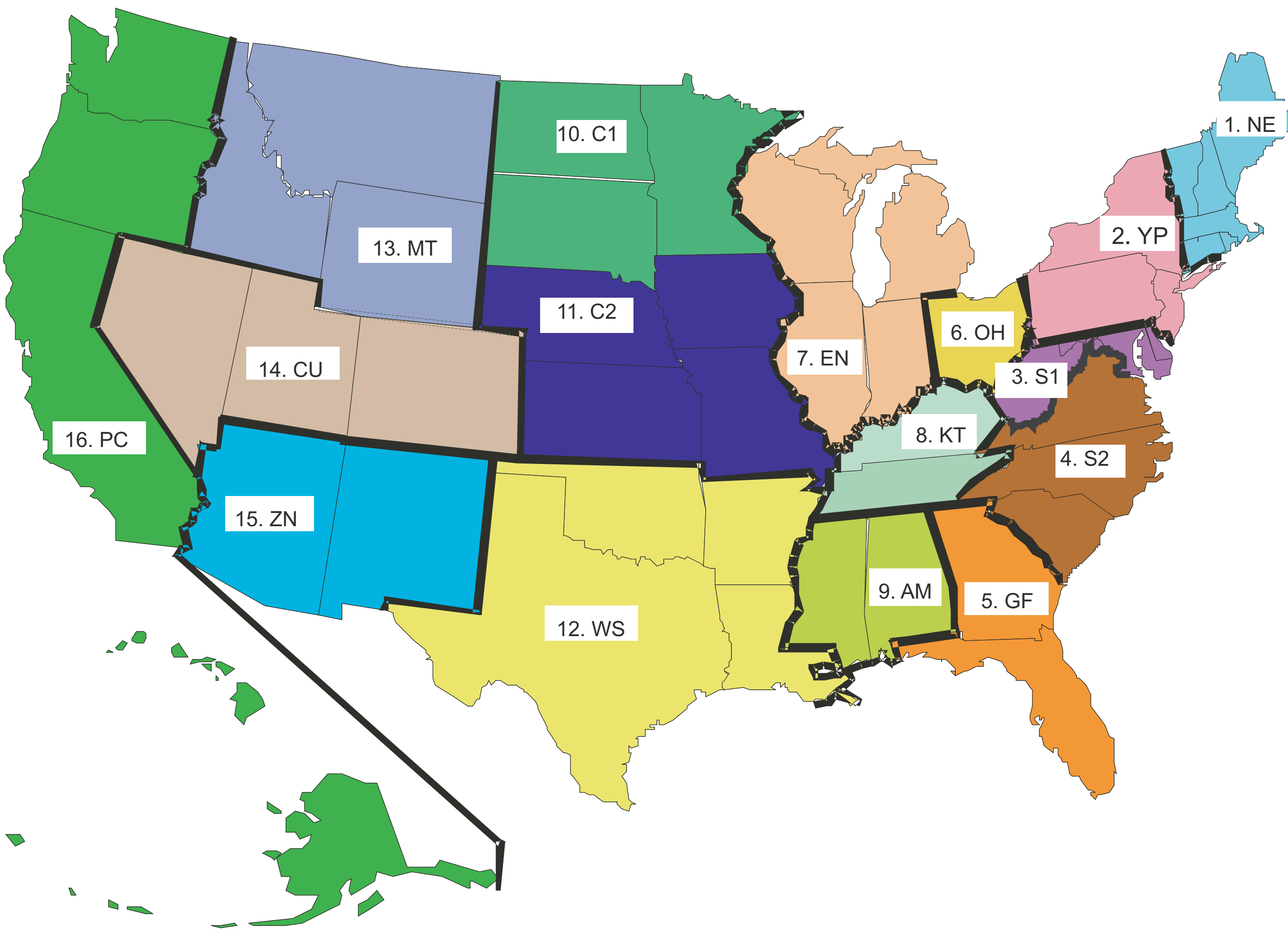
Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F7. Coal supply regions



Source: U.S. Energy Information Administration, Office of Energy Analysis.

Figure F8. Coal demand regions



Region Code	Region Content
1. NE	CT,MA,ME,NH,RI,VT
2. YP	NY,PA,NJ
3. S1	WV,MD,DC,DE
4. S2	VA,NC,SC
5. GF	GA,FL
6. OH	OH
7. EN	IN,IL,MI,WI
8. KT	KY,TN

Region Code	Region Content
9. AM	AL,MS
10. C1	MN,ND,SD
11. C2	IA,NE,MO,KS
12. WS	TX,LA,OK,AR
13. MT	MT,WY,ID
14. CU	CO,UT,NV
15. ZN	AZ,NM
16. PC	AK,HI,WA,OR,CA

Source: U.S. Energy Information Administration, Office of Energy Analysis.

Appendix G

Conversion factors

Table G1. Heat contents

Fuel	Units	Approximate heat content
Coal[1]		
Production	million Btu per short ton	20.02
Consumption	million Btu per short ton	19.49
Coke plants	million Btu per short ton	28.69
Industrial[2]	million Btu per short ton	20.73
Commercial and institutional	million Btu per short ton	23.11
Electric power sector[3]	million Btu per short ton	19.04
Imports	million Btu per short ton	22.73
Exports	million Btu per short ton	26.21
Coal coke	million Btu per short ton	24.80
Crude oil[1]		
Production	million Btu per barrel	5.719
Imports	million Btu per barrel	6.063
Petroleum products and other liquids		
Consumption[1]	million Btu per barrel	5.148
Motor gasoline[1]	million Btu per barrel	5.057
Jet fuel	million Btu per barrel	5.670
Distillate fuel oil[1]	million Btu per barrel	5.778
Diesel fuel[1]	million Btu per barrel	5.778
Residual fuel oil	million Btu per barrel	6.287
Liquefied petroleum gases and other[1,4]	million Btu per barrel	3.559
Kerosene	million Btu per barrel	5.670
Petrochemical feedstocks[1]	million Btu per barrel	5.441
Unfinished oils[1]	million Btu per barrel	6.111
Imports[1]	million Btu per barrel	5.518
Exports[1]	million Btu per barrel	5.398
Ethanol, including denaturant	million Btu per barrel	3.558
Biodiesel	million Btu per barrel	5.359
Natural gas plant liquids[1]		
Production	million Btu per barrel	3.745
Natural gas[1]		
Production, dry	Btu per cubic foot	1,031
Consumption	Btu per cubic foot	1,031
End-use sectors	Btu per cubic foot	1,032
Electric power sector[3]	Btu per cubic foot	1,029
Imports	Btu per cubic foot	1,025
Exports	Btu per cubic foot	1,009
Electricity consumption	Btu per kilowatthour	3,412

[1]Conversion factor varies from year to year. The value shown is for 2015.
[2]Includes combined heat and power plants that have a non-regulatory status, and small on-site generating systems.
[3]Includes all electricity-only and combined heat and power plants that have a regulatory status.
[4]Includes ethane, natural gasoline, and refinery olefins.
Btu = British thermal unit.
Sources: U.S. Energy Information Administration, *Short-Term Energy Outlook*, February 2016 and EIA, AEO2016 National Energy Modeling System run ref2016.d032416a.

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114th Congress, 2nd Session – – – – – – – – – – – – – – House Document 114-145

THE 2016 ANNUAL REPORT OF THE BOARD OF TRUSTEES OF THE FEDERAL OLD-AGE AND SURVIVORS INSURANCE AND FEDERAL DISABILITY INSURANCE TRUST FUNDS

COMMUNICATION

FROM

THE BOARD OF TRUSTEES, FEDERAL OLD-AGE AND SURVIVORS INSURANCE AND FEDERAL DISABILITY INSURANCE TRUST FUNDS

TRANSMITTING

THE 2016 ANNUAL REPORT OF THE BOARD OF TRUSTEES OF THE FEDERAL OLD-AGE AND SURVIVORS INSURANCE AND FEDERAL DISABILITY INSURANCE TRUST FUNDS

June 22, 2016—Referred to the Committee on Ways and Means and ordered to be printed

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U.S. GOVERNMENT PUBLISHING OFFICE

20-505 WASHINGTON: 2016

LETTER OF TRANSMITTAL

BOARD OF TRUSTEES OF THE
FEDERAL OLD-AGE AND SURVIVORS INSURANCE AND
FEDERAL DISABILITY INSURANCE TRUST FUNDS,
Washington, D.C., June 22, 2016

HON. PAUL D. RYAN,
Speaker of the House of Representatives.

HON. JOSEPH R. BIDEN, JR.,
President of the Senate.

DEAR MR. SPEAKER AND MR. PRESIDENT:

We have the honor of transmitting to you the 2016 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds, the 76th such report.

Respectfully,

JACOB J. LEW,
Secretary of the Treasury, and Managing Trustee of the Trust Funds.

THOMAS E. PEREZ,
Secretary of Labor, and Trustee.

SYLVIA M. BURWELL,
Secretary of Health and Human Services, and Trustee.

CAROLYN W. COLVIN,
Acting Commissioner of Social Security, and Trustee.

VACANT,
Public Trustee.

VACANT,
Public Trustee.

VIRGINIA P. RENO,
Deputy Commissioner for Retirement and Disability Policy, Social Security Administration, and Acting Secretary, Board of Trustees.

CONTENTS

THE 2016 ANNUAL REPORT OF THE BOARD OF TRUSTEES OF THE FEDERAL OLD-AGE AND SURVIVORS INSURANCE AND FEDERAL DISABILITY INSURANCE TRUST FUNDS

I. INTRODUCTION

The Old-Age, Survivors, and Disability Insurance (OASDI) program makes monthly income available to insured workers and their families at retirement, death, or disability. The OASDI program consists of two parts. Retired workers, their families, and survivors of deceased workers receive monthly benefits under the Old-Age and Survivors Insurance (OASI) program. Disabled workers and their families receive monthly benefits under the Disability Insurance (DI) program.

The Social Security Act established the Board of Trustees to oversee the financial operations of the OASI and DI Trust Funds. The Board is composed of six members. Four members serve by virtue of their positions in the Federal Government: the Secretary of the Treasury, who is the Managing Trustee; the Secretary of Labor; the Secretary of Health and Human Services; and the Commissioner of Social Security. The President appoints and the Senate confirms the other two members to serve as public representatives. These two positions are currently vacant. The Deputy Commissioner of the Social Security Administration serves as Secretary of the Board.

The Social Security Act requires that the Board, among other duties, report annually to the Congress on the actuarial status and financial operations of the OASI and DI Trust Funds. The 2016 report is the 76th such report.

II. OVERVIEW

A. HIGHLIGHTS

This section summarizes the report's major findings.

In 2015

At the end of 2015, the OASDI program was providing benefit payments[1] to about 60 million people: 43 million retired workers and dependents of retired workers, 6 million survivors of deceased workers, and 11 million disabled workers and dependents of disabled workers. During the year, an estimated 169 million people had earnings covered by Social Security and paid payroll taxes on those earnings. Total expenditures in 2015 were $897 billion. Total income was $920 billion, which consisted of $827 billion in non-interest income and $93 billion in interest earnings. Asset reserves held in special issue U.S. Treasury securities grew from $2,789 billion at the beginning of the year to $2,813 billion at the end of the year. Consistent with practice in prior reports, asset reserves at the end of 2015 reflect the 12 months of benefits scheduled for payment, and exclude from operations shown for 2015 the benefits scheduled for payment on January 3, 2016, which were actually paid on December 31, 2015 as required by the law.[2]

Short-Range Results

Under the Trustees' intermediate assumptions, Social Security's total income is projected to exceed its total cost through 2019, as it has since 1982. The 2015 surplus of total income relative to cost was $23 billion. However, when interest income is excluded, Social Security's cost is projected to exceed its non-interest income throughout the projection period, as it has since 2010. The 2015 deficit of non-interest income relative to cost was $70 billion. For 2016, the program is projected to have a total-income surplus of $16 billion, and a non-interest-income deficit of $73 billion.[3]

The Trustees project that the asset reserves of the OASI Trust Fund, together with continuing program income, will be adequate to cover program costs over the next 10 years under the intermediate assumptions. However, the

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[1] The definitions of "benefit payment" and other terms appear in the Glossary.

[2] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $19.7 billion for the OASI Trust Fund and $6.1 billion for the DI Trust Fund. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.

[3] Amounts for 2015 and 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015.

projected reserves of the DI Trust Fund increase from 21 percent of annual cost at the beginning of 2016 to 48 percent at the beginning of 2019, largely due to the temporary payroll tax rate reallocation described below, and then decline steadily until the trust fund reserves become depleted in the third quarter of 2023. At the time reserves become depleted, continuing income to the DI Trust Fund would be sufficient to pay 89 percent of scheduled DI benefits. The DI Trust Fund does not satisfy the test of short-range financial adequacy.[1] Figure II.D3 illustrates the implications of reserve depletion for the DI Trust Fund.

The Bipartisan Budget Act of 2015 provides for a temporary reallocation of a portion of the 12.40 percent payroll tax rate between the OASI and the DI Trust Funds. For 2016 through 2018, the tax rate directed to the DI Trust Fund increases from 1.80 percent to 2.37 percent, with a corresponding decrease in the rate directed to the OASI Trust Fund. Beginning in 2019, the allocations return to 1.80 percent for DI and 10.60 percent for OASI. The reallocation alone extends the projected date of DI reserve depletion by about 6 years. The projected year of DI reserve depletion in this report is 2023. The reallocation does not affect the operations of the combined OASDI Trust Funds.

To illustrate the actuarial status of the Social Security program as a whole, the operations of the OASI and DI funds are often shown on a combined basis as OASDI. However, by law, the two funds are separate entities and therefore the combined fund operations and reserves are hypothetical. Importantly, combined trust fund reserves are clearly hypothetical after one fund becomes depleted, because under current law the funds cannot borrow from each other.[2]

The projected reserves of the hypothetical combined OASI and DI Trust Funds are adequate over the next 10 years under the intermediate assumptions. The ratio of reserves to cost remains above 100 percent through 2025, declining from 303 percent of annual cost at the beginning of 2016[3] to 165 percent at the beginning of 2025. For last year's report, the Trustees pro-

[1] The test of short-range financial adequacy for a trust fund is met if (1) the estimated trust fund ratio is at least 100 percent at the beginning of the period and remains at or above 100 percent throughout the 10-year short-range period or (2) the ratio is initially less than 100 percent, reaches at least 100 percent within 5 years (without reserve depletion at any time during this period) and remains at or above 100 percent throughout the remainder of the 10-year short-range period.

[2] For example, if the DI Trust Fund reserves were to become depleted in 2023 as is currently projected, the operations of the OASDI Trust Funds, shown in this report on a hypothetical combined basis, would not reflect the aggregated operation of the OASI and DI Trust Funds because part of the DI benefits could not be paid without a change in the law. Implicitly, the values shown for the hypothetical combined trust funds assume the law will have been changed to permit the transfer of resources between funds as needed.

[3] Amounts for 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015.

jected that combined reserves would be 298 percent of annual cost at the beginning of 2016 and 157 percent at the beginning of 2025.

The combined reserves are projected to increase from $2,813 billion at the beginning of 2016[1] to $2,892 billion at the beginning of 2020. Reserves increase through 2019 because annual cost is less than total income for 2016 through 2019. At the same time, however, the ratio of reserves to cost declines, from 303 percent of annual cost for 2016 to 246 percent for 2020. Beginning in 2020, annual cost exceeds total income, and therefore the combined reserves begin to decline, reaching $2,527 billion at the end of 2025.

Long-Range Results

Under the Trustees' intermediate assumptions, projected OASDI cost will exceed total income by increasing amounts starting in 2020, and the dollar level of the combined trust fund reserves declines until reserves become depleted in 2034. Figure II.D2 shows the implications of reserve depletion for the combined OASDI Trust Funds. Considered separately, the DI Trust Fund reserves become depleted in the third quarter of 2023 and the OASI Trust Fund reserves become depleted in 2035. In last year's report, the projected reserve depletion years were 2034 for OASDI, 2016 for DI, and 2035 for OASI. The change in the depletion date for DI is largely due to the temporary tax rate reallocation enacted in the Bipartisan Budget Act of 2015.

Projected OASDI cost generally increases more rapidly than projected non-interest income through 2038 primarily because the retirement of the baby-boom generation will increase the number of beneficiaries much faster than the number of covered workers increases, as subsequent lower-birth-rate generations replace the baby-boom generation at working ages. From 2039 to 2050, the cost rate (the ratio of program cost to taxable payroll) generally declines because the aging baby-boom generation is gradually replaced at retirement ages by historically low-birth-rate generations. Thereafter, increases in life expectancy cause OASDI cost to increase generally relative to non-interest income, but more slowly than between 2010 and 2038.

The projected OASDI annual cost rate increases from 14.05 percent of taxable payroll for 2016[1] to 16.61 percent for 2038 and to 17.68 percent for 2090, a level that is 4.35 percent of taxable payroll more than the projected income rate (the ratio of non-interest income to taxable payroll) for 2090. For last year's report, the Trustees estimated the OASDI cost for 2090 at 18.01 percent, or 4.69 percent of payroll more than the annual income rate

[1] Amounts for 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015.

for that year. Expressed in relation to the projected gross domestic product (GDP), OASDI cost generally rises from 5.0 percent of GDP for 2016 to about 6.0 percent by 2035, then declines to 5.9 percent by 2050, and then generally increases to 6.1 percent by 2090.

For the 75-year projection period, the actuarial deficit is 2.66 percent of taxable payroll, 0.02 percentage point smaller than in last year's report. The closely-related open group unfunded obligation for OASDI over the 75-year period is 2.49 percent of taxable payroll, which is 0.04 percentage point smaller than in last year's report. However, the open group unfunded obligation for OASDI over the 75-year period is $11.4 trillion in present value and is $0.7 trillion more than the measured level of $10.7 trillion a year ago. If the assumptions, methods, starting values, and the law had all remained unchanged, the actuarial deficit would have increased to 2.74 percent of taxable payroll and the unfunded obligation would have risen to about 2.53 percent of taxable payroll and $11.2 trillion in present value due to the change in the valuation date. The remaining changes in the actuarial deficit and the unfunded obligation are due to changes in the law, methods, starting values, and assumptions.

To illustrate the magnitude of the 75-year actuarial deficit, consider that for the combined OASI and DI Trust Funds to remain fully solvent throughout the 75-year projection period: (1) revenues would have to increase by an amount equivalent to an immediate and permanent payroll tax rate increase of 2.58 percentage points[1] to 14.98 percent, (2) scheduled benefits would have to be reduced by an amount equivalent to an immediate and permanent reduction of about 16 percent applied to all current and future beneficiaries, or about 19 percent if the reductions were applied only to those who become initially eligible for benefits in 2016 or later; or (3) some combination of these approaches would have to be adopted.

If substantial actions are deferred for several years, the changes necessary to maintain Social Security solvency would be concentrated on fewer years and fewer generations. Much larger changes would be necessary if action is deferred until the combined trust fund reserves become depleted in 2034. For example, maintaining 75-year solvency with policies that begin in 2034 would require: (1) an increase in revenues by an amount equivalent to a

[1] The necessary tax rate of 2.58 percent differs from the 2.66 percent actuarial deficit for two reasons. First, the necessary tax rate is the rate required to maintain solvency throughout the period that does not result in any trust fund reserve at the end of the period, whereas the actuarial deficit incorporates an ending trust fund reserve equal to 1 year's cost. Second, the necessary tax rate reflects a behavioral response to tax rate changes, whereas the actuarial deficit does not. In particular, the calculation of the necessary tax rate assumes that an increase in payroll taxes results in a small shift of wages and salaries to forms of employee compensation that are not subject to the payroll tax.

3.58 percentage point payroll tax rate increase starting in 2034, (2) a reduction in scheduled benefits by an amount equivalent to a 21 percent reduction in all benefits starting in 2034, or (3) some combination of these approaches would have to be adopted.

Conclusion

Under the intermediate assumptions, DI Trust Fund asset reserves are projected to become depleted in the third quarter of 2023, at which time continuing income to the DI Trust Fund would be sufficient to pay 89 percent of DI scheduled benefits. Therefore, legislative action is needed soon to address the DI program's financial imbalance. The OASI Trust Fund reserves are projected to become depleted in 2035, at which time OASI income would be sufficient to pay 77 percent of OASI scheduled benefits.

The Trustees also project that annual cost for the OASDI program will exceed non-interest income throughout the projection period, and will exceed total income beginning in 2020 under the intermediate assumptions. The projected hypothetical combined OASI and DI Trust Fund asset reserves increase through 2019, begin to decline in 2020, and become depleted and unable to pay scheduled benefits in full on a timely basis in 2034. At the time of depletion of these combined reserves, continuing income to the combined trust funds would be sufficient to pay 79 percent of scheduled benefits. Lawmakers have a broad continuum of policy options that would close or reduce Social Security's long-term financing shortfall. Cost estimates for many such policy options are available at www.ssa.gov/OACT/solvency/provisions/.

The Trustees recommend that lawmakers address the projected trust fund shortfalls in a timely way in order to phase in necessary changes gradually and give workers and beneficiaries time to adjust to them. Implementing changes sooner rather than later would allow more generations to share in the needed revenue increases or reductions in scheduled benefits and could preserve more trust fund reserves to help finance future benefits. Social Security will play a critical role in the lives of 61 million beneficiaries and 171 million covered workers and their families in 2016. With informed discussion, creative thinking, and timely legislative action, Social Security can continue to protect future generations.

B. TRUST FUND FINANCIAL OPERATIONS IN 2015

Table II.B1 shows the income, expenditures, and asset reserves for the OASI, the DI, and the combined OASI and DI Trust Funds in calendar year 2015.

Table II.B1.—Summary of 2015 Trust Fund Financial Operations
[In billions]

	OASI	DI	OASDI
Asset reserves at the end of 2014	$2,729.2	$60.2	$2,789.5
Total income in 2015	801.6	118.6	920.2
Net payroll tax contributions	679.5	115.4	794.9
Reimbursement from General Fund of the Treasury	.3	[a]	.3
Taxation of benefits	30.6	1.1	31.6
Interest	91.2	2.1	93.3
Total expenditures in 2015[b]	750.5	146.6	897.1
Benefit payments[b]	742.9	143.4	886.3
Railroad Retirement financial interchange	4.3	.4	4.7
Administrative expenses	3.4	2.8	6.2
Net increase in asset reserves in 2015[b]	51.0	-28.0	23.0
Asset reserves at the end of 2015[b]	2,780.3	32.3	2,812.5

[a] Less than $50 million.
[b] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $19.7 billion for the OASI Trust Fund and $6.1 billion for the DI Trust Fund. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.

Note: Totals do not necessarily equal the sums of rounded components.

In 2015, net payroll tax contributions accounted for 86 percent of total trust fund income. Net payroll tax contributions consist of taxes paid by employees, employers, and the self-employed on earnings covered by Social Security. These taxes are paid on covered earnings up to a specified maximum annual amount, which was $118,500 in 2015. Table II.B2 shows the tax rates for 2015.

In 2015, approximately 0.04 percent of OASI and DI combined Trust Fund income came from reimbursements from the General Fund of the Treasury. Public Laws 111-312, 112-78, and 112-96 account for most of the reimbursement for the year. These acts specified General Fund reimbursement for temporary reductions in revenue due to reduced payroll tax rates for employees and for self-employed workers for 2011 and 2012.

Three percent of OASI and DI combined Trust Fund income in 2015 came from subjecting up to 50 percent of Social Security benefits to Federal personal income taxation for beneficiaries with income (including half of benefits and all non-taxable interest) exceeding specified levels. Interest earned on invested trust fund asset reserves accounted for 10 percent of OASDI income. The Department of the Treasury invests trust fund reserves in interest-bearing securities issued by the U.S. Government. In 2015, the combined trust fund reserves earned interest at an effective annual rate of 3.4 percent.

Almost 99 percent of expenditures from the combined OASI and DI Trust Funds in 2015 were retirement, survivor, and disability benefits totaling $886.3 billion. A net payment of $4.7 billion was made to the Railroad Retirement Social Security Equivalent Benefit Account from the combined OASI and DI Trust Funds, which was about 0.5 percent of total OASDI expenditures. The administrative expenses of the Social Security program were $6.2 billion, which was about 0.7 percent of total expenditures.

The trust fund investments provide a reserve to pay benefits whenever total program cost exceeds income. Trust fund reserves increased by $23.0 billion for 2015 because total income to the combined funds, including interest earned on trust fund reserves, exceeded total expenditures.[1] At the end of 2015, the combined reserves of the OASI and the DI Trust Funds were $2,813 billion, or 303 percent of estimated expenditures[2] for 2016. In comparison, the combined reserves at the end of 2014 were 311 percent of expenditures for 2015.

Table II.B2.—Payroll Tax Contribution Rates for 2015
[In percent]

	OASI	DI	OASDI
Payroll tax contribution rate for employees	5.30	0.90	6.20
Payroll tax contribution rate for employers	5.30	.90	6.20
Payroll tax contribution rate for self-employed persons	10.60	1.80	12.40

[1] As noted in footnote b of table II.B1 and elsewhere in this report, asset reserves shown for the end of 2015 reflect the 12 months of benefits scheduled for payment in 2015 and thus exclude the benefits scheduled for payment on January 3, 2016, which were actually paid on December 31, 2015 as required by the law.

[2] Estimated expenditures are based on the intermediate set of assumptions.

C. ASSUMPTIONS ABOUT THE FUTURE

The future income and expenditures of the OASI and DI Trust Funds will depend on many factors, including the size and characteristics of the population receiving benefits, the level of monthly benefit amounts, the size of the workforce, and the level of covered workers' earnings. These factors will depend in turn on future birth rates, death rates, immigration, marriage and divorce rates, retirement-age patterns, disability incidence and termination rates, employment rates, productivity gains, wage increases, inflation, interest rates, and many other demographic, economic, and program-specific factors.

Table II.C1 presents key demographic and economic assumptions for three alternative scenarios. The intermediate assumptions reflect the Trustees' best estimates of future experience. Therefore, most of the figures in this overview present outcomes under the intermediate assumptions only. Any projection of the future is, of course, uncertain. For this reason, the Trustees also present results under low-cost and high-cost alternatives to provide a range of possible future experience. The actual future costs are unlikely to be as extreme as those portrayed by the low-cost or high-cost projections. A separate section on the uncertainty of the projections, beginning on page 19, highlights the implications of these alternative scenarios.

The Trustees reexamine the assumptions each year in light of recent experience and new information. This annual review helps to ensure that the Trustees' assumptions provide the best estimate of future possibilities.

Table II.C1.—Long-Range Values[a] of Key Assumptions for the 75-year Projection Period

Long-range assumptions	Intermediate	Low-cost	High-cost
Demographic:			
Total fertility rate (children per woman), for 2032 and later	2.0	2.2	1.8
Average annual percentage reduction in total age-sex-adjusted death rates from 2015 to 2090	.78	.42	1.16
Average annual net immigration (in thousands) for 2016 to 2090	1,291	1,629	961
Economic:			
Average annual percentage change in:			
Productivity (total U.S. economy), for 2026 and later	1.68	1.98	1.38
Average wage in covered employment from 2026 to 2090	3.80	5.03	2.59
Consumer Price Index (CPI-W), for 2019 and later	2.60	3.20	2.00
Average annual real-wage differential (percent) for 2026 to 2090	1.20	1.83	.59
Unemployment rate (percent, age-sex-adjusted), for 2022 and later	5.5	4.5	6.5
Annual trust fund real interest rate (percent), for 2026 and later	2.7	3.2	2.2
Programmatic:			
Disability incidence rate (per 1,000 exposed, age-sex-adjusted) in 2090	5.4	4.3	6.4
Disability recovery rate (per 1,000 beneficiaries, age-sex-adjusted) in 2090	10.4	12.6	8.3

[a] See chapter V for details, including historical and projected values.

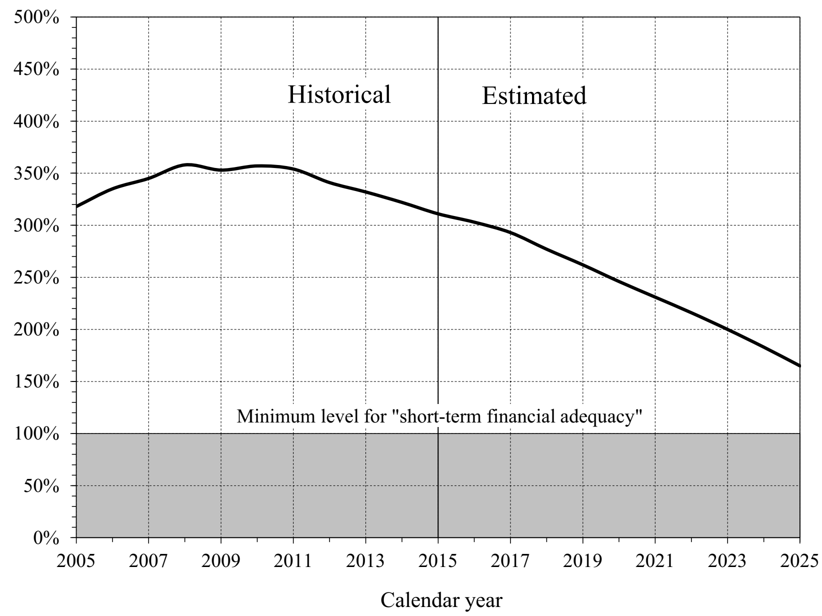
D. PROJECTIONS OF FUTURE FINANCIAL STATUS

Short-Range Actuarial Estimates

For the short-range period (2016 through 2025), the Trustees measure financial adequacy by comparing projected asset reserves at the beginning of each year to projected program cost for that year under the intermediate set of assumptions. Maintaining a trust fund ratio of 100 percent or more—that is, reserves at the beginning of each year at least equal to projected cost for the year—is a good indication that the trust fund can cover most short-term contingencies. The projected trust fund ratios under the intermediate assumptions for OASI alone, and for OASI and DI combined, exceed 100 percent throughout the short-range period. Therefore, OASI and OASDI satisfy the Trustees' short-term test of financial adequacy. However, the DI Trust Fund fails the Trustees' short-term test of financial adequacy. The Trustees estimate that the DI trust fund ratio was at 21 percent at the beginning of 2016. The projected DI trust fund ratio increases to 48 percent at the beginning of 2019, largely due to the temporary payroll tax rate reallocation for 2016 through 2018 from OASI to DI enacted in the Bipartisan Budget Act of 2015, and then declines until the trust fund reserves become depleted in the third quarter of 2023. Figure II.D1 shows that the trust fund ratio for the combined OASI and DI Trust Funds declines consistently after 2010. Figure II.D2 illustrates some of the implications of reserve depletion for the combined OASI and DI Trust Funds; figure II.D3 illustrates similar information for the DI Trust Fund alone.

Projected OASDI cost is less than total income until 2020, when cost begins to exceed total income. While trust fund reserves continue to grow through 2019, they grow more slowly than cost, causing the trust fund ratio to decline, as shown in figure II.D1. OASDI cost exceeds non-interest income throughout the short-range period.

Figure II.D1.—Short-Range OASI and DI Combined Trust Fund Ratio
[Asset reserves as a percentage of annual cost, under Intermediate Assumptions]



Long-Range Actuarial Estimates

The Trustees use three types of measures to assess the actuarial status of the program over the next 75 years: (1) annual cash-flow measures, including income rates, cost rates, and balances; (2) trust fund ratios; and (3) summary measures such as actuarial balances and open group unfunded obligations. The Trustees express these measures as percentages of taxable payroll, as percentages of gross domestic product (GDP), or in dollars. The Trustees also present summary measures over the infinite horizon in appendix F. The infinite horizon values, which are subject to much greater uncertainty, provide an additional indication of Social Security's very-long-run financial condition.

The Trustees also apply a test of long-range close actuarial balance each year. To satisfy the test, a trust fund must meet two conditions: (1) the trust fund satisfies the test of short-range financial adequacy, and (2) the trust fund ratio stays above zero throughout the 75-year projection period, such that benefits would be payable in a timely manner throughout the period. The

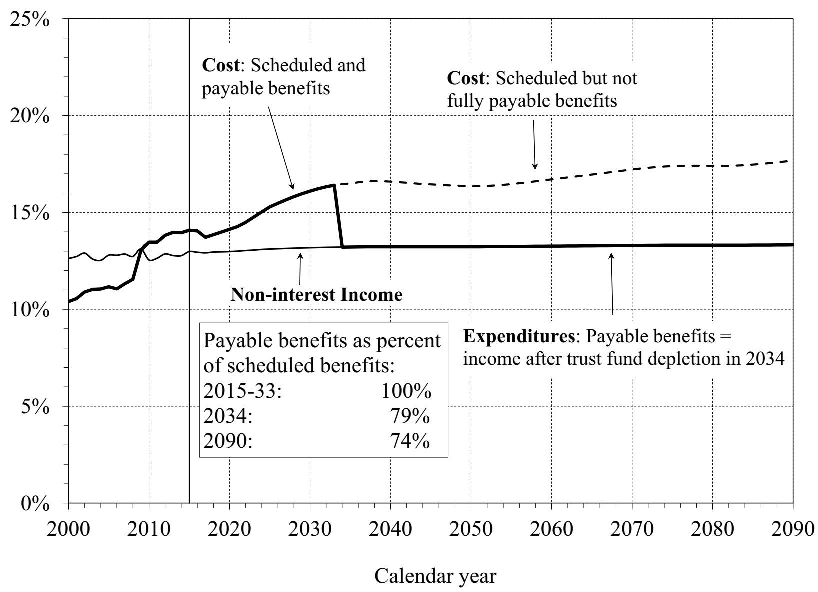
OASI, DI, and combined OASI and DI Trust Funds all fail the test of long-range close actuarial balance under the intermediate assumptions.

Annual Income Rates, Cost Rates, and Balances

Figure II.D2 illustrates the year-by-year relationship among OASDI income (excluding interest), cost (including scheduled benefits), and expenditures (including payable benefits) for the full 75-year period (2016 through 2090). The figure shows all values as percentages of taxable payroll. Under the intermediate assumptions, demographic factors would by themselves cause the projected cost rate to rise rapidly for the next two decades before leveling off in about 2035. However, the recent recession led to lower taxable earnings than expected and more beneficiaries than expected, which in turn sharply, but temporarily, increased the cost rate starting in 2009. From a peak in 2015, the cost rate declines through 2017 under the economic recovery and thereafter returns to a gradually rising trend. The projected income rate is stable at about 13 percent throughout the 75-year period.

Annual OASDI cost exceeded non-interest income in 2010 for the first time since 1983. The Trustees project that cost will continue to exceed non-interest income throughout the 75-year valuation period. Nevertheless, total trust fund income, including interest income, is more than sufficient to cover costs through 2019, so trust fund asset reserves continue to grow. Beginning in 2020, cost exceeds total income, and combined OASI and DI Trust Fund reserves diminish until they become depleted in 2034. After trust fund reserve depletion, continuing income is sufficient to support expenditures at a level of 79 percent of program cost for the rest of 2034, declining to 74 percent for 2090. Figure II.D2 depicts OASDI operations as a combined whole. However, under current law, the differences between scheduled and payable benefits would begin at different times for the program's two trust funds: in 2023 for DI and in 2035 for OASI.

Figure II.D2.—OASDI Income, Cost, and Expenditures as Percentages of Taxable Payroll
[Under Intermediate Assumptions]



To illustrate the more immediate challenges specific to the DI program, figure II.D3 presents the year-by-year relationship among income, cost, and expenditures for the 75-year projection period. The temporary increase in the income rate shown in the figure for 2016 through 2018 reflects the tax rate reallocation enacted in the Bipartisan Budget Act of 2015. The DI Trust Fund reserves are expected to become depleted in the third quarter of 2023 if no legislative action is taken before then. After DI Trust Fund reserve depletion, continuing income is sufficient to support expenditures at a level of 89 percent of program cost for the rest of 2023, rising to a somewhat higher level for 2024 through 2040, then declining to 82 percent by 2090.

Figure II.D3.—DI Income, Cost, and Expenditures as Percentages of Taxable Payroll
[Under Intermediate Assumptions]

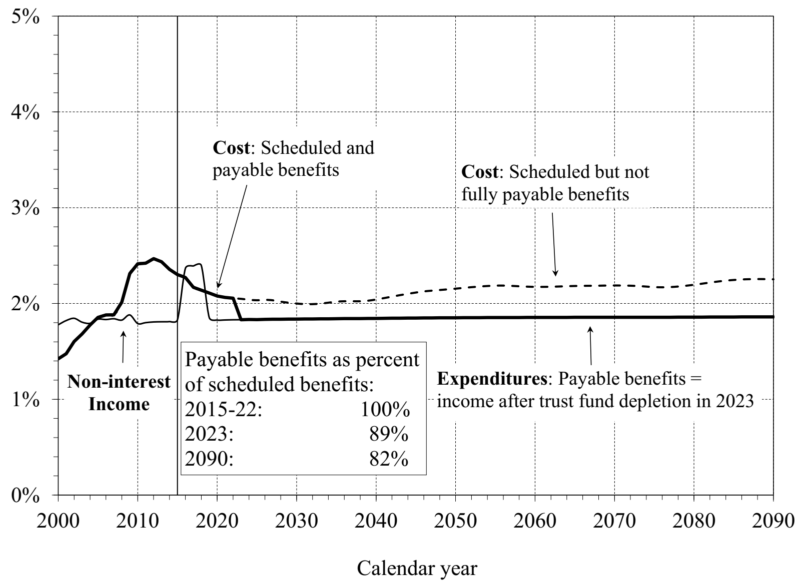
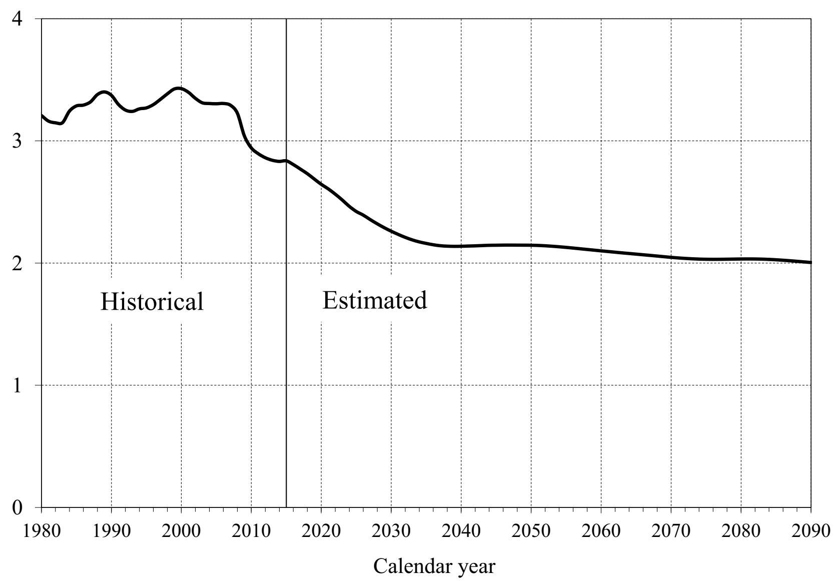


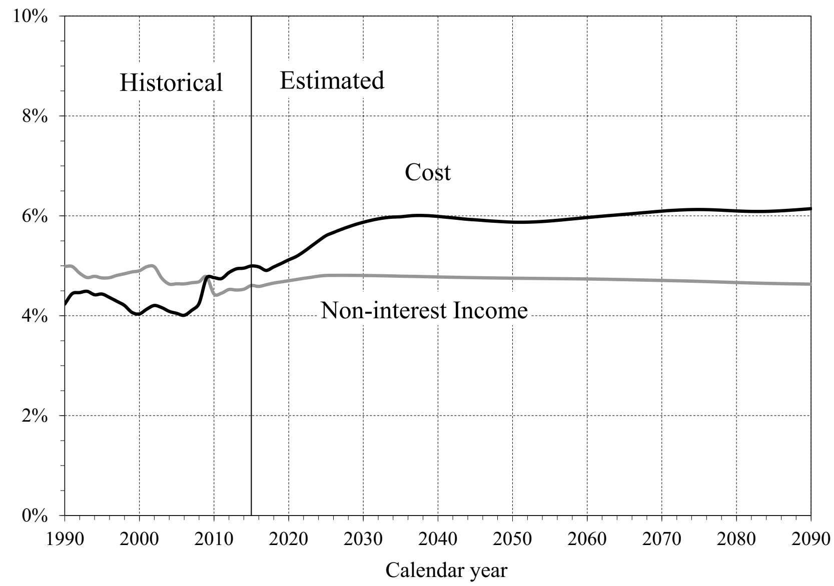
Figure II.D4 shows the estimated number of covered workers per OASDI beneficiary. Figures II.D2 and II.D4 illustrate the inverse relationship between cost rates and the number of workers per beneficiary. In particular, the projected future increase in the cost rate reflects a projected decline in the number of covered workers per beneficiary. There were about 2.8 workers for every OASDI beneficiary in 2015. This ratio had been extremely stable, remaining between 3.2 and 3.4 from 1974 through 2008, and has declined since then due to the economic recession and the beginning of the demographic shift that will drive this ratio down over the next 20 years. The Trustees project that the ratio of workers to beneficiaries will continue to decline, even as the economy recovers, due to this demographic shift—as workers of lower-birth-rate generations replace workers of the baby-boom generation. The ratio of workers to beneficiaries reaches 2.2 by 2035 when the baby-boom generation will have largely retired, with a further gradual decline thereafter due to increasing longevity.

Figure II.D4.—Number of Covered Workers Per OASDI Beneficiary
[Under Intermediate Assumptions]



Another important way to look at Social Security's future is to view its annual cost and non-interest income as a share of U.S. economic output (GDP). As shown in figure II.D5, the Trustees project that Social Security's cost as a percent of GDP will grow from 5.0 percent in 2016 to about 6.0 percent by 2035, then decline to 5.9 percent by 2050, and generally increase to 6.1 percent by 2090. As the economy recovers, Social Security's non-interest income, which reflects scheduled tax rates, increases from its current level of about 4.6 percent of GDP to about 4.8 percent of GDP for 2025. Thereafter, non-interest income as a percent of GDP declines gradually, to about 4.6 percent by 2090, because the Trustees expect the share of employee compensation provided as noncovered fringe benefits to increase gradually.

Figure II.D5.—OASDI Cost and Non-interest Income as a Percentage of GDP
[Under Intermediate Assumptions]



Trust Fund Ratios

The trust fund ratio is defined as the asset reserves at the beginning of a year expressed as a percentage of the cost during the year. The trust fund ratio thus represents the proportion of a year's cost which could be paid solely with the reserves at the beginning of the year. Table II.D1 displays the projected maximum trust fund ratios during the long-range period for the OASI, DI, and combined OASI and DI funds. The table also shows the year of maximum projected trust fund ratio during the long-range projection period (2016 through 2090) and the year of trust fund reserve depletion. Each trust fund ratio has been generally declining in recent years. OASI reached a peak level of 402 in 2011, DI reached a peak level of 219 in 2003, and OASDI reached a peak level of 358 in 2008.

Table II.D1.—Projected Maximum Trust Fund Ratios During the Long-Range Period and Trust Fund Reserve Depletion Dates
[Under the Intermediate Assumptions]

	OASI	DI	OASDI
Maximum projected trust fund ratio (percent).	357	48	303
Year attained.	2016	2019	2016
Projected year of trust fund reserve depletion	2035	2023	2034

Summary Measures

The actuarial balance is a summary measure of the program's financial status through the end of the 75-year valuation period. The actuarial balance measure includes the trust fund asset reserves at the beginning of the period, all cost and income during the valuation period, and the cost of reaching a target trust fund reserve of one year's cost by the end of the period. Therefore, the actuarial balance is essentially the difference between the present values of income and cost from 1937 through the end of the valuation period. Actuarial balance is expressed as a percentage of the taxable payroll for the 75-year valuation period. A negative actuarial balance is called an actuarial deficit. The actuarial deficit represents the average amount of change in income or cost that is needed throughout the valuation period in order to achieve actuarial balance.

In this report, the actuarial deficit for the combined OASI and DI Trust Funds under the intermediate assumptions is 2.66 percent of taxable payroll. The actuarial deficit was 2.68 percent in the 2015 report. If the assumptions, methods, starting values, and the law had all remained unchanged from last year, the actuarial deficit would have increased to 2.74 percent of payroll solely due to advancing the valuation period by 1 year.

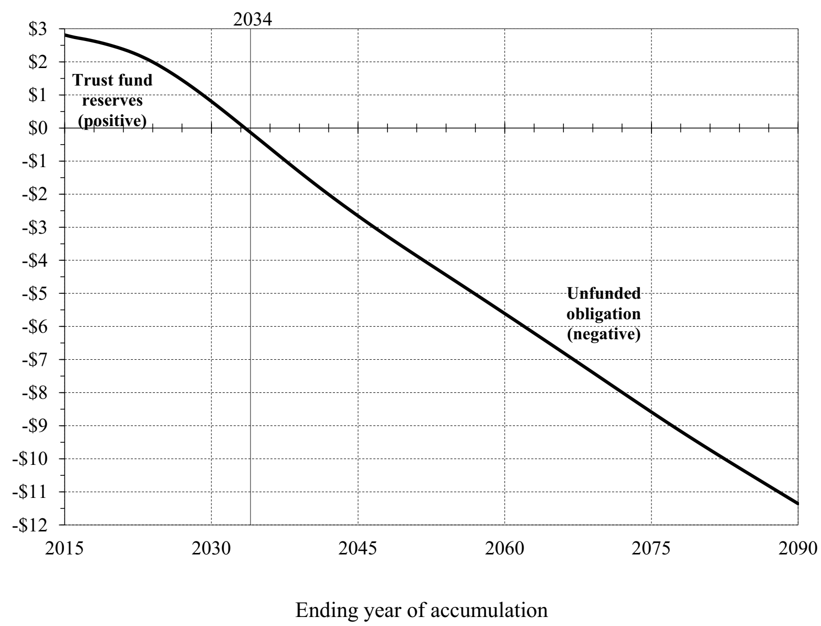
Another way to illustrate the projected financial shortfall of the OASDI program is to examine the cumulative present value of scheduled income less cost. Figure II.D6 shows the present value of cumulative OASDI income less cost from the inception of the program through each of the years from 2015 to 2090. A positive value represents the present value of trust fund reserves at the end of the selected year. A negative value is the unfunded obligation through the selected year. The asset reserves of the combined trust funds were $2.8 trillion at the end of 2015. The trust fund reserves decline on a present value basis after 2015, but remain positive through 2033. However, after 2033 this cumulative amount becomes negative, which means that the combined OASI and DI Trust Funds have a net unfunded obligation through each year after 2033. Through the end of 2090, the combined funds have a present-value unfunded obligation of $11.4 trillion. If the assumptions, methods, starting values, and the law had all remained unchanged from last year, the unfunded obligation would have risen to about $11.2 trillion due to the change in the valuation date.

This unfunded obligation represents 2.49 percent of taxable payroll (reduced from 2.53 percent in last year's report) and 0.9 percent of GDP (unchanged from last year's report) for the 75-year valuation period. The unfunded obligation as a share of taxable payroll (2.49 percent) and the actuarial deficit

(2.66 percent) are similar measures, but differ because the actuarial deficit includes the cost of having an ending trust fund reserve equal to 1 year's cost.

Figures II.D2, II.D5, and II.D6 show that the program's financial condition is worsening at the end of the projection period. Trends in annual balances and cumulative values toward the end of the 75-year period provide an indication of the program's ability to maintain solvency beyond 75 years. Consideration of summary measures alone for a 75-year period can lead to incorrect perceptions and to policy prescriptions that do not achieve sustainable solvency.[1]

Figure II.D6.—Cumulative Scheduled OASDI Income Less Cost, From Program Inception Through Years 2015-2090
[Present value as of January 1, 2016, in trillions, under Intermediate Assumptions]



Appendix F presents summary measures over the infinite horizon. The infinite horizon values provide an additional indication of Social Security's financial condition for the period beginning with the inception of the program and extending indefinitely into the future, but results are subject to

[1] Sustainable solvency for the financing of the program under a specified set of assumptions has been achieved when the projected trust fund ratio is positive throughout the 75-year projection period and is either stable or rising at the end of the period.

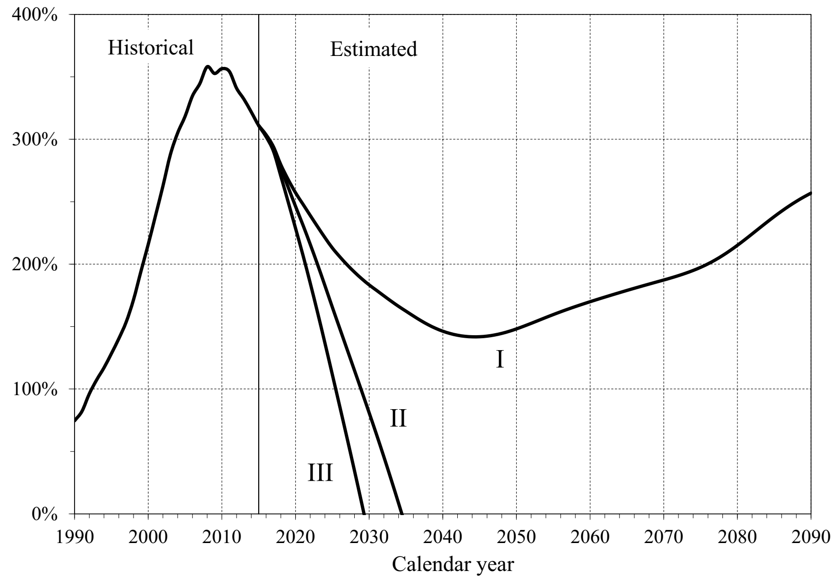
much greater uncertainty. Extending the horizon beyond 75 years increases the measured unfunded obligation. Through the infinite horizon, the unfunded obligation, or shortfall, is equivalent to 4.0 percent of future taxable payroll or 1.4 percent of future GDP.

Uncertainty of the Projections

Significant uncertainty surrounds the intermediate assumptions. The Trustees use several methods to help illustrate that uncertainty.

A first approach uses alternative scenarios reflecting low-cost (alternative I) and high-cost (alternative III) sets of assumptions. Figure II.D7 shows the projected trust fund ratios for the combined OASI and DI Trust Funds under the intermediate, low-cost, and high-cost assumptions. The low-cost alternative includes a higher ultimate total fertility rate, slower improvement in mortality, a higher real-wage differential, a higher ultimate real interest rate, a higher ultimate annual change in the CPI, and a lower unemployment rate. The high-cost alternative, in contrast, includes a lower ultimate total fertility rate, more rapid improvement in mortality, a lower real-wage differential, a lower ultimate real interest rate, a lower ultimate annual change in the CPI, and a higher unemployment rate. These alternatives are not intended to suggest that all parameters would be likely to differ from the intermediate values in the specified directions, but are intended to illustrate the effect of clearly defined scenarios that are, on balance, very favorable or unfavorable for the program's financial status. Actual future costs are unlikely to be as extreme as those portrayed by the low-cost or high-cost projections. The method for constructing the low-cost and high-cost projections does not lend itself to estimating the probability that actual experience will lie within or outside the range they define.

Figure II.D7.—Long-Range OASI and DI Combined Trust Fund Ratios Under Alternative Scenarios
[Asset reserves as a percentage of annual cost]

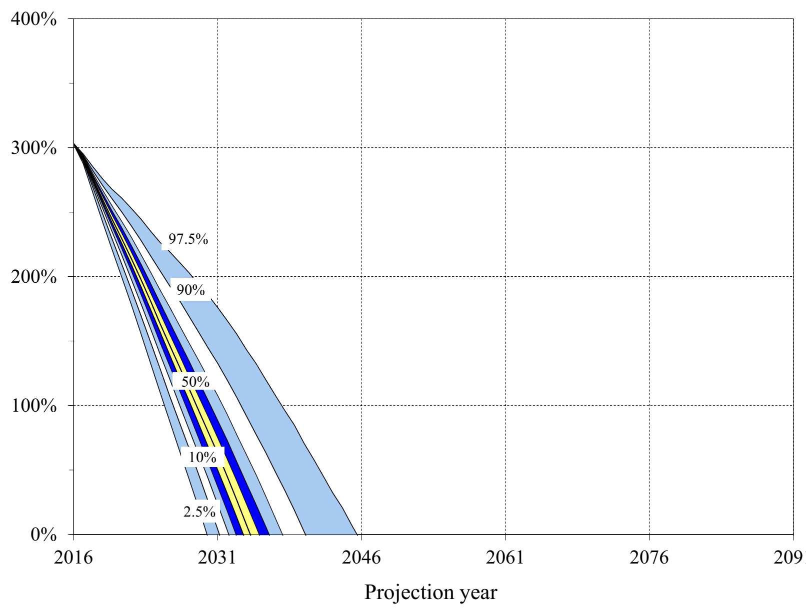


Appendix D of this report presents long-range sensitivity analysis for the OASDI program. By varying one parameter at a time, sensitivity analysis provides a second approach for illustrating the uncertainty surrounding projections into the future.

A third approach uses 5,000 independently generated stochastic simulations that reflect randomly assigned annual values for most of the key parameters. These simulations produce a distribution of projected outcomes and corresponding probabilities that future outcomes will fall within or outside a given range. The results of the stochastic simulations, discussed in more detail in appendix E, suggest that trust fund reserve depletion (i.e., the point at which the trust fund ratio reaches zero) is very likely by mid-century. In particular, figure II.D8 suggests that based on these stochastic simulations, trust fund asset reserves will become depleted between 2029 and 2045 with a 95-percent probability.

The stochastic results suggest that trust fund ratios as high as the low-cost alternative are very unlikely. However, the relationship between the stochastic results and the low-cost and high-cost alternatives may change as the methodology for the stochastic simulations is further developed. As noted in appendix E, future improvements and refinements are expected to be more likely to expand than to reduce the indicated range of uncertainty.

Figure II.D8.—Long-Range OASI and DI Combined Trust Fund Ratios From Stochastic Modeling



Changes From Last Year's Report

The projected long-range OASDI actuarial deficit decreased from 2.68 percent of taxable payroll for last year's report to 2.66 percent of taxable payroll for this year's report. The change in the 75-year projection period alone would have increased the actuarial deficit to 2.74 percent. For a detailed description of the specific changes identified in table II.D2, see section IV.B.6.

Table II.D2.—Reasons for Change in the 75-Year Actuarial Balance, Based on Intermediate Assumptions
[As a percentage of taxable payroll]

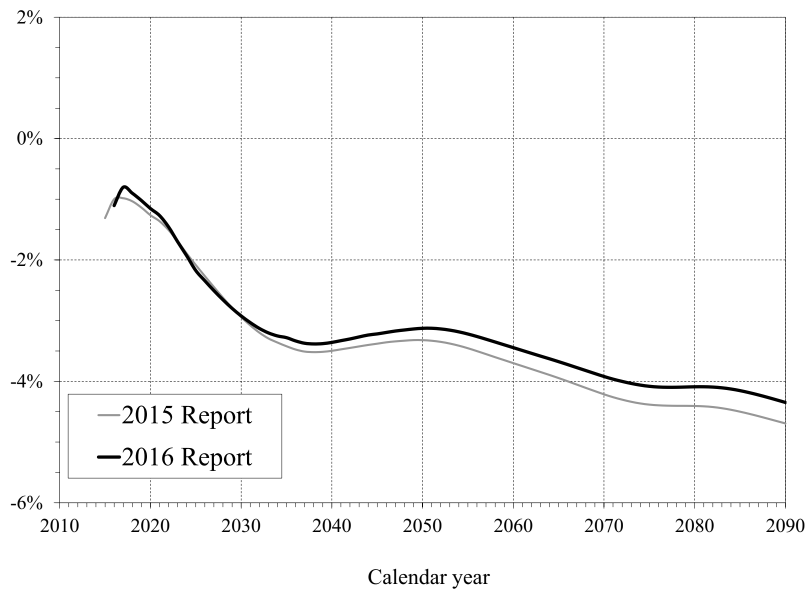
Item	OASI	DI	OASDI
Shown in last year's report:			
Income rate	12.00	1.86	13.86
Cost rate	14.37	2.17	16.55
Actuarial balance	**-2.37**	**-.31**	**-2.68**
Changes in actuarial balance due to changes in:			
Legislation / Regulation	-.01	.04	.03
Valuation period[a]	-.05	-.01	-.06
Demographic data and assumptions	.00	.00	.00
Economic data and assumptions	-.06	-.01	-.07
Disability data and assumptions	.00	.00	.00
Methods and programmatic data	.08	.03	.11
Total change in actuarial balance	-.02	.05	.02
Shown in this report:			
Actuarial balance	**-2.39**	**-.26**	**-2.66**
Income rate	11.96	1.88	13.84
Cost rate	14.36	2.14	16.50

[a] The change in the 75-year valuation period from last year's report to this report means that the 75-year actuarial balance now includes the relatively large negative annual balance for 2090. This change in the valuation period results in a larger long-range actuarial deficit. The actuarial deficit includes the trust fund reserve at the beginning of the projection period.

Note: Totals do not necessarily equal the sums of rounded components.

Figure II.D9 compares this year's projections of annual balances (non-interest income minus cost) to those in last year's report. The annual balances in this year's report are significantly higher (less negative) for most of the projection period. See page 81 for details.

Figure II.D9.—OASDI Annual Balances: 2015 and 2016 Trustees Reports
[As a percentage of taxable payroll, under the intermediate assumptions]



E. CONCLUSION

Under current law, the projected cost of Social Security increases faster than projected income through 2038 primarily because the ratio of workers paying taxes to beneficiaries receiving benefits will decline as the baby-boom generation ages and is replaced at working ages with subsequent lower birth-rate generations. While the effects of the aging baby boom and subsequent lower birth rates will have stabilized after 2038, annual cost will continue to grow faster than income, but to a lesser degree, reflecting continuing increases in life expectancy. Based on the Trustees' intermediate assumptions, Social Security's total income exceeds its total cost in 2016, and surpluses continue through 2019. However, cost exceeds non-interest income for 2016, as it has since 2010, and remains higher than non-interest income throughout the remainder of the 75-year projection period.

The OASI Trust Fund and DI Trust Fund are projected to have sufficient reserves to pay full benefits on time until 2035 and 2023, respectively. Legislative action will be needed soon to prevent depletion of the DI Trust Fund reserves in the third quarter of 2023, at which time continuing income to the DI Trust Fund would be sufficient to pay 89 percent of DI benefits.

Social Security's combined trust funds increase with the help of interest income through 2019 and allow full payment of scheduled benefits on a timely basis until the trust fund asset reserves become depleted in 2034. (Full payment of benefits implicitly assumes that the law will have been changed to permit the transfer of funds between OASI and DI as needed.) At that time, projected continuing income to the combined trust funds equals about 79 percent of the program cost. By 2090, continuing income equals about 74 percent of the program cost.

The 75-year actuarial deficit for the combined trust funds under the intermediate assumptions is 2.66 percent of taxable payroll—0.02 percentage point smaller than the 2.68 percent deficit in last year's report. To illustrate the magnitude of the deficit, consider that for the combined OASI and DI Trust Funds to remain fully solvent throughout the 75-year projection period: (1) revenues would have to be increased by an amount equivalent to an immediate and permanent payroll tax rate increase of 2.58 percentage points to 14.98 percent; (2) scheduled benefits would have to be reduced by an amount equivalent to an immediate and permanent reduction of about 16 percent applied to all current and future beneficiaries, or about 19 percent if the reductions were applied only to those who become initially eligible for benefits in 2016 or later; or (3) some combination of these approaches would have to be adopted. If actions are deferred for several years, the changes necessary to maintain Social Security solvency become concentrated on fewer years and fewer generations.

If lawmakers design legislative solutions only to eliminate the overall actuarial deficit without consideration of year-by-year patterns, then a substantial financial imbalance could remain at the end of the period, and the long-range sustainability of program financing could still be in doubt. Sustainable solvency for the financing of the program under a specified set of assumptions is achieved when the projected trust fund ratio is positive throughout the long-range period and is either stable or rising at the end of the period. Making changes now that achieve sustainable solvency could avoid the need for later legislative changes.

Lawmakers have a broad continuum of policy options that would close or reduce Social Security's long-term financing shortfall. Cost estimates for many such policy options are available at www.ssa.gov/OACT/solvency/provisions/. Broadly speaking, the approaches that lawmakers can take include increasing revenues from workers and employers by raising the tax rate or the maximum level of taxable earnings, or by dedicating revenues from other sources; lowering benefits for some or all beneficiaries by changing certain program parameters; or a combination of these approaches. There are countless variations on these options, including those that vary the timing, magnitude, and other specifics of the change(s) under consideration.

The Trustees recommend that lawmakers address the projected trust fund shortfalls in a timely way in order to phase in necessary changes gradually and give workers and beneficiaries time to adjust to them. Implementing changes sooner rather than later would allow more generations to share in the needed revenue increases or reductions in scheduled benefits and could preserve more trust fund reserves to help finance future benefits. Social Security will play a critical role in the lives of 61 million beneficiaries and 171 million covered workers and their families in 2016. With informed discussion, creative thinking, and timely legislative action, Social Security can continue to protect future generations.

For further information related to the contents of this report, see the following websites:

- www.ssa.gov/OACT/tr/2016/
- www.ssa.gov/OACT/solvency/provisions/
- www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/ReportsTrustFunds/
- www.treasury.gov/resource-center/economic-policy/ss-medicare/Pages/social_security.aspx

III. FINANCIAL OPERATIONS OF THE TRUST FUNDS AND LEGISLATIVE CHANGES IN THE LAST YEAR

A. OPERATIONS OF THE OLD-AGE AND SURVIVORS INSURANCE (OASI) AND DISABILITY INSURANCE (DI) TRUST FUNDS, IN CALENDAR YEAR 2015

This section presents detailed information on the operations of the OASI and DI Trust Funds[1] during calendar year 2015. Chapter IV provides projections for calendar years 2016 through 2090.

1. OASI Trust Fund

Table III.A1 presents a statement of the income and disbursements of the Federal Old-Age and Survivors Insurance Trust Fund in calendar year 2015, and of the asset reserves in the fund at the beginning and end of the calendar year. As shown in this table, total trust fund receipts in 2015 amounted to \$801.6 billion, while disbursements totaled \$750.5 billion, an increase in trust fund reserves during 2015 of \$51.0 billion.[2]

Total receipts during calendar year 2015 included \$681.9 billion in payroll tax contributions. These contributions include initial appropriations of payroll taxes, made on an estimated basis, and adjustments to appropriations for prior years to reflect actual tax receipts. The OASI fund paid the General Fund \$2.4 billion for the estimated amount of employee payroll-tax refunds, partially offsetting these gross contributions. Employees who work for more than one employer during a year and pay contributions on total earnings in excess of the contribution and benefit base are eligible for such refunds. Net payroll tax contributions were therefore \$679.5 billion in 2015.

Net reimbursements from the General Fund of the Treasury amounted to \$0.3 billion in 2015. As shown in the table, adjustments to prior year receipts based on Public Law 111-312, the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010, Public Law 112-78, the Temporary Payroll Tax Cut Continuation Act of 2011, and Public Law 112-96, the Middle Class Tax Relief and Job Creation Act of 2012, account for almost all of the reimbursement for the year, or about \$266 million. These acts specified General Fund reimbursement for tempo-

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[1] See www.ssa.gov/oact/ProgData/fundsQuery.html.

[2] In order to provide values that are comparable with other years, asset reserves shown for the end of 2015 reflect the 12 months of benefits scheduled for payment in 2015 and thus exclude the benefits scheduled for payment on January 3, 2016, which were actually paid on December 31, 2015 as required by the law.

rary reductions in employee and self-employment payroll taxes for earnings in 2011 and 2012.

The remainder was a reimbursement of $12 million in 2015 under the provisions of Public Law 110-246, the Food, Conservation, and Energy Act of 2008.

Income based on taxation of OASI benefits amounted to $30.6 billion in 2015. About 99 percent of this income represents amounts credited to the trust funds, generally in advance of the actual receipt of taxes by the Treasury. These credited amounts represent the net amount of initial estimated taxes transferred for tax liabilities in 2015 and adjustments to initial amounts transferred for prior periods. The remaining one percent of the total income from taxation of benefits represents amounts withheld from the benefits paid to nonresident aliens.

In 2015, the OASI Trust Fund earned $91.2 billion in net interest, which consisted of: (1) interest earned on the investments held by the trust fund, (2) interest on adjustments in the allocation of administrative expenses between the trust fund and the General Fund account for the Supplemental Security Income program, (3) interest arising from the revised allocation of administrative expenses among the trust funds, and (4) interest on certain reimbursements to the trust fund.

The Social Security Act authorizes the deposit of monetary gifts or bequests in the trust funds. In 2015, there were no such receipts by the OASI Trust Fund.

Table III.A1.—Operations of the OASI Trust Fund, Calendar Year 2015
[In millions]

Total asset reserves, December 31, 2014		$2,729,233
Receipts:		
Net payroll tax contributions:		
Payroll tax contributions[a]	$681,896	
Payments from the General Fund of the Treasury for payroll tax contributions subject to refund[a]	-2,393	
Net payroll tax contributions[a]		679,503
Reimbursements from the General Fund:		
Reduction in payroll tax contributions due to P.L. 111-312, P.L. 112-78, and P.L. 112-96[a]	266	
Reimbursements directed by P.L. 110-246	12	
Payroll tax credits due to P.L. 98-21[a]	[b]	
Net General Fund reimbursements[a]		278
Income based on taxation of benefit payments:		
Withheld from benefit payments to nonresident aliens	191	
All other, not subject to withholding[a]	30,363	
Total income from taxation of benefits[a]		30,554
Investment income and interest adjustments:		
Interest on investments	91,225	
Interest adjustments[c]	2	
Total investment income and interest adjustments		91,227
Gifts		—
Total receipts		801,561
Disbursements:		
Benefit payments:		
Monthly benefits and lump-sum death payments[d e]	742,939	
Reimbursement from the General Fund for unnegotiated checks	-33	
Payment for costs of vocational rehabilitation services for disabled beneficiaries	2	
Net benefit payments[d e]		742,908
Financial interchange with the Railroad Retirement "Social Security Equivalent Benefit Account"		4,258
Administrative expenses:		
Costs incurred by:		
Social Security Administration	2,996	
Department of the Treasury	390	
Offsetting miscellaneous receipts	-4	
Miscellaneous reimbursements from the General Fund [f]	-6	
Net administrative expenses		3,376
Total disbursements[e]		750,542
Net increase in asset reserves[e]		51,019
Total invested assets[e]	2,760,518	
Undisbursed balances[e g]	19,734	
Total asset reserves, December 31, 2015[e]		2,780,251

[a] Includes adjustments for prior calendar years.

[b] Between -$0.5 and $0.5 million.

[c] Includes: (1) interest on adjustments in the allocation of administrative expenses between the trust fund and the General Fund account for the Supplemental Security Income program, (2) interest arising from the revised allocation of administrative expenses among the trust funds, and (3) interest on certain reimbursements to the trust fund.

[d] Includes net reductions for the recovery of overpayments.

[e] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $19.7 billion. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.

[f] Reimbursements for costs incurred in performing certain legislatively mandated activities not directly related to administering the OASI program.

[g] Primarily consists of benefit payments designated to be paid on January 3, 2016 that were actually paid on December 31, 2015, as well as a relatively small amount of cash held by the Department of Treasury for payment of benefits.

Note: Totals do not necessarily equal the sums of rounded components.

Of the $750.5 billion in total OASI disbursements in 2015, $742.9 billion was for net benefit payments,[1] including recovered overpayments, reimbursements from the General Fund for unnegotiated checks, and the reimbursable costs of vocational rehabilitation services.[2] Net benefit payments increased by 5.1 percent from calendar year 2014 to calendar year 2015. This increase is due primarily to: (1) an increase in the total number of beneficiaries and (2) an increase in the average benefit amount. The increase in the average benefit amount in 2015 was due in large part to the automatic cost-of-living benefit increase of 1.7 percent which became effective for December 2014 under the automatic-adjustment provisions in section 215(i) of the Social Security Act. In addition, new beneficiaries tend to have higher benefits than previous cohorts.

The Railroad Retirement Act requires an annual financial interchange between the Railroad Retirement program and the OASDI program. The purpose of the interchange is to put the OASI and DI Trust Funds in the same financial position in which they would have been had railroad employment always been covered directly by Social Security. The Railroad Retirement Board and the Social Security Administration calculated an interchange of $4.3 billion from the OASI Trust Fund to the Social Security Equivalent Benefit Account for June 2015.

The remaining $3.4 billion of disbursements from the OASI Trust Fund represents net administrative expenses. The Social Security Administration charges administrative expenses incurred to administer the OASI program directly to the trust fund on an estimated basis. Periodically, as actual expenses are recorded, they adjust the allocations of administrative expenses for prior periods. These adjustments affect the OASI Trust Fund, the DI Trust Fund, the HI Trust Fund, the SMI Trust Fund, and the General Fund account for the Supplemental Security Income program, and include appropriate interest adjustments. As described earlier, the trust fund accounting records such interest adjustments under investment income.

For 2015, the cost incurred by the Social Security Administration to administer the OASI program was 89 percent of OASI net administrative expenses. The Social Security Administration charges such costs to the trust fund ($3.0 billion in 2015). In addition, the Department of the Treasury charges to

[1] As noted in footnote e of table III.A1 and elsewhere in this report, benefit payments shown for 2015 reflect the 12 months of benefits scheduled for payment in 2015 and thus exclude the benefits scheduled for payment on January 3, 2016, which were actually paid on December 31, 2015 as required by the law.

[2] Vocational rehabilitation services are furnished to disabled widow(er) beneficiaries and to those children of retired or deceased workers who receive benefits based on disabilities that began before age 22. The trust funds reimburse the providers of such services only in those cases where the services contributed to the successful rehabilitation of the beneficiary.

the trust fund expenses ($0.4 billion in 2015) for services provided in administering the OASI program. A relatively small offset ($4 million in 2015) to administrative expenses represents income from miscellaneous receipts due to the trust fund, which may include refunds, penalties, fees, and other receipts.

Finally, the General Fund of the Treasury makes net reimbursements for administrative costs incurred by the Social Security Administration in performing legislatively mandated activities that are not directly related to the OASI program. These reimbursements include the costs associated with union activities related to administering the OASI program ($4 million in 2015) and with the provision of information to participants in certain pension plans ($2 million in 2015). These miscellaneous reimbursements totaled $6 million in 2015.

The asset reserves shown for the OASI Trust Fund at the end of calendar year 2015 totaled $2,780.3 billion, consisting of $2,760.5 billion in U.S. Government obligations and cash totaling $19.7 billion that would have been invested at the end of the year except for the advance payment of benefits scheduled for payment on January 3, 2016.[1] The effective annual rate of interest earned by the reserves in the OASI Trust Fund during calendar year 2015 was 3.3 percent, slightly lower than the 3.6 percent earned during calendar year 2014. Table VI.A4, presented in appendix A, shows a detailed listing of OASI Trust Fund holdings by type of security, interest rate, and year of maturity at the end of calendar years 2014 and 2015.

By law, the Department of the Treasury must invest trust fund reserves in interest-bearing securities backed by the full faith and credit of the United States Government. Those securities currently held by the OASI Trust Fund are special issues, that is, securities sold only to the trust funds. These special issues are of two types: short-term certificates of indebtedness and longer-term bonds. Daily receipts are invested in the short-term certificates of indebtedness which mature on the next June 30 following the date of issue. The trust fund normally acquires long-term special-issue bonds when special issues of either type mature on June 30 and must be reinvested. The amount of long-term bonds acquired on June 30 is equal to the amount of special issues maturing (including accrued interest earnings), plus tax receipts for that day, less amounts required to meet expenditures on that day.

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[1] As noted in footnotes e and g of table III.A1 and elsewhere in this report, asset reserves shown for the end of 2015 reflect the 12 months of benefits scheduled for payment in 2015 and thus exclude the benefits scheduled for payment on January 3, 2016, which were actually paid on December 31, 2015 as required by the law.

Section 201(d) of the Social Security Act provides that the obligations issued for purchase by the OASI and DI Trust Funds shall have maturities fixed with due regard for the needs of the funds. The usual practice has been to reinvest the maturing special issues, as of each June 30, so that the value of the securities maturing in each of the next 15 years are approximately equal. Accordingly, the Department of the Treasury, in consultation with the Chief Actuary of the Social Security Administration, selected the amounts and maturity dates of the special-issue bonds purchased on June 30, 2015, so that the maturity dates of the total portfolio of special issues were spread evenly over the 15-year period 2016 through 2030. The bonds purchased on that date have an interest rate of 2.000 percent, reflecting the average market yield, as of the last business day of the prior month, on all of the outstanding marketable U.S. obligations that are due or callable more than 4 years in the future. Table III.A7 shows additional details on the investment transactions during 2015, including the amounts of bonds purchased on June 30, 2015.

2. DI Trust Fund

Table III.A2 presents a statement of the income and disbursements of the Federal Disability Insurance Trust Fund in calendar year 2015, and of the asset reserves in the fund at the beginning and end of the calendar year.

Line entries in the DI statement are similar to those in the OASI statement. The explanations of the OASI entries generally apply to DI as well.

Of the $118.6 billion in total receipts, $115.4 billion was net payroll tax contributions.

Of the $146.6 billion of total disbursements, $143.4 billion was net benefit payments.[1] Net benefit payments increased by 1.2 percent from calendar year 2014 to calendar year 2015. This increase in DI benefit payments was due to the same factors described earlier for OASI benefit payments. Total DI disbursements exceeded non-interest income in years 2005 through 2015 and exceeded total income in years 2009 through 2015.

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[1] As noted in footnote e of table III.A2, and elsewhere in this report, benefit payments shown for 2015 reflect the 12 months of benefits scheduled for payment in 2015 and thus exclude the benefits scheduled for payment on January 3, 2016, which were actually paid on December 31, 2015 as required by the law.

Table III.A2.—Operations of the DI Trust Fund, Calendar Year 2015
[In millions]

Total asset reserves, December 31, 2014		$60,244
Receipts:		
Net payroll tax contributions:		
Payroll tax contributions[a]	$115,796	
Payments from the General Fund of the Treasury for payroll tax contributions subject to refund[a]	-406	
Net payroll tax contributions[a]		115,389
Reimbursements from the General Fund:		
Reduction in payroll tax contributions due to P.L. 111-312, P.L. 112-78, and P.L. 112-96[a]	45	
Reimbursements directed by P.L. 110-246	2	
Payroll tax credits due to P.L. 98-21[a]	[b]	
Net General Fund reimbursements[a]		47
Income based on taxation of benefit payments:		
Withheld from benefit payments to nonresident aliens	4	
All other, not subject to withholding[a]	1,067	
Total income from taxation of benefits[a]		1,071
Investment income and interest adjustments:		
Interest on investments	2,087	
Interest adjustments[c]	1	
Total investment income and interest adjustments		2,088
Total receipts		118,595
Disbursements:		
Benefit payments:		
Monthly benefits[d e]	143,282	
Reimbursement from the General Fund for unnegotiated checks	-19	
Payment for costs of vocational rehabilitation services for disabled beneficiaries	107	
Net benefit payments[d e]		143,370
Financial interchange with the Railroad Retirement "Social Security Equivalent Benefit Account"		419
Administrative expenses:		
Costs incurred by:		
Social Security Administration	2,715	
Department of the Treasury	68	
Demonstration projects	14	
Miscellaneous reimbursements from the General Fund[f]	-4	
Net administrative expenses		2,792
Total disbursements[e]		146,581
Net increase in asset reserves[e]		-27,985
Total invested assets[e]	26,101	
Undisbursed balances[e g]	6,157	
Total asset reserves, December 31, 2015[e]		32,259

[a] Includes adjustments for prior calendar years.
[b] Between -$0.5 and $0.5 million.
[c] Includes: (1) interest on adjustments in the allocation of administrative expenses between the trust fund and the General Fund account for the Supplemental Security Income program, (2) interest arising from the revised allocation of administrative expenses among the trust funds, and (3) interest on certain reimbursements to the trust fund.
[d] Includes net reductions for the recovery of overpayments.
[e] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $6.1 billion. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.
[f] Reimbursements for costs incurred in performing legislatively mandated activities not directly related to administering the DI program.
[g] Primarily consists of benefit payments designated to be paid on January 3, 2016 that were actually paid on December 31, 2015, as well as a relatively small amount of cash held by the Department of Treasury for payment of benefits.

Note: Totals do not necessarily equal the sums of rounded components.

During 2015, the reserves in the DI Trust Fund decreased by $28.0 billion, from $60.2 billion at the end of 2014 to $32.3 billion at the end of 2015. The $32.3 billion reserves in the DI Trust Fund at the end of calendar year 2015 consisted of $26.1 billion in U.S. Government obligations and cash totaling $6.2 billion. The effective annual rate of interest earned by the asset reserves in the DI Trust Fund during calendar year 2015 was 4.6 percent, slightly higher than the 4.5 percent earned during calendar year 2014. Table VI.A5, presented in appendix A, shows a detailed listing of DI Trust Fund holdings by type of security, interest rate, and year of maturity at the end of calendar years 2014 and 2015.

Section 201(d) of the Social Security Act provides that the Treasury securities issued for purchase by the OASI and DI Trust Funds shall have maturities fixed with due regard for the needs of the funds. The usual practice has been to reinvest the maturing special issues, as of each June 30, so that the values of the securities maturing in each of the next 15 years are approximately equal. However, as of June 2015, the Trustees projected that the reserves in the DI Trust Fund would be depleted within 15 years. Therefore, the Department of the Treasury, in consultation with the Chief Actuary of the Social Security Administration, selected the amounts and maturity dates of the DI special-issue bonds purchased on June 30, 2015, so that the amount of special issues would mature on June 30, 2016. The bonds purchased have an interest rate of 2.000 percent, reflecting the average market yield, as of the last business day of the prior month, on all of the outstanding marketable U.S. obligations that are due or callable more than 4 years in the future. As of June 30, 2015, the DI Trust Fund had already redeemed all of the bonds coming due on June 30, 2016, so this investment approach required that all bond purchases on June 30, 2015 be invested in bonds with a maturity date of June 30, 2016. Table III.A7 shows additional details on the investment transactions during 2015.

3. OASI and DI Trust Funds, Combined

Table III.A3 presents a statement of the operations of the OASI and DI Trust Funds on a hypothetical combined basis.[1] The entries in this table represent the sums of the corresponding values from tables III.A1 and III.A2. The two preceding subsections that cover OASI and DI provide a description of the nature of these income and expenditure transactions.

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[1] The OASI and DI Trust Funds are distinct legal entities which operate independently. To illustrate the actuarial status of the program as a whole, the fund operations are often combined on a hypothetical basis.

Table III.A3.—Operations of the Combined OASI and DI Trust Funds, Calendar Year 2015
[In millions]

Total asset reserves, December 31, 2014		$2,789,476
Receipts:		
Net payroll tax contributions:		
Payroll tax contributions[a]	$797,691	
Payments from the General Fund of the Treasury for payroll tax contributions subject to refund[a]	-2,800	
Net payroll tax contributions[a]		794,892
Reimbursements from the General Fund:		
Reduction in payroll tax contributions due to P.L. 111-312, P.L. 112-78, and P.L. 112-96[a]	311	
Reimbursements directed by P.L. 110-246	14	
Payroll tax credits due to P.L. 98-21[a]	[b]	
Net General Fund reimbursements[a]		325
Income based on taxation of benefit payments:		
Withheld from benefit payments to nonresident aliens	195	
All other, not subject to withholding[a]	31,430	
Total income from taxation of benefits[a]		31,625
Investment income and interest adjustments:		
Interest on investments	93,312	
Interest adjustments[c]	3	
Total investment income and interest adjustments		93,314
Gifts		—
Total receipts		920,157
Disbursements:		
Benefit payments:		
Monthly benefits and lump-sum death payments[d e]	886,221	
Reimbursement from the General Fund for unnegotiated checks	-52	
Payment for costs of vocational rehabilitation services for disabled beneficiaries	109	
Net benefit payments[d e]		886,278
Financial interchange with the Railroad Retirement "Social Security Equivalent Benefit Account"		4,677
Administrative expenses:		
Costs incurred by:		
Social Security Administration	5,711	
Department of the Treasury	457	
Offsetting miscellaneous receipts	-4	
Demonstration projects	14	
Miscellaneous reimbursements from the General Fund[f]	-9	
Net administrative expenses		6,169
Total disbursements[e]		897,123
Net increase in asset reserves[e]		23,034
Total invested assets[e]	2,786,619	
Undisbursed balances[e g]	25,891	
Total asset reserves, December 31, 2015[e]		2,812,510

[a] Includes adjustments for prior calendar years.

[b] Between -$0.5 and $0.5 million.

[c] Includes: (1) interest on adjustments in the allocation of administrative expenses between the trust funds and the General Fund account for the Supplemental Security Income program, (2) interest arising from the revised allocation of administrative expenses among the trust funds, and (3) interest on certain reimbursements to the trust funds.

[d] Includes net reductions for the recovery of overpayments.

[e] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $25.9 billion. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.

[f] Reimbursements for costs incurred in performing certain legislatively mandated activities not directly related to administering the OASI and DI programs.

[g] Primarily consists of benefit payments designated to be paid on January 3, 2016 that were actually paid on December 31, 2015, as well as a relatively small amount of cash held by the Department of Treasury for payment of benefits.

Note: Totals do not necessarily equal the sums of rounded components.

Table III.A4 compares estimates of total income and total expenditures for calendar year 2015 from the 2011 through 2015 Trustees Reports to the corresponding actual amounts for 2015.

Table III.A4.—Comparison of Actual Calendar Year 2015 Trust Fund Operations With Estimates Made in Prior Reports, Based on Intermediate Assumptions[a]
[Amounts in billions]

	Total income[b]		Total expenditures[c]	
	Amount	Difference from actual (percent)	Amount	Difference from actual (percent)
OASI Trust Fund:				
Estimate in 2011 report	$893.7	11.5	$757.2	0.9
Estimate in 2012 report	851.6	6.2	773.8	3.1
Estimate in 2013 report	826.9	3.2	770.3	2.6
Estimate in 2014 report	816.8	1.9	758.7	1.1
Estimate in 2015 report	796.3	-.7	754.7	.6
Actual amount	801.6	—	750.5	—
DI Trust Fund:				
Estimate in 2011 report	129.7	9.4	153.8	5.0
Estimate in 2012 report	124.7	5.2	159.3	8.7
Estimate in 2013 report	123.1	3.8	155.2	5.9
Estimate in 2014 report	121.2	2.2	151.0	3.0
Estimate in 2015 report	117.6	-.8	149.9	2.3
Actual amount	118.6	—	146.6	—
OASI and DI Trust Funds, combined:				
Estimate in 2011 report	1,023.4	11.2	911.0	1.5
Estimate in 2012 report	976.3	6.1	933.2	4.0
Estimate in 2013 report	950.0	3.2	925.5	3.2
Estimate in 2014 report	938.0	1.9	909.7	1.4
Estimate in 2015 report	913.9	-.7	904.7	.8
Actual amount	920.2	—	897.1	—

[a] Percentage differences are calculated prior to rounding.

[b] "Actual" income for 2015 reflects adjustments to payroll tax contributions for prior calendar years (see appendix A for description of these adjustments). "Estimated" income also includes such adjustments, but on an estimated basis.

[c] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $19.7 billion for the OASI Trust Fund and $6.1 billion for the DI Trust Fund. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.

Note: Totals do not necessarily equal the sums of rounded components.

A number of factors contribute to differences between estimates and subsequent actual amounts, including: (1) actual values for key demographic, economic, and other variables that differ from earlier assumed levels; and (2) legislation that was enacted or other administrative initiatives that were finalized after the Trustees completed their estimates.

At the end of calendar year 2015, the OASDI program was providing monthly benefits to about 60.0 million people. The OASI Trust Fund was providing benefits to about 49.2 million people and the DI Trust Fund was providing benefits to about 10.8 million people. The number of people receiving benefits from the OASI Trust Fund grew by 2.2 percent while the number of people receiving DI benefits fell by 1.1 percent during calendar year 2015. These changes reflect the gradual aging of the population, with the baby-boom generation moving above normal retirement age, where DI benefits are no longer applicable. Table III.A5 shows the estimated distributions of benefit payments in calendar years 2014 and 2015, by type of beneficiary, for each trust fund separately.

Table III.A5.—Distribution of Benefit Payments[a] by Type of Beneficiary or Payment, Calendar Years 2014 and 2015
[Amounts in millions]

	Calendar year 2014		Calendar year 2015	
	Amount	Percentage of total	Amount	Percentage of total
Total OASDI benefit payments	$848,443	100.0	$886,221	100.0
OASI benefit payments	706,821	83.3	742,939	83.8
DI benefit payments	141,622	16.7	143,282	16.2
OASI benefit payments, total	706,821	100.0	742,939	100.0
Monthly benefits:				
Retired workers and auxiliaries	592,578	83.8	626,378	84.3
Retired workers	560,120	79.2	592,423	79.7
Spouses	27,484	3.9	28,760	3.9
Children	4,974	.7	5,195	.7
Survivors of deceased workers	114,044	16.1	116,352	15.7
Aged widows and widowers	90,862	12.9	92,748	12.5
Disabled widows and widowers	2,330	.3	2,368	.3
Parents	21	[b]	21	[b]
Children	19,192	2.7	19,597	2.6
Widowed mothers and fathers caring for child beneficiaries	1,638	.2	1,618	.2
Lump-sum death payments	199	[b]	209	[b]
DI benefit payments, total	141,622	100.0	143,282	100.0
Disabled workers	132,154	93.3	133,945	93.5
Spouses	598	.4	588	.4
Children	8,870	6.3	8,749	6.1

[a] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $19.7 billion for the OASI Trust Fund and $6.1 billion for the DI Trust Fund. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.
[b] Less than 0.05 percent.

Note: Benefits are monthly benefits and lump-sum death payments. Totals do not necessarily equal the sums of rounded components.

Net administrative expenses of the OASI and DI Trust Funds in calendar year 2015 totaled $6.2 billion. This amount is equal to 0.7 percent of total expenditures and 0.7 percent of non-interest income. Table III.A6 shows corresponding percentages for each trust fund separately and for the OASDI program as a whole for each of the last 5 years.

Table III.A6.—Administrative Expenses as a Percentage of Non-interest Income and of Total Expenditures, Calendar Years 2011-2015

	OASI Trust Fund		DI Trust Fund		OASI and DI Trust Funds, combined	
Calendar year	Non-interest income	Total expenditures	Non-interest income	Total expenditures	Non-interest income	Total expenditures
2011	0.6	0.6	3.0	2.2	0.9	0.9
2012	.5	.5	2.8	2.1	.9	.8
2013	.5	.5	2.6	1.9	.8	.7
2014	.5	.4	2.6	2.0	.8	.7
2015	.5	.4	2.4	1.9	.7	.7

The acquisition and disposition of securities during calendar year 2015 changed the invested reserves of the OASI Trust Fund and the DI Trust Fund. Table III.A7 presents these investment transactions for each trust fund separately and for the trust funds combined.

Table III.A7.—Trust Fund Investment Transactions, Calendar Year 2015
[In millions]

	OASI Trust Fund	DI Trust Fund	OASI and DI Trust Funds, combined
Invested asset reserves, December 31, 2014[a]	$2,729,270	$60,311	$2,789,582
Acquisitions:			
Special issues:			
Certificates of indebtedness	741,358	117,740	859,098
Bonds[b]	236,969	4,502	241,471
Total acquisitions	978,328	122,242	1,100,570
Dispositions:			
Special issues:			
Certificates of indebtedness[c]	759,732	121,234	880,966
Bonds	187,349	35,218	222,566
Total dispositions[c]	947,080	156,452	1,103,532
Net increase in invested asset reserves[c]	31,247	-34,210	-2,962
Invested asset reserves, December 31, 2015[a c]	2,760,518	26,101	2,786,619

[a] Invested asset reserves differ from total asset reserves by the amount of undisbursed balances. See tables VI.A4 and VI.A5 for details.

[b] Purchased on June 30, 2015. The interest rate on these purchases was 2.00 percent.

[c] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. The amount of these payments made on an accelerated basis was approximately $19.7 billion for the OASI Trust Fund and $6.1 billion for the DI Trust Fund. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year. Redemptions of special issues and invested asset reserves reflect the early redemption required in order to pay benefits on a timely basis as required by law.

Note: All investments are shown at par value. Totals do not necessarily equal the sums of rounded components.

B. SOCIAL SECURITY AMENDMENTS SINCE THE 2015 REPORT

Since the Trustees submitted the 2015 report to Congress, one law has been enacted that is expected to have notable effects on the OASDI program.

On November 2, 2015, the President signed into law Public Law 114-74, the Bipartisan Budget Act of 2015. Several sections of the law directly affect the actuarial status of the Social Security program:

- Section 811. Expansion of cooperative disability investigations (CDI) units. This section requires the establishment of CDI units to cover each of the 50 States, the District of Columbia, Puerto Rico, Guam, the Northern Mariana Islands, the Virgin Islands, and American Samoa by 2022. The additional units established under this provision would roughly double CDI capacity and will enhance the Social Security Administration's (SSA) efforts to reduce fraud and overpayments.
- Section 824. Use of electronic payroll data to improve program administration. Access to more timely data on earnings from commercial databases will allow SSA to reduce improper payments.
- Section 831. Closure of unintended loopholes. This provision eliminates (1) the ability to receive only a retired-worker benefit or an aged-spouse benefit when eligible for both, for those attaining age 62 in 2016 and later, and (2) the ability of a family member other than a divorced spouse to receive a benefit based on the earnings of a worker with a voluntarily suspended benefit, for voluntary suspensions requested after April 29, 2016. This provision is expected to have negligible net cost effect through 2025, with increasing net cost reductions thereafter.
- Section 832. Requirement for medical review. This section requires that the medical portion of the case review and any applicable residual functional capacity assessment for an initial disability determination be completed by an appropriate physician, psychiatrist, or psychologist. This provision is projected to reduce DI program cost.
- Section 833. Reallocation of payroll tax rates. For earnings in calendar years 2016 through 2018, this section increases from 1.80 percent to 2.37 percent the portion of the total 12.40 percent OASDI payroll tax that is directed to the DI Trust Fund. There is a corresponding decrease in the portion of the tax rate directed to the OASI Trust Fund. This reallocation of the payroll tax rates is projected to extend the date for DI reserve depletion by about 6 years.
- Section 834. Access to financial information for waivers and adjustments of recovery. This provision provides for access to information that would allow SSA to better determine an individual's ability to repay any past overpayment.

- Section 842. Elimination of quinquennial determinations relating to wage credits for military service prior to 1957. This provision eliminates the requirement that the Commissioner make quinquennial determinations for pre-1957 military service wage credits after the 2010 determination.

In total, this law is expected to have a small but significant net positive financial impact over both the short-range and long-range projection periods. In addition, it significantly improves the status of the DI Trust Fund in the short term, largely due to a temporary tax rate reallocation from the OASI Trust Fund to the DI Trust Fund.

In addition to the change in law, estimates in this report reflect an assumed delay in implementation of portions of the President's 2014 executive actions on immigration. Specifically, the courts have held up implementation of the provision of legal work and residence status for certain individuals who entered the country as children (deferred action for childhood arrivals, or DACA) and the provision for similar status for certain parents of children born in the U.S. or otherwise living in the country legally (deferred action for parents of Americans, or DAPA). As of the time this report was drafted, the Administration is pursuing remedy through the Supreme Court. Last year's report assumed that these actions would become effective late in 2015, with individuals gaining authorization starting around the beginning of 2016. This report assumes that these actions will be implemented one year later, with authorizations beginning at the start of 2017. This assumed delay in implementation has a negligible effect on the financial status of the OASDI program.

Sections IV.A.4 and IV.B.6 of this report provide further description of the magnitude of the effects of these changes on the financial status of the OASDI program.

IV. ACTUARIAL ESTIMATES

This chapter presents actuarial estimates of the future financial condition of the Social Security program. These estimates show the income, cost, and asset reserves or unfunded obligation of the OASI and DI Trust Funds: (1) in dollars over the 10-year short-range period; and (2) as a percentage of taxable payroll, as a percentage of gross domestic product, and in present-value dollars over the 75-year long-range period. In addition, the chapter discusses a variety of measures of the adequacy of current program financing. This report distinguishes between: (1) the cost (obligations) of the program, which includes all future benefits scheduled under current law; and (2) expenditures (disbursements), which include actual payments for the past plus only the portion of projected program cost that would be payable with the financing provisions in current law.

This chapter presents the estimates and measures of trust fund financial adequacy for the short-range period (2016 through 2025) first, followed by estimates and measures of actuarial status for the long-range period (2016 through 2090). Summary measures are also provided for trust fund status over the infinite horizon. As described in chapter II of this report, these estimates depend upon a broad set of demographic, economic, and programmatic factors. This chapter presents estimates under three sets of assumptions to show a wide range of possible outcomes, because assumptions related to these factors are subject to uncertainty. The intermediate set of assumptions, designated as alternative II, reflects the Trustees' best estimate of future experience; the low-cost alternative I is significantly more optimistic and the high-cost alternative III is significantly more pessimistic for the trust funds' future financial outlook. The tables of this report show the intermediate estimates first, followed by the low-cost and high-cost estimates. Chapter V describes these three sets of assumptions, along with the actuarial methods used to produce the estimates. Appendix D and appendix E present two additional methods to illustrate the uncertainty of the projections. Appendix D presents sensitivity analyses of the effects of variation in individual factors and appendix E presents probability distributions generated by a stochastic model.

A. SHORT-RANGE ESTIMATES

The Trustees consider the trust funds to be solvent at any point in time if the funds can pay scheduled benefits in full on a timely basis. A standard measure for assessing solvency is the "trust fund ratio," which is the reserves in a fund at the beginning of a year (not including advance tax transfers) expressed as a percentage of the cost during the year. A positive trust fund ratio indicates that the trust fund was solvent at the end of the prior year. The trust fund ratio represents the proportion of a year's cost which the reserves available at the beginning of that year can cover. The Trustees assume that a trust fund ratio of 100 percent of annual program cost provides a reasonable "contingency reserve." Maintaining a reasonable contingency reserve is important because the trust funds do not have borrowing authority. After reserves are depleted, the trust funds would be unable to pay benefits in full on a timely basis if annual revenue were less than annual cost. Unexpected events, such as severe economic recessions, can quickly diminish reserves. In such cases, a reasonable contingency reserve can maintain the ability to pay scheduled benefits while giving lawmakers time to address possible changes to the program.

The test of short-range financial adequacy applies to the OASI and DI Trust Funds individually and combined on a hypothetical basis.[1] If the estimated trust fund ratio is at least 100 percent at the beginning of the projection period, the test requires that it remain at or above 100 percent throughout the 10-year period. If the ratio is initially less than 100 percent, then it must reach at least 100 percent within 5 years (without reserve depletion at any time during this period) and then remain at or above 100 percent throughout the remainder of the 10-year period. This test is applied using the estimates based on the intermediate assumptions. If either trust fund fails this test, then program solvency in the next 10 years is in question, and lawmakers should take prompt action to improve short-range financial adequacy.

1. Operations of the OASI Trust Fund

This subsection presents estimates, based on the assumptions described in chapter V, of the operations and financial status of the OASI Trust Fund for the period 2016 through 2025. These estimates assume that there are no further changes in the statutory provisions and regulations under which the OASDI program currently operates beyond the changes since last year's report indicated in section III.B.[2]

Estimates of the OASI Trust Fund operations presented in Table IV.A1 indicate that the asset reserves of the OASI Trust Fund increase through 2021 under the intermediate assumptions, increase throughout the next 10 years under the low-cost assumptions, and decrease throughout the next 10 years under the high-cost assumptions. However, trust fund ratios decline throughout the 10-year period under all three sets of assumptions. Based on the intermediate assumptions, the reserves of the OASI Trust Fund continue to

[1] The OASI and DI Trust Funds are distinct legal entities which operate independently. To illustrate the actuarial status of the program as a whole, the fund operations are often combined on a hypothetical basis.

[2] The estimates shown in this subsection reflect 12 months of scheduled benefits in each year of the short-range projection period. In practice, the actual payment dates have at times shifted over calendar year boundaries as a result of the statutory requirement for early delivery of benefit payments when the normal check delivery date is a Saturday, Sunday, or legal public holiday.

exceed 100 percent of annual cost by a large amount through the end of 2025. Consequently, the OASI Trust Fund satisfies the test of short-range financial adequacy by a wide margin. Table IV.A1 also indicates that the OASI Trust Fund would satisfy the short-range test even under the high-cost assumptions. See figure IV.A1 for an illustration of these results.

Table IV.A1.—Operations of the OASI Trust Fund, Calendar Years 2011-2025[a]
[Dollar amounts in billions]

	Income					Cost[b]				Asset Reserves[b]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[c]	Taxation of benefits[d]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
Historical data:												
2011. . .	$698.8	$482.4	$87.8	$22.2	$106.5	$603.8	$596.2	$3.5	$4.1	$95.0	$2,524.1	402
2012. . .	731.1	503.9	97.7	26.7	102.8	645.5	637.9	3.4	4.1	85.6	2,609.7	391
2013. . .	743.8	620.8	4.2	20.7	98.1	679.5	672.1	3.4	3.9	64.3	2,674.0	384
2014. . .	769.4	646.2	.4	28.0	94.8	714.2	706.8	3.1	4.3	55.2	2,729.2	374
2015. . .	801.6	679.5	.3	30.6	91.2	750.5	742.9	3.4	4.3	51.0	2,780.3	364
Intermediate:												
2016. . .	786.7	667.3	.1	32.0	87.4	778.6	771.0	3.4	4.2	8.1	2,788.4	357
2017. . .	826.3	703.5	[f]	37.2	85.6	812.9	805.4	3.3	4.1	13.5	2,801.8	343
2018. . .	873.2	746.0	[f]	40.8	86.4	873.2	865.3	3.4	4.5	.1	2,801.9	321
2019. . .	963.4	830.7	[f]	44.7	88.0	935.5	927.4	3.5	4.6	27.9	2,829.8	300
2020. . .	1,017.1	878.2	[f]	48.7	90.3	1,001.8	993.4	3.6	4.7	15.4	2,845.1	282
2021. . .	1,069.2	924.8	[f]	52.8	91.6	1,067.9	1,059.5	3.8	4.7	1.2	2,846.4	266
2022. . .	1,121.7	971.3	[f]	57.5	92.9	1,141.9	1,133.0	3.9	5.0	-20.2	2,826.2	249
2023. . .	1,174.1	1,016.8	[f]	62.6	94.6	1,221.9	1,212.7	4.0	5.1	-47.8	2,778.4	231
2024. . .	1,229.3	1,065.3	[f]	68.1	95.9	1,307.0	1,297.6	4.2	5.2	-77.7	2,700.7	213
2025. . .	1,283.4	1,113.4	[f]	73.9	96.0	1,395.1	1,385.6	4.3	5.2	-111.7	2,589.0	194
Low-cost:												
2016. . .	792.3	672.0	.1	32.0	88.2	778.1	770.5	3.4	4.2	14.1	2,794.4	357
2017. . .	851.5	724.2	[f]	37.3	90.0	815.6	808.2	3.3	4.1	35.9	2,830.3	343
2018. . .	917.3	781.3	[f]	41.2	94.8	881.8	873.9	3.4	4.5	35.5	2,865.8	321
2019. . .	1,030.0	884.1	[f]	45.3	100.6	949.0	940.8	3.6	4.6	81.0	2,946.8	302
2020. . .	1,105.5	948.0	[f]	49.6	107.9	1,020.7	1,012.2	3.8	4.7	84.8	3,031.6	289
2021. . .	1,180.0	1,010.6	[f]	54.1	115.2	1,093.0	1,084.3	3.9	4.7	87.0	3,118.6	277
2022. . .	1,258.8	1,075.3	[f]	59.2	124.3	1,173.8	1,164.6	4.1	5.0	85.0	3,203.6	266
2023. . .	1,342.0	1,142.1	[f]	64.6	135.2	1,261.7	1,252.3	4.3	5.2	80.2	3,283.8	254
2024. . .	1,431.7	1,214.1	[f]	70.6	147.0	1,356.0	1,346.3	4.5	5.3	75.7	3,359.5	242
2025. . .	1,523.6	1,287.7	[f]	77.1	158.9	1,454.8	1,444.8	4.7	5.3	68.9	3,428.3	231

Table IV.A1.—Operations of the OASI Trust Fund, Calendar Years 2011-2025[a] (Cont.)
[Dollar amounts in billions]

	Income					Cost[b]				Asset Reserves[b]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[c]	Taxation of benefits[d]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
High-cost:												
2016. . .	$777.7	$659.2	$0.1	$32.0	$86.4	$779.1	$771.5	$3.4	$4.2	-$1.4	$2,778.9	357
2017. . .	781.2	662.6	f	37.2	81.4	812.4	805.0	3.3	4.2	-31.3	2,747.6	342
2018. . .	814.6	695.8	f	40.4	78.4	865.2	857.3	3.3	4.6	-50.6	2,697.0	318
2019. . .	884.5	764.3	f	44.1	76.1	923.4	915.3	3.4	4.7	-39.0	2,658.0	292
2020. . .	919.3	797.8	f	47.8	73.8	984.3	976.0	3.5	4.8	-65.0	2,593.1	270
2021. . .	951.4	829.8	f	51.7	70.0	1,044.4	1,036.1	3.6	4.7	-93.0	2,500.1	248
2022. . .	983.3	862.1	f	56.0	65.2	1,111.5	1,102.8	3.7	5.0	-128.2	2,371.9	225
2023. . .	1,014.9	893.8	f	60.6	60.5	1,183.5	1,174.6	3.8	5.1	-168.6	2,203.3	200
2024. . .	1,047.2	926.3	f	65.6	55.3	1,259.3	1,250.3	3.9	5.2	-212.1	1,991.2	175
2025. . .	1,077.1	956.8	f	70.8	49.4	1,336.8	1,327.8	3.9	5.1	-259.7	1,731.5	149

[a] Appendix A presents a detailed description of the components of income and cost, along with complete historical values.

[b] Amounts for 2015 and 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015 as required by the statutory provision for early benefit payments when the normal delivery date is on a weekend or holiday. Such shifts in payments across calendar years have occurred in the past and will occur periodically in the future whenever January 3rd falls on a Sunday. In order to provide a consistent perspective on trust fund operations over time, all trust fund operations in each year reflect the 12 months of benefits that are regularly scheduled for payment in that year.

[c] Includes reimbursements from the General Fund of the Treasury to the OASI Trust Fund for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost of benefits to certain uninsured persons who attained age 72 before 1968; (3) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (4) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (5) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.

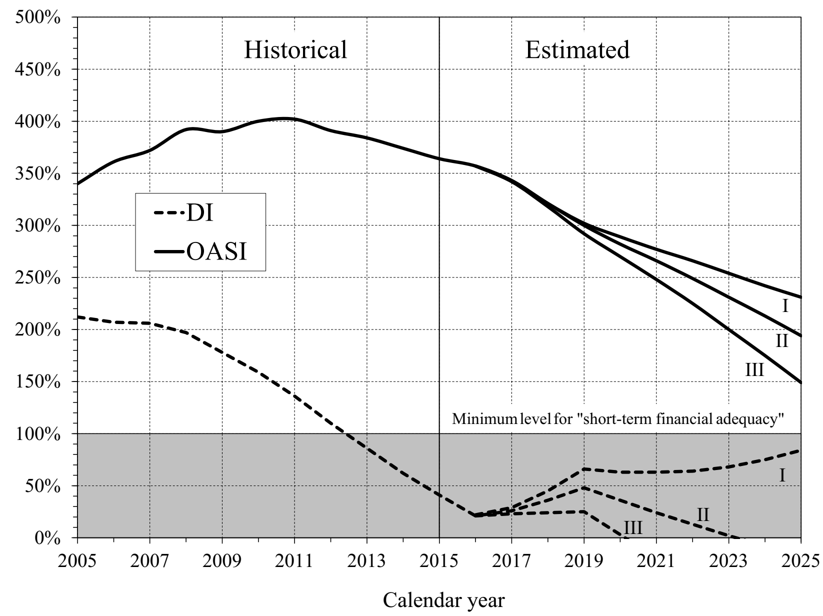
[d] Revenue from taxation of benefits is the amount that would be assessed on benefit amounts scheduled in the law.

[e] The "Trust fund ratio" column represents reserves at the beginning of a year (which are identical to reserves at the end of the prior year shown in the "Amount at end of year" column) as a percentage of cost for the year.

[f] Between -$50 million and $50 million.

Note: Totals do not necessarily equal the sums of rounded components.

Figure IV.A1.—Short-Range OASI and DI Trust Fund Ratios
[Asset reserves as a percentage of annual cost]



After slightly decreasing in 2016 due to the temporary tax rate reallocation from OASI to DI, the estimated income shown in table IV.A1 increases annually under each set of assumptions throughout the short-range projection period. The estimated increases in income reflect increases in estimated OASDI taxable earnings and growth in interest earnings on the invested reserves in the trust fund, as well as a return to pre-reallocation tax rates in 2019. Employment increases in every year through 2025 for all three alternatives: the number of persons with taxable earnings increases on the basis of alternatives I, II, and III from 169 million during calendar year 2015 to about 189 million, 185 million, and 180 million, respectively, in 2025. The total annual amount of taxable earnings increases in every year through 2025 for each alternative. Total earnings increase from $6,395 billion in 2015 to $12,228 billion, $10,569 billion, and $9,080 billion in 2025, on the basis of alternatives I, II, and III, respectively. These increases in taxable earnings are due primarily to: (1) projected increases in employment levels as the working age population increases; (2) trend increases in average earnings in covered employment (reflecting both real growth and price inflation); (3) increases in the contribution and benefit base under the automatic-adjustment provisions; and (4) growth in employment and average earnings, temporarily higher than trend, as the economy continues to recover from the severe economic downturn that began in late 2007.

Interest earnings contribute to the overall projected increase in trust fund income during this period. In the first few years of the projection period, annual interest earnings decline slightly under all three sets of assumptions due to historically low interest rates assumed for newly-issued bonds. Thereafter, interest income increases under the intermediate and low-cost assumptions due to the net effects of changes in reserve levels and the patterns of projected interest rates. Under the high-cost assumptions, declining reserves cause interest income to continue to decrease throughout the short-range period. Although interest earnings generally increase over the short-range period, interest declines as a share of total OASI Trust Fund income under the intermediate assumptions. By 2025, OASI interest income under the intermediate assumptions is about 7 percent of total trust fund income, as compared to 11 percent in 2015.

Rising OASI cost during 2016 through 2025 reflects automatic benefit increases as well as the upward trend in the number of beneficiaries and in the average monthly earnings underlying benefits. The growth in the number of beneficiaries since 2009 and the expected future growth result both from the increase in the aged population and from the increase in the proportion of the population that is eligible for benefits.

The Treasury invests OASI income in financial securities, generally special public-debt obligations of the U.S. Government. The revenue used to make these purchases flows to the General Fund of the Treasury. The trust fund earns interest on these securities, and the Treasury invests maturing securities in new securities if not immediately needed to pay program costs. Program expenditures require the redemption of trust fund securities, generally prior to maturity, to cover the payments made by the General Fund of the Treasury on behalf of the trust fund.[1]

2. Operations of the DI Trust Fund

Table IV.A2 shows the estimated operations and financial status of the DI Trust Fund during calendar years 2016 through 2025 under the three sets of assumptions, together with values for actual experience during 2011 through 2015. Non-interest income for DI is much higher in 2016 through 2018 than in 2015, due to the temporary payroll tax rate reallocation from OASI to DI. As a result, DI Trust Fund reserves increase through 2018 under each alternative. After returning to the ultimate allocation of tax rates in 2019, non-interest income is again less than DI cost except under the low-cost alternative. Non-interest income increases steadily thereafter under each alternative, due to most of the same factors described previously for the OASI Trust Fund. DI cost grows steadily throughout the period under each alternative.

[1] For an explanation of the interrelationship between the Medicare and Social Security trust funds and the overall Federal budget, see appendix F of the 2016 Medicare Trustees Report.

Under the intermediate assumptions, reserves decline after 2018 until their projected depletion in the third quarter of 2023. Under the high-cost assumptions, DI reserves decline until depletion in the first quarter of 2020. Under the low-cost assumptions, after decreasing slightly in 2019, reserves increase through the remainder of the short-range period.

Table IV.A2.—Operations of the DI Trust Fund, Calendar Years 2011-2025[a]
[Dollar amounts in billions]

	Income					Cost[b]				Asset Reserves[b]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[c]	Taxation of benefits[d]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
Historical data:												
2011	$106.3	$81.9	$14.9	$1.6	$7.9	$132.3	$128.9	$2.9	$0.5	-$26.1	$153.9	136
2012	109.1	85.6	16.5	.6	6.4	140.3	136.9	2.9	.5	-31.2	122.7	110
2013	111.2	105.4	.7	.4	4.7	143.4	140.1	2.8	.6	-32.2	90.4	86
2014	114.9	109.7	.1	1.7	3.4	145.1	141.7	2.9	.4	-30.2	60.2	62
2015	118.6	115.4	[f]	1.1	2.1	146.6	143.4	2.8	.4	-28.0	32.3	41
Intermediate:												
2016	157.9	155.2	[f]	1.2	1.4	150.2	146.7	3.2	.3	7.6	39.9	21
2017	170.3	166.2	[f]	2.1	1.9	152.7	149.4	3.1	.2	17.6	57.5	26
2018	181.4	176.3	[f]	2.3	2.9	159.4	156.1	3.2	.1	22.1	79.6	36
2019	149.0	143.5	[f]	2.5	3.1	166.1	162.5	3.6	[f]	-17.1	62.4	48
2020	154.2	149.1	[f]	2.7	2.3	172.7	168.8	3.9	.1	-18.6	43.9	36
2021	161.4	157.0	[f]	2.9	1.5	180.5	176.2	4.2	.1	-19.0	24.8	24
2022	168.7	164.9	[f]	3.1	.7	188.6	184.1	4.5	.1	-19.9	4.9	13
2023	[g]	172.7	[f]	3.3	[g]	197.0	192.2	4.7	[f]	[g]	[g]	2
2024	[g]	180.9	[f]	3.6	[g]	205.3	200.2	5.0	[f]	[g]	[g]	[g]
2025	[g]	189.1	[f]	3.8	[g]	214.1	208.8	5.3	[f]	[g]	[g]	[g]
Low-cost:												
2016	159.1	156.3	[f]	1.2	1.5	148.2	144.7	3.2	.3	10.9	43.1	22
2017	175.8	171.1	[f]	2.1	2.6	149.5	146.2	3.1	.2	26.3	69.4	29
2018	191.1	184.6	[f]	2.2	4.2	155.1	151.8	3.2	.1	36.0	105.4	45
2019	160.2	152.6	[f]	2.4	5.2	160.6	156.9	3.6	[f]	-.3	105.0	66
2020	168.8	161.0	[f]	2.6	5.3	166.0	161.9	4.0	.1	2.8	107.9	63
2021	180.0	171.6	[f]	2.7	5.6	172.5	168.1	4.4	.1	7.4	115.3	63
2022	191.9	182.6	[f]	2.9	6.4	179.6	174.9	4.7	[f]	12.3	127.6	64
2023	204.6	193.9	[f]	3.1	7.6	187.0	181.9	5.1	[f]	17.7	145.3	68
2024	218.5	206.2	[f]	3.4	9.0	194.4	189.0	5.4	[f]	24.1	169.4	75
2025	233.1	218.7	[f]	3.6	10.8	202.5	196.8	5.8	[f]	30.5	199.9	84

Table IV.A2.—Operations of the DI Trust Fund, Calendar Years 2011-2025[a] (Cont.)
[Dollar amounts in billions]

	Income					Cost[b]				Asset Reserves[b]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[c]	Taxation of benefits[d]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
High-cost:												
2016 . . .	$155.9	$153.3	[f]	$1.3	$1.3	$152.2	$148.6	$3.2	$0.3	$3.7	$36.0	21
2017 . . .	160.2	156.6	[f]	2.2	1.4	156.7	153.4	3.1	.2	3.4	39.4	23
2018 . . .	168.4	164.4	[f]	2.4	1.6	165.1	161.7	3.2	.1	3.3	42.8	24
2019 . . .	135.7	132.1	[f]	2.6	1.0	173.3	169.7	3.5	.1	-37.5	5.2	25
2020 . . .	[g]	135.5	[f]	2.8	[g]	180.3	176.4	3.8	.1	[g]	[g]	3
2021 . . .	[g]	140.9	[f]	3.0	[g]	188.1	184.0	4.0	.1	[g]	[g]	[g]
2022 . . .	[g]	146.4	[f]	3.2	[g]	196.5	192.3	4.2	.1	[g]	[g]	[g]
2023 . . .	[g]	151.8	[f]	3.5	[g]	205.1	200.6	4.4	.1	[g]	[g]	[g]
2024 . . .	[g]	157.3	[f]	3.7	[g]	213.5	208.9	4.6	[f]	[g]	[g]	[g]
2025 . . .	[g]	162.5	[f]	4.0	[g]	222.5	217.7	4.8	[f]	[g]	[g]	[g]

[a] The DI Trust Fund becomes depleted in the third quarter of 2023 and the first quarter of 2020 under the intermediate and high-cost assumptions, respectively. For any period during which reserves would be depleted, scheduled benefits could not be paid in full on a timely basis, income from taxing benefits would be less than would apply to scheduled benefits, and interest on trust fund reserves would be negligible. Appendix A presents a detailed description of the components of income and cost, along with complete historical values.
[b] Amounts for 2015 and 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015 as required by the statutory provision for early benefit payments when the normal delivery date is on a weekend or holiday. Such shifts in payments across calendar years have occurred in the past and will occur periodically in the future whenever January 3rd falls on a Sunday. In order to provide a consistent perspective on trust fund operations over time, all trust fund operations in each year reflect the 12 months of benefits that are regularly scheduled for payment in that year.
[c] Includes reimbursements from the General Fund of the Treasury to the DI Trust Fund for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (3) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (4) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.
[d] Revenue from taxation of benefits is the amount that would be assessed on benefit amounts scheduled in the law.
[e] The "Trust fund ratio" column represents reserves at the beginning of a year (which are identical to reserves at the end of the prior year shown in the "Amount at end of year" column) as a percentage of cost for the year.
[f] Between -$50 million and $50 million.
[g] While the fund is depleted, values under current law would reflect permissible expenditures only, which are inconsistent with the cost of scheduled benefits shown in this table.
Note: Totals do not necessarily equal the sums of rounded components.

In the future, DI cost increases in part due to increases in average benefit levels resulting from: (1) automatic benefit increases and (2) projected increases in the amounts of average monthly earnings on which benefits are based. The number of DI beneficiaries in current-payment status increases but at a much slower rate during the short-range projection period than over the past 20 years, largely due to long-anticipated demographic trends and expected economic conditions. In addition, certain provisions in the Bipartisan Budget Act of 2015 are expected to reduce the number of future new DI beneficiaries by slightly less than 1 percent.

At the beginning of calendar year 2015, the reserves of the DI Trust Fund represented 41 percent of annual cost. During 2015, DI cost exceeded income, and the trust fund ratio for the beginning of 2016 decreased to about

21 percent. Under the intermediate assumptions, the reallocation of the payroll tax rate from OASI to DI causes DI total income to exceed cost through 2018, and reserves to increase to a level of 48 percent of annual cost at the beginning of 2019. Thereafter, cost exceeds total income throughout the short-range projection period. The projected cost in excess of income results in the estimated depletion of the DI Trust Fund reserves in the third quarter of 2023.

Because the reserves of the DI Trust Fund at the beginning of 2016 were less than the estimated annual cost for 2016, and they are projected to remain below annual cost throughout the short-range period, the DI Trust Fund fails the Trustees' test of short-range financial adequacy under all three alternatives.

3. Operations of the Combined OASI and DI Trust Funds

Table IV.A3 shows the estimated operations and status of the combined OASI and DI Trust Funds for calendar years 2016 through 2025 under the three alternatives, together with actual experience in 2011 through 2015. Income and cost for the OASI Trust Fund represent over 80 percent of the corresponding amounts for the combined OASI and DI Trust Funds. Therefore, based on the relative strength of the OASI Trust Fund over the next 10 years, the combined OASI and DI Trust Funds would have sufficient financial resources to pay all scheduled benefits through the end of the short-range period, although it is important to note that under current law, one trust fund cannot share financial resources with another trust fund. In addition, the combined OASI and DI Trust Funds would satisfy the test of short-range financial adequacy under the intermediate and low-cost assumptions. However, under the high-cost assumptions, reserves are projected to drop to about 86 percent of annual cost by the end of 2025, and hence the combined funds would not satisfy the test of short-range financial adequacy.

Table IV.A3.—Operations of the Combined OASI and DI Trust Funds, Calendar Years 2011-2025[a]
[Dollar amounts in billions]

	Income					Cost[b]				Asset Reserves[b]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[c]	Taxation of benefits[d]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
Historical data:												
2011 . .	$805.1	$564.2	$102.7	$23.8	$114.4	$736.1	$725.1	$6.4	$4.6	$69.0	$2,677.9	354
2012 . .	840.2	589.5	114.3	27.3	109.1	785.8	774.8	6.3	4.7	54.4	2,732.3	341
2013 . .	855.0	726.2	4.9	21.1	102.8	822.9	812.3	6.2	4.5	32.1	2,764.4	332
2014 . .	884.3	756.0	.5	29.6	98.2	859.2	848.5	6.1	4.7	25.0	2,789.5	322
2015 . .	920.2	794.9	.3	31.6	93.3	897.1	886.3	6.2	4.7	23.0	2,812.5	311

Table IV.A3.—Operations of the Combined OASI and DI Trust Funds, Calendar Years 2011-2025[a] (Cont.)
[Dollar amounts in billions]

	Income					Cost[b]				Asset Reserves[b]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[c]	Taxation of benefits[d]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
Intermediate:												
2016 . .	944.6	822.5	.1	33.2	88.8	928.9	917.7	6.6	4.6	15.7	2,828.2	303
2017 . .	996.6	869.8	[f]	39.3	87.6	965.5	954.8	6.4	4.3	31.1	2,859.3	293
2018 . .	1,054.7	922.3	[f]	43.1	89.2	1,032.5	1,021.4	6.6	4.6	22.1	2,881.5	277
2019 . .	1,112.4	974.1	[f]	47.2	91.1	1,101.6	1,089.9	7.1	4.7	10.7	2,892.2	262
2020 . .	1,171.3	1,027.4	[f]	51.3	92.6	1,174.5	1,162.2	7.5	4.8	-3.2	2,889.0	246
2021 . .	$1,230.6	$1,081.8	[f]	$55.7	$93.1	$1,248.4	$1,235.7	$8.0	$4.8	$-17.8	$2,871.2	231
2022 . .	1,290.4	1,136.2	[f]	60.6	93.6	1,330.5	1,317.1	8.4	5.1	-40.1	2,831.1	216
2023 . .	1,349.8	1,189.5	[f]	65.9	94.4	1,418.8	1,404.9	8.8	5.1	-69.0	2,762.1	200
2024 . .	1,412.4	1,246.2	[f]	71.6	94.6	1,512.2	1,497.8	9.1	5.2	-99.9	2,662.2	183
2025 . .	1,473.7	1,302.5	[f]	77.8	93.5	1,609.2	1,594.4	9.5	5.2	-135.5	2,526.7	165
Low-cost:												
2016 . .	951.4	828.4	.1	33.2	89.7	926.3	915.2	6.6	4.6	25.0	2,837.5	304
2017 . .	1,027.3	895.4	[f]	39.4	92.5	965.1	954.4	6.4	4.3	62.2	2,899.7	294
2018 . .	1,108.4	965.9	[f]	43.5	99.0	1,036.9	1,025.8	6.6	4.6	71.5	2,971.2	280
2019 . .	1,190.2	1,036.8	[f]	47.7	105.8	1,109.6	1,097.7	7.2	4.7	80.7	3,051.9	268
2020 . .	1,274.3	1,109.0	[f]	52.2	113.2	1,186.7	1,174.1	7.8	4.8	87.6	3,139.5	257
2021 . .	1,359.9	1,182.3	[f]	56.8	120.8	1,265.5	1,252.4	8.3	4.8	94.4	3,233.9	248
2022 . .	1,450.7	1,257.9	[f]	62.1	130.7	1,353.4	1,339.5	8.8	5.1	97.3	3,331.2	239
2023 . .	1,546.6	1,336.0	[f]	67.8	142.8	1,448.7	1,434.2	9.4	5.2	97.9	3,429.1	230
2024 . .	1,650.2	1,420.2	[f]	74.0	156.0	1,550.4	1,535.3	9.9	5.3	99.8	3,528.9	221
2025 . .	1,756.7	1,506.4	[f]	80.7	169.6	1,657.3	1,641.5	10.5	5.3	99.4	3,628.3	213
High-cost:												
2016 . .	933.6	812.5	.1	33.3	87.7	931.2	920.1	6.6	4.6	2.4	2,814.9	302
2017 . .	941.3	819.2	[f]	39.3	82.8	969.2	958.4	6.4	4.3	-27.8	2,787.1	290
2018 . .	983.0	860.2	[f]	42.8	80.0	1,030.3	1,019.0	6.5	4.7	-47.3	2,739.8	271
2019 . .	1,020.2	896.3	[f]	46.7	77.2	1,096.7	1,085.0	6.9	4.8	-76.5	2,663.3	250
2020 . .	1,057.0	933.2	[f]	50.6	73.2	1,164.5	1,152.4	7.3	4.9	-107.6	2,555.7	229
2021 . .	1,093.0	970.7	[f]	54.7	67.7	1,232.6	1,220.1	7.6	4.8	-139.6	2,416.2	207
2022 . .	1,128.6	1,008.5	[f]	59.2	60.9	1,308.1	1,295.1	7.9	5.1	-179.4	2,236.7	185
2023 . .	1,163.6	1,045.6	[f]	64.1	53.9	1,388.6	1,375.2	8.2	5.1	-225.0	2,011.8	161
2024 . .	1,199.2	1,083.7	[f]	69.3	46.2	1,472.8	1,459.1	8.5	5.2	-273.7	1,738.1	137
2025 . .	1,231.8	1,119.3	[f]	74.8	37.6	1,559.4	1,545.4	8.7	5.2	-327.6	1,410.5	111

[a] Appendix A presents a detailed description of the components of income and cost, along with complete historical values.

[b] Amounts for 2015 and 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015 as required by the statutory provision for early benefit payments when the normal delivery date is on a weekend or holiday. Such shifts in payments across calendar years have occurred in the past and will occur periodically in the future whenever January 3rd falls on a Sunday. In order to provide a consistent perspective on trust fund operations over time, all trust fund operations in each year reflect the 12 months of benefits that are regularly scheduled for payment in that year.

[c] Includes reimbursements from the General Fund of the Treasury to the OASI and DI Trust Funds for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost of benefits to certain uninsured persons who attained age 72 before 1968; (3) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (4) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (5) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.

[d] Revenue from taxation of benefits is the amount that would be assessed on benefit amounts scheduled in the law.

[e] The "Trust fund ratio" column represents reserves at the beginning of a year (which are identical to reserves at the end of the prior year shown in the "Amount at end of year" column) as a percentage of cost for the year.

[f] Between -$50 million and $50 million.

Note: Totals do not necessarily equal the sums of rounded components.

4. Factors Underlying Changes in 10-Year Trust Fund Ratio Estimates From the 2015 Report

Table IV.A4 presents an analysis of the factors underlying the changes in the intermediate estimates over the short-range projection period for the OASI, DI, and the combined funds from last year's report to this report.

In the 2015 report under intermediate assumptions, the trust fund ratio for OASI reached 216 percent at the beginning of 2024—the tenth projection year for that report. The change in the short-range valuation period alone, from 2015 through 2024 to 2016 through 2025, lowered the estimated trust fund ratio for the tenth year by 17 percentage points, to 199 percent. All other changes to reflect modifications in law and regulations since last year's report, the most recent data, adjustments to the assumptions for future years, and changes in projection methods combined for a net decrease in the ratio for the tenth projection year of 5 percentage points. Therefore, the total change for this report is a reduction of 22 percentage points to 194 percent.

The Bipartisan Budget Act of 2015 is projected to decrease the tenth year OASI trust fund ratio by 12 percentage points, primarily due to the temporary reallocation of payroll tax rates from OASI to DI for 2016 through 2018. Changes in demographic assumptions over the short-range period increased the projected tenth-year trust fund ratio for OASI by 4 percentage points. Changes in economic data and assumptions, primarily the combined effects of lower cost-of-living adjustments, lower interest rates, and lower payroll tax revenues over the ten year period, caused a net reduction in the OASI trust fund ratio of 3 percentage points by the beginning of 2025. Incorporating recent programmatic data resulted in an increase of 10 percentage points in the tenth year OASI trust fund ratio. This increase was primarily due to recent data showing that retired workers have been starting benefits at later ages, which in turn led to lower beneficiary counts, somewhat offset by higher average benefit amounts, throughout the short-range period. Finally, an improvement in the short-range methodology for projecting average benefits for newly awarded retired workers decreased the tenth year trust fund ratio by 4 percentage points.

Table IV.A4 also shows corresponding estimates of the factors underlying the changes in the financial projections for the DI Trust Fund and for the combined OASI and DI Trust Funds. The ratios at the beginning of 2024 for the DI Trust Fund and the combined OASI and DI Trust Funds in last year's report, as well as the corresponding ratios for the beginning of 2025 in this year's report, are hypothetical because the Trustees project that the DI Trust Fund reserves will be depleted prior to the end of the short-range projection period. The 77-percentage-point increase in the DI trust fund ratio is the net effect of increases and decreases from the factors described in the prior paragraph for the OASI Trust Fund, the largest of which was the increase caused by the Bipartisan Budget Act of 2015. For the DI Trust Fund, the effect of this law was an increase of about 81 percentage points, which is a combination of a 79-percentage-point increase due to the temporary tax rate reallocation and an increase of about 2 percentage points caused by other provisions affecting DI benefits. For the combined OASI and DI Trust Funds, the payroll tax rate reallocation has no net effect; the remaining change due to other provisions is an increase of slightly less than 0.5 percentage point in the trust fund ratio.

Table IV.A4.—Reasons for Change in Trust Fund (Unfunded Obligation) Ratios at the Beginning of the Tenth Year of Projection Under Intermediate Assumptions
[In percent]

Item	OASI Trust Fund	DI Trust Fund	OASI and DI Trust Funds, combined
Trust fund ratio shown in last year's report for calendar year 2024[a]	216	-95	173
Change in trust fund ratio due to changes in:			
Legislation and regulations	-12	81	[b]
Valuation period	-17	-11	-15
Demographic data and assumptions	4	[b]	3
Economic data and assumptions	-3	-9	-4
Programmatic data and assumptions	10	16	12
Projection methods and data	-4	-1	-3
Total change in trust fund ratio	-22	77	-8
Trust fund ratio shown in this report for calendar year 2025[a]	194	-18	165

[a] Figures for DI, and OASI and DI combined, are hypothetical because the DI Trust Fund reserves are depleted before the beginning of the tenth year under the assumptions of each report. The magnitudes of the negative values for DI represent the ratios of the unfunded obligation at the beginning of the tenth year to cost for that year.
[b] Between -0.5 and 0.5 percent.

Note: Totals do not necessarily equal the sums of rounded components.

B. LONG-RANGE ESTIMATES

The Trustees use three types of financial measures to assess the actuarial status of the Social Security trust funds under the financing approach specified in current law: (1) annual cash-flow measures, including income rates, cost rates, and balances; (2) trust fund ratios; and (3) summary measures such as actuarial balances and unfunded obligations.

The difference between the annual income rate and annual cost rate, both expressed as percentages of taxable payroll, is the annual balance. The level and trend of the annual balances at the end of the 75-year projection period are factors that the Trustees use to assess the financial condition of the program.

The trust fund ratio for a year is the proportion of the year's projected cost that could be paid with funds available at the beginning of the year. Critical factors considered by the Trustees in assessing actuarial status include: (1) the level and year of maximum trust fund ratio, (2) the year of depletion of the fund reserves and the percent of scheduled benefits that is still payable after reserves are depleted, and (3) the stability of the trust fund ratio at the end of the long-range period.

Solvency at any point in time requires that sufficient financial resources are available to pay all scheduled benefits at that time. Solvency is generally indicated by a positive trust fund ratio. "Sustainable solvency" for the financing of the program under a specified set of assumptions has been achieved when the projected trust fund ratio is positive throughout the 75-year projection period and is either stable or rising at the end of the period.

Summarized measures for any period indicate whether projected income is sufficient, on average, for the whole period. Summarized measures can only indicate the solvency status of a fund for the end of the period. The Trustees summarize the total income and cost over valuation periods that extend through 75 years and over the infinite horizon.[1] This section presents two summarized measures: the actuarial balance and the open group unfunded obligation. The actuarial balance indicates the size of any surplus or shortfall as a percentage of the taxable payroll over the period. The open group unfunded obligation indicates the size of any shortfall in present-value dollars.

This section also includes additional information that the Trustees use to assess the financial status of the Social Security program, including: (1) a comparison of the number of beneficiaries to the number of covered workers,

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[1] See appendix F.

(2) the test of long-range close actuarial balance, and (3) the reasons for the change in the actuarial balance from the last report.

1. Annual Income Rates, Cost Rates, and Balances

The concepts of income rate and cost rate, expressed as percentages of taxable payroll, are important in the consideration of the long-range actuarial status of the trust funds. The annual income rate is the ratio of all non-interest income to the OASDI taxable payroll for the year. Non-interest income includes payroll taxes, taxes on scheduled benefits, and any General Fund transfers or reimbursements. The OASDI taxable payroll consists of the total earnings subject to OASDI taxes with some relatively small adjustments.[1] The annual cost rate is the ratio of the cost of the program to the taxable payroll for the year. The cost includes scheduled benefits, administrative expenses, net interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries. For any year, the income rate minus the cost rate is the "balance" for the year.

Table IV.B1 presents a comparison of the estimated annual income rates and cost rates by trust fund and alternative. Table IV.B2 shows the separate components of the annual income rates.

Under the intermediate assumptions, the Trustees project that the OASI income rate will decline from 11.15 percent of payroll for 2015 to 10.58 percent of payroll for 2016. This temporary reduction results from the payroll tax rate reallocation of 0.57 percentage point from OASI to DI for 2016 through 2018 enacted in the Bipartisan Budget Act of 2015. After returning to the pre-reallocation level for 2019, the income rate will rise at a very gradual rate to 11.47 percent of taxable payroll for 2090. Income from taxation of benefits causes this increase for two main reasons: (1) total benefits are rising faster than payroll; and (2) the benefit-taxation threshold amounts are fixed (not indexed), and therefore an increasing share of total benefits will be subject to tax as incomes and benefits rise.

The pattern of the cost rate is much different. The OASI cost rate is projected to decrease from 2016[2] to 2017 primarily because the projected percentage

[1] Adjustments include adding deemed wage credits based on military service for 1983-2001 and reflecting the lower effective tax rates (as compared to the combined employee-employer rate) that apply to multiple-employer "excess wages." Lower rates also applied to net earnings from self-employment before 1984 and to income from tips before 1988.

[2] Amounts for 2015 and 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015 as required by the statutory provision for early benefit payments when the normal delivery date is on a weekend or holiday. Such shifts in payments across calendar years have occurred in the past and will occur periodically in the future whenever January 3rd falls on a Sunday. In order to provide a consistent perspective on trust fund operations over time, all trust fund operations in each year reflect the 12 months of benefits that are regularly scheduled for payment in that year.

increase in average taxable earnings is greater than the projected increase in the average benefit from 2016 to 2017, largely due to the small 0.2 percentage point projected COLA for December 2016. From 2017 to 2035, the cost rate rises rapidly because the retirement of the baby-boom generation will increase the number of beneficiaries much faster than the number of workers increases, as subsequent lower-birth-rate generations replace the baby-boom generation at working ages. From 2038 to 2051, the cost rate declines because the aging baby-boom generation is gradually replaced at retirement ages by the historically low-birth-rate generation born between 1966 and 1989. After 2051, the projected OASI cost rate generally rises slowly, reaching 15.42 percent of taxable payroll for 2090, primarily because of projected reductions in death rates at higher ages.

Projections of income rates under the low-cost and high-cost sets of assumptions are similar to those projected for the intermediate assumptions, because income rates are largely a reflection of the payroll tax rates specified in the law, with the gradual change from taxation of benefits noted above. In contrast, OASI cost rates for the low-cost and high-cost assumptions are significantly different from those projected for the intermediate assumptions. For the low-cost assumptions, the OASI cost rate decreases through 2017, and then rises until it peaks in 2033 at 12.43 percent of payroll. The cost rate then declines to 11.41 percent for 2054, rises to 11.57 percent for 2070, and declines again to 11.17 percent for 2084 before rising to 11.31 percent for 2090, at which point the income rate reaches 11.23 percent. For the high-cost assumptions, the OASI cost rate rises throughout the 75-year period. It rises relatively rapidly through about 2039 because of the aging of the baby-boom generation. Thereafter, the cost rate continues to rise and reaches 21.71 percent of payroll for 2090, at which point the income rate reaches 11.83 percent.

The pattern of the projected OASI annual balance is important in the analysis of the financial condition of the program. Under the intermediate assumptions, the annual balance is negative throughout the projection period. This annual deficit is temporarily higher for years 2016 through 2018 because of the 0.57-percentage-point payroll tax rate reallocation from OASI to DI. After returning to the pre-reallocation level for 2019, the annual deficit then rises relatively rapidly from 0.76 percent for 2019 to 3.20 percent for 2038. It then declines to 2.81 percent of payroll for 2051, and generally rises thereafter, reaching 3.96 percent of taxable payroll for 2090.

Under the low-cost assumptions, after the 2016-2018 payroll tax rate reallocation period, the annual deficit rises from 0.23 percent of payroll for 2019 to 1.17 percent of payroll for 2033. Then the annual deficit generally declines until it becomes a positive annual balance for 2082. The annual balance turns negative again for 2088, reaching a deficit of 0.09 percent of payroll for

2090. Under the high-cost assumptions, the OASI balance worsens throughout the projection period. Annual deficits rise to 1.84 percent for 2020, 6.22 percent for 2050, and 9.87 percent of payroll for 2090.

Table IV.B1.—Annual Income Rates, Cost Rates, and Balances, Calendar Years 1990-2090
[As a percentage of taxable payroll]

	OASI			DI			OASDI		
Calendar year	Income rate[a]	Cost rate[b]	Balance[b]	Income rate[a]	Cost rate[b]	Balance[b]	Income rate[a]	Cost rate[b]	Balance[b]
Historical data:									
1990	11.47	9.66	1.82	1.18	1.09	0.10	12.66	10.74	1.91
1995	10.64	10.22	.42	1.87	1.44	.43	12.51	11.67	.85
2000	10.85	8.98	1.87	1.78	1.42	.36	12.62	10.40	2.23
2001	10.90	9.08	1.82	1.82	1.48	.35	12.73	10.56	2.17
2002	11.06	9.29	1.76	1.85	1.60	.24	12.90	10.89	2.01
2003	10.79	9.35	1.44	1.80	1.68	.12	12.59	11.03	1.56
2004	10.73	9.27	1.46	1.79	1.78	.02	12.53	11.05	1.48
2005	10.96	9.31	1.65	1.84	1.85	-.02	12.80	11.16	1.63
2006	10.96	9.18	1.78	1.83	1.88	-.05	12.79	11.06	1.73
2007	11.01	9.44	1.57	1.84	1.88	-.04	12.85	11.32	1.53
2008	10.90	9.54	1.37	1.83	2.01	-.19	12.73	11.55	1.18
2009	11.23	10.74	.50	1.88	2.31	-.43	13.11	13.05	.06
2010	10.75	11.06	-.30	1.79	2.41	-.62	12.54	13.47	-.92
2011	10.84	11.05	-.21	1.80	2.42	-.62	12.64	13.47	-.83
2012	11.05	11.35	-.30	1.81	2.47	-.66	12.86	13.82	-.96
2013	10.97	11.54	-.57	1.81	2.44	-.63	12.77	13.98	-1.20
2014	10.96	11.60	-.64	1.81	2.36	-.55	12.77	13.96	-1.19
2015	11.15	11.78	-.63	1.83	2.30	-.47	12.98	14.08	-1.10
Intermediate:									
2016	10.58	11.78	-1.20	2.37	2.27	.09	12.94	14.05	-1.10
2017	10.52	11.55	-1.02	2.39	2.17	.22	12.92	13.72	-.80
2018	10.56	11.72	-1.16	2.40	2.14	.26	12.96	13.86	-.90
2019	11.11	11.88	-.76	1.85	2.11	-.26	12.97	13.99	-1.02
2020	11.15	12.05	-.90	1.83	2.08	-.25	12.98	14.13	-1.15
2021	11.18	12.21	-1.03	1.83	2.06	-.24	13.00	14.27	-1.27
2022	11.20	12.44	-1.23	1.83	2.05	-.22	13.03	14.49	-1.46
2023	11.23	12.71	-1.48	1.83	2.05	-.22	13.06	14.76	-1.70
2024	11.26	12.98	-1.72	1.83	2.04	-.21	13.09	15.02	-1.93
2025	11.28	13.25	-1.97	1.83	2.03	-.20	13.11	15.29	-2.17
2030	11.34	14.10	-2.76	1.84	2.00	-.16	13.18	16.10	-2.92
2035	11.37	14.48	-3.10	1.84	2.02	-.18	13.22	16.50	-3.28
2040	11.39	14.55	-3.16	1.84	2.04	-.20	13.23	16.59	-3.36
2045	11.38	14.34	-2.95	1.85	2.11	-.27	13.23	16.45	-3.22
2050	11.38	14.20	-2.82	1.85	2.15	-.30	13.23	16.36	-3.13
2055	11.39	14.28	-2.89	1.85	2.19	-.33	13.24	16.46	-3.22
2060	11.41	14.53	-3.13	1.85	2.17	-.32	13.26	16.71	-3.44
2065	11.42	14.77	-3.35	1.86	2.18	-.33	13.28	16.96	-3.68
2070	11.44	15.03	-3.59	1.86	2.19	-.33	13.30	17.22	-3.92
2075	11.45	15.22	-3.77	1.86	2.17	-.31	13.31	17.39	-4.08
2080	11.45	15.21	-3.75	1.86	2.20	-.34	13.31	17.40	-4.09
2085	11.46	15.22	-3.77	1.86	2.25	-.39	13.32	17.47	-4.15
2090	11.47	15.42	-3.96	1.86	2.25	-.39	13.33	17.68	-4.35
First year balance becomes negative and remains negative throughout the projection period			2010			2019			2010

Table IV.B1.—Annual Income Rates, Cost Rates, and Balances, Calendar Years 1990-2090 (Cont.)
[As a percentage of taxable payroll]

Calendar year	OASI Income rate[a]	OASI Cost rate[b]	OASI Balance[b]	DI Income rate[a]	DI Cost rate[b]	DI Balance[b]	OASDI Income rate[a]	OASDI Cost rate[b]	OASDI Balance[b]
Low-cost:									
2016	10.53	11.64	-1.11	2.36	2.22	0.14	12.89	13.86	-0.97
2017	10.50	11.25	-.75	2.39	2.06	.33	12.89	13.31	-.42
2018	10.53	11.29	-.76	2.39	1.99	.41	12.93	13.28	-.35
2019	11.08	11.31	-.23	1.85	1.91	-.07	12.93	13.23	-.30
2020	11.11	11.37	-.26	1.82	1.85	-.03	12.94	13.22	-.28
2021	11.13	11.43	-.30	1.82	1.80	.02	12.95	13.23	-.28
2022	11.15	11.54	-.39	1.82	1.77	.06	12.98	13.31	-.33
2023	11.17	11.68	-.51	1.82	1.73	.09	12.99	13.41	-.42
2024	11.19	11.81	-.62	1.83	1.69	.13	13.02	13.51	-.49
2025	11.20	11.94	-.74	1.82	1.66	.16	13.03	13.60	-.58
2030	11.25	12.35	-1.10	1.83	1.54	.28	13.07	13.89	-.82
2035	11.26	12.38	-1.12	1.83	1.50	.33	13.09	13.88	-.79
2040	11.25	12.15	-.90	1.83	1.47	.36	13.08	13.62	-.53
2045	11.24	11.74	-.51	1.83	1.49	.35	13.07	13.23	-.16
2050	11.22	11.47	-.25	1.83	1.49	.34	13.06	12.96	.10
2055	11.22	11.42	-.19	1.84	1.49	.34	13.06	12.91	.15
2060	11.23	11.51	-.28	1.84	1.47	.36	13.07	12.98	.09
2065	11.24	11.55	-.32	1.84	1.47	.37	13.07	13.02	.05
2070	11.24	11.57	-.34	1.84	1.46	.37	13.07	13.04	.04
2075	11.24	11.51	-.27	1.84	1.45	.39	13.07	12.96	.11
2080	11.22	11.28	-.06	1.84	1.47	.37	13.06	12.75	.31
2085	11.22	11.17	.05	1.84	1.52	.32	13.05	12.68	.37
2090	11.23	11.31	-.09	1.84	1.53	.31	13.06	12.84	.22
First year balance becomes negative and remains negative throughout the projection period			2088			[c]			[c]
High-cost:									
2016	10.66	12.01	-1.35	2.38	2.35	.04	13.04	14.35	-1.32
2017	10.58	12.28	-1.70	2.40	2.37	.03	12.97	14.65	-1.67
2018	10.59	12.45	-1.86	2.40	2.37	.02	12.99	14.82	-1.83
2019	11.16	12.75	-1.59	1.86	2.39	-.53	13.02	15.15	-2.12
2020	11.21	13.05	-1.84	1.83	2.39	-.56	13.04	15.44	-2.40
2021	11.24	13.31	-2.08	1.83	2.40	-.56	13.07	15.71	-2.64
2022	11.27	13.65	-2.37	1.84	2.41	-.58	13.11	16.06	-2.95
2023	11.30	14.01	-2.71	1.84	2.43	-.59	13.14	16.44	-3.30
2024	11.34	14.39	-3.06	1.84	2.44	-.60	13.18	16.83	-3.66
2025	11.37	14.78	-3.42	1.84	2.46	-.62	13.21	17.24	-4.04

Table IV.B1.—Annual Income Rates, Cost Rates, and Balances, Calendar Years 1990-2090 (Cont.)
[As a percentage of taxable payroll]

Calendar year	OASI Income rate[a]	OASI Cost rate[b]	OASI Balance[b]	DI Income rate[a]	DI Cost rate[b]	DI Balance[b]	OASDI Income rate[a]	OASDI Cost rate[b]	OASDI Balance[b]
High-cost (Cont.):									
2030	11.45	16.12	-4.67	1.85	2.54	-0.69	13.30	18.66	-5.36
2035	11.51	16.95	-5.45	1.85	2.65	-.80	13.36	19.61	-6.24
2040	11.55	17.49	-5.95	1.86	2.75	-.89	13.41	20.24	-6.84
2045	11.56	17.64	-6.07	1.87	2.90	-1.04	13.43	20.54	-7.11
2050	11.58	17.80	-6.22	1.87	3.00	-1.13	13.45	20.79	-7.34
2055	11.61	18.14	-6.53	1.87	3.08	-1.21	13.48	21.22	-7.74
2060	11.64	18.69	-7.05	1.88	3.09	-1.21	13.52	21.78	-8.27
2065	11.68	19.27	-7.59	1.88	3.13	-1.25	13.56	22.39	-8.84
2070	11.72	19.93	-8.21	1.88	3.15	-1.27	13.60	23.09	-9.48
2075	11.76	20.58	-8.82	1.88	3.13	-1.25	13.64	23.71	-10.07
2080	11.79	21.00	-9.21	1.88	3.14	-1.26	13.67	24.14	-10.47
2085	11.81	21.33	-9.52	1.88	3.19	-1.30	13.69	24.52	-10.82
2090	11.83	21.71	-9.87	1.88	3.18	-1.30	13.72	24.89	-11.17
First year balance becomes negative and remains negative throughout the projection period.			2010			2019			2010

[a] Income rates include certain reimbursements from the General Fund of the Treasury.
[b] Benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.
[c] The annual balance is projected to be negative for a temporary period and return to positive levels before the end of the projection period.

Notes:
1. The income rate excludes interest income.
2. Revisions of taxable payroll may change some historical values.
3. Totals do not necessarily equal the sums of rounded components.

The DI cost rate rose substantially from 1.09 percent of taxable payroll for 1990 to 1.88 percent of taxable payroll for 2007 as the baby boom generation moved into prime disability ages, and further to a peak of 2.47 percent for 2012 due to the recent economic recession. Under the intermediate assumptions, the projected DI cost rate generally declines to 1.99 percent for 2032, and then generally increases gradually to 2.19 percent for 2056. From 2056 to 2079, the DI cost rate stays relatively stable before increasing slowly to 2.25 percent of payroll for 2090. Because of the temporary 2016-18 payroll tax rate reallocation, the income rate increases to between 2.37 and 2.40 percent of payroll for those years. The income rate drops to 1.85 percent of payroll for 2019 and then increases only very slightly to 1.86 percent for 2090. The annual balance is positive for years 2016 through 2018, reflecting the reallocation. Thereafter, the annual deficit reappears, but generally declines from 0.26 percent for 2019 to a low of 0.15 percent for 2032, and then generally increases to 0.39 percent for 2090.

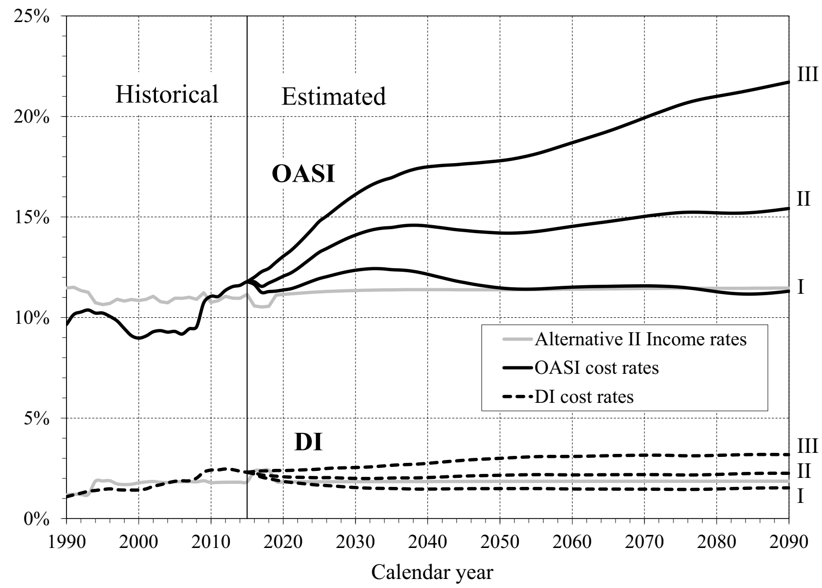
Under the low-cost assumptions, the DI cost rate declines from 2.47 percent of payroll for 2012 to 1.47 percent for 2039, and remains relatively stable thereafter, reaching 1.53 percent for 2090. The annual balance is positive for 2016 through 2018, negative for 2019 through 2020, and is positive throughout the remainder of the long-range period. Under the high-cost assumptions, the DI cost rate generally rises throughout the projection period, reaching 3.18 percent for 2090. The annual deficit is negative from 2019 through the remainder of the projection period, reaching 0.53 percent for 2019, 1.13 percent for 2050, and 1.30 percent for 2090.

Figure IV.B1 shows the patterns of the OASI and DI annual cost rates. Annual DI cost rates rose substantially between 1990 and 2010 in large part due to: (1) aging of the working population as the baby-boom generation moved from ages 25-44 in 1990, where disability prevalence is low, to ages 45-64 in 2010, where disability prevalence is much higher; (2) a substantial increase in the percentage of women insured for DI benefits as a result of increased and more consistent rates of employment; and (3) increased disability incidence rates for women to a level similar to those for men by 2010. After 2010, all of these factors stabilize, and therefore the DI cost rate stabilizes also. Annual OASI cost rates follow a similar pattern to that for DI, but displaced 20 to 25 years later, because the baby-boom generation enters retirement ages 20 to 25 years after entering prime disability ages. Figure IV.B1 shows only the income rates for alternative II because the variation in income rates by alternative is very small. Income rates generally increase slowly for each of the alternatives over the long-range period. Taxation of benefits, which is a relatively small portion of income, is the main source of both the increases in the income rate and the variation among the alternatives. Increases in income from taxation of benefits reflect: (1) increases in the total amount of benefits paid and (2) the increasing share of individual benefits that will be subject to taxation because benefit taxation threshold amounts are not indexed.

Figure IV.B1 shows the patterns of the annual balances for OASI and DI. For each alternative and for historical data, the magnitude of each of the positive balances, as a percentage of taxable payroll, is the distance between the appropriate cost-rate curve and the income-rate curve above it. The magnitude of each of the deficits is the distance between the appropriate cost-rate curve and the income-rate curve below it. Annual balances follow closely the pattern of annual cost rates after 1990 because the payroll tax rate does not change for the OASDI program, with only small variations in the allocation between DI and OASI except for the 2016-2018 payroll tax rate reallocation. The pattern of the projected OASDI annual balances is important to the analysis of the financial condition of the Social Security program as a whole.

In the future, the costs of OASI, DI, and the combined OASDI programs as a percentage of taxable payroll are unlikely to fall outside the range encompassed by alternatives I and III because alternatives I and III define a wide range of demographic and economic conditions.

Figure IV.B1.—Long-Range OASI and DI Annual Income Rates and Cost Rates
[As a percentage of taxable payroll]



Long-range OASDI cost and income are most often expressed as percentages of taxable payroll. However, the Trustees also present cost and income as shares of gross domestic product (GDP), the value of goods and services produced during the year in the United States. Under alternative II, the Trustees project the OASDI cost to decrease from about 5.0 percent of GDP for 2016 to about 4.9 percent of GDP for 2017, and then increase to a peak of about 6.0 percent for 2037. After 2037, OASDI cost as a percentage of GDP declines to a low of about 5.9 percent for 2051 and thereafter generally increases slowly, reaching about 6.1 percent by 2090. Appendix G presents full estimates of income and cost relative to GDP.

Table IV.B2 contains historical and projected annual income rates and their components by trust fund and alternative. The annual income rates consist of the scheduled payroll tax rates, the rates of income from taxation of benefits, and the rates of income from General Fund reimbursements. Projected income from taxation of benefits increases over time for reasons discussed on page 56. Historical General Fund reimbursements include temporary reductions in revenue due to reduced payroll tax rates and certain other miscellaneous items.

Table IV.B2.—Components of Annual Income Rates, Calendar Years 1990-2090
[As a percentage of taxable payroll]

	OASI				DI				OASDI			
Calendar year	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]
Historical:												
1990 . .	11.29	0.21	-0.03	11.47	1.21	0.01	-0.03	1.18	12.50	0.21	-0.06	12.66
1995 . .	10.46	.19	-.01	10.64	1.87	.01	-.01	1.87	12.33	.20	-.01	12.51
2000 . .	10.56	.29	c	10.85	1.78	.02	-.02	1.78	12.34	.31	-.02	12.62
2001 . .	10.62	.29	c	10.90	1.80	.02	c	1.82	12.42	.31	c	12.73
2002 . .	10.74	.30	.01	11.06	1.82	.02	c	1.85	12.56	.33	.01	12.90
2003 . .	10.50	.29	c	10.79	1.78	.02	c	1.80	12.28	.31	c	12.59
2004 . .	10.41	.32	c	10.73	1.77	.02	c	1.79	12.18	.35	c	12.53
2005 . .	10.68	.29	-.01	10.96	1.81	.02	c	1.84	12.49	.31	-.01	12.80
2006 . .	10.65	.31	c	10.96	1.81	.02	c	1.83	12.46	.34	c	12.79
2007 . .	10.68	.33	c	11.01	1.81	.03	c	1.84	12.50	.35	c	12.85
2008 . .	10.61	.29	c	10.90	1.80	.02	c	1.83	12.42	.31	c	12.73
2009 . .	10.85	.38	c	11.23	1.84	.04	c	1.88	12.70	.42	c	13.11
2010 . .	10.30	.42	.04	10.75	1.75	.04	.01	1.79	12.05	.45	.05	12.54
2011 . .	8.82	.41	1.61	10.84	1.50	.03	.27	1.80	10.32	.44	1.88	12.64
2012 . .	8.86	.47	1.72	11.05	1.51	.01	.29	1.81	10.37	.48	2.01	12.86
2013 . .	10.54	.35	.07	10.97	1.79	.01	.01	1.81	12.33	.36	.08	12.77
2014 . .	10.50	.45	.01	10.96	1.78	.03	c	1.81	12.28	.48	.01	12.77
2015	10.67	.48	c	11.15	1.81	.02	c	1.83	12.48	.50	.01	12.98
Intermediate:												
2016 . .	10.09	.48	c	10.58	2.35	.02	c	2.37	12.44	.50	c	12.94
2017 . .	10.00	.53	c	10.52	2.36	.03	c	2.39	12.36	.56	c	12.92
2018 . .	10.01	.55	c	10.56	2.37	.03	c	2.40	12.38	.58	c	12.96
2019 . .	10.55	.57	c	11.11	1.82	.03	c	1.85	12.37	.60	c	12.97
2020 . .	10.57	.59	c	11.15	1.79	.03	c	1.83	12.36	.62	c	12.98
2021 . .	10.57	.60	c	11.18	1.80	.03	c	1.83	12.37	.64	c	13.00
2022 . .	10.58	.63	c	11.20	1.80	.03	c	1.83	12.37	.66	c	13.03
2023 . .	10.58	.65	c	11.23	1.80	.03	c	1.83	12.37	.69	c	13.06
2024 . .	10.58	.68	c	11.26	1.80	.04	c	1.83	12.38	.71	c	13.09
2025 . .	10.58	.70	c	11.28	1.80	.04	c	1.83	12.37	.74	c	13.11
2030 . .	10.58	.77	c	11.34	1.80	.04	c	1.84	12.37	.81	c	13.18
2035 . .	10.58	.80	c	11.37	1.80	.05	c	1.84	12.37	.84	c	13.22
2040 . .	10.58	.81	c	11.39	1.80	.05	c	1.84	12.37	.86	c	13.23
2045 . .	10.58	.81	c	11.38	1.80	.05	c	1.85	12.37	.86	c	13.23
2050 . .	10.58	.80	c	11.38	1.80	.05	c	1.85	12.37	.86	c	13.23
2055 . .	10.58	.81	c	11.39	1.80	.06	c	1.85	12.37	.87	c	13.24
2060 . .	10.58	.83	c	11.41	1.80	.06	c	1.85	12.37	.89	c	13.26
2065 . .	10.58	.85	c	11.42	1.80	.06	c	1.86	12.37	.91	c	13.28
2070 . .	10.58	.86	c	11.44	1.80	.06	c	1.86	12.37	.92	c	13.30
2075 . .	10.58	.88	c	11.45	1.80	.06	c	1.86	12.37	.94	c	13.31
2080 . .	10.58	.88	c	11.45	1.80	.06	c	1.86	12.37	.94	c	13.31
2085 . .	10.58	.88	c	11.46	1.80	.06	c	1.86	12.37	.94	c	13.32
2090 . .	10.58	.89	c	11.47	1.80	.06	c	1.86	12.37	.95	c	13.33

Table IV.B2.—Components of Annual Income Rates, Calendar Years 1990-2090 (Cont.)
[As a percentage of taxable payroll]

	OASI				DI				OASDI			
Calendar year	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]
Low-cost:												
2016 . .	10.05	0.48	[c]	10.53	2.34	0.02	[c]	2.36	12.39	0.50	[c]	12.89
2017 . .	9.99	.51	[c]	10.50	2.36	.03	[c]	2.39	12.35	.54	[c]	12.89
2018 . .	10.00	.53	[c]	10.53	2.36	.03	[c]	2.39	12.37	.56	[c]	12.93
2019 . .	10.54	.54	[c]	11.08	1.82	.03	[c]	1.85	12.36	.57	[c]	12.93
2020 . .	10.56	.55	[c]	11.11	1.79	.03	[c]	1.82	12.35	.58	[c]	12.94
2021 . .	10.57	.57	[c]	11.13	1.79	.03	[c]	1.82	12.36	.59	[c]	12.95
2022 . .	10.57	.58	[c]	11.15	1.80	.03	[c]	1.82	12.37	.61	[c]	12.98
2023 . .	10.57	.60	[c]	11.17	1.79	.03	[c]	1.82	12.37	.63	[c]	12.99
2024 . .	10.58	.62	[c]	11.19	1.80	.03	[c]	1.83	12.37	.64	[c]	13.02
2025 . .	10.57	.63	[c]	11.20	1.79	.03	[c]	1.82	12.36	.66	[c]	13.03
2030 . .	10.57	.67	[c]	11.25	1.80	.03	[c]	1.83	12.37	.71	[c]	13.07
2035 . .	10.57	.69	[c]	11.26	1.80	.03	[c]	1.83	12.37	.72	[c]	13.09
2040 . .	10.57	.68	[c]	11.25	1.80	.04	[c]	1.83	12.37	.72	[c]	13.08
2045 . .	10.57	.67	[c]	11.24	1.80	.04	[c]	1.83	12.37	.70	[c]	13.07
2050 . .	10.57	.65	[c]	11.22	1.80	.04	[c]	1.83	12.37	.69	[c]	13.06
2055 . .	10.57	.65	[c]	11.22	1.80	.04	[c]	1.84	12.37	.69	[c]	13.06
2060 . .	10.57	.66	[c]	11.23	1.80	.04	[c]	1.84	12.37	.70	[c]	13.07
2065 . .	10.57	.66	[c]	11.24	1.80	.04	[c]	1.84	12.37	.71	[c]	13.07
2070 . .	10.57	.67	[c]	11.24	1.80	.04	[c]	1.84	12.37	.71	[c]	13.07
2075 . .	10.57	.66	[c]	11.24	1.80	.04	[c]	1.84	12.37	.71	[c]	13.07
2080 . .	10.57	.65	[c]	11.22	1.80	.04	[c]	1.84	12.37	.69	[c]	13.06
2085 . .	10.57	.65	[c]	11.22	1.80	.04	[c]	1.84	12.37	.69	[c]	13.05
2090 . .	10.57	.65	[c]	11.23	1.80	.04	[c]	1.84	12.37	.70	[c]	13.06

Table IV.B2.—Components of Annual Income Rates, Calendar Years 1990-2090 (Cont.)
[As a percentage of taxable payroll]

	OASI				DI				OASDI			
Calendar year	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]	Payroll tax	Taxation of benefits	General Fund Reimbursements[a]	Total[b]
High-cost:												
2016 . .	10.16	0.49	c	10.66	2.36	0.02	c	2.38	12.53	0.51	c	13.04
2017 . .	10.01	.56	c	10.58	2.37	.03	c	2.40	12.38	.59	c	12.97
2018 . .	10.01	.58	c	10.59	2.36	.03	c	2.40	12.37	.62	c	12.99
2019 . .	10.55	.61	c	11.16	1.82	.04	c	1.86	12.38	.64	c	13.02
2020 . .	10.57	.63	c	11.21	1.80	.04	c	1.83	12.37	.67	c	13.04
2021 . .	10.58	.66	c	11.24	1.80	.04	c	1.83	12.37	.70	c	13.07
2022 . .	10.58	.69	c	11.27	1.80	.04	c	1.84	12.38	.73	c	13.11
2023 . .	10.58	.72	c	11.30	1.80	.04	c	1.84	12.38	.76	c	13.14
2024 . .	10.59	.75	c	11.34	1.80	.04	c	1.84	12.39	.79	c	13.18
2025 . .	10.58	.78	c	11.37	1.80	.04	c	1.84	12.38	.83	c	13.21
2030 . .	10.58	.87	c	11.45	1.80	.05	c	1.85	12.38	.92	c	13.30
2035 . .	10.58	.92	c	11.51	1.80	.06	c	1.85	12.38	.98	c	13.36
2040 . .	10.58	.96	c	11.55	1.80	.06	c	1.86	12.38	1.03	c	13.41
2045 . .	10.58	.98	c	11.56	1.80	.07	c	1.87	12.38	1.05	c	13.43
2050 . .	10.58	1.00	c	11.58	1.80	.07	c	1.87	12.38	1.07	c	13.45
2055 . .	10.58	1.02	c	11.61	1.80	.08	c	1.87	12.38	1.10	c	13.48
2060 . .	10.58	1.06	c	11.64	1.80	.08	c	1.88	12.38	1.14	c	13.52
2065 . .	10.59	1.09	c	11.68	1.80	.08	c	1.88	12.38	1.17	c	13.56
2070 . .	10.59	1.14	c	11.72	1.80	.08	c	1.88	12.38	1.22	c	13.60
2075 . .	10.59	1.18	c	11.76	1.80	.08	c	1.88	12.38	1.26	c	13.64
2080 . .	10.59	1.20	c	11.79	1.80	.08	c	1.88	12.38	1.29	c	13.67
2085 . .	10.59	1.22	c	11.81	1.80	.09	c	1.88	12.38	1.31	c	13.69
2090 . .	10.59	1.25	c	11.83	1.80	.09	c	1.88	12.38	1.33	c	13.72

[a] Includes payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96, and other miscellaneous reimbursements.
[b] Values exclude interest income.
[c] Between -0.005 and 0.005 percent of taxable payroll.

Note: Totals do not necessarily equal the sums of rounded components.

2. Comparison of Workers to Beneficiaries

Under the intermediate assumptions, the Trustees project the OASDI cost rate will rise rapidly between 2017 and 2035, primarily because the number of beneficiaries rises much more rapidly than the number of covered workers as the baby-boom generation retires. The ratio of OASDI beneficiaries to workers is dominated by the OASI program because all workers eventually die or retire, but only a relatively small minority become disabled. The trends described below are primarily due to demographic changes and thus affect the DI program roughly 20 years earlier than the OASI and OASDI programs. The baby-boom generation had lower fertility rates than their parents, and the Trustees expect that lower fertility rates will persist for all future generations; therefore, the ratio of OASDI beneficiaries to workers will rise rapidly and reach a permanently higher level after the baby-boom generation retires. Due to increasing longevity, the ratio of beneficiaries to workers will generally rise slowly thereafter. Table IV.B3 provides a comparison of the numbers of covered workers and beneficiaries.

Table IV.B3.—Covered Workers and Beneficiaries, Calendar Years 1945-2090

Calendar year	Covered workers[a] (in thousands)	Beneficiaries[b] (in thousands)			Covered workers per OASDI beneficiary	OASDI beneficiaries per 100 covered workers
		OASI	DI	OASDI[c]		
Historical data:						
1945	46,390	1,106	-	1,106	41.9	2
1950	48,280	2,930	-	2,930	16.5	6
1955	65,066	7,564	-	7,564	8.6	12
1960	72,371	13,740	522	14,262	5.1	20
1965	80,539	18,509	1,648	20,157	4.0	25
1970	92,963	22,618	2,568	25,186	3.7	27
1975	100,193	26,998	4,125	31,123	3.2	31
1980	112,651	30,384	4,734	35,117	3.2	31
1985	120,398	32,763	3,874	36,636	3.3	30
1990	133,087	35,255	4,204	39,459	3.4	30
1995	140,929	37,364	5,731	43,096	3.3	31
2000	154,805	38,556	6,606	45,162	3.4	29
2001	155,189	38,888	6,780	45,668	3.4	29
2002	154,615	39,117	7,060	46,176	3.3	30
2003	154,827	39,315	7,438	46,753	3.3	30
2004	156,599	39,558	7,810	47,368	3.3	30
2005	159,030	39,961	8,172	48,133	3.3	30
2006	161,549	40,435	8,428	48,863	3.3	30
2007	163,314	40,863	8,739	49,603	3.3	30
2008	162,704	41,355	9,065	50,420	3.2	31
2009	157,729	42,385	9,475	51,860	3.0	33
2010	157,112	43,440	9,958	53,398	2.9	34
2011	158,674	44,388	10,428	54,816	2.9	35
2012	160,777	45,377	10,799	56,176	2.9	35
2013	163,302	46,517	10,954	57,471	2.8	35
2014	165,885	47,603	10,971	58,574	2.8	35
2015	168,899	48,663	10,881	59,543	2.8	35
Intermediate:						
2016	170,822	50,019	10,853	60,872	2.8	36
2020	179,102	56,505	11,231	67,736	2.6	38
2025	184,836	64,643	11,664	76,307	2.4	41
2030	188,769	71,615	11,890	83,506	2.3	44
2035	192,233	76,637	12,321	88,957	2.2	46
2040	197,022	79,319	12,849	92,168	2.1	47
2045	202,482	80,709	13,640	94,349	2.1	47
2050	207,610	82,520	14,226	96,746	2.1	47
2055	212,456	85,075	14,747	99,823	2.1	47
2060	217,070	88,345	15,021	103,366	2.1	48
2065	221,854	91,566	15,445	107,011	2.1	48
2070	227,089	95,079	15,874	110,953	2.0	49
2075	232,692	98,376	16,184	114,560	2.0	49
2080	238,422	100,509	16,744	117,253	2.0	49
2085	244,162	102,982	17,475	120,457	2.0	49
2090	249,698	106,626	17,931	124,557	2.0	50

Table IV.B3.—Covered Workers and Beneficiaries, Calendar Years 1945-2090 (Cont.)

Calendar year	Covered workers[a] (in thousands)	Beneficiaries[b] (in thousands)			Covered workers per OASDI beneficiary	OASDI beneficiaries per 100 covered workers
		OASI	DI	OASDI[c]		
Low-cost:						
2016	171,545	50,004	10,803	60,807	2.8	35
2020	182,507	56,386	10,676	67,062	2.7	37
2025	188,925	64,318	10,539	74,857	2.5	40
2030	193,605	70,713	10,291	81,004	2.4	42
2035	198,130	75,146	10,319	85,465	2.3	43
2040	204,791	77,208	10,499	87,708	2.3	43
2045	212,901	78,079	10,985	89,064	2.4	42
2050	220,970	79,491	11,379	90,870	2.4	41
2055	228,799	81,803	11,783	93,585	2.4	41
2060	236,623	84,883	12,057	96,940	2.4	41
2065	245,082	87,931	12,500	100,431	2.4	41
2070	254,625	91,227	12,996	104,223	2.4	41
2075	265,145	94,186	13,464	107,649	2.5	41
2080	276,175	96,031	14,196	110,227	2.5	40
2085	287,265	98,727	15,124	113,850	2.5	40
2090	298,093	103,444	15,819	119,264	2.5	40
High-cost:						
2016	170,151	50,032	10,897	60,929	2.8	36
2020	174,217	56,604	11,873	68,476	2.5	39
2025	180,301	64,991	12,773	77,763	2.3	43
2030	183,821	72,638	13,531	86,168	2.1	47
2035	186,485	78,324	14,375	92,699	2.0	50
2040	189,536	81,713	15,246	96,959	2.0	51
2045	192,741	83,742	16,338	100,080	1.9	52
2050	195,267	86,050	17,086	103,136	1.9	53
2055	197,241	88,921	17,699	106,619	1.8	54
2060	198,857	92,412	17,921	110,333	1.8	55
2065	200,311	95,812	18,251	114,063	1.8	57
2070	201,750	99,581	18,507	118,088	1.7	59
2075	203,168	103,215	18,512	121,727	1.7	60
2080	204,403	105,645	18,704	124,349	1.6	61
2085	205,569	107,833	19,016	126,849	1.6	62
2090	206,635	110,312	19,105	129,417	1.6	63

[a] Workers who are paid at some time during the year for employment on which OASDI taxes are due.
[b] Beneficiaries with monthly benefits in current-payment status as of June 30.
[c] This column is the sum of OASI and DI beneficiaries. A small number of beneficiaries receive benefits from both funds.

Notes:
1. The number of beneficiaries does not include uninsured individuals who received benefits under Section 228 of the Social Security Act. The General Fund of the Treasury reimbursed the trust funds for the costs of most of these individuals.
2. Historical covered worker and beneficiary data are subject to revision.
3. Totals do not necessarily equal the sums of rounded components.

The effect of the demographic shift under the three alternatives on the OASDI cost rates is clear when one considers the projected number of OASDI beneficiaries per 100 covered workers. Compared to the 2015 level of 35 beneficiaries per 100 covered workers, the Trustees project that this ratio rises to 46 by 2035 under the intermediate assumptions because the growth in beneficiaries greatly exceeds the growth in workers. By 2090, this projected ratio rises further under the intermediate and high-cost assumptions, reaching 50 under the intermediate assumptions and 63 under the high-cost assumptions. Under the low-cost assumptions, this ratio rises to 43 by 2035 and then declines, reaching 40 by 2090. Figure IV.B2 shows beneficiaries per 100 covered workers.

For each alternative, the curve in figure IV.B2 is strikingly similar to the corresponding cost-rate curve in figure IV.B1. This similarity emphasizes the extent to which the cost rate is determined by the age distribution of the population. The cost rate is essentially the product of the number of beneficiaries and their average benefit, divided by the product of the number of covered workers and their average taxable earnings. For this reason, the pattern of the annual cost rates is similar to that of the annual ratios of beneficiaries to workers.

Figure IV.B2.—Number of OASDI Beneficiaries Per 100 Covered Workers

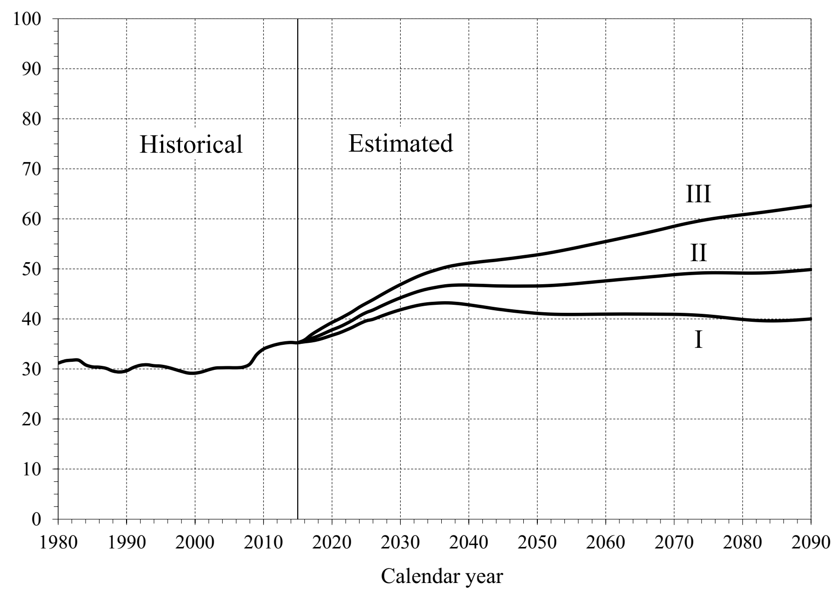


Table IV.B3 also shows the number of covered workers per OASDI beneficiary, which was about 2.8 for 2015. Under the low-cost assumptions, this ratio declines to 2.3 for 2035, generally rises from 2035 through 2080, and remains relatively stable at 2.5 through 2090. Under the intermediate assumptions, this ratio declines generally throughout the long-range period, reaching 2.2 for 2035 and 2.0 by 2090. Under the high-cost assumptions, this ratio decreases steadily to 1.6 by 2090.

3. Trust Fund Ratios and Test of Long-Range Close Actuarial Balance

Trust fund ratios are critical indicators of the adequacy of the financial resources of the Social Security program. The trust fund ratio for a year is the amount of asset reserves in a fund at the beginning of a year expressed as a percentage of the cost for the year. Under present law, the OASI and DI Trust Funds do not have the authority to borrow other than in the form of advance tax transfers, which are limited to expected taxes for the current calendar month. If reserves held in either trust fund become depleted during a year, and continuing tax revenues fall short of the cost of scheduled benefits, then full scheduled benefits would not be payable on a timely basis. For this reason, the trust fund ratio is a very critical financial measure.

The trust fund ratio serves an additional important purpose in assessing the actuarial status of the program. If the projected trust fund ratio is positive throughout the period and is either level or increasing at the end of the period, then projected adequacy for the long-range period is likely to continue for subsequent reports. Under these conditions, the program has achieved sustainable solvency.

Table IV.B4 shows the Trustees' projections of trust fund ratios by alternative, without regard to advance tax transfers that would be effected, for the separate and combined OASI and DI Trust Funds. The table also shows the years of trust fund reserve depletion and the percentage of scheduled benefits that would be payable thereafter, by alternative.

Under the intermediate assumptions, the OASI trust fund ratio has declined since 2011 and continues to decline from 357 percent at the beginning of 2016[1] until the trust fund reserves become depleted in 2035 (the same year as projected in last year's report), at which time 77 percent of scheduled benefits would be payable. The DI trust fund ratio has been declining steadily since 2003 (at first slowly and then more rapidly due to reduced employment and increased disability claims during the recent recession), reaching 21 percent at the beginning of 2016. The 0.57-percentage-point reallocation of payroll tax rate (for 2016 through 2018) from OASI to DI will increase the trust fund ratio to 48 percent at the beginning of 2019. After 2019, the trust fund ratio declines until the trust fund reserves become depleted in 2023, at which time 89 percent of scheduled benefits would be payable.

Under the intermediate assumptions, the trust fund ratio for the combined OASI and DI Trust Funds declines from 303 percent at the beginning of 2016 until the combined fund reserves become depleted in 2034 (the same

[1] If the scheduled January 3, 2016 payment, actually paid on December 31, 2015, were counted as reducing trust fund reserves at the end of 2015 for presentation in this report, then the OASI trust fund ratio shown for 2016 would be 355 percent.

year as projected in last year's report), at which time 79 percent of scheduled benefits would be payable.

Under the low-cost assumptions, the trust fund ratio for the DI program increases from 22 percent at the beginning of 2016 to 66 percent at the beginning of 2019, again reflecting the temporary payroll tax rate reallocation. The DI trust fund ratio is then stable through 2023 and thereafter increases through the end of the long-range projection period, reaching the extremely high level of 1,930 percent for 2091. For the OASI program, the trust fund ratio generally declines steadily, from 357 percent for 2016 to 35 percent for 2091. The expectation would be for the OASI Trust Fund reserves to become depleted several years after the 75-year projection period. For the combined OASDI program, the trust fund ratio declines from 304 percent for 2016 to a low of 142 percent in 2044, then rises thereafter reaching 260 percent by 2091. Because the trust fund ratio is positive throughout the projection period and increasing at the end of the period, under the low-cost assumptions, the DI program and the combined OASDI program achieve sustainable solvency.

Under the high-cost assumptions, the OASI trust fund ratio declines continually until reserves become depleted in 2030, at which time 69 percent of scheduled benefits would still be payable. The DI trust fund ratio stays relatively stable between 21 and 25 percent through 2019 because of the payroll tax rate reallocation, but reserves decline quickly after that and become depleted in 2020. At that time, 76 percent of scheduled benefits would still be payable. The combined OASI and DI trust fund ratio declines from 302 percent for 2016 until reserves become depleted in 2029, at which time 71 percent of scheduled benefits would still be payable.

The Trustees project trust fund reserve depletion within the 75-year projection period with the exceptions of the combined OASDI Trust Funds and the individual OASI and DI Trust Funds under the low-cost assumptions. It is therefore very likely that lawmakers will need to increase income, reduce program costs, or both, in order to maintain solvency for the trust funds. The stochastic projections discussed in appendix E suggest that trust fund reserve depletion is highly probable by mid-century.

Even under the high-cost assumptions, however, the combined OASI and DI Trust Fund reserves on hand plus their estimated future income are sufficient to fully cover their combined cost until 2029. Under the intermediate assumptions, the combined starting fund reserves plus estimated future income are sufficient to fully cover cost until 2034. In the 2015 report, the Trustees projected that the combined trust fund reserves would become depleted in 2028 and 2034 under the high-cost and intermediate assumptions, respectively, and would achieve sustainable solvency under the low-cost assumptions.

Table IV.B4.—Trust Fund Ratios, Calendar Years 2016-2090[a]
[In percent]

Calendar year	Intermediate			Low-cost			High-cost		
	OASI	DI	OASDI	OASI	DI	OASDI	OASI	DI	OASDI
2016	357	21	303	357	22	304	357	21	302
2017	343	26	293	343	29	294	342	23	290
2018	321	36	277	321	45	280	318	24	271
2019	300	48	262	302	66	268	292	25	250
2020	282	36	246	289	63	257	270	3	229
2021	266	24	231	277	63	248	248	[b]	207
2022	249	13	216	266	64	239	225	[b]	185
2023	231	2	200	254	68	230	200	[b]	161
2024	213	[b]	183	242	75	221	175	[b]	137
2025	194	[b]	165	231	84	213	149	[b]	111
2030	102	[b]	81	186	160	183	17	[b]	[b]
2035	3	[b]	[b]	149	276	162	[b]	[b]	[b]
2040	[b]	[b]	[b]	114	410	146	[b]	[b]	[b]
2045	[b]	[b]	[b]	92	536	142	[b]	[b]	[b]
2050	[b]	[b]	[b]	81	665	148	[b]	[b]	[b]
2055	[b]	[b]	[b]	76	800	160	[b]	[b]	[b]
2060	[b]	[b]	[b]	69	959	170	[b]	[b]	[b]
2065	[b]	[b]	[b]	59	1,121	179	[b]	[b]	[b]
2070	[b]	[b]	[b]	48	1,288	187	[b]	[b]	[b]
2075	[b]	[b]	[b]	37	1,471	197	[b]	[b]	[b]
2080	[b]	[b]	[b]	31	1,625	215	[b]	[b]	[b]
2085	[b]	[b]	[b]	34	1,745	238	[b]	[b]	[b]
2090	[b]	[b]	[b]	36	1,895	257	[b]	[b]	[b]
Trust fund reserves permanently become depleted in	2035	2023	2034	[c]	[c]	[c]	2030	2020	2029
Payable benefits as percent of scheduled benefits:									
At the time of permanent reserve depletion	77	89	79	[c]	[c]	[c]	69	76	71
For 2090	73	82	74	[c]	[c]	[c]	52	58	53

[a] Benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund ratios reflect the 12 months of benefits scheduled for payment each year.
[b] Trust fund reserves would be depleted at the beginning of this year.
[c] Trust fund reserves would not be depleted within the projection period.

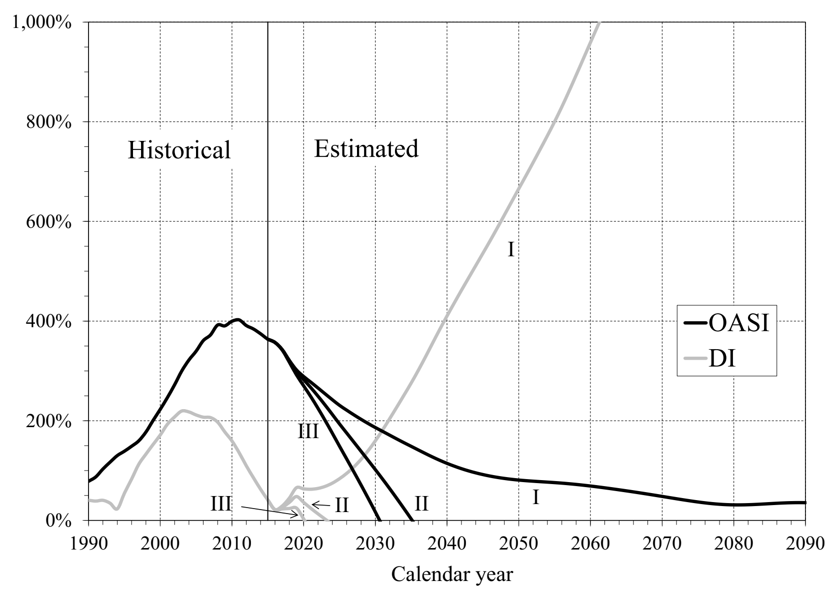
Note: The definition of trust fund ratio appears in the Glossary. The ratios shown for the combined trust funds for years after reserve depletion of either the DI or OASI Trust Fund are hypothetical.

Since 2013, when the Trustees modified the test of long-range close actuarial balance, the standard for each trust fund requires meeting two conditions: (1) the test of short-range financial adequacy is satisfied; and (2) the trust fund ratios stay above zero throughout the 75-year projection period, allowing scheduled benefits to be paid in a timely manner throughout the period.

As discussed in section IV.A, the DI Trust Fund fails the test of short-range financial adequacy under the intermediate assumptions because trust fund reserves become depleted in the third quarter of 2023. Under the intermediate assumptions, the OASI Trust Fund reserves become depleted in 2035, and the combined OASI and DI Trust Fund reserves become depleted in 2034. Therefore, the OASI, DI, and combined OASI and DI Trust Funds all fail the long-range test of close actuarial balance.

Figure IV.B3 illustrates the trust fund ratios for the separate OASI and DI Trust Funds for each of the alternative sets of assumptions. DI Trust Fund status is more uncertain than OASI Trust Fund status because there is a high degree of uncertainty associated with future disability prevalence. A graph of the trust fund ratios for the combined trust funds appears in figure II.D7.

Figure IV.B3.—Long-Range OASI and DI Trust Fund Ratios
[Asset reserves as a percentage of annual cost]



4. Summarized Income Rates, Summarized Cost Rates, and Actuarial Balances

Summarized values for the full 75-year period are useful in analyzing the program's long-range financial adequacy over the period as a whole, both under present law and under proposed modifications to the law. All annual amounts included in a summarized value are present-value discounted to the valuation date. It is important to note that the actuarial balance indicates the solvency status of the fund only for the very end of the period.

Table IV.B5 presents summarized income rates, summarized cost rates, and actuarial balances for 25-year, 50-year, and 75-year valuation periods. Summarized income rates are the sum of the present value of non-interest income for a period (which includes scheduled payroll taxes, the projected income from the taxation of scheduled benefits, and reimbursements from the General Fund of the Treasury) and the starting trust fund asset reserves, expressed as a percentage of the present value of taxable payroll over the period. Under current law, the total OASDI payroll tax rate will remain at 12.4 percent in the future. In contrast, the Trustees expect income from taxation of benefits, expressed as a percentage of taxable payroll, to increase in most years of the long-range period for the two reasons discussed earlier on page 53. Summarized cost rates are the sum of the present value of cost for a period (which includes scheduled benefits, administrative expenses, net interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries) and the present value of the cost of reaching a target trust fund of 100 percent of annual cost at the end of the period, expressed as a percentage of the present value of taxable payroll over the period.

The actuarial balance for a valuation period is equal to the difference between the summarized income rate and the summarized cost rate for the period. An actuarial balance of zero for any period indicates that cost for the period could be met for the period as a whole (but not necessarily at all points within the period), with a remaining trust fund reserve at the end of the period equal to 100 percent of the following year's cost. A negative actuarial balance for a period indicates that the present value of income to the program plus the existing trust fund is less than the present value of the cost of the program plus the cost of reaching a target trust fund reserve of 1 year's cost by the end of the period. Generally, a trust fund is deemed to be adequately financed for a period if the actuarial balance is zero or positive, meaning that the reserves at the end of the period are at least equal to annual cost. Note that solvency is possible with a small negative actuarial balance where reserves are still positive.[1]

Table IV.B5 contains summarized rates for the intermediate, low-cost, and high-cost assumptions. The low-cost and high-cost assumptions define a

[1] A program is solvent over any period for which the trust fund maintains a positive level of asset reserves. In contrast, the actuarial balance for a period includes the cost of having a target fund equal to 100 percent of the following year's cost at the end of the period. Therefore, if a program ends the period with reserves that are positive but not sufficient to cover the following year's costs, it will be solvent at the end of the period and yet still have a small negative actuarial balance for that period.

wide range of possibilities. Financial outcomes as good as the low-cost scenario or as bad as the high-cost scenario are unlikely to occur.

For the 25-year valuation period, the OASDI program has an actuarial balance of 0.24 percent of taxable payroll under the low-cost assumptions, -1.48 percent under the intermediate assumptions, and -3.53 percent under the high-cost assumptions. These balances indicate that the program is adequately financed for the 25-year valuation period under only the low-cost assumptions.

For the 50-year valuation period, the OASDI program has actuarial balances of 0.19 percent under the low-cost assumptions, -2.23 percent under the intermediate assumptions, and -5.23 percent under the high-cost assumptions. These actuarial balances mean that the OASDI program is adequately financed for the 50-year valuation period under only the low-cost assumptions.

For the entire 75-year valuation period, the combined OASDI program has actuarial balances of 0.22 percent of taxable payroll under the low-cost assumptions, -2.66 percent under the intermediate assumptions, and -6.30 percent under the high-cost assumptions. These balances indicate that the combined OASDI program is adequately financed for the 75-year valuation period under only the low-cost assumptions.

Assuming the intermediate assumptions accurately capture future demographic and economic trends, solvency for the program over the next 75 years could be restored using a variety of approaches. For example, revenues could be increased in a manner equivalent to an immediate and permanent increase in the combined Social Security payroll tax rate from 12.40 percent to 14.98 percent (a relative increase of 20.8 percent), cost could be reduced in a manner equivalent to an immediate and permanent reduction in scheduled benefits of about 16 percent, or some combination of approaches could be used.

However, eliminating the actuarial deficit for the next 75-year valuation period requires raising payroll taxes or lowering benefits by more than is required just to achieve solvency, because the actuarial deficit includes the cost of attaining a target trust fund equal to 100 percent of annual program cost by the end of the period. The actuarial deficit could be eliminated for the 75-year period by increasing revenues in a manner equivalent to an immediate and permanent increase in the combined payroll tax from 12.40 percent to 15.15 percent (a relative increase of 22.2 percent),[1] reducing cost in a manner equivalent to an immediate reduction in scheduled benefits of about 17 percent, or some combination of approaches could be used.

Under the intermediate assumptions, the OASDI program has large annual deficits toward the end of the long-range period that are increasing and reach 4.35 percent of payroll for 2090 (see table IV.B1). These large deficits indicate that annual cost continues to exceed non-interest income after 2090, so continued adequate financing would require larger changes than those needed to maintain solvency for the 75-year period. Over the period extending through the infinite horizon, the actuarial deficit is 4.0 percent of payroll under the intermediate assumptions.

Under the intermediate assumptions, the financial shortfall of the DI program is larger than that of the OASI program for the first 25 years when measured relative to the level of program cost. Summarized over the full 75-year period, however, the financial shortfall for the OASI program is larger than that of the DI program, measured relative to the level of program cost. Increases in longevity after 2027, when the age of conversion from disabled-worker benefits to retired-worker benefits remains fixed, have a greater effect on OASI cost than on DI cost. As a result of this greater effect on OASI cost, the financial shortfall for the OASI program in the later portion of the 75-year projection period is larger than the financial shortfall for the DI program.

Table IV.B5.—Components of Summarized Income Rates and Cost Rates, Calendar Years 2016-2090
[As a percentage of taxable payroll]

	Summarized income rate			Summarized cost rate			
Valuation period	Non-interest income	Beginning asset reserves[a]	Total	Cost[a]	Ending target fund[a]	Total	Actuarial balance
OASI:							
Intermediate:							
2016-40.	11.24	1.51	12.75	13.46	0.56	14.02	-1.27
2016-65.	11.31	.82	12.14	13.89	.24	14.13	-1.99
2016-90.	11.35	.61	11.96	14.21	.14	14.36	-2.39
Low-cost:							
2016-40.	11.16	1.38	12.54	12.00	.48	12.49	.05
2016-65.	11.20	.72	11.93	11.81	.21	12.01	-.08
2016-90.	11.21	.52	11.73	11.69	.12	11.81	-.08
High-cost:							
2016-40.	11.33	1.69	13.01	15.21	.64	15.85	-2.84
2016-65.	11.45	.95	12.40	16.47	.29	16.76	-4.35
2016-90.	11.53	.73	12.26	17.44	.17	17.61	-5.35

[1] The indicated increase in the payroll tax rate of 2.75 percent is somewhat larger than the 2.66 percent 75-year actuarial deficit because the indicated increase reflects a behavioral response to tax rate changes. In particular, the calculation assumes that an increase in payroll taxes results in a small shift of wages and salaries to forms of employee compensation that are not subject to the payroll tax.

Table IV.B5.—Components of Summarized Income Rates and Cost Rates, Calendar Years 2016-2090 (Cont.)
[As a percentage of taxable payroll]

	Summarized income rate			Summarized cost rate			
Valuation period	Non-interest income	Beginning asset reserves[a]	Total	Cost[a]	Ending target fund[a]	Total	Actuarial balance
DI:							
Intermediate:							
2016-40.	1.90	0.02	1.92	2.05	0.08	2.13	-0.21
2016-65.	1.88	.01	1.89	2.10	.04	2.13	-.24
2016-90.	1.87	.01	1.88	2.12	.02	2.14	-.26
Low-cost:							
2016-40.	1.89	.02	1.90	1.65	.06	1.71	.19
2016-65.	1.86	.01	1.87	1.57	.03	1.60	.27
2016-90.	1.86	.01	1.86	1.55	.02	1.56	.30
High-cost:							
2016-40.	1.91	.02	1.93	2.52	.10	2.63	-.69
2016-65.	1.89	.01	1.91	2.73	.05	2.78	-.87
2016-90.	1.89	.01	1.90	2.83	.02	2.86	-.95
OASDI:							
Intermediate:							
2016-40.	13.14	1.53	14.67	15.51	.64	16.15	-1.48
2016-65.	13.19	.83	14.03	15.98	.28	16.26	-2.23
2016-90.	13.23	.62	13.84	16.34	.16	16.50	-2.66
Low-cost:							
2016-40.	13.05	1.39	14.44	13.66	.54	14.20	.24
2016-65.	13.07	.73	13.80	13.38	.23	13.61	.19
2016-90.	13.07	.52	13.59	13.23	.14	13.37	.22
High-cost:							
2016-40.	13.24	1.71	14.95	17.73	.75	18.48	-3.53
2016-65.	13.35	.96	14.31	19.20	.33	19.53	-5.23
2016-90.	13.42	.74	14.16	20.27	.19	20.46	-6.30

[a] Benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.

Note: Totals do not necessarily equal the sums of rounded components.

5. Open Group Unfunded Obligation

Consistent with practice since 1965, this report focuses on a 75-year open group valuation to evaluate the long-run financial status of the OASDI program. The open group valuation includes non-interest income and cost for past, current, and future participants through the year 2090. The open group unfunded obligation measures the adequacy of financing over the period as a whole for a program financed on a pay-as-you-go basis. On this basis, payroll taxes and scheduled benefits for all participants are included through 2090.

The open group unfunded obligation increased from $10.7 trillion shown in last year's report to $11.4 trillion in this report. If there had been no changes in starting values, assumptions, laws, or methods for this report, then the open group unfunded obligation would have increased to $11.2 trillion solely due to the change in the valuation period. This expected increase in the unfunded obligation occurs because: (1) the unfunded obligation is now discounted to January 1, 2016, rather than to January 1, 2015, which tends to increase the unfunded obligation by the annual nominal interest rate; and (2) the unfunded obligation now includes an additional year (2090). However, changes in the law, assumptions, methods, and starting values resulted in a net $0.2 trillion increase in the unfunded obligation.

The 75-year unfunded obligation is equivalent to 2.49 percent of future OASDI taxable payroll and 0.9 percent of GDP through 2090. These percentages were 2.53 and 0.9, respectively, for last year's report. The 75-year unfunded obligation as a percentage of taxable payroll is less than the actuarial deficit, because the unfunded obligation excludes the cost of having an ending target trust fund value.

The actuarial deficit was 2.68 percent of payroll in last year's report, and was expected to increase to a deficit of 2.74 percent of payroll solely due to the change in the valuation period. Changes in the law, assumptions, methods, and starting values combined to account for a 0.08 percent decrease (improvement) in the actuarial deficit to 2.66 percent of payroll. For additional details on these changes, see section IV.B.6.

As mentioned above, the open group unfunded obligation expressed in dollars increased (worsened) more than would be expected from changing the valuation period alone. In large part, this increase occurred because near-term and ultimate real interest rates are significantly reduced in this report, thus discounting more distant years' annual shortfalls less. The actuarial balance, in contrast, increased (improved) relative to the change based on the valuation period effect alone. Lower interest rates have a much smaller worsening effect on the actuarial balance because interest rate changes affect the numerator and denominator similarly.

Table IV.B6 presents the components and the calculation of the long-range (75-year) actuarial balance under the intermediate assumptions. The present value of future cost less future non-interest income over the long-range period, minus the amount of trust fund asset reserves at the beginning of the projection period, amounts to $11.4 trillion for the OASDI program. This amount is the 75-year "open group unfunded obligation" (see row H). The actuarial deficit (which is the negative of the actuarial balance) combines this unfunded obligation with the present value of the ending target trust fund and expresses the total as a percentage of the present value of the taxable payroll for the period. The present value of future non-interest income minus cost, plus starting trust fund reserves, minus the present value of the ending target trust fund, is -$12.1 trillion for the OASDI program.

Table IV.B6.—Components of 75-Year Actuarial Balance and Unfunded Obligation Under Intermediate Assumptions

Item	OASI	DI	OASDI
Present value as of January 1, 2016 (in billions):			
A. Payroll tax revenue	$48,095	$8,301	$56,396
B. Reimbursements from general revenue	a	a	a
C. Taxation of benefits revenue	3,606	230	3,836
D. Non-interest income (A + B + C)	51,701	8,531	60,232
E. Cost	64,730	9,672	74,401
F. Cost minus non-interest income (E - D)	13,028	1,141	14,169
G. Trust fund asset reserves at start of period	2,780	32	2,813
H. Open group unfunded obligation (F - G)	10,248	1,109	11,357
I. Ending target trust fund[b]	649	94	743
J. Income minus cost, plus reserves at start of period, minus ending target trust fund (D - E + G - I = - H - I)	-10,897	-1,203	-12,100
K. Taxable payroll	455,364	455,364	455,364
Percent of taxable payroll:			
Actuarial balance (100 × J ÷ K)	-2.39	-.26	-2.66

[a] Less than $0.5 billion.
[b] The calculation of the actuarial balance includes the cost of accumulating a target trust fund reserve equal to 100 percent of annual cost at the end of the period.

Note: Totals do not necessarily equal the sums of rounded components.

Consideration of summary measures alone (such as the actuarial balance and open group unfunded obligation) for a 75-year period can lead to incorrect perceptions and to policy prescriptions that do not achieve sustainable solvency. These concerns can be addressed by considering the trend in trust fund ratios toward the end of the period. (See the discussion of “sustainable solvency” beginning on page 52.)

Another measure of trust fund finances, discussed in appendix F, is the infinite horizon unfunded obligation, which takes account of all annual balances, even those after 75 years. The extension of the time period past 75 years assumes that the current-law OASDI program and the demographic and economic trends used for the 75-year projection continue indefinitely. This infinite horizon unfunded obligation is estimated to be 4.0 percent of taxable payroll or 1.4 percent of GDP. These percentages were 3.9 and 1.3, respectively, for last year’s report. Of course, the degree of uncertainty associated with estimates increases substantially for years further in the future.

6. Reasons for Change in Actuarial Balance From Last Report

Table IV.B7 shows the effects of changes on the long-range actuarial balance under the intermediate assumptions, by category, between last year's report and this report.

Table IV.B7.—Reasons for Change in the 75-Year Actuarial Balance, Based on Intermediate Assumptions
[As a percentage of taxable payroll]

Item	OASI	DI	OASDI
Shown in last year's report:			
Income rate	12.00	1.86	13.86
Cost rate	14.37	2.17	16.55
Actuarial balance	**-2.37**	**-.31**	**-2.68**
Changes in actuarial balance due to changes in:			
Legislation / Regulation	-.01	.04	.03
Valuation period[a]	-.05	-.01	-.06
Demographic data and assumptions	.00	.00	.00
Economic data and assumptions	-.06	-.01	-.07
Disability data and assumptions	.00	.00	.00
Methods and programmatic data	.08	.03	.11
Total change in actuarial balance	-.02	.05	.02
Shown in this report:			
Actuarial balance	**-2.39**	**-.26**	**-2.66**
Income rate	11.96	1.88	13.84
Cost rate	14.36	2.14	16.50

[a] The change in the 75-year valuation period from last year's report to this report means that the 75-year actuarial balance now includes the relatively large negative annual balance for 2090. This change in the valuation period results in a larger long-range actuarial deficit. The actuarial deficit includes the trust fund reserve at the beginning of the projection period.

Note: Totals do not necessarily equal the sums of rounded components.

If the assumptions, methods, starting values, and the law had all remained unchanged from last year's Trustees Report, the long-range OASDI actuarial balance would have decreased (become more negative) by 0.06 percent of taxable payroll solely due to the change in the valuation period. However, as described below, projections in this report also reflect changes in law, data, assumptions, and methods. These changes, including the change in the valuation period, combined to improve the long-range OASDI actuarial balance, from -2.68 percent of taxable payroll in last year's report to -2.66 percent in this report.

Since the last report, one law was enacted that is expected to have a significant effect on the long-range cost of the OASDI program. On November 2, 2015, the President signed into law Public Law 114-74, the Bipartisan Budget Act of 2015. Several sections of the law had significant effects on long-range actuarial status, including:

- Section 831. Closure of unintended loopholes. This provision eliminates (1) the ability to receive only a retired-worker benefit or an aged-spouse benefit when eligible for both, for those attaining age 62 in 2016 and later, and (2) the ability of a family member other than a divorced spouse to receive a benefit based on the earnings of a worker with a voluntarily suspended benefit, for voluntary suspensions requested after April 29, 2016. This provision is expected to increase (improve) the long-range actuarial balance by 0.02 percent of taxable payroll.
- Section 832. Requirement for medical review. This section requires that the medical portion of the case review and any applicable residual functional capacity assessment for an initial disability determination be completed by an appropriate physician, psychiatrist, or psychologist. This provision increased the long-range actuarial balance by 0.01 percent of payroll.
- Section 833. Reallocation of payroll tax rates. For earnings in calendar years 2016 through 2018, this section increases from 1.80 percent to 2.37 percent the portion of the total 12.40 percent OASDI payroll tax that is directed to the DI Trust Fund. This reallocation of the payroll tax rates had no cost effect on the combined OASDI program, but extended projected DI Trust Fund reserve depletion by about 6 years.

Overall, the effects of this law are projected to increase the long-range OASDI actuarial balance by 0.03 percent of taxable payroll.

Changing the 75-year valuation period from 2015 through 2089 to 2016 through 2090 decreased (worsened) the projected long-range OASDI actuarial balance by 0.06 percent of taxable payroll. This decrease is mainly the result of including the relatively large negative annual balance for 2090 in this year's 75-year projection period. Note that the actuarial balance calculation includes trust fund asset reserves at the beginning of the projection period. These reserves at the start of the period reflect the program's net financial flows for all past years up to the start of the projection period, including 2015.

With the exception of a small change in marriage rates, ultimate demographic assumptions are unchanged from those in last year's report. All changes in demographic data and assumptions combined to have a negligible net effect on the long-range OASDI actuarial balance. The following paragraph describes four of the demographic assumptions and data changes that, individually, had significant effects on the long-range OASDI actuarial balance.

First, final fertility (birth) data for 2013 and 2014 indicate slightly lower birth rates than were assumed for last year's report for these years. The data also show an increase in birth rates starting in 2014, one year later than assumed in last year's report. As in last year's report, the estimates reflect: (1) the effect of the recent economic recession on the total fertility rate for recent years and (2) the assumption that the total fertility rate will rebound to a level temporarily above the ultimate level and will subsequently decline to the ultimate level. This year's estimates use a slightly smaller rebound in the path to the ultimate total fertility rate, which is again reached in 2027. These changes in historical and projected birth rates decreased the long-range OASDI actuarial balance by about 0.03 percent of taxable payroll. Second, incorporating mortality data obtained from the National Center for Health Statistics at ages under 65 for 2012 and 2013 and from Medicare experience at ages 65 and older for 2013 resulted in slightly higher death rates than were projected in last year's report. These updated data combined to increase the long-range OASDI actuarial balance by about 0.04 percent of taxable payroll. Third, the assumed ultimate marriage rates were decreased somewhat to reflect a continuation of recent trends. This change increased the actuarial balance by 0.01 percent of taxable payroll. Fourth, including more recent legal and other-than-legal immigration data and updating historical population data combined to decrease the long-range OASDI actuarial balance by 0.02 percent of taxable payroll.

Overall, changes in ultimate and near-term economic data and assumptions decreased the actuarial balance by 0.07 percent of payroll. The following paragraph describes the ultimate economic assumptions that had significant effects on the long-range OASDI actuarial balance.

Three ultimate economic assumptions in this year's report were changed from the values used in last year's report. First, the ultimate rate of price inflation (CPI-W) was lowered by 0.1 percentage point, from 2.7 percent for last year's report to 2.6 percent for this year's report. While very low inflation in recent years is reflective of U.S. and international supply and demand factors that have been affected by the global recession, the average rate of change in the CPI-W over the last two complete business cycles (from 1989 to 2007) is 2.63 percent. This change decreases the OASDI actuarial balance by 0.02 percent of payroll. Second, the ultimate average real wage differential is 1.20 percent per year in this report, increased from the 1.17 percent in last year's report. This change increased the long-range OASDI actuarial balance by 0.05 percent of taxable payroll. The higher real wage differential assumption is based on new projections by the Centers for Medicare and Medicaid Services of slower growth in employer sponsored group health insurance premiums. Because these premiums are not subject to the payroll tax, slower growth in these premiums means that a greater share of employee compensation will be in the form of wages that are subject to the payroll tax. Third, the ultimate real interest rate was lowered by 0.2 percentage point, from 2.9 percent for last year's report to 2.7 percent for this year's report. Real interest rates have been low since 2000, and particularly low since the start of the recent recession. An ongoing and much-debated question among experts is how much of this change is cyclic or a temporary response to extraordinary events, versus a fundamental permanent change. The Trustees believe that lowering the long-term ultimate real interest rate somewhat is appropriate at this time. This change decreased the OASDI actuarial balance by 0.08 percent of payroll.

In addition to the three changes in ultimate economic assumptions, updated starting values and changes in near-term economic assumptions combined to decrease the long-range OASDI actuarial balance slightly. In particular, this report reflects the July 2015 revisions in historical GDP estimated by the Bureau of Economic Analysis of the Department of Commerce and further assumed reductions in the ultimate level of actual and potential GDP of about 0.8 percent. Beyond this revision, a further reduction in the ultimate level of actual and potential GDP of about 1 percent is assumed. Thus, by the end of the short-range period (2025) and for all years thereafter, projected GDP in 2009 dollars is about 1.8 percent below the level in last year's report. These changes to assumed actual and potential GDP decreased the actuarial balance by about 0.03 percent of taxable payroll. Other changes to starting values and near-term economic assumptions combined for a net increase the actuarial balance of 0.02 percent of taxable payroll.

The projections in this report also reflect several methodological improvements and updates of program-specific data. These methodological changes, programmatic data updates, and interactions combined to increase the long-range OASDI actuarial balance by 0.11 percent of taxable payroll. Descriptions of six significant methodological changes and programmatic data updates follow.

First, for this year's report, the transition from recent mortality rates to the ultimate rates starts sooner, immediately after the year of final data. The approach used for the 2015 report extended the trend of the last 10 years through the valuation year for the report and only thereafter started the transition to assumed ultimate rates of decline. The new approach will make the projections less influenced by recent fluctuations in the rate of improvement in mortality, thus diminishing volatility from one report to the next. This methodological improvement increased the long-range OASDI actuarial balance by 0.03 percent of taxable payroll.

Second, several improvements were made to immigration methods. Historical non-immigrant population counts were revised to match recent totals provided by the Department of Homeland Security. In addition, emigration rates for the never-authorized and visa-overstayer populations were recalibrated to reflect a longer historical period and to be less influenced by the high emigration rates experienced during the recent recession. Finally, the method for projecting emigration of the never-authorized population was altered to reflect lower rates of emigration for those who have resided here longer. These methodological improvements increased the long-range OASDI actuarial balance by 0.09 percent of taxable payroll.

The third significant change was an improvement in the method for disaggregating the other-than-legal population in order to assign them appropriate earnings and quarters of coverage. This change led to a small decrease in the number of covered workers and number of insured workers, and decreased the actuarial balance by 0.01 percent of payroll.

Fourth, enhancements were made to methods for modeling the number of beneficiaries utilizing “claiming strategies” to better reflect their growing popularity and the growth in the underlying population eligible to use the strategies. This year’s report also incorporates new historical data, which allowed projection of “deemed filer” aged spouses by sex and marital status. These improved methods for modeling claiming strategies were incorporated prior to estimating the effects of elimination of such strategies per the Bipartisan Budget Act of 2015, described above. These methodological changes decreased the actuarial balance by 0.01 percent of payroll, which was offset by the changes made as a part of the Bipartisan Budget Act of 2015.

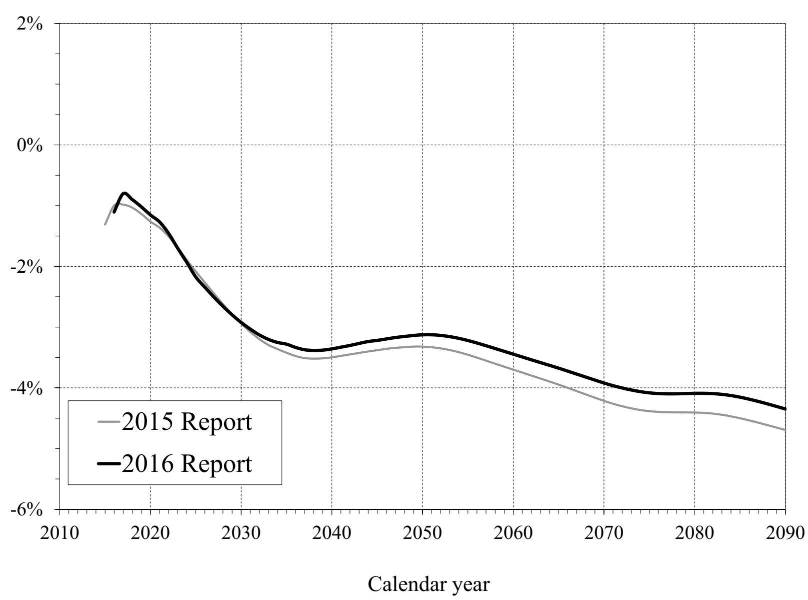
The fifth significant change relates to the long-range model for projecting average benefit levels of retired worker and disabled-worker beneficiaries newly entitled for benefits, which is based on a large sample of 10 percent of all newly entitled retired-worker beneficiaries in a recent year. The sample used in the 2015 report was for worker beneficiaries newly entitled in 2008. This year’s report uses the results from worker beneficiaries newly entitled in 2013. In addition, the method used to determine initial entitlements was improved, primarily to take into account the recent increase of “file and suspend” cases, which were not fully included under the previous methodology. Using this more recent sample and the associated method improvement increased the OASDI actuarial balance by 0.02 percent of payroll.

The sixth significant change is a programmatic data update that resulted in an increase in income from taxation of benefits in this year’s report. Recent data and estimates provided by the Office of Tax Analysis at the Department of Treasury indicate higher levels of revenue from taxation of OASDI benefits than projected in last year’s report. The increase in the near-term and ultimate projected ratios of income from taxation of benefits to benefits resulted in an increase in the long-range OASDI actuarial balance of 0.03 percent of taxable payroll.

In addition to these six significant methodological changes and programmatic data updates, changes in projected OASI and DI beneficiaries and benefit levels over the first 10 years of the projection period, updating other programmatic data, other small methodological improvements, and interactions combined to decrease the long-range OASDI actuarial balance by 0.04 percent of taxable payroll.

Figure IV.B4 compares the annual cash-flow balances for this report and the prior year's report for the combined OASDI program over the long-range (75-year) projection period. The figure illustrates the annual effects of the changes described earlier in this section.

Figure IV.B4.—OASDI Annual Balances: 2015 and 2016 Trustees Reports
[As a percentage of taxable payroll, based on intermediate assumptions]



This pattern of differences between the annual balances (income rate minus cost rate) in the two reports is due to the changes described earlier in this section. The annual balances are higher (less negative) each year in this year's report, with the exception of 2016 and 2023 through 2029, and average 0.20 percentage point higher over the 75-year projection period. For 2089, the projected annual deficit is 4.30 percent of taxable payroll in this report, compared to 4.65 percent in last year's report.

V. ASSUMPTIONS AND METHODS UNDERLYING ACTUARIAL ESTIMATES

The future income and cost of the OASDI program will depend on many demographic, economic, and program-specific factors. Trust fund income will depend on how these factors affect the size and composition of the working population as well as the level and distribution of earnings. Similarly, program cost will depend on how these factors affect the size and composition of the beneficiary population as well as the general level of benefits.

The Trustees make basic assumptions for several of these factors based on analysis of historical trends, historical conditions, and expected future conditions. These factors include fertility, mortality, immigration, marriage, divorce, productivity, inflation, average earnings, unemployment, real interest rate, and disability incidence and termination. Other factors depend on these basic assumptions. These other, often interdependent, factors include total population, life expectancy, labor force participation, gross domestic product, and program-specific factors. Each year the Trustees reexamine these assumptions and methods in light of new information and make appropriate revisions. The Trustees selected the assumptions for this report by the end of December 2015.

Future levels of these factors and their interrelationships are inherently uncertain. To address these uncertainties, this report uses three sets of assumptions, designated as intermediate (alternative II), low-cost (alternative I), and high-cost (alternative III). The intermediate set represents the Trustees' best estimate of the future course of the population and the economy. With regard to the net effect on the actuarial status of the OASDI program, the low-cost set is more optimistic and the high-cost set is more pessimistic. The low-cost and high-cost sets of assumptions reflect significant potential changes in the interrelationships among factors, as well as changes in the values for individual factors.

While it is unlikely that all of the factors and interactions will differ in the specified directions from the intermediate values, many combinations of individual differences in the factors could have a similar overall effect. Outcomes with overall long-range cost as low as the low-cost scenario or as high as the high-cost scenario are very unlikely. This report also includes sensitivity analysis, where factors are changed one at a time (see appendix D), and a stochastic projection, which provides a probability distribution of possible future outcomes, with each input assumption centered around the intermediate alternative (see appendix E).

Readers should interpret with care the estimates based on the three sets of alternative assumptions. These estimates are not specific predictions of the future financial status of the OASDI program. Rather, they provide a reasonable range of future income and cost bounded by two plausible, albeit very unlikely, demographic and economic scenarios.

The Trustees assume that values for each of the demographic, economic, and program-specific factors change toward long-range ultimate values from recent levels or trends within the next 25 years. For extrapolations beyond the 75-year long-range period, the ultimate levels or trends reached by the end of the 75-year period remain unchanged. The assumed ultimate values represent average annual experience or growth rates. Actual future values will exhibit fluctuations or cyclical patterns, as in the past.

The following sections briefly discuss the various assumptions and methods required to make the estimates of trust fund financial status, which are the heart of this report.[1] There are, of course, many interrelationships among these factors that are important but are beyond the scope of this discussion.

A. DEMOGRAPHIC ASSUMPTIONS AND METHODS

This section of the report provides a brief overview of the demographic historical data and the assumptions used for the projections.

1. Fertility Assumptions

Birth rates by single year of age, for women aged 14 to 49,[2] are the basis for the fertility assumptions. These rates apply to the total number of women, across all marital statuses, in the midyear population at each age. Table V.A1 displays the historical and projected total fertility rates.[3]

Historically, birth rates in the United States have fluctuated widely. The total fertility rate decreased from 3.31 children per woman at the end of World

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[1] Actuarial Studies published by the Office of the Chief Actuary, Social Security Administration, contain further details about the assumptions, methods, and actuarial estimates. A complete list of available studies may be found at www.ssa.gov/OACT/NOTES/actstud.html. To obtain copies of such studies or of this report, please submit a request at www.ssa.gov/OACT/request.html or write to: Office of the Chief Actuary, 700 Altmeyer Building, 6401 Security Boulevard, Baltimore, MD 21235. This entire report, along with supplemental year-by-year tables and additional documentation on assumptions and methods, may be found at www.ssa.gov/OACT/TR/2016/.

[2] Birth rates at age 14 include births to women aged 14 and under, and birth rates at age 49 include births to women aged 49 and over.

[3] The total fertility rate may be interpreted as the average number of children that would be born to a woman in her lifetime if she were to experience, at each age of her life, the birth rate observed in, or assumed for, a specified year, and if she were to survive the entire childbearing period. A rate of about 2.1 would ultimately result in a nearly constant population if immigration and emigration were both zero, and if death rates were to remain at current levels.

War I (1918) to 2.15 during the Great Depression (1936). After 1936, the total fertility rate rose to 3.68 in 1957 and then fell to 1.74 by 1976. After 1976, the total fertility rate rose slightly through 2007, reaching 2.12, but dropped to 1.85 by 2013. The recession and high unemployment are likely reasons for this drop.

These variations in the total fertility rate resulted from changes in many factors, including social attitudes, economic conditions, birth-control practices, and the racial/ethnic composition of the population. The Trustees expect future total fertility rates to remain close to recent levels. Certain population characteristics, such as the higher percentages of women who have never married, of women who are divorced, and of young women who are in the labor force, are consistent with continued lower total fertility rates than experienced during the baby-boom era (1946-65). Based on consideration of these factors, the Trustees assume ultimate total fertility rates of 2.20, 2.00, and 1.80 children per woman for the low-cost, intermediate, and high-cost assumptions, respectively. These ultimate rates are unchanged from last year's report.

For the intermediate assumptions, the projected total fertility rate rises until it reaches 2.05 for 2023. This reflects the assumption that the drop in the total fertility rate below 2.0 children per woman during the recent economic downturn was in part a deferral in childbearing that will be partially offset with full economic recovery. Thereafter, the total fertility rate follows a linear trend toward the ultimate level in 2027. The assumed low-cost and high-cost total fertility rates trend away from the intermediate path and reach the ultimate values in 2024 and 2032, respectively.

2. Mortality Assumptions

For the projections in this year's report, ultimate average annual percentage reductions in future mortality rates were assumed by age group and cause of death. These assumptions were then used to estimate future central death rates by age group, sex, and cause of death. From these estimated central death rates, probabilities of death by single year of age and sex were calculated.

Historical death rates are calculated for years 1900 through 2013 for ages below 65 (and for all ages for years prior to 1968) using data from the National Center for Health Statistics (NCHS).[1] For ages 65 and over, final Medicare data on deaths and enrollments for years 1968 through 2012 and

[1] These rates reflect NCHS data on deaths and Census estimates of population.

preliminary data for 2013 are used. Death rates by cause of death are produced for all ages for years 1979-2013 using data from the NCHS.

The total age-sex-adjusted death rate[1] declined at an average annual rate of 1.05 percent between 1900 and 2013. Between 1979 and 2013, the period for which death rates were analyzed by cause, the total age-sex-adjusted death rate, for all causes combined, declined at an average rate of 0.93 percent per year.

Death rates have declined substantially in the U.S. since 1900, with rapid declines over some periods and slow or no improvement over the other periods. Historical death rates generally declined more slowly for older ages and more rapidly for children and infants than for the rest of the population. Between 1900 and 2013, the age-sex-adjusted death rate for ages 65 and over declined at an average rate of 0.78 percent per year, while declining at an average rate of 3.08 percent per year for ages under 15.

Many factors are responsible for historical reductions in death rates, including increased medical knowledge, increased availability of health-care services, and improvements in sanitation and nutrition. Considering the expected rate of future progress in these and other areas, the Trustees present three alternative sets of ultimate annual percentage reductions in central death rates by age group and cause of death, for 2040 and later. The intermediate set, alternative II, represents the Trustees' best estimate. The average annual percentage reductions for alternative I (low-cost) are smaller than those for alternative II, while those for alternative III (high-cost) are larger. These ultimate annual percentage reductions are the same as those in last year's report.

The trends in the annual reductions in central death rates are calculated for the period from 2003 to 2013 by age group, sex, and cause of death. These trends are the starting reductions for alternative II. For alternatives I and III, 50 and 150 percent of the starting reductions are used, respectively. These annual reductions, by alternative, are assumed to transition rapidly from the starting reductions until they reach the ultimate annual percentage reductions assumed for 2040 and later.

Table V.A1 contains historical and projected age-sex-adjusted death rates for the total population (all ages), for ages under 65, and for ages 65 and over. Age-sex adjustment eliminates the effect of a changing distribution of population by age and sex, allowing the pure effects of changes in death rates to

[1] Based on the enumerated total population as of April 1, 2010, if that population were to experience the death rates by age and sex for the selected year.

be observed. Under the intermediate assumptions, projected age-sex-adjusted death rates are, in general, slightly higher than the death rates in last year's report. These changes primarily result from incorporating additional historical data and from beginning the transition to the ultimate rates of improvement immediately after the final historical data year. Prior to this year's report, rates of improvement after the last historical data year and before the first year of the projection period were assumed to be the same as the average annual rates of improvement over the prior 10 years.

The projected average annual rate of decline for the total age-sex-adjusted death rate is about 0.42 percent, 0.78 percent, and 1.16 percent between 2015 and 2090 for alternatives I, II, and III, respectively. In keeping with the patterns observed in the historical data, the assumed future rates of decline are greater for younger ages than for older ages, but to a substantially lesser degree than in the past. Accordingly, the projected age-sex-adjusted death rates for ages 65 and over decline at average annual rates of about 0.37 percent, 0.69 percent, and 1.02 percent between 2015 and 2090 for alternatives I, II, and III, respectively. The projected age-sex-adjusted death rates for ages under 15 decline at average annual rates of about 0.80 percent, 1.59 percent, and 2.59 percent between 2015 and 2090 for alternatives I, II, and III, respectively.

Demographers express a wide range of views on the likely rate of future decline in death rates. For example, some believe that the long-standing historical tendency for mortality to decline more slowly at the highest ages will cease in the future. Others believe that biological factors, social factors, and limitations on health care spending may slow future rates of decline in mortality.[1]

The Trustees periodically revise the assumed ultimate rates of decline in mortality based on experience, new conditions, and expert opinion. Evolving trends in health care and lifestyle will determine what modifications to the assumed ultimate rates of decline in mortality will be warranted for future reports. The Trustees intend to carefully consider the mortality assumptions for the 2017 report.

[1] The 2015 Technical Panel on Assumptions and Methods, appointed by the Social Security Advisory Board, recommended retaining ultimate rates of improvement that vary by age and cause of death as assumed by the Trustees, but with an overall rate of improvement on an age-sex-adjusted basis of 1.00 percent.

Table V.A1.—Fertility and Mortality Assumptions,[a] Calendar Years 1940-2090

Calendar year	Total fertility rate[b]	Age-sex-adjusted death rate[c] per 100,000, by age		
		Total	Under 65	65 and over
Historical data:				
1940	2.23	1,919.8	750.1	9,718.8
1945	2.42	1,716.6	674.8	8,662.9
1950	3.03	1,561.9	570.2	8,173.7
1955	3.50	1,453.8	508.2	7,758.4
1960	3.61	1,454.3	503.2	7,795.4
1965	2.88	1,428.8	495.2	7,653.3
1970	2.43	1,340.0	485.7	7,036.3
1975	1.77	1,204.8	426.6	6,393.6
1980	1.82	1,136.9	384.3	6,154.3
1985	1.83	1,081.0	353.3	5,932.9
1990	2.07	1,021.3	333.6	5,606.3
1995	1.98	1,001.5	317.9	5,559.5
1996	1.98	987.8	306.6	5,529.1
1997	1.97	971.9	293.3	5,496.4
1998	2.00	963.8	285.4	5,487.1
1999	2.01	970.6	283.2	5,553.6
2000	2.05	960.7	281.0	5,492.3
2001	2.03	951.1	280.4	5,422.8
2002	2.03	947.0	279.0	5,400.6
2003	2.05	933.4	277.2	5,308.6
2004	2.06	898.9	269.7	5,093.9
2005	2.06	901.3	270.7	5,105.4
2006	2.11	876.1	267.6	4,933.5
2007	2.12	856.8	261.6	4,825.2
2008	2.07	857.0	258.8	4,845.5
2009	2.00	827.1	255.3	4,639.7
2010	1.93	821.3	248.5	4,640.1
2011	1.89	819.3	249.1	4,621.4
2012	1.87	811.9	248.5	4,568.2
2013	1.85	[d]812.2	249.1	[d]4,566.1
2014	1.86	[d]790.4	[d]242.6	[d]4,442.9
2015	[e]1.87	[e]781.4	[e]239.8	[e]4,392.3
Intermediate:				
2020	2.00	742.8	226.5	4,185.1
2025	2.03	709.5	213.8	4,014.5
2030	2.00	679.1	201.8	3,861.1
2035	2.00	650.8	190.6	3,719.3
2040	2.00	624.5	180.2	3,586.9
2045	2.00	599.9	170.5	3,462.8
2050	2.00	576.8	161.4	3,346.3
2055	2.00	555.1	153.0	3,236.6
2060	2.00	534.8	145.1	3,133.2
2065	2.00	515.7	137.7	3,035.7
2070	2.00	497.6	130.8	2,943.6
2075	2.00	480.7	124.3	2,856.5
2080	2.00	464.6	118.2	2,774.0
2085	2.00	449.5	112.5	2,695.7
2090	2.00	435.1	107.2	2,621.5

Table V.A1.—Fertility and Mortality Assumptions,[a] Calendar Years 1940-2090 (Cont.)

Calendar year	Total fertility rate[b]	Age-sex-adjusted death rate[c] per 100,000, by age		
		Total	Under 65	65 and over
Low-cost:				
2020	2.09	777.4	237.2	4,378.5
2025	2.20	760.5	230.7	4,292.9
2030	2.20	743.8	224.1	4,208.6
2035	2.20	727.5	217.7	4,126.4
2040	2.20	711.7	211.5	4,046.8
2045	2.20	696.4	205.5	3,969.7
2050	2.20	681.7	199.7	3,895.1
2055	2.20	667.4	194.1	3,823.0
2060	2.20	653.6	188.7	3,753.1
2065	2.20	640.2	183.5	3,685.5
2070	2.20	627.3	178.5	3,620.0
2075	2.20	614.8	173.6	3,556.6
2080	2.20	602.7	168.9	3,495.1
2085	2.20	591.0	164.4	3,435.5
2090	2.20	579.7	160.0	3,377.7
High-cost:				
2020	1.91	706.0	214.6	3,982.4
2025	1.89	655.1	195.1	3,722.7
2030	1.82	610.9	177.6	3,500.4
2035	1.80	571.7	162.0	3,303.3
2040	1.80	536.5	148.0	3,126.2
2045	1.80	504.7	135.6	2,965.8
2050	1.80	476.0	124.5	2,820.0
2055	1.80	450.0	114.5	2,686.7
2060	1.80	426.3	105.5	2,564.6
2065	1.80	404.6	97.4	2,452.4
2070	1.80	384.7	90.1	2,348.8
2075	1.80	366.4	83.5	2,252.9
2080	1.80	349.6	77.5	2,163.9
2085	1.80	334.0	72.0	2,081.1
2090	1.80	319.6	67.0	2,003.7

[a] This table contains basic assumptions along with key summary values that are derived from basic assumptions.
[b] The total fertility rate for any year is the average number of children that would be born to a woman in her lifetime if she were to experience, at each age of her life, the birth rate observed in, or assumed for, the selected year, and if she were to survive the entire childbearing period.
[c] Based on the enumerated total population as of April 1, 2010, if that population were to experience the death rates by age and sex observed in, or assumed for, the selected year.
[d] Estimated.
[e] Estimated, intermediate alternative.

3. Immigration Assumptions

Projections of the total Social Security area population reflect assumptions for annual legal immigration, legal emigration, “other immigration,” and “other emigration.” Legal immigration consists of persons who are granted legal permanent resident status. Legal emigration consists of legal permanent residents and citizens who leave the Social Security area population. Net legal immigration is the difference between legal immigration and legal emigration. “Other immigration” consists of immigrants who enter the Social

Security area in a given year and stay to the end of that year without having legal permanent resident status, such as undocumented immigrants and temporary foreign workers and students. "Other emigration" consists of other immigrants who leave the Social Security area population or who adjust their status to become legal permanent residents. Net other immigration is the difference between other immigration and other emigration. Net immigration refers to the sum of net legal immigration and net other immigration.

Immigration assumptions differ for the low-cost, intermediate, and high-cost scenarios. The low-cost scenario includes higher annual net immigration and the high-cost scenario includes lower annual net immigration. Table V.A2 contains historical and projected levels of various immigration flows.

Legal immigration has increased significantly since World War II, due to various events and legislative changes, including the Immigration Act of 1965 and the Immigration Act of 1990.

The assumed ratios of annual legal emigration to legal immigration are 20, 25, and 30 percent for alternatives I, II, and III, respectively. This range is consistent with the limited historical data for legal emigration from the Social Security area. These ratios are unchanged from last year's report. Under the intermediate alternative, by combining the ultimate annual legal immigration and emigration assumptions, ultimate annual net legal immigration is 795,000 persons. For the low-cost and high-cost scenarios, ultimate annual net legal immigration is about 1,008,000 persons and 602,000 persons, respectively.

The estimated number of other immigrants residing in the Social Security area and the annual level of other immigration have been affected significantly by the recent recession. Net immigration was greatly reduced during the economic downturn. Under the intermediate assumptions, annual other immigration is expected to increase from recent levels, reflecting a continued recovery from levels experienced during the recession.

Emigration from the other-immigrant population includes those who leave the Social Security area and those who adjust their status to become legal permanent residents. This other-immigrant population is highly mobile and far more likely to leave the Social Security area than is the citizen or legal permanent resident population. This year's report reflects lower assumed departure rates for the unauthorized portion of the other immigrant population. As individuals from this population reside in the country for extended periods of time, they generally become less likely to leave the country.

Under the intermediate assumptions, the total annual number of other emigrants who leave the Social Security area averages about 415,000 through the 75-year projection period. In addition, the ultimate annual number of other immigrants who adjust status to become legal permanent residents is assumed to be 450,000 for the intermediate assumptions. This is one-third of the assumed ultimate annual number of other immigrants entering the Social Security area. For the low-cost and high-cost scenarios, the total annual number of other emigrants averages about 488,000 and 325,000, respectively, through the 75-year projection period. The ultimate annual number of people adjusting status to legal permanent resident status is assumed to be 550,000 persons and 350,000 persons, for the low-cost and high-cost scenarios, respectively. While the ultimate annual number of people adjusting status to become legal permanent residents is unchanged from last year's report, the annual number of other emigrants who leave the Social Security area is about 110,000 to 163,000 lower than in last year's report for each alternative. This lower level of other emigration reflects revisions in the assumed departure rates of the unauthorized portion of the other immigrant population.

Under the assumptions and methods described above, the projected size of the other-immigrant population grows substantially. This growth reflects the excess of annual other immigration over the combined annual numbers of emigrants and deaths that occur within the other-immigrant population.

Under the intermediate assumptions, projected net other immigration reaches a peak in 2018, reflecting the recovering economy, then sharply decreases over the next few years, primarily due to the decline in the number of other immigrants entering the country, to a stable long-term level. This is followed by a gradual decrease in net other immigration after 2022, due to the increasing number of other immigrants residing in the Social Security area. Because the number of other immigrants leaving the Social Security area is based on rates of departure, an increase in the number of other immigrants residing in the Social Security area results in an increase in the number who emigrate out of the area. All other components of other immigration and emigration are assumed to be stable after 2022, and thus do not contribute toward any change in net other immigration. Under the intermediate assumptions, the projected average annual level of net other immigration over the 75-year projection period is about 496,000 persons. For the low-cost and high-cost assumptions, projected average annual net other immigration is about 621,000 persons and 359,000 persons, respectively.

The projected average total level of net immigration (legal and other, combined) is about 1,291,000 persons per year during the 75-year projection period under the intermediate assumptions. For the low-cost and high-cost assumptions, projected average annual total net immigration is about 1,629,000 persons and 961,000 persons, respectively.

Demographers express a wide range of views about the future course of immigration for the United States. Some believe that net immigration will increase substantially in the future. Others believe that potential immigrants may be increasingly attracted to other countries, that the number of potential immigrants may be lower due to lower birth rates in many countries, or that changes in the law or enforcement of the law could reduce immigration. The average of the 2015 Technical Panel's recommended annual levels of total net immigration is very close to the average projected in this year's report.

Table V.A2.—Immigration Assumptions,[a] Calendar Years 1940-2090
[in thousands]

Calendar year	Legal immigration: Legal in	Legal out	Adjustments of status[c d]	Net legal	Other-than-legal immigration[b]: Other in	Other out	Adjustments of status[c d]	Net other	Total net immigration
Historical data:									
1940	-	-	-	46	-	-	-	-	-
1945	73	18	-	55	-	-	-	-	-
1950	227	57	-	171	-	-	-	-	-
1955	280	70	-	210	-	-	-	-	-
1960	268	67	-	201	-	-	-	-	-
1965	261	77	49	232	-	-	49	-	-
1970	307	93	65	279	-	-	65	-	-
1975	340	98	53	294	-	-	53	-	-
1980	431	136	112	407	-	-	112	208	614
1985	458	144	119	432	-	-	119	264	696
1990	548	166	114	497	-	-	114	620	1,116
1995	511	192	255	575	-	-	255	557	1,132
1996	535	221	349	663	-	-	349	473	1,137
1997	468	190	294	571	-	-	294	545	1,117
1998	418	163	233	488	-	-	233	605	1,093
1999	451	174	243	521	1,307	438	243	625	1,146
2000	482	224	413	672	1,408	338	413	657	1,329
2001	517	265	542	794	1,322	122	542	658	1,453
2002	483	243	487	728	1,259	112	487	660	1,388
2003	414	192	354	575	1,139	123	354	662	1,237
2004	466	250	533	749	1,304	108	533	662	1,411
2005	561	290	597	869	1,791	52	597	1,141	2,010
2006	639	303	573	910	1,450	76	573	801	1,710
2007	584	267	482	800	883	328	482	72	872
2008	635	278	478	835	672	948	478	-754	81
2009	633	277	475	832	752	170	475	106	938
2010	622	262	426	786	678	199	426	53	838
2011	647	264	408	791	606	263	408	-66	725
2012	621	255	401	766	776	131	401	244	1,011
2013	589	249	409	748	939	184	409	346	1,094
2014[e]	616	254	401	762	1,200	245	401	554	1,316
2015[f]	610	265	450	795	1,400	188	450	762	1,557
Intermediate:									
2020	610	265	450	795	1,450	287	450	713	1,508
2025	610	265	450	795	1,350	333	450	567	1,362
2030	610	265	450	795	1,350	363	450	537	1,332
2035	610	265	450	795	1,350	390	450	510	1,305
2040	610	265	450	795	1,350	411	450	489	1,284
2045	610	265	450	795	1,350	426	450	474	1,269
2050	610	265	450	795	1,350	436	450	464	1,259
2055	610	265	450	795	1,350	445	450	455	1,250
2060	610	265	450	795	1,350	451	450	449	1,244
2065	610	265	450	795	1,350	456	450	444	1,239
2070	610	265	450	795	1,350	460	450	440	1,235
2075	610	265	450	795	1,350	463	450	437	1,232
2080	610	265	450	795	1,350	465	450	435	1,230
2085	610	265	450	795	1,350	466	450	434	1,229
2090	610	265	450	795	1,350	467	450	433	1,228

Table V.A2.—Immigration Assumptions,[a] Calendar Years 1940-2090 (Cont.)
[in thousands]

Calendar year	Legal immigration: Legal in	Legal out	Adjustments of status[c d]	Net legal	Other-than-legal immigration[b]: Other in	Other out	Adjustments of status[c d]	Net other	Total net immigration
Low-cost:									
2020	710	252	550	1,008	1,750	304	550	896	1,904
2025	710	252	550	1,008	1,650	366	550	734	1,742
2030	710	252	550	1,008	1,650	409	550	691	1,699
2035	710	252	550	1,008	1,650	448	550	652	1,660
2040	710	252	550	1,008	1,650	480	550	620	1,628
2045	710	252	550	1,008	1,650	502	550	598	1,606
2050	710	252	550	1,008	1,650	519	550	581	1,589
2055	710	252	550	1,008	1,650	532	550	568	1,576
2060	710	252	550	1,008	1,650	543	550	557	1,565
2065	710	252	550	1,008	1,650	550	550	550	1,558
2070	710	252	550	1,008	1,650	556	550	544	1,552
2075	710	252	550	1,008	1,650	560	550	540	1,548
2080	710	252	550	1,008	1,650	562	550	538	1,546
2085	710	252	550	1,008	1,650	564	550	536	1,544
2090	710	252	550	1,008	1,650	565	550	535	1,543
High-cost:									
2020	510	258	350	602	850	231	350	269	871
2025	510	258	350	602	1,050	259	350	441	1,043
2030	510	258	350	602	1,050	282	350	418	1,020
2035	510	258	350	602	1,050	302	350	398	1,000
2040	510	258	350	602	1,050	318	350	382	984
2045	510	258	350	602	1,050	330	350	370	972
2050	510	258	350	602	1,050	339	350	361	963
2055	510	258	350	602	1,050	345	350	355	957
2060	510	258	350	602	1,050	351	350	349	951
2065	510	258	350	602	1,050	356	350	344	946
2070	510	258	350	602	1,050	359	350	341	943
2075	510	258	350	602	1,050	362	350	338	940
2080	510	258	350	602	1,050	364	350	336	938
2085	510	258	350	602	1,050	365	350	335	937
2090	510	258	350	602	1,050	366	350	334	936

[a] This table contains basic assumptions along with key summary values that are derived from basic assumptions.
[b] Historical other immigration and emigration estimates depend on a residual method, using Department of Homeland Security January 1 stock estimates for 2005 through 2012.
[c] Estimates do not include persons who attained legal permanent resident status under the special one-time provisions of the Immigration Reform and Control Act of 1986.
[d] Adjustments of status are a positive for net legal immigration and a negative for net other immigration.
[e] Estimated.
[f] Estimated, intermediate alternative.

Note: Totals do not necessarily equal the sums of rounded components.

4. Total Population Estimates

The starting Social Security area population for December 31, 2013, is derived from the Census Bureau's estimate of the residents of the 50 States and D.C. and U.S. Armed Forces overseas. Adjustments are made to reflect mortality assumptions for the aged population since 2010 that are consistent with Medicare and Social Security data, net immigration assumptions for the aged population since 2010, estimates of the net undercount in the 2010 census, inclusion of U.S. citizens living abroad (including residents of U.S. territories), and inclusion of non-citizens living abroad who are insured for Social Security benefits. The Office of the Chief Actuary projects the population in the Social Security area by age, sex, and marital status for December 31 of each year from 2014 through 2090 by combining the assumptions for future fertility, mortality, and immigration with assumptions for marriage and divorce. Previous sections of this chapter present the assumptions for future fertility, mortality, and immigration. Assumptions for future rates of marriage and divorce reflect historical data from the National Center for Health Statistics, the Census Bureau, and selected individual States.

This report presents a July 1 (i.e., midyear) population for each year, which is derived from surrounding December populations. Table V.A3 shows the historical and projected population for July 1 by broad age group, for the three alternatives. It also shows the aged and total dependency ratios (see table footnotes for definitions).

Table V.A3.—Social Security Area Population on July 1 and Dependency Ratios, Calendar Years 1945-2090

Calendar year	Population (in thousands)				Dependency ratio	
	Under 20	20-64	65 and over	Total	Aged[a]	Total[b]
Historical data:						
1945	49,121	88,109	10,900	148,130	0.124	0.681
1950	53,903	92,382	12,769	159,053	.138	.722
1955	63,293	96,207	15,075	174,576	.157	.815
1960	73,074	99,802	17,277	190,153	.173	.905
1965	80,020	104,885	19,071	203,975	.182	.945
1970	81,019	112,995	20,898	214,912	.185	.902
1975	78,623	122,663	23,316	224,602	.190	.831
1980	74,844	134,100	26,307	235,251	.196	.754
1985	72,997	144,545	29,144	246,686	.202	.707
1990	74,800	152,764	31,924	259,489	.209	.699
1995	79,285	160,718	34,316	274,318	.214	.707
2000	82,006	170,160	35,505	287,671	.209	.691
2005	84,014	180,875	37,163	302,052	.205	.670
2010	85,699	188,331	41,050	315,080	.218	.673
2015[c]	85,146	193,941	47,841	326,928	.247	.686
Intermediate:						
2020	87,420	198,796	56,165	342,381	.283	.722
2025	90,466	201,895	65,471	357,831	.324	.772
2030	92,811	205,362	73,686	371,859	.359	.811
2035	96,512	209,092	78,803	384,407	.377	.838
2040	98,987	214,843	81,678	395,509	.380	.841
2045	100,113	221,772	83,745	405,630	.378	.829
2050	101,761	227,380	86,376	415,517	.380	.827
2055	104,060	232,085	89,709	425,854	.387	.835
2060	106,735	236,185	93,823	436,743	.397	.849
2065	109,355	240,929	97,653	447,938	.405	.859
2070	111,631	245,765	101,733	459,129	.414	.868
2075	113,540	250,737	105,899	470,176	.422	.875
2080	115,432	257,432	108,244	481,108	.420	.869
2085	117,605	263,085	111,404	492,095	.423	.870
2090	120,005	267,398	115,804	503,208	.433	.882
Low-cost:						
2020	88,667	199,947	55,919	344,534	.280	.723
2025	93,942	204,348	64,816	363,106	.317	.777
2030	99,315	209,133	72,464	380,911	.346	.821
2035	106,148	214,176	76,902	397,226	.359	.855
2040	111,278	221,815	79,068	412,161	.356	.858
2045	114,401	231,604	80,496	426,502	.348	.842
2050	117,880	240,838	82,638	441,356	.343	.833
2055	122,679	249,205	85,653	457,538	.344	.836
2060	128,391	257,024	89,562	474,977	.348	.848
2065	134,132	265,779	93,208	493,119	.351	.855
2070	139,256	275,263	97,031	511,550	.353	.858
2075	143,747	285,674	100,849	530,270	.353	.856
2080	148,245	298,408	102,869	549,523	.345	.842
2085	153,333	309,988	106,232	569,554	.343	.837
2090	158,959	319,693	111,699	590,351	.349	.847

Table V.A3.—Social Security Area Population on July 1 and Dependency Ratios, Calendar Years 1945-2090 (Cont.)

	Population (in thousands)				Dependency ratio	
Calendar year	Under 20	20-64	65 and over	Total	Aged[a]	Total[b]
High-cost:						
2020	85,533	196,457	56,404	338,393	0.287	0.722
2025	86,427	198,104	66,151	350,682	.334	.770
2030	86,390	200,376	74,993	361,760	.374	.805
2035	87,190	202,934	80,865	370,988	.398	.828
2040	87,293	206,890	84,529	378,713	.409	.830
2045	86,731	211,116	87,297	385,144	.414	.824
2050	86,536	213,757	90,444	390,737	.423	.828
2055	86,922	215,078	94,053	396,054	.437	.841
2060	87,314	215,747	98,263	401,323	.455	.860
2065	87,566	216,819	102,143	406,527	.471	.875
2070	87,645	217,476	106,352	411,473	.489	.892
2075	87,597	217,638	110,760	415,994	.509	.911
2080	87,596	219,055	113,343	419,994	.517	.917
2085	87,765	219,694	116,105	423,564	.528	.928
2090	88,025	219,606	119,175	426,805	.543	.944

[a] Ratio of the population at ages 65 and over to the population at ages 20-64.
[b] Ratio of the population at ages 65 and over and the population under age 20 to the population at ages 20-64.
[c] Estimated, intermediate alternative.

Notes:
1. Historical data are subject to revision.
2. Totals do not necessarily equal the sums of rounded components.

5. Life Expectancy Estimates

Life expectancy, or the average remaining number of years expected prior to death, is an additional way to summarize the Trustees' mortality assumptions. This report includes life expectancy in two different forms (period and cohort) for two separate purposes.

- Period life expectancy for a given year uses the actual or expected death rates at each age for that year. It is a useful summary statistic for illustrating the overall level of the death rates experienced in a single year. Period life expectancy for a particular year provides an individual's expected average remaining lifetime at a selected age, assuming no change in death rates after that year. Table V.A4 presents historical and projected life expectancy calculated on a period basis.
- Cohort life expectancy does not use death rates for a single year, but for the series of years in which the individual will actually reach each succeeding age if he or she survives. Cohort life expectancy provides an individual's expected average remaining lifetime at a selected age in a given year, using actual or expected future changes in death rates. Table V.A5 presents historical and projected life expectancy calculated

> on a cohort basis. Cohort life expectancy is somewhat greater than period life expectancy for a given year because: (1) death rates at any age tend to decline over time; and (2) cohort life expectancy uses death rates from future years, while period life expectancy uses death rates only from the given year.

Life expectancy at a given age reflects death rates at that and all older ages. Period life expectancy is somewhat related to the age-sex-adjusted death rate discussed in section V.A.2. However, life expectancy places far greater weight on death rates at lower ages than at higher ages. Therefore, changes in death rates at lower ages have far greater effects in changing life expectancy over time. It is important to keep this concept in mind when considering trends in life expectancy.

Table V.A4.—Period Life Expectancy[a]

Calendar year	Historical data: At birth Male	Historical data: At birth Female	Historical data: At age 65 Male	Historical data: At age 65 Female
1940	61.4	65.7	11.9	13.4
1945	62.9	68.4	12.6	14.4
1950	65.6	71.1	12.8	15.1
1955	66.7	72.8	13.1	15.6
1960	66.7	73.2	12.9	15.9
1965	66.8	73.8	12.9	16.3
1970	67.2	74.9	13.1	17.1
1975	68.7	76.6	13.7	18.0
1980	69.9	77.5	14.0	18.4
1985	71.1	78.2	14.4	18.6
1990	71.8	78.9	15.1	19.1
1995	72.5	79.1	15.4	19.1
2000	74.0	79.4	15.9	19.0
2001	74.1	79.5	16.1	19.1
2002	74.2	79.5	16.2	19.1
2003	74.4	79.6	16.3	19.2
2004	74.8	80.0	16.7	19.5
2005	74.8	80.0	16.7	19.5
2006	75.1	80.2	17.0	19.7
2007	75.4	80.5	17.2	19.9
2008	75.5	80.5	17.2	19.9
2009	75.9	80.8	17.5	20.2
2010	76.1	80.9	17.6	20.2
2011	76.2	81.0	17.7	20.2
2012	76.3	81.0	17.8	20.3
2013[b] . . .	76.3	81.1	17.8	20.3
2014[b] . . .	76.6	81.2	18.0	20.5
2015[c] . . .	76.8	81.5	18.1	20.6

Calendar year	Intermediate				Low-cost				High-cost			
	At birth		At age 65		At birth		At age 65		At birth		At age 65	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
2020	77.5	82.0	18.6	21.0	77.0	81.5	18.2	20.6	78.2	82.5	19.0	21.3
2025	78.2	82.5	19.0	21.3	77.3	81.8	18.4	20.8	79.2	83.3	19.6	21.9
2030	78.8	83.0	19.3	21.6	77.6	82.0	18.6	20.9	80.1	84.1	20.1	22.3
2035	79.3	83.4	19.6	21.9	77.9	82.3	18.8	21.1	80.9	84.8	20.6	22.8
2040	79.8	83.9	19.9	22.2	78.2	82.5	18.9	21.3	81.7	85.4	21.1	23.2
2045	80.4	84.3	20.2	22.4	78.5	82.8	19.1	21.4	82.5	86.0	21.5	23.6
2050	80.9	84.7	20.5	22.7	78.7	83.0	19.2	21.5	83.2	86.6	22.0	24.0
2055	81.3	85.1	20.8	23.0	79.0	83.2	19.4	21.7	83.8	87.2	22.4	24.4
2060	81.8	85.5	21.1	23.2	79.3	83.4	19.6	21.8	84.4	87.7	22.8	24.7
2065	82.2	85.8	21.3	23.4	79.6	83.7	19.7	22.0	85.0	88.2	23.1	25.1
2070	82.7	86.2	21.6	23.7	79.8	83.9	19.9	22.1	85.6	88.6	23.5	25.4
2075	83.1	86.5	21.9	23.9	80.1	84.1	20.0	22.2	86.1	89.1	23.8	25.7
2080	83.5	86.9	22.1	24.1	80.3	84.3	20.2	22.4	86.6	89.5	24.2	26.0
2085	83.8	87.2	22.3	24.3	80.6	84.5	20.3	22.5	87.1	89.9	24.5	26.3
2090	84.2	87.5	22.6	24.6	80.8	84.7	20.5	22.6	87.6	90.3	24.8	26.6

[a] The period life expectancy at a given age for a given year is the average remaining number of years expected prior to death for a person at that exact age, born on January 1, using the mortality rates for that year over the course of his or her remaining life.
[b] Estimated.
[c] Estimated, intermediate alternative.

Table V.A5.—Cohort Life Expectancy[a]

Calendar year	Intermediate				Low-cost				High-cost			
	At birth[b]		At age 65[c]		At birth[b]		At age 65[c]		At birth[b]		At age 65[c]	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1940	70.5	76.7	12.7	14.7	70.3	76.4	12.7	14.7	70.7	77.0	12.7	14.7
1945	72.3	78.4	13.0	15.4	72.0	78.0	13.0	15.4	72.7	78.8	13.0	15.4
1950	73.5	79.7	13.1	16.2	73.0	79.2	13.1	16.2	74.1	80.3	13.1	16.2
1955	74.2	80.3	13.1	16.7	73.5	79.6	13.1	16.7	75.0	81.1	13.1	16.7
1960	74.9	80.7	13.2	17.4	74.1	79.9	13.2	17.4	75.9	81.8	13.2	17.4
1965	75.9	81.3	13.5	18.0	74.8	80.3	13.5	18.0	77.1	82.6	13.5	18.0
1970	77.1	82.2	13.8	18.5	75.8	81.0	13.8	18.5	78.6	83.6	13.8	18.5
1975	78.1	82.9	14.2	18.7	76.6	81.5	14.2	18.7	79.8	84.6	14.2	18.7
1980	78.9	83.6	14.7	18.8	77.2	82.0	14.7	18.8	80.9	85.4	14.7	18.8
1985	79.7	84.2	15.4	19.1	77.7	82.4	15.4	19.1	81.9	86.2	15.4	19.1
1990	80.4	84.7	16.1	19.4	78.2	82.8	16.1	19.4	82.8	86.9	16.1	19.5
1995	81.1	85.3	16.8	19.8	78.8	83.2	16.7	19.7	83.7	87.6	16.8	19.9
2000	81.7	85.7	17.6	20.3	79.1	83.5	17.4	20.1	84.5	88.2	17.7	20.5
2001	81.8	85.8	17.7	20.4	79.2	83.5	17.5	20.2	84.6	88.3	17.9	20.6
2002	81.8	85.8	17.8	20.5	79.2	83.6	17.6	20.2	84.7	88.4	18.1	20.8
2003	81.9	85.9	18.0	20.6	79.3	83.6	17.7	20.3	84.8	88.5	18.2	20.9
2004	82.0	86.0	18.1	20.7	79.4	83.7	17.8	20.4	85.0	88.6	18.4	21.0
2005	82.1	86.1	18.2	20.8	79.4	83.7	17.9	20.5	85.1	88.7	18.5	21.1
2006	82.2	86.1	18.3	20.9	79.5	83.8	18.0	20.5	85.2	88.8	18.7	21.3
2007	82.3	86.2	18.4	20.9	79.5	83.8	18.1	20.6	85.3	88.9	18.8	21.4
2008	82.4	86.3	18.5	21.0	79.6	83.9	18.1	20.6	85.5	89.0	18.9	21.5
2009	82.5	86.4	18.6	21.1	79.7	83.9	18.2	20.7	85.6	89.1	19.1	21.6
2010	82.6	86.5	18.7	21.2	79.7	84.0	18.2	20.7	85.8	89.2	19.2	21.7
2011	82.7	86.5	18.8	21.3	79.8	84.0	18.3	20.8	85.9	89.3	19.3	21.8
2012	82.8	86.6	18.8	21.3	79.8	84.1	18.3	20.8	86.0	89.4	19.5	22.0
2013	82.9	86.7	18.9	21.4	79.9	84.1	18.4	20.8	86.1	89.5	19.6	22.1
2014	83.0	86.8	19.0	21.5	80.0	84.1	18.4	20.9	86.2	89.6	19.7	22.2
2015	83.1	86.8	19.1	21.5	80.0	84.2	18.5	20.9	86.4	89.7	19.9	22.3
2020	83.5	87.2	19.5	21.9	80.3	84.4	18.6	21.1	87.0	90.2	20.4	22.8
2025	83.9	87.5	19.8	22.1	80.5	84.6	18.8	21.2	87.5	90.6	21.0	23.3
2030	84.3	87.9	20.1	22.4	80.8	84.8	19.0	21.4	88.1	91.1	21.4	23.7
2035	84.7	88.2	20.4	22.7	81.0	85.0	19.2	21.5	88.6	91.5	21.9	24.1
2040	85.1	88.5	20.7	23.0	81.3	85.2	19.3	21.7	89.1	91.9	22.4	24.5
2045	85.5	88.8	21.0	23.2	81.5	85.4	19.5	21.8	89.5	92.2	22.8	24.9
2050	85.8	89.1	21.3	23.5	81.8	85.6	19.6	22.0	90.0	92.6	23.2	25.2
2055	86.2	89.4	21.6	23.7	82.0	85.8	19.8	22.1	90.4	93.0	23.6	25.6
2060	86.5	89.6	21.8	24.0	82.2	86.0	20.0	22.2	90.8	93.3	23.9	25.9
2065	86.8	89.9	22.1	24.2	82.4	86.2	20.1	22.4	91.2	93.6	24.3	26.3
2070	87.1	90.2	22.3	24.4	82.7	86.4	20.3	22.5	91.5	93.9	24.6	26.6
2075	87.4	90.4	22.6	24.7	82.9	86.5	20.4	22.6	91.9	94.2	25.0	26.9
2080	87.7	90.6	22.8	24.9	83.1	86.7	20.6	22.8	92.3	94.5	25.3	27.2
2085	88.0	90.9	23.1	25.1	83.3	86.9	20.7	22.9	92.6	94.8	25.6	27.5
2090	88.3	91.1	23.3	25.3	83.5	87.0	20.8	23.0	92.9	95.1	25.9	27.7

[a] The cohort life expectancy at a given age for a given year is the average remaining number of years expected prior to death for a person at that exact age, born on January 1, using the mortality rates for the series of years in which the individual will actually reach each succeeding age if he or she survives.

[b] Cohort life expectancy at birth for those born in the calendar year is based on a combination of actual, estimated, and projected death rates for birth years 1940 through 2013. For birth years after 2013, these values depend on estimated and projected death rates.

[c] Age 65 cohort life expectancy for those attaining age 65 in calendar years 1940 though 2012 depends on actual death rates or on a combination of actual, estimated, and projected death rates. After 2012, these values depend on estimated and projected death rates.

B. ECONOMIC ASSUMPTIONS AND METHODS

The three alternative sets of economic assumptions provide a reasonable range for estimating the financial status of the trust funds. The intermediate assumptions reflect the Trustees' consensus expectation of sustained moderate economic growth and their best estimate for various other economic parameters. The low-cost assumptions represent a more optimistic outlook: a faster recovery, stronger long-term economic growth, and relatively optimistic levels for other parameters. The high-cost assumptions represent a more pessimistic scenario: a slower recovery, interrupted by a brief recession, weaker long-term economic growth, and relatively pessimistic levels for other parameters.

Actual economic data were available through the third quarter of 2015 at the time the Trustees set the assumptions for this report. The data indicated that economic activity peaked in the fourth quarter of 2007[1] with the level of gross domestic product (GDP) about 1 percent above the estimated long-term sustainable trend level. A severe recession followed, with a low point in the economic cycle reached in the second quarter of 2009 with GDP about 7 percent below the estimated sustainable trend level. The annual growth rate in real GDP has been positive in all years since then, but not as strong as in most past recoveries. The Trustees project that the economy will return to its sustainable trend level of output within the first 10 years of the projection period and remain on that trend thereafter. However, the speed of the return varies by alternative. The economy is projected to return to its sustainable trend level of output by 2022 for the intermediate assumptions, and 2020 for the low-cost assumptions, the same as in last year's report. The economy is projected to return to its sustainable trend level of output by 2025 for the high-cost assumption, about 1 year later than in last year's report. Complete economic cycles have little effect on the long-range estimates of financial status, so the assumptions do not include cycles beyond the short-range period (2016 through 2025).

The key economic assumptions underlying the three sets of projections of the future financial status of the OASI and DI Trust Funds are discussed in the remainder of this section.

[1] See www.nber.org/cycles/cyclesmain.html.

1. Productivity Assumptions

Total U.S. economy productivity is defined as the ratio of real GDP to hours worked by all workers.[1] The rate of change in total-economy productivity is a major determinant in the growth of average earnings. Over the last five complete economic cycles (1966-73, 1973-79, 1979-89, 1989-2000, and 2000-07, measured peak to peak), the annual increases in total productivity averaged 2.27, 1.10, 1.38, 1.78 and 2.15 percent, respectively. For the 41-year period from 1966 to 2007, covering those last five complete economic cycles, the annual increase in total-economy productivity averaged 1.73 percent.

The assumed ultimate annual increases in total-economy productivity are 1.98, 1.68, and 1.38 percent for the low-cost, intermediate, and high-cost assumptions, respectively.[2] These rates of increase are unchanged from the 2015 report.

The average annual rate of change in total economy productivity from 2007 (the end of the last complete economic cycle) to 2015 is estimated to be 0.98 percent. For the intermediate assumptions, the annual change in productivity is assumed to be 1.68 percent for 2016, then increase to 2.03 percent for 2017, gradually decline to 1.67 percent for 2022 and 2023, and then rise to its ultimate value of 1.68 percent for 2024 and later. For the low-cost assumptions, the assumed annual change in productivity is 1.95 percent for 2016, then increases to 2.26 percent for 2017, averages 2.06 percent for 2018 through 2021, and reaches its ultimate value of 1.98 percent for 2022. For the high-cost assumptions, the assumed annual change in productivity is 0.91 percent for 2016, 1.36 percent for 2017, then averages 1.70 percent for 2018 through 2021, 1.46 percent for 2022 through 2025, and reaches its ultimate value of 1.38 percent after 2025.

2. Price Inflation Assumptions

Future changes in the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI) will directly affect the OASDI program through the automatic cost-of-living benefit increases. Future changes in the GDP price

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[1] Historical levels of real GDP are from the Bureau of Economic Analysis' National Income and Product Accounts. Historical total hours worked are provided by the Bureau of Labor Statistics and cover all U.S. Armed Forces and civilian employment.

[2] These assumptions are consistent with ultimate annual increases in private non-farm business productivity of 2.42, 2.06, and 1.69 percent. Compared to total-economy productivity, private non-farm business productivity is a more widely known concept that excludes the farm, government, non-profit institution, and private household sectors.

index (GDP deflator) affect the nominal levels of GDP, wages, self-employment income, average earnings, and taxable payroll.

The annual increases in the CPI averaged 4.61, 8.54, 5.31, 2.96, and 2.65 percent over the economic cycles 1966-73, 1973-79, 1979-89, 1989-2000, and 2000-07, respectively. The annual increases in the GDP deflator averaged 4.60, 7.52, 4.68, 2.20, and 2.50 percent for the same respective economic cycles. For the 41 years from 1966 to 2007, covering the last five complete economic cycles, the annual increases in the CPI and GDP deflator averaged 4.56 and 4.03 percent, respectively. The estimated average annual change from 2007 (the end of the last complete economic cycle) to 2015 is 1.68 percent for the CPI and 1.52 percent for the GDP deflator.

The assumed ultimate annual increases in the CPI are 3.2, 2.6, and 2.0 percent for the low-cost, intermediate, and high-cost assumptions, respectively. When compared to the 2015 report, the low-cost assumption is 0.2 percentage point lower and the intermediate assumption is 0.1 percentage point lower. The high-cost assumption is unchanged from the 2015 report. For a given rate of growth in average real earnings, a higher price inflation rate results in faster nominal earnings and revenue growth immediately, while the resulting added growth in benefit levels occurs with a delay, causing an overall improvement in the actuarial balance. Similarly, a lower price inflation rate causes an overall decline in the actuarial balance.

The Federal Reserve Board's monetary policy changed in the 1980s toward more vigilance in preventing high inflation. Consistent with the Board's continued emphasis on containing inflation, as indicated by their current target for the GDP deflator,[1] the Trustees lowered the assumed ultimate annual rate of increase in the CPI for the intermediate case from 4.0 percent for the 1996 report to 2.8 percent for the 2004 through 2013 reports, to 2.7 percent for the 2014 and 2015 reports, and to 2.6 percent for this report.

For the intermediate assumptions, the assumed annual change in the CPI is 0.86 percent for 2016, 2.76 percent for 2017, 2.65 percent for 2018, and reaches the ultimate growth rate of 2.60 percent for 2019 and later. For the low-cost assumptions, the assumed annual change in the CPI is 1.23 percent for 2016, increases to 3.63 percent for 2017, declines to 3.28 percent in 2018, and drops to its ultimate annual growth rate of 3.20 percent for 2019 and later. For the high-cost assumptions, the assumed annual rate of change in the CPI is 0.02 percent for 2016, increases to 2.44 percent for 2017, declines to

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[1] The Federal Open Market Committee (FOMC) targets a rate of 2 percent for the price index for Personal Consumption Expenditures, which is similar to the GDP deflator. See www.federalreserve.gov/newsevents/press/monetary/20150128a.htm.

2.13 percent in 2018, and drops to the ultimate annual change of 2.00 percent for 2019 and later. The projections for the first two years are influenced by changes in the price of oil.

The annual increase in the GDP deflator differs from the annual increase in the CPI because the two indices are constructed using different computational methods and coverage. The difference between the rate of change in the CPI and the rate of change in the GDP deflator is called the price differential in this report. For the 41-year period including 1967 through 2007, covering the last five complete economic cycles, the average annual price differential was 0.54 percentage point. From 2007 (the end of the last complete economic cycle) to 2015, the average annual price differential is estimated to be 0.18 percentage point.

The assumed ultimate price differential is 0.3, 0.4, and 0.5 percentage point for the low-cost, intermediate, and high-cost alternatives, respectively. Varying the ultimate projected price differential across alternatives recognizes the historical variation in this measure. Accordingly, the assumed ultimate annual increase in the GDP deflator is 2.9 (3.2 less 0.3), 2.2 (2.6 less 0.4), and 1.5 (2.0 less 0.5) percent for the low-cost, intermediate, and high-cost alternatives, respectively. The ultimate price differentials for the three alternatives are unchanged from the 2015 report.

The price differential was 0.26 percentage point for 2012, -0.26 percentage point for 2013, -0.14 percentage point for 2014, and is estimated to be -1.44 for 2015 and assumed to be -0.26 for 2016. The negative price differential since 2013 primarily reflects a general decline in oil prices in recent years. Changes in oil prices affect the CPI much more than the GDP deflator because oil represents a much larger share of U.S. consumption than of U.S. production. For 2017 and later, oil prices are assumed to grow at a relatively stable rate. For the intermediate assumptions, the assumed price differential is 0.51 percentage point for 2017 and 0.40 percentage point for 2018 and later.

3. Average Earnings Assumptions

The average level of nominal earnings in OASDI covered employment for each year has a direct effect on the size of the taxable payroll and on the future level of average benefits. In addition, under the automatic adjustment provisions in the law, growth in the average wage in the U.S. economy directly affects certain parameters used in the OASDI benefit formulas as well as the contribution and benefit base, the exempt amounts under the retirement earnings test, the amount of earnings required for a quarter of coverage, and in certain circumstances, the automatic cost-of-living benefit increases.

Projected growth rates in average covered earnings and average wages are derived from projections of the most inclusive measure, average U.S. earnings. Average U.S. earnings is defined as the ratio of the sum of total U.S. wage and salary disbursements and net proprietors' income to the sum of total U.S. civilian employment and armed forces. The growth rate in average U.S. earnings for any period is equal to the combined growth rates for total U.S. economy productivity, average hours worked, the ratio of earnings to total compensation (which includes fringe benefits), the ratio of total compensation to GDP, and the GDP deflator.

The average annual change in average hours worked was -0.27 percent over the last five complete economic cycles covering the period from 1966 to 2007. The annual change in average hours worked averaged -0.71, -0.56, 0.00, 0.16, and -0.63 percent over the economic cycles 1966-73, 1973-79, 1979-89, 1989-2000, and 2000-07, respectively. From 2007 (the end of the last complete economic cycle) to 2015, the average annual change in average hours worked is estimated to be 0.00 percent.

The ultimate annual rates of change for average hours worked are assumed to be 0.05, -0.05, and -0.15 percent for the low-cost, intermediate, and high-cost assumptions, respectively. These ultimate annual rates of change for average hours worked are unchanged from the 2015 report.

The average annual change in the ratio of earnings to total compensation was -0.20 percent from 1966 to 2007. Most of this decrease was due to the relative increase in the cost of employer-sponsored group health insurance for wage workers. Assuming that the level of total employee compensation is not affected by the amount of employer-sponsored group health insurance, any increase or decrease in employer-sponsored group health insurance leads to a commensurate decrease or increase in other components of employee compensation, including wages. Projections of future ratios of earnings to total compensation follow this principle. The Trustees assume that the total amount of future employer-sponsored group health insurance premiums will increase more slowly than in the past due to provisions of the Affordable Care Act of 2010, as described in the 2010 report. Data from the Bureau of Economic Analysis (BEA) indicate that the other significant component of non-wage employee compensation is employer contributions to retirement plans. The other component is assumed to grow faster than employee compensation in the future as life expectancy and potential time in retirement increase.

The average annual rate of change in the ratio of wages to employee compensation from 2030 to 2090 is assumed to be about 0.03, -0.07, and -0.17 percent for the low-cost, intermediate, and high-cost assumptions, respectively. These assumed rates are 0.02 percentage point higher (less negative) than those assumed in the 2015 report. The change is due to updated estimates from the Centers for Medicare and Medicaid Services that produce slower growth in the total amount of employer-sponsored health insurance premiums. Under the intermediate assumptions, the ratio of wages to employee compensation is assumed to decline from 0.810 for 2015 to 0.775 for 2090. The assumed ultimate annual rate of this decline, now 0.07 percent, compares with 0.09 percent assumed for the 2015 report, 0.13 percent assumed for the 2014 report, and 0.20 percent assumed for the 2009 report, prior to enactment of the Affordable Care Act of 2010. The ratio of earnings to compensation includes self-employment income both in the numerator and in the denominator. As a result, the rate of decline in earnings to compensation (which, under the intermediate assumptions, averages 0.06 percent from 2030 to 2090) is less than the rate of decline in wages to employee compensation.

The ratio of total compensation (i.e., employee compensation and net proprietors' income) to GDP varies over the economic cycle and with changes in the relative sizes of different sectors of the economy. Over the last five economic cycles from 1966 to 2007, this ratio has averaged 0.627. The ratio declined from 0.648 for 2001 to 0.601 in 2010, and is 0.611 in 2014. This ratio is assumed to rise as the economy recovers, reaching a level of 0.633 for 2025. For years after 2025, relative sizes of different sectors of the economy are assumed to remain constant, and therefore the ratio of total compensation to GDP remains at the 2025 level for each alternative.

The projected average annual growth rate in average nominal U.S. earnings from 2030 to 2090 is about 3.81 percent for the intermediate alternative. This growth rate reflects the average annual growth rate of approximately -0.06 percent for the ratio of earnings to total compensation, and also reflects the assumed ultimate annual growth rates of 1.68, -0.05, and 2.20 percent for productivity, average hours worked, and the GDP deflator, respectively. Similarly, the projected average annual growth rate in average nominal U.S. earnings is 5.02 percent for the low-cost assumptions and 2.60 percent for the high-cost assumptions.

Over long periods, the average annual growth rate in the average wage in OASDI covered employment (henceforth the "average covered wage") is expected to be very close to the average annual growth rate in average U.S. earnings. The assumed average annual growth rates in the average covered wage from 2030 to 2090 are 5.02, 3.80, and 2.50 percent for the low-cost, intermediate, and high-cost assumptions, respectively. The estimated annual rate of change in the average covered wage is 2.74 percent for 2015. For the intermediate assumptions, as the economy recovers, the annual rate of change in the average covered wage is projected to average 4.16 percent from 2015 to 2025. Thereafter, the assumed average annual rate of change in the average covered wage is 3.80 percent.

4. Assumed Real-Wage Differential

For these reports, the real increase in the average covered wage has traditionally been expressed in the form of a real-wage differential—the annual percentage change in the average covered wage minus the annual percentage change in the CPI. For the 41-year period from 1966 to 2007, covering the last five complete economic cycles, the real-wage differential averaged 0.89 percentage point, the result of averages of 1.48, -0.01, 0.47, 1.55, and 0.61 percentage points over the economic cycles 1966-73, 1973-79, 1979-89, 1989-2000, and 2000-07, respectively.

For the years 2030-90, the assumed annual real-wage differentials for OASDI covered employment average 1.82, 1.20, and 0.58 percentage points for the low-cost, intermediate, and high-cost assumptions, respectively. The real-wage differential is higher than the assumed values from last year's report by about 0.03 percentage point for each alternative.

The estimated real-wage differential averaged 0.45 percentage point for 2008 through 2015 (the years since the last complete economic cycle ending in a peak). For the intermediate assumptions, the real-wage differential increased from 1.94 percentage points in 2014 to 3.17 percentage points in 2015, an improvement that reflects both the economic recovery and low inflation. The wage differential is projected to rise from 2.08 in 2016 to 2.17 in 2018, and then gradually decline to an average of 1.20 percentage points for 2030 through 2090. For the low-cost assumptions, the real-wage differential is 2.41 percentage points for 2016, increases to 2.83 percentage points in 2018, declines to 1.95 percentage points in 2021, and reaches its long-run average of 1.82 percentage points for 2030 through 2090. For the high-cost assumptions, the real-wage differential is 1.22 percentage points for 2016, drops to 0.10 percentage point in 2017, and rises to 1.73 percentage points in 2018 before gradually declining to its long-run average of 0.58 percentage point for 2030 through 2090.

Table V.B1.—Principal Economic Assumptions

Calendar year	Annual percentage change[a] in— Productivity (Total U.S. economy)	Earnings as a percent of compensation	Average hours worked	GDP price index	Average annual wage in covered employment	Consumer Price Index	Real-wage differential[b]
Historical data:							
5-year periods:							
1960 to 1965	3.27	-0.18	0.16	1.36	3.22	1.24	1.98
1965 to 1970	2.06	-.31	-.68	4.03	5.84	4.23	1.61
1970 to 1975	2.07	-.50	-.87	6.60	6.58	6.76	-.22
1975 to 1980	.95	-.32	-.17	7.19	8.89	8.91	-.04
1980 to 1985	1.74	-.33	.02	5.21	6.53	5.22	1.30
1985 to 1990	1.37	-.19	-.07	3.11	4.77	3.83	.94
1990 to 1995	1.25	-.11	.41	2.44	3.54	3.03	.51
1995 to 2000	2.31	.28	.15	1.67	5.32	2.43	2.89
2000 to 2005	2.63	-.41	-.80	2.35	2.70	2.49	.22
2005 to 2010	1.61	-.08	-.46	1.93	2.50	2.30	.22
Economic cycles:[c]							
1966 to 1973	2.27	-.29	-.71	4.60	6.09	4.61	1.48
1973 to 1979	1.10	-.43	-.56	7.52	8.53	8.54	-.01
1979 to 1989	1.38	-.28	[d]	4.68	5.82	5.31	.47
1989 to 2000	1.78	.05	.16	2.20	4.50	2.96	1.55
2000 to 2007	2.15	-.23	-.63	2.50	3.25	2.65	.61
2007 to 2015	.98	.05	[d]	1.52	2.14	1.68	.45
Single years:							
2005	1.83	-.22	-.23	3.22	3.71	3.52	.19
2006	.84	.49	-.03	3.07	4.74	3.19	1.54
2007	1.04	-.05	-.38	2.67	4.49	2.88	1.62
2008	.75	-.06	-.60	1.93	2.41	4.09	-1.68
2009	2.87	-.66	-1.85	.79	-1.59	-.67	-.91
2010	2.55	-.10	.56	1.23	2.58	2.07	.51
2011	.07	.28	.97	2.06	3.12	3.56	-.43
2012	.47	.40	-.05	1.84	3.35	2.10	1.25
2013	.21	.01	.29	1.63	1.13	1.37	-.24
2014	.49	.39	.31	1.64	3.44	1.50	1.94
2015[e]	.44	.11	.37	1.01	2.74	-.43	3.17
Intermediate:							
2016	1.68	.14	-.05	1.12	2.94	.86	2.08
2017	2.03	.18	-.07	2.25	4.86	2.76	2.10
2018	1.91	.10	-.07	2.25	4.82	2.65	2.17
2019	1.84	-.06	-.07	2.20	4.46	2.60	1.86
2020	1.77	-.10	-.06	2.20	4.28	2.60	1.68
2021	1.77	-.08	-.06	2.20	4.23	2.60	1.63
2022	1.67	-.07	-.06	2.20	4.07	2.60	1.47
2023	1.67	-.06	-.05	2.20	3.98	2.60	1.38
2024	1.68	-.03	-.05	2.20	4.04	2.60	1.44
2025	1.68	-.03	-.05	2.20	3.93	2.60	1.33
2025 to 2030	1.68	-.03	-.05	2.20	3.89	2.60	1.29
2030 to 2090	1.68	-.06	-.05	2.20	3.80	2.60	1.20

Table V.B1.—Principal Economic Assumptions (Cont.)

	Annual percentage change[a] in—						
Calendar year	Productivity (Total U.S. economy)	Earnings as a percent of compensation	Average hours worked	GDP price index	Average annual wage in covered employment	Consumer Price Index	Real-wage differential[b]
Low-cost:							
2016	1.95	0.14	0.01	1.25	3.64	1.23	2.41
2017	2.26	.20	.02	2.95	6.22	3.63	2.59
2018	2.23	.12	.03	2.98	6.11	3.28	2.83
2019	2.06	-.03	.04	2.90	5.54	3.20	2.34
2020	2.00	-.05	.04	2.90	5.29	3.20	2.09
2021	1.96	-.03	.05	2.90	5.15	3.20	1.95
2022	1.98	-.01	.05	2.90	5.16	3.20	1.96
2023	1.98	[d]	.05	2.90	5.21	3.20	2.01
2024	1.98	.05	.05	2.90	5.28	3.20	2.08
2025	1.98	.06	.05	2.90	5.18	3.20	1.98
2025 to 2030	1.98	.05	.05	2.90	5.14	3.20	1.94
2030 to 2090	1.98	.03	.05	2.90	5.02	3.20	1.82
High-cost:							
2016	.91	.14	-.11	.71	1.24	.02	1.22
2017	1.36	.19	-.12	1.91	2.54	2.44	.10
2018	1.89	.08	-.17	1.63	3.87	2.13	1.73
2019	1.73	-.10	-.18	1.50	3.66	2.00	1.66
2020	1.59	-.14	-.18	1.50	3.40	2.00	1.40
2021	1.58	-.13	-.17	1.50	3.36	2.00	1.36
2022	1.50	-.14	-.17	1.50	3.24	2.00	1.24
2023	1.47	-.14	-.16	1.50	3.13	2.00	1.13
2024	1.45	-.11	-.16	1.50	3.08	2.00	1.08
2025	1.40	-.12	-.16	1.50	2.87	2.00	.87
2025 to 2030	1.38	-.12	-.15	1.50	2.66	2.00	.66
2030 to 2090	1.38	-.14	-.15	1.50	2.58	2.00	.58

[a] For rows with a single year listed, the value is the annual percentage change from the prior year. For rows with a range of years listed, the value is the compound average annual percentage change.
[b] For rows with a single year listed, the value is the annual percentage change in the average annual wage in covered employment less the annual percentage change in the Consumer Price Index. For rows with a range of years listed, the value is the average of annual values of the differential. Values are rounded after all computations.
[c] Economic cycles are shown from peak to peak, except for the last cycle, which is not yet complete.
[d] Greater than -0.005 and less than 0.005 percent.
[e] Historical data are not available for the full year. Estimated values vary slightly by alternative and are shown for the intermediate assumptions.

5. Labor Force and Unemployment Projections

The model used by the Office of the Chief Actuary at the Social Security Administration for this report projects the civilian labor force by age, sex, marital status, and presence of children. Projections of the labor force participation rates reflect changes in disability prevalence, educational attainment, the average level of Social Security retirement benefits, the state of the economy, and the change in life expectancy. The projections also include a "cohort effect," which reflects an upward trend in female participation rates across cohorts born through 1948.

The annual rate of growth in the size of the labor force decreased from an average of about 2.4 percent during the 1966-73 economic cycle and 2.7 percent during the 1973-79 cycle to 1.7 percent during the 1979-89 cycle, 1.3 percent during the 1989-2000 cycle, and 1.0 percent during the 2000-07 cycle. Further slowing of labor force growth will follow from a substantial slowing of growth in the working age population in the future—a consequence of the baby-boom generation reaching retirement and succeeding lower-birth-rate cohorts reaching working age. Under the intermediate assumptions, the labor force is projected to increase by an average of 1.0 percent per year from 2015 to 2025 and 0.5 percent per year over the remainder of the 75-year projection period.

The projected labor force participation rates are derived from a model reflecting the historically based structural relationship that uses demographic and economic assumptions specific to each alternative. More optimistic economic assumptions in the low-cost alternative are consistent with higher labor force participation rates, but demographic assumptions in the low-cost alternative (such as slower improvement in longevity) are consistent with lower labor force participation rates. These relationships with various basic assumptions move the labor force participation rates in opposite directions. Therefore, the projected labor force participation rates do not vary substantially across alternatives.

Historically, labor force participation rates reflect trends in demographics and pensions. Between the mid-1960s and the mid-1980s, labor force participation rates at ages 50 and over declined for males but were fairly stable for females. During this period, the baby-boom generation reached working age and more women entered the labor force. This increasing supply of labor allowed employers to offer attractive early retirement options. Between the mid-1980s and the mid-1990s, participation rates at ages 55 and older roughly stabilized for males and increased for females. Since the mid-1990s, however, participation rates for both sexes at ages 50 and over have generally risen.

Many economic and demographic factors, including longevity, health, disability prevalence, the business cycle, incentives for retirement in Social Security and private pensions, education, and marriage patterns, will influence future labor force participation rates. The Office of the Chief Actuary models some of these factors directly. To model the effects of other factors related to increases in life expectancy, projected participation rates are adjusted upward for mid-career and older ages to reflect projected increases in life expectancy. For the intermediate projections, this adjustment increases the total labor force by 2.9 percent for 2090.

For men age 16 and over, the projected age-adjusted labor force participation rate[1] for 2090 is 72.9, 73.0, and 72.9 percent for the low-cost, intermediate, and high-cost assumptions, respectively. The low-cost assumptions result in a larger working-age population and a larger labor force when compared to the intermediate assumptions, but a lower labor force participation rate for men. This occurs because the low-cost assumptions include shorter life expectancies and relatively higher numbers of never-married individuals in the population. Shorter life expectancies tend to reduce work at older ages, while labor force participation rates tend to be lower for never-married men and higher for never-married women compared to their married counterparts.[2] For women age 16 and over, the projected age-adjusted labor force participation rates for 2090 are 61.6, 61.0, and 60.1 percent for the low-cost, intermediate, and high-cost assumptions, respectively. The age-adjusted rates for 2090 are higher under all three alternatives than the age-adjusted rates for 2014 of 70.1 percent for men and 57.7 percent for women (based on actual age-specific rates published by the Bureau of Labor Statistics), primarily due to the Trustees' projected increases in life expectancy. In the first ten years, the assumed labor force participation rates also increase as the economic recovery draws more people into the labor force. Increasing disability prevalence rates offset these increases somewhat in the intermediate and high-cost assumptions, but a decrease in disability prevalence further contributes to increases in labor force participation in the low-cost assumptions.

The unemployment rates presented in table V.B2 are in the most commonly cited form, the civilian rate. For years through 2025, the table presents total civilian rates without adjustment for the changing age-sex distribution of the population. For years after 2025, the table presents unemployment rates as age-sex-adjusted rates, using the age-sex distribution of the 2011 civilian labor force. Age-sex-adjusted rates allow for more meaningful comparisons across longer time periods. The age-sex adjusted unemployment rate is about 0.1 percentage point lower than the unadjusted rate for 2026.

The total civilian unemployment rate reflects the projected levels of unemployment for various age-sex groups of the population. Each group's unemployment rate is projected in relation to changes in the economic cycle, as

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[1] The Office of the Chief Actuary adjusts the labor force participation rates to the 2011 age distribution of the civilian noninstitutional U.S. population.

[2] The high-cost labor force participation rate is lower than the intermediate because life expectancy has a non-linear effect on labor force participation rates in the Office of the Chief Actuary's model.

measured by the ratio of actual to potential GDP.[1] For each alternative, the total civilian unemployment rate moves toward the ultimate assumed rate as the economy moves toward the long-range sustainable growth path.

The ultimate assumed age-sex-adjusted unemployment rates are 4.5, 5.5, and 6.5 percent for the low-cost, intermediate, and high-cost assumptions, respectively. These values are unchanged from the 2015 report. The decline in the overall rate from 5.3 for 2015 to 5.1 for 2016 under intermediate assumptions reflects a rapid increase in employment with a relatively small change in labor force participation. Improvements in labor market conditions will eventually draw more nonparticipants back into the labor force and unemployment will reach the ultimate rate in 2020 under the intermediate assumptions. Under low-cost assumptions the ultimate unemployment rate is reached in 2018. Under the high-cost assumptions, unemployment will reach the ultimate rate in 2022.[2]

6. Gross Domestic Product Projections

The value of real GDP equals the product of three components: (1) average weekly total employment,[3] (2) productivity, and (3) average hours worked per week. Consequently, the growth rate in real GDP is approximately equal to the sum of the growth rates for total employment, productivity, and average hours worked. For the period from 1966 to 2007, which covers the last five complete economic cycles, the average growth rate in real GDP was 3.1 percent. This average growth rate approximately equals the sum of the average growth rates of 1.6, 1.7, and -0.3 percent for total employment, productivity, and average hours worked, respectively. As a result of the 2007-2009 recession, the real GDP in 2014 was only 7.3 percent above the 2007 level. The estimated real GDP growth from 2014 to 2015 is 2.5 percent.

For the intermediate assumptions, the average annual growth in real GDP is 2.7 percent from 2015 to 2025, the approximate sum of component growth rates of 0.9 percent for total employment, 1.8 percent for productivity, and -0.06 percent for average hours worked. The projected average annual growth in real GDP of 2.7 percent for this period is 0.4 percentage point higher than the underlying sustainable trend rate of 2.3 percent. This

[1] Potential GDP is the level of GDP assuming the economy is operating at the underlying sustainable trend rate of growth.

[2] The assumed ultimate unemployment rate is an age-sex-adjusted rate. The quarterly age-sex-adjusted unemployment rate is used to determine the calendar year when the ultimate assumption is reached within the short-range period.

[3] Total employment is the sum of the U.S. Armed Forces and total civilian employment, which depends on the total civilian labor force and unemployment rate.

0.4-percentage-point above-trend component reflects a relatively rapid increase in employment as the economy recovers. After 2025, the assumptions do not explicitly reflect economic cycles. The projected annual growth rate in real GDP combines the projected growth rates for total employment, total U.S. economy productivity, and average hours worked. After 2025, the annual growth in real GDP averages 2.1 percent, based on the projected average annual growth rate of 0.5 percent for total employment and the assumed ultimate growth rates of 1.7 percent for productivity and -0.05 percent for average hours worked. The assumed growth rate of real GDP is slower than the past average growth rate mainly because the working-age population is expected to grow slower than in the past.

For the low-cost assumptions, the annual growth in real GDP averages 3.3 percent over the decade ending in 2025. The relatively faster growth is due mostly to higher assumed rates of growth for employment and worker productivity. For the high-cost assumptions, the annual growth in real GDP averages 1.9 percent for the decade ending in 2025.

7. Interest Rates

Table V.B2 presents average annual nominal and real interest rates for newly issued trust fund securities. The nominal rate is the average of the nominal interest rates for special U.S. Government obligations issuable to the trust funds in each of the 12 months of the year. Interest for these securities is generally compounded semiannually. The real interest rate is defined as the annual yield rate for investments in these securities divided by the annual rate of growth in the CPI for the first year after issuance. The real rate shown for each year reflects the actual realized (historical) or expected (future) real yield on securities issuable in the prior year.

To develop a reasonable range of assumed ultimate future real interest rates for the three alternatives, the Office of the Chief Actuary examined historical experience for the last five complete economic cycles. For the 41-year period from 1966 to 2007, the real interest rate averaged 2.8 percent per year. The real interest rates averaged 1.3, -1.0, 5.2, 4.0, and 2.2 percent per year over the economic cycles 1966-73, 1973-79, 1979-89, 1989-2000, and 2000-07, respectively. The assumed ultimate real interest rates are 3.2 percent, 2.7 percent, and 2.2 percent for the low-cost, intermediate, and high-cost assumptions, respectively. These rates are 0.2 percentage point lower than the rates used in the 2015 report. The lower assumed real interest rates reflect recent lower realized rates and an expectation that low real interest rates will persist.

The actual average annual nominal interest rate was approximately 2.3 percent for 2014, which means that securities newly issued in 2014 would yield 2.3 percent if held one year. Estimated average prices fell from 2014 to 2015 by approximately 0.4 percent. The annual real interest rate for 2015 is 2.7 percent, the approximate difference between the nominal interest rate and the rate of price increase. For the 10-year short-range projection period, projected nominal interest rates depend on changes in the economic cycle and in the CPI. When combined with the ultimate CPI assumptions of 3.2, 2.6, and 2.0 percent, the assumed ultimate real interest rates yield ultimate nominal interest rates of 6.4 percent for the low-cost assumptions, 5.3 percent for the intermediate assumptions, and 4.2 percent for the high-cost assumptions. These nominal rates for newly issued trust fund securities reach their ultimate levels by the end of the short-range period.

Table V.B2.—Additional Economic Factors

Calendar year	Average annual unemployment rate[a]	Annual percentage change[b] in—			Average annual interest rate	
		Labor force[c]	Total employment[d]	Real GDP[e]	Nominal[f]	Real[g]
Historical data:						
5-year periods:						
1960 to 1965	5.5	1.3	1.6	5.0	4.0	2.5
1965 to 1970	3.9	2.2	2.1	3.5	5.9	1.0
1970 to 1975	6.1	2.5	1.5	2.7	6.7	[h]
1975 to 1980	6.8	2.7	2.9	3.7	8.5	-.9
1980 to 1985	8.3	1.5	1.5	3.3	12.1	6.9
1985 to 1990	5.9	1.7	2.0	3.4	8.5	5.1
1990 to 1995	6.6	1.0	.9	2.6	7.0	4.3
1995 to 2000	4.6	1.5	1.8	4.3	6.2	3.9
2000 to 2005	5.4	.9	.7	2.5	4.6	2.4
2005 to 2010	6.8	.6	-.4	.8	3.8	1.8
Economic cycles:[i]						
1966 to 1973	4.6	2.4	2.0	3.6	6.1	1.3
1973 to 1979	6.8	2.7	2.4	3.0	7.7	-1.0
1979 to 1989	7.3	1.7	1.7	3.1	10.5	5.2
1989 to 2000	5.6	1.3	1.3	3.3	6.8	4.0
2000 to 2007	5.2	1.0	.9	2.4	4.6	2.2
2007 to 2015	7.6	.3	.2	1.2	2.4	1.1
Single years:						
2005	5.1	1.3	1.7	3.3	4.3	.8
2006	4.6	1.4	1.8	2.7	4.8	1.1
2007	4.6	1.1	1.1	1.8	4.7	1.9
2008	5.8	.8	-.4	-.3	3.6	.6
2009	9.3	-.1	-3.7	-2.8	2.9	4.4
2010	9.6	-.2	-.6	2.5	2.8	.9
2011	8.9	-.2	.6	1.6	2.4	-.7
2012	8.1	.9	1.8	2.2	1.5	.3
2013	7.4	.3	1.0	1.5	1.9	.1
2014	6.2	.3	1.6	2.4	2.3	.4
2015[j]	5.3	.8	1.6	2.5	2.0	2.7

Table V.B2.—Additional Economic Factors (Cont.)

Calendar year	Average annual unemployment rate[a]	Annual percentage change[b] in— Labor force[c]	Total employment[d]	Real GDP[e]	Average annual interest rate Nominal[f]	Real[g]
Intermediate:						
2016	5.1	0.9	1.1	2.8	2.4	1.2
2017	5.2	1.3	1.2	3.1	3.6	-.3
2018	5.3	1.4	1.2	3.1	4.2	1.0
2019	5.4	1.3	1.2	3.0	4.5	1.6
2020	5.5	1.2	1.1	2.8	4.7	1.9
2021	5.5	1.0	1.0	2.7	4.8	2.1
2022	5.5	.8	.8	2.4	5.0	2.2
2023	5.5	.6	.6	2.2	5.2	2.4
2024	5.6	.6	.6	2.2	5.3	2.6
2025	5.6	.6	.5	2.2	5.3	2.7
2030	5.5	.5	.5	2.1	5.3	2.7
2035	5.5	.5	.5	2.1	5.3	2.7
2040	5.5	.6	.6	2.2	5.3	2.7
2045	5.5	.6	.6	2.2	5.3	2.7
2050	5.5	.5	.5	2.2	5.3	2.7
2055	5.5	.5	.5	2.1	5.3	2.7
2060	5.5	.4	.4	2.1	5.3	2.7
2065	5.5	.5	.5	2.1	5.3	2.7
2070	5.5	.5	.5	2.1	5.3	2.7
2075	5.5	.5	.5	2.1	5.3	2.7
2080	5.5	.5	.5	2.1	5.3	2.7
2085	5.5	.4	.4	2.1	5.3	2.7
2090	5.5	.4	.4	2.0	5.3	2.7
Low-cost:						
2016	4.8	1.1	1.6	3.6	3.2	.8
2017	4.7	1.8	1.9	4.2	4.9	-.4
2018	4.6	1.6	1.7	4.0	5.2	1.7
2019	4.6	1.5	1.5	3.7	5.4	2.0
2020	4.6	1.3	1.3	3.3	5.5	2.2
2021	4.6	1.0	1.0	3.0	5.7	2.3
2022	4.6	.8	.8	2.8	6.0	2.5
2023	4.6	.7	.7	2.8	6.3	2.8
2024	4.6	.7	.7	2.8	6.4	3.0
2025	4.6	.7	.7	2.7	6.4	3.2
2030	4.5	.6	.6	2.7	6.4	3.2
2035	4.5	.6	.6	2.7	6.4	3.2
2040	4.5	.8	.8	2.8	6.4	3.2
2045	4.5	.8	.8	2.8	6.4	3.2
2050	4.5	.8	.8	2.8	6.4	3.2
2055	4.5	.7	.7	2.7	6.4	3.2
2060	4.5	.7	.7	2.7	6.4	3.2
2065	4.5	.7	.7	2.8	6.4	3.2
2070	4.5	.8	.8	2.8	6.4	3.2
2075	4.5	.8	.8	2.8	6.4	3.2
2080	4.5	.8	.8	2.8	6.4	3.2
2085	4.5	.7	.7	2.8	6.4	3.2
2090	4.5	.7	.7	2.7	6.4	3.2

Table V.B2.—Additional Economic Factors (Cont.)

Calendar year	Average annual unemployment rate[a]	Annual percentage change[b] in—			Average annual interest rate	
		Labor force[c]	Total employment[d]	Real GDP[e]	Nominal[f]	Real[g]
High-cost:						
2016	5.6	0.8	0.5	1.3	1.7	2.0
2017	7.3	1.1	-.7	.6	2.3	-.7
2018	7.2	.4	.5	2.2	3.3	.2
2019	7.0	.6	.9	2.5	3.7	1.3
2020	6.8	.8	.9	2.4	3.8	1.7
2021	6.7	.7	.8	2.3	3.9	1.8
2022	6.6	.7	.8	2.2	4.1	1.9
2023	6.5	.7	.7	2.1	4.3	2.1
2024	6.5	.7	.7	2.0	4.3	2.2
2025	6.5	.6	.6	1.9	4.2	2.3
2030	6.5	.4	.4	1.6	4.2	2.2
2035	6.5	.4	.4	1.6	4.2	2.2
2040	6.5	.4	.4	1.6	4.2	2.2
2045	6.5	.3	.3	1.6	4.2	2.2
2050	6.5	.3	.3	1.5	4.2	2.2
2055	6.5	.2	.2	1.4	4.2	2.2
2060	6.5	.2	.2	1.4	4.2	2.2
2065	6.5	.2	.2	1.4	4.2	2.2
2070	6.5	.1	.1	1.4	4.2	2.2
2075	6.5	.1	.1	1.4	4.2	2.2
2080	6.5	.1	.1	1.4	4.2	2.2
2085	6.5	.1	.1	1.3	4.2	2.2
2090	6.5	.1	.1	1.3	4.2	2.2

[a] The Office of the Chief Actuary adjusts the civilian unemployment rates for 2026 and later to the age-sex distribution of the civilian labor force in 2011. For years through 2025, the values are the total rates without adjustment for the changing age-sex distribution.

[b] For rows with a single year listed, the value is the annual percentage change from the prior year. For rows with a range of years listed, the value is the compounded average annual percentage change.

[c] The U.S. civilian labor force.

[d] Total U.S. military and civilian employment.

[e] The value of the total output of goods and services in 2009 dollars.

[f] The average of the nominal interest rates, which compound semiannually, for special public-debt obligations issuable to the trust funds in each of the 12 months of the year.

[g] The realized or expected annual real yield for each year on securities issuable in the prior year.

[h] Greater than -0.05 and less than 0.05 percent.

[i] Economic cycles are shown from peak to peak, except for the last cycle, which is not yet complete.

[j] Historical data are not available for the full year. Estimated values vary slightly by alternative and are shown for the intermediate assumptions.

C. PROGRAM-SPECIFIC ASSUMPTIONS AND METHODS

The Office of the Chief Actuary at the Social Security Administration uses a set of models to project future income and cost under the OASDI program. These models rely not only on the demographic and economic assumptions described in the previous sections, but also on a number of program-specific assumptions and methods. Values of many program parameters change from year to year as prescribed by formulas set out in the Social Security Act. These program parameters affect the level of payroll taxes collected and the level of benefits paid. The office uses more complex models to project the numbers of future workers covered under OASDI and the levels of their covered earnings, as well as the numbers of future beneficiaries and the expected levels of their benefits. The following subsections provide descriptions of these program-specific assumptions and methods.

1. Automatically Adjusted Program Parameters

The Social Security Act requires that certain parameters affecting the determination of OASDI benefits and taxes be adjusted annually to reflect changes in particular economic measures. Formulas prescribed in the law, applied to reported statistics, change these program parameters annually. The law bases these automatic adjustments on measured changes in the national average wage index (AWI) and the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI).[1] This section shows values for program parameters adjusted using these indices from the time that these adjustments became effective through 2025. Projected values for future years depend on the economic assumptions described in the preceding section of this report.

Tables V.C1 and V.C2 present the historical and projected values of the CPI-based benefit increases, the AWI series, and the values of many of the wage-indexed program parameters. Each table shows projections under the three alternative sets of economic assumptions. Table V.C1 includes:

- *The annual cost-of-living benefit increase percentages.* The automatic cost-of-living adjustment provisions in the Social Security Act specify increases in OASDI benefits based on increases in the CPI. Volatility in oil prices has resulted in substantial volatility in recent cost-of-living adjustments. A large cost-of-living adjustment in December 2008 was followed by no cost-of-living adjustments in December 2009 and December 2010. More recent volatility in oil prices has again affected

[1] The *Federal Register* publishes details of these indexation procedures annually. Also see www.ssa.gov/OACT/COLA/.

the CPI, resulting in no cost-of-living adjustment for December 2015. Under the intermediate and low-cost assumptions, annual cost-of-living adjustments resume in December 2016. Under the high-cost assumptions, there is no cost-of-living adjustment for December 2016, but annual cost-of-living adjustments resume in December 2017. After cost-of-living adjustments resume, all three sets of assumptions have automatic cost-of-living adjustments in all later years.

- *The annual levels of and percentage increases in the AWI.* Under section 215(b)(3) of the Social Security Act, Social Security benefit computations index taxable earnings (for most workers first becoming eligible for benefits in 1979 or later) using the AWI for each year after 1950. This procedure converts a worker's past earnings to approximately average-wage-indexed equivalent values near the time of his or her benefit eligibility. Other program parameters presented in this section that are subject to the automatic-adjustment provisions also rely on the AWI.

- *The wage-indexed contribution and benefit base.* For any year, the contribution and benefit base is the maximum amount of earnings subject to the OASDI payroll tax and creditable toward benefit computation. The Social Security Act defers any increase in the contribution and benefit base if there is no cost-of-living adjustment effective for December of the preceding year. There was no increase in the contribution and benefit base for 2010, 2011, or 2016 because there was no cost-of-living adjustment for the immediate prior December. Under the intermediate and low-cost assumptions, the contribution and benefit base increases in all years after 2016. Under the high-cost assumptions, the contribution and benefit base remains the same in 2017 and then increases in 2018 and all later years.

- *The wage-indexed retirement earnings test exempt amounts.* The exempt amounts are the annual amount of earnings below which beneficiaries do not have benefits withheld. A lower exempt amount applies in years before normal retirement age. A higher amount applies for the year in which a beneficiary attains normal retirement age. Starting in 2000, the retirement earnings test no longer applies beginning with the month of normal retirement age attainment. The Social Security Act defers any increase in these exempt amounts if there is no cost-of-living adjustment effective for December of the preceding year. There was no increase in these exempt amounts in 2010, 2011, or 2016 because there was no cost-of-living adjustment for the immediate prior December. Under the intermediate and low-cost assumptions, the exempt amounts increase in all years after 2016. Under the high-cost assumptions, the exempt amounts remain the same in 2017 and then increase in 2018 and all later years.

Table V.C1.—Cost-of-Living Benefit Increases, Average Wage Index, Contribution and Benefit Bases, and Retirement Earnings Test Exempt Amounts, 1975-2025

Calendar year	Cost-of-living benefit increase[a] (percent)	Average wage index (AWI)[b] Amount	Average wage index (AWI)[b] Increase (percent)	Contribution and benefit base[c]	Retirement earnings test exempt amount Under NRA[d]	Retirement earnings test exempt amount At NRA[e]
Historical data:						
1975	8.0	$8,630.92	7.5	$14,100	$2,520	$2,520
1976	6.4	9,226.48	6.9	15,300	2,760	2,760
1977	5.9	9,779.44	6.0	16,500	3,000	3,000
1978	6.5	10,556.03	7.9	17,700	3,240	4,000
1979	9.9	11,479.46	8.7	22,900	3,480	4,500
1980	14.3	12,513.46	9.0	25,900	3,720	5,000
1981	11.2	13,773.10	10.1	29,700	4,080	5,500
1982	7.4	14,531.34	5.5	32,400	4,440	6,000
1983	3.5	15,239.24	4.9	35,700	4,920	6,600
1984	3.5	16,135.07	5.9	37,800	5,160	6,960
1985	3.1	16,822.51	4.3	39,600	5,400	7,320
1986	1.3	17,321.82	3.0	42,000	5,760	7,800
1987	4.2	18,426.51	6.4	43,800	6,000	8,160
1988	4.0	19,334.04	4.9	45,000	6,120	8,400
1989	4.7	20,099.55	4.0	48,000	6,480	8,880
1990	5.4	21,027.98	4.6	51,300	6,840	9,360
1991	3.7	21,811.60	3.7	53,400	7,080	9,720
1992	3.0	22,935.42	5.2	55,500	7,440	10,200
1993	2.6	23,132.67	.9	57,600	7,680	10,560
1994	2.8	23,753.53	2.7	60,600	8,040	11,160
1995	2.6	24,705.66	4.0	61,200	8,160	11,280
1996	2.9	25,913.90	4.9	62,700	8,280	12,500
1997	2.1	27,426.00	5.8	65,400	8,640	13,500
1998	1.3	28,861.44	5.2	68,400	9,120	14,500
1999	[f]2.5	30,469.84	5.6	72,600	9,600	15,500
2000	3.5	32,154.82	5.5	76,200	10,080	17,000
2001	2.6	32,921.92	2.4	80,400	10,680	25,000
2002	1.4	33,252.09	1.0	84,900	11,280	30,000
2003	2.1	34,064.95	2.4	87,000	11,520	30,720
2004	2.7	35,648.55	4.6	87,900	11,640	31,080
2005	4.1	36,952.94	3.7	90,000	12,000	31,800
2006	3.3	38,651.41	4.6	94,200	12,480	33,240
2007	2.3	40,405.48	4.5	97,500	12,960	34,440
2008	5.8	41,334.97	2.3	102,000	13,560	36,120
2009	.0	40,711.61	-1.5	106,800	14,160	37,680
2010	.0	41,673.83	2.4	106,800	14,160	37,680
2011	3.6	42,979.61	3.1	106,800	14,160	37,680
2012	1.7	44,321.67	3.1	110,100	14,640	38,880
2013	1.5	44,888.16	1.3	113,700	15,120	40,080
2014	1.7	46,481.52	3.5	117,000	15,480	41,400
Intermediate:						
2015	[g].0	47,730.20	2.7	[g]118,500	[g]15,720	[g]41,880
2016	.2	49,121.32	2.9	[g]118,500	[g]15,720	[g]41,880
2017	2.9	51,467.41	4.8	126,000	16,680	44,520
2018	2.6	53,929.00	4.8	129,900	17,160	45,840
2019	2.6	56,341.78	4.5	135,900	18,000	48,000

Table V.C1.—Cost-of-Living Benefit Increases, Average Wage Index, Contribution and Benefit Bases, and Retirement Earnings Test Exempt Amounts, 1975-2025 (Cont.)

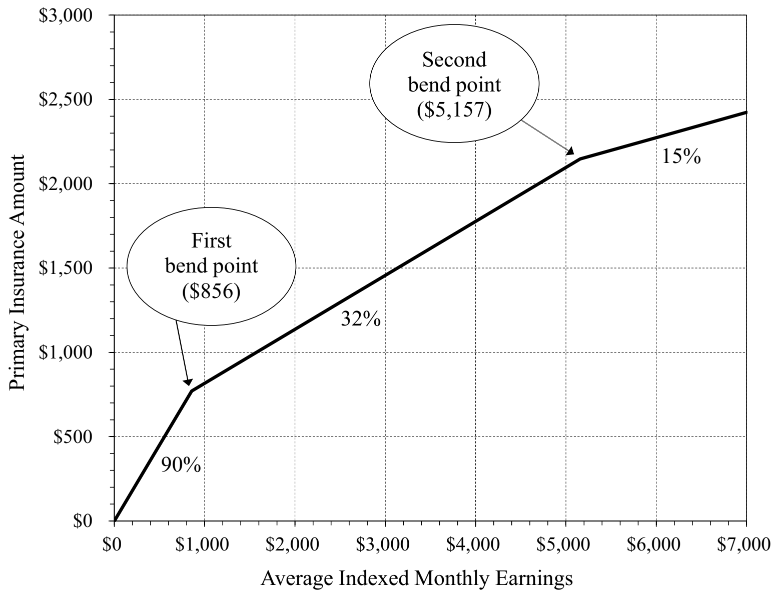
Calendar year	Cost-of-living benefit increase[a] (percent)	Average wage index (AWI) [b] Amount	Average wage index (AWI) [b] Increase (percent)	Contribution and benefit base [c]	Retirement earnings test exempt amount: Under NRA[d]	Retirement earnings test exempt amount: At NRA[e]
2020	2.6	$58,754.57	4.3	$142,500	$18,960	$50,280
2021	2.6	61,237.90	4.2	148,800	19,800	52,560
2022	2.6	63,735.69	4.1	155,100	20,640	54,840
2023	2.6	66,277.05	4.0	161,700	21,480	57,120
2024	2.6	68,952.47	4.0	168,300	22,320	59,520
2025	2.6	71,668.95	3.9	175,200	23,280	61,800
Low-cost:						
2015	[g].0	47,738.57	2.7	[g]118,500	[g]15,720	[g]41,880
2016	.7	49,447.98	3.6	[g]118,500	[g]15,720	[g]41,880
2017	3.7	52,465.16	6.1	126,000	16,680	44,520
2018	3.2	55,650.39	6.1	130,800	17,280	46,080
2019	3.2	58,743.24	5.6	138,600	18,360	48,960
2020	3.2	61,849.15	5.3	147,000	19,560	51,960
2021	3.2	65,032.70	5.1	155,100	20,640	54,840
2022	3.2	68,392.20	5.2	163,500	21,720	57,720
2023	3.2	71,951.98	5.2	171,900	22,800	60,720
2024	3.2	75,746.74	5.3	180,600	24,000	63,840
2025	3.2	79,674.91	5.2	190,200	25,200	67,080
High-cost:						
2015	[g].0	47,686.76	2.6	[g]118,500	[g]15,720	[g]41,880
2016	.0	48,298.98	1.3	[g]118,500	[g]15,720	[g]41,880
2017	1.9	49,518.62	2.5	118,500	15,720	41,880
2018	2.1	51,416.70	3.8	127,500	16,920	45,120
2019	2.0	53,305.83	3.7	130,800	17,400	46,200
2020	2.0	55,122.98	3.4	135,900	18,000	48,000
2021	2.0	56,973.96	3.4	140,700	18,720	49,680
2022	2.0	58,817.79	3.2	145,500	19,320	51,480
2023	2.0	60,655.65	3.1	150,600	19,920	53,160
2024	2.0	62,523.17	3.1	155,400	20,640	54,840
2025	2.0	64,321.07	2.9	160,200	21,240	56,640

[a] Effective with benefits payable for June in each year 1975-82, and for December in each year after 1982.
[b] See table VI.G6 for projected dollar amounts of the AWI for years beyond the last year of this table.
[c] Public Law 95-216 specified amounts for 1978-81. Public Law 101-239 changed the indexing procedure and caused slightly higher bases after 1989.
[d] Normal retirement age. See table V.C3 for specific values.
[e] In 1955-82, the retirement earnings test did not apply at ages 72 and over. In 1983-99, the test did not apply at ages 70 and over. Beginning in 2000, the test does not apply beginning with the month of normal retirement age attainment. In the year of normal retirement age attainment, the higher exempt amount applies to earnings prior to the month of normal retirement age attainment. Public Law 95-216 specified amounts for 1978-82. Public Law 104-121 specified amounts for 1996-2002.
[f] Originally determined as 2.4 percent. Pursuant to Public Law 106-554, effectively 2.5 percent.
[g] Actual amount, as determined under automatic-adjustment provisions.

Table V.C2 shows values for other wage-indexed parameters. The table provides historical values from 1978, when indexing of the amount of earnings required for a quarter of coverage first began, through 2016, and also shows projected values through 2025. These other wage-indexed program parameters are:

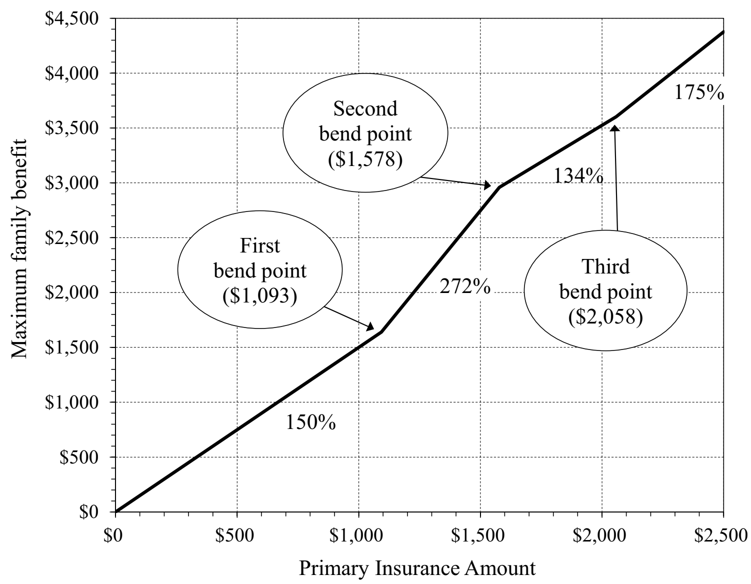
- *The bend points in the formula for computing the primary insurance amount (PIA) for workers who reach age 62, become disabled, or die in a given year.* As figure V.C1 illustrates, these two bend points define three ranges in a worker's average indexed monthly earnings (AIME). The formula for the worker's PIA multiplies a 90, 32, or 15 percent factor by the portion of the worker's AIME that falls within the three respective ranges, and then adds the resulting products together.

Figure V.C1.—Primary-Insurance-Amount Formula for Those Newly Eligible in 2016



- *The bend points in the formula for computing the maximum total amount of monthly benefits payable based on the earnings record of a retired or deceased worker (maximum family benefit).* As figure V.C2 illustrates, these three bend points define four ranges in a worker's PIA. The formula for the maximum family benefit multiplies a 150, 272, 134, or 175 percent factor by the portion of the worker's PIA that falls within the four respective ranges, and then adds the resulting products together.

Figure V.C2.—OASI Maximum-Family-Benefit Formula for Those Newly Eligible in 2016



- *The amount of earnings required in a year to earn a quarter of coverage (QC).* The number and timing of QCs earned determines an individual's insured status—the basic requirement for benefit eligibility under OASDI.

- *The old-law contribution and benefit base—the contribution and benefit base that would have been in effect without enactment of the 1977 amendments.* This old-law base is used in determining special-minimum benefits for certain workers who have many years of low earnings in covered employment. Since 1986, the calculation of OASDI benefits for certain workers who are eligible to receive pensions based on non-covered employment uses the old-law base. In addition, the Railroad Retirement program and the Employee Retirement Income Security Act of 1974 use the old-law base for certain purposes.

Table V.C2.—Values for Selected Wage-Indexed Program Parameters, Calendar Years 1978-2025

	AIME bend points in PIA formula[a]		PIA bend points in OASI maximum-family-benefit formula[b]			Earnings required for a quarter of coverage	Old-law contribution and benefit base[c]
Calendar year	First	Second	First	Second	Third		
Historical data:							
1978	[d]	[d]	[d]	[d]	[d]	[e] $250	[e] $17,700
1979	[e] $180	[e] $1,085	[e] $230	[e] $332	[e] $433	260	18,900
1980	194	1,171	248	358	467	290	20,400
1981	211	1,274	270	390	508	310	22,200
1982	230	1,388	294	425	554	340	24,300
1983	254	1,528	324	468	610	370	26,700
1984	267	1,612	342	493	643	390	28,200
1985	280	1,691	358	517	675	410	29,700
1986	297	1,790	379	548	714	440	31,500
1987	310	1,866	396	571	745	460	32,700
1988	319	1,922	407	588	767	470	33,600
1989	339	2,044	433	626	816	500	35,700
1990	356	2,145	455	656	856	520	38,100
1991	370	2,230	473	682	890	540	39,600
1992	387	2,333	495	714	931	570	41,400
1993	401	2,420	513	740	966	590	42,900
1994	422	2,545	539	779	1,016	620	45,000
1995	426	2,567	544	785	1,024	630	45,300
1996	437	2,635	559	806	1,052	640	46,500
1997	455	2,741	581	839	1,094	670	48,600
1998	477	2,875	609	880	1,147	700	50,700
1999	505	3,043	645	931	1,214	740	53,700
2000	531	3,202	679	980	1,278	780	56,700
2001	561	3,381	717	1,034	1,349	830	59,700
2002	592	3,567	756	1,092	1,424	870	63,000
2003	606	3,653	774	1,118	1,458	890	64,500
2004	612	3,689	782	1,129	1,472	900	65,100
2005	627	3,779	801	1,156	1,508	920	66,900
2006	656	3,955	838	1,210	1,578	970	69,900
2007	680	4,100	869	1,255	1,636	1,000	72,600
2008	711	4,288	909	1,312	1,711	1,050	75,900
2009	744	4,483	950	1,372	1,789	1,090	79,200
2010	761	4,586	972	1,403	1,830	1,120	79,200
2011	749	4,517	957	1,382	1,803	1,120	79,200
2012	767	4,624	980	1,415	1,845	1,130	81,900
2013	791	4,768	1,011	1,459	1,903	1,160	84,300
2014	816	4,917	1,042	1,505	1,962	1,200	87,000
2015	826	4,980	1,056	1,524	1,987	1,220	88,200
2016	856	5,157	1,093	1,578	2,058	1,260	88,200
Intermediate:							
2017	879	5,296	1,123	1,620	2,113	1,290	93,600
2018	904	5,450	1,155	1,668	2,175	1,330	96,300
2019	947	5,710	1,210	1,747	2,279	1,390	101,100
2020	993	5,983	1,268	1,831	2,388	1,460	105,900
2021	1,037	6,251	1,325	1,913	2,495	1,530	110,400
2022	1,081	6,519	1,382	1,995	2,601	1,590	115,200
2023	1,127	6,794	1,440	2,079	2,711	1,660	120,300
2024	1,173	7,071	1,499	2,164	2,822	1,730	125,100
2025	1,220	7,353	1,559	2,250	2,935	1,800	129,900

Table V.C2.—Values for Selected Wage-Indexed Program Parameters, Calendar Years 1978-2025 (Cont.)

Calendar year	AIME bend points in PIA formula[a]		PIA bend points in OASI maximum-family-benefit formula[b]			Earnings required for a quarter of coverage	Old-law contribution and benefit base[c]
	First	Second	First	Second	Third		
Low-cost:							
2017	$879	$5,296	$1,123	$1,621	$2,114	$1,290	$93,600
2018	910	5,486	1,163	1,679	2,189	1,340	96,900
2019	966	5,821	1,234	1,781	2,323	1,420	102,900
2020	1,024	6,174	1,309	1,889	2,464	1,510	109,200
2021	1,081	6,517	1,382	1,994	2,601	1,590	115,200
2022	1,138	6,862	1,455	2,100	2,738	1,680	121,200
2023	1,197	7,215	1,529	2,208	2,879	1,760	127,500
2024	1,259	7,588	1,608	2,322	3,028	1,850	134,100
2025	1,324	7,983	1,692	2,443	3,186	1,950	141,300
High-cost:							
2017	878	5,291	1,122	1,619	2,111	1,290	88,200
2018	889	5,359	1,136	1,640	2,139	1,310	94,800
2019	911	5,494	1,165	1,681	2,193	1,340	97,200
2020	946	5,705	1,209	1,746	2,277	1,390	100,800
2021	981	5,914	1,254	1,810	2,360	1,440	104,700
2022	1,015	6,116	1,296	1,871	2,441	1,490	108,300
2023	1,049	6,321	1,340	1,934	2,523	1,540	111,900
2024	1,083	6,526	1,383	1,997	2,604	1,590	115,500
2025	1,116	6,730	1,427	2,059	2,686	1,640	119,100

[a] The formula to compute a PIA is: (1) 90% of AIME below the first bend point, plus (2) 32% of AIME in excess of the first bend point but not in excess of the second, plus (3) 15% of AIME in excess of the second bend point. The bend points are determined based on the first year a beneficiary becomes eligible for benefits.
[b] The formula to compute an OASI family maximum is: (1) 150% of PIA below the first bend point, plus (2) 272% of PIA in excess of the first bend point but not in excess of the second, plus (3) 134% of PIA in excess of the second bend point but not in excess of the third, plus (4) 175% of PIA in excess of the third bend point. This formula also determines family maximums for disabled workers first eligible after 1978 and entitled before July 1980.
[c] Contribution and benefit base that would have been in effect without enactment of the Social Security Amendments of 1977. Public Law 101-239 changed the indexing procedure and caused slightly higher bases after 1989.
[d] No provision in law for this amount in this year.
[e] Amount specified by Social Security Amendments of 1977.

In addition to the economic factors that affect the determination of OASDI benefits, there are certain legislated changes that affect current and future benefit amounts. Two such changes are the scheduled increases in the normal retirement age and in the delayed retirement credits. Table V.C3 shows the scheduled changes in these parameters and the resulting effects on benefit levels expressed as a percentage of PIA.

Table V.C3.—Legislated Changes in Normal Retirement Age and Delayed Retirement Credits for Persons Reaching Age 62 in Each Year 1986 and Later

Year of birth	Year of attainment of age 62	Normal retirement age (NRA)	Credit for each year of delayed retirement after NRA (percent)	Benefit, as a percentage of PIA, beginning at age —				
				62	65	66	67	70
1924	1986	65	3	80	100	103	106	115
1925	1987	65	$3\frac{1}{2}$	80	100	$103\frac{1}{2}$	107	$117\frac{1}{2}$
1926	1988	65	$3\frac{1}{2}$	80	100	$103\frac{1}{2}$	107	$117\frac{1}{2}$
1927	1989	65	4	80	100	104	108	120
1928	1990	65	4	80	100	104	108	120
1929	1991	65	$4\frac{1}{2}$	80	100	$104\frac{1}{2}$	109	$122\frac{1}{2}$
1930	1992	65	$4\frac{1}{2}$	80	100	$104\frac{1}{2}$	109	$122\frac{1}{2}$
1931	1993	65	5	80	100	105	110	125
1932	1994	65	5	80	100	105	110	125
1933	1995	65	$5\frac{1}{2}$	80	100	$105\frac{1}{2}$	111	$127\frac{1}{2}$
1934	1996	65	$5\frac{1}{2}$	80	100	$105\frac{1}{2}$	111	$127\frac{1}{2}$
1935	1997	65	6	80	100	106	112	130
1936	1998	65	6	80	100	106	112	130
1937	1999	65	$6\frac{1}{2}$	80	100	$106\frac{1}{2}$	113	$132\frac{1}{2}$
1938	2000	65, 2 mo	$6\frac{1}{2}$	$79\frac{1}{6}$	$98\frac{8}{9}$	$105\frac{5}{12}$	$111\frac{11}{12}$	$131\frac{5}{12}$
1939	2001	65, 4 mo	7	$78\frac{1}{3}$	$97\frac{7}{9}$	$104\frac{2}{3}$	$111\frac{2}{3}$	$132\frac{2}{3}$
1940	2002	65, 6 mo	7	$77\frac{1}{2}$	$96\frac{2}{3}$	$103\frac{1}{2}$	$110\frac{1}{2}$	$131\frac{1}{2}$
1941	2003	65, 8 mo	$7\frac{1}{2}$	$76\frac{2}{3}$	$95\frac{5}{9}$	$102\frac{1}{2}$	110	$132\frac{1}{2}$
1942	2004	65, 10 mo	$7\frac{1}{2}$	$75\frac{5}{6}$	$94\frac{4}{9}$	$101\frac{1}{4}$	$108\frac{3}{4}$	$131\frac{1}{4}$
1943-54	2005-16	66	8	75	$93\frac{1}{3}$	100	108	132
1955	2017	66, 2 mo	8	$74\frac{1}{6}$	$92\frac{2}{9}$	$98\frac{8}{9}$	$106\frac{2}{3}$	$130\frac{2}{3}$
1956	2018	66, 4 mo	8	$73\frac{1}{3}$	$91\frac{1}{9}$	$97\frac{7}{9}$	$105\frac{1}{3}$	$129\frac{1}{3}$
1957	2019	66, 6 mo	8	$72\frac{1}{2}$	90	$96\frac{2}{3}$	104	128
1958	2020	66, 8 mo	8	$71\frac{2}{3}$	$88\frac{8}{9}$	$95\frac{5}{9}$	$102\frac{2}{3}$	$126\frac{2}{3}$
1959	2021	66, 10 mo	8	$70\frac{5}{6}$	$87\frac{7}{9}$	$94\frac{4}{9}$	$101\frac{1}{3}$	$125\frac{1}{3}$
1960 & later	2022 & later	67	8	70	$86\frac{2}{3}$	$93\frac{1}{3}$	100	124

2. Covered Employment

Projections of the total U.S. labor force and unemployment rate (see table V.B2) are based on Bureau of Labor Statistics definitions from the Current Population Survey (CPS). These projections represent the average weekly number of employed and unemployed persons, age 16 and over, in the U.S. in a calendar year. Covered employment for a calendar year is defined as the total number of persons who have any OASDI covered earnings (that is, earnings subject to the OASDI payroll tax) at any time during that year. For those age 16 and over, projected covered employment is the sum of age-sex components, each reflecting the growth projected for the component's total U.S employment and average weeks worked per year.[1] For the short-range period, the average weeks worked for each component is assumed to increase during the economic recovery. After 2025, the average weeks worked for each component is assumed to remain constant. The pro-

[1] For those under age 16, projected covered employment is the sum of age-sex components, each of which is projected as a ratio to the Social Security area population.

jection method also accounts for changes in non-OASDI-covered employment, the increase in coverage of Federal civilian employment as a result of the 1983 Social Security Amendments, and changes in the number and employment status of other immigrants residing within the Social Security coverage area.

The covered-worker rate is the ratio of OASDI covered workers to the Social Security area population. For men age 16 and over, the projected age-adjusted covered-worker rates[1] for 2090 are 69.1, 68.7, and 68.3 percent for the low-cost, intermediate, and high-cost assumptions, respectively. For women age 16 and over, the projected covered-worker rates for 2090 are 66.1, 64.7, and 63.2 percent for the low-cost, intermediate, and high-cost assumptions, respectively. These rates are higher than the 2014 levels of 67.6 percent for males and 61.6 percent for women, due to the assumed decreases in unemployment rates and assumed increase in labor force participation rates.

3. Insured Population

Eligibility for worker benefits under the OASDI program requires some threshold level of work in covered employment. A worker satisfies this requirement by his or her accumulation of quarters of coverage (QCs). Prior to 1978, a worker earned one QC for each calendar quarter in which he or she earned at least $50. In 1978, when annual earnings reporting replaced quarterly reporting, the amount required to earn a QC (up to a maximum of four per year) was set at $250. As specified in the law, the Social Security Administration has adjusted this amount each year since then according to changes in the AWI. Its value in 2016 is $1,260.

There are three types of insured status that a worker can acquire under the OASDI program. The number and recency of QCs earned determine each status. A worker acquires fully insured status when his or her total number of QCs is greater than or equal to the number of years elapsed after the year of attainment of age 21 (but not less than six). Once a worker has accumulated 40 QCs, he or she remains permanently fully insured. A worker acquires disability insured status if he or she is: (1) a fully insured worker who has accumulated 20 QCs during the 40-quarter period ending with the current quarter, (2) a fully insured worker aged 24-30 who has accumulated QCs during one-half of the quarters elapsed after the quarter of attainment of age 21 and up to and including the current quarter, or (3) a fully insured worker under age 24

[1] Age-adjusted covered-worker rates are adjusted to the 2012 age distribution of the Social Security area population.

who has accumulated six QCs during the 12-quarter period ending with the current quarter. A worker acquires currently insured status when he or she has accumulated six QCs during the 13-quarter period ending with the current quarter. Periods of disability reduce the number of quarters required for insured status, but not below the minimum of six QCs.

There are many types of benefits payable to workers and their family members under the OASDI program. A worker must be fully insured to be eligible for a primary retirement benefit and for his or her spouse or children to be eligible for auxiliary benefits. A deceased worker must have been either currently insured or fully insured at the time of death for his or her children (and their mother or father) to be eligible for benefits. If there are no eligible surviving children, the deceased worker must have been fully insured at the time of death for his or her surviving spouse to be eligible. A worker must be disability insured to be eligible for a primary disability benefit and for his or her spouse or children to be eligible for auxiliary benefits.

The Office of the Chief Actuary estimates the fully insured population, as a percentage of the Social Security area population, by single year of age and sex starting in 1969. The short-range model extrapolates the historical trend in these rates from data in the Continuous Work History Sample. The model uses information on quarters of coverage earned due to employment covered by Social Security derived from tabulations of the Continuous Work History Sample. The model also uses historical administrative data on beneficiaries in force and estimated historical mortality rates. The model combines this information to estimate the proportion of individuals who were alive and fully insured as of the end of each historical year. Using projected mortality rates and covered workers, the model extrapolates these rates into the future and applies them to the historical and projected population to arrive at the fully insured population by age and sex through the end of the short-range period.

The long-range fully insured model uses 30,000 simulated work histories for each sex and birth cohort, representing everyone except the other immigrant population.[1] For the other immigrant population, the model generates substantially lower percentages attaining fully insured status. The model constructs simulated work histories using past coverage rates, earnings distributions, and amounts required for crediting QCs, and develops them in a manner that replicates historical individual variations in work patterns. The probability of covered employment in any year is assumed to be higher for

[1] Those given legal work authorization through the Deferred Action for Childhood Arrivals and the Deferred Action for Parents of Americans programs are included in the simulations.

those who have worked more consistently in the recent past. Model parameters are selected so that simulated fully insured percentages are consistent with the fully insured percentages estimated by the short-range model for the recent historical period.

The Office of the Chief Actuary estimates the disability insured population, as a percentage of the fully insured population, by age and sex starting in 1970. The office bases historical values on a tabulation of the disability insured population from the Continuous Work History Sample and estimates of the fully insured population. The short-range model projects these percentages by using the relationship between the historical percentages and covered-worker rates. The long-range model projects these percentages by using the same simulated work histories used to project the fully insured percentages. The long-range model makes additional adjustments to the model simulations in order to bring the disability insured percentages in the historical and short-range periods into close agreement with those estimated from the Continuous Work History Sample and the short-range model.

The office does not project the currently insured population because the number of beneficiaries who are entitled to benefits based solely on currently insured status has been very small and is likely to remain small in the future.

Using these insured models, the percentage of the Social Security area population aged 62 and over that is fully insured will increase from its estimated level of 85.2 for December 31, 2013, to 86.6, 87.3, and 88.5 for December 31, 2090, under the low-cost, intermediate, and high-cost alternatives, respectively. Over the projection period, the percentage for females increases significantly, reflecting the past substantial growth in the employment of younger cohorts of women. The percentage for males declines, reflecting, in part, increases in the percent of the population that is classified as other immigrants and is thus less likely to have earnings reported and credited to them. Under the intermediate assumptions, for example, the percentage for males decreases from 93.0 to 86.7, and the percentage for females increases from 78.7 to 87.8.

4. Old-Age and Survivors Insurance Beneficiaries

The Office of the Chief Actuary projects the number of OASI beneficiaries for each type of benefit separately by the sex of the worker on whose earnings the benefits are based and by the age of the beneficiary. For the long-range period, the office also projects the number of beneficiaries by marital status for several types of benefits. The office uses two separate models in making these projections. The short-range model makes projections during the first 10 years of the projection period and the long-range model makes projections thereafter.

The short-range model develops the number of retired-worker beneficiaries by applying award rates to the aged fully insured population, excluding those already receiving retired-worker, disabled-worker, aged-widow(er)'s, or aged-spouse's benefits, and by applying termination rates to the number of retired-worker beneficiaries.

The long-range model projects the number of retired-worker beneficiaries who were not previously converted from disabled-worker beneficiary status as a percentage of the exposed population.[1] For age 62, the model projects this percentage by using a linear regression based on the historical relationship between this percentage, the labor force participation rate at age 62, and the number of months from age 62 to normal retirement age. The percentage for ages 70 and over is nearly 100 because delayed retirement credits cannot be earned after age 70. The long-range model projects the percentage for each age 63 through 69 based on historical experience with an adjustment for changes in the portion of the primary insurance amount that is payable at each age of entitlement. The model adjusts these percentages for ages 62 through 69 to reflect changes in the normal retirement age.

The long-range model calculates the number of retired-worker beneficiaries previously converted from disabled-worker beneficiary status using an extension of disabled-worker death rates by age, sex, and duration.

The Office of the Chief Actuary estimates the number of aged-spouse beneficiaries, excluding those who are also receiving a retired-worker benefit, from the population projected by age and sex. Benefits of aged-spouse beneficiaries depend on the earnings records of their husbands or wives, who are referred to as "earners." The short-range model projects insured aged-spouse beneficiaries in conjunction with the retired-worker beneficiaries. This model projects uninsured aged-spouse beneficiaries by applying award rates to the aged uninsured male or female population and by applying termination rates to the population already receiving such benefits.

The long-range model estimates aged-spouse beneficiaries separately for those married and divorced. The model projects the number of married aged-spouse beneficiaries, by age and sex, by applying a series of factors to the number of spouses, aged 62 and over, in the population. These factors are the probabilities that the spouse and the earner meet all of the conditions of

[1] The exposed population is the fully insured population age 62 and over, excluding persons entitled to or converted from disabled-worker benefits and fully insured persons entitled only to widow(er)'s benefits.

eligibility—that is, the probabilities that: (1) the earner is 62 or over, (2) the earner is insured, (3) the earner is either receiving benefits or has suspended benefits, (4) the spouse is not receiving a benefit for the care of an entitled child, (5) the spouse is either not insured or is insured but not receiving benefits, and (6) the spouse is not eligible to receive a significant government pension based on earnings in noncovered employment. Due to the Bipartisan Budget Act of 2015, aged spouses will no longer be eligible to receive an aged-spouse benefit if the earner suspends their benefit after April 29, 2016. Additionally, for those turning age 62 in 2016 and later, deemed filing will now apply to all retired workers and spouses even after initial entitlement, regardless of age. Thus, spouses who are insured will no longer be eligible to delay their retired-worker benefit while receiving an aged-spouse benefit. To calculate the estimated number of aged-spouse beneficiaries, the model applies a projected prevalence rate to the resulting number of spouses.

The long-range model estimates the number of divorced aged-spouse beneficiaries, by age and sex, by applying the same factors to the number of divorced persons aged 62 and over in the population, with three differences. First, the model applies a factor to reflect the probability that the earner (former spouse) is still alive. If the former spouse is not alive, the person may be entitled to a divorced widow(er)'s benefit. Second, the model applies a factor to reflect the probability that the marriage to the former spouse lasted at least 10 years. Third, the model does not apply factor (3) in the previous paragraph because, effective January 1985, a divorced person is generally no longer required to wait for the former spouse to receive benefits.

The Office of the Chief Actuary bases the projected numbers of children under age 18, and students aged 18 and 19, who are eligible for benefits as children of retired-worker beneficiaries, on the projected number of children in the population. The short-range model develops the number of entitled children by applying award rates to the number of children in the population who have two living parents and by applying termination rates to the number of children already receiving benefits.

The long-range model projects separately the number of entitled children by sex of the earner parent. For each age under 18, the model multiplies the projected number of children with a parent aged 62 and over by the ratio of the number of retired workers aged 62 to 71 to the number of members of the population aged 62 to 71. For student beneficiaries, the model multiplies the number of children aged 18 and 19 in the population by the probabilities that: (1) the parent is alive, aged 62 or over, insured, and receiving a retired-worker benefit; and (2) the child is attending high school.

The Office of the Chief Actuary projects the number of disabled children, aged 18 and over, of retired-worker beneficiaries from the adult population. The short-range model applies award rates to the population and applies termination rates to the number of disabled children already receiving benefits. The long-range model projects the number of disabled children in a manner similar to that used for student children except for a factor that reflects the probability of being disabled before age 22.

The short-range model develops the number of spouses of retired workers, who are entitled to spouse benefits because they are caring for a child who is under age 16 or disabled, by applying award rates to the number of awards to children of retired workers and by applying termination rates to the number of young spouses with a child in their care who are already receiving benefits. The long-range model projects the number of young-spouse beneficiaries with a child in their care as a proportion of the number of child beneficiaries of retired workers, including projected changes in average family size.

The Office of the Chief Actuary projects the number of aged-widow(er) beneficiaries, excluding those who are also receiving a retired-worker benefit, from the population by age and sex. The short-range model projects fully insured aged-widow(er) beneficiaries in conjunction with the retired-worker beneficiaries. The model projects the number of uninsured aged-widow(er) beneficiaries by applying award rates to the aged uninsured male or female population and by applying termination rates to the population already receiving such benefits. The long-range model projects uninsured aged-widow(er) beneficiaries by marital status. The model multiplies the number of widow(er)s in the population aged 60 and over by the probabilities that: (1) the deceased earner is fully insured at death, (2) the widow(er) is not receiving a benefit for the care of an entitled child, (3) the widow(er) is not fully insured, and (4) the widow(er)'s benefits are not withheld because of receipt of a significant government pension based on earnings in noncovered employment. In addition, the model applies the same factors to the number of divorced persons aged 60 and over in the population and includes additional factors representing the probability that the person's former earner spouse has died and that the marriage lasted at least 10 years. The model projects the number of insured aged-widow(er) beneficiaries who are ages 60 through 70 in a manner similar to that for uninsured aged-widow(er) beneficiaries. In addition, the model assumes that some insured widow(er)s who had not applied for their retired-worker benefits will receive widow(er)'s benefits. The model projects insured aged-widow(er) beneficiaries over age 70 by applying termination rates to the population that started receiving such benefits prior to age 70.

The short-range model develops the number of disabled-widow(er) beneficiaries by applying award rates to the uninsured male or female population and by applying termination rates to the population already receiving a disabled-widow(er) benefit. The long-range model projects the number for each cohort by age from 50 to normal retirement age as percentages of the widowed and divorced populations, adjusted for the insured status of the deceased spouse, the prevalence of disability, and the probability that the disabled spouse is not receiving another type of benefit.

The Office of the Chief Actuary bases the projected number of children under age 18, and students aged 18 and 19, who are entitled to benefits as survivors of deceased workers, on the number of children in the population whose mothers or fathers are deceased. The short-range model develops the number of entitled children by applying award rates to the number of orphaned children and by applying termination rates to the number of children already receiving benefits.

The long-range model projects the number of child-survivor beneficiaries in a manner similar to that for student beneficiaries of retired workers, except that the model replaces the probability that the parent is aged 62 or over with the probability that the parent is deceased.

The Office of the Chief Actuary projects the number of disabled-child-survivor beneficiaries, aged 18 and over, from the adult population. The short-range model applies award rates to the population and applies termination rates to the number of disabled-child-survivor beneficiaries already receiving benefits. The long-range model projects the number of disabled-child-survivor beneficiaries in a manner similar to that for student-child-survivor beneficiaries, except for including an additional factor to reflect the probability of being disabled before age 22.

The short-range model develops the numbers of entitled mother-survivor and father-survivor beneficiaries by applying award rates to the number of awards to child-survivor beneficiaries, in cases where the children are either under age 16 or disabled, and by applying termination rates to the number of mother-survivors and father-survivors already receiving benefits. The long-range model estimates the numbers of mother-survivor and father-survivor beneficiaries, assuming they are not remarried, from the number of child-survivor beneficiaries.

The Office of the Chief Actuary projects the number of parent-survivor beneficiaries based on the historical pattern of the number of such beneficiaries.

Table V.C4 shows the projected number of beneficiaries under the OASI program by type of benefit. The retired-worker beneficiary counts include those persons who receive a residual auxiliary benefit in addition to their retired-worker benefit. The office makes estimates of the number and amount of residual payments separately for spouses and widow(er)s.

Table V.C4.—OASI Beneficiaries With Benefits in Current-Payment Status at the End of Calendar Years 1945-2090
[In thousands]

	Retired workers and auxiliaries			Survivors				
Calendar year	Worker[a]	Spouse	Child	Widow-widower	Mother-father	Child	Parent	Total
Historical data:								
1945	518	159	13	94	121	377	6	1,288
1950	1,771	508	46	314	169	653	15	3,477
1955	4,474	1,192	122	701	292	1,154	25	7,961
1960	8,061	2,269	268	1,544	401	1,577	36	14,157
1965	11,101	2,614	461	2,371	472	2,074	35	19,128
1970	13,349	2,668	546	3,227	523	2,688	29	23,030
1975	16,589	2,867	643	3,888	582	2,919	21	27,509
1980	19,564	3,018	639	4,415	563	2,610	15	30,823
1985	22,435	3,069	456	4,862	372	1,918	10	33,122
1990	24,841	3,104	421	5,098	304	1,777	6	35,551
1995	26,679	3,027	441	5,213	275	1,884	4	37,522
1996	26,905	2,971	442	5,199	242	1,898	4	37,661
1997	27,282	2,926	441	5,043	230	1,893	3	37,817
1998	27,518	2,866	439	4,981	221	1,884	3	37,911
1999	27,784	2,811	442	4,936	212	1,885	3	38,073
2000	28,505	2,798	459	4,901	203	1,878	3	38,747
2001	28,843	2,742	467	4,828	197	1,890	3	38,969
2002	29,195	2,681	477	4,771	194	1,908	2	39,227
2003	29,537	2,622	480	4,707	190	1,910	2	39,448
2004	29,952	2,569	482	4,643	184	1,901	2	39,733
2005	30,461	2,524	488	4,569	178	1,903	2	40,126
2006	30,976	2,476	490	4,494	171	1,899	2	40,508
2007	31,528	2,431	494	4,436	165	1,892	2	40,947
2008	32,274	2,370	525	4,380	160	1,915	2	41,625
2009	33,514	2,343	561	4,327	160	1,921	2	42,828
2010	34,593	2,316	580	4,285	159	1,913	2	43,847
2011	35,600	2,291	594	4,239	158	1,907	2	44,791
2012	36,720	2,280	612	4,193	154	1,907	1	45,868
2013	37,893	2,285	625	4,139	150	1,899	1	46,992
2014	39,009	2,303	635	4,092	143	1,892	1	48,075
2015	40,089	2,335	648	4,050	140	1,893	1	49,155
Intermediate:								
2016	41,497	2,336	675	4,042	137	1,897	1	50,584
2020	48,038	2,287	773	4,016	128	1,915	1	57,158
2025	56,067	2,065	863	4,055	125	1,935	1	65,112
2030	62,977	2,281	1,012	3,893	133	1,958	1	72,255
2035	67,625	2,353	1,119	3,738	141	2,019	1	76,996
2040	70,286	2,323	1,155	3,539	138	2,014	1	79,455

Table V.C4.—OASI Beneficiaries With Benefits in Current-Payment Status at the End of Calendar Years 1945-2090 (Cont.)
[In thousands]

	Retired workers and auxiliaries			Survivors				
Calendar year	Worker[a]	Spouse	Child	Widow-widower	Mother-father	Child	Parent	Total
Intermediate (Cont.):								
2045	71,904	2,330	1,155	3,369	134	1,969	1	80,862
2050	73,894	2,355	1,185	3,228	129	1,926	1	82,718
2055	76,617	2,409	1,219	3,127	125	1,882	1	85,381
2060	79,917	2,482	1,247	3,055	123	1,844	1	88,669
2065	83,112	2,557	1,261	3,023	121	1,825	1	91,900
2070	86,525	2,664	1,301	3,014	119	1,818	1	95,442
2075	89,639	2,756	1,335	3,001	116	1,806	1	98,654
2080	91,614	2,854	1,339	2,995	113	1,787	1	100,702
2085	94,075	2,975	1,366	3,009	111	1,765	1	103,301
2090	97,629	3,087	1,416	3,026	108	1,750	1	107,018
Low-cost:								
2016	41,475	2,335	675	4,038	137	1,898	1	50,559
2020	47,900	2,288	776	4,004	130	1,931	1	57,030
2025	55,671	2,074	873	4,036	129	1,992	1	64,776
2030	61,822	2,239	1,042	3,939	131	2,119	1	71,293
2035	65,757	2,289	1,173	3,812	138	2,272	1	75,443
2040	67,718	2,232	1,227	3,626	137	2,347	1	77,287
2045	68,782	2,206	1,244	3,462	135	2,355	1	78,185
2050	70,356	2,195	1,296	3,322	133	2,354	1	79,658
2055	72,806	2,220	1,357	3,214	134	2,357	1	82,090
2060	75,865	2,263	1,414	3,133	136	2,377	1	85,189
2065	78,820	2,310	1,455	3,090	140	2,432	1	88,246
2070	81,947	2,375	1,525	3,073	143	2,502	1	91,566
2075	84,650	2,428	1,586	3,055	146	2,557	1	94,423
2080	86,310	2,496	1,607	3,057	147	2,595	1	96,212
2085	88,966	2,598	1,662	3,103	149	2,630	1	99,108
2090	93,522	2,701	1,760	3,168	151	2,676	1	103,981
High-cost:								
2016	41,516	2,336	674	4,046	136	1,895	1	50,605
2020	48,172	2,285	768	4,026	127	1,893	1	57,271
2025	56,513	2,052	847	4,074	119	1,868	1	65,473
2030	64,274	2,340	982	3,820	134	1,788	1	73,338
2035	69,688	2,454	1,069	3,634	138	1,769	1	78,753
2040	73,109	2,461	1,090	3,420	131	1,705	1	81,917
2045	75,385	2,500	1,076	3,245	122	1,622	1	83,952
2050	77,892	2,550	1,078	3,107	114	1,547	1	86,289
2055	80,947	2,626	1,083	3,009	106	1,478	1	89,250
2060	84,512	2,711	1,082	2,939	99	1,409	1	92,754
2065	87,926	2,810	1,074	2,908	93	1,354	1	96,166
2070	91,657	2,934	1,090	2,894	87	1,311	1	99,975
2075	95,167	3,038	1,099	2,874	81	1,272	1	103,532
2080	97,464	3,145	1,089	2,846	76	1,233	1	105,853
2085	99,617	3,277	1,092	2,824	71	1,192	1	108,074
2090	102,035	3,396	1,105	2,798	67	1,156	1	110,557

[a] Retired-worker beneficiaries include persons who also receive a residual benefit consisting of the excess of an auxiliary benefit over their retired-worker benefit.

Notes:
1. The number of beneficiaries does not include uninsured individuals who receive benefits under Section 228 of the Social Security Act. Transfers from the General Fund of the Treasury reimburse the OASI Trust Fund for the cost of most of these individuals.
2. Totals do not necessarily equal the sums of rounded components.

5. Disability Insurance Beneficiaries

The DI Trust Fund pays for benefits to disabled workers who: (1) satisfy the disability insured requirements, (2) are unable to engage in any substantial gainful activity due to a medically determinable physical or mental impairment severe enough to satisfy the requirements of the program, and (3) have not yet attained normal retirement age. Spouses and children of such disabled workers may also receive DI benefits provided they satisfy certain criteria, primarily age and earnings requirements.

The Office of the Chief Actuary projects the number of disabled-worker beneficiaries in current-payment status (disability prevalence) for each future year. The projections start with the number in current-payment status as of December 2015. Projections of the number of new beneficiaries awarded benefits each year (disability incidence) and the number of beneficiaries leaving the disability rolls each year then determine the number in current-payment status in later years. Beneficiaries leave the rolls due to death and recovery (disability terminations) and due to conversion from disabled-worker to retired-worker beneficiary status at normal retirement age, after which the OASI Trust Fund pays for benefits. The remainder of this section describes the concepts of disability incidence, termination, and prevalence.

a. Disability Incidence

The disability incidence rate is the ratio of the number of new beneficiaries awarded benefits each year to the number of individuals who meet insured requirements but are not yet receiving benefits (the disability-exposed population[1]). The Office of the Chief Actuary projects the number of newly awarded beneficiaries for each future year by multiplying assumed age-sex-specific disability incidence rates and the projected disability-exposed population by age and sex.

Figure V.C3 illustrates the historical and estimated incidence rates under the three alternatives. Incidence rates have varied substantially during the historical period since 1970 due to a variety of demographic and economic factors, along with changes in legislation and program administration. The solid lines in figure V.C3 show the incidence rate adjusted to the age-sex distribution of the disability-exposed population for 2000. This adjustment allows a comparison of incidence rates over time by focusing on the likelihood of becom-

[1] The disability-exposed population excludes those receiving benefits, while the disability insured population includes them. Section V.C.3 of this report describes the projection of the disability insured population.

ing disabled, and by excluding the effects of a changing distribution of the population toward ages where disability is more or less likely.

The dashed lines in figure V.C3 represent the gross (unadjusted) incidence rates. The changing age-sex distribution of the exposed population over time influences these unadjusted rates. The gross incidence rate fell substantially below the age-sex-adjusted rate between 1975 and 1995 as the baby-boom generation swelled the size of the younger working-age population, where disability incidence is lower than in older populations. After 1995, the gross rate rose faster than the age-sex-adjusted rate as the baby-boom generation moved into an age range where disability incidence peaks. After 2023, the projected gross incidence rate declines relative to the age-sex-adjusted rate as the baby-boom generation moves above the normal retirement age and the lower-birth-rate cohorts of the 1970s enter prime disability ages (50 to normal retirement age). As these smaller cohorts age beyond normal retirement age, by about 2050, the gross incidence rate returns to a higher relative level under the intermediate assumptions. Thereafter, the gross rate remains higher than the age-sex-adjusted rate, and reflects the persistently higher average age of the working-age population, which is largely due to lower birth rates since 1965, and to the increase in the normal retirement age.

For the first 10 years of the projection period (through 2025), incidence rates reflect several factors including: (1) aspects of program administration, such as efforts to reduce the disability backlog and recent changes to how claims are adjudicated; (2) assumed future unemployment rates; and (3) underlying trends in incidence. As described in section V.B.5, all three sets of economic assumptions reflect a continuation of the gradual economic recovery from the recession that began in December 2007. The corresponding projected unemployment rates follow near-term paths specific to the three alternative sets of economic assumptions, then gradually move toward their respective ultimate levels. At the beginning of the recent period of high unemployment, disability incidence rates were well above the general trend level, with rates reaching a peak in 2010. Over the last few years, incidence rates have subsided as the economy has recovered. At the beginning of the projection period, disability incidence rates remain briefly below the general trend level for each alternative because some of the earlier additional awards would have occurred in a later year. Due to expected efforts to reduce backlogs in processing disability determinations which have developed over the last few years, incidence rates are projected to rise above the general trend level through about 2020. Over the rest of the short-range period, disability incidence rates under each alternative evolve toward their ultimate levels along trajectories consistent with the assumed unemployment rates. After 2025, age-sex-specific incidence rates trend toward the ultimate rates assumed for the long-range projections and reach these ultimate rates in 2035. These ultimate age-sex-specific disability incidence rates were selected based on careful analysis of historical levels and patterns and expected future conditions, including the impact of scheduled increases in the normal retirement age.[1] The ultimate incidence rates represent the expected average rates of incidence for the future.

For the intermediate alternative, the Trustees assume that the ultimate age-sex-adjusted incidence rate (adjusted to the disability-exposed population for the year 2000) will be 5.4 awards per thousand exposed,[2] which is the same as in last year's report. Figure V.C3 illustrates that the estimated ultimate age-sex-adjusted incidence rate of 5.4 is slightly higher than the average rate for the historical period 1970 through 2015, reflecting the increase in female incidence rates over this period. However, a similar comparison using gross incidence rates gives a different result. The estimated ultimate gross incidence rate is substantially greater than the average gross rate over the historical period due to the large changes in the age-sex distribution of the disability-exposed population between 1970 and 2010.

The Trustees assume that the ultimate age-sex-adjusted incidence rates for the low-cost and high-cost alternatives will be 4.3 and 6.4 awards per thousand exposed, or about 17 percent lower and 23 percent higher than the average for the historical period, respectively. These ultimate age-sex-adjusted incidence rates are similar to those in last year's report.

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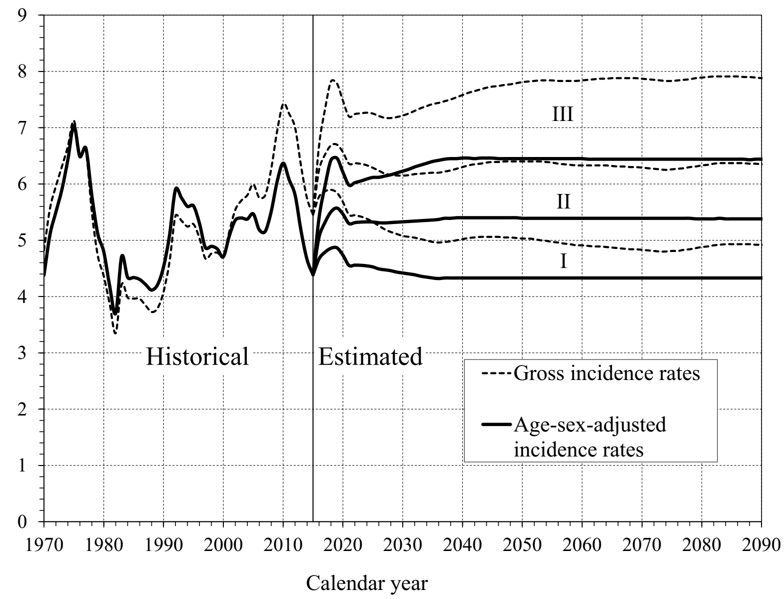
[1] Projected incidence rates are adjusted upward to account for additional workers who are expected to file for disability benefits (rather than retirement benefits) in response to reductions in retirement benefits as the normal retirement age rises.

[2] The ultimate age-sex-adjusted incidence rate decreased from 5.42 in last year's report to 5.38 in this year's report due to a new physician review requirement mandated by the Bipartisan Budget Act of 2015.

Figure V.C3.—DI Disability Incidence Rates, 1970-2090
[Awards per thousand disability-exposed]



b. Disability Termination

Beneficiaries stop receiving disability benefits when they die, recover from their medically-determinable disabling condition, or return to work. Disabled-worker beneficiaries who return to substantial work for an extended period are deemed to have recovered, and their benefits are then terminated. The termination rate is the ratio of the number of terminations for these reasons to the average number of disabled-worker beneficiaries during the year.

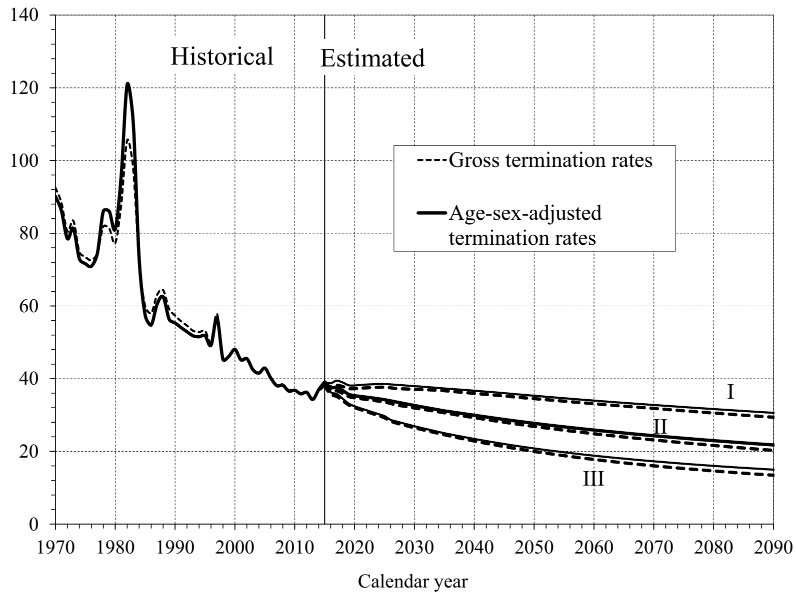
The Office of the Chief Actuary projects termination rates by age, sex, and reason for termination. In addition, the office projects termination rates by duration of entitlement to disabled-worker benefits in the long-range period (post-2025).

In the short-range period (through 2025), the projected age-sex-adjusted death rate (adjusted to the 2000 disabled-worker population) under the intermediate assumptions gradually declines from 25.7 deaths per thousand beneficiaries for 2015 to about 22.9 per thousand for 2025. The projected age-sex-adjusted recovery rate (medical improvement and return to work) under the intermediate assumptions evolves from a level of 13.4 per thousand beneficiaries for 2015 to 11.3 per thousand beneficiaries for 2025. Under the low-cost and high-cost assumptions, total age-sex-adjusted termination rates due to death and recovery are roughly 10-15 percent higher or lower, respectively, than under the intermediate assumptions.

For the long-range period (post-2025), the Office of the Chief Actuary projects death and recovery rates by age, sex, and duration of entitlement relative to the average level of rates experienced over the base period 2006 through 2010. The assumed ultimate age-sex-adjusted recovery rate for disabled workers is about 10.4 per thousand beneficiaries. The assumed ultimate age-sex-adjusted recovery rates for the low-cost and high-cost alternatives are about 12.6 and 8.3 recoveries per thousand beneficiaries, respectively. Recovery rates by age, sex, and duration of entitlement reach ultimate levels in the twentieth year of the projection period (2035) for all three sets of assumptions. In contrast, death rates by age and sex change throughout the long-range period at the same rate as death rates in the general population. From the age-sex-adjusted death rate of 25.7 per thousand beneficiaries in 2015, this rate decreases to 18.1, 11.4, and 6.7 per thousand disabled-worker beneficiaries for 2090 under the low-cost, intermediate, and high-cost assumptions, respectively.

Figure V.C4 illustrates gross and age-sex-adjusted total termination rates (including both recoveries and deaths) for disabled-worker beneficiaries for the historical period since 1970, and for the projection period through 2090. In the near term, through 2018, recovery terminations are projected to remain at relatively high levels, consistent with the assumption that the Social Security Administration will receive sufficient budget appropriations to reduce the pending backlog of continuing disability reviews. As with incidence rates, the age-sex-adjusted termination rate illustrates the real change in the tendency to terminate benefits. Changes in the age-sex distribution of the beneficiary population influence the gross termination rate. A shift in the beneficiary population to older ages, as occurred over the past 20 years when the baby-boom generation moved into pre-retirement ages, increases gross death termination rates relative to the age-sex-adjusted rates.

Figure V.C4.—DI Disability Termination Rates, 1970-2090
[Terminations per thousand disabled-worker beneficiaries]



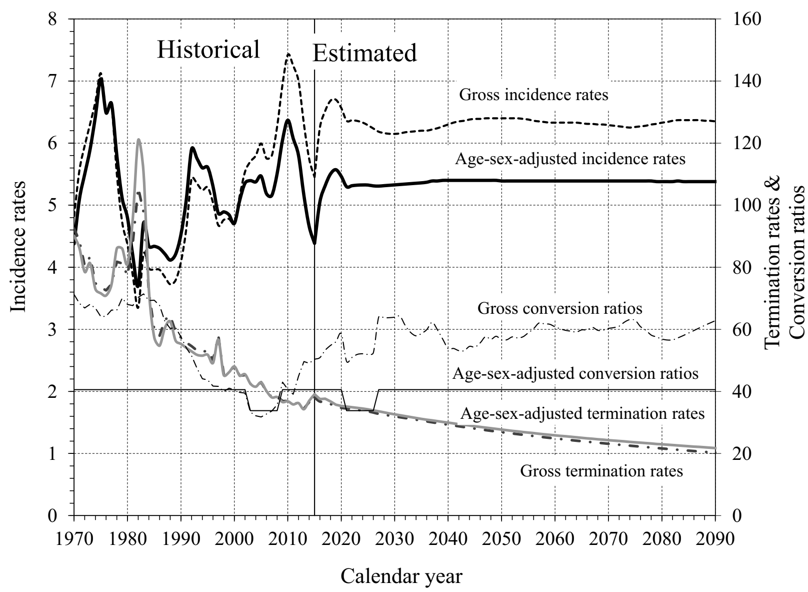
c. Comparison of Incidence, Termination, and Conversion

Incidence and termination rates are the foundation for projecting the number of disabled-worker beneficiaries in current-payment status. At normal retirement age, disabled-worker beneficiaries convert to retired-worker status and leave the DI rolls.

Figure V.C5 compares the historical and projected (intermediate) levels of incidence, termination, and conversion on both a gross basis and an age-sex-adjusted basis. Incidence rates have varied widely, and the Trustees expect the age-sex adjusted rates under the intermediate assumptions to remain near the middle of the high and low extremes experienced since 1970. Termination rates have declined and the Trustees expect them to continue to decline, largely because of declining death rates.

Conversions are simply a transfer of beneficiaries at normal retirement age from the DI Trust Fund account to the OASI Trust Fund account. Therefore, the disability "conversion" rate is 100 percent for disabled-worker beneficiaries reaching normal retirement age in a given year and zero at all other ages. After conversion, recovery from the disabling condition is no longer relevant for benefit eligibility. The conversion ratio is the number of conversions in a given year (that is, beneficiaries who reach normal retirement age) divided by the average number of disabled-worker beneficiaries at all ages in that year. The ratio is constant on an age-sex-adjusted basis, except for the two periods during which normal retirement age increases under current law. On a gross basis, however, the conversion ratio rises and falls with the changing proportion of all disabled-worker beneficiaries who attain normal retirement age in a given year. The gross conversion ratio generally increases from 2002 to 2030 due to aging of the beneficiary population.

Figure V.C5.—Comparison of DI Disability Incidence Rates, Termination Rates and Conversion Ratios Under Intermediate Assumptions, 1970-2090
[Awards per thousand disability-exposed;
terminations and conversions per thousand disabled-worker beneficiaries]



d. DI Beneficiaries and Disability Prevalence Rates

The Office of the Chief Actuary makes detailed projections of disabled-worker awards, terminations, and conversions and combines these to project the number of disabled workers receiving benefits over the next 75 years. Table V.C5 presents the projected numbers of disabled workers in current-payment status. The number of disabled workers in current-payment status grows from 8.9 million at the end of 2015, to 12.6 million, 14.6 million, and 15.8 million at the end of 2090, under the low-cost, intermediate, and high-cost assumptions, respectively. Of course, much of this growth results from the growth and aging of the population described earlier in this chapter. Table V.C5 also presents projected numbers of auxiliary beneficiaries and disability prevalence rates on both a gross basis and an age-sex-adjusted basis.

Table V.C5.—DI Beneficiaries With Benefits in Current-Payment Status at the End of Calendar Years 1960-2090
[Beneficiaries in thousands; prevalence rates per thousand persons insured for disability benefits]

Calendar year	Disabled-worker beneficiaries	Auxiliary beneficiaries		Total beneficiaries	Disability prevalence rates	
		Spouse	Child		Gross	Age-sex-adjusted[a]
Historical data:						
1960	455	77	155	687		
1965	988	193	558	1,739		
1970	1,493	283	889	2,665	20	18
1975	2,488	453	1,411	4,351	29	28
1980	2,856	462	1,359	4,677	28	31
1985	2,653	306	945	3,904	24	26
1990	3,007	266	989	4,261	25	28
1995	4,179	264	1,409	5,852	33	35
1996	4,378	224	1,463	6,065	34	36
1997	4,501	207	1,438	6,146	34	36
1998	4,691	190	1,446	6,327	35	36
1999	4,870	176	1,468	6,514	36	36
2000	5,036	165	1,466	6,667	36	36
2001	5,268	157	1,482	6,907	38	37
2002	5,539	152	1,526	7,217	39	38
2003	5,869	151	1,571	7,590	41	38
2004	6,198	153	1,599	7,950	43	39
2005	6,519	157	1,633	8,309	45	40
2006	6,807	156	1,652	8,615	46	40
2007	7,099	154	1,665	8,918	48	41
2008	7,427	155	1,692	9,273	50	41
2009	7,788	159	1,749	9,695	52	43
2010	8,204	161	1,820	10,185	55	44
2011	8,576	164	1,874	10,614	58	45
2012	8,827	163	1,900	10,890	59	46
2013	8,941	157	1,889	10,987	60	46
2014	8,955	150	1,828	10,932	59	46
2015	8,909	143	1,756	10,808	59	45
Intermediate:						
2016	8,993	139	1,739	10,871	59	45
2020	9,349	139	1,764	11,252	60	45
2025	9,790	153	1,800	11,742	62	45
2030	9,771	166	1,966	11,904	59	45
2035	9,988	184	2,208	12,381	59	45
2040	10,391	193	2,346	12,929	60	46
2045	11,078	207	2,429	13,714	62	47
2050	11,577	211	2,497	14,284	64	47
2055	12,012	220	2,556	14,788	65	48
2060	12,210	222	2,622	15,054	64	48
2065	12,547	232	2,709	15,488	65	49
2070	12,866	243	2,805	15,914	65	49
2075	13,082	245	2,884	16,210	65	49
2080	13,613	256	2,951	16,820	66	49
2085	14,246	270	3,020	17,536	67	50
2090	14,594	275	3,094	17,963	67	50

Table V.C5.—DI Beneficiaries With Benefits in Current-Payment Status at the End of Calendar Years 1960-2090 (Cont.)
[Beneficiaries in thousands; prevalence rates per thousand persons insured for disability benefits]

Calendar year	Disabled-worker beneficiaries	Auxiliary beneficiaries: Spouse	Auxiliary beneficiaries: Child	Total beneficiaries	Disability prevalence rates: Gross	Disability prevalence rates: Age-sex-adjusted[a]
Low-cost:						
2016	8,919	139	1,716	10,774	59	44
2020	8,845	136	1,653	10,634	57	42
2025	8,790	150	1,630	10,569	55	40
2030	8,386	136	1,743	10,265	50	38
2035	8,263	142	1,934	10,339	48	37
2040	8,365	140	2,040	10,545	47	37
2045	8,784	146	2,103	11,033	48	37
2050	9,117	145	2,159	11,421	48	37
2055	9,443	149	2,224	11,817	48	37
2060	9,627	150	2,314	12,091	47	37
2065	9,950	156	2,440	12,547	47	38
2070	10,303	163	2,581	13,047	47	38
2075	10,642	165	2,703	13,510	47	38
2080	11,303	175	2,810	14,289	47	38
2085	12,100	188	2,919	15,207	48	38
2090	12,642	194	3,040	15,876	49	38
High-cost:						
2016	9,060	140	1,758	10,957	60	45
2020	9,923	141	1,883	11,947	65	49
2025	10,802	154	1,940	12,896	69	50
2030	11,208	204	2,174	13,587	69	52
2035	11,786	240	2,450	14,476	71	54
2040	12,496	260	2,606	15,362	74	56
2045	13,458	285	2,692	16,435	78	57
2050	14,115	293	2,750	17,158	81	59
2055	14,642	307	2,794	17,742	83	60
2060	14,819	307	2,819	17,946	84	60
2065	15,116	318	2,848	18,282	86	61
2070	15,320	330	2,876	18,526	87	61
2075	15,283	326	2,890	18,500	86	61
2080	15,505	337	2,898	18,740	87	61
2085	15,777	350	2,910	19,037	88	61
2090	15,826	351	2,928	19,104	88	62

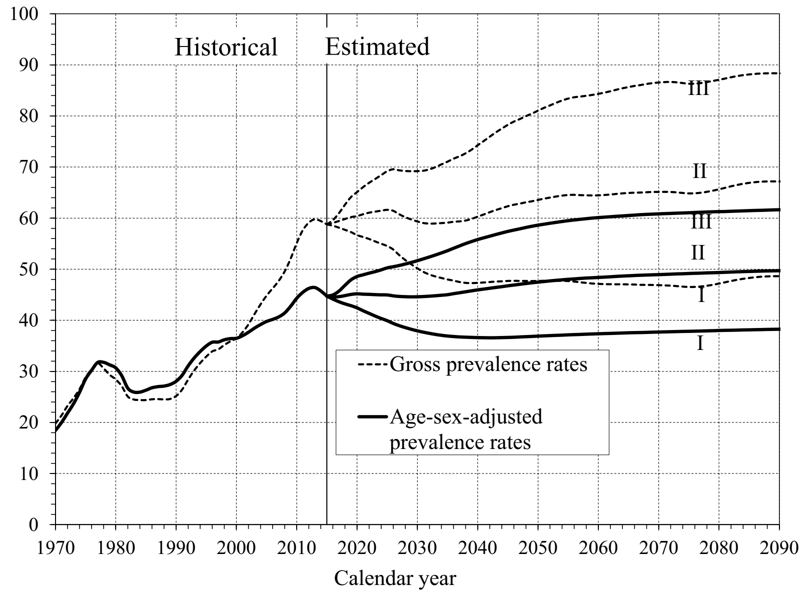
[a] Adjusted to the age-sex distribution of the insured population for the year 2000.

Note: Totals do not necessarily equal the sums of rounded components.

The disability prevalence rate is the ratio of the number of disabled-worker beneficiaries in current-payment status to the number of persons insured for disability benefits. Figure V.C6 illustrates the historical and projected disability prevalence rates on both a gross basis and on an age-sex-adjusted basis (adjusted to the age-sex distribution of the insured population for the year 2000).

Changes in prevalence rates are a direct result of changes in incidence rates and termination rates. Figure V.C5 depicts patterns for incidence and termination rates, which are helpful for understanding the trend in prevalence rates. Annual incidence and termination rates are not directly comparable or combinable because their denominators differ.

Figure V.C6.—DI Disability Prevalence Rates, 1970-2090
[Rate per thousand persons insured for disability benefits]



Age-sex-adjusted prevalence rates have increased primarily because: (1) termination rates have declined, (2) incidence rates at younger ages have increased relative to rates at older ages, and (3) incidence rates have increased substantially for women to parity with men. Gross prevalence rates have increased more than age-sex-adjusted prevalence rates ever since the baby-boom generation began to reach ages 45 through normal retirement age, a time of life when disability incidence rates are relatively high. The Office of the Chief Actuary projects both gross and age-sex adjusted prevalence rates to grow at a slower pace based on assumed stabilization in three factors: (1) the age distribution of the general population, (2) the age distribution of the disability insured population, and (3) incidence rates by age and gender. As these factors gradually stabilize, the declining death termination rate continues to have a small influence toward higher disability prevalence rates.

As mentioned above in the discussion of incidence and termination rates, the age-sex-adjusted prevalence rate isolates the changing trend in the underlying likelihood of receiving benefits for the insured population, without reflecting changes in the age distribution of the population. As with incidence rates, gross disability prevalence rates declined relative to the age-sex-adjusted rate when the baby-boom generation reached working age between 1970 and 1990; this trend reflects the lower disability prevalence rates associated with younger ages. Conversely, the gross rate of disability prevalence has increased relative to the age-sex-adjusted rate after 1990 due to the aging of the baby-boom generation into ages with higher disability prevalence rates.

Under the intermediate assumptions, the projected age-sex-adjusted disability prevalence rate grows from 44.7 per thousand disability insured at the end of 2015 to 49.7 per thousand at the end of 2090. As mentioned above, the Office of the Chief Actuary projects that the growth in prevalence will slow relative to the historical period.

Under the low-cost and high-cost assumptions, the age-sex-adjusted disability prevalence rate decreases to 38.3 per thousand and increases to 61.6 per thousand insured workers at the end of 2090, respectively.

Table V.C5 presents projections of the numbers of auxiliary beneficiaries paid from the DI Trust Fund. As indicated at the beginning of this subsection, auxiliary beneficiaries are qualifying spouses and children of disabled workers. A spouse must either be at least age 62 or have an eligible child beneficiary in his or her care who is either under age 16 or disabled prior to age 22. A child must be: (1) under age 18, (2) age 18 or 19 and still a student in high school, or (3) age 18 or older and disabled prior to age 22.

The projection of the number of auxiliary beneficiaries relies on the projected number of disabled-worker beneficiaries. In the short-range period (2016 through 2025), the Office of the Chief Actuary projects incidence and termination rates for each category of auxiliary beneficiary. After 2025, the office projects child beneficiaries at ages 18 and under in relation to the projected number of children in the population using the probability that either of their parents is a disabled-worker beneficiary. The office projects the remaining categories of children and spouses in a similar manner.

6. Covered and Taxable Earnings, Taxable Payroll, and Payroll Tax Contributions

Covered earnings are the sum of covered wages and covered self-employment net earnings. The Office of the Chief Actuary projects covered wages for component sectors of the economy (i.e., private, State and local, Federal civilian, and military) based on the projected overall growth of sectoral and total wages in the U.S. economy. The projections of covered wages also reflect changes in covered employment due to a relative increase in non-covered undocumented immigrants and to the mandatory coverage of new hires in the Federal civilian sector. The office projects covered self-employment net earnings based on the growth in net proprietors' income in the U.S. economy.

Taxable earnings are the amount of covered earnings subject to the Social Security payroll tax. Taxable wages for an employee are total covered wages from all wage employment up to the contribution and benefit base. Taxable wages for an employer are the sum of all covered wages paid to each employee up to the base. Employees with multiple jobs whose total wages exceed the base are eligible for a refund of excess employee taxes withheld; employers are not eligible for a refund on this basis. For self-employed workers with no taxable wages, taxable earnings are the amount of covered self-employment net earnings up to the base. For self-employed workers with taxable wages less than the base, covered self-employment net earnings are taxable up to the difference between the base and their taxable wages. For projection purposes, the Office of the Chief Actuary computes taxable earnings based on a proportion of covered earnings that is at or below the base.

The OASDI taxable payroll (see table VI.G6) for a year is the amount of earnings which, when multiplied by the combined OASDI employee-employer payroll tax rate for that year, yields the total amount of payroll taxes due from wages paid and self-employment net earnings for the year. The Trustees use taxable payroll to determine income rates, cost rates, and actuarial balances. Taxable payroll is derived by adjusting total taxable earnings to account for categories of earnings that are taxed at rates other than the combined employee-employer rate and to take into account amounts credited as wages that were not included in normally reported wages. For 1951 and later, taxable earnings are reduced by one-half of the amount of wages paid to employees with multiple jobs that exceed the contribution and benefit base. For 1983 through 2001, deemed wage credits for military service after 1956 are added to taxable earnings. The self-employment tax rates for 1951 through 1983 were less than the combined employee-employer rates; therefore, the self-employment component of taxable payroll for those years is reduced by multiplying the ratio of the self-employment rate to the combined employee-employer rate times the taxable self-employment net earnings. Finally, for 1966 through 1979, employers were exempt from paying their share of payroll tax on their employees' tips and, for 1980 through 1987, employers paid tax on only part of their employees' tips. For those years, the taxable payroll is reduced by half of the amount of tips for which the employer owed no payroll tax.

The ratio of taxable payroll to covered earnings (the taxable ratio) fell from 88.3 percent for 1984 to 82.6 percent for 2000, mostly due to much higher increases in wage levels for very high earners than for all other earners. From 2000 to 2010, the taxable ratio varied with the business cycle, rising during economic downturns and falling during recoveries. Specifically, the taxable ratio rose to 85.7 percent for 2002, declined to 82.4 percent for 2007, rose to 85.2 percent for 2009, and was 83.0 percent for 2014.

For this report, the Trustees assume a level for the taxable ratio at the end of the short-range period (2025) of 82.5 percent for the intermediate assumptions, 81.0 percent for the high-cost assumptions (or 1.5 percentage points lower than the intermediate assumptions), and 84.0 percent for the low-cost assumptions (or 1.5 percentage points higher than the intermediate assumptions). These are the same assumptions that the Trustees made for the end of the short-range period (2024) for the 2015 report.

The Office of the Chief Actuary projects payroll tax contributions using the patterns of tax collection required by Federal laws and regulations. The office determines payroll tax liabilities by multiplying the scheduled tax rates for each year by the amount of taxable wages and self-employment net earnings for that year. The office then splits these liabilities into amounts by collection period. For wages, Federal law requires that employers withhold OASDI and HI payroll taxes and Federal individual income taxes from employees' pay. As an employer's accumulation of such taxes (including the employer share of payroll taxes) meets certain thresholds, which the Department of the Treasury determines, the employer must deposit these taxes with the U.S. Treasury by a specific day, depending on the amount of money involved.[1] For projection purposes, the office splits the payroll tax contributions related to wages into amounts paid in the same quarter as incurred and in the following quarter. Self-employed workers must make estimated tax payments on their earnings four times during the year and make up any underestimate on their individual income tax returns. The projection splits the self-employed tax liabilities by collection quarter to reflect this pattern of receipts.

[1] Generally, the higher the amount of liability, the sooner the taxes must be paid. For smaller employers, payment is due by the middle of the month following when the liability was incurred. Medium-size employers have three banking days in which to make their deposits. Larger employers must make payment on the next business day after paying their employees.

The projected tax contributions also reflect the method used to ensure that money transferred to the trust funds is adjusted, over time, to equal the actual liability owed. Because payers generally make tax payments without identifying the separate OASDI contribution amounts, Treasury makes daily transfers of money from the General Fund to the trust funds on an initial estimated basis. The Social Security Administration periodically certifies the amounts of wages and self-employment net earnings on which tax contributions are owed for each year, at which time Treasury determines adjustments to appropriations to reconcile tax liabilities with deposits in the trust funds. This process also includes periodic transfers from the trust funds to the General Fund for contributions on wages in excess of the contribution and benefit base.

Table V.C6 shows the payroll tax contribution rates applicable under current law in each calendar year and the allocation of these rates between the OASI and DI Trust Funds.[1] It also shows the contribution and benefit base for each year through 2016.

[1] Table VI.G1 shows the payroll tax contribution rates for the Hospital Insurance (HI) program.

Table V.C6.—Contribution and Benefit Base and Payroll Tax Contribution Rates

		Payroll tax contribution rates (percent)					
		Employees and employers, combined[a]			Self-employed[b]		
Calendar years	Contribution and benefit base	OASDI	OASI	DI	OASDI	OASI	DI
1937-49	$3,000	2.00	2.00	—	—	—	—
1950	3,000	3.00	3.00	—	—	—	—
1951-53	3,600	3.00	3.00	—	2.2500	2.2500	—
1954	3,600	4.00	4.00	—	3.0000	3.0000	—
1955-56	4,200	4.00	4.00	—	3.0000	3.0000	—
1957-58	4,200	4.50	4.00	0.50	3.3750	3.0000	0.3750
1959	4,800	5.00	4.50	.50	3.7500	3.3750	.3750
1960-61	4,800	6.00	5.50	.50	4.5000	4.1250	.3750
1962	4,800	6.25	5.75	.50	4.7000	4.3250	.3750
1963-65	4,800	7.25	6.75	.50	5.4000	5.0250	.3750
1966	6,600	7.70	7.00	.70	5.8000	5.2750	.5250
1967	6,600	7.80	7.10	.70	5.9000	5.3750	.5250
1968	7,800	7.60	6.65	.95	5.8000	5.0875	.7125
1969	7,800	8.40	7.45	.95	6.3000	5.5875	.7125
1970	7,800	8.40	7.30	1.10	6.3000	5.4750	.8250
1971	7,800	9.20	8.10	1.10	6.9000	6.0750	.8250
1972	9,000	9.20	8.10	1.10	6.9000	6.0750	.8250
1973	10,800	9.70	8.60	1.10	7.0000	6.2050	.7950
1974	13,200	9.90	8.75	1.15	7.0000	6.1850	.8150
1975	14,100	9.90	8.75	1.15	7.0000	6.1850	.8150
1976	15,300	9.90	8.75	1.15	7.0000	6.1850	.8150
1977	16,500	9.90	8.75	1.15	7.0000	6.1850	.8150
1978	17,700	10.10	8.55	1.55	7.1000	6.0100	1.0900
1979	22,900	10.16	8.66	1.50	7.0500	6.0100	1.0400
1980	25,900	10.16	9.04	1.12	7.0500	6.2725	.7775
1981	29,700	10.70	9.40	1.30	8.0000	7.0250	.9750
1982	32,400	10.80	9.15	1.65	8.0500	6.8125	1.2375
1983	35,700	10.80	9.55	1.25	8.0500	7.1125	.9375
1984[c]	37,800	11.40	10.40	1.00	11.4000	10.4000	1.0000
1985[c]	39,600	11.40	10.40	1.00	11.4000	10.4000	1.0000
1986[c]	42,000	11.40	10.40	1.00	11.4000	10.4000	1.0000
1987[c]	43,800	11.40	10.40	1.00	11.4000	10.4000	1.0000
1988[c]	45,000	12.12	11.06	1.06	12.1200	11.0600	1.0600
1989[c]	48,000	12.12	11.06	1.06	12.1200	11.0600	1.0600
1990	51,300	12.40	11.20	1.20	12.4000	11.2000	1.2000
1991	53,400	12.40	11.20	1.20	12.4000	11.2000	1.2000
1992	55,500	12.40	11.20	1.20	12.4000	11.2000	1.2000
1993	57,600	12.40	11.20	1.20	12.4000	11.2000	1.2000
1994	60,600	12.40	10.52	1.88	12.4000	10.5200	1.8800
1995	61,200	12.40	10.52	1.88	12.4000	10.5200	1.8800
1996	62,700	12.40	10.52	1.88	12.4000	10.5200	1.8800
1997	65,400	12.40	10.70	1.70	12.4000	10.7000	1.7000
1998	68,400	12.40	10.70	1.70	12.4000	10.7000	1.7000
1999	72,600	12.40	10.70	1.70	12.4000	10.7000	1.7000
2000	76,200	12.40	10.60	1.80	12.4000	10.6000	1.8000
2001	80,400	12.40	10.60	1.80	12.4000	10.6000	1.8000
2002	84,900	12.40	10.60	1.80	12.4000	10.6000	1.8000
2003	87,000	12.40	10.60	1.80	12.4000	10.6000	1.8000
2004	87,900	12.40	10.60	1.80	12.4000	10.6000	1.8000
2005	90,000	12.40	10.60	1.80	12.4000	10.6000	1.8000

Table V.C6.—Contribution and Benefit Base and Payroll Tax Contribution Rates (Cont.)

Calendar years	Contribution and benefit base	Payroll tax contribution rates (percent)					
		Employees and employers, combined[a]			Self-employed[b]		
		OASDI	OASI	DI	OASDI	OASI	DI
2006	$94,200	12.40	10.60	1.80	12.4000	10.6000	1.8000
2007	97,500	12.40	10.60	1.80	12.4000	10.6000	1.8000
2008	102,000	12.40	10.60	1.80	12.4000	10.6000	1.8000
2009	106,800	12.40	10.60	1.80	12.4000	10.6000	1.8000
2010[d]	106,800	12.40	10.60	1.80	12.4000	10.6000	1.8000
2011[d]	106,800	10.40	8.89	1.51	10.4000	8.8900	1.5100
2012[d]	110,100	10.40	8.89	1.51	10.4000	8.8900	1.5100
2013	113,700	12.40	10.60	1.80	12.4000	10.6000	1.8000
2014	117,000	12.40	10.60	1.80	12.4000	10.6000	1.8000
2015	118,500	12.40	10.60	1.80	12.4000	10.6000	1.8000
2016[e]	118,500	12.40	10.03	2.37	12.4000	10.0300	2.3700
2017-18[e]	f	12.40	10.03	2.37	12.4000	10.0300	2.3700
2019 and later	f	12.40	10.60	1.80	12.4000	10.6000	1.8000

[a] Except as noted below, the combined employee/employer rate is divided equally between employees and employers.
[b] Beginning in 1990, self-employed persons receive a deduction, for purposes of computing their net earnings, equal to half of the combined OASDI and HI contributions that would be payable without regard to the contribution and benefit base. The OASDI contribution rate then applies to net earnings after this deduction, but subject to the OASDI base.
[c] In 1984 only, employees received an immediate credit of 0.3 percent of taxable wages against their OASDI payroll tax contributions. The self-employed received similar credits of 2.7 percent, 2.3 percent, and 2.0 percent against their combined OASDI and Hospital Insurance (HI) contributions on net earnings from self-employment in 1984, 1985, and 1986-89, respectively. The General Fund of the Treasury reimbursed the trust funds for these credits.
[d] Public Law 111-147 exempted most employers from paying the employer share of OASDI payroll tax on wages paid during the period March 19, 2010 through December 31, 2010 to certain qualified individuals hired after February 3, 2010. Public Law 111-312 reduced the OASDI payroll tax rate for 2011 by 2 percentage points for employees and for self-employed workers. Public Law 112-96 extended the 2011 rate reduction through 2012. These laws require that the General Fund of the Treasury reimburse the OASI and DI Trust Funds for these temporary reductions in 2010 through 2012 payroll tax revenue, in order to "replicate to the extent possible" revenue that would have been received if the combined employee/employer payroll tax rates had remained at 12.4 percent for OASDI (10.6 percent for OASI and 1.8 percent for DI).
[e] Section 833 of the Bipartisan Budget Act of 2015 reallocated payroll tax rates on a temporary basis. For earnings in calendar years 2016 through 2018, 0.57 percentage point of the 12.40 percent OASDI payroll tax rate is reallocated from OASI to DI.
[f] Subject to automatic adjustment based on increases in average wages.

7. Income From Taxation of Benefits

Under current law, the OASI and DI Trust Funds are credited with income tax revenue from the taxation of up to the first 50 percent of OASI and DI benefit payments. (The HI Trust Fund receives the remainder of the income tax revenue from the taxation of up to 85 percent of OASI and DI benefit payments.) Benefits are taxed for beneficiaries with adjusted income (including half of benefits and all non-taxable interest) exceeding specified threshold amounts. The threshold amounts are $25,000 for single filers, $32,000 for joint filers, and $0 for those married but filing separately.

For the short-range period, the Office of the Chief Actuary estimates the income to the trust funds from taxation of benefits by applying the following two factors (projected by the Office of Tax Analysis, Department of the Treasury) to total OASI and DI scheduled benefits: (1) the percentage of scheduled benefits (limited to 50 percent) that is taxable and (2) the average marginal tax rate applicable to those benefits.

For the long-range period, the office estimates the income to the trust funds from taxation of benefits by applying projected ratios of taxation of OASI and DI benefits to total OASI and DI scheduled benefits. The income thresholds used for benefit taxation are, by law, constant in the future, while income and benefit levels continue to rise. Accordingly, projected ratios of income from taxation of benefits to the amount of benefits increase gradually. Ultimate tax ratios for OASI and DI benefits used in the projection rely on estimates from the Office of Tax Analysis in the Department of the Treasury.

8. Average Benefits

Projections of average benefits for each benefit type reflect recent historical averages, projected average primary insurance amounts (PIAs), and projected ratios of average benefits to average PIAs. Calculations of average PIAs are based on projected distributions of beneficiaries by duration from year of initial entitlement, average PIAs at initial entitlement, and increases in PIAs after initial entitlement. Projected increases in average PIAs after initial entitlement depend on automatic benefit increases, recomputations to reflect additional covered earnings, and differences in mortality by level of lifetime earnings. Calculations of future average PIAs at initial entitlement are based on projected earnings histories, which in turn reflect a combination of the actual earnings histories associated with a sample of 2013 initial entitlements and more recent actual earnings levels by age and sex for covered workers.

For retired-worker, aged-spouse, and aged-widow(er) benefits, the percentage of the PIA that is payable depends on the age at initial entitlement to benefits. Projected ratios of average benefits to average PIAs for these types of benefits are based on projections of age distributions at initial entitlement.

9. Scheduled Benefits

For each type of benefit, scheduled benefits are the product of the number of beneficiaries and the corresponding average monthly benefit. The short-range model calculates scheduled benefits on a quarterly basis. The long-range model calculates all scheduled benefits on an annual basis, using the number of beneficiaries at the beginning and end of the year. Adjustments to these annual scheduled benefits include retroactive payments to newly awarded beneficiaries and other amounts not reflected in the regular monthly scheduled benefits.

Scheduled lump-sum death benefits are estimated as the product of: (1) the number of lump-sum death payments projected on the basis of the assumed death rates, the projected fully insured population, and the estimated percentage of the fully insured population that will qualify for lump-sum death payments; and (2) the amount of the lump-sum death payment, which is $255 (unindexed since 1973).

10. Illustrative Scheduled Benefit Amounts

Table V.C7 shows, under the intermediate assumptions, future benefit amounts payable upon retirement at the normal retirement age and at age 65, for various hypothetical workers attaining age 65 in 2016 and subsequent years. The illustrative benefit amounts in table V.C7 are presented in CPI-indexed 2016 dollars—that is, adjusted to 2016 levels by the CPI indexing series shown in table VI.G6. As a point of comparison, table V.C7 also shows the national average wage index (AWI) for 2016 and subsequent years in CPI-indexed 2016 dollars.

The normal retirement age was 65 for individuals who reached age 62 before 2000. It increased to age 66 during the period 2000 through 2005, at a rate of 2 months per year as workers attained age 62. Under current law, the normal retirement age will increase to age 67 during the period 2017 through 2022, also by 2 months per year as workers attain age 62. The illustrative benefit amounts shown in table V.C7 for retirees at age 65 are lower than the amounts shown for retirees at normal retirement age because the statute requires an actuarial reduction for monthly benefits taken before normal retirement age to reflect the expected additional years benefits will be collected. For example, those who collect benefits starting in 2027 at age 65 will receive benefits for two more years than if they instead claim benefits at the normal retirement age (age 67) unless they die between the ages of 65 and 67.

Table V.C7 shows five different pre-retirement earnings patterns. Four of these patterns assume the earnings history of workers with scaled-earnings patterns[1] and reflect very low, low, medium, and high career-average levels of pre-retirement earnings starting at age 21. The fifth pattern assumes the

[1] Actuarial Note 2016.3 has more details on scaled-earnings patterns. See www.ssa.gov/OACT/NOTES/ran3/an2016-3.pdf.

earnings history of a steady maximum earner starting at age 22. The four scaled-earnings patterns derive from earnings experienced by insured workers during 1993-2012. These earnings levels differ by age. The career-average level of earnings for each scaled case targets a percent of the AWI.

For the scaled medium earner, the career-average earnings level is about equal to the AWI (or $49,121 for 2016). For the scaled very low, low, and high earners, the career-average earnings level is about 25 percent, 45 percent, and 160 percent of the AWI, respectively (or $12,280, $22,105, and $78,594, respectively, for 2016). The steady maximum earner has earnings at or above the contribution and benefit base for each year starting at age 22 through the year prior to retirement (or $118,500 for 2016).

Table V.C7.—Annual Scheduled Benefit Amounts for Retired Workers With Various Pre-Retirement Earnings Patterns Based on Intermediate Assumptions, Calendar Years 2016-2090

		Benefits in 2016 dollars[a] with retirement at normal retirement age					
Year attain age 65[b]	Age at retirement	Scaled very low earnings[c]	Scaled low earnings[d]	Scaled medium earnings[e]	Scaled high earnings[f]	Steady maximum earnings[g]	National Average Wage Index in 2016 dollars[h]
2016	66:0	$9,025	$11,800	$19,455	$25,788	$31,418	$49,121
2020	66:2	9,722	12,722	20,976	27,794	34,021	52,913
2025	67:0	10,488	13,728	22,641	29,990	36,948	56,770
2030	67:0	11,255	14,733	24,284	32,171	39,661	60,429
2035	67:0	11,985	15,681	25,846	34,247	42,249	64,288
2040	67:0	12,752	16,681	27,499	36,434	44,913	68,226
2045	67:0	13,534	17,704	29,186	38,669	47,681	72,471
2050	67:0	14,376	18,811	31,001	41,076	50,593	77,033
2055	67:0	15,280	19,994	32,952	43,657	53,667	81,797
2060	67:0	16,226	21,230	34,987	46,359	56,913	86,764
2065	67:0	17,211	22,517	37,112	49,174	60,375	91,888
2070	67:0	18,229	23,848	39,302	52,077	63,945	97,169
2075	67:0	19,275	25,218	41,562	55,070	67,630	102,716
2080	67:0	20,379	26,660	43,934	58,214	71,500	108,546
2085	67:0	21,534	28,172	46,427	61,519	75,567	114,712
2090	67:0	22,757	29,773	49,065	65,012	79,871	121,296
		Benefits in 2016 dollars[a] with retirement at age 65					
2016	65:0	$8,617	$11,270	$18,579	$24,628	$29,897	$49,121
2020	65:0	8,967	11,729	19,343	25,624	31,256	52,913
2025	65:0	9,088	11,898	19,614	25,987	31,778	56,770
2030	65:0	9,753	12,768	21,039	27,883	34,134	60,429
2035	65:0	10,384	13,589	22,403	29,677	36,360	64,288
2040	65:0	11,051	14,454	23,827	31,573	38,657	68,226
2045	65:0	11,727	15,347	25,290	33,511	41,048	72,471
2050	65:0	12,461	16,302	26,867	35,598	43,550	77,033
2055	65:0	13,240	17,324	28,554	37,837	46,200	81,797
2060	65:0	14,062	18,399	30,321	40,177	48,999	86,764
2065	65:0	14,917	19,517	32,162	42,616	51,979	91,888
2070	65:0	15,798	20,668	34,062	45,133	55,054	97,169

Table V.C7.—Annual Scheduled Benefit Amounts for Retired Workers With Various Pre-Retirement Earnings Patterns Based on Intermediate Assumptions, Calendar Years 2016-2090 (Cont.)

2075	65:0	16,706	21,856	36,020	47,727	58,230	102,716
2080	65:0	17,661	23,105	38,076	50,452	61,564	108,546
2085	65:0	18,662	24,417	40,236	53,316	65,065	114,712
2090	65:0	19,723	25,803	42,522	56,343	68,770	121,296

[a] Annual amounts are the total for the 12-month period starting with the month of retirement, adjusted to be in 2016 dollars by using the CPI indexing series from table VI.G6.

[b] Attains age 65 on January 1 of the year.

[c] Career-average earnings at about 25 percent of the AWI.

[d] Career-average earnings at about 45 percent of the AWI.

[e] Career-average earnings at about 100 percent of the AWI. Such a worker would have career-average earnings at approximately the 56th percentile of all new retired-worker beneficiaries.

[f] Career-average earnings at about 160 percent of the AWI.

[g] Earnings for each year at or above the contribution and benefit base.

[h] Average Wage Index from table VI.G6, adjusted to be in 2016 dollars by using the CPI indexing series from table VI.G6.

Note: Benefits shown at age 65 reflect adjustments for early retirement. For early retirement as early as age 62, the benefit amount is reduced 5/9 of one percent for each month before normal retirement age, up to 36 months. If the number of months exceeds 36, then the benefit is further reduced 5/12 of one percent per month. For example, if the number of reduction months is 60 (the maximum number for retirement at 62 when normal retirement age is 67), then the benefit is reduced by 30 percent. *Delayed retirement credit* is generally given for retirement after the normal retirement age. The delayed retirement credit is 2/3 of one percent per month for persons born in 1943 and later. No credit is given for delaying benefits after attaining age 70. See table V.C3 for additional details, including adjustments applying to other birth years.

11. Administrative Expenses

The projection of administrative expenses through the short-range period is based on historical experience and the projected growth in average wages. The Office of Budget of the Social Security Administration provides estimates for the first several years of the projection. For years after the short-range period, projected administrative expenses reflect increases in the number of beneficiaries in current-payment status, and increases in the average wage. However, the increases in average wage are partially offset by assumed administrative productivity gains.

12. Railroad Retirement Financial Interchange

Railroad workers are covered under a separate multi-tiered benefit plan, with a first tier of coverage similar to OASDI coverage. An annual financial interchange between the Railroad Retirement fund and the OASI and DI Trust Funds is made to resolve the difference between: (1) the amount of OASDI benefits that would be paid to railroad workers and their families if railroad employment had been covered under the OASDI program, plus administrative expenses associated with these benefits; and (2) the amount of OASDI payroll tax and income tax that would be received with allowances for interest from railroad workers.

Calculation of the financial interchange with the Railroad Retirement reflects trends similar to those used in estimating the cost of OASDI benefits. The annual short-range net cost for the OASI and DI Trust Funds is about $4-$5 billion and the long-range summarized net cost for the OASI and DI Trust Funds is 0.04 percent of taxable payroll.

13. Military Service Transfers

Beginning in 1966, the General Fund of the Treasury reimbursed the OASI and DI Trust Funds annually for the cost (including administrative expenses) of providing additional benefit payments resulting from noncontributory wage credits for military service performed prior to 1957. The 1983 amendments modified the reimbursement mechanism and the timing of the reimbursements, and required a reimbursement in 1983 to include all future costs attributable to the wage credits. The amendments also require adjustments to that 1983 reimbursement every fifth year, beginning with 1985, to account for actual data. The Bipartisan Budget Act of 2015 eliminated the requirement for this adjustment every fifth year.

VI. APPENDICES

A. HISTORY OF OASI AND DI TRUST FUND OPERATIONS

The Federal Old-Age and Survivors Insurance (OASI) Trust Fund was established on January 1, 1940 as a separate account in the United States Treasury. The Federal Disability Insurance (DI) Trust Fund, another separate account in the United States Treasury, was established on August 1, 1956. These funds conduct the financial operations of the OASI and DI programs. The Board of Trustees is responsible for overseeing the financial operations of these funds. The following paragraphs describe the various components of trust fund income and outgo. Following this description, tables VI.A1 and VI.A2 present the historical operations of the separate trust funds since their inception, and table VI.A3 presents the operations of the hypothetical combined trust funds[1] during the period when they have co-existed.

The primary receipts of these two funds are amounts appropriated under permanent authority on the basis of payroll tax contributions. Federal law requires that all employees who work in OASDI covered employment, and their employers, make payroll tax contributions on their wages. Employees and their employers must also make payroll tax contributions on monthly cash tips if such tips are at least $20. Self-employed persons must make payroll tax contributions on their covered net earnings from self-employment. The Federal Government pays amounts equivalent to the combined employer and employee contributions that would be paid on deemed wage credits attributable to military service performed between 1957 and 2001, if such wage credits were covered wages. Treasury initially deposits payroll tax contributions to the trust funds each month on an estimated basis. Subsequently, Treasury makes adjustments based on the certified amount of wages and self-employment earnings in the records of the Social Security Administration.

Income also includes various reimbursements from the General Fund of the Treasury, such as: (1) the cost of noncontributory wage credits for military service before 1957, and periodic adjustments to previous determinations of this cost; (2) the cost in 1971 through 1982 of deemed wage credits for military service performed after 1956; (3) the cost of benefits to certain uninsured persons who attained age 72 before 1968; (4) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984 through 1989 by Public Law 98-21; (5) the cost in 2009 through 2017 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (6) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.

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[1] The OASI and DI Trust Funds are distinct legal entities which operate independently. To illustrate the actuarial status of the program as a whole, the fund operations are often combined on a hypothetical basis.

Beginning in 1984, Federal law subjected up to 50 percent of an individual's or couple's OASDI benefits to Federal income taxation under certain circumstances. Effective for taxable years beginning after 1993, the law increased the maximum percentage from 50 percent to 85 percent. Treasury credits the proceeds from this taxation of up to 50 percent of benefits to the OASI and DI Trust Funds in advance, on an estimated basis, at the beginning of each calendar quarter, with no reimbursement to the General Fund for interest costs attributable to the advance transfers.[1] Treasury makes subsequent adjustments based on the actual amounts shown on annual income tax records. Each of the OASI and DI Trust Funds receives the income taxes paid on the benefits from that trust fund.[2]

Another source of income to the trust funds is interest received on investments held by the trust funds. On a daily basis, Treasury invests trust fund income not required to meet current operating expenses, primarily in interest-bearing obligations of the U.S. Government. These investments include the special public-debt obligations described in the next paragraph. The Social Security Act also authorizes the trust funds to hold obligations guaranteed as to both principal and interest by the United States. The act therefore permits the trust funds to hold certain Federally sponsored agency obligations and marketable obligations.[3] The trust funds may acquire any of these obligations on original issue at the issue price or by purchase of outstanding obligations at their market price.

The Social Security Act authorizes the issuance of special public-debt obligations for purchase exclusively by the trust funds. The act provides that the interest rate for special obligations newly issued in any month is the average market yield, as of the last business day of the prior month, on all of the outstanding marketable U.S. obligations that are due or callable more than 4 years in the future. This rate is rounded to the nearest one-eighth of one percent. Beginning January 1999, in calculating the average market yield rate for this purpose, the Treasury incorporates the yield to the call date when a callable bond's market price is above par.

Although the Social Security Act does not authorize the purchase or sale of special issues in the open market, Treasury redeems special issues prior to

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[1] The HI Trust Fund receives the additional tax revenue resulting from the increase to 85 percent.

[2] A special provision applies to benefits paid to nonresident aliens. Effective for taxable years beginning after 1994, Public Law 103-465 subjects benefits to a flat-rate tax, usually 25.5 percent, before they are paid. Therefore, this tax remains in the trust funds. From 1984 to 1994, the flat-rate tax was usually 15 percent.

[3] The Social Security Act requires the trust funds to acquire special-issue obligations unless the Managing Trustee determines that the purchase of marketable obligations is in the public interest. The purchase of marketable obligations has been quite limited and has not occurred since 1980.

maturity at par value when needed to meet current operating expenses. Given this separation from market-based valuations, changes in market yield rates do not cause fluctuations in principal value. As is true for marketable Treasury securities held by the public, the full faith and credit of the U.S. Government backs all of the investments held by the trust funds.

The primary annual expenditures of the OASI and DI Trust Funds are: (1) OASDI benefit payments[1], net of any reimbursements from the General Fund of the Treasury for unnegotiated benefit checks; and (2) expenses incurred by the Social Security Administration and the Department of the Treasury in administering the OASDI program and the provisions of the Internal Revenue Code relating to the collection of contributions. Such administrative expenses include expenditures for construction, rental and lease, or purchase of office buildings and related facilities for the Social Security Administration. The Social Security Act prohibits expenditures from the OASI and DI Trust Funds for any purpose not related to the payment of benefits or administrative costs for the OASDI program.

The expenditures of the trust funds also include: (1) the costs of vocational rehabilitation services furnished to disabled persons receiving cash benefits because of their disabilities, where such services contributed to their successful rehabilitation; and (2) net costs of the provisions of the Railroad Retirement Act that provide for a system of coordination and financial interchange between the Railroad Retirement program and the Social Security program. Under the financial interchange provisions, the Railroad Retirement program's Social Security Equivalent Benefit Account and the trust funds interchange amounts on an annual basis so that each trust fund is in the same position it would have been had railroad employment always been covered under Social Security.

The statements of the operations of the trust funds in this report do not include the net worth of facilities and other fixed capital assets because the value of fixed capital assets is not available in the form of a financial asset redeemable for the payment of benefits or administrative expenditures. As a result of this unavailability, the actuarial status of the trust funds does not take these assets into account.

[1] Periodically, benefit payments which were scheduled to be paid on January 3 were actually paid on December 31 of the preceding year as required by the statutory provision included in the 1977 Social Security Amendments for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. Such advance payments have occurred about every 7 years, first for benefits scheduled for January 3, 1982. The most recent such accelerated payment affected benefits scheduled to be paid on January 3, 2016. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.

Table VI.A1.— Operations of the OASI Trust Fund, Calendar Years 1937-2015
[Dollar amounts in billions]

Calendar year	Income					Cost				Asset Reserves[a]		
	Total	Net payroll tax contributions	GF reimbursements[b]	Taxation of benefits	Net interest[c]	Total[a]	Benefit payments[ad]	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
1937[f] . .	$0.8	$0.8	—	—	[g]	[g]	[g]	—	—	$0.8	$0.8	—
1938[f] . .	.4	.4	—	—	[g]	[g]	[g]	—	—	.4	1.1	7,660
1939[f] . .	.6	.6	—	—	[g]	[g]	[g]	—	—	.6	1.7	8,086
1940 . .	.4	.3	—	—	[g]	$0.1	[g]	[g]	—	.3	2.0	2,781
1941 . .	.8	.8	—	—	$0.1	.1	$0.1	[g]	—	.7	2.8	1,782
1942 . .	1.1	1.0	—	—	.1	.2	.1	[g]	—	.9	3.7	1,737
1943 . .	1.3	1.2	—	—	.1	.2	.2	[g]	—	1.1	4.8	1,891
1944 . .	1.4	1.3	—	—	.1	.2	.2	[g]	—	1.2	6.0	2,025
1945 . .	1.4	1.3	—	—	.1	.3	.3	[g]	—	1.1	7.1	1,975
1946 . .	1.4	1.3	—	—	.2	.4	.4	[g]	—	1.0	8.1	1,704
1947 . .	1.7	1.6	[g]	—	.2	.5	.5	[g]	—	1.2	9.4	1,592
1948 . .	2.0	1.7	[g]	—	.3	.6	.6	$0.1	—	1.4	10.7	1,542
1949 . .	1.8	1.7	[g]	—	.1	.7	.7	.1	—	1.1	11.8	1,487
1950 . .	2.9	2.7	[g]	—	.3	1.0	1.0	.1	—	1.9	13.7	1,156
1951 . .	3.8	3.4	[g]	—	.4	2.0	1.9	.1	—	1.8	15.5	698
1952 . .	4.2	3.8	—	—	.4	2.3	2.2	.1	—	1.9	17.4	681
1953 . .	4.4	3.9	—	—	.4	3.1	3.0	.1	—	1.3	18.7	564
1954 . .	5.6	5.2	—	—	.4	3.7	3.7	.1	[g]	1.9	20.6	500
1955 . .	6.2	5.7	—	—	.5	5.1	5.0	.1	[g]	1.1	21.7	405
1956 . .	6.7	6.2	—	—	.5	5.8	5.7	.1	[g]	.9	22.5	371
1957 . .	7.4	6.8	—	—	.6	7.5	7.3	.2	[g]	-.1	22.4	300
1958 . .	8.1	7.6	—	—	.6	8.6	8.3	.2	$0.1	-.5	21.9	259
1959 . .	8.6	8.1	—	—	.5	10.3	9.8	.2	.3	-1.7	20.1	212
1960 . .	11.4	10.9	—	—	.5	11.2	10.7	.2	.3	.2	20.3	180
1961 . .	11.8	11.3	—	—	.5	12.4	11.9	.2	.3	-.6	19.7	163
1962 . .	12.6	12.1	—	—	.5	14.0	13.4	.3	.4	-1.4	18.3	141
1963 . .	15.1	14.5	—	—	.5	14.9	14.2	.3	.4	.1	18.5	123
1964 . .	16.3	15.7	—	—	.6	15.6	14.9	.3	.4	.6	19.1	118
1965 . .	16.6	16.0	—	—	.6	17.5	16.7	.3	.4	-.9	18.2	109
1966 . .	21.3	20.6	$0.1	—	.6	19.0	18.3	.3	.4	2.3	20.6	96
1967 . .	24.0	23.1	.1	—	.8	20.4	19.5	.4	.5	3.7	24.2	101
1968 . .	25.0	23.7	.4	—	.9	23.6	22.6	.5	.4	1.5	25.7	103
1969 . .	29.6	27.9	.4	—	1.2	25.2	24.2	.5	.5	4.4	30.1	102
1970 . .	32.2	30.3	.4	—	1.5	29.8	28.8	.5	.6	2.4	32.5	101
1971 . .	35.9	33.7	.5	—	1.7	34.5	33.4	.5	.6	1.3	33.8	94
1972 . .	40.1	37.8	.5	—	1.8	38.5	37.1	.7	.7	1.5	35.3	88
1973 . .	48.3	46.0	.4	—	1.9	47.2	45.7	.6	.8	1.2	36.5	75
1974 . .	54.7	52.1	.4	—	2.2	53.4	51.6	.9	.9	1.3	37.8	68
1975 . .	59.6	56.8	.4	—	2.4	60.4	58.5	.9	1.0	-.8	37.0	63
1976 . .	66.3	63.4	.6	—	2.3	67.9	65.7	1.0	1.2	-1.6	35.4	54
1977 . .	72.4	69.6	.6	—	2.2	75.3	73.1	1.0	1.2	-2.9	32.5	47
1978 . .	78.1	75.5	.6	—	2.0	83.1	80.4	1.1	1.6	-5.0	27.5	39
1979 . .	90.3	87.9	.6	—	1.8	93.1	90.6	1.1	1.4	-2.9	24.7	30
1980 . .	105.8	103.5	.5	—	1.8	107.7	105.1	1.2	1.4	-1.8	22.8	23
1981 . .	125.4	122.6	.7	—	2.1	126.7	123.8	1.3	1.6	-1.3	21.5	18
1982 . .	125.2	123.7	.7	—	.8	142.1	138.8	1.5	1.8	[h] .6	22.1	15
1983 . .	150.6	138.3	5.5	—	6.7	153.0	149.2	1.5	2.3	-2.4	19.7	14
1984 . .	169.3	159.5	4.7	$2.8	2.3	161.9	157.8	1.6	2.4	7.4	27.1	[i]20
1985 . .	184.2	175.1	4.0	3.2	1.9	171.2	167.2	1.6	2.3	[h]8.7	35.8	[i]24
1986 . .	197.4	189.1	1.8	3.4	3.1	181.0	176.8	1.6	2.6	[h]3.2	39.1	[i]28
1987 . .	210.7	201.1	1.7	3.3	4.7	187.7	183.6	1.5	2.6	23.1	62.1	[i]30
1988 . .	240.8	227.7	2.1	3.4	7.6	200.0	195.5	1.8	2.8	40.7	102.9	[i]41
1989 . .	264.7	248.1	2.1	2.4	12.0	212.5	208.0	1.7	2.8	52.2	155.1	[i]59
1990 . .	286.7	266.1	-.7	4.8	16.4	227.5	223.0	1.6	3.0	59.1	214.2	[i]78
1991 . .	299.3	272.5	.1	5.9	20.8	245.6	240.5	1.8	3.4	53.7	267.8	87
1992 . .	311.2	281.1	-.1	5.9	24.3	259.9	254.9	1.8	3.1	51.3	319.1	103
1993 . .	323.3	290.9	[g]	5.3	27.0	273.1	267.8	2.0	3.4	50.2	369.3	117
1994 . .	328.3	293.3	[g]	5.0	29.9	284.1	279.1	1.6	3.4	44.1	413.5	130

Table VI.A1.— Operations of the OASI Trust Fund, Calendar Years 1937-2015 (Cont.)
[Dollar amounts in billions]

	Income					Cost				Asset Reserves[a]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[b]	Taxation of benefits	Net interest[c]	Total[a]	Benefit payments[a d]	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
1995 . .	$342.8	$304.7	-$0.2	$5.5	$32.8	$297.8	$291.6	$2.1	$4.1	$45.0	$458.5	139
1996 . .	363.7	321.6	[g]	6.5	35.7	308.2	302.9	1.8	3.6	55.5	514.0	149
1997 . .	397.2	349.9	[g]	7.4	39.8	322.1	316.3	2.1	3.7	75.1	589.1	160
1998 . .	424.8	371.2	[g]	9.1	44.5	332.3	326.8	1.9	3.7	92.5	681.6	177
1999 . .	457.0	396.4	[g]	10.9	49.8	339.9	334.4	1.8	3.7	117.2	798.8	201
2000 . .	490.5	421.4	[g]	11.6	57.5	358.3	352.7	2.1	3.5	132.2	931.0	223
2001 . .	518.1	441.5	[g]	11.9	64.7	377.5	372.3	2.0	3.3	140.6	1,071.5	247
2002 . .	539.7	455.2	.4	12.9	71.2	393.7	388.1	2.1	3.5	146.0	1,217.5	272
2003 . .	543.8	456.1	[g]	12.5	75.2	406.0	399.8	2.6	3.6	137.8	1,355.3	300
2004 . .	566.3	472.8	[g]	14.6	79.0	421.0	415.0	2.4	3.6	145.3	1,500.6	322
2005 . .	604.3	506.9	-.3	13.8	84.0	441.9	435.4	3.0	3.6	162.4	1,663.0	340
2006 . .	642.2	534.8	[g]	15.6	91.8	461.0	454.5	3.0	3.5	181.3	1,844.3	361
2007 . .	675.0	560.9	[g]	17.2	97.0	495.7	489.1	3.1	3.6	179.3	2,023.6	372
2008 . .	695.5	574.6	[g]	15.6	105.3	516.2	509.3	3.2	3.6	179.3	2,202.9	392
2009 . .	698.2	570.4	[g]	19.9	107.9	564.3	557.2	3.4	3.7	133.9	2,336.8	390
2010 . .	677.1	544.8	2.0	22.1	108.2	584.9	577.4	3.5	3.9	92.2	2,429.0	400
2011 . .	698.8	482.4	87.8	22.2	106.5	603.8	596.2	3.5	4.1	95.0	2,524.1	402
2012 . .	731.1	503.9	97.7	26.7	102.8	645.5	637.9	3.4	4.1	85.6	2,609.7	391
2013 . .	743.8	620.8	4.2	20.7	98.1	679.5	672.1	3.4	3.9	64.3	2,674.0	384
2014 . .	769.4	646.2	.4	28.0	94.8	714.2	706.8	3.1	4.3	55.2	2,729.2	374
2015 . .	801.6	679.5	.3	30.6	91.2	750.5	742.9	3.4	4.3	51.0	2,780.3	364

[a] Beginning in 1979, benefit payments scheduled to be paid on January 3 of a given year were paid on December 31 of the preceding year as required by the statutory provision included in the 1977 Social Security Amendments for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. Such advance payments have occurred about every 7 years, first for benefits scheduled for January 3, 1982. For comparability with other historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.
[b] Includes net reimbursements from the General Fund of the Treasury to the OASI Trust Fund for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost in 1971-82 of deemed wage credits for military service performed after 1956; (3) the cost of benefits to certain uninsured persons who attained age 72 before 1968; (4) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (5) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (6) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.
[c] Net interest includes net profits or losses on marketable investments. Beginning in 1967, the trust fund pays administrative expenses on an estimated basis, with a final adjustment including interest made in the following fiscal year. Net interest includes the amounts of these interest adjustments. The 1970 report describes the accounting for administrative expenses for years prior to 1967. Beginning in October 1973, figures include relatively small amounts of gifts to the fund. Net interest for 1983-86 reflects payments for interest on amounts owed under the interfund borrowing provisions. During 1983-90, net interest reflects interest reimbursements paid from the trust fund to the General Fund on advance tax transfers.
[d] Beginning in 1966, includes payments for vocational rehabilitation services furnished to disabled persons receiving benefits because of their disabilities. Beginning in 1983, net benefit amounts include reimbursements paid from the General Fund to the trust fund for unnegotiated benefit checks. Excluding the portion attributable to vocational rehabilitation services and unnegotiated benefit checks, amounts are the same as benefits scheduled under law at that time for all historical years.
[e] The “Trust fund ratio” column represents asset reserves at the beginning of a year as a percentage of expenditures during the year. The table shows no ratio for 1937 because no reserves existed at the beginning of the year.
[f] Operations prior to 1940 are for the Old-Age Reserve Account established by the original Social Security Act. The 1939 Amendments transferred the asset reserves of the Account to the OASI Trust Fund effective January 1, 1940.
[g] Between -$50 million and $50 million.
[h] Reflects interfund borrowing and subsequent repayment of loans. The OASI Trust Fund borrowed $17.5 billion from the DI and HI Trust Funds in 1982 and repaid the loans in 1985 ($4.4 billion) and 1986 ($13.2 billion).
[i] Reserves used for the trust fund ratio calculation include January advance tax transfers.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.A2.— Operations of the DI Trust Fund, Calendar Years 1957-2015
[Dollar amounts in billions]

	Income					Cost				Asset Reserves[a]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[b]	Taxation of benefits	Net interest[c]	Total[a]	Benefit payments[a d]	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
1957	$0.7	$0.7	—	—	[f]	$0.1	$0.1	[f]	—	$0.6	$0.6	—
1958	1.0	1.0	—	—	[f]	.3	.2	[f]	—	.7	1.4	249
1959	.9	.9	—	—	[f]	.5	.5	[f]	[f]	.4	1.8	284
1960	1.1	1.0	—	—	$0.1	.6	.6	[f]	[f]	.5	2.3	304
1961	1.1	1.0	—	—	.1	1.0	.9	$0.1	[f]	.1	2.4	239
1962	1.1	1.0	—	—	.1	1.2	1.1	.1	[f]	-.1	2.4	206
1963	1.2	1.1	—	—	.1	1.3	1.2	.1	[f]	-.1	2.2	183
1964	1.2	1.2	—	—	.1	1.4	1.3	.1	[f]	-.2	2.0	159
1965	1.2	1.2	—	—	.1	1.7	1.6	.1	[f]	-.4	1.6	121
1966	2.1	2.0	[f]	—	.1	1.9	1.8	.1	[f]	.1	1.7	82
1967	2.4	2.3	[f]	—	.1	2.1	1.9	.1	[f]	.3	2.0	83
1968	3.5	3.3	[f]	—	.1	2.5	2.3	.1	[f]	1.0	3.0	83
1969	3.8	3.6	[f]	—	.2	2.7	2.6	.1	[f]	1.1	4.1	111
1970	4.8	4.5	[f]	—	.3	3.3	3.1	.2	[f]	1.5	5.6	126
1971	5.0	4.6	$0.1	—	.4	4.0	3.8	.2	[f]	1.0	6.6	140
1972	5.6	5.1	.1	—	.4	4.8	4.5	.2	[f]	.8	7.5	140
1973	6.4	5.9	.1	—	.5	6.0	5.8	.2	[f]	.5	7.9	125
1974	7.4	6.8	.1	—	.5	7.2	7.0	.2	[f]	.2	8.1	110
1975	8.0	7.4	.1	—	.5	8.8	8.5	.3	[f]	-.8	7.4	92
1976	8.8	8.2	.1	—	.4	10.4	10.1	.3	[f]	-1.6	5.7	71
1977	9.6	9.1	.1	—	.3	11.9	11.5	.4	[f]	-2.4	3.4	48
1978	13.8	13.4	.1	—	.3	13.0	12.6	.3	[f]	.9	4.2	26
1979	15.6	15.1	.1	—	.4	14.2	13.8	.4	[f]	1.4	5.6	30
1980	13.9	13.3	.1	—	.5	15.9	15.5	.4	[f]	-2.0	3.6	35
1981	17.1	16.7	.2	—	.2	17.7	17.2	.4	[f]	-.6	3.0	21
1982	22.7	22.0	.2	—	.5	18.0	17.4	.6	[f]	[g]-.4	2.7	17
1983	20.7	18.0	1.1	—	1.6	18.2	17.5	.6	[f]	2.5	5.2	15
1984	17.3	15.5	.4	$0.2	1.2	18.5	17.9	.6	[f]	-1.2	4.0	[h]35
1985	19.3	17.0	1.2	.2	.9	19.5	18.8	.6	[f]	[g]2.4	6.3	[h]27
1986	19.4	18.2	.2	.2	.8	20.5	19.9	.6	$0.1	[g]1.5	7.8	[h]38
1987	20.3	19.5	.2	[f]	.6	21.4	20.5	.8	.1	-1.1	6.7	[h]44
1988	22.7	21.8	.2	.1	.6	22.5	21.7	.7	.1	.2	6.9	[h]38
1989	24.8	23.8	.2	.1	.7	23.8	22.9	.8	.1	1.0	7.9	[h]38
1990	28.8	28.4	-.6	.1	.9	25.6	24.8	.7	.1	3.2	11.1	[h]40
1991	30.4	29.1	[f]	.2	1.1	28.6	27.7	.8	.1	1.8	12.9	39
1992	31.4	30.1	[f]	.2	1.1	32.0	31.1	.8	.1	-.6	12.3	40
1993	32.3	31.2	[f]	.3	.8	35.7	34.6	1.0	.1	-3.4	9.0	35
1994	52.8	51.4	[f]	.3	1.2	38.9	37.7	1.0	.1	14.0	22.9	23
1995	56.7	54.4	-.2	.3	2.2	42.1	40.9	1.1	.1	14.6	37.6	55
1996	60.7	57.3	[f]	.4	3.0	45.4	44.2	1.2	[f]	15.4	52.9	83
1997	60.5	56.0	[f]	.5	4.0	47.0	45.7	1.3	.1	13.5	66.4	113
1998	64.4	59.0	[f]	.6	4.8	49.9	48.2	1.6	.2	14.4	80.8	133
1999	69.5	63.2	[f]	.7	5.7	53.0	51.4	1.5	.1	16.5	97.3	152
2000	77.9	71.1	-.8	.7	6.9	56.8	55.0	1.6	.2	21.1	118.5	171
2001	83.9	74.9	[f]	.8	8.2	61.4	59.6	1.7	[f]	22.5	141.0	193
2002	87.4	77.3	[f]	.9	9.2	67.9	65.7	2.0	.2	19.5	160.5	208
2003	88.1	77.4	[f]	.9	9.7	73.1	70.9	2.0	.2	15.0	175.4	219
2004	91.4	80.3	[f]	1.1	10.0	80.6	78.2	2.2	.2	10.8	186.2	218
2005	97.4	86.1	[f]	1.1	10.3	88.0	85.4	2.3	.3	9.4	195.6	212
2006	102.6	90.8	[f]	1.2	10.6	94.5	91.7	2.3	.4	8.2	203.8	207
2007	109.9	95.2	[f]	1.4	13.2	98.8	95.9	2.5	.4	11.1	214.9	206
2008	109.8	97.6	[f]	1.3	11.0	109.0	106.0	2.5	.4	.9	215.8	197
2009	109.3	96.9	[f]	2.0	10.5	121.5	118.3	2.7	.4	-12.2	203.5	178

Table VI.A2.— Operations of the DI Trust Fund, Calendar Years 1957-2015 (Cont.)
[Dollar amounts in billions]

	Income					Cost				Asset Reserves[a]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[b]	Taxation of benefits	Net interest[c]	Total[a]	Benefit payments[a d]	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
2010. . .	$104.0	$92.5	$0.4	$1.9	$9.3	$127.7	$124.2	$3.0	$0.5	-$23.6	$179.9	159
2011. . .	106.3	81.9	14.9	1.6	7.9	132.3	128.9	2.9	.5	-26.1	153.9	136
2012. . .	109.1	85.6	16.5	.6	6.4	140.3	136.9	2.9	.5	-31.2	122.7	110
2013. . .	111.2	105.4	.7	.4	4.7	143.4	140.1	2.8	.6	-32.2	90.4	86
2014. . .	114.9	109.7	.1	1.7	3.4	145.1	141.7	2.9	.4	-30.2	60.2	62
2015. . .	118.6	115.4	[f]	1.1	2.1	146.6	143.4	2.8	.4	-28.0	32.3	41

[a] Beginning in 1979, benefit payments scheduled to be paid on January 3 of a given year were paid on December 31 of the preceding year as required by the statutory provision included in the 1977 Social Security Amendments for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. Such advance payments have occurred about every 7 years, first for benefits scheduled for January 3, 1982. For comparability with other historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.
[b] Includes net reimbursements from the General Fund of the Treasury to the DI Trust Fund for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost in 1971-82 of deemed wage credits for military service performed after 1956; (3) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (4) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (5) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.
[c] Net interest includes net profits or losses on marketable investments. Beginning in 1967, the trust fund pays administrative expenses on an estimated basis, with a final adjustment including interest made in the following fiscal year. Net interest includes the amounts of these interest adjustments. The 1970 report describes the accounting for administrative expenses for years prior to 1967. Beginning in July 1974, figures include relatively small amounts of gifts to the fund. Net interest for 1983-86 reflects payments for interest on amounts owed under the interfund borrowing provisions. During 1983-90, net interest reflects interest reimbursements paid from the trust fund to the General Fund on advance tax transfers.
[d] Beginning in 1966, includes payments for vocational rehabilitation services furnished to disabled persons receiving benefits because of their disabilities. Beginning in 1983, net benefit amounts include reimbursements paid from the General Fund to the trust fund for unnegotiated benefit checks. Excluding the portion attributable to vocational rehabilitation services and unnegotiated benefit checks, amounts are the same as benefits scheduled under law at that time for all historical years.
[e] The "Trust fund ratio" column represents asset reserves at the beginning of a year as a percentage of expenditures during the year. The table shows no ratio for 1957 because no reserves existed at the beginning of the year.
[f] Between -$50 million and $50 million.
[g] Reflects interfund borrowing and subsequent repayment of loans. The DI Trust Fund loaned $5.1 billion to the OASI Trust Fund in 1982. The OASI Trust Fund repaid the loan in 1985 ($2.5 billion) and 1986 ($2.5 billion).
[h] Reserves used for the trust fund ratio calculation include January advance tax transfers.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.A3.— Operations of the Combined OASI and DI Trust Funds, Calendar Years 1957-2015
[Dollar amounts in billions]

	Income					Cost				Asset Reserves[a]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[b]	Taxation of benefits	Net interest[c]	Total[a]	Benefit payments[a d]	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
1957 . .	$8.1	$7.5	—	—	$0.6	$7.6	$7.4	$0.2	[f]	$0.5	$23.0	298
1958	9.1	8.5	—	—	.6	8.9	8.6	.2	$0.1	.2	23.2	259
1959 . .	9.5	8.9	—	—	.6	10.8	10.3	.2	.3	-1.3	22.0	215
1960 . .	12.4	11.9	—	—	.6	11.8	11.2	.2	.3	.6	22.6	186
1961 . .	12.9	12.3	—	—	.6	13.4	12.7	.3	.3	-.5	22.2	169
1962 . .	13.7	13.1	—	—	.6	15.2	14.5	.3	.4	-1.5	20.7	146
1963 . .	16.2	15.6	—	—	.6	16.2	15.4	.3	.4	[f]	20.7	128
1964 . .	17.5	16.8	—	—	.6	17.0	16.2	.4	.4	.5	21.2	122
1965 . .	17.9	17.2	—	—	.7	19.2	18.3	.4	.5	-1.3	19.8	110
1966 . .	23.4	22.6	$0.1	—	.7	20.9	20.1	.4	.5	2.5	22.3	95
1967 . .	26.4	25.4	.1	—	.9	22.5	21.4	.5	.5	3.9	26.3	99
1968 . .	28.5	27.0	.4	—	1.0	26.0	25.0	.6	.5	2.5	28.7	101
1969 . .	33.3	31.5	.5	—	1.3	27.9	26.8	.6	.5	5.5	34.2	103
1970 . .	37.0	34.7	.5	—	1.8	33.1	31.9	.6	.6	3.9	38.1	103
1971 . .	40.9	38.3	.5	—	2.0	38.5	37.2	.7	.6	2.4	40.4	99
1972 . .	45.6	42.9	.5	—	2.2	43.3	41.6	.9	.7	2.3	42.8	93
1973 . .	54.8	51.9	.5	—	2.4	53.1	51.5	.8	.8	1.6	44.4	80
1974 . .	62.1	58.9	.5	—	2.7	60.6	58.6	1.1	.9	1.5	45.9	73
1975 . .	67.6	64.3	.5	—	2.9	69.2	67.0	1.2	1.0	-1.5	44.3	66
1976 . .	75.0	71.6	.7	—	2.7	78.2	75.8	1.2	1.2	-3.2	41.1	57
1977 . .	82.0	78.7	.7	—	2.5	87.3	84.7	1.4	1.2	-5.3	35.9	47
1978 . .	91.9	88.9	.8	—	2.3	96.0	93.0	1.4	1.6	-4.1	31.7	37
1979 . .	105.9	103.0	.7	—	2.2	107.3	104.4	1.5	1.5	-1.5	30.3	30
1980 . .	119.7	116.7	.7	—	2.3	123.5	120.6	1.5	1.4	-3.8	26.5	25
1981 . .	142.4	139.4	.8	—	2.2	144.4	141.0	1.7	1.6	-1.9	24.5	18
1982 . .	147.9	145.7	.9	—	1.4	160.1	156.2	2.1	1.8	[g] .2	24.8	15
1983 . .	171.3	156.3	6.7	—	8.3	171.2	166.7	2.2	2.3	.1	24.9	14
1984 . .	186.6	175.0	5.2	$3.0	3.4	180.4	175.7	2.3	2.4	6.2	31.1	[h]21
1985 . .	203.5	192.1	5.2	3.4	2.7	190.6	186.1	2.2	2.4	[g]11.1	42.2	[h]24
1986 . .	216.8	207.4	1.9	3.7	3.9	201.5	196.7	2.2	2.7	[g] 4.7	46.9	[h]29
1987 . .	231.0	220.6	1.9	3.2	5.3	209.1	204.1	2.4	2.6	21.9	68.8	[h]31
1988 . .	263.5	249.5	2.3	3.4	8.2	222.5	217.1	2.5	2.9	41.0	109.8	[h]41
1989 . .	289.4	271.9	2.3	2.5	12.7	236.2	230.9	2.4	2.9	53.2	163.0	[h]57
1990 . .	315.4	294.5	-1.3	5.0	17.2	253.1	247.8	2.3	3.0	62.3	225.3	[h]75
1991 . .	329.7	301.6	.1	6.1	21.9	274.2	268.2	2.6	3.5	55.5	280.7	82
1992 . .	342.6	311.3	-.1	6.1	25.4	291.9	286.0	2.7	3.2	50.7	331.5	96
1993 . .	355.6	322.0	.1	5.6	27.9	308.8	302.4	3.0	3.4	46.8	378.3	107
1994 . .	381.1	344.7	[f]	5.3	31.1	323.0	316.8	2.7	3.5	58.1	436.4	117
1995 . .	399.5	359.1	-.4	5.8	35.0	339.8	332.6	3.1	4.1	59.7	496.1	128
1996 . .	424.5	378.9	[f]	6.8	38.7	353.6	347.0	3.0	3.6	70.9	567.0	140
1997 . .	457.7	406.0	[f]	7.9	43.8	369.1	362.0	3.4	3.7	88.6	655.5	154
1998 . .	489.2	430.2	[f]	9.7	49.3	382.3	375.0	3.5	3.8	106.9	762.5	171
1999 . .	526.6	459.6	[f]	11.6	55.5	392.9	385.8	3.3	3.8	133.7	896.1	194
2000 . .	568.4	492.5	-.8	12.3	64.5	415.1	407.6	3.8	3.7	153.3	1,049.4	216
2001 . .	602.0	516.4	[f]	12.7	72.9	438.9	431.9	3.7	3.3	163.1	1,212.5	239
2002 . .	627.1	532.5	.4	13.8	80.4	461.7	453.8	4.2	3.6	165.4	1,378.0	263
2003 . .	631.9	533.5	[f]	13.4	84.9	479.1	470.8	4.6	3.7	152.8	1,530.8	288
2004 . .	657.7	553.0	[f]	15.7	89.0	501.6	493.3	4.5	3.8	156.1	1,686.8	305
2005 . .	701.8	592.9	-0.3	14.9	94.3	529.9	520.7	5.3	3.9	171.8	1,858.7	318
2006 . .	744.9	625.6	[f]	16.9	102.4	555.4	546.2	5.3	3.8	189.5	2,048.1	335
2007 . .	784.9	656.1	[f]	18.6	110.2	594.5	584.9	5.5	4.0	190.4	2,238.5	345
2008 . .	805.3	672.1	[f]	16.9	116.3	625.1	615.3	5.7	4.0	180.2	2,418.7	358
2009 . .	807.5	667.3	[f]	21.9	118.3	685.8	675.5	6.2	4.1	121.7	2,540.3	353

Table VI.A3.— Operations of the Combined OASI and DI Trust Funds, Calendar Years 1957-2015 (Cont.)
[Dollar amounts in billions]

	Income					Cost				Asset Reserves[a]		
Calendar year	Total	Net payroll tax contributions	GF reimbursements[b]	Taxation of benefits	Net interest[c]	Total[a]	Benefit payments[a d]	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[e]
2010 . . .	$781.1	$637.3	$2.4	$23.9	$117.5	$712.5	$701.6	$6.5	$4.4	$68.6	$2,609.0	357
2011 . . .	805.1	564.2	102.7	23.8	114.4	736.1	725.1	6.4	4.6	69.0	2,677.9	354
2012 . . .	840.2	589.5	114.3	27.3	109.1	785.8	774.8	6.3	4.7	54.4	2,732.3	341
2013 . . .	855.0	726.2	4.9	21.1	102.8	822.9	812.3	6.2	4.5	32.1	2,764.4	332
2014 . . .	884.3	756.0	.5	29.6	98.2	859.2	848.5	6.1	4.7	25.0	2,789.5	322
2015 . . .	920.2	794.9	.3	31.6	93.3	897.1	886.3	6.2	4.7	23.0	2,812.5	311

[a] Beginning in 1979, benefit payments scheduled to be paid on January 3 of a given year were paid on December 31 of the preceding year as required by the statutory provision included in the 1977 Social Security Amendments for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. Such advance payments have occurred about every 7 years, first for benefits scheduled for January 3, 1982. For comparability with other historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year.
[b] Includes net reimbursements from the General Fund of the Treasury to the OASI and DI Trust Funds for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost in 1971-82 of deemed wage credits for military service performed after 1956; (3) the cost of benefits to certain uninsured persons who attained age 72 before 1968; (4) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (5) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (6) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.
[c] Net interest includes net profits or losses on marketable investments. Beginning in 1967, the trust funds pay administrative expenses on an estimated basis, with a final adjustment including interest made in the following fiscal year. Net interest includes the amounts of these interest adjustments. The 1970 report describes the accounting for administrative expenses for years prior to 1967. Beginning in October 1973, figures include relatively small amounts of gifts to the funds. Net interest for 1983-86 reflects payments for interest on amounts owed under the interfund borrowing provisions. During 1983-90, net interest reflects interest reimbursements paid from the trust funds to the General Fund on advance tax transfers.
[d] Beginning in 1966, includes payments for vocational rehabilitation services furnished to disabled persons receiving benefits because of their disabilities. Beginning in 1983, net benefit amounts include reimbursements paid from the General Fund to the trust funds for unnegotiated benefit checks. Excluding the portion attributable to vocational rehabilitation services and unnegotiated benefit checks, amounts are the same as benefits scheduled under law at that time for all historical years.
[e] The “Trust fund ratio” column represents asset reserves at the beginning of a year as a percentage of expenditures during the year.
[f] Between -$50 million and $50 million.
[g] Reflects interfund borrowing and subsequent repayment of loans. The OASI Trust Fund borrowed $12.4 billion from the HI Trust Fund in 1982 and repaid the loan in 1985 ($1.8 billion) and 1986 ($10.6 billion).
[h] Reserves used for the trust fund ratio calculation include January advance tax transfers.

Note: Totals do not necessarily equal the sums of rounded components.

Tables VI.A4 and VI.A5 show the total asset reserves of the OASI Trust Fund and the DI Trust Fund, respectively, at the end of calendar years 2014 and 2015. The tables show reserves by interest rate and year of maturity. Bonds issued to the trust funds in 2015 had an interest rate of 2.00 percent, compared with an interest rate of 2.25 percent for bonds issued in 2014.

Table VI.A4.—OASI Trust Fund Asset Reserves, End of Calendar Years 2014 and 2015
[In thousands]

	December 31, 2014	December 31, 2015
Obligations sold only to the trust funds (special issues):		
Certificates of indebtedness:		
2.000 percent, 2015	$57,308,984	—
2.125 percent, 2016	—	$38,935,438
Bonds:		
1.375 percent, 2016	6,693,019	—
1.375 percent, 2017-25	60,237,180	60,237,180
1.375 percent, 2026	6,693,019	6,693,019
1.375 percent, 2027	173,240,401	173,240,401
1.750 percent, 2016	4,908,186	—
1.750 percent, 2017-18	9,816,372	9,816,372
1.750 percent, 2019-25	34,357,295	34,357,295
1.750 percent, 2026-27	9,816,372	9,816,372
1.750 percent, 2028	178,148,587	178,148,587
2.000 percent, 2017-19	—	10,966,887
2.000 percent, 2020-25	—	21,933,768
2.000 percent, 2026-29	—	14,622,516
2.000 percent, 2030	—	185,790,628
2.250 percent, 2016	3,986,412	—
2.250 percent, 2017-18	7,972,824	7,972,824
2.250 percent, 2019-25	27,904,891	27,904,891
2.250 percent, 2026-28	11,959,236	11,959,236
2.250 percent, 2029	182,134,999	182,134,999
2.500 percent, 2016	5,971,788	—
2.500 percent, 2017-25	53,746,083	53,746,083
2.500 percent, 2026	166,547,382	166,547,382
2.875 percent, 2016	7,264,432	—
2.875 percent, 2017-24	58,115,456	58,115,456
2.875 percent, 2025	160,575,595	160,575,595
3.250 percent, 2016	10,628,270	—
3.250 percent, 2017-23	74,397,890	74,397,890
3.250 percent, 2024	153,311,163	153,311,163
3.500 percent, 2016	9,513,752	—
3.500 percent, 2017	9,513,752	9,513,752
3.500 percent, 2018	86,900,994	86,900,994
4.000 percent, 2015	977,473	—
4.000 percent, 2016	12,075,192	—
4.000 percent, 2017-22	72,451,152	72,451,152
4.000 percent, 2023	142,682,893	142,682,893
4.125 percent, 2015	10,516,946	—
4.125 percent, 2016	10,516,946	9,936,522
4.125 percent, 2017-19	31,550,838	31,550,838
4.125 percent, 2020	106,585,700	106,585,700
4.625 percent, 2015	9,167,664	—
4.625 percent, 2016-18	27,502,989	27,502,989
4.625 percent, 2019	96,068,657	96,068,657
5.000 percent, 2015	12,454,232	—
5.000 percent, 2016-21	74,725,392	74,725,392
5.000 percent, 2022	130,607,701	130,607,701
5.125 percent, 2015	11,567,866	—
5.125 percent, 2016-19	46,271,464	46,271,464
5.125 percent, 2020	11,567,769	11,567,769
5.125 percent, 2021	118,153,469	118,153,469

Table VI.A4.—OASI Trust Fund Asset Reserves, End of Calendar Years 2014 and 2015
[In thousands]

	December 31, 2014	December 31, 2015
Bonds (Cont.):		
5.250 percent, 2015	$9,235,912	—
5.250 percent, 2016	9,235,911	$9,235,911
5.250 percent, 2017	77,387,242	77,387,242
5.625 percent, 2015	9,621,437	—
5.625 percent, 2016	68,151,331	68,151,331
6.500 percent, 2015	58,529,893	—
Total investments	2,729,270,403	2,760,517,758
Undisbursed balances[a]	-37,873	19,733,589
Total asset reserves	2,729,232,530	2,780,251,347

[a] A negative amount for each year represents a situation where actual program cash expenditures exceeded the amount of invested securities of the OASI Trust Fund that were redeemed to pay for such expenditures. In this situation, future redemption of additional invested securities will be required to pay for this shortfall. For 2015 and other calendar years where January 3 of the following year is a Sunday, a positive amount is shown on a liability basis for benefits scheduled to be paid on January 3 of the following year that were, by law, actually paid on the preceding December 31.

Note: Amounts of special issues are at par value. The trust fund purchases and redeems special issues at par value. The table groups equal amounts that mature in two or more years at a given interest rate.

Table VI.A5.—DI Trust Fund Asset Reserves, End of Calendar Years 2014 and 2015
[In thousands]

	December 31, 2014	December 31, 2015
Obligations sold only to the trust funds (special issues):		
Certificates of indebtedness:		
2.000 percent, 2015	$3,493,788	—
Bonds:		
4.000 percent, 2021	622,572	—
4.000 percent, 2022	622,572	—
4.000 percent, 2023	14,675,554	$14,675,554
4.125 percent, 2020	11,649,018	—
5.000 percent, 2020	476,584	—
5.000 percent, 2021	476,584	—
5.000 percent, 2022	14,052,982	11,425,890
5.125 percent, 2020	665,115	—
5.125 percent, 2021	13,576,398	—
Total investments	60,311,167	26,101,444
Undisbursed balances[a]	-67,279	6,157,191
Total asset reserves	60,243,888	32,258,635

[a] A negative amount for each year represents a situation where actual program cash expenditures exceeded the amount of invested securities of the DI Trust Fund that were redeemed to pay for such expenditures. In this situation, future redemption of additional invested securities will be required to pay for this shortfall. For 2015 and other calendar years where January 3 of the following year is a Sunday, a positive amount is shown on a liability basis for benefits scheduled to be paid on January 3 of the following year that were, by law, actually paid on the preceding December 31.

Note: Amounts of special issues are at par value. The trust fund purchases and redeems special issues at par value. The table groups equal amounts that mature in two or more years at a given interest rate.

B. HISTORY OF ACTUARIAL STATUS ESTIMATES

This appendix chronicles the history of the OASDI actuarial balance and the year of combined OASI and DI Trust Fund reserve depletion since 1982. The actuarial balance is the principal summary measure of long-range actuarial status. The 1983 report was the last report for which the actuarial balance was positive. The two basic components of actuarial balance are the summarized income rate and the summarized cost rate, both of which are expressed as percentages of taxable payroll. Section IV.B.4 defines summarized income rate, summarized cost rate, and actuarial balance in detail. For any given period, the actuarial balance is the difference between the present value of non-interest income for the period and the present value of the cost for the period, each divided by the present value of taxable payroll for all years in the period. The computation of the actuarial balance also includes:

- In the reports for 1988 and later, the amount of the trust fund asset reserves on hand at the beginning of the valuation period; and
- In the reports for 1991 and later, the present value of a target trust fund asset reserve equal to 100 percent of the annual cost to be reached and maintained at the end of the valuation period.

Reports prior to 1973 used the current method of calculating the actuarial balance based on present values, but the reports of 1973-87 did not. During that period, the reports used the average-cost method, a simpler method which approximates the results of the present-value approach. Under the average-cost method, the sum of the annual cost rates over the 75-year projection period was divided by the total number of years, 75, to obtain the average cost rate per year. A similar computation produced the average income rate. The actuarial balance was the difference between the average income rate and the average cost rate.

When the 1973 report introduced the average-cost method, the long-range financing of the program was more nearly on a pay-as-you-go basis. Also, the long-range demographic and economic assumptions in that report produced an annual rate of growth in taxable payroll which was about the same as the annual rate at which the trust funds earned interest. In either situation (i.e., pay-as-you-go financing, where the annual income rate is the same as the annual cost rate, or an annual rate of growth in taxable payroll equal to the annual interest rate), the average-cost method produces the same result as the present-value method. However, by 1988, neither of these situations still existed.

After the 1977 and 1983 Social Security Amendments, estimates showed substantial increases in the trust funds continuing well into the 21st century. These laws changed the program's financing from essentially pay-as-you-go to partial advance funding. Also, the reports from 1973 through 1987 phased in reductions in long-range fertility rates and average real-wage growth, which produced an annual rate of growth in long-range taxable earnings which was significantly lower than the assumed interest rate. As a result of the difference between this rate of growth and the assumed interest rate, the results of the average-cost method and the present-value method in the reports for 1973 through 1987 began to diverge, and by 1988 they were quite different. While the average-cost method still accounted for most of the effects of the assumed interest rate, it no longer accounted for all of the interest effects. The present-value method, by contrast, accounts for the full effect of the assumed interest rates. The 1988 report reintroduced the present-value method of calculating the actuarial balance in order to fully reflect the effects of interest.

A positive actuarial balance indicates that estimated income is more than sufficient to meet estimated trust fund obligations for the period as a whole. A negative actuarial balance indicates that estimated income is insufficient to meet estimated trust fund obligations for the entire period. An actuarial balance of zero indicates that the estimated income exactly matches estimated trust fund obligations for the period.

Table VI.B1 contains the estimated OASDI actuarial balances, summarized income rates, and summarized cost rates for the 1982 report through the current report. The reports presented these values on the basis of the intermediate assumptions, which recent reports refer to as alternative II and reports prior to 1991 referred to as alternative II-B.

Table VI.B1.—Long-Range OASDI Actuarial Balances and Trust Fund Reserve Depletion Dates as Shown in the Trustees Reports for 1982-2016[a]
[As a percentage of taxable payroll]

Year of report	Summarized income rate	Summarized cost rate	Actuarial balance[b]	Change from previous year[c]	Year of combined trust fund reserve depletion
1982	12.27	14.09	-1.82	[d]	1983
1983	12.87	12.84	+.02	+1.84	solvent
1984	12.90	12.95	-.06	-.08	solvent
1985	12.94	13.35	-.41	-.35	2049
1986	12.96	13.40	-.44	-.03	2051
1987	12.89	13.51	-.62	-.18	2051
1988	12.94	13.52	-.58	+.04	2048
1989	13.02	13.72	-.70	-.13	2046
1990	13.04	13.95	-.91	-.21	2043
1991	13.11	14.19	-1.08	-.17	2041
1992	13.16	14.63	-1.46	-.38	2036
1993	13.21	14.67	-1.46	[d]	2036
1994	13.24	15.37	-2.13	-.66	2029
1995	13.27	15.44	-2.17	-.04	2030
1996	13.33	15.52	-2.19	-.02	2029
1997	13.37	15.60	-2.23	-.03	2029
1998	13.45	15.64	-2.19	+.04	2032
1999	13.49	15.56	-2.07	+.12	2034
2000	13.51	15.40	-1.89	+.17	2037
2001	13.58	15.44	-1.86	+.03	2038
2002	13.72	15.59	-1.87	-.01	2041
2003	13.78	15.70	-1.92	-.04	2042
2004	13.84	15.73	-1.89	+.03	2042
2005	13.87	15.79	-1.92	-.04	2041
2006	13.88	15.90	-2.02	-.09	2040
2007	13.92	15.87	-1.95	+.06	2041
2008	13.94	15.63	-1.70	+.26	2041
2009	14.02	16.02	-2.00	-.30	2037
2010	14.01	15.93	-1.92	+.08	2037
2011	14.02	16.25	-2.22	-.30	2036
2012	14.02	16.69	-2.67	-.44	2033
2013	13.88	16.60	-2.72	-.05	2033
2014	13.89	16.77	-2.88	-.16	2033
2015	13.86	16.55	-2.68	+.20	2034
2016	13.84	16.50	-2.66	+.02	2034

[a] The reports compute the actuarial balance and year of trust fund reserve depletion based on the intermediate assumptions, which the 1982-90 reports referred to as alternative II-B and the 1991 and later reports refer to as alternative II.
[b] The definition and method of calculating the actuarial balance were changed in 1988 and 1991. See text for details.
[c] A detailed year-by-year breakdown of the reasons for the changes in the actuarial balance since the 1983 Trustees Report may be found in Actuarial Note 2016.8 at www.ssa.gov/OACT/NOTES/ran8/.
[d] Between -0.005 and 0.005 percent of taxable payroll.

Note: Totals do not necessarily equal the sums of rounded components.

For several of the years included in the table, significant legislative changes or definitional changes affected the estimated actuarial balance. The Social

Security Amendments of 1983 accounted for the largest single change in recent history: the actuarial balance of -1.82 for the 1982 report improved to +0.02 for the 1983 report. In 1985, the estimated actuarial balance changed largely because of an adjustment made to the method for estimating the age distribution of immigrants.

Rebenchmarking of the National Income and Product Accounts and changes in demographic assumptions contributed to the change in the actuarial balance for 1987. Various changes in assumptions and methods for the 1988 report had roughly offsetting effects on the actuarial balance. In 1989 and 1990, changes in economic assumptions accounted for most of the changes in the estimated actuarial balance.

In 1991, the effect of legislation, changes in economic assumptions, and the introduction of the cost of reaching and maintaining an ending target trust fund combined to produce the change in the actuarial balance. In 1992, changes in disability assumptions and the method for projecting average benefit levels accounted for most of the change in the actuarial balance. In 1993, numerous small changes in assumptions and methods had offsetting effects on the actuarial balance. In 1994, changes in the real-wage assumptions, disability rates, and the earnings sample used for projecting average benefit levels accounted for most of the change in the actuarial balance. In 1995, numerous small changes had largely offsetting effects on the actuarial balance, including a substantial reallocation of the payroll tax rate, which reduced the OASI actuarial balance, but increased the DI actuarial balance.

In 1996, a change in the method of projecting dually-entitled beneficiaries produced a large increase in the actuarial balance, which almost totally offset decreases produced by changes in the valuation period and in the demographic and economic assumptions. Various changes in assumptions and methods for the 1997 report had roughly offsetting effects on the actuarial balance. In 1998, increases caused by changes in the economic assumptions, although partially offset by decreases produced by changes in the valuation period and in the demographic assumptions, accounted for most of the changes in the estimated actuarial balance. In 1999, increases caused by changes in the economic assumptions (related to improvements in the CPI by the Bureau of Labor Statistics) accounted for most of the changes in the estimated actuarial balance.

For the 2000 report, changes in economic assumptions and methodology caused increases in the actuarial balance, although reductions in the balance caused by the change in valuation period and changes in demographic assumptions partially offset these increases. For the 2001 report, increases caused by changes in the demographic starting values, although partially offset by a decrease produced by the change in the valuation period, accounted for most of the changes in the estimated actuarial balance. For the 2002 report, changes in the valuation period and the demographic assumptions—both decreases in the actuarial balance—were offset by changes in the economic assumptions, while an increase due to disability assumptions was slightly more than offset by a decrease due to changes in the projection methods and data. For the 2003 report, an increase due to the change in program assumptions was more than offset by decreases due to the change in valuation period and changes in demographic assumptions. In the 2004 report, increases due to changing the method of projecting benefit levels for higher earners more than offset decreases in the actuarial balance arising from the change in the valuation period and the net effect of other changes in programmatic data and methods.

For the 2005 report, an increase due to changing the method of projecting future average benefit levels was more than offset by decreases due to changes in the valuation period, updated starting values for the economic assumptions, and other methodological changes. In 2006, decreases in the actuarial balance due to the change in the valuation period, a reduction in the ultimate annual real interest rate, and improvements in calculating mortality for disabled workers, were greater in aggregate than increases in the actuarial balance due to changes in demographic starting values and the ultimate total fertility rate, as well as other programmatic data and method changes. For the 2007 report, increases in the actuarial balance arising from revised disability incidence rate assumptions, improvements in average benefit level projections, and changes in near-term economic projections, more than offset decreases in the balance due to the valuation period change and updated historical mortality data.

For the 2008 report, the large increase in the actuarial balance was primarily due to changes in immigration projection methods and assumptions. These changes more than offset the decreases in the actuarial balance due to the change in the valuation period and the lower starting and ultimate mortality rates. In 2009, changes in starting values and near-term economic assumptions due to the economic recession, faster ultimate rates of decline in death rates for ages 65-84, and the change in the valuation period accounted for most of the large decrease in the actuarial balance. Legislative changes, in particular the estimated effects of the Patient Protection and Affordable Care Act and the Health Care and Education Reconciliation Act of 2010, were the main reason for the increase in the actuarial balance for the 2010 report. The change in the valuation period partially offset this increase; there were also changes in several assumptions, methods, and recent data which had largely offsetting effects.

For the 2011 report, changes in mortality projections, due to new starting values and revised methods, were the most significant of several factors contributing to the increase in the deficit. These mortality changes resulted in lower death rates for the population age 65 and over. Adding to this negative effect were near-term lower levels of net other immigration and real earnings than assumed in the 2010 report.

For the 2012 report, changes in economic assumptions and starting values accounted for about half of the decrease in actuarial balance. Updating starting economic data resulted in higher benefit levels, lower payroll taxes, and lower real interest rates in the short term than projected in the previous year. Other factors worsening the actuarial balance were the change in valuation period, changes to starting demographic values, changes to ultimate disability incidence assumptions, and methodology changes and data updates.

For the 2013 report, the change in valuation period accounted for the entire net change in the actuarial balance. The effects of substantially lower death rates for 2009 than previously projected and the American Taxpayer Relief Act of 2012 (which lowered the Federal marginal income tax rates) were offset by updates of program-specific data and methodology improvements. The primary factors improving the actuarial balance were changes in ultimate age-sex specific unemployment rates, changes in modeling the number of workers insured, changes in average benefit levels due to the update of the sample, changes in projections of income from taxation of benefits, and other method changes and data updates.

For the 2014 report, changes in economic data and assumptions accounted for the majority of the net change in the actuarial balance. In particular, the 2014 report includes a lower projected ratio of average taxable earnings to the average wage index throughout the long-range period, resulting in lower payroll taxes relative to benefit levels. In addition, the estimated level of full-employment (potential) GDP is about 1 percent lower in the 2014 report, resulting in lower earnings and payroll taxes for the future. This change reflects the fact that GDP growth has not been as strong so far in the economic recovery as had been experienced in prior recoveries. Other factors worsening the actuarial balance were the change in the valuation period and various methodology improvements and data updates.

For the 2015 report, methodological improvements and updates of programmatic data accounted for the majority of the net increase in the actuarial balance. The most significant methodological changes were improvements to the method for projecting earnings levels of newly entitled worker beneficiaries, using a 10-percent sample of actual worker beneficiaries. Also increasing the actuarial balance were a lower assumed ultimate average wage differential and changes in near-term economic assumptions. These increases were offset somewhat by the change in the valuation period and updates to historical and near-term projected birth rates.

Section IV.B.6 describes changes affecting the actuarial balance shown for the 2016 report.

C. FISCAL YEAR HISTORICAL AND PROJECTED TRUST FUND OPERATIONS THROUGH 2025

Tables VI.C1, VI.C2, and VI.C3 contain details of the fiscal year 2015 operations of the OASI, DI, and the combined OASI and DI Trust Funds, respectively. The fiscal year for the U.S. Government is the 12-month period ending September 30. Fiscal year 2015 is the most recent fiscal year for which complete information is available. The descriptions of the values in these tables are similar to the corresponding descriptions and values in the calendar year operations tables in section III.A. Please see that section for a description of the various items of income and outgo.

Table VI.C1.—Operations of the OASI Trust Fund, Fiscal Year 2015
[In millions]

Total asset reserves, September 30, 2014		$2,712,699
Receipts:		
Net payroll tax contributions:		
Payroll tax contributions[a]	$674,639	
Payments from the General Fund of the Treasury for payroll tax contributions subject to refund[a]	-2,393	
Net payroll tax contributions[a]		672,246
Reimbursements from the General Fund:		
Reduction in payroll tax contributions due to P.L.s 111-312, 112-78, and 112-96[a]	205	
Reimbursements directed by P.L. 110-246	7	
Payroll tax credits due to P.L. 98-21[a]	[b]	
Net General Fund reimbursements[a]		211
Income based on taxation of benefit payments:		
Withheld from benefit payments to nonresident aliens	189	
All other, not subject to withholding[a]	29,438	
Total income from taxation of benefits[a]		29,627
Investment income and interest adjustments:		
Interest on investments	93,234	
Interest adjustments[c]	1	
Total investment income and interest adjustments		93,235
Gifts		—
Total receipts		795,319
Disbursements:		
Benefit payments:		
Monthly benefits and lump-sum death payments[d]	733,742	
Reimbursement from the General Fund for unnegotiated checks	-34	
Payment for costs of vocational rehabilitation services for disabled beneficiaries	2	
Net benefit payments[d]		733,711
Financial interchange with the Railroad Retirement "Social Security Equivalent Benefit Account"		4,258
Administrative expenses:		
Costs incurred by:		
Social Security Administration	3,003	
Department of the Treasury	502	
Offsetting miscellaneous receipts	-5	
Miscellaneous reimbursements from the General Fund [e]	-5	
Net administrative expenses		3,496
Total disbursements		741,464
Net increase in asset reserves		53,855
Total invested assets	2,766,649	
Undisbursed balances[f]	-95	
Total asset reserves, September 30, 2015		2,766,554

[a] Includes adjustments for prior years
[b] Between -$0.5 and $0.5 million.
[c] Includes: (1) interest on adjustments in the allocation of administrative expenses between the trust fund and the General Fund account for the Supplemental Security Income program, (2) interest arising from the revised allocation of administrative expenses among the trust funds, and (3) interest on certain reimbursements to the trust fund.
[d] Includes net reductions for the recovery of overpayments.
[e] Reimbursements for costs incurred in performing certain legislatively mandated activities not directly related to administering the OASI program.
[f] A negative balance represents a situation where the actual program cash expenditures exceeded the amount of invested securities of the OASI Trust Fund that were redeemed to pay for such expenditures. In this situation, future redemption of additional invested securities will be required to pay for this shortfall.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.C2.—Operations of the DI Trust Fund, Fiscal Year 2015
[In millions]

Total asset reserves, September 30, 2014		$69,925
Receipts:		
Net payroll tax contributions:		
Payroll tax contributions[a]	$114,562	
Payments from the General Fund of the Treasury for payroll tax contributions subject to refund[a]	-406	
Net payroll tax contributions[a]		114,156
Reimbursements from the General Fund:		
Reduction in payroll tax contributions due to P.L.s 111-312, 112-78, and 112-96[a]	38	
Reimbursements directed by P.L. 110-246	1	
Payroll tax credits due to P.L. 98-21[a]	[b]	
Net General Fund reimbursements[a]		39
Income based on taxation of benefit payments:		
Withheld from benefit payments to nonresident aliens	4	
All other, not subject to withholding[a]	1,032	
Total income from taxation of benefits[a]		1,036
Investment income and interest adjustments:		
Interest on investments	2,732	
Interest adjustments[c]	1	
Total investment income and interest adjustments		2,733
Total receipts		117,965
Disbursements:		
Benefit payments:		
Monthly benefits[d]	142,835	
Reimbursement from the General Fund for unnegotiated checks	-19	
Payment for costs of vocational rehabilitation services for disabled beneficiaries	108	
Net benefit payments[d]		142,923
Financial interchange with the Railroad Retirement "Social Security Equivalent Benefit Account"		419
Administrative expenses:		
Costs incurred by:		
Social Security Administration	2,793	
Department of the Treasury	88	
Demonstration projects	15	
Miscellaneous reimbursements from the General Fund[e]	-3	
Net administrative expenses		2,892
Total disbursements		146,234
Net increase in asset reserves		-28,269
Total invested assets	41,638	
Undisbursed balances[f]	18	
Total asset reserves, September 30, 2015		41,656

[a] Includes adjustments for prior years.
[b] Between -$0.5 and $0.5 million.
[c] Includes: (1) interest on adjustments in the allocation of administrative expenses between the trust fund and the General Fund account for the Supplemental Security Income program, (2) interest arising from the revised allocation of administrative expenses among the trust funds, and (3) interest on certain reimbursements to the trust fund.
[d] Includes net reductions for the recovery of overpayments.
[e] Reimbursements for costs incurred in performing certain legislatively mandated activities not directly related to administering the DI program.
[f] A positive balance represents a situation where more of the invested securities of the DI Trust Fund were redeemed than was needed to cover actual program cash expenditures.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.C3.—Operations of the Combined OASI and DI Trust Funds, Fiscal Year 2015
[In millions]

Total asset reserves, September 30, 2014		$2,782,624
Receipts:		
Net payroll tax contributions:		
Payroll tax contributions[a]	$789,201	
Payments from the General Fund of the Treasury for payroll tax contributions subject to refund[a]	-2,800	
Net payroll tax contributions[a]		786,402
Reimbursements from the General Fund:		
Reduction in payroll tax contributions due to P.L.s 111-312, 112-78, and 112-96[a]	243	
Reimbursements directed by P.L. 110-246	8	
Payroll tax credits due to P.L. 98-21[a]	[b]	
Net General Fund reimbursements[a]		251
Income based on taxation of benefit payments:		
Withheld from benefit payments to nonresident aliens	193	
All other, not subject to withholding[a]	30,470	
Total income from taxation of benefits[a]		30,663
Investment income and interest adjustments:		
Interest on investments	95,966	
Interest adjustments[c]	2	
Total investment income and interest adjustments		95,968
Gifts		—
Total receipts		913,284
Disbursements:		
Benefit payments:		
Monthly benefits and lump-sum death payments[d]	876,577	
Reimbursement from the General Fund for unnegotiated checks	-53	
Payment for costs of vocational rehabilitation services for disabled beneficiaries	110	
Net benefit payments[d]		876,634
Financial interchange with the Railroad Retirement "Social Security Equivalent Benefit Account"		4,677
Administrative expenses:		
Costs incurred by:		
Social Security Administration	5,796	
Department of the Treasury	590	
Offsetting miscellaneous receipts	-5	
Demonstration projects	15	
Miscellaneous reimbursements from the General Fund[e]	-8	
Net administrative expenses		6,388
Total disbursements		887,698
Net increase in asset reserves		25,586
Total invested assets	2,808,287	
Undisbursed balances[f]	-78	
Total asset reserves, September 30, 2015		2,808,210

[a] Includes adjustments for prior years.
[b] Between -$0.5 and $0.5 million.
[c] Includes: (1) interest on adjustments in the allocation of administrative expenses between the trust funds and the General Fund account for the Supplemental Security Income program, (2) interest arising from the revised allocation of administrative expenses among the trust funds, and (3) interest on certain reimbursements to the trust funds.
[d] Includes net reductions for the recovery of overpayments.
[e] Reimbursements for costs incurred in performing certain legislatively mandated activities not directly related to administering the OASI and DI programs.
[f] A negative net balance represents a situation where the actual combined program cash expenditures exceeded the amount of invested securities of the OASI and DI Trust Funds that were redeemed to pay for such expenditures. In this situation, future net redemption of additional invested securities will be required to pay for this shortfall.

Note: Totals do not necessarily equal the sums of rounded components.

Tables VI.C4, VI.C5, and VI.C6 show estimates of the operations and status of the OASI, DI, and the hypothetical combined OASI and DI Trust Funds, respectively, during fiscal years 2011 through 2025.

Table VI.C4.—Operations of the OASI Trust Fund, Fiscal Years 2011-2025
[Dollar amounts in billions]

	Income					Cost				Asset Reserves		
Fiscal year	Total	Net payroll tax contributions	GF reimbursements[a]	Taxation of benefits[b]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[c]
Historical data:												
2011 . .	$692.5	$495.0	$68.9	$21.2	$107.4	$599.2	$591.5	$3.6	$4.1	$93.3	$2,491.7	400
2012 . .	729.0	500.7	95.9	27.2	105.2	634.7	627.2	3.4	4.1	94.3	2,585.9	393
2013 . .	739.7	590.0	26.4	23.1	100.1	670.6	663.2	3.4	3.9	69.1	2,655.0	386
2014 . .	763.3	642.3	.1	24.6	96.3	705.6	698.2	3.2	4.3	57.6	2,712.7	376
2015 . .	795.3	672.2	.2	29.6	93.2	741.5	733.7	3.5	4.3	53.9	2,766.6	366
Intermediate:												
2016 . .	789.4	669.1	.1	31.2	89.1	770.9	763.4	3.2	4.2	18.6	2,785.1	359
2017 . .	815.8	692.9	[d]	36.4	86.5	804.0	796.5	3.3	4.1	11.8	2,796.9	346
2018 . .	862.7	737.4	[d]	39.9	85.4	857.8	849.9	3.3	4.5	4.9	2,801.9	326
2019 . .	942.3	811.0	[d]	43.7	87.6	919.7	911.6	3.5	4.6	22.6	2,824.5	305
2020 . .	999.9	863.6	[d]	47.6	88.6	985.0	976.7	3.6	4.7	14.9	2,839.4	287
2021 . .	1,058.5	915.6	[d]	51.8	91.1	1,051.0	1,042.5	3.7	4.7	7.5	2,846.9	270
2022 . .	1,113.6	964.4	[d]	56.4	92.9	1,123.2	1,114.4	3.9	5.0	-9.7	2,837.2	253
2023 . .	1,161.5	1,006.5	[d]	61.3	93.7	1,201.8	1,192.7	4.0	5.1	-40.3	2,796.9	236
2024 . .	1,216.4	1,054.3	[d]	66.7	95.4	1,285.8	1,276.5	4.1	5.2	-69.4	2,727.4	218
2025 . .	1,269.2	1,100.9	[d]	72.4	95.8	1,372.7	1,363.2	4.2	5.2	-103.5	2,623.9	199
Low-cost:												
2016 . .	791.8	671.2	.1	31.2	89.3	770.6	763.1	3.2	4.2	21.2	2,787.8	359
2017 . .	836.0	710.9	[d]	36.5	88.6	805.9	798.5	3.3	4.1	30.1	2,817.9	346
2018 . .	902.6	769.7	[d]	40.2	92.7	864.9	857.1	3.3	4.5	37.7	2,855.6	326
2019 . .	1,002.0	860.4	[d]	44.3	97.3	932.0	923.8	3.5	4.6	70.0	2,925.6	306
2020 . .	1,082.5	929.4	[d]	48.5	104.6	1,002.6	994.1	3.7	4.7	79.9	3,005.5	292
2021 . .	1,162.4	997.9	[d]	52.9	111.6	1,074.5	1,065.9	3.9	4.7	88.0	3,093.5	280
2022 . .	1,241.4	1,064.3	[d]	57.9	119.3	1,153.4	1,144.3	4.1	5.0	88.0	3,181.5	268
2023 . .	1,319.9	1,127.0	[d]	63.3	129.6	1,239.6	1,230.2	4.3	5.2	80.2	3,261.7	257
2024 . .	1,408.2	1,197.9	[d]	69.1	141.1	1,332.5	1,322.8	4.4	5.3	75.7	3,337.4	245
2025 . .	1,497.6	1,269.1	[d]	75.4	153.0	1,429.7	1,419.7	4.6	5.3	67.9	3,405.3	233
High-cost:												
2016 . .	785.9	665.6	.1	31.2	89.0	771.2	763.7	3.2	4.2	14.8	2,781.3	359
2017 . .	779.2	659.2	[d]	36.4	83.6	803.8	796.3	3.3	4.2	-24.6	2,756.7	346
2018 . .	805.5	686.5	[d]	39.6	79.4	851.7	843.8	3.3	4.6	-46.2	2,710.5	324
2019 . .	869.3	748.9	[d]	43.2	77.3	908.7	900.5	3.4	4.7	-39.3	2,671.2	298
2020 . .	908.6	786.7	[d]	46.9	75.1	968.8	960.6	3.5	4.8	-60.2	2,611.0	276
2021 . .	946.6	823.8	[d]	50.7	72.2	1,029.0	1,020.7	3.6	4.7	-82.3	2,528.6	254
2022 . .	981.0	857.8	[d]	54.9	68.3	1,094.6	1,085.9	3.7	5.0	-113.6	2,415.0	231
2023 . .	1,008.8	886.6	[d]	59.5	62.7	1,165.5	1,156.6	3.8	5.1	-156.7	2,258.3	207
2024 . .	1,041.1	919.0	[d]	64.4	57.8	1,240.5	1,231.5	3.9	5.2	-199.4	2,058.9	182
2025 . .	1,070.4	948.7	[d]	69.5	52.2	1,317.1	1,308.1	3.9	5.1	-246.7	1,812.2	156

[a] Includes reimbursements from the General Fund of the Treasury to the OASI Trust Fund for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost of benefits to certain uninsured persons who attained age 72 before 1968; (3) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (4) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (5) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.
[b] Revenue from taxation of benefits is the amount that would be assessed on benefit amounts scheduled in the law.
[c] The "Trust fund ratio" column represents asset reserves at the beginning of a year (which are identical to reserves at the end of the prior year shown in the "Amount at end of year" column) as a percentage of cost for the year.
[d] Between -$50 million and $50 million.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.C5.—Operations of the DI Trust Fund, Fiscal Years 2011-2025[a]
[Dollar amounts in billions]

	Income					Cost				Asset Reserves		
Fiscal year	Total	Net payroll tax contributions	GF reimbursements[b]	Taxation of benefits[c]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[d]
Historical data:												
2011	$106.2	$84.0	$11.7	$1.9	$8.6	$131.5	$128.0	$3.0	$0.5	-$25.3	$161.7	142
2012	108.8	85.1	16.2	.4	7.2	138.5	135.1	2.9	.5	-29.7	132.0	117
2013	111.3	100.2	4.5	1.1	5.5	142.8	139.4	2.8	.6	-31.5	100.5	92
2014	114.1	109.1	[e]	1.0	4.0	144.7	141.3	2.9	.4	-30.6	69.9	69
2015	118.0	114.2	[e]	1.0	2.7	146.2	142.9	2.9	.4	-28.3	41.7	48
Intermediate:												
2016	148.4	145.7	[e]	1.2	1.5	148.9	145.5	3.1	.3	-.5	41.2	28
2017	167.4	163.7	[e]	2.1	1.6	151.9	148.6	3.1	.2	15.5	56.7	27
2018	178.9	174.2	[e]	2.2	2.4	157.5	154.3	3.1	.1	21.3	78.0	36
2019	156.9	151.3	[e]	2.4	3.2	164.4	160.9	3.5	[e]	-7.5	70.5	47
2020	152.0	146.7	[e]	2.6	2.7	171.1	167.2	3.8	.1	-19.1	51.3	41
2021	160.2	155.5	[e]	2.8	1.9	178.5	174.3	4.1	.1	-18.3	33.0	29
2022	168.0	163.8	[e]	3.0	1.2	186.5	182.1	4.4	.1	-18.6	14.4	18
2023	[f]	170.9	[e]	3.3	[f]	194.8	190.1	4.7	[e]	[f]	[f]	7
2024	[f]	179.0	[e]	3.5	[f]	203.0	198.1	4.9	[e]	[f]	[f]	[f]
2025	[f]	186.9	[e]	3.8	[f]	212.0	206.8	5.2	[e]	[f]	[f]	[f]
Low-cost:												
2016	148.9	146.2	[e]	1.2	1.6	147.5	144.1	3.1	.3	1.5	43.1	28
2017	172.0	168.0	[e]	2.0	2.0	149.1	145.8	3.1	.2	22.9	66.0	29
2018	187.4	181.9	[e]	2.2	3.3	153.6	150.4	3.1	.1	33.8	99.8	43
2019	167.6	160.3	[e]	2.4	4.9	159.2	155.6	3.5	[e]	8.4	108.2	63
2020	165.6	157.8	[e]	2.5	5.2	164.7	160.7	3.9	.1	.9	109.1	66
2021	177.6	169.5	[e]	2.7	5.4	170.9	166.5	4.3	.1	6.7	115.8	64
2022	189.5	180.7	[e]	2.9	5.9	177.8	173.1	4.6	[e]	11.8	127.5	65
2023	201.5	191.4	[e]	3.1	7.0	185.0	180.1	5.0	[e]	16.4	144.0	69
2024	215.0	203.4	[e]	3.3	8.2	192.4	187.1	5.3	[e]	22.6	166.5	75
2025	228.9	215.5	[e]	3.5	9.8	200.6	194.9	5.7	[e]	28.3	194.8	83
High-cost:												
2016	147.6	144.8	[e]	1.2	1.5	150.2	146.8	3.1	.3	-2.6	39.0	28
2017	159.2	155.8	[e]	2.1	1.4	155.4	152.1	3.1	.2	3.8	42.9	25
2018	166.1	162.2	[e]	2.3	1.5	162.8	159.5	3.1	.1	3.3	46.1	26
2019	144.0	139.9	[e]	2.5	1.6	171.2	167.7	3.4	.1	-27.3	18.9	27
2020	[f]	133.6	[e]	2.8	[f]	178.6	174.8	3.7	.1	[f]	[f]	11
2021	[f]	139.9	[e]	3.0	[f]	186.2	182.1	3.9	.1	[f]	[f]	[f]
2022	[f]	145.7	[e]	3.2	[f]	194.4	190.1	4.2	.1	[f]	[f]	[f]
2023	[f]	150.6	[e]	3.4	[f]	202.9	198.4	4.4	.1	[f]	[f]	[f]
2024	[f]	156.1	[e]	3.6	[f]	211.3	206.7	4.6	[e]	[f]	[f]	[f]
2025	[f]	161.1	[e]	3.9	[f]	220.4	215.6	4.8	[e]	[f]	[f]	[f]

[a] The DI Trust Fund becomes depleted in fiscal years 2023 and 2020 under the intermediate and high-cost assumptions, respectively. For any period during which reserves would be depleted, scheduled benefits could not be paid in full on a timely basis, income from taxing benefits would be less than would apply to scheduled benefits, and interest on trust fund reserves would be negligible.
[b] Includes reimbursements from the General Fund of the Treasury to the DI Trust Fund for: (1) the cost of non-contributory wage credits for military service before 1957; (2) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (3) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (4) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.
[c] Revenue from taxation of benefits is the amount that would be assessed on benefit amounts scheduled in the law.
[d] The "Trust fund ratio" column represents asset reserves at the beginning of a year (which are identical to reserves at the end of the prior year shown in the "Amount at end of year" column) as a percentage of cost for the year.
[e] Between -$50 million and $50 million.
[f] While the fund is depleted, values under current law would reflect permissible expenditures only, which are inconsistent with the cost of scheduled benefits shown in this table.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.C6.—Operations of the Combined OASI and DI Trust Funds, Fiscal Years 2011-2025
[Dollar amounts in billions]

	Income					Cost				Asset Reserves		
Fiscal year	Total	Net payroll tax contributions	GF reimbursements[a]	Taxation of benefits[b]	Net interest	Total	Scheduled benefits	Administrative costs	RRB interchange	Net increase during year	Amount at end of year	Trust fund ratio[c]
Historical data:												
2011	$798.7	$579.1	$80.6	$23.1	$116.0	$730.7	$719.5	$6.7	$4.6	$68.0	$2,653.3	354
2012	837.8	585.7	112.2	27.5	112.4	773.2	762.3	6.3	4.7	64.6	2,717.9	343
2013	850.9	690.1	30.9	24.2	105.7	813.3	802.6	6.2	4.5	37.6	2,755.5	334
2014	877.4	751.3	.2	25.7	100.3	850.3	839.6	6.0	4.7	27.1	2,782.6	324
2015	913.3	786.4	.3	30.7	96.0	887.7	876.6	6.4	4.7	25.6	2,808.2	313
Intermediate:												
2016	937.9	814.7	.1	32.4	90.6	919.8	908.9	6.3	4.6	18.1	2,826.3	305
2017	983.2	856.6	[d]	38.5	88.1	955.9	945.2	6.4	4.3	27.3	2,853.6	296
2018	1,041.5	911.6	[d]	42.1	87.8	1,015.3	1,004.2	6.4	4.6	26.2	2,879.9	281
2019	1,099.2	962.3	[d]	46.1	90.8	1,084.1	1,072.5	7.0	4.7	15.1	2,894.9	266
2020	1,151.9	1,010.3	[d]	50.3	91.3	1,156.1	1,143.9	7.4	4.8	-4.3	2,890.7	250
2021	1,218.7	1,071.1	[d]	54.6	93.0	1,229.5	1,216.9	7.9	4.8	-10.8	2,879.9	235
2022	1,281.5	1,128.1	[d]	59.4	94.0	1,309.8	1,296.5	8.3	5.1	-28.2	2,851.6	220
2023	1,335.7	1,177.4	[d]	64.6	93.7	1,396.6	1,382.8	8.7	5.1	-60.9	2,790.7	204
2024	1,398.0	1,233.3	[d]	70.2	94.5	1,488.8	1,474.6	9.1	5.2	-90.8	2,699.9	187
2025	1,457.9	1,287.9	[d]	76.2	93.9	1,584.7	1,570.0	9.4	5.2	-126.7	2,573.2	170
Low-cost:												
2016	940.7	817.3	.1	32.4	90.9	918.0	907.2	6.3	4.6	22.7	2,830.9	306
2017	1,008.0	878.9	[d]	38.5	90.5	955.0	944.3	6.4	4.3	53.0	2,883.9	296
2018	1,090.0	951.6	[d]	42.4	96.0	1,018.5	1,007.5	6.4	4.6	71.5	2,955.4	283
2019	1,169.6	1,020.8	[d]	46.6	102.2	1,091.2	1,079.5	7.1	4.7	78.4	3,033.8	271
2020	1,248.1	1,087.2	[d]	51.0	109.8	1,167.3	1,154.8	7.6	4.8	80.8	3,114.6	260
2021	1,340.0	1,167.4	[d]	55.6	117.0	1,245.4	1,232.4	8.2	4.8	94.6	3,209.3	250
2022	1,430.9	1,245.0	[d]	60.7	125.2	1,331.2	1,317.4	8.7	5.1	99.8	3,309.1	241
2023	1,521.3	1,318.4	[d]	66.3	136.6	1,424.7	1,410.3	9.2	5.2	96.6	3,405.7	232
2024	1,623.1	1,401.4	[d]	72.4	149.3	1,524.9	1,509.9	9.8	5.3	98.2	3,503.9	223
2025	1,726.5	1,484.6	[d]	79.0	162.8	1,630.2	1,614.6	10.3	5.3	96.2	3,600.1	215
High-cost:												
2016	933.5	810.5	.1	32.4	90.5	921.4	910.5	6.3	4.6	12.1	2,820.3	305
2017	938.4	814.9	[d]	38.5	84.9	959.1	948.4	6.4	4.3	-20.8	2,799.6	294
2018	971.6	848.8	[d]	41.9	80.9	1,014.5	1,003.3	6.4	4.7	-42.9	2,756.7	276
2019	1,013.3	888.7	[d]	45.7	78.8	1,079.9	1,068.3	6.9	4.8	-66.6	2,690.1	255
2020	1,045.1	920.3	[d]	49.6	75.2	1,147.5	1,135.4	7.2	4.9	-102.4	2,587.7	234
2021	1,088.0	963.7	[d]	53.6	70.7	1,215.2	1,202.8	7.5	4.8	-127.1	2,460.6	213
2022	1,126.6	1,003.4	[d]	58.1	65.1	1,289.0	1,276.1	7.8	5.1	-162.5	2,298.1	191
2023	1,157.3	1,037.2	[d]	62.9	57.3	1,368.4	1,355.1	8.1	5.1	-211.0	2,087.1	168
2024	1,193.0	1,075.0	[d]	68.0	50.0	1,451.8	1,438.2	8.4	5.2	-258.8	1,828.3	144
2025	1,225.0	1,109.8	[d]	73.4	41.8	1,537.5	1,523.6	8.7	5.2	-312.4	1,515.8	119

[a] Includes reimbursements from the General Fund of the Treasury to the OASI and DI Trust Funds for: (1) the cost of noncontributory wage credits for military service before 1957; (2) the cost of benefits to certain uninsured persons who attained age 72 before 1968; (3) the cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21; (4) the cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246; and (5) payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.
[b] Revenue from taxation of benefits is the amount that would be assessed on benefit amounts scheduled in the law.
[c] The “Trust fund ratio” column represents asset reserves at the beginning of a year (which are identical to reserves at the end of the prior year shown in the “Amount at end of year” column) as a percentage of cost for the year.
[d] Between -$50 million and $50 million.

D. LONG-RANGE SENSITIVITY ANALYSIS

This appendix presents estimates that illustrate the sensitivity of the long-range actuarial status of the OASDI program to changes in selected individual assumptions. The estimates based on the three alternative sets of assumptions, which were presented earlier in this report, illustrate the effects of varying all of the principal assumptions simultaneously, in order to portray a significantly more optimistic or pessimistic future. For each sensitivity analysis presented in this appendix, the intermediate alternative II projection is the reference point, and one assumption is varied within that alternative. The variation used for each individual assumption is the same as the level used for that assumption in the low-cost alternative I and high-cost alternative III projections.

Each table in this section shows the effects of changing a particular assumption on the OASDI summarized income rates, summarized cost rates, and actuarial balances for 25-year, 50-year, and 75-year valuation periods. Following each table is a discussion of the estimated changes in cost rates. The change in each of the actuarial balances is approximately equal to the change in the corresponding cost rate, but in the opposite direction. This appendix does not discuss income rates following each table because income rates vary only slightly with changes in assumptions that affect revenue from taxation of benefits.

1. Total Fertility Rate

Table VI.D1 shows OASDI income rates, cost rates, and actuarial balances on the basis of alternative II with various assumptions about the ultimate total fertility rate. The Trustees assume that total fertility will ultimately be 1.8, 2.0, and 2.2 children per woman under alternatives III, II, and I, respectively. The total fertility rate reaches ultimate values in 2032, 2027, and 2024 under alternatives III, II, and I, respectively.

Table VI.D1.—Sensitivity of OASDI Measures to Varying Fertility Assumptions
[As a percentage of taxable payroll]

Valuation period	Ultimate total fertility rate[a b] 1.8	2.0	2.2
Summarized income rate:			
25-year: 2016-40	14.66	14.67	14.67
50-year: 2016-65	14.04	14.03	14.01
75-year: 2016-90	13.88	13.84	13.80
Summarized cost rate:			
25-year: 2016-40	16.14	16.15	16.16
50-year: 2016-65	16.41	16.26	16.10
75-year: 2016-90	16.90	16.50	16.09
Actuarial balance:			
25-year: 2016-40	-1.47	-1.48	-1.50
50-year: 2016-65	-2.36	-2.23	-2.09
75-year: 2016-90	-3.02	-2.66	-2.28
Annual balance for 2090	-5.84	-4.35	-3.03
Year of combined trust fund reserve depletion	2034	2034	2034

[a] The total fertility rate for any year is the average number of children that would be born to a woman in her lifetime if she were to experience, at each age of her life, the birth rate observed in, or assumed for, the selected year, and if she were to survive the entire childbearing period. The ultimate total fertility rate is reached in 2032, 2027, and 2024 under alternatives III, II, and I, respectively.

[b] Ultimate total fertility rates used for this analysis are: 1.8 from the alternative III assumptions, 2.0 from the alternative II assumptions, and 2.2 from the alternative I assumptions. All other assumptions used for this analysis are from alternative II.

For the 25-year period, the cost rate for the three fertility assumptions varies by only about 0.03 percent of taxable payroll. In contrast, the 75-year cost rate varies over a wide range, decreasing from 16.90 to 16.09 percent, as the assumed ultimate total fertility rate increases from 1.8 to 2.2. Similarly, while the 25-year actuarial balance varies by only 0.03 percent of taxable payroll, the 75-year actuarial balance varies over a much wider range, from -3.02 to -2.28 percent.

During the 25-year period, the very slight increases in the working population resulting from higher fertility (than that experienced in an alternative scenario) are more than offset by decreases in the female labor force and increases in the number of child beneficiaries. Therefore, program cost increases slightly with higher fertility. For the 75-year long-range period, however, changes in fertility have a relatively greater effect on the labor force than on the beneficiary population. As a result, an increase in fertility significantly reduces the cost rate. Each increase of 0.1 in the ultimate total fertility rate increases the long-range actuarial balance by about 0.18 percent of taxable payroll.

2. Death Rates

Table VI.D2 shows OASDI income rates, cost rates, and actuarial balances on the basis of alternative II with various assumptions about future reductions in death rates for the period from 2015 to 2090. These assumptions are described in section V.A.2. The Trustees assume that the age-sex-adjusted death rates will decline at average annual rates of 0.42 percent, 0.78 percent, and 1.16 percent for alternatives I, II, and III, respectively.

Table VI.D2.—Sensitivity of OASDI Measures to Varying Death-Rate Assumptions
[As a percentage of taxable payroll]

Valuation period	Average annual death-rate reduction[a b]		
	0.42 percent	0.78 percent	1.16 percent
Summarized income rate:			
25-year: 2016-40	14.67	14.67	14.66
50-year: 2016-65	14.02	14.03	14.04
75-year: 2016-90	13.83	13.84	13.86
Summarized cost rate:			
25-year: 2016-40	15.99	16.15	16.32
50-year: 2016-65	15.91	16.26	16.64
75-year: 2016-90	16.01	16.50	17.02
Actuarial balance:			
25-year: 2016-40	-1.32	-1.48	-1.66
50-year: 2016-65	-1.89	-2.23	-2.60
75-year: 2016-90	-2.18	-2.66	-3.16
Annual balance for 2090	-3.37	-4.35	-5.31
Year of combined trust fund reserve depletion	2034	2034	2033

[a] The average annual death-rate reduction is the average annual geometric rate of decline in the age-sex-adjusted death rate between 2015 and 2090. The overall age-sex-adjusted death rate decreases from 2015 to 2090 by 27 percent, 44 percent, and 58 percent for alternatives I, II, and III, respectively.
[b] The average annual death-rate reductions used for this analysis are: 0.42 percent from the alternative I assumptions, 0.78 percent from the alternative II assumptions, and 1.16 percent from the alternative III assumptions. All other assumptions used for this analysis are from alternative II.

The variation in cost for the 25-year period is less pronounced than the variation for the 75-year period because decreases in death rates have cumulative effects. The 25-year cost rate increases from 15.99 percent (for an average annual death-rate reduction of 0.42 percent) to 16.32 percent (for an average annual death-rate reduction of 1.16 percent). The 75-year cost rate increases from 16.01 to 17.02 percent. The actuarial balance decreases from -1.32 to -1.66 percent for the 25-year period, and from -2.18 to -3.16 percent for the 75-year period.

Lower death rates raise both the income (through increased taxable payroll) and the cost of the OASDI program. The relative increase in cost, however, exceeds the relative increase in taxable payroll. For any given year, reductions in the death rates for people who are age 62 and over (ages at which death rates are the highest) increase the number of retired-worker beneficiaries (and, therefore, the amount of retirement benefits paid) without adding significantly to the number of covered workers (and, therefore, to the taxable payroll). Reductions for people at age 50 to retirement eligibility age result in significant increases to the taxable payroll. However, those increases are not large enough to offset the sum of the additional retirement benefits mentioned above and the disability benefits paid to additional beneficiaries at these pre-retirement ages, which are ages of high disability incidence. At ages under 50, death rates are so low that even substantial reductions in death rates do not result in significant increases in the numbers of covered workers or beneficiaries. Consequently, if death rates decline by about the same relative amount for all ages, the cost increases faster than the rate of growth in payroll, which results in higher cost rates and lower actuarial balances. Each additional 0.1-percentage-point increase in the average annual rate of decline in the death rate decreases the long-range actuarial balance by about 0.13 percent of taxable payroll.

3. Immigration

Table VI.D3 shows OASDI income rates, cost rates, and actuarial balances under alternative II with various assumptions about the magnitude of net immigration (immigration minus emigration). The Trustees assume annual levels of immigration and emigration, with new annual immigration averaging 961,000 persons, 1,291,000 persons, and 1,629,000 persons over the long-range period under alternatives III, II, and I, respectively.

Table VI.D3.—Sensitivity of OASDI Measures to Varying Net-Immigration Assumptions
[As a percentage of taxable payroll]

	Average annual net immigration[a b]		
Valuation period	961,000	1,291,000	1,629,000
Summarized income rate:			
25-year: 2016-40	14.70	14.67	14.64
50-year: 2016-65	14.06	14.03	13.99
75-year: 2016-90	13.88	13.84	13.81
Summarized cost rate:			
25-year: 2016-40	16.35	16.15	15.98
50-year: 2016-65	16.53	16.26	16.02
75-year: 2016-90	16.81	16.50	16.24
Actuarial balance:			
25-year: 2016-40	-1.65	-1.48	-1.34
50-year: 2016-65	-2.46	-2.23	-2.03
75-year: 2016-90	-2.93	-2.66	-2.43
Annual balance for 2090	-4.81	-4.35	-3.96
Year of combined trust fund reserve depletion	2033	2034	2035

[a] Net immigration per year is the annual net immigration to the Social Security area, including both legal and other immigration, averaged over the 75-year projection period.
[b] The average annual net immigration assumptions used for this analysis are: 961,000 from the alternative III assumptions, 1,291,000 from the alternative II assumptions, and 1,629,000 from the alternative I assumptions. All other assumptions used for this analysis are from alternative II.

For all three periods, when net immigration increases, the cost rate decreases. For the 25-year period, the cost rate decreases from 16.35 percent of taxable payroll (for average annual net immigration of 961,000 persons) to 15.98 percent (for average annual net immigration of 1,629,000 persons). For the 50-year period, it decreases from 16.53 percent to 16.02 percent, and for the 75-year period, it decreases from 16.81 percent to 16.24 percent. The actuarial balance increases from -1.65 to -1.34 percent for the 25-year period, from -2.46 to -2.03 percent for the 50-year period, and from -2.93 to -2.43 percent for the 75-year period.

The cost rate decreases with an increase in net immigration because immigration occurs at relatively young ages, thereby increasing the numbers of covered workers earlier than the numbers of beneficiaries. Increasing average annual net immigration by 100,000 persons improves the long-range actuarial balance by about 0.07 percent of taxable payroll.

4. Real-Wage Differential

Table VI.D4 shows OASDI income rates, cost rates, and actuarial balances on the basis of alternative II with various assumptions about the real-wage differential. The Trustees assume the ultimate real-wage differential will be 0.59 percentage point, 1.21 percentage points, and 1.83 percentage points under alternatives III, II, and I, respectively. In each case, the ultimate annual increase in the CPI is 2.60 percent (consistent with alternative II). Therefore, the ultimate percentage increases in average annual wages in covered employment are 3.19, 3.81, and 4.43 percent.

For the 25-year period, the cost rate decreases from 16.92 percent (for a real-wage differential of 0.59 percentage point) to 15.39 percent (for a differential of 1.83 percentage points). For the 50-year period, it decreases from 17.36 to 15.18 percent, and for the 75-year period it decreases from 17.72 to 15.31 percent. The actuarial balance increases from -2.12 to -0.86 percent for the 25-year period, from -3.17 to -1.31 percent for the 50-year period, and from -3.69 to -1.64 percent for the 75-year period.

Table VI.D4.—Sensitivity of OASDI Measures to Varying Real-Wage Assumptions
[As a percentage of taxable payroll]

Valuation period	Ultimate percentage increase in wages-CPI[a b]		
	3.19-2.60	3.81-2.60	4.43-2.60
Summarized income rate:			
25-year: 2016-40	14.80	14.67	14.54
50-year: 2016-65	14.19	14.03	13.87
75-year: 2016-90	14.03	13.84	13.67
Summarized cost rate:			
25-year: 2016-40	16.92	16.15	15.39
50-year: 2016-65	17.36	16.26	15.18
75-year: 2016-90	17.72	16.50	15.31
Actuarial balance:			
25-year: 2016-40	-2.12	-1.48	-.86
50-year: 2016-65	-3.17	-2.23	-1.31
75-year: 2016-90	-3.69	-2.66	-1.64
Annual balance for 2090	-6.23	-4.35	-2.69
Year of combined trust fund reserve depletion	2032	2034	2038

[a] The first value in each pair is the ultimate annual percentage increase in average wages in covered employment. The second value is the ultimate annual percentage increase in the Consumer Price Index. The difference between the two values is the ultimate real-wage differential.
[b] The ultimate real-wage differentials of 0.59, 1.21, and 1.83 percentage points are the same as in alternatives III, II, and I, respectively. All other assumptions used for this analysis are from alternative II.

The cost rate decreases with increasing real-wage differentials. Higher wages increase taxable payroll immediately, but they increase benefit levels only gradually as new beneficiaries become entitled. In addition, cost-of-living adjustments (COLAs) to benefits depend not on changes in wages, but on changes in prices. Each 0.5-percentage-point increase in the real-wage differential increases the long-range actuarial balance by about 0.83 percent of taxable payroll.

5. Consumer Price Index

Table VI.D5 shows OASDI income rates, cost rates, and actuarial balances on the basis of alternative II with various assumptions about the rate of increase for the Consumer Price Index (CPI). The Trustees assume the annual increase in the CPI will be 3.20 percent, 2.60 percent, and 2.00 percent under alternatives I, II, and III, respectively.[1] In each case, the ultimate real-wage differential is 1.21 percentage points (consistent with alternative II), yielding ultimate percentage increases in average annual wages in covered employment of 4.41, 3.81, and 3.21 percent.

[1] Prior to the 2014 report, alternative I included a lower ultimate annual change in the CPI and alternative III included a higher ultimate annual change in the CPI than was included for alternative II.

Table VI.D5.—Sensitivity of OASDI Measures to Varying CPI-Increase Assumptions
[As a percentage of taxable payroll]

Valuation period	Ultimate percentage increase in wages-CPI[a b] 4.41-3.20	3.81-2.60	3.21-2.00
Summarized income rate:			
25-year: 2016-40	14.64	14.67	14.69
50-year: 2016-65	14.01	14.03	14.04
75-year: 2016-90	13.83	13.84	13.86
Summarized cost rate:			
25-year: 2016-40	16.04	16.15	16.25
50-year: 2016-65	16.12	16.26	16.38
75-year: 2016-90	16.35	16.50	16.64
Actuarial balance:			
25-year: 2016-40	-1.40	-1.48	-1.56
50-year: 2016-65	-2.11	-2.23	-2.34
75-year: 2016-90	-2.52	-2.66	-2.78
Annual balance for 2090	-4.16	-4.35	-4.51
Year of combined trust fund reserve depletion	2034	2034	2034

[a] The first value in each pair is the ultimate annual percentage increase in average wages in covered employment. The second value is the ultimate annual percentage increase in the Consumer Price Index. The difference between the two values is the ultimate real-wage differential.

[b] The ultimate CPI increases of 3.20, 2.60, and 2.00 percent are the same as in alternatives I, II, and III, respectively. The ultimate real-wage differential of 1.21 percentage points is the same as in alternative II. All other assumptions used for this analysis are also from alternative II.

For all three periods, the cost rate increases when the assumed rates of increase in the CPI are smaller. For the 25-year period, the cost rate increases from 16.04 (for CPI increases of 3.20 percent) to 16.25 percent (for CPI increases of 2.00 percent). For the 50-year period, it increases from 16.12 to 16.38 percent, and for the 75-year period, it increases from 16.35 to 16.64 percent. The actuarial balance decreases from -1.40 to -1.56 percent for the 25-year period, from -2.11 to -2.34 percent for the 50-year period, and from -2.52 to -2.78 percent for the 75-year period.

The time lag between the effects of the CPI changes on taxable payroll and on scheduled benefits explains these patterns. When the rate of increase in the CPI is greater and the real-wage differential is constant, then: (1) the effect on taxable payroll due to a greater rate of increase in average wages occurs immediately and (2) the effect on benefits due to a larger COLA occurs with a lag of about 1 year. As a result of these effects, the higher taxable payrolls have a stronger effect than the higher benefits, which results in lower cost rates. Each 1.0-percentage-point decrease in the rate of the change in the CPI decreases the long-range actuarial balance by about 0.22 percent of taxable payroll.

6. Real Interest Rate

Table VI.D6 shows OASDI income rates, cost rates, and actuarial balances under alternative II with various assumptions about the annual real interest rate (compounded semiannually) for special public-debt obligations issuable to the trust funds. The Trustees assume that the ultimate annual real interest rate will be 2.2 percent, 2.7 percent, and 3.2 percent under alternatives III, II, and I, respectively. In each case, the ultimate annual increase in the CPI is 2.60 percent, which is consistent with alternative II. Therefore, the ultimate annual yields are 4.9, 5.4, and 5.9 percent, respectively.

Table VI.D6.—Sensitivity of OASDI Measures to Varying Real-Interest Assumptions
[As a percentage of taxable payroll]

	Ultimate annual real interest rate[a b]		
Valuation period	2.2 percent	2.7 percent	3.2 percent
Summarized income rate:			
25-year: 2016-40	14.61	14.67	14.73
50-year: 2016-65	13.95	14.03	14.10
75-year: 2016-90	13.77	13.84	13.93
Summarized cost rate:			
25-year: 2016-40	16.22	16.15	16.08
50-year: 2016-65	16.34	16.26	16.18
75-year: 2016-90	16.62	16.50	16.39
Actuarial balance:			
25-year: 2016-40	-1.61	-1.48	-1.36
50-year: 2016-65	-2.39	-2.23	-2.08
75-year: 2016-90	-2.85	-2.66	-2.46
Annual balance for 2090	-4.35	-4.35	-4.35
Year of combined trust fund reserve depletion	2034	2034	2034

[a] The ultimate real interest rate is the effective annual yield on asset reserves held by the trust funds divided by the annual rate of growth in the CPI.
[b] The ultimate annual real interest rates used for this analysis are: 2.2 percent from the alternative III assumptions, 2.7 percent from the alternative II assumptions, and 3.2 percent from the alternative I assumptions. All other assumptions used for this analysis are from alternative II.

For the 25-year period, the cost rate decreases with increasing real interest rates from 16.22 percent (for an ultimate real interest rate of 2.2 percent) to 16.08 percent (for an ultimate real interest rate of 3.2 percent). For the 50-year period, it decreases from 16.34 to 16.18 percent and, for the 75-year period, it decreases from 16.62 to 16.39 percent. The actuarial balance increases from -1.61 to -1.36 percent for the 25-year period, from -2.39 to -2.08 percent for the 50-year period, and from -2.85 to -2.46 percent for the 75-year period. Each 0.5-percentage-point increase in the real interest rate increases the long-range actuarial balance by about 0.20 percent of taxable payroll.

7. Disability Incidence Rates

Table VI.D7 shows OASDI income rates, cost rates, and actuarial balances on the basis of alternative II with various assumptions concerning future disability incidence rates. For all three alternatives, the Trustees assume that incidence rates by age and sex will vary during the early years of the projection period before attaining ultimate levels. In comparison to the historical period 1970 through 2015, the ultimate age-sex-adjusted incidence rate is about 4 percent higher for alternative II, 17 percent lower for alternative I, and 23 percent higher for alternative III.

Table VI.D7.—Sensitivity of OASDI Measures to Varying Disability Incidence Assumptions
[As a percentage of taxable payroll]

Valuation period	Disability incidence rates based on alternative— I	II	III
Summarized income rate:			
25-year: 2016-40	14.66	14.67	14.67
50-year: 2016-65	14.02	14.03	14.03
75-year: 2016-90	13.84	13.84	13.85
Summarized cost rate:			
25-year: 2016-40	15.94	16.15	16.36
50-year: 2016-65	16.00	16.26	16.52
75-year: 2016-90	16.23	16.50	16.77
Actuarial balance:			
25-year: 2016-40	-1.28	-1.48	-1.69
50-year: 2016-65	-1.97	-2.23	-2.48
75-year: 2016-90	-2.39	-2.66	-2.92
Annual balance for 2090	-4.04	-4.35	-4.65
Year of combined trust fund reserve depletion	2035	2034	2033

For the 25-year period, the cost rate increases with increasing disability incidence rates, from 15.94 percent (for the relatively low rates assumed for alternative I) to 16.36 percent (for the relatively high rates assumed for alternative III). For the 50-year period, it increases from 16.00 to 16.52 percent, and for the 75-year period, it increases from 16.23 to 16.77 percent. The actuarial balance decreases from -1.28 to -1.69 percent for the 25-year period, from -1.97 to -2.48 percent for the 50-year period, and from -2.39 to -2.92 percent for the 75-year period.

8. Disability Termination Rates

Table VI.D8 shows OASDI income rates, cost rates, and actuarial balances on the basis of alternative II with various assumptions about future disability termination rates, including deaths and recoveries up to the age at which disabled-worker beneficiaries convert to retired-worker status.

For all three alternatives, the Trustees assume that death rates for disabled-worker beneficiaries will decline throughout the long-range period. For alternative II, the age-sex-adjusted[1] disability death rate declines to a level in 2090 that is about 56 percent lower than the level in 2015. For alternative I, the age-sex-adjusted disability death rate declines to a level in 2090 that is about 30 percent lower than the level in 2015. For alternative III, the age-sex-adjusted disability death rate declines to a level in 2090 that is about 74 percent lower than the level in 2015.

For all three alternatives, ultimate recovery rates by age, sex, and duration are attained in the twentieth year of the projection period. For alternative II, the age-sex-adjusted[1] recovery rate in 2035 is about 10 recoveries per thousand disabled-worker beneficiaries. For alternative I, the age-sex-adjusted recovery rate in 2035 is about 13 recoveries per thousand disabled-worker beneficiaries. For alternative III, the age-sex-adjusted recovery rate in 2035 is about 8 recoveries per thousand disabled-worker beneficiaries.

Table VI.D8.—Sensitivity of OASDI Measures to Varying Disability Termination Assumptions
[As a percentage of taxable payroll]

	Disability termination rates based on alternative—		
Valuation period	I	II	III
Summarized income rate:			
25-year: 2016-40	14.67	14.67	14.67
50-year: 2016-65	14.03	14.03	14.03
75-year: 2016-90	13.85	13.84	13.84
Summarized cost rate:			
25-year: 2016-40	16.12	16.15	16.18
50-year: 2016-65	16.22	16.26	16.29
75-year: 2016-90	16.47	16.50	16.53
Actuarial balance:			
25-year: 2016-40	-1.45	-1.48	-1.52
50-year: 2016-65	-2.20	-2.23	-2.26
75-year: 2016-90	-2.62	-2.66	-2.68
Annual balance for 2090	-4.32	-4.35	-4.34
Year of combined trust fund reserve depletion	2034	2034	2034

For the 25-year period, the cost rate increases with decreasing disability termination rates, from 16.12 percent (for the relatively high termination rates assumed for alternative I) to 16.18 percent (for the relatively low termination rates assumed for alternative III). For the 50-year period, it increases from 16.22 to 16.29 percent, and for the 75-year period, it increases from 16.47 to

[1] Age adjusted to the total disabled workers in current-payment status as of the year 2000.

16.53 percent. The actuarial balance decreases from -1.45 to -1.52 percent for the 25-year period, from -2.20 to -2.26 percent for the 50-year period, and from -2.62 to -2.68 percent for the 75-year period.

E. STOCHASTIC PROJECTIONS AND UNCERTAINTY

Significant uncertainty surrounds the estimates under the intermediate assumptions, especially for a period as long as 75 years. This appendix presents a way to illustrate the uncertainty of these estimates. The stochastic projections supplement the traditional methods of examining such uncertainty.

1. Background

The Trustees have traditionally shown estimates using the low-cost and high-cost sets of specified assumptions to illustrate the presence of uncertainty. These alternative estimates provide a range of possible outcomes for the projections. However, they do not provide an indication of the probability that actual future experience will be inside or outside this range. This appendix presents the results of a model, based on stochastic modeling techniques, that estimates a probability distribution of future outcomes of the financial status of the combined OASI and DI Trust Funds. This model, which was first included in the 2003 report, is subject to further development in the future, most notably by incorporating parameter uncertainty. This will allow the stochastic model to reflect persistent uncertainties that are now reflected in the low-cost and high-cost alternatives.

2. Stochastic Methodology

Other sections of this report provide estimates of the financial status of the combined OASI and DI Trust Funds using a scenario-based model. For the scenario-based model, the Trustees use three alternative scenarios (low-cost, intermediate, and high-cost) that make assumptions about levels of fertility, changes in mortality, legal and other immigration levels, legal and other emigration levels, changes in the Consumer Price Index, changes in average real wages, unemployment rates, trust fund real yield rates, and disability incidence and recovery rates. In general, the Trustees assume that each of these variables will reach an ultimate value at a specific point during the long-range period, and will maintain that value throughout the remainder of the period. The three alternative scenarios assume separate, specified values for each of these variables. Chapter V contains more details about each of these assumptions.

This appendix presents estimates of the probability that key measures of OASDI solvency will fall in certain ranges, based on 5,000 independent stochastic simulations. Each simulation allows the above variables to vary throughout the long-range period. The fluctuation of each variable over time is simulated using historical data and standard time-series techniques. Generally, each variable is modeled using an equation that: (1) captures a relationship between current and prior years' values of the variable; and (2) introduces year-by-year random variation as observed in the historical period. For some variables, the equations also reflect relationships with other variables. The equations contain parameters that are estimated using historical data for periods of at least 5 years and at most 112 years, depending on the nature and quality of the available data. Each time-series equation is designed so that, in the absence of random variation over time, the value of the variable for each year equals its value under the intermediate assumptions.[1]

For each simulation, the stochastic method develops year-by-year random variation for each variable using Monte Carlo techniques. Each simulation produces an estimate of the financial status of the combined OASI and DI Trust Funds. This appendix shows the distribution of results from 5,000 simulations of the model.

Readers should interpret the results from this model with caution and with an understanding of the model's limitations. Results are sensitive to equation specifications, degrees of interdependence among variables, and the historical periods used for the estimates. For some variables, recent historical variation may not provide a realistic representation of the potential variation for the future. Also, results would differ if additional variables (such as labor force participation rates, retirement rates, marriage rates, and divorce rates) were also allowed to vary randomly. Furthermore, more variability would result if statistical approaches were used to model uncertainty in the central tendencies of the variables. Time-series modeling reflects only what occurred in the historical period. Future uncertainty exists not only for the underlying central tendency but also for the frequency and size of occasional longer-term shifts in the central tendency. Many experts predict, and history suggests, that the future will likely bring substantial shifts that are not fully reflected in the current model. As a result, readers should understand that the true range of uncertainty is larger than indicated in this appendix.

3. Stochastic Results

This section illustrates the results for the stochastic simulations of two fundamental measures of actuarial status: the annual cost rates and the trust fund ratio. The latter measure is highlighted in the Overview of this report.

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[1] More detail on this model, and stochastic modeling in general, is available at www.ssa.gov/OACT/stochastic/index.html.

Section 4 follows with a comparison of stochastic results to results from the alternative scenarios for these and other measures, and an analysis of the differences.

Figure VI.E1 displays the probability distribution of the year-by-year OASDI cost rates (that is, cost as a percentage of taxable payroll). The range of the annual cost rates widens as the projections move further into the future, which reflects increasing uncertainty. Because there is relatively little variation in income rates across the 5,000 stochastic simulations, the figure includes the income rate only under the intermediate assumptions. The two extreme lines in this figure illustrate the range within which future annual cost rates are projected by the current model to occur 95 percent of the time (i.e., a 95-percent confidence interval). In other words, the current model indicates that there is a 2.5 percent probability that the cost rate for a given year will exceed the upper end of this range and a 2.5 percent probability that it will fall below the lower end of this range. Other lines in the figure delineate additional confidence intervals (80-percent, 60-percent, 40-percent, and 20-percent) around future annual cost rates. The median (50th percentile) cost rate for each year is the rate for which half of the simulated outcomes are higher and half are lower for that year. These lines do not represent the results of individual stochastic simulations. Instead, for each given year, they represent the percentile distribution of annual cost rates based on all stochastic simulations for that year.

Figure VI.E1.—Long-Range OASDI Cost Rates From Stochastic Modeling

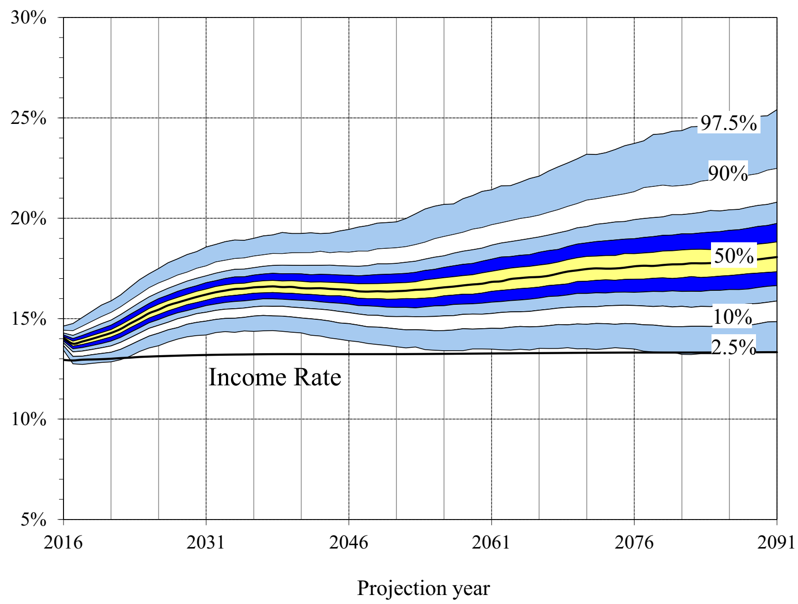
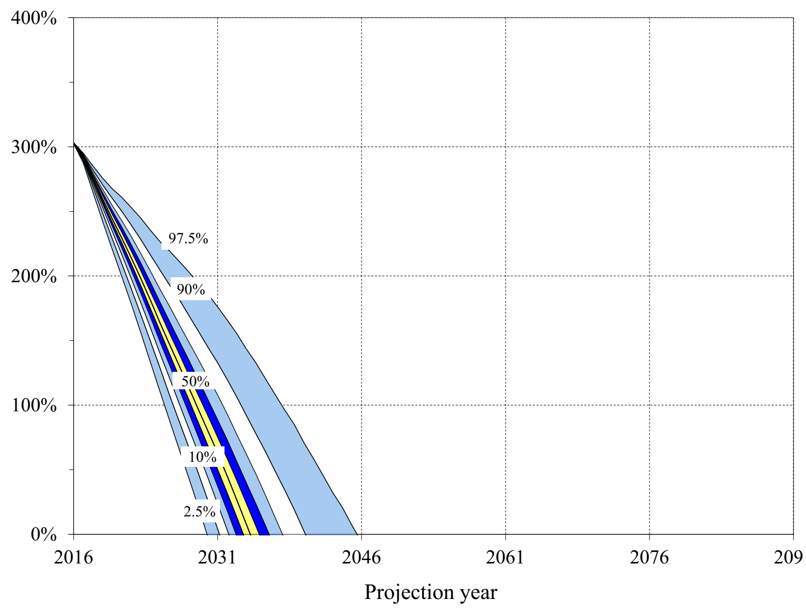


Figure VI.E2 presents the simulated probability distribution of the annual trust fund ratios for the combined OASI and DI Trust Funds. The lines in this figure display the median set (50th percentile) of estimated annual trust fund ratios and delineate the 95-percent, 80-percent, 60-percent, 40-percent, and 20-percent confidence intervals expected for future annual trust fund ratios. Again, none of these lines represents the time path of a single simulation. For each given year, they represent the percentile distribution of trust fund ratios based on all stochastic simulations for that year.

Figure VI.E2 shows that the 95-percent confidence interval for the trust fund depletion year ranges from 2029 to 2045, and there is a 50-percent probability of trust fund depletion by the end of 2034 (the median depletion year). The median depletion year is the same as the Trustees project under the intermediate assumptions. The figure also shows confidence intervals for the trust fund ratio in each year. For example, the 95-percent confidence interval for the trust fund ratio in 2025 ranges from 227 to 110 percent of annual cost.

Figure VI.E2.—Long-Range OASDI Trust Fund Ratios From Stochastic Modeling



4. Comparison of Results: Stochastic to Low-Cost, Intermediate, and High-Cost Alternatives

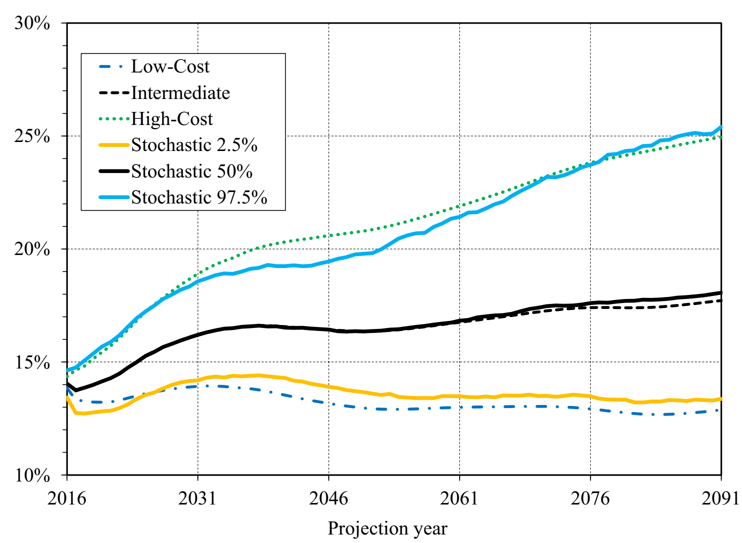
This section compares results from two different approaches for illustrating ranges of uncertainty for trust fund actuarial status. One approach uses results from the low-cost, intermediate, and high-cost alternative scenarios. The other approach uses distributions of results from 5,000 independent stochastic simulations. Each of these approaches provides insights into uncertainty. Comparison of the results requires an understanding of fundamental differences in the approaches.

One fundamental difference relates to the presentation of distributional results. Figure VI.E3 shows projected OASDI annual cost rates for the low-cost, intermediate, and high-cost alternatives along with the annual cost rates at the 97.5th percentile, 50th percentile, and 2.5th percentile for the stochastic simulations. While all values on each line for the alternatives are results from a single specified scenario, the values on each stochastic line may be results from different simulations for different years. The one stochastic simulation (from the 5,000 simulations) that yields results closest to a particular percentile for one projected year may yield results that are distant from that percentile in another projected year.

Because each stochastic simulation shows substantial variability from year to year, the range shown between the 97.5th and 2.5th percentiles is broader than would be seen if simulations followed a smooth trend like in the alternatives. In spite of this effect, the range from high-cost to low-cost annual rates for the stochastic distribution is generally contained slightly within the range for the high-cost and low-cost alternatives. With introduction of parameter uncertainty for the stochastic simulations expected in future reports, the range for the 95-percent confidence interval is expected to expand.

Both the alternatives and the stochastic results suggest that the range of potential cost rates above the central levels (those for the intermediate alternative and for the median, respectively) is larger than the range below these central results. The difference between the central results and the higher cost levels (the high-cost alternative and the upper end of the 95-percent confidence range, respectively) is about 1.5 times as large as the difference between the central and lower cost levels for both models by the end of the projection period.

Figure VI.E3.—OASDI Cost Rates: Comparison of Stochastic to Low-Cost, Intermediate, and High-Cost Alternatives
[as a percentage of taxable payroll]

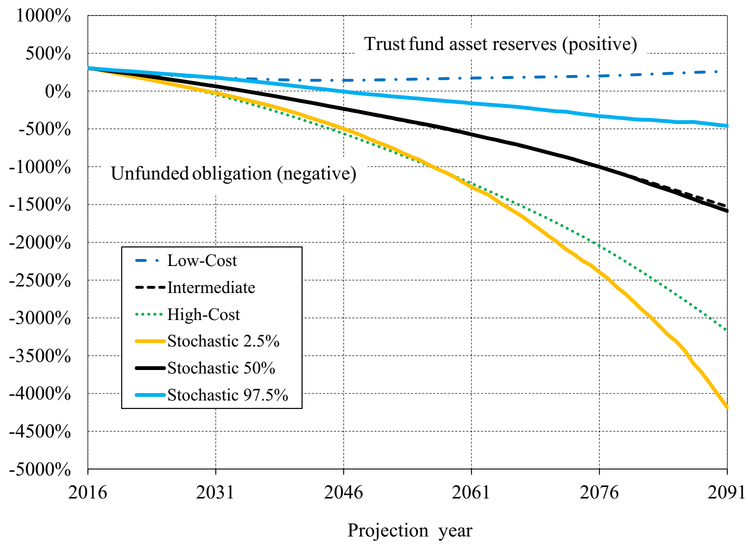


Another fundamental difference between the alternatives and the stochastic simulations is the method of assigning values for assumptions. For the alternatives, specific values are assigned for each of the key demographic and economic variables. Values for all parameters that affect annual cost or payroll are assigned to the high-cost alternative in order to raise estimated annual cost as a percent of payroll, and values are assigned to the low-cost alternative in order to reduce it. (One parameter, the interest rate, has no effect on annual cost as a percent of payroll.) In contrast, the stochastic method essentially randomly assigns values for each of the key demographic and economic variables for each year in each of the 5,000 independent stochastic simulations. For each of the stochastic simulations, randomly assigned values for different variables result in varying and often offsetting effects on projected cost as a percent of payroll, with some tending toward higher cost and some tending toward lower cost. This difference tends to reduce the range of cost as a percent of payroll across the 95-percent confidence interval. Again, the future introduction of parameter uncertainty is expected to broaden this range.

It is important to understand that the stochastic model's 95-percent confidence intervals for any summary measure of trust fund finances would tend to be narrower than the range produced for the low-cost and high-cost alternatives, even if the stochastic model's 95-percent confidence interval for annual cost rates were identical to the range defined by the low-cost and high-cost projections. This is true because summary measures of trust fund finances depend on cost rates for many years, and the probability that annual cost rates, on average for individual stochastic simulations, will be at least as low (high) as the 2.5 (97.5) percentile line is significantly lower than 2.5 percent. As a result, the relationship between the ranges presented for annual cost rates and summary measures of trust fund finances is fundamentally different for the stochastic model than it is for the low-cost and high-cost alternatives.

Figure VI.E4 compares the ranges of trust fund (unfunded obligation) ratios for the alternative scenarios and the 95-percent confidence interval of the stochastic simulations. This figure extends figure VI.E2 to show unfunded obligation ratios, expressed as negative values below the zero percent line. An unfunded obligation ratio is the ratio of the unfunded obligation accumulated through the beginning of the year to the cost for that year.

Figure VI.E4.—OASDI Trust Fund (Unfunded Obligation) Ratios: Comparison of Stochastic to Low-Cost, Intermediate, and High-Cost Alternatives[a]
[Asset reserves (unfunded obligation) as a percentage of annual cost]



[a] An unfunded obligation, shown as a negative value in this figure, is equivalent to the amount the trust funds would need to have borrowed to date in order to pay all scheduled benefits (on a timely basis) after trust fund asset reserves are depleted. Note that current law does not permit the trust funds to borrow.

As mentioned above, a summary measure that accumulates annual values tends to smooth the kind of annual fluctuations that occur in stochastic simulations. Therefore, one might expect the range across the stochastic confidence interval for trust fund (unfunded obligation) ratios to be narrower and fall within the range seen across the high-cost and low-cost alternatives, as it does for the actuarial balance measure. But this is not the case, largely due to the way interest rates are assigned.

For the stochastic model, real interest rates for each simulation are assigned essentially randomly, so the rate for compounding of trust fund reserves (unfunded obligations) is essentially uncorrelated with the level of cost as a percent of payroll. On the other hand, real interest rates are assigned to be higher for the low-cost alternative and lower for the high-cost alternative. High interest rates raise the level of the positive trust fund ratio in the low-cost alternative somewhat, but this effect is limited because the magnitude of reserves is small. However, low interest rates substantially reduce the magnitude of the unfunded obligation ratio for the high-cost alternative because the magnitude of unfunded obligations is relatively large. As a result, the trust fund (unfunded obligation) ratios are shifted, albeit unevenly, higher (or less negative) for both the high-cost and low-cost alternatives.

This interest rate effect on the alternatives is not as evident for some other summary measures of actuarial status, such as the actuarial balance. Because the actuarial balance reflects the cumulative effects of interest in both its numerator and denominator, the interest rate effect is much less pronounced. In contrast, cumulative interest affects only the numerator of the trust fund (unfunded obligation) ratio. There is also no significant interest rate effect on the trust fund depletion date.

Other factors also contribute, to varying degrees, to the difference in ranges between the results of the alternative scenarios and the stochastic simulations. The contrasts in results and methods do not mean that either approach to illustrating ranges of uncertainty is superior to the other. The ranges are different and explainable.

Table VI.E1 displays long-range actuarial estimates for the combined OASDI program using the two methods of illustrating uncertainty: alternative scenarios and stochastic simulations. The table shows stochastic estimates for the median (50th percentile) and for the 95-percent and 80-percent confidence intervals. For comparison, the table shows scenario-based estimates for the intermediate, low-cost, and high-cost assumptions. Each individual stochastic estimate in the table is the level at that percentile from the distribution of the 5,000 simulations. For each given percentile, the values in the table for each long-range actuarial measure are generally from different stochastic simulations.

The median stochastic estimates displayed in table VI.E1 are, in general, slightly more pessimistic than the intermediate scenario-based estimates. The median estimate of the long-range actuarial balance is -2.67 percent of taxable payroll, about 0.01 percentage point lower than projected under the intermediate assumptions. The median first projected year that cost exceeds non-interest income (as it did in 2010 through 2015), and remains in excess of non-interest income throughout the remainder of the long-range period, is 2016. This is the same year as projected under the intermediate assumptions. The median year that asset reserves first become depleted is 2034, also the same as projected under the intermediate assumptions. The median estimates of the annual cost rate for the 75th year of the projection period are 18.01 percent of taxable payroll and 6.26 percent of gross domestic product (GDP). The comparable estimates under the intermediate assumptions are 17.68 percent of payroll and 6.14 percent of GDP.

For three measures in table VI.E1 (the actuarial balance, the first year cost exceeds non-interest income and remains in excess through 2090, and the first projected year asset reserves become depleted), the 95-percent stochastic confidence interval is narrower than the range defined by the low-cost and high-cost alternatives. In other words, for these measures, the range defined by the low-cost and high-cost alternatives contains the 95-percent confidence interval of the stochastic modeling projections. For the remaining three measures (the open group unfunded obligation, the annual cost in the 75th year as a percent of taxable payroll, and the annual cost in the 75th year as a percent of GDP), one or both of the bounds of the 95-percent stochastic confidence interval fall outside the range defined by the low-cost and high-cost alternatives.

Table VI.E1.—Long-Range Estimates Relating to the Actuarial Status of the Combined OASDI Program
[Comparison of scenario-based and stochastic results]

	Traditional scenario-based model			Stochastic model				
				Median	80-percent confidence interval		95-percent confidence interval	
	Intermediate	Low-cost	High-cost	50th percentile	10th percentile	90th percentile	2.5th percentile	97.5th percentile
Actuarial balance	-2.66	0.22	-6.30	-2.67	-4.08	-1.52	-4.95	-0.93
Open group unfunded obligation (in trillions)	$11.4	-$1.9	$23.3	$11.4	$5.4	$21.2	$3.2	$30.0
First projected year cost exceeds non-interest income and remains in excess through 2090[a]	2016	[b]	2016	2016	2016	2042	2016	2088
First year asset reserves become depleted[c]	2034	[d]	2029	2034	2031	2040	2029	2045
Annual cost in 75th year (percent of taxable payroll)	17.68	12.84	24.89	18.01	14.84	22.39	13.30	25.11
Annual cost in 75th year (percent of GDP)	6.14	4.85	7.96	6.26	5.19	7.71	4.67	8.62

[a] Cost also exceeded non-interest income in 2010 through 2015.
[b] The annual balance is projected to be negative for a temporary period, returning to positive levels before the end of the projection period.
[c] For some stochastic simulations, the first year in which trust fund reserves become depleted does not indicate a permanent depletion of reserves.
[d] Trust fund reserves are not estimated to be depleted within the projection period.

F. INFINITE HORIZON PROJECTIONS

Another measure of trust fund finances is the infinite horizon unfunded obligation, which takes account of all annual balances, even those after 75 years. The extension of the time period past 75 years assumes that the current-law OASDI program and the demographic and economic trends used for the 75-year projection continue indefinitely.

Table VI.F1 shows that the OASDI open group unfunded obligation over the infinite horizon is $32.1 trillion in present value, which is $20.7 trillion larger than for the 75-year period. The $20.7 trillion increment reflects a significant financing gap projected for OASDI for years after 2090 into perpetuity. Of course, the degree of uncertainty associated with estimates increases substantially for years further in the future.

The $32.1 trillion infinite horizon open group unfunded obligation is equivalent to 4.0 percent of taxable payroll or 1.4 percent of GDP. These relative measures of the unfunded obligation over the infinite horizon express its magnitude in relation to the resources potentially available to finance the shortfall.

The summarized shortfalls for the 75-year period and through the infinite horizon both reflect annual cash-flow shortfalls for all years after trust fund reserve depletion. The annual shortfalls after trust fund reserve depletion rise slowly and reflect increases in life expectancy after 2034. The summarized shortfalls for the 75-year period, as percentages of taxable payroll and GDP, are lower than those for the infinite horizon principally because only about three-quarters of the years in the 75-year period have unfunded annual shortfalls, and annual shortfalls within the 75-year period represent a smaller share of taxable payroll and GDP than do the shortfalls in later years.

To illustrate the magnitude of the projected infinite horizon shortfall, consider that it could be eliminated with additional revenue equivalent to an immediate increase in the combined payroll tax rate from 12.4 percent to about 16.6 percent,[1] or with cost reductions equivalent to an immediate and permanent reduction in benefits for all current and future beneficiaries by about 24 percent.

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[1] The indicated increase in the payroll tax rate of 4.2 percent is somewhat larger than the 4.0 percent infinite horizon actuarial deficit because the indicated increase reflects a behavioral response to tax rate changes. In particular, the calculation assumes that an increase in payroll taxes results in a small shift of wages and salaries to forms of employee compensation that are not subject to the payroll tax.

Table VI.F1.—Unfunded OASDI Obligations Through the Infinite Horizon, Based on Intermediate Assumptions
[Present values as of January 1, 2016; dollar amounts in trillions]

		Expressed as a percentage of future payroll and GDP	
	Present value	Taxable payroll	GDP
Unfunded obligation through the infinite horizon[a]	$32.1	4.0	1.4
Unfunded obligation through 2090[b]	11.4	2.5	0.9

[a] Present value of future cost less future non-interest income, reduced by the amount of trust fund asset reserves at the beginning of 2016. Expressed as a percentage of payroll and GDP for the period 2016 through the infinite horizon.
[b] Present value of future cost less future non-interest income through 2090, reduced by the amount of trust fund reserves at the beginning of 2016. Expressed as a percentage of payroll and GDP for the period 2016 through 2090.

Notes:
1. The present values of future taxable payroll for 2016-90 and for 2016 through the infinite horizon are $455.4 trillion and $801.4 trillion, respectively.
2. The present values of GDP for 2016-90 and for 2016 through the infinite horizon are $1,270.1 trillion and $2,361.4 trillion, respectively. Present values of GDP shown in the Medicare Trustees Report differ slightly due to the use of interest discount rates that are specific to each program's trust fund holdings.

Last year, the Trustees projected that the infinite horizon unfunded obligation was $25.8 trillion in present value. If the assumptions, methods, and starting values had not changed, moving the valuation date forward by 1 year would have increased the unfunded obligation by about $0.9 trillion, to $26.6 trillion. The net effects of changes in assumptions, methods, law, and starting values increased the infinite horizon unfunded obligation by $5.5 trillion. The major change affecting the infinite horizon unfunded obligation for this report is the reduction in the ultimate real interest rate from 2.9 percent to 2.7 percent, which provides more weight to annual shortfalls in the more distant future. The same interest rate change also increased the present values of future taxable payroll and GDP for this report.

The infinite horizon unfunded obligation is 0.1 percentage point higher than in last year's report when expressed as a share of taxable payroll, and 0.1 percentage point higher than last year when expressed as a share of GDP. Because the reduction in the ultimate real interest rate substantially increased taxable payroll and GDP, the infinite horizon unfunded obligation as a share of either changed relatively little. See section IV.B.6 for details regarding changes in law, data, methods, and assumptions.

a. Unfunded Obligations for Past, Current, and Future Participants

Table VI.F2 separates the components of the infinite horizon unfunded obligation (with the exception of General Fund reimbursements) among past, current, and future participants. The table does not separate past General

Fund reimbursements among participants because there is no clear basis for attributing the reimbursements across generations.

Past participants are defined as those no longer alive as of the valuation date. Current participants are those age 15 and older as of 2016. Future participants are those under age 15 or not yet born.

The excess of the present value of cost for past and current participants over the present value of dedicated tax income for past and current participants produces an unfunded obligation for past and current participants of $29.7 trillion. Table VI.F2 also shows an unfunded obligation of $29.1 trillion for past and current participants, including past and future General Fund reimbursements. Future participants are scheduled to pay dedicated taxes of $3.0 trillion less into the system than the cost of their benefits ($76.2 trillion of dedicated tax income as compared to $79.2 trillion of cost). The unfunded obligation for all participants through the infinite horizon thus equals $32.1 trillion.

This accounting demonstrates that some generations are scheduled to receive benefits with a present value exceeding the present value of their dedicated tax income, while other generations are scheduled to receive benefits with a present value less than the present value of their dedicated tax income, whether past General Fund reimbursements are included or not. Making Social Security solvent over the infinite horizon requires some combination of increased revenue or reduced benefits for current and future participants amounting to $32.1 trillion in present value, 4.0 percent of future taxable payroll, or 1.4 percent of future GDP.

Table VI.F2.—Present Values of OASDI Cost Less Non-interest Income and Unfunded Obligations for Program Participants, Based on Intermediate Assumptions
[Present values as of January 1, 2016; dollar amounts in trillions]

		Expressed as a percentage of future payroll and GDP	
	Present value	Taxable payroll	GDP
Present value of past cost	$56.4	7.0	2.4
Less present value of past dedicated tax income	58.6	7.3	2.5
Plus present value of future cost for current participants	62.5	7.8	2.6
Less present value of future dedicated tax income for current participants	30.6	3.8	1.3
Equals unfunded obligation for past and current participants excluding General Fund reimbursements	29.7	3.7	1.3
Less present value of past General Fund reimbursements[a]	.6	.1	[b]
Less present value of future General Fund reimbursements over the infinite horizon[a]	[c]	[d]	[b]
Equals unfunded obligation for past and current participants including General Fund reimbursements	29.1	3.6	1.2
Plus present value of cost for future participants over the infinite horizon	79.2	9.9	3.4
Less present value of dedicated tax income for future participants over the infinite horizon	76.2	9.5	3.2
Equals unfunded obligation for all participants through the infinite horizon	32.1	4.0	1.4

[a] Distribution of General Fund reimbursements among past, current, and future participants cannot be determined.
[b] Less than 0.05 percent of GDP.
[c] Less than $50 billion.
[d] Less than 0.05 percent of taxable payroll.

Notes:
1. The present value of future taxable payroll for 2016 through the infinite horizon is $801.4 trillion.
2. The present value of GDP for 2016 through the infinite horizon is $2,361.4 trillion.
3. Totals do not necessarily equal the sums of rounded components.

G. ESTIMATES FOR OASDI AND HI, SEPARATE AND COMBINED

In this appendix, the Trustees present long-range actuarial estimates for the OASDI and Hospital Insurance (HI) programs both separately and on a combined basis. These estimates facilitate analysis of the adequacy of the income and asset reserves of these programs relative to their cost under current law. This appendix does not include estimates for the Supplementary Medical Insurance (SMI) program because adequate financing is guaranteed in the law, and because the SMI program is not financed through a payroll tax. For more information on Medicare estimates, please see the 2016 Medicare Trustees Report.

The information in this appendix on combined operations, while significant, should not obscure the analysis of the financial status of the individual trust funds, which are legally separate and cannot be commingled. In addition, the factors which determine the costs of the OASI, DI, and HI programs differ substantially.

1. Estimates as a Percentage of Taxable Payroll

Comparing cost and income rates for the OASDI and HI programs as percentages of taxable payroll requires a note of caution. The taxable payrolls for the HI program are larger than those estimated for the OASDI program because: (1) a larger maximum taxable amount was established for the HI program in 1991, with the maximum eliminated altogether for the HI program in 1994; (2) a larger proportion of Federal, State, and local government employees are covered under the HI program; and (3) the earnings of railroad workers are included directly in the HI taxable payroll but not in the OASDI taxable payroll. (Railroad contributions for the equivalent of OASDI benefits are accounted for in a net interchange that occurs annually between the OASDI and Railroad Retirement programs.) As a result, the HI taxable payroll is about 25 percent larger than the OASDI taxable payroll throughout the long-range period.

As with the OASI and DI Trust Funds, income to the HI Trust Fund comes primarily from contributions paid by employees, employers, and self-employed persons. Table VI.G1 shows the OASDI and HI contribution rates that are authorized in the Federal Insurance Contributions Act.

Table VI.G1.—Payroll Tax Contribution Rates for the OASDI and HI Programs
[In percent]

	Employees and employers, combined[a]		Employees only	Self employed[b]		
Calendar years	OASDI up to base[c]	HI all earnings[d]	HI over limit[e]	OASDI up to base[c]	HI all earnings[d]	HI over limit[e]
1966	7.70	0.70	—	5.80	0.35	—
1967	7.80	1.00	—	5.90	.50	—
1968	7.60	1.20	—	5.80	.60	—
1969-70	8.40	1.20	—	6.30	.60	—
1971-72	9.20	1.20	—	6.90	.60	—
1973	9.70	2.00	—	7.00	1.00	—
1974-77	9.90	1.80	—	7.00	.90	—
1978	10.10	2.00	—	7.10	1.00	—
1979-80	10.16	2.10	—	7.05	1.05	—
1981	10.70	2.60	—	8.00	1.30	—
1982-83	10.80	2.60	—	8.05	1.30	—
1984[f]	11.40	2.60	—	11.40	2.60	—
1985[f]	11.40	2.70	—	11.40	2.70	—
1986-87[f]	11.40	2.90	—	11.40	2.90	—
1988-89[f]	12.12	2.90	—	12.12	2.90	—
1990-2010[g]	12.40	2.90	—	12.40	2.90	—
2011-2012[g]	10.40	2.90	—	10.40	2.90	—
2013 and later	12.40	2.90	0.90	12.40	2.90	0.90

[a] Except as noted below, the combined employee/employer rate is divided equally between employees and employers.

[b] Beginning in 1990, self-employed persons receive a deduction, for purposes of computing their net earnings, equal to half of the combined OASDI and HI contributions that would be payable without regard to the contribution and benefit base. The OASDI contribution rate then applies to net earnings after this deduction, but subject to the OASDI base.

[c] The payroll tax on earnings for the OASDI program applies to annual earnings up to a contribution and benefit base indexed to the average wage level. The base is $118,500 for 2016.

[d] Prior to 1994, the payroll tax on earnings for the HI program applied to annual earnings up to a contribution base. The HI contribution base was eliminated beginning in 1994.

[e] Starting with Federal personal income tax returns for tax year 2013, earned income exceeding $200,000 for individual filers and $250,000 for married couples filing jointly is subject to an additional HI tax of 0.9 percent. These income limits are not indexed after 2013.

[f] In 1984 only, employees received an immediate credit of 0.3 percent of taxable wages against their OASDI payroll tax contributions. The self-employed received similar credits of 2.7 percent, 2.3 percent, and 2.0 percent against their combined OASDI and Hospital Insurance (HI) contributions on net earnings from self-employment in 1984, 1985, and 1986-89, respectively. The General Fund of the Treasury reimbursed the trust funds for these credits.

[g] Public Law 111-147 exempted most employers from paying the employer share of OASDI payroll tax on wages paid during the period March 19, 2010 through December 31, 2010 to certain qualified individuals hired after February 3, 2010. Public Law 111-312, Public Law 112-78, and Public Law 112-96 reduced the OASDI payroll tax rate for 2011 and 2012 by 2 percentage points for employees and for self-employed workers. These laws require that the General Fund of the Treasury reimburse the OASI and DI Trust Funds for these temporary reductions in 2010, 2011, and 2012 payroll tax revenue, in order to "replicate to the extent possible" revenue that would have been received if the combined employee/employer payroll tax rates had remained at 12.4 percent for OASDI (10.6 percent for OASI and 1.8 percent for DI).

Table VI.G2 shows the Trustees' estimates of annual income rates and cost rates for the OASDI program and the HI program under the low-cost, intermediate, and high-cost sets of assumptions described earlier in this report. The income rates reflect the payroll tax rates shown in table VI.G1 and revenue from taxation of OASDI benefits for both the OASDI and HI Trust Funds. For the HI program, the income rates also reflect: (1) the additional 0.9-percent tax on employees for relatively high earnings and the portion of total payroll to which the 0.9-percent rate applies; (2) premium revenues; (3) monies from fraud and abuse control activities; and (4) reimbursements from the General Fund of the Treasury, if any. Annual income and cost rates indicate the cash-flow operation of the programs. Therefore, income rates exclude interest earned on trust fund asset reserves. Table VI.G2 also shows annual balances, which are the differences between annual income rates and cost rates.

The Trustees project that the OASDI and HI cost rates will rise generally above current levels under the intermediate and high-cost sets of assumptions. The greatest increase occurs from 2018 to 2038 under both sets of assumptions for OASDI and under the intermediate assumptions for HI. Under the intermediate assumptions, the OASDI cost rate increases by 26 percent from its current level by 2090, while under the high-cost assumptions, the cost rate increases by 73 percent by 2090. For HI, cost rates increase 47 percent and 204 percent from 2016 to 2090 under the intermediate and high-cost assumptions, respectively. Under the low-cost assumptions, the OASDI and HI cost rates decrease from 2016 to 2090 by 7 percent and 29 percent, respectively.

The Trustees project annual deficits for every year of the projection period under the intermediate and high-cost assumptions for the OASDI program and for the HI program. Under the low-cost assumptions, OASDI annual balances are negative through 2047 and positive thereafter. HI annual balances are positive throughout the projection period.

Table VI.G2.—OASDI and HI Annual Income Rates, Cost Rates, and Balances, Calendar Years 2016-2090
[As a percentage of taxable payroll[a]]

	OASDI			HI		
Calendar year	Income rate	Cost rate[b]	Balance[b]	Income rate	Cost rate	Balance
Intermediate:						
2016	12.94	14.05	-1.10	3.37	3.44	-0.08
2017	12.92	13.72	-.80	3.38	3.41	-.03
2018	12.96	13.86	-.90	3.39	3.40	[c]
2019	12.97	13.99	-1.02	3.41	3.42	-.01
2020	12.98	14.13	-1.15	3.43	3.47	-.04
2021	13.00	14.27	-1.27	3.45	3.53	-.08
2022	13.03	14.49	-1.46	3.47	3.61	-.14
2023	13.06	14.76	-1.70	3.49	3.69	-.20
2024	13.09	15.02	-1.93	3.51	3.75	-.24
2025	13.11	15.29	-2.17	3.54	3.81	-.27
2030	13.18	16.10	-2.92	3.63	4.25	-.62
2035	13.22	16.50	-3.28	3.71	4.57	-.87
2040	13.23	16.59	-3.36	3.77	4.77	-1.00
2045	13.23	16.45	-3.22	3.83	4.87	-1.04
2050	13.23	16.36	-3.13	3.89	4.88	-.99
2055	13.24	16.46	-3.22	3.96	4.84	-.88
2060	13.26	16.71	-3.44	4.03	4.84	-.81
2065	13.28	16.96	-3.68	4.10	4.89	-.79
2070	13.30	17.22	-3.92	4.17	4.98	-.81
2075	13.31	17.39	-4.08	4.23	5.06	-.83
2080	13.31	17.40	-4.09	4.28	5.08	-.81
2085	13.32	17.47	-4.15	4.32	5.08	-.76
2090	13.33	17.68	-4.35	4.37	5.08	-.71
Low-cost:						
2016	12.89	13.86	-.97	3.36	3.35	.01
2017	12.89	13.31	-.42	3.37	3.22	.14
2018	12.93	13.28	-.35	3.38	3.15	.23
2019	12.93	13.23	-.30	3.39	3.11	.28
2020	12.94	13.22	-.28	3.41	3.10	.31
2021	12.95	13.23	-.28	3.42	3.09	.33
2022	12.98	13.31	-.33	3.44	3.09	.35
2023	12.99	13.41	-.42	3.46	3.10	.36
2024	13.02	13.51	-.49	3.48	3.09	.38
2025	13.03	13.60	-.58	3.50	3.08	.42
2030	13.07	13.89	-.82	3.59	3.11	.48
2035	13.09	13.88	-.79	3.67	3.03	.64
2040	13.08	13.62	-.53	3.75	2.86	.89
2045	13.07	13.23	-.16	3.81	2.66	1.16
2050	13.06	12.96	.10	3.89	2.47	1.41
2055	13.06	12.91	.15	3.96	2.34	1.62
2060	13.07	12.98	.09	4.03	2.27	1.76
2065	13.07	13.02	.05	4.10	2.28	1.82
2070	13.07	13.04	.04	4.15	2.32	1.83
2075	13.07	12.96	.11	4.19	2.36	1.84
2080	13.06	12.75	.31	4.23	2.37	1.86
2085	13.05	12.68	.37	4.26	2.37	1.89
2090	13.06	12.84	.22	4.30	2.37	1.93

Table VI.G2.—OASDI and HI Annual Income Rates, Cost Rates, and Balances, Calendar Years 2016-2090 (Cont.)
[As a percentage of taxable payroll[a]]

	OASDI			HI		
Calendar year	Income rate	Cost rate[b]	Balance[b]	Income rate	Cost rate	Balance
High-cost:						
2016	13.04	14.35	-1.32	3.37	3.58	-0.21
2017	12.97	14.65	-1.67	3.39	3.67	-.28
2018	12.99	14.82	-1.83	3.42	3.72	-.31
2019	13.02	15.15	-2.12	3.44	3.81	-.38
2020	13.04	15.44	-2.40	3.46	3.95	-.49
2021	13.07	15.71	-2.64	3.48	4.09	-.61
2022	13.11	16.06	-2.95	3.51	4.26	-.75
2023	13.14	16.44	-3.30	3.53	4.44	-.91
2024	13.18	16.83	-3.66	3.56	4.61	-1.05
2025	13.21	17.24	-4.04	3.59	4.76	-1.17
2030	13.30	18.66	-5.36	3.69	5.86	-2.17
2035	13.36	19.61	-6.24	3.77	6.95	-3.18
2040	13.41	20.24	-6.84	3.85	8.02	-4.18
2045	13.43	20.54	-7.11	3.90	8.97	-5.06
2050	13.45	20.79	-7.34	3.96	9.63	-5.68
2055	13.48	21.22	-7.74	4.02	10.05	-6.04
2060	13.52	21.78	-8.27	4.08	10.35	-6.27
2065	13.56	22.39	-8.84	4.15	10.55	-6.40
2070	13.60	23.09	-9.48	4.22	10.73	-6.50
2075	13.64	23.71	-10.07	4.29	10.89	-6.59
2080	13.67	24.14	-10.47	4.36	10.93	-6.58
2085	13.69	24.52	-10.82	4.41	10.91	-6.50
2090	13.72	24.89	-11.17	4.47	10.89	-6.43

[a] The taxable payroll for HI is significantly larger than the taxable payroll for OASDI because the HI taxable maximum amount was eliminated beginning in 1994, and because HI covers all Federal civilian employees, all State and local government employees hired after April 1, 1986, and railroad employees.
[b] OASDI benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.
[c] Between -0.005 and 0 percent of taxable payroll.

Notes:
1. The income rate excludes interest income.
2. The Trustees show income and cost estimates generally on a cash basis for the OASDI program and on an incurred basis for the HI program.
3. Totals do not necessarily equal the sums of rounded components.

Table VI.G3 shows summarized values over the 25-year, 50-year, and 75-year valuation periods. For each of those periods, the summarized income rates include beginning trust fund asset reserves, and the summarized cost rates include the cost of accumulating an ending fund reserve equal to 100 percent of annual cost at the end of the period.

Table VI.G3.—Summarized OASDI and HI Income Rates and Cost Rates for Valuation Periods,[a] Calendar Years 2016-2090
[As a percentage of taxable payroll[b]]

Valuation period	OASDI			HI		
	Income rate	Cost rate[c]	Actuarial balance	Income rate	Cost rate	Actuarial balance
Intermediate:						
25-year:						
2016-40	14.67	16.15	-1.48	3.67	4.24	-0.58
50-year:						
2016-65	14.03	16.26	-2.23	3.79	4.50	-.72
75-year:						
2016-90	13.84	16.50	-2.66	3.91	4.63	-.73
Low-cost:						
25-year:						
2016-40	14.44	14.20	.24	3.63	3.19	.45
50-year:						
2016-65	13.80	13.61	.19	3.77	2.83	.94
75-year:						
2016-90	13.59	13.37	.22	3.90	2.69	1.21
High-cost:						
25-year:						
2016-40	14.95	18.48	-3.53	3.72	5.77	-2.05
50-year:						
2016-65	14.31	19.53	-5.23	3.84	7.44	-3.60
75-year:						
2016-90	14.16	20.46	-6.30	3.95	8.20	-4.25

[a] Income rates include beginning trust fund asset reserves and cost rates include the cost of reaching an ending target trust fund equal to 100 percent of annual cost at the end of the period.
[b] The taxable payroll for HI is significantly larger than the taxable payroll for OASDI because the HI taxable maximum amount was eliminated beginning 1994, and because HI covers all Federal civilian employees, all State and local government employees hired after April 1, 1986, and railroad employees.
[c] OASDI benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.

Note: Totals do not necessarily equal the sums of rounded components.

The Trustees project that the OASDI and HI programs will each experience large actuarial deficits for the 25-year, 50-year, and 75-year valuation periods under the high-cost assumptions. Actuarial deficits under the intermediate assumptions are smaller than those for the high-cost assumptions for all three valuation periods. Under the low-cost assumptions, the OASDI and HI programs have positive actuarial balances for all three valuation periods.

2. Estimates as a Percentage of Gross Domestic Product

This section contains long-range projections of the operations of the combined Old-Age and Survivors Insurance and Disability Insurance (OASI and DI) Trust Funds and of the Hospital Insurance (HI) Trust Fund, expressed as a percentage of gross domestic product (GDP). While expressing fund operations as a percentage of taxable payroll is a very useful approach for assessing the financial status of the programs (see section IV.B.1), expressing them as a percentage of the total value of goods and services produced in the United States provides an additional perspective.

Table VI.G4 shows non-interest income, total cost, and the resulting balance of the combined OASI and DI Trust Funds, of the HI Trust Fund, and of the combined OASI, DI, and HI Trust Funds, expressed as percentages of GDP on the basis of each of the three alternative sets of assumptions. Table VI.G4 also contains estimates of GDP. For OASDI, non-interest income consists of payroll tax contributions, proceeds from taxation of benefits, and reimbursements from the General Fund of the Treasury, if any. Cost consists of scheduled benefits, administrative expenses, financial interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries. For HI, non-interest income consists of payroll tax contributions (including contributions from railroad employment), up to an additional 0.9 percent tax on earned income for relatively high earners, proceeds from taxation of OASDI benefits, premium revenues, monies from fraud and abuse control activities, and reimbursements from the General Fund of the Treasury, if any. Cost consists of outlays (benefits and administrative expenses) for beneficiaries. The Trustees show income and cost estimates generally on a cash basis for the OASDI program[1] and on an incurred basis for the HI program.

The Trustees project the OASDI annual balance (non-interest income less cost) as a percentage of GDP to be negative throughout the projection period under the intermediate and high-cost assumptions, and to be negative through 2047 and positive thereafter under the low-cost assumptions. Under the low-cost assumptions, the OASDI annual deficit as a percentage of GDP decreases through 2021. After 2021, deficits increase to a peak in 2032, decrease through 2047, and then the annual balance becomes positive starting in 2048. The positive annual balances increase through 2054, decrease

[1] OASDI benefits paid for entitlement for a particular month are generally paid in the succeeding month. There are two primary exceptions to this general rule. First, payments can occur with a greater delay when a benefit award is made after the month of initial benefit entitlement. At the time of benefit award, benefits owed for months of prior entitlement are then also paid to the beneficiary. For the projections in this report, such retroactive payments are included in the period where they are paid (at time of award). Second, when benefit payments scheduled for January 3 are paid on the prior December 31, because January 3 falls on a Sunday, such payments are shown in this report for the period they were scheduled to be paid.

through 2070, and fluctuate thereafter. Under the intermediate assumptions, annual deficits decrease from 2016 to 2017, increase through 2038, decrease from 2038 through 2051, and mostly increase thereafter. Under the high-cost assumptions, annual deficits increase throughout the projection period.

The Trustees project that the HI balance as a percentage of GDP will be positive throughout the projection period under the low-cost assumptions. Under the intermediate assumptions, the HI balance is negative for each year of the projection period. Annual deficits decrease from 2016 to 2018, increase through 2045, and then generally decline thereafter. Under the high-cost assumptions, the HI balance is negative for all years of the projection period. Annual deficits reach a peak in 2074 and decline slowly thereafter.

The combined OASDI and HI annual balance as a percentage of GDP is negative throughout the projection period under both the intermediate and high-cost assumptions. Under the low-cost assumptions, the combined OASDI and HI balance is negative from 2016 through 2018, positive from 2019 through 2023, negative from 2024 through 2034, and then positive and mostly rising thereafter. Under the intermediate assumptions, combined OASDI and HI annual deficits decline from 2016 to 2017, increase from 2017 through 2039, and decrease through 2054. After 2054, annual deficits generally rise, reaching 1.82 percent of GDP by 2090. Under the high-cost assumptions, combined annual deficits rise throughout the projection period.

By 2090, the combined OASDI and HI annual balances as percentages of GDP range from a positive balance of 0.98 percent for the low-cost assumptions to a deficit of 6.21 percent for the high-cost assumptions. Balances differ by a much smaller amount for the tenth projection year, 2025, ranging from a deficit of 0.02 percent for the low-cost assumptions to a deficit of 1.99 percent for the high-cost assumptions.

The summarized long-range (75-year) balance as a percentage of GDP for the combined OASDI and HI programs varies among the three alternatives by a relatively large amount, from a positive balance of 0.64 percent under the low-cost assumptions to a deficit of 4.05 percent under the high-cost assumptions. The 25-year summarized balance varies by a smaller amount, from a positive balance of 0.30 percent to a deficit of 2.19 percent. Summarized rates are calculated on a present-value basis. They include the trust fund balances on January 1, 2016 and the cost of reaching a target trust fund level equal to 100 percent of the following year's annual cost at the end of the period. (See section IV.B.4 for further explanation.)

Table VI.G4.—OASDI and HI Annual and Summarized Income, Cost, and Balance as a Percentage of GDP, Calendar Years 2016-2090

	Percentage of GDP									GDP in dollars (billions)
	OASDI			HI			Combined			
Calendar year	Income[a]	Cost[b]	Balance[b]	Income[a]	Cost	Balance	Income[a]	Cost[b]	Balance[b]	
Intermediate:										
2016	4.59	4.98	-0.39	1.51	1.54	-0.03	6.09	6.52	-0.43	$18,659
2017	4.62	4.91	-.29	1.52	1.54	-.01	6.14	6.44	-.30	19,677
2018	4.65	4.98	-.32	1.54	1.54	[c]	6.19	6.52	-.32	20,745
2019	4.68	5.05	-.37	1.55	1.56	[c]	6.23	6.60	-.37	21,836
2020	4.70	5.12	-.42	1.57	1.59	-.02	6.27	6.70	-.44	22,948
2021	4.72	5.18	-.46	1.58	1.62	-.04	6.30	6.80	-.50	24,081
2022	4.75	5.28	-.53	1.59	1.65	-.06	6.34	6.93	-.59	25,204
2023	4.77	5.39	-.62	1.60	1.69	-.09	6.37	7.08	-.71	26,327
2024	4.79	5.50	-.71	1.62	1.73	-.11	6.41	7.22	-.82	27,499
2025	4.81	5.60	-.80	1.63	1.75	-.13	6.43	7.36	-.92	28,719
2030	4.81	5.87	-1.07	1.66	1.94	-.28	6.47	7.81	-1.35	35,680
2035	4.79	5.98	-1.19	1.68	2.08	-.40	6.48	8.06	-1.58	44,187
2040	4.78	5.99	-1.21	1.71	2.16	-.45	6.48	8.15	-1.67	54,881
2045	4.76	5.92	-1.16	1.73	2.20	-.47	6.49	8.12	-1.63	68,304
2050	4.75	5.87	-1.12	1.75	2.20	-.44	6.50	8.07	-1.57	84,817
2055	4.74	5.90	-1.15	1.78	2.18	-.40	6.52	8.07	-1.55	105,031
2060	4.74	5.97	-1.23	1.81	2.17	-.36	6.54	8.13	-1.59	129,808
2065	4.72	6.03	-1.31	1.83	2.18	-.35	6.55	8.21	-1.66	160,417
2070	4.71	6.09	-1.39	1.85	2.21	-.36	6.56	8.30	-1.75	198,390
2075	4.69	6.13	-1.44	1.87	2.23	-.37	6.56	8.36	-1.80	245,548
2080	4.66	6.10	-1.43	1.88	2.24	-.35	6.54	8.33	-1.79	303,911
2085	4.64	6.09	-1.45	1.89	2.22	-.33	6.54	8.32	-1.78	375,722
2090	4.63	6.14	-1.51	1.90	2.21	-.31	6.54	8.36	-1.82	463,784
Summarized rates: [d]										
25-year:										
2016-40 . .	5.32	5.86	-.54	1.67	1.94	-.26	7.00	7.80	-.80	
50-year:										
2016-65 . .	5.06	5.87	-.81	1.72	2.04	-.32	6.78	7.91	-1.13	
75-year:										
2016-90 . .	4.96	5.92	-.95	1.76	2.08	-.33	6.72	8.00	-1.28	
Low-cost:										
2016	4.57	4.92	-.34	1.51	1.50	[c]	6.08	6.42	-.34	18,843
2017	4.62	4.77	-.15	1.52	1.46	.06	6.14	6.23	-.09	20,219
2018	4.66	4.79	-.13	1.54	1.43	.10	6.20	6.22	-.02	21,655
2019	4.70	4.80	-.11	1.55	1.42	.13	6.25	6.22	.02	23,097
2020	4.73	4.83	-.10	1.56	1.42	.14	6.29	6.25	.04	24,560
2021	4.76	4.86	-.10	1.57	1.42	.15	6.33	6.28	.05	26,035
2022	4.79	4.91	-.12	1.58	1.42	.16	6.37	6.33	.04	27,550
2023	4.82	4.97	-.15	1.59	1.42	.16	6.41	6.40	.01	29,135
2024	4.85	5.03	-.18	1.60	1.42	.18	6.45	6.46	-.01	30,806
2025	4.87	5.09	-.22	1.61	1.42	.19	6.49	6.51	-.02	32,556
2030	4.88	5.19	-.31	1.65	1.43	.22	6.53	6.62	-.09	42,912
2035	4.88	5.17	-.29	1.68	1.39	.29	6.56	6.56	[c]	56,428
2040	4.88	5.08	-.20	1.72	1.31	.41	6.59	6.39	.21	74,581
2045	4.88	4.94	-.06	1.75	1.22	.53	6.63	6.16	.47	99,022
2050	4.89	4.85	.04	1.79	1.14	.65	6.68	5.99	.69	131,321
2055	4.90	4.84	.06	1.83	1.08	.75	6.73	5.92	.80	173,643
2060	4.91	4.88	.03	1.86	1.05	.82	6.78	5.93	.85	229,200
2065	4.92	4.90	.02	1.90	1.05	.84	6.81	5.95	.86	302,759
2070	4.92	4.91	.01	1.92	1.07	.85	6.85	5.98	.86	400,758
2075	4.93	4.88	.04	1.94	1.09	.85	6.87	5.98	.89	531,492
2080	4.92	4.81	.12	1.96	1.10	.86	6.88	5.91	.98	705,051
2085	4.93	4.79	.14	1.98	1.10	.88	6.90	5.89	1.02	933,466
2090	4.94	4.85	.09	2.00	1.10	.90	6.94	5.96	.98	1,232,721

Table VI.G4.—OASDI and HI Annual and Summarized Income, Cost, and Balance as a Percentage of GDP, Calendar Years 2016-2090 (Cont.)

	Percentage of GDP									GDP in dollars (billions)
	OASDI			HI			Combined			
Calendar year	Income[a]	Cost[b]	Balance[b]	Income[a]	Cost	Balance	Income[a]	Cost[b]	Balance[b]	
Low-cost (Cont.):										
Summarized rates: [d]										
25-year:										
2016-40 . .	5.35	5.26	0.09	1.67	1.46	0.21	7.02	6.72	0.30	
50-year:										
2016-65 . .	5.14	5.07	.07	1.73	1.30	.44	6.88	6.37	.51	
75-year:										
2016-90 . .	5.08	5.00	.08	1.80	1.24	.56	6.88	6.24	.64	
High-cost:										
2016	4.62	5.09	-.47	1.51	1.60	-.10	6.13	6.69	-.56	$18,299
2017	4.58	5.17	-.59	1.52	1.64	-.12	6.10	6.81	-.71	18,757
2018	4.63	5.29	-.65	1.54	1.68	-.14	6.17	6.96	-.79	19,490
2019	4.65	5.41	-.76	1.56	1.73	-.17	6.21	7.13	-.93	20,275
2020	4.67	5.53	-.86	1.57	1.79	-.22	6.24	7.32	-1.08	21,065
2021	4.69	5.64	-.95	1.59	1.87	-.28	6.28	7.51	-1.23	21,862
2022	4.71	5.77	-1.06	1.60	1.95	-.35	6.31	7.72	-1.41	22,670
2023	4.73	5.91	-1.19	1.62	2.04	-.42	6.35	7.95	-1.60	23,483
2024	4.74	6.06	-1.32	1.64	2.12	-.48	6.38	8.17	-1.80	24,309
2025	4.75	6.20	-1.45	1.65	2.19	-.54	6.40	8.39	-1.99	25,140
2030	4.74	6.66	-1.91	1.68	2.67	-.99	6.42	9.33	-2.90	29,477
2035	4.72	6.93	-2.21	1.70	3.14	-1.44	6.42	10.07	-3.64	34,409
2040	4.70	7.09	-2.40	1.72	3.59	-1.87	6.42	10.68	-4.27	40,162
2045	4.67	7.14	-2.47	1.74	3.99	-2.25	6.41	11.13	-4.72	46,875
2050	4.64	7.18	-2.54	1.75	4.25	-2.51	6.39	11.43	-5.04	54,511
2055	4.62	7.27	-2.65	1.76	4.41	-2.65	6.38	11.68	-5.30	63,148
2060	4.60	7.41	-2.81	1.78	4.50	-2.73	6.37	11.91	-5.54	72,980
2065	4.57	7.54	-2.98	1.79	4.55	-2.76	6.35	12.09	-5.73	84,250
2070	4.53	7.69	-3.16	1.80	4.58	-2.77	6.34	12.27	-5.94	97,193
2075	4.50	7.82	-3.32	1.81	4.60	-2.78	6.31	12.42	-6.10	112,090
2080	4.46	7.88	-3.42	1.82	4.57	-2.75	6.28	12.44	-6.16	129,172
2085	4.42	7.92	-3.50	1.83	4.51	-2.69	6.25	12.43	-6.18	148,733
2090	4.39	7.96	-3.57	1.83	4.47	-2.63	6.22	12.43	-6.21	171,138
Summarized rates: [d]										
25-year:										
2016-40 . .	5.32	6.58	-1.26	1.69	2.62	-.93	7.01	9.20	-2.19	
50-year:										
2016-65 . .	5.02	6.85	-1.83	1.72	3.33	-1.61	6.74	10.18	-3.44	
75-year:										
2016-90 . .	4.89	7.06	-2.18	1.74	3.61	-1.87	6.63	10.68	-4.05	

[a] Income for individual years excludes interest on the trust funds. Interest is implicit in all summarized values.

[b] OASDI benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.

[c] Between -0.005 and 0.005 percent of GDP.

[d] Summarized rates are calculated on a present-value basis. They include the value of the trust funds on January 1, 2016 and the cost of reaching a target trust fund level equal to 100 percent of annual cost at the end of the period.

Notes:
1. The Trustees show income and cost estimates generally on a cash basis for the OASDI program and on an incurred basis for the HI program.

2. Totals do not necessarily equal the sums of rounded components.

To compare trust fund operations expressed as percentages of taxable payroll and those expressed as percentages of GDP, table VI.G5 displays ratios of OASDI taxable payroll to GDP. HI taxable payroll is about 25 percent larger than the OASDI taxable payroll throughout the long-range period; see section 1 of this appendix for a detailed description of the difference. The cost as a percentage of GDP is equal to the cost as a percentage of taxable payroll multiplied by the ratio of taxable payroll to GDP.

Table VI.G5.—Ratio of OASDI Taxable Payroll to GDP, Calendar Years 2016-2090

Calendar year	Intermediate	Low-cost	High-cost
2016	0.354	0.355	0.355
2017	.358	.359	.353
2018	.359	.361	.357
2019	.361	.363	.357
2020	.362	.365	.358
2021	.363	.367	.359
2022	.364	.369	.359
2023	.365	.371	.360
2024	.366	.373	.360
2025	.367	.374	.360
2030	.365	.374	.357
2035	.363	.373	.353
2040	.361	.373	.350
2045	.360	.373	.348
2050	.359	.374	.345
2055	.358	.375	.343
2060	.357	.376	.340
2065	.356	.376	.337
2070	.354	.377	.333
2075	.352	.377	.330
2080	.350	.377	.326
2085	.349	.377	.323
2090	.348	.378	.320

Projections of GDP reflect projected increases in U.S. employment, labor productivity, average hours worked, and the GDP deflator. Projections of taxable payroll reflect the components of growth in GDP along with assumed changes in the ratio of worker compensation to GDP, the ratio of earnings to worker compensation, the ratio of OASDI covered earnings to total earnings, and the ratio of taxable to total covered earnings.

Over the long-range period, the ratio of OASDI taxable payroll to GDP is projected to decline mostly due to a projected decline in the ratio of wages to employee compensation. Over the last five complete economic cycles, the ratio of wages to employee compensation declined at an average annual rate of 0.23 percent. Over the 65-year period ending in 2090, the ratio of wages to employee compensation is projected to decline at an average annual rate of 0.07 and 0.17 percent for the intermediate and high-cost assumptions, respectively, and to increase at an average annual rate of 0.03 percent for the low-cost assumptions.

3. Estimates in Dollars

This section contains long-range projections, in dollars, of the operations of the combined OASI and DI Trust Funds and in some cases the HI Trust Fund. Comparing current dollar values over long periods of time is difficult because of the effect of inflation. In order to compare dollar values in a meaningful way, table VI.G6 provides several economic series or indices which can be used to adjust current dollars for changes in prices, wages, or other aspects of economic growth during the projection period. Any series of values can be adjusted by dividing the value for each year by the corresponding index value for the year.

One of the most common forms of standardization is price indexing, which uses some measure of change in the prices of consumer goods. The Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W, hereafter referred to as CPI), published by the Bureau of Labor Statistics, Department of Labor, is one such price index. The Social Security Administration (SSA) uses this index to determine the annual cost-of-living increases for OASDI monthly benefits. The ultimate annual rate of increase in the CPI is assumed to be 3.2, 2.6, and 2.0 percent for the low-cost, intermediate, and high-cost sets of assumptions, respectively. Table VI.G7 provides CPI-indexed dollar values (those adjusted using the CPI in table VI.G6), which indicate the relative purchasing power of the values over time.

Wage indexing is another type of standardization. It combines the effects of price inflation and real-wage growth. The wage index presented here is the national average wage index, as defined in section 209(k)(1) of the Social Security Act. SSA uses this index to annually adjust the contribution and benefit base and other earnings-related program amounts. The average wage is assumed to grow by an average rate of 5.0, 3.8, and 2.6 percent under the low-cost, intermediate, and high-cost assumptions, respectively, between 2025 and 2090. Wage-indexed values indicate the level of a series relative to the changing standard of living of workers over time.

The taxable payroll index adjusts for the effects of changes in the number of workers and changes in the proportion of earnings that are taxable, as well as for the effects of price inflation and real-wage growth. The OASDI taxable payroll consists of all earnings subject to OASDI taxation, with an adjustment for the lower effective tax rate on multiple-employer excess wages. A series of values, divided by the taxable payroll, indicates the percentage of payroll that each value represents, and thus the extent to which the series of values increases or decreases as a percent of payroll over time.

The GDP index adjusts for the growth in the aggregate amount of goods and services produced in the United States. Values adjusted by GDP (see section 2 of this appendix) indicate their relative share of the total output of the economy. No explicit assumption is made about growth in taxable payroll or GDP. These series reflect the basic demographic and economic assumptions, as discussed in sections V.A and V.B, respectively.

Discounting at the rate of interest is another way of adjusting current dollars. The compound new-issue interest factor shown in table VI.G6 increases each year by the assumed annualized nominal yield for special public-debt obligations issuable to the trust funds in the 12 months of the prior year. The compound effective trust-fund interest factor shown in table VI.G6 uses the effective annual yield on all currently-held securities in the combined OASI and DI Trust Funds. The reciprocal of the compound effective trust-fund interest factor approximates the cumulative discount factor used to convert nominal dollar values to present values as of the start of the valuation period in order to create summarized values for this report.

Table VI.G6.—Selected Economic Variables, Calendar Years 2015-2090
[GDP and taxable payroll in billions]

Calendar year	Adjusted CPI[a]	Average wage index	Taxable payroll[b]	Gross domestic product	Compound new-issue interest factor[c]	Compound effective trust-fund interest factor[d]
Intermediate:						
2015	99.14	$47,730.20	$6,370	$17,956	0.9801	0.9834
2016	100.00	49,121.32	6,611	18,659	1.0000	1.0159
2017	102.76	51,467.41	7,038	19,677	1.0244	1.0479
2018	105.48	53,929.00	7,452	20,745	1.0617	1.0806
2019	108.23	56,341.78	7,876	21,836	1.1068	1.1148
2020	111.04	58,754.57	8,310	22,948	1.1567	1.1505
2021	113.93	61,237.90	8,748	24,081	1.2112	1.1879
2022	116.89	63,735.69	9,182	25,204	1.2702	1.2269
2023	119.93	66,277.05	9,614	26,327	1.3345	1.2680
2024	123.05	68,952.47	10,066	27,499	1.4043	1.3119
2025	126.25	71,668.95	10,528	28,719	1.4790	1.3587
2030	143.53	86,735.71	13,009	35,680	1.9212	1.6916
2035	163.19	104,911.08	16,021	44,187	2.4955	2.1973
2040	185.53	126,583.75	19,809	54,881	3.2416	2.8542
2045	210.94	152,870.45	24,583	68,304	4.2106	3.7074
2050	239.83	184,745.46	30,455	84,817	5.4693	4.8157
2055	272.67	223,035.42	37,622	105,031	7.1043	6.2553
2060	310.01	268,973.83	46,355	129,808	9.2280	8.1253
2065	352.46	323,866.96	57,050	160,417	11.9867	10.5542
2070	400.73	389,381.61	70,219	198,390	15.5700	13.7093
2075	455.60	467,975.33	86,490	245,548	20.2245	17.8076
2080	517.99	562,255.34	106,495	303,911	26.2704	23.1310
2085	588.92	675,560.16	131,067	375,722	34.1236	30.0457
2090	669.57	812,158.51	161,175	463,784	44.3245	39.0276
Low-cost:						
2015	98.79	47,738.57	6,370	17,960	0.9801	0.9834
2016	100.00	49,447.98	6,685	18,843	1.0000	1.0161
2017	103.63	52,465.16	7,250	20,219	1.0322	1.0489
2018	107.03	55,650.39	7,809	21,655	1.0838	1.0839
2019	110.46	58,743.24	8,388	23,097	1.1411	1.1217
2020	113.99	61,849.15	8,976	24,560	1.2030	1.1623
2021	117.64	65,032.70	9,566	26,035	1.2706	1.2061
2022	121.40	68,392.20	10,172	27,550	1.3437	1.2536
2023	125.29	71,951.98	10,805	29,135	1.4252	1.3056
2024	129.30	75,746.74	11,479	30,806	1.5157	1.3633
2025	133.43	79,674.91	12,183	32,556	1.6142	1.4270
2030	156.19	102,353.16	16,031	42,912	2.2117	1.8798
2035	182.84	131,327.31	21,040	56,428	3.0306	2.5758
2040	214.02	167,921.92	27,797	74,581	4.1526	3.5295
2045	250.53	214,861.87	36,962	99,022	5.6901	4.8362
2050	293.26	275,323.92	49,138	131,321	7.7968	6.6268
2055	343.29	352,602.26	65,137	173,643	10.6834	9.0803
2060	401.84	451,078.57	86,155	229,200	14.6389	12.4421
2065	470.39	576,054.69	113,939	302,759	20.0588	17.0487
2070	550.62	734,521.01	150,927	400,758	27.4854	23.3609
2075	644.54	936,225.61	200,313	531,492	37.6616	32.0100
2080	754.48	1,192,904.72	265,851	705,051	51.6055	43.8615
2085	883.18	1,520,008.42	352,357	933,466	70.7119	60.1008
2090	1,033.82	1,937,676.32	466,117	1,232,721	96.8924	82.3525

Table VI.G6.—Selected Economic Variables, Calendar Years 2015-2090 (Cont.)
[GDP and taxable payroll in billions]

Calendar year	Adjusted CPI[a]	Average wage index	Taxable payroll[b]	Gross domestic product	Compound new-issue interest factor[c]	Compound effective trust-fund interest factor[d]
High-cost:						
2015	99.98	$47,686.76	$6,366	$17,943	0.9801	0.9834
2016	100.00	48,298.98	6,488	18,299	1.0000	1.0158
2017	102.44	49,518.62	6,617	18,757	1.0169	1.0469
2018	104.63	51,416.70	6,952	19,490	1.0404	1.0778
2019	106.72	53,305.83	7,241	20,275	1.0755	1.1091
2020	108.86	55,122.98	7,544	21,065	1.1151	1.1407
2021	111.03	56,973.96	7,845	21,862	1.1579	1.1724
2022	113.25	58,817.79	8,146	22,670	1.2039	1.2038
2023	115.52	60,655.65	8,447	23,483	1.2540	1.2349
2024	117.83	62,523.17	8,749	24,309	1.3079	1.2658
2025	120.19	64,321.07	9,042	25,140	1.3641	1.2964
2030	132.70	73,319.47	10,513	29,477	1.6791	1.5462
2035	146.51	83,570.21	12,159	34,409	2.0670	1.9034
2040	161.75	95,135.81	14,071	40,162	2.5445	2.3431
2045	178.59	108,367.47	16,302	46,875	3.1322	2.8843
2050	197.18	123,500.22	18,824	54,511	3.8557	3.5506
2055	217.70	140,558.33	21,645	63,148	4.7464	4.3707
2060	240.36	159,754.04	24,810	72,980	5.8428	5.3803
2065	265.38	181,290.58	28,370	84,250	7.1924	6.6231
2070	293.00	205,436.00	32,392	97,193	8.8538	8.1530
2075	323.49	232,710.81	36,967	112,090	10.8989	10.0363
2080	357.16	263,552.88	42,139	129,172	13.4165	12.3546
2085	394.33	298,548.17	48,028	148,733	16.5156	15.2084
2090	435.38	338,407.02	54,747	171,138	20.3306	18.7214

[a] CPI-W indexed to calendar year 2016.
[b] Total earnings subject to OASDI contribution rates, adjusted to reflect the lower effective contribution rates (compared to the combined employee-employer rate) that apply to multiple-employer "excess wages."
[c] For each alternative, incorporates the average of the assumed annual yield for special public-debt obligations issuable to the trust funds in the 12 months of the prior year.
[d] For each alternative, incorporates the annual effective yield for all outstanding special public-debt obligations held by the trust fund, with a half-year's interest effect in each row. The effective yield for a period equals total interest earned during the period divided by the total exposure to interest on asset reserves and all income and outgo items during the period. The reciprocals of the factors approximate the discounting/accumulation factors that are used to calculate summarized rates and balances in this report.

Table VI.G7 shows the operations of the combined OASI and DI Trust Funds in CPI-indexed 2016 dollars—that is, adjusted by the CPI indexing series as discussed above. The following items are presented in the table: (1) non-interest income, (2) interest income, (3) total income, (4) cost, and (5) asset reserves at the end of the year. Non-interest income consists of payroll tax contributions, income from taxation of benefits, and reimbursements from the General Fund of the Treasury, if any. Cost consists of scheduled benefits, administrative expenses, financial interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries. Table VI.G7 shows trust fund operations under the low-cost, intermediate, and high-cost sets of assumptions.

Table VI.G7.—Operations of the Combined OASI and DI Trust Funds, in CPI-indexed 2016 Dollars,[a] Calendar Years 2016-2090
[In billions]

Calendar year	Non-interest income	Interest income	Total income	Cost[b]	Asset reserves at end of year[b]
Intermediate:					
2016	$855.8	$88.8	$944.6	$928.9	$2,828.2
2017	884.6	85.2	969.8	939.6	2,782.5
2018	915.3	84.6	999.9	978.9	2,731.7
2019	943.7	84.1	1,027.8	1,017.9	2,672.4
2020	971.5	83.4	1,054.8	1,057.7	2,601.8
2021	998.5	81.7	1,080.2	1,095.8	2,520.2
2022	1,023.9	80.1	1,104.0	1,138.3	2,422.0
2023	1,046.8	78.7	1,125.5	1,183.1	2,303.1
2024	1,071.0	76.8	1,147.8	1,229.0	2,163.6
2025	1,093.3	74.0	1,167.3	1,274.6	2,001.4
2030[c]	1,194.6	57.8	1,252.4	1,459.4	973.3
Low-cost:					
2016	861.6	89.7	951.4	926.3	2,837.5
2017	902.0	89.3	991.3	931.3	2,798.2
2018	943.1	92.5	1,035.6	968.8	2,776.0
2019	981.8	95.8	1,077.6	1,004.6	2,763.0
2020	1,018.6	99.3	1,117.9	1,041.0	2,754.2
2021	1,053.3	102.7	1,156.0	1,075.8	2,749.0
2022	1,087.3	107.7	1,194.9	1,114.8	2,743.9
2023	1,120.5	114.0	1,234.4	1,156.3	2,737.0
2024	1,155.7	120.7	1,276.3	1,199.1	2,729.3
2025	1,189.4	127.1	1,316.5	1,242.0	2,719.2
2030	1,341.8	169.4	1,511.2	1,426.1	2,699.9
2035	1,506.1	167.9	1,674.0	1,596.8	2,669.1
2040	1,699.3	168.7	1,868.0	1,768.6	2,686.7
2045	1,928.1	182.3	2,110.4	1,951.9	2,927.4
2050	2,188.1	213.1	2,401.2	2,172.0	3,446.9
2055	2,478.1	259.0	2,737.1	2,450.1	4,197.8
2060	2,801.7	312.5	3,114.1	2,783.3	5,060.0
2065	3,166.3	372.3	3,538.6	3,153.5	6,028.2
2070	3,583.7	441.2	4,024.9	3,573.5	7,144.7
2075	4,062.3	524.5	4,586.8	4,027.5	8,510.6
2080	4,601.6	639.2	5,240.8	4,494.0	10,412.8
2085	5,208.5	796.3	6,004.7	5,060.2	12,992.2
2090	5,890.3	979.4	6,869.7	5,788.8	15,951.5
High-cost:					
2016	845.9	87.7	933.6	931.2	2,814.9
2017	838.1	80.8	918.9	946.0	2,720.6
2018	863.0	76.5	939.5	984.7	2,618.6
2019	883.6	72.3	955.9	1,027.6	2,495.5
2020	903.8	67.2	971.0	1,069.8	2,347.8
2021	923.5	60.9	984.4	1,110.1	2,176.1
2022	942.7	53.8	996.5	1,155.0	1,975.0
2023	960.6	46.7	1,007.3	1,202.0	1,741.5
2024	978.5	39.2	1,017.7	1,249.9	1,475.1
2025[c]	993.6	31.3	1,024.9	1,297.5	1,173.6

[a] CPI-indexed 2016 dollars equal current dollars adjusted by the CPI indexing series in table VI.G6.
[b] Benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.
[c] The combined OASI and DI Trust Funds become depleted in 2034 under the intermediate assumptions and in 2029 under the high-cost assumptions, so estimates for later years are not shown.

Note: Totals do not necessarily equal the sums of rounded components.

Figure VI.G1 compares annual cost with annual total income and annual non-interest income. The figure shows only the OASDI program under intermediate assumptions, and presents values in CPI-indexed 2016 dollars, consistent with table VI.G7. The difference between the income values for each year is equal to the trust fund interest earnings. The figure illustrates that, under intermediate assumptions: (1) annual cost exceeds non-interest income in each year of the projection period; (2) total annual income, which includes interest earnings on trust fund asset reserves, is sufficient to cover annual cost for years 2016 through 2019; and (3) total annual income is not sufficient to cover annual cost for years beginning in 2020. From 2020 through 2033 (the year preceding the year of trust fund reserve depletion), annual cost is covered by drawing down combined trust fund reserves.

Figure VI.G1.—Estimated OASDI Income and Cost in CPI-indexed 2016 Dollars, Based on Intermediate Assumptions
[In billions]

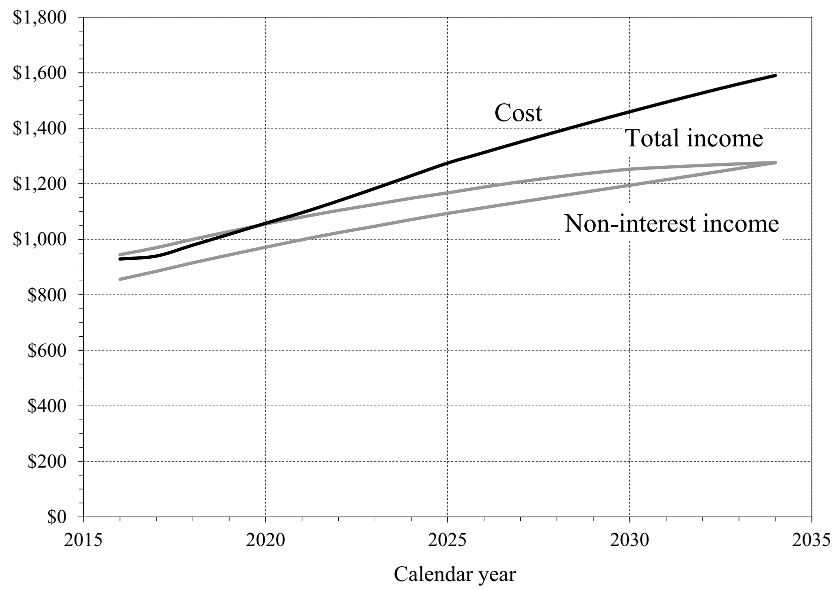

Table VI.G8 shows the operations of the combined OASI and DI Trust Funds in current, or nominal, dollars—that is, in dollars unadjusted for inflation. The following items are presented in the table: (1) non-interest income, (2) interest income, (3) total income, (4) cost, and (5) asset reserves at the end of the year. The Trustees present these estimates using the low-cost, intermediate, and high-cost sets of demographic and economic assumptions to facilitate independent analysis.

Table VI.G8.—Operations of the Combined OASI and DI Trust Funds, in Current Dollars, Calendar Years 2016-2090
[In billions]

Calendar year	Non-interest income	Interest income	Total income	Cost[a]	Asset reserves at end of year[a]
Intermediate:					
2016	$855.8	$88.8	$944.6	$928.9	$2,828.2
2017	909.1	87.6	996.6	965.5	2,859.3
2018	965.4	89.2	1,054.7	1,032.5	2,881.5
2019	1,021.3	91.1	1,112.4	1,101.6	2,892.2
2020	1,078.7	92.6	1,171.3	1,174.5	2,889.0
2021	1,137.5	93.1	1,230.6	1,248.4	2,871.2
2022	1,196.8	93.6	1,290.4	1,330.5	2,831.1
2023	1,255.4	94.4	1,349.8	1,418.8	2,762.1
2024	1,317.8	94.6	1,412.4	1,512.2	2,662.2
2025	1,380.2	93.5	1,473.7	1,609.2	2,526.7
2030[b]	1,714.7	83.0	1,797.7	2,094.8	1,397.0
Low-cost:					
2016	861.6	89.7	951.4	926.3	2,837.5
2017	934.8	92.5	1,027.3	965.1	2,899.7
2018	1,009.4	99.0	1,108.4	1,036.9	2,971.2
2019	1,084.5	105.8	1,190.2	1,109.6	3,051.9
2020	1,161.1	113.2	1,274.3	1,186.7	3,139.5
2021	1,239.1	120.8	1,359.9	1,265.5	3,233.9
2022	1,320.0	130.7	1,450.7	1,353.4	3,331.2
2023	1,403.8	142.8	1,546.6	1,448.7	3,429.1
2024	1,494.2	156.0	1,650.2	1,550.4	3,528.9
2025	1,587.1	169.6	1,756.7	1,657.3	3,628.3
2030	2,095.8	264.5	2,360.4	2,227.4	4,217.0
2035	2,753.7	307.1	3,060.8	2,919.5	4,880.1
2040	3,637.0	361.0	3,998.0	3,785.2	5,750.1
2045	4,830.6	456.7	5,287.2	4,890.1	7,334.1
2050	6,416.9	625.1	7,042.0	6,369.8	10,108.4
2055	8,506.9	889.3	9,396.2	8,410.8	14,410.4
2060	11,258.3	1,255.6	12,514.0	11,184.3	20,333.3
2065	14,893.9	1,751.2	16,645.1	14,833.6	28,355.8
2070	19,732.6	2,429.2	22,161.8	19,676.6	39,340.3
2075	26,183.3	3,380.7	29,564.0	25,959.1	54,854.5
2080	34,718.6	4,822.5	39,541.1	33,906.8	78,562.7
2085	46,000.0	7,032.6	53,032.6	44,690.8	114,744.4
2090	60,894.9	10,125.4	71,020.2	59,846.2	164,910.6
High-cost:					
2016	845.9	87.7	933.6	931.2	2,814.9
2017	858.5	82.8	941.3	969.2	2,787.1
2018	903.0	80.0	983.0	1,030.3	2,739.8
2019	943.0	77.2	1,020.2	1,096.7	2,663.3
2020	983.8	73.2	1,057.0	1,164.5	2,555.7
2021	1,025.3	67.7	1,093.0	1,232.6	2,416.2
2022	1,067.7	60.9	1,128.6	1,308.1	2,236.7
2023	1,109.7	53.9	1,163.6	1,388.6	2,011.8
2024	1,153.0	46.2	1,199.2	1,472.8	1,738.1
2025[b]	1,194.1	37.6	1,231.8	1,559.4	1,410.5

[a] Benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.

[b] The combined OASI and DI Trust Funds become depleted in 2034 under the intermediate assumptions and in 2029 under the high-cost assumptions, so estimates for later years are not shown.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.G9 shows values in CPI-indexed 2016 dollars—that is, adjusted by the CPI indexing series discussed at the beginning of this section. This table contains the annual non-interest income and cost of the combined OASI and DI Trust Funds, of the HI Trust Fund, and of the combined OASI, DI, and HI Trust Funds, based on the low-cost, intermediate, and high-cost sets of assumptions. For OASDI, non-interest income consists of payroll tax contributions, proceeds from taxation of OASDI benefits, and reimbursements from the General Fund of the Treasury, if any. Cost consists of scheduled benefits, administrative expenses, financial interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries. For HI, non-interest income consists of payroll tax contributions (including contributions from railroad employment), up to an additional 0.9 percent tax on earned income for relatively high earners, proceeds from the taxation of OASDI benefits, premium revenues, monies from fraud and abuse control activities, and reimbursements from the General Fund of the Treasury, if any. Total cost consists of outlays (scheduled benefits and administrative expenses) for beneficiaries. The Trustees show income and cost estimates generally on a cash basis for the OASDI program[1] and on an incurred basis for the HI program. Table VI.G9 also shows the balance, which equals the difference between non-interest income and cost.

[1] OASDI benefits paid for entitlement for a particular month are generally paid in the succeeding month. There are two primary exceptions to this general rule. First, payments can occur with a greater delay when a benefit award is made after the month of initial benefit entitlement. At the time of benefit award, benefits owed for months of prior entitlement are then also paid to the beneficiary. For the projections in this report, such retroactive payments are included in the period where they are paid (at time of award). Second, when benefit payments scheduled for January 3 are paid on the prior December 31, because January 3 falls on a Sunday, such payments are shown in this report for the period they were scheduled to be paid.

Table VI.G9.—OASDI and HI Annual Non-interest Income, Cost, and Balance in CPI-Indexed Dollars, Calendar Years 2016-2090
[In billions]

	OASDI			HI			Combined		
Calendar year	Non-interest income	Cost[a]	Balance[a]	Non-interest income	Cost	Balance	Non-interest income	Cost[a]	Balance[a]
Intermediate:									
2016	$856	$929	-$73	$281	$288	-$6	$1,137	$1,217	-$80
2017	885	940	-55	291	294	-3	1,176	1,234	-58
2018	915	979	-64	303	303	[b]	1,218	1,282	-64
2019	944	1,018	-74	314	314	-1	1,257	1,332	-75
2020	971	1,058	-86	324	328	-4	1,295	1,386	-90
2021	998	1,096	-97	334	342	-8	1,332	1,438	-105
2022	1,024	1,138	-114	343	357	-14	1,367	1,495	-128
2023	1,047	1,183	-136	352	372	-20	1,399	1,555	-156
2024	1,071	1,229	-158	361	386	-25	1,432	1,615	-183
2025	1,093	1,275	-181	370	399	-29	1,463	1,673	-210
2030	1,195	1,459	-265	413	483	-70	1,607	1,942	-335
2035	1,297	1,619	-322	456	563	-107	1,754	2,183	-429
2040	1,413	1,771	-359	505	639	-134	1,918	2,410	-493
2045	1,542	1,917	-375	559	712	-152	2,101	2,629	-527
2050	1,680	2,077	-397	619	776	-157	2,300	2,854	-554
2055	1,827	2,272	-444	685	838	-153	2,512	3,109	-597
2060	1,983	2,498	-515	756	908	-152	2,739	3,406	-667
2065	2,149	2,744	-595	833	993	-160	2,982	3,738	-755
2070	2,330	3,017	-687	917	1,094	-178	3,247	4,111	-865
2075	2,527	3,302	-775	1,007	1,204	-197	3,534	4,506	-972
2080	2,737	3,578	-841	1,103	1,311	-208	3,840	4,889	-1,049
2085	2,963	3,888	-924	1,206	1,418	-212	4,170	5,306	-1,136
2090	3,208	4,255	-1,047	1,319	1,534	-215	4,527	5,789	-1,261
Low-cost:									
2016	862	926	-65	284	283	1	1,145	1,210	-64
2017	902	931	-29	297	284	13	1,199	1,216	-17
2018	943	969	-26	311	290	21	1,254	1,259	-5
2019	982	1,005	-23	324	297	27	1,306	1,302	4
2020	1,019	1,041	-22	336	305	31	1,355	1,346	8
2021	1,053	1,076	-22	347	313	34	1,400	1,389	11
2022	1,087	1,115	-28	358	322	36	1,446	1,437	9
2023	1,120	1,156	-36	370	331	38	1,490	1,488	2
2024	1,156	1,199	-43	381	339	42	1,537	1,538	-1
2025	1,189	1,242	-53	393	346	47	1,583	1,588	-5
2030	1,342	1,426	-84	453	393	61	1,795	1,819	-24
2035	1,506	1,597	-91	520	429	91	2,026	2,025	[b]
2040	1,699	1,769	-69	599	457	142	2,298	2,225	73
2045	1,928	1,952	-24	692	482	210	2,620	2,434	187
2050	2,188	2,172	16	801	510	291	2,989	2,682	307
2055	2,478	2,450	28	924	546	379	3,403	2,996	407
2060	2,802	2,783	18	1,063	598	465	3,865	3,382	483
2065	3,166	3,153	13	1,220	678	542	4,386	3,831	555
2070	3,584	3,574	10	1,398	781	617	4,982	4,355	628
2075	4,062	4,028	35	1,602	900	702	5,664	4,928	737
2080	4,602	4,494	108	1,830	1,027	804	6,432	5,521	911
2085	5,208	5,060	148	2,089	1,162	927	7,297	6,222	1,075
2090	5,890	5,789	101	2,383	1,313	1,070	8,274	7,102	1,171

Table VI.G9.—OASDI and HI Annual Non-interest Income, Cost, and Balance in CPI-Indexed Dollars, Calendar Years 2016-2090 (Cont.)
[In billions]

	OASDI			HI			Combined		
Calendar year	Non-interest income	Cost[a]	Balance[a]	Non-interest income	Cost	Balance	Non-interest income	Cost[a]	Balance[a]
High-cost:									
2016	$846	$931	-$85	$276	$293	-$17	$1,122	$1,225	-$103
2017	838	946	-108	278	301	-23	1,116	1,247	-131
2018	863	985	-122	286	312	-26	1,149	1,297	-147
2019	884	1,028	-144	295	328	-32	1,179	1,355	-176
2020	904	1,070	-166	304	347	-43	1,208	1,417	-209
2021	923	1,110	-187	313	368	-55	1,236	1,478	-242
2022	943	1,155	-212	321	390	-69	1,264	1,545	-281
2023	961	1,202	-241	329	414	-85	1,290	1,616	-326
2024	978	1,250	-271	337	437	-99	1,316	1,687	-371
2025	994	1,297	-304	345	458	-113	1,339	1,756	-417
2030	1,054	1,479	-425	373	593	-220	1,427	2,072	-645
2035	1,109	1,627	-518	400	737	-337	1,509	2,364	-856
2040	1,166	1,761	-595	428	892	-464	1,594	2,653	-1,059
2045	1,226	1,875	-649	455	1,046	-591	1,681	2,921	-1,240
2050	1,284	1,985	-701	483	1,176	-693	1,767	3,161	-1,394
2055	1,340	2,110	-769	511	1,278	-768	1,851	3,388	-1,537
2060	1,395	2,249	-853	539	1,367	-828	1,935	3,615	-1,681
2065	1,449	2,394	-945	568	1,443	-875	2,017	3,837	-1,820
2070	1,504	2,552	-1,049	598	1,518	-920	2,101	4,070	-1,969
2075	1,559	2,710	-1,151	628	1,593	-964	2,187	4,303	-2,115
2080	1,613	2,849	-1,236	658	1,652	-994	2,271	4,501	-2,229
2085	1,668	2,986	-1,318	689	1,703	-1,014	2,356	4,689	-2,332
2090	1,725	3,130	-1,405	720	1,756	-1,036	2,445	4,885	-2,440

[a] OASDI benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.
[b] Between -$500 million and $500 million.

Note: Totals do not necessarily equal the sums of rounded components.

Table VI.G10 shows values in current, or nominal, dollars—that is, in dollars unadjusted for inflation. This table contains the annual non-interest income, cost, and balance of the combined OASI and DI Trust Funds, of the HI Trust Fund, and of the combined OASI, DI, and HI Trust Funds, based on the low-cost, intermediate, and high-cost sets of assumptions.

Table VI.G10.—OASDI and HI Annual Non-interest Income, Cost, and Balance in Current Dollars, Calendar Years 2016-2090
[In billions]

Calendar year	OASDI			HI			Combined		
	Non-interest income	Cost[a]	Balance[a]	Non-interest income	Cost	Balance	Non-interest income	Cost[a]	Balance[a]
Intermediate:									
2016	$856	$929	-$73	$281	$288	-$6	$1,137	$1,217	-$80
2017	909	966	-56	300	302	-3	1,209	1,268	-59
2018	965	1,033	-67	320	320	[b]	1,285	1,352	-67
2019	1,021	1,102	-80	339	340	-1	1,361	1,442	-81
2020	1,079	1,175	-96	360	364	-4	1,438	1,539	-100
2021	1,138	1,248	-111	380	390	-9	1,518	1,638	-120
2022	1,197	1,331	-134	401	417	-16	1,598	1,748	-150
2023	1,255	1,419	-163	422	446	-24	1,677	1,865	-187
2024	1,318	1,512	-194	444	475	-30	1,762	1,987	-225
2025	1,380	1,609	-229	467	503	-36	1,847	2,112	-265
2030	1,715	2,095	-380	592	693	-101	2,307	2,788	-481
2035	2,117	2,643	-526	744	919	-175	2,862	3,562	-700
2040	2,621	3,286	-665	937	1,186	-249	3,558	4,472	-914
2045	3,252	4,044	-791	1,180	1,501	-321	4,432	5,545	-1,112
2050	4,030	4,982	-952	1,485	1,862	-377	5,515	6,844	-1,329
2055	4,982	6,194	-1,212	1,868	2,285	-417	6,850	8,479	-1,629
2060	6,148	7,744	-1,597	2,344	2,814	-470	8,492	10,559	-2,067
2065	7,576	9,673	-2,097	2,936	3,501	-565	10,512	13,174	-2,662
2070	9,337	12,090	-2,753	3,673	4,386	-713	13,010	16,476	-3,466
2075	11,512	15,042	-3,530	4,589	5,488	-898	16,101	20,530	-4,429
2080	14,176	18,532	-4,356	5,714	6,793	-1,079	19,890	25,324	-5,434
2085	17,452	22,896	-5,444	7,105	8,354	-1,248	24,557	31,249	-6,692
2090	21,482	28,490	-7,008	8,831	10,269	-1,438	30,313	38,759	-8,446
Low-cost:									
2016	862	926	-65	284	283	1	1,145	1,210	-64
2017	935	965	-30	308	295	13	1,242	1,260	-17
2018	1,009	1,037	-28	333	311	22	1,343	1,348	-5
2019	1,084	1,110	-25	358	328	30	1,442	1,438	5
2020	1,161	1,187	-26	383	348	35	1,544	1,535	10
2021	1,239	1,266	-26	408	369	40	1,648	1,634	13
2022	1,320	1,353	-33	435	391	44	1,755	1,745	11
2023	1,404	1,449	-45	463	415	48	1,867	1,864	3
2024	1,494	1,550	-56	493	439	54	1,987	1,989	-2
2025	1,587	1,657	-70	525	462	63	2,112	2,119	-7
2030	2,096	2,227	-132	708	613	95	2,804	2,841	-37
2035	2,754	2,919	-166	950	784	166	3,704	3,703	1
2040	3,637	3,785	-148	1,281	977	304	4,918	4,762	156
2045	4,831	4,890	-60	1,735	1,207	527	6,565	6,097	468
2050	6,417	6,370	47	2,349	1,496	853	8,766	7,866	901
2055	8,507	8,411	96	3,174	1,873	1,300	11,680	10,284	1,396
2060	11,258	11,184	74	4,273	2,405	1,868	15,531	13,589	1,942
2065	14,894	14,834	60	5,738	3,187	2,550	20,631	18,021	2,610
2070	19,733	19,677	56	7,700	4,301	3,400	27,433	23,977	3,456
2075	26,183	25,959	224	10,326	5,802	4,524	36,509	31,761	4,749
2080	34,719	33,907	812	13,810	7,745	6,064	48,528	41,652	6,876
2085	46,000	44,691	1,309	18,447	10,263	8,184	64,447	54,954	9,493
2090	60,895	59,846	1,049	24,639	13,578	11,061	85,534	73,424	12,110

Table VI.G10.—OASDI and HI Annual Non-interest Income, Cost, and Balance in Current Dollars, Calendar Years 2016-2090 (Cont.)
[In billions]

Calendar year	OASDI			HI			Combined		
	Non-interest income	Cost[a]	Balance[a]	Non-interest income	Cost	Balance	Non-interest income	Cost[a]	Balance[a]
High-cost:									
2016	$846	$931	-$85	$276	$293	-$17	$1,122	$1,225	-$103
2017	859	969	-111	285	308	-23	1,143	1,277	-134
2018	903	1,030	-127	300	326	-27	1,203	1,357	-154
2019	943	1,097	-154	315	350	-35	1,258	1,447	-188
2020	984	1,165	-181	331	378	-47	1,315	1,542	-227
2021	1,025	1,233	-207	347	408	-61	1,373	1,641	-268
2022	1,068	1,308	-240	364	442	-78	1,432	1,750	-319
2023	1,110	1,389	-279	380	478	-98	1,490	1,867	-377
2024	1,153	1,473	-320	398	514	-117	1,551	1,987	-437
2025	1,194	1,559	-365	415	551	-136	1,609	2,110	-501
2030	1,398	1,962	-564	495	787	-292	1,893	2,749	-856
2035	1,625	2,384	-759	586	1,080	-494	2,210	3,464	-1,254
2040	1,887	2,848	-962	692	1,443	-751	2,578	4,291	-1,713
2045	2,189	3,348	-1,159	813	1,868	-1,055	3,003	5,217	-2,214
2050	2,532	3,914	-1,383	952	2,319	-1,366	3,484	6,233	-2,749
2055	2,918	4,593	-1,675	1,112	2,783	-1,671	4,030	7,376	-3,346
2060	3,354	5,405	-2,051	1,296	3,285	-1,989	4,650	8,690	-4,040
2065	3,846	6,353	-2,507	1,507	3,829	-2,322	5,354	10,183	-4,829
2070	4,406	7,478	-3,072	1,751	4,448	-2,696	6,157	11,926	-5,768
2075	5,043	8,766	-3,723	2,033	5,153	-3,120	7,076	13,918	-6,842
2080	5,760	10,174	-4,414	2,351	5,900	-3,549	8,112	16,075	-7,963
2085	6,577	11,775	-5,199	2,715	6,714	-3,999	9,292	18,490	-9,197
2090	7,510	13,626	-6,116	3,135	7,644	-4,509	10,645	21,270	-10,625

[a] OASDI benefit payments which were scheduled to be paid on January 3 for some past and future years were actually paid on December 31 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. For comparability with the values for historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment each year.
[b] Between -$500 million and $0.

Note: Totals do not necessarily equal the sums of rounded components.

H. ANALYSIS OF BENEFIT DISBURSEMENTS FROM THE OASI TRUST FUND WITH RESPECT TO DISABLED BENEFICIARIES

(Required by section 201(c) of the Social Security Act)

Effective January 1957, the OASI Trust Fund pays monthly benefits to disabled children aged 18 and over of retired and deceased workers if the disability began before age 18. The age by which disability must have begun was later changed to age 22. Effective February 1968, the OASI Trust Fund pays reduced monthly benefits to disabled widows and widowers at ages 50 and over. Effective January 1991, the requirements for the disability of the widow or widower were made less restrictive.

At the end of 2015, the OASI Trust Fund was providing monthly benefit payments to about 1,096,000 people because of their disabilities or the disabilities of children. This total includes approximately 25,000 mothers and fathers (wives or husbands under normal retirement age of retired-worker beneficiaries and widows or widowers of deceased insured workers) who met all other qualifying requirements and were receiving unreduced benefits solely because they had disabled-child beneficiaries (or disabled children aged 16 or 17) in their care. In calendar year 2015, the OASI Trust Fund paid a total of $10,736[1] million to the people described above. Table VI.H1 shows OASI scheduled benefits for disability for selected calendar years during 1960 through 2015 and estimates for 2016 through 2025 based on the intermediate set of assumptions.

[1] Benefit payments which were scheduled to be paid on January 3, 2016 were actually paid on December 31, 2015 as required by the statutory provision for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or public holiday. For comparability with the values for historical years and the projections in this report, all benefit amounts in this section reflect the 12 months of benefits scheduled for payment in each year.

Table VI.H1.—Scheduled Benefit Disbursements From the OASI Trust Fund With Respect to Disabled Beneficiaries
[Beneficiaries in thousands; scheduled benefits in millions]

Calendar year	Disabled beneficiaries, end of year			Amount of scheduled benefits[a b]		
	Total	Children[c]	Widows-widowers[d]	Total	Children[c]	Widows-widowers[e]
Historical data:						
1960	117	117	—	$59	$59	—
1965	214	214	—	134	134	—
1970	316	281	36	301	260	$41
1975	435	376	58	664	560	104
1980	519	460	59	1,223	1,097	126
1985	594	547	47	2,072	1,885	187
1990	662	613	49	2,882	2,649	233
1991	687	627	61	3,179	2,875	304
1992	715	643	72	3,459	3,079	380
1993	740	659	81	3,752	3,296	456
1994	758	671	86	3,973	3,481	492
1995	772	681	91	4,202	3,672	531
1996	782	687	94	4,410	3,846	565
1997	789	693	96	4,646	4,050	596
1998	797	698	99	4,838	4,210	627
1999	805	702	102	4,991	4,336	655
2000	811	707	104	5,203	4,523	680
2001	817	712	105	5,520	4,802	718
2002	823	717	106	5,773	5,024	749
2003	827	722	105	5,950	5,184	764
2004	828	723	105	6,099	5,316	781
2005	836	728	108	6,449	5,556	834
2006	840	732	108	6,720	5,852	864
2007	851	744	107	7,053	6,181	869
2008	922	813	109	7,688	6,776	908
2009	969	857	112	8,595	7,618	974
2010	996	879	117	8,858	7,848	1,008
2011	1,020	899	121	9,136	8,085	1,050
2012	1,045	920	125	9,698	8,595	1,102
2013	1,065	939	126	9,953	8,840	1,109
2014	1,079	954	125	10,326	9,217	1,108
2015	1,096	972	124	10,736	9,624	1,109

Table VI.H1.—Scheduled Benefit Disbursements From the OASI Trust Fund With Respect to Disabled Beneficiaries (Cont.)
[Beneficiaries in thousands; scheduled benefits in millions]

Calendar year	Disabled beneficiaries, end of year			Amount of scheduled benefits[a b]		
	Total	Children[c]	Widows-widowers[d]	Total	Children[c]	Widows-widowers[e]
Estimates under the intermediate assumptions:						
2016	1,113	991	121	$10,970	$9,881	$1,086
2017	1,128	1,010	118	11,220	10,162	1,055
2018	1,144	1,028	116	11,790	10,724	1,063
2019	1,159	1,046	113	12,343	11,272	1,066
2020	1,176	1,064	112	12,923	11,838	1,081
2021	1,193	1,081	112	13,544	12,430	1,110
2022	1,209	1,098	112	14,197	13,050	1,142
2023	1,226	1,114	112	14,881	13,701	1,175
2024	1,243	1,130	113	15,621	14,390	1,225
2025	1,260	1,146	114	16,383	15,110	1,268

[a] Beginning in 1966, includes payments for vocational rehabilitation services.
[b] Amounts for 2015 and 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015 as required by the statutory provision for early benefit payments when the normal delivery date is on a Saturday, Sunday, or public holiday. Such shifts in payments across calendar years occur periodically whenever January 3rd falls on a Sunday. In order to provide a consistent perspective on scheduled benefits over time, scheduled benefits in each year reflect the 12 months of benefits that are regularly scheduled for payment in that year.
[c] Also includes certain mothers and fathers (see text).
[d] In 1984 and later years, includes only disabled widows and widowers aged 50-59, because disabled widows and widowers age 60 and older are eligible for the same benefit as a nondisabled aged widow or widower. Therefore, they are not receiving benefits solely because of a disability.
[e] In 1983 and prior years, includes the offsetting effect of lower benefits payable to disabled widows and widowers who continued to receive benefits after attaining age 60 (62, for disabled widowers prior to 1973), compared to the higher nondisabled widow's and widower's benefits that would otherwise be payable. In 1984 and later years, includes only scheduled benefits to disabled widows and widowers aged 50-59 (see footnote d).

Note: Totals do not necessarily equal the sums of rounded components.

Under the intermediate assumptions, estimated total scheduled benefits from the OASI Trust Fund with respect to disabled beneficiaries will increase from $10,970 million in calendar year 2016 to $16,383 million in calendar year 2025.

In calendar year 2015, benefit payments (including expenditures for vocational rehabilitation services) with respect to disabled persons from the OASI Trust Fund and from the DI Trust Fund (including payments from the DI fund to all children and spouses of disabled-worker beneficiaries) totaled $154,124 million. Of this amount, $10,736 million, or 7.0 percent, represented payments from the OASI Trust Fund. Table VI.H2 contains these and similar figures for selected calendar years during 1960 through 2015 and estimates for calendar years 2016 through 2025.

Table VI.H2.—Scheduled Benefit Disbursements[a] Under the OASDI Program With Respect to Disabled Beneficiaries
[Amounts in millions]

Calendar year	Total[b]	DI Trust Fund[c]	OASI Trust Fund	
			Amount[d]	Percentage of total
Historical data:				
1960	$627	$568	$59	9.4
1965	1,707	1,573	134	7.9
1970	3,386	3,085	301	8.9
1975	9,169	8,505	664	7.2
1980	16,738	15,515	1,223	7.3
1985	20,908	18,836	2,072	9.9
1990	27,717	24,835	2,882	10.4
1991	30,877	27,698	3,179	10.3
1992	34,583	31,124	3,459	10.0
1993	38,378	34,626	3,752	9.8
1994	41,730	37,757	3,973	9.5
1995	45,140	40,937	4,202	9.3
1996	48,615	44,205	4,410	9.1
1997	50,358	45,712	4,646	9.2
1998	53,062	48,224	4,838	9.1
1999	56,390	51,399	4,991	8.9
2000	60,204	55,001	5,203	8.6
2001	65,157	59,637	5,520	8.5
2002	71,493	65,721	5,773	8.1
2003	76,902	70,952	5,950	7.7
2004	84,350	78,251	6,099	7.2
2005	91,835	85,386	6,449	7.0
2006	99,165	92,446	6,720	6.8
2007	106,200	99,147	7,053	6.6
2008	114,064	106,376	7,688	6.7
2009	127,002	118,407	8,595	6.8
2010	133,103	124,245	8,858	6.7
2011	138,115	128,979	9,136	6.6
2012	146,623	136,925	9,698	6.6
2013	150,108	140,155	9,953	6.6
2014	152,031	141,705	10,326	6.8
2015	154,124	143,388	10,736	7.0
Estimates under the intermediate assumptions:				
2016	157,679	146,709	10,970	7.0
2017	160,598	149,378	11,220	7.0
2018	167,864	156,074	11,790	7.0
2019	174,860	162,517	12,343	7.1
2020	181,682	168,759	12,923	7.1
2021	189,761	176,217	13,544	7.1
2022	198,324	184,127	14,197	7.2
2023	207,097	192,215	14,881	7.2
2024	215,864	200,243	15,621	7.2
2025	225,221	208,838	16,383	7.3

[a] Amounts for 2015 and 2016 are adjusted to include in 2016 operations those benefit payments regularly scheduled in the law to be paid on January 3, 2016, which were actually paid on December 31, 2015 as required by the statutory provision for early benefit payments when the normal delivery date is on a Saturday, Sunday, or public holiday. Such shifts in payments across calendar years occur periodically whenever January 3rd falls on a Sunday. In order to provide a consistent perspective on scheduled benefits over time, scheduled benefits in each year reflect the 12 months of benefits that are regularly scheduled for payment in that year.
[b] Beginning in 1966, includes payments for vocational rehabilitation services.
[c] Scheduled benefits for disabled workers and their children and spouses.
[d] Scheduled benefits for disabled children aged 18 and over, for certain mothers and fathers (see text), and for disabled widows and widowers (see footnote e, table VI.H1).

Note: Totals do not necessarily equal the sums of rounded components.

I. GLOSSARY

Actuarial balance. The difference between the summarized income rate and the summarized cost rate as a percentage of taxable payroll over a given valuation period.

Actuarial deficit. A negative actuarial balance.

Administrative expenses. Expenses incurred by the Social Security Administration and the Department of the Treasury in administering the OASDI program and the provisions of the Internal Revenue Code relating to the collection of contributions. Such administrative expenses are paid from the OASI and DI Trust Funds.

Advance tax transfers. Amounts representing the estimated total OASDI tax contributions for a given month. From May 1983 through November 1990, such amounts were credited to the OASI and DI Trust Funds at the beginning of each month. The trust funds reimbursed the General Fund of the Treasury for the associated loss of interest. Advance tax transfers are no longer made unless needed in order to pay benefits.

Alternatives I, II, or III. See "Assumptions."

Annual balance. The difference between the income rate and the cost rate for a given year.

Asset reserves. Treasury notes and bonds, other securities guaranteed by the Federal Government, certain Federally sponsored agency obligations, and cash, held by the trust funds for investment purposes.

Assumptions. Values related to future trends in key factors that affect the trust funds. Demographic assumptions include fertility, mortality, net immigration, marriage, and divorce. Economic assumptions include unemployment rates, average earnings, inflation, interest rates, and productivity. Program-specific assumptions include retirement patterns, and disability incidence and termination rates. This report presents three sets of demographic, economic, and program-specific assumptions:

- Alternative II is the intermediate set of assumptions, and represents the Trustees' best estimates of likely future demographic, economic, and program-specific conditions.
- Alternative I is a low-cost set of assumptions—it assumes relatively rapid economic growth, high inflation, and favorable (from the standpoint of program financing) demographic and program-specific conditions.
- Alternative III is a high-cost set of assumptions—it assumes relatively slow economic growth, low inflation, and unfavorable (from the standpoint of program financing) demographic and program-specific conditions.

See tables V.A2, V.B1, and V.B2.

Automatic cost-of-living benefit increase. The annual increase in benefits, effective for December, reflecting the increase, if any, in the cost of living. A benefit increase is applicable only after a beneficiary becomes eligible for benefits. In general, the benefit increase equals the percentage increase in the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) measured from the third quarter of the previous year to the third quarter of the current year. If there is no increase in the CPI-W, there is no cost-of-living benefit increase. See table V.C1.

Auxiliary benefits. Monthly benefits payable to a spouse or child of a retired or disabled worker, or to a survivor of a deceased worker.

Average indexed monthly earnings—AIME. The measure of lifetime earnings used in determining the primary insurance amount (PIA) for most workers who attain age 62, become disabled, or die after 1978. A worker's actual past earnings are adjusted by changes in the average wage index, in order to bring them up to their approximately equivalent value at the time of retirement or other eligibility for benefits.

Average wage index—AWI. A series that generally increases with the average amount of total wages for each year after 1950, including wages in noncovered employment and wages in covered employment in excess of the OASDI contribution and benefit base. (See Title 20, Chapter III, section 404.211(c) of the Code of Federal Regulations for a more precise definition.) These average wage amounts are used to index the taxable earnings of most workers first becoming eligible for benefits in 1979 or later, and for automatic adjustments in the contribution and benefit base, bend points, earnings test exempt amounts, and other wage-indexed amounts. See table V.C1.

Award. An administrative determination that an individual is entitled to receive a specified type of OASDI benefit. Awards can represent not only new entrants to the benefit rolls but also persons already on the rolls who become entitled to a different type of benefit. Awards usually result in the immediate payment of benefits, although payments may be deferred or withheld depending on the individual's particular circumstances.

Baby boom. The period from the end of World War II (1946) through 1965 marked by unusually high birth rates.

Bend points. The dollar amounts defining the AIME or PIA brackets in the benefit formulas. For the bend points for years 1979 and later, see table V.C2.

Beneficiary. A person who has been awarded benefits on the basis of his or her own or another's earnings record. The benefits may be either in current-payment status or withheld.

Benefit award. See "Award."

Benefit conversion. See "Disability conversion."

Benefit payments. The amounts disbursed for OASI and DI benefits by the Department of the Treasury.

Benefit termination. See "Termination."

Best estimate assumptions. See "Assumptions."

Board. See "Board of Trustees."

Board of Trustees. A Board established by the Social Security Act to oversee the financial operations of the Federal Old-Age and Survivors Insurance Trust Fund and the Federal Disability Insurance Trust Fund. The Board is composed of six members. Four members serve by virtue of their positions in the Federal Government: the Secretary of the Treasury, who is the Managing Trustee; the Secretary of Labor; the Secretary of Health and Human Services; and the Commissioner of Social Security. The President appoints and the Senate confirms the other two members to serve as public representatives. Also referred to as the "Board" or the "Trustees."

Cash flow. Actual or projected revenue and costs reflecting the levels of payroll tax contribution rates and benefits scheduled in the law. Net cash flow is the difference between non-interest income and cost.

Consumer Price Index—CPI. An official measure of inflation in consumer prices. In this report, CPI refers to the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W). The Bureau of Labor Statistics, Department of Labor, publishes historical values for the CPI-W.

Contribution and benefit base. Annual dollar amount above which earnings in employment covered under the OASDI program are neither taxable nor creditable for benefit-computation purposes. (Also referred to as maximum contribution and benefit base, annual creditable maximum, taxable maximum, and maximum taxable.) See tables V.C1 and V.C6. See "Hospital Insurance (HI) contribution base."

Contributions. See "Payroll tax contributions."

Conversion. See "Disability conversion."

Cost. The cost shown for a year includes benefits scheduled for payment in the year, administrative expenses, financial interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries.

Cost-of-living adjustment. See "Automatic cost-of-living benefit increase."

Cost rate. The cost rate for a year is the ratio of the cost of the program to the taxable payroll for the year.

Covered earnings. Wages or earnings from self-employment covered by the OASDI program.

Covered employment. All employment for which earnings are creditable for Social Security purposes. The program covers almost all employment. Some exceptions are:

- State and local government employees whose employer has not elected to be covered under Social Security and who are participating in an employer-provided pension plan.
- Current Federal civilian workers hired before 1984 who have not elected to be covered.
- Self-employed workers earning less than $400 in a calendar year.

Covered worker. A person who has earnings creditable for Social Security purposes based on services for wages in covered employment or income from covered self-employment.

CPI-indexed dollars. Amounts adjusted by the CPI to the value of the dollar in a particular year.

Creditable earnings. Wages or self-employment earnings posted to a worker's earnings record. Such earnings determine eligibility for benefits and the amount of benefits on that worker's record. The contribution and benefit base is the maximum amount of creditable earnings for each worker in a calendar year.

Current-cost financing. See "Pay-as-you-go financing."

Current dollars. Amounts expressed in nominal dollars with no adjustment for inflation.

Currently insured status. A worker acquires currently insured status when he or she has accumulated six quarters of coverage during the 13-quarter period ending with the current quarter.

Current-payment status. Status of a beneficiary to whom a benefit is being paid for a given month (with or without deductions, provided the deductions add to less than a full month's benefit).

Deemed filing. Under certain circumstances, a person applying for or receiving either an aged-spouse benefit or a retired-worker benefit is required to also file for the other of these two types of benefits. For those first eligible for benefits before 2016, this requirement applies to any person under normal retirement age who is eligible for the other benefit as of the starting month for the first benefit. For those first eligible for benefits in 2016 and later, this requirement applies whenever the person is eligible for the other benefit. This can occur at any age, and in months after the starting month of the first benefit.

Deemed wage credit. See "Military service wage credits."

Delayed retirement credits. Increases in the benefit amount for certain individuals who did not receive benefits for months after attaining normal retirement age but before age 70. Delayed retirement credits apply to benefits for

January of the year following the year they are earned or for the month of attainment of age 70, whichever comes first. See table V.C3.

Demographic assumptions. See “Assumptions.”

Disability. For Social Security purposes, the inability to engage in substantial gainful activity (see “Substantial gainful activity—SGA”) by reason of any medically determinable physical or mental impairment that can be expected to result in death or to last for a continuous period of not less than 12 months. Special rules apply for workers at ages 55 and over whose disability is based on blindness.

The law generally requires that a person be disabled continuously for 5 months before he or she can qualify for a disabled-worker benefit.

Disability conversion ratio. For a given year, the ratio of the number of disability conversions to the average number of disabled-worker beneficiaries at all ages during the year.

Disability conversion. Upon attainment of normal retirement age, a disabled-worker beneficiary is automatically converted to retired-worker status.

Disability incidence rate. The proportion of workers in a given year, insured for but not receiving disability benefits, who apply for and are awarded disability benefits.

Disability Insurance (DI) Trust Fund. See “Trust fund.”

Disability insured status. A worker acquires disability insured status if he or she is: (1) a fully insured worker who has accumulated 20 quarters of coverage during the 40-quarter period ending with the current quarter, (2) a fully insured worker aged 24-30 who has accumulated quarters of coverage during one-half of the quarters elapsed after the quarter of attainment of age 21 and up to and including the current quarter, or (3) a fully insured worker under age 24 who has accumulated six quarters of coverage during the 12-quarter period ending with the current quarter.

Disability prevalence rate. The proportion of persons insured for disability benefits who are disabled-worker beneficiaries in current-payment status.

Disability termination rate. The proportion of disabled-worker beneficiaries in a given year whose disability benefits terminate as a result of their recovery or death.

Disabled-worker benefit. A monthly benefit payable to a disabled worker under normal retirement age and insured for disability. Before November 1960, disability benefits were limited to disabled workers aged 50-64.

Disbursements. Actual expenditures (outgo) made or expected to be made under current law, including benefits paid or payable, administrative expenses, financial interchange with the Railroad Retirement program, and payments for vocational rehabilitation services for disabled beneficiaries.

Earnings. Unless otherwise qualified, all wages from employment and net earnings from self-employment, whether or not they are taxable or covered.

Earnings test. The provision requiring the withholding of benefits if beneficiaries under normal retirement age have earnings in excess of certain exempt amounts. See table V.C1.

Economic assumptions. See "Assumptions."

Effective interest rate. See "Interest rate."

Excess wages. Wages in excess of the contribution and benefit base on which a worker initially makes payroll tax contributions, usually as a result of working for more than one employer during a year. Employee payroll taxes on excess wages are refundable to affected employees, while the employer taxes are not refundable.

Expenditures. See "Disbursements."

Federal Insurance Contributions Act—FICA. Provision authorizing payroll taxes on the wages of employed persons to provide for Old-Age, Survivors, and Disability Insurance, and for Hospital Insurance. Workers and their employers generally pay the tax in equal amounts.

File and suspend. The ability to apply for a retired-worker benefit at or after normal retirement age, then voluntarily suspend it, allowing the worker to earn delayed retirement credits and a spouse or child to receive benefits on the worker's record. Voluntary suspensions which are requested after April 29, 2016 will no longer allow spouses (other than divorced spouses) and children to receive benefits while the worker's benefit is suspended.

Financial interchange. Provisions of the Railroad Retirement Act providing for transfers between the trust funds and the Social Security Equivalent Benefit Account of the Railroad Retirement program in order to place each trust fund in the same financial position it would have been had railroad employment always been covered under Social Security.

Fiscal year. The accounting year of the United States Government. A fiscal year is the 12-month period ending September 30. For example, fiscal year 2016 began October 1, 2015, and will end September 30, 2016.

Full advance funding. A financing method in which contributions are established to match the full cost of future benefits as these costs are incurred through current service. Such financing methods also provide for amortization over a fixed period of any financial obligation that is incurred at the beginning of the program (or subsequent modification) as a result of granting credit for past service.

Fully insured status. A worker acquires fully insured status when his or her total number of quarters of coverage is greater than or equal to the number of years elapsed after the year of attainment of age 21 (but not less than six).

Once a worker has accumulated 40 quarters of coverage, he or she remains permanently fully insured.

General Fund of the Treasury. Funds held by the Treasury of the United States, other than receipts collected for a specific purpose (such as Social Security), and maintained in a separate account for that purpose.

General Fund reimbursements. Payments from the General Fund of the Treasury to the trust funds for specific purposes defined in the law, including:

- The cost of noncontributory wage credits for military service before 1957, and periodic adjustments of previous determinations.
- The cost in 1971-82 of deemed wage credits for military service performed after 1956.
- The cost of benefits to certain uninsured persons who attained age 72 before 1968.
- The cost of payroll tax credits provided to employees in 1984 and self-employed persons in 1984-89 by Public Law 98-21.
- The cost in 2009-17 of excluding certain self-employment earnings from SECA taxes under Public Law 110-246.
- Payroll tax revenue forgone under the provisions of Public Laws 111-147, 111-312, 112-78, and 112-96.

The General Fund also reimburses the trust funds for various other items, including interest on checks which are not negotiated 6 months after the month of issue and costs incurred in performing certain legislatively mandated activities not directly related to administering the OASI and DI programs.

Gross domestic product—GDP. The total dollar value of all goods and services produced by labor and property located in the United States, regardless of who supplies the labor or property.

Hospital Insurance (HI) contribution base. Annual dollar amount above which earnings in employment covered under the HI program are not taxable. (Also referred to as maximum contribution base, taxable maximum, and maximum taxable.) Beginning in 1994, the HI contribution base was eliminated.

High-cost assumptions. See “Assumptions.”

Hospital Insurance (HI) Trust Fund. See “Trust fund.”

Immigration. See “Legal immigration” and “Other immigration.”

Income. Income for a given year is the sum of tax revenue on a cash basis (payroll tax contributions and income from the taxation of scheduled benefits), reimbursements from the General Fund of the Treasury, if any, and interest credited to the trust funds.

Income rate. Ratio of non-interest income to the OASDI taxable payroll for the year.

Infinite horizon. The period extending indefinitely into the future.

Inflation. An increase in the general price level of goods and services.

Insured status. The state or condition of having sufficient quarters of coverage to meet the eligibility requirements for retired-worker or disabled-worker benefits, or to permit the worker's spouse and children or survivors to establish eligibility for benefits in the event of his or her disability, retirement, or death. See "Quarters of coverage."

Interest. A payment in exchange for the use of money during a specified period.

Interest rate. Interest rates on new public-debt obligations issuable to Federal trust funds (see "Special public-debt obligation") are determined monthly. Such rates are equal to the average market yield on all outstanding marketable U.S. securities not due or callable until after 4 years from the date the rate is determined. See table V.B2 for historical and assumed future interest rates on new special-issue securities. The effective interest rate for a trust fund is the ratio of the interest earned by the fund over a given period of time to the average level of asset reserves held by the fund during the period. The effective rate of interest thus represents a measure of the overall average interest earnings on the fund's portfolio of investments.

Interfund borrowing. The borrowing of asset reserves by a trust fund (OASI, DI, or HI) from another trust fund when the first fund is in danger of depletion. The Social Security Act permitted interfund borrowing only during 1982 through 1987, and required all amounts borrowed to be repaid prior to the end of 1989. The only exercise of this authority occurred in 1982, when the OASI Trust Fund borrowed from the DI and HI Trust Funds. The final repayment of borrowed amounts occurred in 1986.

Intermediate assumptions. See "Assumptions."

Legal emigration. Legal emigration for a given year consists of those legal permanent residents and native-born citizens who leave the Social Security area during the year.

Legal immigration. Consistent with the definition used by the Department of Homeland Security, legal immigration for a given year consists of foreign-born individuals who are granted legal permanent resident status during the year.

Life expectancy. Average remaining number of years expected prior to death. Period life expectancy is calculated for a given year using the actual or expected death rates at each age for that year. Cohort life expectancy, sometimes referred to as generational life expectancy, is calculated for individuals at a specific age in a given year using actual or expected death rates from the years in which the individuals would actually reach each succeeding age if they survive.

Long-range. The next 75 years. The Trustees make long-range actuarial estimates for this period because it covers approximately the maximum remaining lifetime for virtually all current Social Security participants.

Low-cost assumptions. See "Assumptions."

Lump-sum death payment. A lump sum, generally $255, payable on the death of a fully or currently insured worker. The lump sum is payable to the surviving spouse of the worker, under most circumstances, or to the worker's children.

Maximum family benefit. The maximum monthly amount that can be paid on a worker's earnings record. Whenever the total of the individual monthly benefits payable to all the beneficiaries entitled on one earnings record exceeds the maximum, each dependent's or survivor's benefit is proportionately reduced. Benefits payable to divorced spouses or surviving divorced spouses are not reduced under the family maximum provision.

Medicare. A nationwide, Federally administered health insurance program authorized in 1965 under Title XVIII of the Social Security Act to cover the cost of hospitalization, medical care, and some related services for most people age 65 and over. In 1972, lawmakers extended coverage to people receiving Social Security Disability Insurance payments for 2 years and people with End-Stage Renal Disease. (For beneficiaries whose primary or secondary diagnosis is Amyotrophic Lateral Sclerosis, the 2-year waiting period is waived.) In 2010, people exposed to environmental health hazards within areas under a corresponding emergency declaration became Medicare-eligible. In 2006, prescription drug coverage was added as well. Medicare consists of two separate but coordinated trust funds—Hospital Insurance (HI, Part A) and Supplementary Medical Insurance (SMI). The SMI trust fund is composed of two separate accounts—the Part B account and the Part D account. Almost all persons who are aged 65 and over or disabled and who are entitled to HI are eligible to enroll in Part B and Part D on a voluntary basis by paying monthly premiums.

Military service wage credits. Credits toward OASDI earnings records for benefit computation purposes, recognizing that military personnel receive non-wage compensation (such as food and shelter) in addition to their basic pay and other cash payments. Military personnel do not pay payroll taxes on these credits. Noncontributory wage credits of $160 were provided for each month of active military service from September 16, 1940, through December 31, 1956. For years after 1956, the basic pay of military personnel is covered under the Social Security program on a contributory basis. In addition to the contributory credits for basic pay, noncontributory wage credits of $300 were granted for each calendar quarter, from January 1957 through December 1977, in which a person received pay for military service. Noncontributory wage credits of $100 were granted for each $300 of military wages, up to a maximum credit of $1,200 per calendar year, from January 1978 through December 2001.

National average wage index—AWI. See “Average wage index—AWI.”

Non-interest income. Non-interest income for a given year is the sum of tax revenue on a cash basis (payroll tax contributions and income from the taxation of scheduled benefits) and reimbursements from the General Fund of the Treasury, if any.

Normal retirement age—NRA. The age at which a person may first become entitled to retirement benefits without reduction based on age. For persons reaching age 62 before 2000, the normal retirement age is 65. It will increase gradually to 67 for persons reaching that age in 2027 or later, beginning with an increase to 65 years and 2 months for persons reaching age 65 in 2003. See table V.C3.

Old-Age and Survivors Insurance (OASI) Trust Fund. See “Trust fund.”

Old-law base. Amount the contribution and benefit base would have been if the 1977 amendments had not provided for ad hoc increases. The Social Security Amendments of 1972 provided for automatic annual indexing of the contribution and benefit base. The Social Security Amendments of 1977 specified ad hoc bases for 1978-81, with subsequent bases updated in accordance with the normal indexing procedure. See table V.C2.

Open group unfunded obligation. See “Unfunded obligation.”

Other emigration. Other emigration for a given year consists of individuals from the other-immigrant population who leave the Social Security area during the year or who adjust status to become legal permanent residents during the year.

Other immigration. Other immigration for a given year consists of individuals who enter the Social Security area and stay 6 months or more but without legal permanent resident status, such as undocumented immigrants and temporary workers and students.

Outgo. See “Disbursements.”

Par value. The value printed on the face of a bond. For both public and special issues held by the trust funds, par value is also the redemption value at maturity.

Partial advance funding. A financing method in which contributions are established to provide a substantial accumulation of trust fund asset reserves, thereby generating additional interest income to the trust funds and reducing the need for payroll tax increases in periods when costs are relatively high. Higher general contributions or additional borrowing may be required, however, to support the payment of such interest. While substantial, the trust fund buildup under partial advance funding is much smaller than it would be with full advance funding.

Pay-as-you-go financing. A financing method in which contributions are established to produce just as much income as required to pay current benefits, with trust fund asset reserves built up only to the extent needed to prevent depletion of the fund by random economic fluctuations.

Payment cycling. Beneficiaries who applied for benefits before May 1, 1997, are scheduled to be paid on the third of the month. Persons applying for OASDI benefits after April 1997 generally are scheduled to be paid on the second, third, or fourth Wednesday of the month following the month for which payment is due. The particular Wednesday payment date is based on the earner's date of birth. For those born on the first through tenth, the scheduled benefit payment day is the second Wednesday of the month; for those born on the eleventh through the twentieth, the scheduled benefit payment day is the third Wednesday of the month; and for those born after the twentieth of the month, the scheduled payment day is the fourth Wednesday of the month.

Payroll tax contributions. The amount based on a percent of earnings, up to an annual maximum, that must be paid by:

- employers and employees on wages from employment under the Federal Insurance Contributions Act,
- the self-employed on net earnings from self-employment under the Self-Employment Contributions Act, and
- States on the wages of State and local government employees covered under the Social Security Act through voluntary agreements under section 218 of the act.

Also referred to as payroll taxes.

Population in the Social Security area. See "Social Security area population."

Present value. The equivalent value, at the present time, of a stream of values (either income or cost, past or future). Present values are used widely in calculations involving financial transactions over long periods of time to account for the time value of money, by discounting or accumulating these transactions at the rate of interest. Present-value calculations for this report use the effective yield on trust fund asset reserves.

Primary insurance amount—PIA. The monthly amount payable to a retired worker who begins to receive benefits at normal retirement age or, generally, to a disabled worker. This amount, which is typically related to the worker's average monthly wage or average indexed monthly earnings, is also used as a base for computing all types of benefits payable on an individual's earnings record.

Primary-insurance-amount formula. The mathematical formula relating the PIA to the AIME for workers who attain age 62, become disabled, or die after 1978. The PIA is equal to the sum of 90 percent of AIME up to the first bend point, plus 32 percent of AIME above the first bend point up to the second bend point, plus 15 percent of AIME in excess of the second bend point. Automatic benefit increases are applied beginning with the year of eligibility. See table V.C2 for historical and assumed future bend points and table V.C1 for historical and assumed future benefit increases.

Quarters of coverage. Basic unit of measurement for determining insured status. In 2016, a worker receives one quarter of coverage (up to a total of four) for each $1,260 of annual covered earnings. For years after 1978, the amount of earnings required for a quarter of coverage is subject to annual automatic increases in proportion to increases in average wages. See table V.C2.

Railroad Retirement. A Federal insurance program, similar to Social Security, designed for workers in the railroad industry. The provisions of the Railroad Retirement Act provide for a system of coordination and financial interchange between the Railroad Retirement program and the Social Security program.

Reallocation of payroll tax rates. An increase in the payroll tax rate for either the OASI or DI Trust Fund, with a corresponding reduction in the rate for the other fund, so that the total OASDI payroll tax rate is not changed.

Real-wage differential. The difference between the percentage increases in: (1) the average annual wage in covered employment and (2) the average annual Consumer Price Index. See table V.B1.

Recession. A period of adverse economic conditions; in particular, two or more successive calendar quarters of negative growth in gross domestic product.

Reserves. See "Asset reserves."

Retired-worker benefit. A monthly benefit payable to a fully insured retired worker aged 62 or older or to a person entitled under the transitionally insured status provision in the law.

Retirement earnings test. See "Earnings test."

Retirement eligibility age. The age, currently age 62, at which a fully insured individual first becomes eligible to receive retired-worker benefits.

Retirement test. See "Earnings test."

Scheduled benefits. The level of benefits specified under current law.

Scenario-based model. A model with specified assumptions for and relationships among variables. Under such a model, any specified set of assumptions determines a single outcome directly reflecting the specifications.

Self-employment. Operation of a trade or business by an individual or by a partnership in which an individual is a member.

Self-Employment Contributions Act–SECA. Provision authorizing Social Security payroll taxes on the net earnings of most self-employed persons.

Short-range. The next 10 years. The Trustees prepare short-range actuarial estimates for this period because of the test of short-range financial adequacy. The Social Security Act requires estimates for 5 years; the Trustees prepare estimates for an additional 5 years to help clarify trends which are only starting to develop in the mandated first 5-year period.

Social Security Act. Provisions of the law governing most operations of the Social Security program. The original Social Security Act is Public Law 74-271, enacted August 14, 1935. With subsequent amendments, the Social Security Act consists of 21 titles, of which three have been repealed. Title II of the Social Security Act authorized the Old-Age, Survivors, and Disability Insurance program.

Social Security area population. The population comprised of: (1) residents of the 50 States and the District of Columbia (adjusted for net census undercount); (2) civilian residents of Puerto Rico, the Virgin Islands, Guam, American Samoa and the Northern Mariana Islands; (3) Federal civilian employees and persons in the U.S. Armed Forces abroad and their dependents; (4) non-citizens living abroad who are insured for Social Security benefits; and (5) all other U.S. citizens abroad.

Solvency. A program is solvent at a point in time if it is able to pay scheduled benefits when due with scheduled financing. For example, the OASDI program is solvent over any period for which the trust funds maintain a positive level of asset reserves.

Special public-debt obligation. Securities of the United States Government issued exclusively to the OASI, DI, HI, and SMI Trust Funds and other Federal trust funds. Section 201(d) of the Social Security Act provides that the public-debt obligations issued for purchase by the OASI and DI Trust Funds shall have maturities fixed with due regard for the needs of the funds. The usual practice has been to spread the holdings of special issues, as of each June 30, so that the amounts maturing in each of the next 15 years are approximately equal. Special public-debt obligations are redeemable at par value at any time and carry interest rates determined by law (see “Interest rate”). See tables VI.A4 and VI.A5 for a listing of the obligations held by the OASI and DI Trust Funds, respectively.

Statutory blindness. Central visual acuity of 20/200 or less in the better eye with the use of a correcting lens or tunnel vision of 20 degrees or less.

Stochastic model. A model used for projecting a probability distribution of potential outcomes. Such models allow for random variation in one or more variables through time. The random variation is generally based on fluctuations observed in historical data for a selected period. A large number of simulations, each of which reflects random variation in the variable(s), produce a distribution of potential outcomes.

Substantial gainful activity—SGA. The level of work activity used to establish disability. A finding of disability requires that a person be unable to engage in substantial gainful activity. A person who earns more than a certain monthly amount (net of impairment-related work expenses) is ordinarily considered to be engaging in SGA. The amount of monthly earnings considered as SGA depends on the nature of a person's disability. The Social Security Act specifies a higher SGA amount for statutorily blind individuals; Federal regulations specify a lower SGA amount for non-blind individuals. Both SGA amounts increase with increases in the national average wage index.

Summarized balance. The difference between the summarized income rate and the summarized cost rate, expressed as a percentage of GDP. The difference between the summarized income rate and cost rate as a percentage of taxable payroll is referred to as the actuarial balance.

Summarized cost rate. The ratio of the present value of cost to the present value of the taxable payroll (or GDP) for the years in a given period, expressed as a percentage. To evaluate the financial adequacy of the program, the summarized cost rate is adjusted to include the cost of reaching and maintaining a target trust fund level. A trust fund level of about 1 year's cost is considered to be an adequate reserve for unforeseen contingencies; therefore, the targeted trust fund ratio is 100 percent of annual cost. Accordingly, the adjusted summarized cost rate is equal to the ratio of: (1) the sum of the present value of the cost during the period plus the present value of the targeted ending trust fund level to (2) the present value of the taxable payroll (or GDP) during the projection period.

Summarized income rate. The ratio of the present value of scheduled non-interest income to the present value of taxable payroll (or GDP) for the years in a given period, expressed as a percentage. To evaluate the financial adequacy of the program, the summarized income rate is adjusted to include asset reserves on hand at the beginning of the period. Accordingly, the adjusted summarized income rate equals the ratio of: (1) the sum of the trust fund reserve at the beginning of the period plus the present value of non-interest income during the period to (2) the present value of the taxable payroll (or GDP) for the years in the period.

Supplemental Security Income—SSI. A Federally administered program (often with State supplementation) of cash assistance for needy aged, blind, or disabled persons. The General Fund of the Treasury funds SSI and the Social Security Administration administers it.

Supplementary Medical Insurance (SMI) Trust Fund. See "Trust fund."

Survivor benefit. Benefit payable to a survivor of a deceased worker.

Sustainable solvency. Sustainable solvency for the financing of the program under a specified set of assumptions is achieved when the projected trust fund ratio is positive throughout the 75-year projection period and is either stable or rising at the end of the period.

Taxable earnings. Wages or self-employment income, in employment covered by the OASDI or HI programs, that is under the applicable annual maximum taxable limit. For 1994 and later, no maximum taxable limit applies to the HI program.

Taxable payroll. A weighted sum of taxable wages and taxable self-employment income. When multiplied by the combined employee-employer payroll tax rate, taxable payroll yields the total amount of payroll taxes incurred by employees, employers, and the self-employed for work during the period.

Taxable self-employment income. The maximum amount of net earnings from self-employment by an earner which, when added to any taxable wages, does not exceed the contribution and benefit base. For HI beginning in 1994, all net earnings from self-employment.

Taxable wages. See "Taxable earnings."

Taxation of benefits. Beginning in 1984, Federal law subjected up to 50 percent of an individual's or a couple's OASDI benefits to Federal income taxation under certain circumstances. Treasury allocates the revenue derived from this provision to the OASI and DI Trust Funds on the basis of the income taxes paid on the benefits from each fund. Beginning in 1994, the law increased the maximum percentage from 50 percent to 85 percent. The HI Trust Fund receives the additional tax revenue resulting from the increase to 85 percent.

Taxes. See "Payroll tax contributions" and "Taxation of benefits."

Termination. Cessation of payment because the beneficiary is no longer entitled to receive a specific type of benefit. For example, benefits might terminate as a result of the death of the beneficiary, the recovery of a disabled beneficiary, or the attainment of age 18 by a child beneficiary. In some cases, an individual may cease one benefit and this is not a termination because they become immediately entitled to another type of benefit, such as the conversion of a disabled-worker beneficiary at normal retirement age to a retired-worker beneficiary.

Test of long-range close actuarial balance. The conditions required to meet this test are:

- The trust fund satisfies the test of short-range financial adequacy; and
- The trust fund ratios stay above zero throughout the 75-year projection period, such that benefits would be payable in a timely manner throughout the period.

The Trustees apply the test to OASI, DI, and the combined OASDI program based on the intermediate set of assumptions.

Test of short-range financial adequacy. The conditions required to meet this test are:

- If the trust fund ratio for a fund is at least 100 percent at the beginning of the projection period, the test requires that it remain at or above 100 percent throughout the 10-year projection period;
- If the ratio is initially less than 100 percent, then it must reach at least 100 percent within 5 years (without asset reserve depletion at any time during this period) and then remain at or above 100 percent throughout the remainder of the 10-year period.

The Trustees apply the test to OASI, DI, and the combined OASDI program based on the intermediate set of assumptions.

Total-economy productivity. The ratio of real GDP to hours worked by all workers. Also referred to as "labor productivity."

Total fertility rate. The sum of the single year of age birth rates for women aged 14 through 49, where the rate for age 14 includes births to women aged 14 and under, and the rate for age 49 includes births to women aged 49 and over. The total fertility rate may be interpreted as the average number of children that would be born to a woman in her lifetime if she were to experience, at each age of her life, the birth rate observed in, or assumed for, a specified year, and if she were to survive the entire childbearing period.

Trust fund. Separate accounts in the United States Treasury which hold the payroll taxes received under the Federal Insurance Contributions Act and the Self-Employment Contributions Act; payroll taxes resulting from coverage of State and local government employees; any sums received under the financial interchange with the railroad retirement account; voluntary hospital and medical insurance premiums; and reimbursements or payments from the General Fund of the Treasury. As required by law, the Department of the Treasury invests funds not required to meet current expenditures in interest-bearing securities backed by the full faith and credit of the U.S. Government. The interest earned is also deposited in the trust funds.

- **Old-Age and Survivors Insurance (OASI).** The trust fund used for paying monthly benefits to retired-worker (old-age) beneficiaries, their spouses and children, and to survivors of deceased insured workers.
- **Disability Insurance (DI).** The trust fund used for paying monthly benefits to disabled-worker beneficiaries, their spouses and children, and for providing rehabilitation services to the disabled.
- **Hospital Insurance (HI).** The trust fund used for paying part of the costs of inpatient hospital services and related care for aged and disabled individuals who meet the eligibility requirements. Also known as Medicare Part A.

- **Supplementary Medical Insurance (SMI).** The Medicare trust fund composed of the Part B Account, the Part D Account, and the Transitional Assistance Account. The Part B Account pays for a portion of the costs of physicians' services, outpatient hospital services, and other related medical and health services for voluntarily enrolled aged and disabled individuals. The Part D Account pays private plans to provide prescription drug coverage, beginning in 2006. The Transitional Assistance Account paid for transitional assistance under the prescription drug card program in 2004 and 2005.

The trust funds are distinct legal entities which operate independently. Fund operations are sometimes combined on a hypothetical basis.

Trust fund ratio. A measure of trust fund adequacy. The asset reserves at the beginning of a year, which do not include advance tax transfers, expressed as a percentage of the cost for the year. The trust fund ratio represents the proportion of a year's cost which could be paid solely with the reserves at the beginning of the year.

Trustees. See "Board of Trustees."

Undisbursed balances. In general, refers to the cumulative differences between the actual cash expenditures that the Social Security Administration (SSA) made each month compared to security redemptions from the Trust Fund reserves made on a preliminary basis to cover such cash expenditures during the same month. On a monthly basis, SSA pays benefits and makes payments for other programmatic expenses associated with the Trust Funds. During each month, SSA draws cash from the Trust Funds on a preliminary basis, which results in Treasury redeeming invested securities to cover these expenditures. This monthly difference can be either positive or negative depending on net monthly activity, and is added to the balance at the end of the prior month.

A net positive undisbursed balance represents a situation where cumulative redemptions from the Trust Fund's securities are more than was needed to cover actual program cash expenditures through the end of the month. A net negative balance represents a situation where cumulative program cash expenditures exceeded the amount redeemed from the invested securities. A negative value requires future redemption of additional invested securities.

In addition, about every seven years, when January 3 falls on a Sunday, benefit payments scheduled to be paid on January 3rd are actually paid on December 31 of the preceding year, as required by the statutory provision included in the 1977 Social Security Amendments for early delivery of benefit payments when the normal payment delivery date is a Saturday, Sunday, or legal public holiday. Consistent with practice in prior reports and for comparability with other historical years and the projections in this report, all trust fund operations and asset reserves reflect the 12 months of benefits scheduled for payment in each year. Therefore, such advance payments are included as positive values in the undisbursed balance at the end of the calendar years in which the advance payments are made.

Unfunded obligation. A measure of the shortfall of trust fund income to fully cover program cost through a specified date after depletion of trust fund asset reserves. This measure can be expressed in present value dollars, discounted to the beginning of the valuation period, by computing the excess of the present value of the projected cost of the program through a specified date over the sum of: (1) the value of trust fund reserves at the beginning of the valuation period; and (2) the present value of the projected non-interest income of the program through a specified date, assuming scheduled tax rates and benefit levels. This measure can apply for all participants through a specified date, i.e., the open group, or be limited to a specified subgroup of participants.

Unfunded obligation ratio. The unfunded obligation accumulated through the beginning of a year expressed as a percentage of the cost for the year.

Unnegotiated check. A check which has not been cashed 6 months after the end of the month in which the check was issued. When a check has been outstanding for a year, the Department of the Treasury administratively cancels the check and reimburses the issuing trust fund separately for the amount of the check and interest for the period the check was outstanding. The appropriate trust fund also receives an interest adjustment for the time the check was outstanding if it is cashed 6-12 months after the month of issue. If a check is presented for payment after it has been administratively canceled, a replacement check is issued.

Valuation period. A period of years which is considered as a unit for purposes of calculating the financial status of a trust fund.

Vocational rehabilitation. Services provided to disabled persons to help them to return to gainful employment. The trust funds reimburse the providers of such services only in those cases where the services contributed to the successful rehabilitation of the beneficiaries.

Year of depletion. The year in which a trust fund becomes unable to pay benefits when due because the fund's asset reserves have been used up.

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STATEMENT OF ACTUARIAL OPINION

It is my opinion that, with the important caveat noted below: (1) the techniques and methodology used herein to evaluate the actuarial status of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds are based upon sound principles of actuarial practice and are generally accepted within the actuarial profession; and (2) the assumptions used and the resulting actuarial estimates are, individually and in the aggregate, reasonable for the purpose of evaluating the actuarial status of the trust funds, taking into consideration the past experience and future expectations for the population, the economy, and the program. I am an Associate of the Society of Actuaries, a member of the American Academy of Actuaries, and I meet the Qualification Standards of the American Academy of Actuaries to render the actuarial opinion contained herein.

Federal Budget Accounting

This report focuses on the actuarial status of the OASI and DI Trust Funds, as required by law. It includes important information on (1) the years in which trust fund asset reserves are projected to be depleted and (2) the degree to which benefits scheduled in the law would no longer be fully payable on a timely basis after reserve depletion. However, the footnote on page 45 of this report directs the reader to an appendix in the Medicare Trustees Report, which states, "The trust fund perspective does not encompass the interrelationship between the Medicare and Social Security trust funds and the overall Federal budget." The reader of this report should consider this "overall" Federal unified budget perspective with care because the assumptions underlying unified budget accounting are inconsistent with the assumptions of trust fund accounting.

In particular, trust fund accounting accurately reflects the law, under which benefits cannot be paid in full on a timely basis after reserve depletion. In contrast, unified budget accounting assumes that full scheduled benefits will continue to be paid through transfers from the General Fund of the Treasury, thus representing "a draw on other Federal resources for which there is no earmarked source of revenue from the public." Not only are such "draws" not permissible under the law, no precedent exists for a change in the Social Security Act to finance unfunded trust fund obligations with such draws on other Federal resources. Under this unified budget accounting assumption, \$11.4 trillion of OASDI unfunded obligations, which are not payable under the law over the next 75 years, are referred to as "expenditures" requiring a "draw" from the General Fund of the Treasury.

In addition, unified budget accounting treats redemptions of trust fund reserves as an addition to annual Federal deficits, referring to these redemptions also as “a draw on other Federal resources.” In fact, redemptions of trust fund reserves represent a deferred use of revenues earmarked for the trust fund program alone, which have been collected in prior years and saved for later use. These redemptions utilize the entire $2.8 trillion accumulation of net past earmarked revenue for OASDI, but are referred to as draws on the General Fund of the Treasury under the unified budget perspective.

Therefore, the actual operations of the trust funds under current law do not draw on other Federal resources. Expenditures can only be paid from current or deferred earmarked resources for the specific program financed from the trust fund. Assertions that trust fund reserve redemption and shortfalls after reserve depletion represent draws on other Federal resources are based on assumptions that are inconsistent with the law and with actual trust fund annual cash-flow operations.

In addition to Federal budget annual cash flows, the budget perspective is equally concerned with the build-up of Federal debt. The total Federal debt subject to limit includes trust fund reserves. Thus, as trust fund reserves are accumulated or redeemed, they are offset in the total Federal debt by securities issued to the public, with no net effect on the total Federal debt. Moreover, even in considering the Federal debt owed to (held by) the public, there is no net direct effect on that debt from accumulating and then redeeming trust fund asset reserves. However, budget analysis frequently refers to both trust fund reserve redemptions and trust fund obligations not payable under the law after reserve depletion as factors that increase the Federal debt held by the public in the future. This assertion is not consistent with a full assessment of the investment and redemption flows of the trust funds or with the limitations in the law on paying benefits after trust fund reserves are depleted.

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