This Integrated Resource Plan represents a snapshot of an ongoing resource planning process using current business assumptions. The planning process is constantly evolving and may be revised as conditions change and as new information becomes available. Before embarking on any final strategic decisions or physical actions, the Companies will continue to evaluate alternatives for providing reliable energy while complying with all regulations in a least-cost manner. Such decisions or actions will be supported by specific analyses and will be subject to the appropriate regulatory approval processes.

Technical Appendix – Volume II

The U.S. Economy, 30-Year Focus, IHS Global Insight

2014 IRP

U.S. Economy: Report

U.S. Economy

REPORT PRINTED ON 20 FEBRUARY 2014

Overview: Forecast Overview

This issue of *The US Economy, 30-Year Focus* presents IHS Global Insight's most recent set of long-range projections. Given the detail available in the current IHS Global Insight model, the projections for the next 30 years cover not just the macro concepts such as output, inflation, and unemployment, but also the more disaggregated variables such as production and employment by industry. This disaggregation provides a variety of concepts for analysts to use in their planning models. Many of these variables serve as inputs to IHS Global Insight's US regional, energy, and country forecasting models.

While the long-range outlooks have been of particular interest to utilities and state and local governments, which have relatively long planning horizons, they can be equally relevant to analysts dealing with shorter intervals. This is especially true of the trend scenario, the principal long-range projection. The trend is completely consistent with IHS Global Insight's September short-term baseline (Control) solution (detailed in the September 2013 issue of *The US Economic Outlook*), which represents our forecast through 2023. Thereafter, the economy is expected to make a transition to full employment (4.5–5.5% unemployment), and then evolve gradually along this full-employment growth path. Hence, the transition between the short- and long-term forecasts is smooth, making the trend projection an excellent base for 10-year planning purposes and policy simulations.

The four long-term projections

This *30-Year Focus* presents four projections: baseline, cyclical, optimistic, and pessimistic.

The **trend projection** is the baseline scenario. It assumes that after the economy gets back on track from the current slowdown in growth, it suffers no major mishaps between now and 2043. It grows smoothly, in the sense that actual output follows potential output relatively closely. This projection is best described as depicting the mean of all possible paths that the economy could follow in the absence of major disruptions. Such disruptions include large oil price shocks, untoward swings in macroeconomic policy, natural disasters, a financial meltdown, or a sudden collapse of the Eurozone.

The **cyclical projection** is the primary alternative scenario. It superimposes business-cycle behavior on the trend scenario. Economic growth proceeds in a series of starts and stops, with periods of rapid expansion, followed by externally, or policy-induced recessions. The timing of the recessions is merely suggestive. Because it is impossible to predict the exact timing of business cycles much in advance, it is unwise to focus on specific years. It is also inappropriate to calculate average growth rates between different points in the business cycle.

The **optimistic projection** is the upside scenario, in which economic growth proceeds smoothly but more rapidly than in the baseline, while prices rise more slowly. In this projection, population, labor force, and capital stock growth, as well as exogenous technological changes, occur more quickly than in the trend. Potential output thus climbs more rapidly, and because output is primarily supply-determined in the long run, real per capita GDP grows 0.4 percentage point quicker per year.

The **pessimistic projection** is the downside scenario. Here, growth proceeds smoothly, but more slowly than in the baseline, and productivity growth is weaker. In this projection, population, labor force, and capital stock growth, together with exogenous technological changes, occur less rapidly than in the trend. Output per capita thus climbs 0.5 percentage point more slowly per year.

Probabilities

The underlying rate of growth in TREND30YR0913 is consistent with history, as well as with conjecture about the economy's unfolding structure. It can be regarded as the best-unbiased projection of the economy. Although any

probabilities attached to long-run projections must be highly subjective, IHS Global Insight believes there is only a 10% chance that the economy's underlying path will be outside the bandwidth encompassed by the optimistic and pessimistic projections.

Key assumptions

Demographics. Demographic factors are a primary driving force in any long-term economic projection. The population's growth rate and changes in its composition have considerable impacts on the labor force, the full-employment unemployment rate, housing demand, and other spending categories-most notably, consumption of health services and purchases by state and local governments.

The population projections in IHS Global Insight's trend and cyclical scenarios are built on the Census Bureau's latest projections, which were released in December 2012 These projections replaced the Census 2008 projections, and incorporated new basic fertility, mortality, and migration assumptions.

The "middle" projection is based on specific assumptions about immigration, fertility, and mortality rates. According to the Census, the fertility rate (the average number of births per woman upon completion of childbearing) will slip from 2.02 in 2001 to 2.0 in 2012 to 1.94 in 2043, while the mortality rate should continue to improve. Meanwhile, net immigration (including undocumented immigration) is expected to rise on average by about 1.0 million per year through 2043. Based on these assumptions, the US population will average 0.7% growth per year through 2043, down from the 1.0% pace during the last 30 years. Thus, total population will rise from 314 million in 2012 to 387 million in 2043.

The age distribution of the population is also an important factor in the long-term outlook. As baby boomers begin to retire, the share of the US population aged 65 years and over will jump from 14% in 2012 to 21% by 2043, pushing up outlays for Social Security, Medicare, and Medicaid. In addition, the growth rate of the working-age population will slow more than that of the overall population. After increasing 1.2% annually over the past 30 years, the population aged 16–64 years will grow only 0.4% over the forecast period.

The optimistic and pessimistic alternatives embody population projections different from those in the trend. These projections are also based on Census projections. The optimistic outlook assumes the US population will increase more quickly because of higher net immigration. Conversely, the pessimistic alternative constricts growth in the labor force because of lower-assumed net immigration from the start of the forecast period. As a result, annual population growth averages 0.8% in the optimistic scenario and 0.6% in the pessimistic scenario. By 2043, the current population increases to 397 million in the optimistic projection, but to only 377 million in the pessimistic scenario, compared with 387 million in the baseline.

Fiscal policy. We expect federal spending on defense, transfer payments, and federal aid to state and local governments to consume a good share of GDP. As a result, the federal government should post deficits in the unified budget over the forecast period. In the trend forecast, the deficit averages 2.6% of GDP in 2013–43. In the longer run, the baby boomers' retirement will cause deficits to grow, despite some increases in the Social Security tax rate.

Monetary policy and inflation. Monetary policy remains important in the long-term projections, not so much in determining the level of output, but rather in determining the rate of inflation. Ultimately, the Federal Reserve decides on the steady-state rate of inflation. Monetary policy can cause inflation to accelerate by being overly accommodative and pushing the unemployment rate temporarily below the rate at which inflation is stable. Alternatively, it can cause inflation to decelerate by being restrictive and pushing the unemployment rate temporarily above the rate at which inflation is stable.

In this forecast, we assume that the Fed's ultimate goal is a stable inflation rate. The CPI inflation rate is jumpy in the early years of the forecast because of spiking oil prices, and eventually settles to about 2.0%.

Bond yields will generally move parallel to the funds rate over the forecast interval, but run somewhat higher. The yield on 10-year treasuries rises slowly, and eventually converges to about 4.6%. The forecast implies a real federal funds rate of about 1.6% and a real long-term bond rate of 2.3%.

In the cyclical scenario, periods of overly expansive monetary policy are followed by intervals of overly restrictive policy, which translates into the periodic acceleration and deceleration of inflation. In the optimistic scenario, the Fed is assumed to keep a tight rein on the money supply, permitting little acceleration of inflation. Conversely, in the pessimistic scenario, the central bank is assumed to be reluctant to put the economy through the pain necessary to bring inflation back to baseline levels, choosing instead to tolerate an inflation rate that is higher than in the baseline.

Energy. Oil prices have climbed back, after having plunged during the global recession. They should continue to climb in nominal dollars. IHS Global Insight's Energy Service expects the price of Brent oil to remain above $90 per barrel over the forecast period. With worldwide demand steadily increasing, the OPEC cartel will maintain some pricing power. The West Texas Intermediate price for oil is projected to reach $166 per barrel by 2043, compared with the average price of $26 in 2001.

In the long run, scarcity tends to bid energy prices up, while new technologies tend to hold them down. In the end, we project that these two forces will roughly balance out over the forecast period.

The oil price path in the cyclical scenario contains several oil spikes, where oil producers are assumed to mimic their behavior of the 1970s, raising oil prices substantially when the world economy is close to a cyclical peak. In the pessimistic scenario, nominal and real oil prices are higher than in the trend. In the optimistic scenario, nominal and real oil prices are below what they are in the trend.

Price projections are a trend. It is likely that there will be periods, possibly of several years at a time, when prices are either above or below the trend. A price outcome higher than the projected trend could result from stronger demand growth (perhaps notably in China and India) and/or weaker supply (more disappointments in non-OPEC and loss of productive capacity in OPEC due to political upsets). A price outcome lower than the projected trend could arise from recession, enforcement of higher efficiency standards, or better than expected supply prospects.

International. In the trend projection, the major US trading partners are assumed to follow a growth pattern similar to that in the United States, with the pace of growth averaging 1.9% over the forecast period, down from an average 2.3% over the past 30 years. This slowdown reflects demographic forces similar to those operating in the United States. Owing to steady pressure from the current account deficit, the real value of the dollar will fluctuate, but on average, depreciate throughout our long-term forecast.

Variations in the international environment help explain some of the differences among the alternative scenarios. A faster (slower) rate of growth abroad partially explains the higher (lower) level of exports in the optimistic (pessimistic) scenario. Meanwhile, a cycle in the real exchange rate due to swings in domestic interest rates helps explain the trade pattern in the cyclical scenario.

Demand mix. Although the overall level of output is determined by supply conditions, many mixes of aggregate demand are consistent with that level of output. Over the forecast period, the demand mix will be dominated by the need to boost exports to balance the current account. Over the forecast period, the share of GDP going to exports rises from 14% in 2011 to 23% in 2043.

The sum of the remaining shares of GDP must decline to make room for the rising share devoted to exports. Government spending will bear some of the burden in 2012–43; the government's share of GDP will decline about 6 percentage points.

Methodology over the short-term forecasting horizon

The trend remains consistent with the September control forecast through 2023. The two bandwidth scenarios-optimistic and pessimistic-take the trend solution as their starting point and immediately diverge from it-according to their own underlying assumptions-at the beginning of the solution interval. This ensures that growth is always higher in the optimistic alternative, and lower in the pessimistic alternative. However, while average GDP growth, inflation, unemployment, and interest rates may be higher or lower than in the trend, depending on which is appropriate, these relationships will not necessarily hold for every individual quarter of the forecast period.

Capsule summary of the long-term projections

		Trend	Cyclical
	General outlook	The economy exhibits mild variations in growth and approaches its balanced-growth path. CPI inflation rises slowly, averaging 2.0%.	Typical business-cycle fluctuations.
I.	**Principal exogenous assumptions**		
	Demographic	Projections consistent with the Census Bureau's latest middle-growth forecast. Fertility rate drops to 1.94 births (from 1.99 in 2015). Immigration averages 1.0 million	
	Energy imports	Real oil prices eventually stabilize over the forecast period. No embargoes are assumed.	Sharp price hikes occur in periods of peak demand.
	Food prices	Wholesale farm prices average 0.2% annual increases.	Wholesale farm prices average 1.6% annual increases.
II.	**Principal policy dimensions**		
	Tax changes	Marginal personal tax rates inch up. Corporate tax stays at 35%.	Similar to baseline.
	Growth of federal spending	Real, +0.5% per year.	Real, +0.5% per year. Growth pattern resembles the trend's.
	Federal Transfers	Real growth of 3.2% per year.	Real growth of 3.8% per year.
	Budget deficit	Deficit averages 2.6% of GDP.	Deficit averages 2.4% of GDP.
	Average federal government share of GDP	23.0%	23.1%
	Monetary policy	Sufficient funds made available to promote stable credit growth. Money (M2) growth averages 4.3%.	Fluctuations in monetary policy contribute to severity of cycles. M2 averages 5.3% annual growth.
	Federal funds rate	Rises gradually, eventually settling at 4.00%.	Ranges between 0.01% and 8.00%.

		Trend	Cyclical
III.	**Behavior of economic agents**		
	Consumers	Consumer confidence relatively constant.	Cyclical swings in confidence, income, and wealth cause large fluctuations in expenditures, particularly on durable goods.
	Average annual real consumption growth	2.3%	2.1%
	Business	Decisions made in relatively stable environment.	Fluctuations in output, interest rates, and inflation lead to fluctuations in investment.
	Average business fixed investment share in GDP	13.7%	13.8%

	Average share of corporate cash flow in GNP	11.3%	11.7%
	State and local government	Real expenditures dictated by demographics and ability to raise taxes. Average real growth in purchases of 1.0% per year.	Average real growth in purchases of 0.9% per year.
	Federal budget position (Fiscal years)	Deficits.	Deficits
	International Average annual wholesale price inflation for major trading partners	1.7% (OECD countries) 3.1% (Developing countries)	1.7% (OECD countries) 3.1% (Developing countries)
	Real US exchange rate	Declines over forecast period.	Cycles over the forecast.
IV.	**Other parameters**		
	Average annual productivity growth	1.8%	1.6%
	Average annual potential output growth	2.2%	2.0%
	Consumer price inflation	Eventually stabilized at 2.0%	Periodic demand surges, oil price shocks, and more aggressive wage responses boost the average inflation rate.
	Consumer price index Average annual increase	2.0%	3.1%
	Hourly earnings Average annual rise	3.4%	4.6%
	Housing market	Demographics dictate slower growth of the housing stock.	Cycles in incomes and monetary policy affect the housing sector more severely.
	Median new home price in 2043 Average annual rise	$509,900 2.4%	$738,200 3.7%
	Unemployment	Settles at about 5.1%.	Fluctuates with the business cycle.
	Average rate	5.3%	5.5%

Capsule summary of the long-term projections

	Optimistic	**Pessimistic**
General Outlook	High growth.	Low growth.

		Deviations from trend due to differences in demographic assumptions, productivity growth, and investment.	
I.	**Principal exogenous assumptions**		
	Demographic	Projections above the trend are a result of higher net immigration.	Projections below the trend due to lower net immigration.
	Energy imports	Real oil prices rise slower than in the trend.	Real oil prices increase more than in the trend forecast.
	Food prices	Wholesale farm prices: no growth.	Wholesale farm prices average 1.9% annual increases.
II.	**Principal policy dimensions**		
	Tax changes	Lower tax rates.	Higher tax rates.
	Growth of federal spending	Real, +0.5% per year.	Real, +0.4% per year.
	Federal Transfers	Real growth of 3.1% per year.	Real growth of 3.8% per year.
	Budget deficit	Surpluses after 2028.	Deficits throughout.
	Average federal government share of GDP	20.5%	26.7%
	Monetary policy	Stable and predictable.	Tight policies required to contain rising inflationary pressures.
	Federal funds rate	Settles at 3.5%.	Rises to 7.25%.

		Optimistic	**Pessimistic**
III.	**Behavior of economic agents**		
	Consumers	Consumer confidence upbeat.	Lower real incomes depress consumer expenditures.
	Average annual real consumption growth	2.7%	1.6%
	Business	High demand expectations plus low inflation and interest rates enhance the business environment.	Higher inflation, higher interest rates, and weaker demand make investors more cautious.
	Average business fixed investment share in GDP Average share of corporate cash flow in GNP	13.9% 11.5%	13.8% 10.1%
	State and local government	Average real growth in purchases of 1.4% per year.	Average real growth in purchases of 0.4% per year.
	Federal budget position (Fiscal years)	Surpluses after FY 2028.	Deficits throughout.

	International Average annual wholesale price inflation for major trading partners	1.9% (Major currency trading partners) 3.3% (Other important trading partners)	1.8% (Major currency trading partners) 3.5% (Other important trading partners)
	US exchange rate	Real exchange rate declines.	Real exchange rate declines.
IV.	**Other parameters**		
	Average annual productivity growth	2.1%	1.4%
	Average annual potential output growth	2.5%	1.6%
	Consumer price inflation	Converges to about 2.0%.	Inflation approaches 4.0%
	Consumer price index Average annual increase	1.6%	3.6%
	Hourly earnings Average annual rise	3.2%	4.7%
	Housing market	The higher population projections push the housing stock above the trend.	Lower real incomes and high cost of funds depress housing starts.
	Median new home price in 2043 Average annual rise	$440,500 1.9%	$771,600 3.8%
	Unemployment	Remains below trend throughout forecast period.	Remains above trend throughout forecast period.

Trend Projection

Slowing growth and federal deficits: Trend projection

Highlights

- Real GDP growth will average 2.5% per year in 2013–43.
- The outlook for inflation remains moderate. Consumer Price Index (CPI) inflation will average 2.0% per year over the forecast period. Core inflation will average 1.9%.
- Nonfarm business productivity growth averages 1.8% over the forecast period, compared with its 2.0% 50-year average.
- The current-account deficit remains negative over the entire forecast period.
- Real oil prices eventually stabilize just below current levels.
- The labor market improves over the forecast period, with the unemployment rate eventually settling at about 5%.
- The federal budget deficit remains in deficit throughout the forecast period.

Introduction

Economists focus on the short run. When will the Federal Reserve raise interest rates? Is the stock market overvalued, and if so, by how much? Could the economy slip into recession again next year? Will Greece leave the Eurozone? Is a bubble forming? This focus is understandable. We care more about what happens next year than what happens 10 years from today. The focus, though, is misplaced. When historians look back on the 20th century, the most striking economic fact that will distinguish it from previous centuries will not be the 21 recessions, but rather the steady, inexorable rise in per capita income.

The driving force behind rising per capita income is one that economists struggle to understand: productivity growth. While they agree that new technologies eventually make workers more productive, many questions remain under debate. What determines the pace of technological progress? How long does it take for new technologies to catch on? As a growth accelerant, how does an innovation such as the Internet, GPS, smart phones, or hydraulic fracturing compare with the invention of the transistor, the airplane, or the electric bulb? Not knowing these answers makes productivity—and the course of the economy—difficult to forecast.

A few words on productivity

Nonfarm business sector productivity (henceforth, productivity) has been growing at a 1.5% annual rate during the 16 quarters since the economy emerged from the Great Recession. This is the slowest rate among the nine postwar expansions that have lasted that long. The slowdown has been mostly recent.

A handful of economists (lamentably, not many) have written about this slowdown, which, until recently, had been masked by a 2009 cyclical rebound. The topic is an important one because productivity growth is probably the best indicator of an economy's long-run performance. In a September 2012 Federal Reserve of San Francisco Working Paper, John Fernald pointed out that if one makes a few necessary adjustments to the data, productivity's recent performance, while weak, is not all that out of the ordinary—it picked up speed early in the recovery because companies kept their more productive employees employed, and these workers had more capital to work with. As the recovery took hold, productivity growth came back to trend. But that trend, according to Fernald, was on a slower trajectory than most analysts had come to expect. His research indicates that the gains from investing in information technology began petering out around 2004—and that we have been moving along a slow growth trajectory since.

In a January 2013 Federal Reserve of Chicago letter, Jake Fabina and Mark L. Wright wrote that “there has been a dramatic reduction in the growth of productivity across almost all advanced economies over the past 10 years.” While they do not disagree with Fernald’s hypothesis, they do not believe that the exhaustion of gains from information technology can explain the productivity slowdown across so many countries .

Robert Gordon of Northwestern University, one of the top experts in this topic, created a stir in a 21 December *Wall Street Journal* op-ed when he wrote that the era of fast growth was behind us, and that living standards, which have been doubling every 35 years since 1890, will double every 100 years going forward. He believes that a set of innovations made between 1875 and 1900—including the light bulb, electric power, and the internal combustion engine—laid the foundations for 20th century growth. Innovations in the last 100 years have impacted growth much less.

His research leads him to conclude that something analogous to the law of diminishing returns applies to innovations. The Boeing 707 (introduced in 1958), travelling at 500 miles per hour, represented a huge improvement in transportation speed over the horse-drawn carriage used 100 years earlier. But improvements in transportation speed since 1958 have been evolutionary, not revolutionary.

"Evolutionary" describes most recent innovations. The tablet computer, smart phones, 3-D printing, micro-robots, Google’s driverless car, and hydraulic fracturing leave Gordon unimpressed. He thinks that we are entering a period of sharply lower growth and there is not much we can do about it.

Compared with Robert Gordon, we are optimists. Compared with the historical experience, we are not. In our latest forecast, productivity growth averages 1.9% over the next 30 years, just below the 50-year average of 2.0%. A caveat: the recent historical productivity estimates are revised several times over several years before they solidify. The latest estimates are tentative. Things may not be as bad as we think. Or they could be worse.

Changes to the 30-year forecast

The purpose of this note is to outline changes to the latest long-term forecast (updated in mid- December). The changes were small, which is to be expected since only two months have passed since the forecast had been previously updated.

The key concepts are unchanged. Real GDP growth still averages 2.5% over the 30-year interval. Average productivity growth (1.8%), CPI inflation (2.0%), and core PCE inflation (1.9%) also all round to the same number as in the September update. The unemployment rate still converges to 5.0%. The level and the structure of interest rates is the same after 2016. The population projections are also the same.

The energy forecast is slightly different. Oil and gas prices are not that different, but production of oil and natural gas is about 3% higher in 2023 than in the September forecast.

We will next be updating the forecast in late February.

Long-term forecast assumptions

In the trend scenario, after the first five years of the forecast, we assume an environment free of exogenous shocks. Economic output will converge towards its potential level, with all resources fully utilized. As a result, the growth rates of output, real incomes, real expenditures, and the general standard of living of the population are determined by the growth rate of potential GDP. The long-range outlook is dominated by supply factors, such as population growth and demographics, labor force participation rates, average weekly hours worked, national saving and capital stock accumulation, and productivity growth.

Population and demographics

The population projections are built on the Census Bureau's latest projections, which were released in December 2012. These projections have the US population expanding at an annual rate of 0.7% in 2013–43, when the population reaches 387 million. Growth in the older-age cohorts will be stronger as the baby boomers age. The 65-years-and-over population share rises from 13.8% in 2012 to 20.8% in 2043.

Productivity and aggregate supply

It is the economy's ability to increase supply in the long run that determines its potential growth path. Growth in aggregate supply depends on the increase in the labor force, the growth of the capital stock, and improvements in productivity.

IHS Global Insight believes that productivity growth will average 1.8% per year in 2013–43. This is lower than the stellar 2.9% average annual growth achieved during the 1960s, and just below the average 2.0% of the past 50 years. The real effective capital stock will grow 3.5% annually, compared with 3.3% for the last 30 years.

The declining price of capital goods relative to other inputs accounts for the robust capital stock growth rates.

Government policy

For the near term, we have assumed that the automatic spending cuts (or “sequester”), which began on 1 March, will continue through the end of the year. We assume cuts of $85 billion in budget authority that translate into cuts in actual outlays of $44 billion this fiscal year and $66 billion this calendar year (spending cuts lag behind cuts in budget authority). We assume that the sequester is ultimately replaced by an agreement on spending cuts that fall on Medicare, Medicaid, and Social Security in addition to discretionary spending. We assume that Social Security payments are indexed to the chained CPI from 2014 onwards.

The federal deficit, which peaked at $1.4 trillion in fiscal year 2009, drops below $1.0 trillion after fiscal year 2012, gets smaller through 2016, but then starts to grow again.

With the economy growing faster than the pace of government spending, the government sector's share of GDP will decline over the forecast period. The state and local government sector maintains the dominant share of total government purchases, growing from 60% in 2012 to 70% in 2043. At the federal level, the military accounted for 63% of federal purchases in 2012, and inches down to 62% in 2043.

Monetary policy and financial markets

The Federal Reserve decides on the steady-state rate of inflation. Monetary policy can cause inflation to accelerate by being overly accommodative. Alternatively, it can cause inflation to decelerate by being restrictive. In the forecast, the monetary authorities opt to maintain core inflation near 2%.

Bond yields will generally move parallel to the funds rate over the forecast interval, but run somewhat higher. The yield on 10-year Treasuries remains low by historical standards, hovering around 4.6% after 2017. The forecast implies a real federal funds rate of about 1.8% and a real long-term bond rate of about 2.6%.

Oil prices

Oil prices tumbled during the global recession. Once the world economy got back on track, though, oil prices came back up.

IHS Global Insight's Energy Service expects the average acquisition price of foreign oil to remain high. With worldwide demand steadily increasing, the OPEC cartel will maintain some pricing power. In the end, scarcity tends to bid energy prices up, while new technologies tend to hold them down. Our projection is that these two forces will balance out—and that the real price of oil will stabilize after 2020. Nonetheless, real oil prices will remain high by historical standards.

Foreign assumptions

The major US industrialized trading partners are assumed to follow a growth pattern similar to that in the United States, with the pace of growth averaging 1.9% over the forecast period, down from an average 2.3% over the past 30 years. This slowdown reflects demographic forces similar to those operating in the United States. The developing countries that trade with the United States will grow 4.0%, down from 4.5% growth during the past 30 years.

Over the forecast period, the real US trade-weighted dollar relative to major trading country currencies depreciates 0.2% annually, while the US trade-weighted dollar relative to other important trading countries depreciates 1.2% annually.

Long-term forecast highlights

Real GDP. The trend projection assumes that the US economy experiences no major mishaps between now and 2043. The projection is identical with our September 2013 baseline forecast through 2023, and represents IHS Global Insight's best estimate of the economy's path over that period. Beyond 2023, the projection should be interpreted as the mean of all possible near-full-employment paths the economy could follow. The smooth-growth characteristics of the trend projection make it most useful for tasks largely impervious to short-term cyclical fluctuations, such as planning capacity additions and evaluating new markets. This projection is also the best base from which to evaluate the effects of various assumptions about key exogenous elements, such as fiscal policy or energy prices, on the overall economic outlook.

Annual real GDP growth averages 2.5% in 2013–43, 0.2 percentage point slower than during the past 30 years. The economy's underlying growth will slow as baby boomers begin to retire, slowing labor force growth. Potential output growth should hold up fairly well in the future, with greater business fixed investment and R&D spending offsetting the slowdown in labor force growth. Eventually, though, the effects of weaker labor force growth become dominant and, in a sense, self-perpetuating. As output growth drops off, business fixed investment rises more slowly, limiting capital stock growth and thus future output gains.

Employment. Slower long-run increases in the labor force indicate more moderate long-run employment growth in the future. Total civilian employment will rise at an average annual rate of 0.7% from 2013 to 2043. Total establishment employment will rise from 133.7 million in 2012 to 173.6 million in 2043. Manufacturing's share of total employment will continue to decline over the forecast period, falling to 6% in 2043, from 9% in 2012. The broad service sector will generate an increasing share of employment growth in the forecast period, although the federal government's share of employment will decline during the forecast period.

Inflation. Over the long run, inflation is a monetary phenomenon. Its future course will be determined by policies implemented by Ben Bernanke, Janet Yellen (assuming she is confirmed), and their successors. Since we do not know who these successors will be, we assumed the Fed will try to contain inflation over the forecast period. The CPI is expected to average 2.0% annual increases in 2013–43, somewhat less than the 3.0% average in 1982–2012. The broader-based GDP deflator will rise 1.8% per year.

Consumption. Expenditures, in the long term, are primarily determined by the growth of real permanent income, demographic influences, and changes in relative prices. The share of personal consumption expenditures in GDP hovers around 66–69% of GDP over the forecast period. Real consumption growth will average 2.3% per year over the forecast period. In per capita terms, growth will advance about 1.6% per year, down 0.4 percentage point from the 1982–2012 rate. The share of consumption devoted to services will rise, mainly because of rising health expenditures, while that for goods will fall over the forecast period.

The long-term outlook for auto and light truck sales calls for a slowdown in the rate of increase relative to past performances. Light-vehicle sales are forecast to reach 18.6 million units by 2043. Although the number of vehicles per person has increased significantly in the past 20 years, the United States is approaching a saturation point in the rate of vehicle ownership. Future growth in vehicle sales will be primarily driven by growth in population and demand for replacement vehicles. Automobile sales should be relatively strong throughout the projection period, averaging 9.1 million units per year.

Energy conservation efforts will continue. This stems partly from a stock/flow phenomenon: despite the trend toward minivans and sport/utility vehicles, for example, the average new vehicle is still more fuel-efficient than the existing stock. Gasoline usage per vehicle should fall for several more years, even if relative energy prices remain flat. Similar considerations apply to business capital and housing stocks. The ongoing employment shift from manufacturing to services also implies lower energy usage per unit of output.

Real personal disposable income, which climbed 2.8% in 1982–2012, will again rise 2.4% annually over the next 30 years. This does not take into account the rising volume of withdrawals from existing retirement plans.

Housing. Household growth clearly depends on population growth, but real incomes, employment, the age distribution of the population, and societal values also influence it. Net additions to the housing stock are closely linked to household growth, which is the primary driver of housing starts. Many analysts tend to overlook another key factor for housing starts: the geographic location of the demand for net additions.

The 25–34 year-old cohort is key for the demand for new housing. This is the age group where individuals typically purchase their first home. The demand for new housing was boosted by the large gains in this age group in the late 1960s and 1970s, as the baby-boom generation entered the housing market. Unfortunately for the housing sector, the baby-boom generation began to pass through this age bracket in the mid-1980s, limiting the demand for additions to the housing stock. The number of households in this cohort began a modest increase after 2005. The overall headship rate will gradually increase toward older segments due to the shift in the age composition.

The demographic demand for housing will be a bit stronger over the next 30 years than over the past 30 years. Thus, housing starts are projected to average 1.52 million units annually in 2013–43, compared with 1.42 million for 1982–2012. Meanwhile, the housing stock (excluding mobile homes and seasonal units) will climb from 117.0 million units in 2012 to 148.5 million units in 2043.

Business fixed investment. Good profitability and solid demand growth should keep investment healthy over the next 30 years. The share of GDP devoted to business fixed investment will hover around 12.0–14.1% of GDP through most of the forecast period. The effective capital stock (in 2005 dollar terms) is projected to increase 3.5% annually, the same growth rate recorded for 1982–2012. Inventory investment will remain a small percentage of GDP. Although inventories have played significant roles during past business cycles, inventory investment represents an average in the stable growth scenario and is thus artificially smooth. Capital inflow will contribute to net domestic investment throughout the forecast period, although the federal debt clearly hurt it in the later years of the forecast. The government saving projection assumes that state and local governments continue to run modest operating surpluses.

International trade. A decline in the dollar relative to industrialized-country-currencies, combined with modest unit labor cost growth, will stimulate US exports abroad and result in an eventual improvement in the US current-account balance. IHS Global Insight projects that real exports will expand at an average annual rate of 5.4% over the entire projection period. Real imports, meanwhile, will grow at an average annual rate of 3.9%.

by Patrick J. Newport

Cyclical Projection

Business planning in an uncertain environment: Cyclical projection

Highlights

- Four recessions (and borderline recessions in 2014 and 2041) disrupt economic growth in the cyclical projection, but the economy rebounds each time. The current struggling recovery stalls, as real GDP is driven lower in 2014 as Europe stalls.
- The shocks to confidence, income, and employment work together to keep real investment below the trend through most of the forecast period, producing a lower capital stock and lower potential GDP.
- The unemployment rate averages 0.25 percentage point above the trend (5.50% in the cycle versus 5.25% in the baseline), but at times approaches 8.0%.
- As in the recessions of 1974, 1982, and 2008, oil price spikes exacerbate business downturns.

This long-term planning scenario explicitly includes business-cycle fluctuations. The expansions and contractions are built to typify those of the postwar period. As in the past, exogenous shocks exacerbate the business cycles depicted in this projection. The timing of the recessions (beyond the first) is, of course, only **suggestive**. Cycles are assumed to be products of policy mistakes exacerbated by oil-price shocks and are slightly milder in this forecast than past cyclical projections.

Peak-to-trough movements during recessions

Starting from 2013, the cyclical projection includes four recessions and two near recessions. Collectively, these resemble the depth and duration of a typical postwar downturn, with the decline in real GDP from the peak of economic expansion to the trough of activity average. The four clear recessions over the forecast period are progressively deeper, as overreactions to prior mistakes compound future mistakes. Descriptively, they vary from short and shallow to long and deep or long and shallow, depending on their cause.

The world economy is still emerging from a major recession. The recent expansion ran longer than the postwar average, but less than the expansions of the 1980s or 1990s. The housing downturn greatly magnified other imbalances both directly and via the wealth effect and threw the credit system into turmoil. The economy fell 4.3% peak to trough during the last recession and real GDP only exceeded its fourth-quarter 2007 prerecession peak in the second quarter of 2011. These descriptions differ from previous forecast because of the benchmark GDP revision.

The near recession (early 2014) is an oil-driven recession, compounded by European woes that trim exports, with oil prices shooting up over $150/barrel presumably because of the Middle East, along with a worse recession in Europe. Deteriorating consumer confidence and pain at $5 gasoline prices throw the housing market back into decline and short-circuits recovery in investment—a prospect that the Federal Reserve finds hard to deal with when interest rates are already near zero. The economy only has one negative quarter, but essentially stalls for nine months.

The next expansion continues until late 2018, when a slump in consumer confidence and higher oil prices reduce consumer spending, pushing the economy into another recession before the economy has fully recovered from this one. The economy falls 2.1% peak to trough, or half as bad as the last recession. Over the remainder of the projection period, four additional recessions start in 2025, 2029, and 2036. The 2041 near-recession is long, recording two years without beating even 1% growth.

The current weakness purges some excess inventories and allows an extended run before the next batch of problems develop, but another run-up in oil prices happens when the economy is vulnerable. The severity of these downturns

varies, although each falls within the range of other postwar recessions. The 2029 and 2036 episodes are long and deep. The 2041 episode describes an economy that cannot get its act together after the cyclical recovery from the 2036 recession, and just drifts.

Projection detail

Participation rates and the labor force. The cyclical and trend projections use the same population assumptions. Projected labor force growth is thus similar. In the cyclical projection, lower real wages and higher average unemployment discourage some workers from entering the labor force when the economy is weak, but have the opposite effect when the economy is strong. Overall participation is 183 million by 2043, just 1.3 million below the trend. Demographics interact with the state of the economy, to prevent people from looking for work.

Inflation. Prices are more volatile in the cyclical projection than in the trend. As the expansion matures, demand pressures rekindle inflation, prompting the Federal Reserve to restrict the growth of reserves. Eventually, the higher interest rates dampen demand pressures and slow inflation. However, the increased volatility raises inflationary expectations, forcing the Fed to intervene quickly in response to any evidence of higher prices. Racked by chronically uncomfortable jobless rates, the Fed goes too far, too often to push growth. The Fed is too willing to err on the side of trying to prevent higher inflation rather than a higher unemployment rate, and often ends up with both.

In this scenario, consumer price inflation averages 3.4% annually through 2043, about 1.4 percentage points higher than the trend, although at times it is much worse. Quarterly changes (at annual rates) in the consumer price index range from -5.1% to 8.1%, with oil spikes exacerbating core inflation as much as eight percentage points. The economy stays comfortably away from general deflation, but gets close to it in 2019 at less than 1.0% core inflation. The depth and duration of the last two recession are enough to wring a lot of price pressures out of the economy, but policy mistakes impart an inflation bias in planning. Inflation rates run about two percentage points higher late in the forecast.

The duration and timing of inflationary periods are of prime importance to the business planner. Inflation typically begins to accelerate about a year or so before a recession. Then, when CPI inflation exceeds 2.5–3.0%, the Fed tightens its reins, interest rates rise, and the economy slows. Typically, price increases begin to moderate about two quarters after the onset of recession. The cyclical scenarios assume the Federal Open Market Committee gets well behind the curve and has to slam on the brakes, and near cyclical peaks raises the real federal funds rate 5% above its baseline average of nearly half that. There is no single model variable to measure financial market stress, but wild gyrations in rates can trigger it.

One of the frequent failures in monetary policy is to fight the last war with monetary policy, and the last seven years of the forecast shows this phenomenon. Long and drawn-out recessions ratchet up pressure on the Federal Reserve to do something, so the FOMC tends to wait too long to remove the punchbowl near the next business cycle peak. While the timing of this inflationary episode is purely speculative, the shift in priorities is always a potential fatigue concept when severe pain becomes chronic. The balance between wanting low inflation and wanting low unemployment can always be shifted by politics.

Financial conditions. Before the Federal Reserve adopted its gradualist approach to monetary policy, it was often guilty of stepping too hard on the accelerator or the brake, creating a stop-and-go environment. In the cyclical scenario, we expect some return to that abruptness, predicated on imperfect information, reaction to external shocks, and simple policy mistakes. The Fed does not want to reverse its success of the 1990s, and therefore remains more vigilant than in the 1970s. But it still is prone to overreacting, as well as waiting too long to tighten rates when a recovery gets under way.

Because inflation is more volatile in this cyclical scenario, the federal funds rate is also more volatile. During periods of Fed tightening, the funds rate can rise to 9%, or almost 500 basis points above trend levels.

The yield curve typically inverts during credit crunches, which means that short-term interest rates are higher than long-term rates. This usually happens when the Fed is determined to reduce inflation by raising short-term rates and slowing economic growth. Credible Fed action thus reassures markets that the return on bonds will not be eroded by inflation. Greater market confidence then moderates the rise in long-term yields, while the immediate shortage of liquidity

boosts short-term rates sharply, causing an inversion of the yield curve. As the recession unfolds, a decline in demand for long-term funds by businesses scaling back their investment plans can maintain the inversion.

The business planner should note that interest rates usually begin to rise progressively faster about three quarters or so before a recession arrives, and generally peak in the early stages of the contraction. During the recession and early recovery, rates will decline dramatically. Given this, planners should remember that short-term interest rate cycles, while extremely volatile, are only temporary.

Consumer spending and income. Consumer spending—the single-largest component of GDP—is somewhat insulated from business-cycle fluctuations because of its nondiscretionary components. Total real consumption grows 0.2 percentage point slower than in the baseline. Real consumption of services and nondurable goods (such as food and clothing) therefore remains fairly stable throughout the projection period; nondurables grow 2.2%, while services grow 1.8%, both just under trend growth. Durable goods growth is cooler than in the baseline (0.3 percentage points).

Discretionary purchases of durable goods, however, fluctuate with interest rates and economic conditions, which influence consumers' buying decisions about such big-ticket items as cars and home appliances. Spending on new cars and light trucks, for instance, can rise or fall by 30–40% per year, especially going from boom to bust.

Consumer confidence also plays an important role in the cyclical projection. In favorable economic times, when the unemployment rate is low and people feel more secure about their jobs, consumers spend more and save less. When interest rates rise and fears of inflation take over, consumers cut back or postpone discretionary purchases. On average, though, the underlying uncertainty within this scenario dampens demand for big-ticket items over the entire projection period.

The consumer confidence index provides a fairly accurate gauge of consumers' buying patterns, although it does a better job of predicting recessions than recoveries. Confidence typically slips a quarter or two before a recession (often from rising inflation), and rebounds only when positive economic news convinces consumers that the recession is over. A core component of consumer confidence is the classic misery index of the inflation rate + the unemployment rate. The misery index averages 1.6 percentage points worse in the cycle, but at times is 5 percentage points worse.

Housing. Over the short term, the housing market reacts to prevailing economic conditions. Typically, housing activity leads the economic cycle; home sales begin to decline midway through an expansion in response to rising mortgage rates and home prices, and then revive toward the end of a recession as rates fall and affordability improves. Builders respond quickly to changing demand by adjusting the pace of residential construction. Thus, housing starts can exhibit volatile cyclical swings from year to year, ranging from about 1.0 million to 1.8 million units. The current housing market is so bad that it would be difficult to make it worse, so 2012–13 dominates the low end of the range. Total housing starts only average about 100,000 units lower per year, but the shortfall adds up over 30 years to a large decrease in the stock of houses.

Although demographics and replacement demand are the primary determinants of long-term housing activity, this cyclical economic environment nevertheless takes its toll during recessions, often exacerbated by rising inflation expectations near the peak, which push up mortgage rates. During downturns, housing starts fall as much as 30% below the trend level; conversely, in upturns, they rise 15%. These swings are not unusual: next to inventories, housing is the most volatile sector of the economy. Periods of high inflation-uncertainty and high short-rates push mortgage rates up to levels dampening consumer's desire to buy homes.

Business fixed investment. An uncertain economic landscape is bad for business investment, which suffers long-term damage. In a downturn, climbing interest rates and weak final demand reduce the rate of return on investments. In addition, sluggish cash flow restricts a corporation's ability to replace, upgrade, and expand its capital base. During periods of tight monetary policy, high interest rates choke real fixed investment, which falls below its trend levels during recessions.

Slumping business confidence also undercuts investment. An investment rebound typically lags the overall recovery, as companies first use existing spare capacity to meet growing demand. The business community must also be convinced that the rebound in demand is solid enough to justify adding new plant and equipment. Moreover, investment decisions take time to implement, with projects requiring a period of planning and preparation. Eventually, though, corporations upgrade their facilities during expansions to return capacity utilization rates to their trend levels.

Still, sharp fluctuations in business investment have a slight dampening effect on long-term capital formation. As a share of GDP, business investment averages 13.9% in the cyclical scenario. At key turning points in the cycle, investment's share of GDP can be as much as 1.0 percentage points above or below the trend, but total investment over the 30 years is lower because GDP is lower. The capacity shortfall widens as time goes on because of the lower capital stock accumulated in the cycle.

Inventories traditionally play a key role in business-cycle fluctuations. In this scenario, swings in stock accumulation continue to exacerbate the falloff in real GDP, as firms strive to reduce inventory by trimming production schedules. Stocks usually mirror the peak-to-trough movements in the overall economy, with some buildup occurring near the peak and drawdowns occurring just after the trough. Swings are wildest in durable goods, such as motor vehicles, as well as the broader manufacturing sector.

Government. Changing economic conditions cause wide swings in the budgets of federal, state, and local governments. In the cyclical projection, the federal budget remains in deficit throughout the forecast period. Still, the underlying economic volatility creates a cycle in the surplus: rising transfer payments during recessions increase the federal government's mandatory spending, causing the surplus to narrow.

At the state and local government levels, operating budget surpluses shrink sharply during recessions. Rising demand for services, combined with lower tax receipts and less federal support, erodes the customary cushion. Since states and localities cannot run consistent deficits, spending sometimes has to be cut, exacerbating the cycle and directly reducing employment.

International. Fluctuating economic conditions cause greater volatility in the exchange rate, as the dollar responds to shifting inflation and interest rates. Although higher interest rates attract investment funds to the United States, higher inflation discourages investors from holding dollar-denominated assets. On balance, the real exchange—the nominal exchange rate adjusted for changes between price levels here and abroad—rise above the trend in order to induce foreigners to hold dollars. The exchange rate rises when the US economy becomes an attractive place to invest—that is, when interest rates are high and inflation is low. The dollar usually strengthens in the period immediately following a recession. The 2013 experience is atypical, though, as the dollar rises because Europe is in a mess.

Incorporating business cycles increase the volatility of the real trade balance, but the lower demand for manufactured goods during recessions also reduces this balance. Over the forecast period, the current-account balance as a percent of GNP averages 0.9% in the cyclical projection, as opposed to a 1.6% deficit in the baseline. While that sounds better, it is an artifact of weak consumption and output rather than an exercise in balancing the trade deficit. In individual years, the deficit can be lower or higher depending on how strong consumer and raw materials demands are.

Profits and equities. Corporate profits fluctuate sharply during business cycles. Pretax profits fall dramatically in a recession, but rebound just as quickly with the recovery; the cycle in profits is thus short but steep. Before taxes, profits as a percent of GNP range from 4% above the baseline to 2.5% below, but average close to the baseline over the whole 30-year span. Real GNP is lower in the cycle, so although the shares are close to the same level, the cycle produces less purchasing power in the profits.

Equities follow earnings and thus also exhibit strong, yet short, cyclical patterns: the stock market can lose more than 30% of its value during an economic downturn, but rally just as quickly during the ensuing recovery. Over the longer term, higher inflation raises the stock averages, but undermines their value. Typically, stocks begin to decline a quarter before the onset of recession, and then fall precipitously as the downturn deepens. Stock prices generally start to rebound a

quarter before the recession ends. Stock market moves were not exaggerated in the cycle scenario, but often magnify swings in consumption. The nominal value of stocks may be close in both scenarios, but adjusted for higher inflation in the cycle, the purchasing power of stock prices is much lower in the cycle on average and barely recoups the baseline at the end.

Production and employment. On average, total industrial production declines sharply in recessions. Utilization rates in manufacturing are also volatile, ranging from near 90% during periods of peak demand to below 65% in recessions, like in the second quarter of 2009. Those industries particularly sensitive to interest-rate fluctuations, such as motor vehicles, suffer deeper output declines. On the other hand, industries such as instruments (often medical), food, and utilities remain relatively resistant to changing economic conditions.

Consequently, employment weathers recessions better in some industries than it does in others such as primary metals, rubber and plastics, and lumber. Overall, weaker productivity gains and shifts in labor force composition prevent the unemployment rate from reaching the double-digit rates of the early 1980s. The reorientation of the economy away from manufacturing and toward services also moderates the swings in unemployment. Therefore, we anticipate a jobless rate between 3.5% and 8.0% after the current cycle. Steady declines in labor-force growth also help contain unemployment in the cyclical projection. The unemployment rate swings between feast and famine. The last seven years of stagflation are very hard on manufacturing of goods, so manufacturing payrolls fall to 10.25 million in the 2038 recession, compared with the baseline, which stays near 11.1 million.

Energy. Oil price assumptions strongly influence economic conditions. The inflation-adjusted US refiners' acquisition price of foreign crude exceeds the level in the trend projection; however, this simulation includes several sharp oil price jumps during periods of strong demand, when OPEC can exert greater leverage or let market forces alone drive prices. As in the past, higher energy prices fuel inflationary pressures, which can help precipitate recessions. While a cyclical peak produces very high prices, extremely severe recessions produce very weak demand and depressed prices for long periods of time.

OPEC's oil price shocks have been sustained in some past cases, but have failed in others. This projection incorporates the same assumption on future oil price shocks as our previous cyclical simulation: price increases are always successful, but the shocks themselves are less disruptive than they have been in the past. Although industries dependent on oil remain vulnerable to temporary price volatility, energy price run-ups are generally short-lived, although often to extremes. The economy has managed real oil prices (in 2009 dollars) above $100/barrel, so it may require very sharp acceleration to tip the economy over the edge without another major issue; in 2008 that problem was a financial crunch from the housing bubble. It should be remembered that $100/barrel oil is more of a macroeconomic shock when it is reached by rising from $40/barrel than when it is consistently high—the amount of increase, more than the price level itself, creates the shock. Real prices range from only 70% of the baseline to double the baseline. The 30-year average real oil price is only about $3/barrel higher in the cyclical scenario, but the troughs are deeper and longer. Nominal price swings are compounded by higher inflation in the cyclical scenario, yielding nominal prices as high as $250/barrel. The potential of oil to trigger large shifts in consumer spending diminishes as the energy share of spending declines from almost 6% of consumer spending in 2008 to just over 3% by 2043. Thus, energy's share of total consumption is one-half the share of total consumption in 2043 than it was in 2011. Needless to say, wild fluctuations in oil and gas prices yield wild swings in drilling expenditures. The oil price spike of 2024–25 really gets drilling expenditures booming, since the high oil prices last long enough to trigger massive drilling gains.

by Michael Montgomery

Optimistic and Pessimistic Projections

A range of possibilities: Optimistic and pessimistic projections

Highlights

- Real GDP advances 2.9% per year on average over the next 30 years in the optimistic scenario (optim). This is above the 2.7% average for 1982–2012, and higher than the projected averages of 2.5% in the baseline (trend) and 1.9% in the pessimistic scenario (pessim).
- Despite optim's strong growth, inflation as measured by the GDP deflator averages a moderate 1.5%, compared with the averages of 1.8% in the trend and 3.5% in the pessim.
- While the federal budget remains in deficit over the next 30 years in the trend and the pessim, the budget swings into surplus after 2028 in the optim.
- In the pessim, business fixed investment grows 3.4% a year on average, compared with 3.8% in the optim and 3.4% in the baseline.
- Output per man-hour rises 2.1% in the optim, 1.8% in trend, and 1.4% in the pessim.

The optimistic scenario is characterized by strong GDP growth and moderate inflation, with higher rates of growth in capital spending and factor-productivity relative to the trend. The pessimistic alternative (which encompasses opposite assumptions on labor force, capital stock, and factor productivity) exhibits higher inflation than optim, partly because of escalating energy prices.

In the optimistic case, real GDP growth averages 2.9% annually, above the 2.7% average for 1982–2012, and higher than the projected averages of 2.5% in the baseline. Consumer price inflation, on the other hand, averages only 1.6%, well below the previous 30-year rate of 3.0%. The high-growth, low-inflation environment depicted here is especially favorable to durable-goods spending categories such as business fixed investment, housing construction, and motor vehicles. In contrast, the low-growth environment of the pessimistic projection debilitates these same sectors. For example, in optim, housing starts are 51% higher than its trend level by 2043, while in pessim, it is 39% lower.

Projection detail

Participation rates and the labor force. These two scenarios incorporate different demographic assumptions from those in the trend, leading to varying labor force growth and participation rates. The optimistic outlook assumes that the US population will grow more quickly because of higher net immigration. The pessimistic alternative constricts growth in the labor force, the result of lower assumed net immigration. As a result, the US population increases from 315 million in 2012 to 397 million by 2043 in the optim, but to 377 million in the pessim, compared with the 387 million in the trend. Annual population growth averages 0.8% in optim, 0.6% in pessim and 0.7% in the baseline.

Thus, by 2043, the adult population (aged 16 and over) is roughly 3.0% higher in optim than in the trend, while it is 2.8% lower in pessim, directly affecting the labor force. By 2043, the civilian labor force is 6.4% higher in optim and 3.8% lower in pessim relative to the trend. Labor-force growth averages 0.8% in optim and 0.4% in pessim over the next 30 years, compared with the 0.6% annual gains in the trend.

Potential output. Over the longer term, the economy's actual growth is constrained by the expansion of potential output. The optimistic scenario, with its above-trend supply factors, yields average potential output growth of 2.5% per year through 2043. In the pessimistic scenario, with its slower labor-force and capital-stock growth, potential production is limited to 1.6% gains over the forecast interval.

Inflation. The subdued inflation in the optimistic scenario depends on relatively low energy prices and moderate wage increases. When combined with faster productivity growth, consumer price inflation averages 1.6% per year through 2043, compared with 2.0% in the trend and 3.0% over the past 30 years. In the pessimistic case, inflation is fanned by higher

commodity prices. Rising energy prices, wages, and import prices combine to push consumer price inflation also up to 4.0% annually in 2043 in the pessim.

Financial conditions. The federal funds rate averages 5.9% in pessim and 3.1% in optim, compared with the trend's 3.6% rate. The rate would be higher in pessim, but the Federal Reserve compromises between fighting the inflationary forces of rising oil prices and pushing the economy into recession. At the long end of the maturity spectrum, the 10-year government bond yield stabilizes at 3.9% in the optim, while topping out at 7.8% in 2043 in the pessim. The steeper yield curve in pessim reflects mounting concerns about the inflationary outlook, given the Fed's accommodative monetary policy and accelerating inflation.

Consumer spending and income. Real consumer spending averages 2.7% annual growth in optim, 0.4 percentage point above the trend rate. Real per capita consumption expands an average of 2.0% (optim), exactly matching its 2.0% annual rate over the past 30 years.

Income-sensitive durable goods are affected the most. Spending on consumer durables rises an average 5.2% per year in optim, 0.6 percentage point stronger than the trend growth rate; in pessim, growth in the same spending category averages just 3.5%. In the optimistic scenario, light-vehicle sales average 18.3 million units per year, pushing the stock of cars and light trucks 12.3% above its trend level by 2043.

Real personal income averages 2.8% annual gains in optim, up from 2.5% in the trend. Income grows only 2.1% per year in pessim.

Housing. Since the demographic forces of population growth and household formation are the main long-term determinants of new residential construction, we would expect the housing outlook to be weaker in pessim and stronger in optim relative to the trend. In fact, the disparity between interest rates in the two bandwidth alternatives drives their respective housing outlooks even further apart. The conventional mortgage rate averages 6.0% in optim, below its 8.5% average in pessim and 6.4% in the trend.

Demographics and interest rates determine the housing outlook. Housing starts average slightly more than 2.2 million units per year in optim and 1.0 million in pessim. By 2043, the housing stock in optim is 13% above the trend level, while in pessim, it stands about 10% below. Because of the gloomier inflation picture in pessim, the slower economy pushes the average nominal price of a new home to $950,800 in 2043, compared with $631,600 in the trend and $547,100 in the optimistic alternative.

Business fixed investment. The extremely volatile investment sector reacts strongly to the differing assumptions in the alternatives. Business investment suffers long-term damage in pessim, as weak final demand and higher interest rates raise the cost of capital, lower the rate of return on investments, and weaken investor confidence. The economy's overall sluggishness also hurts the profitability of corporations, limiting the funds available for investment. Thus, business fixed investment grows only 2.9% annually in the pessimistic case, compared with 3.4% in the trend and 3.8% in the optimistic scenario.

Corporations may choose from several options to finance plant and equipment expansion. The type of inflationary environment in which they operate is likely to influence whether they finance by issuing stocks or bonds, selling short-term commercial paper or obtaining bank loans, or using internally generated funds. The higher inflation in the pessimistic environment encourages firms to rely more heavily on relatively scarce internal funds to finance investment—avoiding the payouts associated with stocks, bonds, and bank loans. In addition, high inflation depresses the real value of depreciation allowances, constraining corporate cash flow and, subsequently, business fixed investment.

Government. The taxation policy assumptions in the two bandwidth scenarios are similar to those in the trend. The government expenditure assumptions are different, however, largely reflecting the different growth paths and demographic assumptions of the optim and pessim projections. In pessim, a weaker economy leads to a higher ratio of federal spending to GDP. Higher interest rates on past debt and larger operating deficits boost federal interest payments, exacerbating the persistent shortfalls.

Federal government outlays as a share of GDP average 20.5% in optim, 26.7% in pessim, and 23.0% in the trend. They are higher in pessim because of the slower economy and the need to make larger transfer payments. As a share of GDP, the federal budget deficit is 2.0% of GDP in the trend, compared with 5.4% in the pessim and 0.0% in optim.

Unlike the federal government, state and local governments must maintain budgets close to balance. Therefore, their spending is tied closely to available revenue, which is created by economic activity within their regions. Increases in real state and local government purchases average 1.4% in optim, 1.0% in trend, and 0.4% in pessim.

International. The world is assumed to become more open to trade in all the scenarios, but it opens up most quickly in the optimistic alternative and most slowly in the pessimistic projection. In the optimistic outlook, the nation's major trading partners are also assumed to experience strong output growth and low inflation. Real export growth averages 6.0% per year in optim, versus 5.4% in the trend and 5.2% in the pessim; real import growth averages 4.5% annually in optim, versus 3.9% in the trend and 3.2% in the pessim.

Industrial production and employment. In the pessimistic scenario, the index of industrial production is about 21% below the trend level by 2043. Total nonfarm employment is about 5% lower, consistent with the labor-force participation projections. The pattern of employment losses by industry reflects output differences from trend levels, as well as productivity losses in individual industries.

Over the projection period, total payroll employment rises by about 40 million in the trend, 49 million in optim, and 32 million in pessim; the last 30 years saw total payrolls increase by about 44 million workers. Payroll employment in the optimistic scenario is about 5% above its trend level by 2043. Manufacturing employment slips up from 11.9 million in 2012 to 11.4 million in 2043 in the optim. In the pessim, manufacturing payrolls decline to 10.3 million.

Energy. The optimistic scenario assumes that energy availability is greater than in the trend, facilitating stronger economic growth by the United States and its major trading partners. Total US energy usage is boosted to 120 quadrillion British thermal units (quads) by 2043 in this scenario, compared with 107 quads in the trend.

In the long run, production costs determine energy prices. Technological improvements lower production costs, but drilling deeper holes raises them. In the optim scenario, technology wins out, and real oil prices drop; in the pessim, rising costs dominate, and real oil prices rise. In the baseline, the two forces offset, and real oil prices stabilize.

Technical Appendix – Volume II

KU, LG&E, & ODP
Commercial Forecast Models

2014 IRP

Table of Contents

Commercial Forecast

The following sections summarize the design of the companies' commercial model and key input data sources. Average monthly use is forecast for LG&E, KU and ODP under the assumption of normal weather. In the 2014 IRP, commercial forecasting is done on a total use basis and then use-per-customer is derived. This allows for response to the changing economic conditions surrounding commercial growth. A total use model allows for a weighted employment and production economic term to be used in place of the output term described in the following sections. The use of employment within the model allows for a better fit and more accurate forecast. The model takes advantage of all end-use data.

Model Design

The commercial statistically adjusted end-use model framework begins by defining energy use ($USE_{y,m}$) in year (y) and month (m) as the sum of energy used by heating equipment ($Heat_{y,m}$), cooling equipment ($Cool_{y,m}$) and other equipment ($Other_{y,m}$). Formally,

$$USE_{y,m} = Heat_{y,m} + Cool_{y,m} + Other_{y,m}$$

Although monthly sales are measured for individual customers, the end-use components are not. Substituting estimates for the end-use elements gives the following econometric equation.

$$USE_{m} = a + b_1 XHeat_{m} + b_2 XCool_{m} + b_3 XOther_{m}$$

Here, $XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, weather data, and market data. As will be shown below, the equations used to construct these X-variables are simplified end-use models, and the X-variables are the estimated usage levels for each of the major end uses based on these models. The estimated model can then be thought of as a statistically adjusted end-use model, where the estimated slopes are the adjustment factors.

The sections shown below are copied from the Itron Commercial SAE document.

X Variables: XHeat

As represented in the Commercial SAE spreadsheets, energy use by space heating systems depends on the following types of variables.

- Heating degree days,
- Heating equipment saturation levels,
- Heating equipment operating efficiencies,
- Average number of days in the billing cycle for each month, and
- Commercial output and energy price.

The heating variable is represented as the product of an annual equipment index and a monthly usage multiplier. That is,

$$\mathrm{XHeat}_{y,m} = \mathrm{HeatIndex}_{y} \times \mathrm{HeatUse}_{y,m} \qquad (3)$$

where, $XHeat_{y,m}$ is estimated heating energy use in year (y) and month (m),
$HeatIndex_y$ is the annual index of heating equipment, and
$HeatUse_{y,m}$ is the monthly usage multiplier.

The heating equipment index is composed of electric space heating equipment saturation levels normalized by operating efficiency levels. The index will change over time with changes in heating equipment saturations (*HeatShare*) and operating efficiencies (*Eff*). Formally, the equipment index is defined as:

$$HeatIndex_y = HeatSales_{04} \times \frac{\left(HeatShare_y / Eff_y \right)}{\left(HeatShare_{04} / Eff_{04} \right)} \quad (4)$$

In this expression, 2004 is used as a base year for normalizing the index. The ratio on the right is equal to 1.0 in 2004. In other years, it will be greater than one if equipment saturation levels are above their 2004 level. This will be counteracted by higher efficiency levels, which will drive the index downward. Base year space heating sales are defined as follows.

$$HeatSales_{04} = \left(\frac{kWh}{Sqft} \right)_{Heating} \times \left(\frac{CommercialSales_{04}}{\sum_e kWh / Sqft_e} \right) \quad (5)$$

Here, base-year sales for space heating is the product of the average space heating intensity value and the ratio of total commercial sales in the base year over the sum of the end-use intensity values. In the Commercial SAE Spreadsheets, the space heating sales value is defined on the *BaseYrInput* tab. The resulting $HeatIndex_y$ value in 2004 will be equal to the estimated annual heating sales in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

Heating system usage levels are impacted on a monthly basis by several factors, including weather, commercial level economic activity, prices and billing days. Using the COMMEND default elasticity parameters, the estimates for space heating equipment usage levels are computed as follows:

$$HeatUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5} \right) \times \left(\frac{WgtHDD_{y,m}}{HDD_{04}} \right) \times \left(\frac{Output_y}{Output_{04}} \right)^{0.20} \times \left(\frac{Price_{y,m}}{Price_{04}} \right)^{-0.18} \quad (6)$$

where, *BDays* is the number of billing days in year (y) and month (m), these values are normalized by 30.5 which is the average number of billing days
WgtHDD is the weighted number of heating degree days in year (y) and month (m). This is constructed as the weighted sum of the current month's HDD and the prior month's HDD. The weights are 75% on the current month and 25% on the prior month.
HDD is the annual heating degree days for 2004,

Output is a real commercial output driver in year (y),
Price is the average real price of electricity in month (m) and year (y),

By construction, the $HeatUse_{y,m}$ variable has an annual sum that is close to one in the base year (2004). The first two terms, which involve billing days and heating degree days, serve to allocate annual values to months of the year. The remaining terms average to one in the base year. In other years, the values will reflect changes in commercial output and prices, as transformed through the end-use elasticity parameters. For example, if the real price of electricity goes up 10% relative to the base year value, the price term will contribute a multiplier of about .98 (computed as 1.10 to the -0.18 power).

X Variables: XCool

The explanatory variable for cooling loads is constructed in a similar manner. The amount of energy used by cooling systems depends on the following types of variables.

- Cooling degree days,
- Cooling equipment saturation levels,
- Cooling equipment operating efficiencies,
- Average number of days in the billing cycle for each month, and
- Commercial output and energy price.

The cooling variable is represented as the product of an equipment-based index and monthly usage multiplier. That is,

$$\mathrm{XCool}_{y,m} = \mathrm{CoolIndex}_{y} \times \mathrm{CoolUse}_{y,m} \tag{7}$$

where, $XCool_{y,m}$ is estimated cooling energy use in year (y) and month (m),
$CoolIndex_y$ is an index of cooling equipment, and
$CoolUse_{y,m}$ is the monthly usage multiplier.

As with heating, the cooling equipment index depends on equipment saturation levels (*CoolShare*) normalized by operating efficiency levels (*Eff*). Formally, the cooling equipment index is defined as:

$$CoolIndex_{y} = CoolSales_{04} \times \frac{\left(CoolShare_{y} / Eff_{y} \right)}{\left(CoolShare_{04} / Eff_{04} \right)} \tag{8}$$

Data values in 2004 are used as a base year for normalizing the index, and the ratio on the right is equal to 1.0 in 2004. In other years, it will be greater than one if equipment saturation levels are above their 2004 level. This will be counteracted by higher efficiency levels, which will drive the index downward. Estimates of base year cooling sales are defined as follows.

$$CoolSales_{04} = \left(\frac{kWh}{Sqft}\right)_{Cooling} \times \left(\frac{CommercialSales_{04}}{\sum_{e} kWh/Sqft_{e}}\right) \tag{9}$$

Here, base-year sales for space cooling is the product of the average space cooling intensity value and the ratio of total commercial sales in the base year over the sum of the end-use intensity values. In the Commercial SAE Spreadsheets, the space cooling sales value is defined on the *BaseYrInput* tab. The resulting *CoolIndex* value in 2004 will be equal to the estimated annual cooling sales in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

Cooling system usage levels are impacted on a monthly basis by several factors, including weather, economic activity levels and prices. Using the COMMEND default parameters, the estimates of cooling equipment usage levels are computed as follows:

$$CoolUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5}\right) \times \left(\frac{WgtCDD_{y,m}}{CDD_{04}}\right) \times \left(\frac{Output_{y}}{Output_{04}}\right)^{0.20} \times \left(\frac{Price_{y,m}}{Price_{04}}\right)^{-0.18} \tag{10}$$

where, *WgtCDD* is the weighted number of cooling degree days in year (y) and month (m). This is constructed as the weighted sum of the current month's CDD and the prior month's CDD. The weights are 75% on the current month and 25% on the prior month.

CDD is the annual cooling degree days for 2004.

By construction, the *CoolUse* variable has an annual sum that is close to one in the base year (2004). The first two terms, which involve billing days and cooling degree days, serve to allocate annual values to months of the year. The remaining terms average to one in the base year. In other years, the values will change to reflect changes in commercial output and prices.

X Variables: XOther

Monthly estimates of non-weather sensitive sales can be derived in a similar fashion to space heating and cooling. Based on end-use concepts, other sales are driven by:

- Equipment saturation levels,
- Equipment efficiency levels,
- Average number of days in the billing cycle for each month, and
- Real commercial output and real prices.

The explanatory variable for other uses is defined as follows:

$$\text{XOther}_{y,m} = \text{OtherIndex}_{y,m} \times \text{OtherUse}_{y,m} \tag{11}$$

The second term on the right hand side of this expression embodies information about equipment saturation levels and efficiency levels. The equipment index for other uses is defined as follows:

$$OtherIndex_{y,m} = \sum_{Type} Weight_{04}^{Type} \times \left(\frac{Share_y^{Type} \Big/ Eff_y^{Type}}{Share_{04}^{Type} \Big/ Eff_{04}^{Type}} \right) \tag{12}$$

where, *Weight* is the weight for each equipment type,
Share represents the fraction of floor stock with an equipment type, and
Eff is the average operating efficiency.

This index combines information about trends in saturation levels and efficiency levels for the main equipment categories. The weights are defined as follows.

$$Weight_{04}^{Type} = \left(\frac{kWh}{Sqft} \right)_{Type} \times \left(\frac{CommercialSales_{04}}{\sum_e kWh \Big/ Sqft_e} \right) \tag{13}$$

Further monthly variation is introduced by multiplying by usage factors that cut across all end uses, constructed as follows:

$$OtherUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5} \right) \times \left(\frac{Output_y}{Output_{04}} \right)^{0.20} \times \left(\frac{\text{Price}_{y,m}}{\text{Price}_{04}} \right)^{-0.18} \tag{14}$$

In this expression, the elasticities on output and real price are computed from the COMMEND default values.

Input Data Sources

Developing the 'X' variables for the SAE model is data intensive, and employs inputs from a number of sources. The 2014 IRP residential forecast models relied on inputs from the Energy Information Administration (EIA) for forecasts of saturations and efficiencies, which are inputs into the Index variables mentioned above. The results of an appliance saturation survey conducted in 2011 provided base-year saturations, as well as demographic variables such as the number of people per household, and structural variables such as dwelling size, age and type (single-family, multi-family, mobile home). Unit Energy Consumption (UEC) values were obtained from the EIA (also an input into the aforementioned Index variables).

Use variables are predominantly functions of weather, demographics, and economics. In the 2014 IRP, data sources include the National Oceanic & Atmospheric Association (NOAA) and Global Insight. The elasticities of demand (i.e., the exponents of each of the components in the Use equations) were created via a discussion with Itron and research by LG&E/KU.

Technical Appendix – Volume II

KU, LG&E, & ODP
Residential Use-per-Customer Forecast Models

2014 IRP

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Residential Use-per-Customer Forecast

The following sections summarize the design of the companies' residential use-per-customer model and key input data sources. Average monthly use per customer is forecast for LG&E, KU and ODP under the assumption of normal weather.

Model Design

Average use per customer is forecasted using a Statistically-Adjusted End-Use (SAE) Model. Such a model combines an econometric model – that relates monthly sales to various explanatory variables such as weather and economic conditions – with traditional end-use modeling. The SAE approach defines energy use as a function of energy used by heating equipment, cooling equipment, and other equipment.

$$\text{Use-per-Customer} = a_1*\text{XHeat} + a_2*\text{XCool} + a_3*\text{XOther}$$

The heating, cooling and other components (the X variables) are based on various input variables like appliance saturations, efficiencies, and economic and demographic variables such as income, population, member per household and electricity prices. Once these components have been computed, a regression model is specified to forecast use-per-customer as a function of these components. Each of these components is discussed in more detail in the following paragraphs.

X Variables: XHeat

Heating use is dependent upon heating degree days, heating equipment saturation levels, heating equipment operation efficiencies, thermal integrity of homes, average household size, average household income, and electric price. The heating variable is represented as the product of an annual equipment index and a usage multiplier as illustrated below:

$$\text{XHeat}_{y,m} = \text{HeatIndex}_y * \text{HeatUse}_{y,}$$

Where:

$\text{XHeat}_{y,}$ = Estimated heating energy use for the year
HeatIndex_y = Annual index of heating equipment
HeatUse_y = Annual usage multiplier

The Heating Index variable above is defined as a weighted average across equipment type of equipment saturation levels normalized by operating efficiency levels. Heating equipment modeled include heat pumps, electric space heating, and electric furnaces. Formally, this heating equipment index is:

$$HeatIndex_y = \sum_{Type} Wgt^{Type} * \frac{\left[HeatShare^{Type}_{y} \Big/ Eff^{Type}_{y} \right]}{\left[HeatShare^{Type}_{by} \Big/ Eff^{Type}_{by} \right]}$$

Where:

$HeatShare^{Type}_{y}$	= Share of heating appliance for each year
$HeatShare^{Type}_{by}$	= Share of heating appliance in base year
Eff^{Type}_{y}	= Efficiency of heating appliance for each year
Eff^{Type}_{by}	= Efficiency of heating appliance in base year
Wgt^{Type}	= Base year heating appliance energy divided by total households in base year

The HeatUse variable defined above is impacted by the following exogenous variables: heating degree-days, household size, household income, and electric price. The heating degree-days are derived using daily high/low temperature observations (from the Lexington and Louisville weather stations for KU and LG&E, respectively) and a 65-degree base. The HeatUse variable is defined as:

$$HeatUse_{y,m} = \left[\frac{HDD_y}{NormHDD} \right] \left[\frac{HHSize_y}{HHSize_{by}} \right] 0.35 \left[\frac{Income_y}{Income_{by}} \right] 0.20 \left[\frac{Price_y}{Price_{y-1,2,3}} \right] -e$$

Where:

HDD_y	= Heating Degree days in a given year
NormHDD	= Normal value of annual heating degree days
$HHSize_y$	= Average household size in a year
$HHSize_{by}$	= Average household size in a base year
$Income_y$	= Average real income per household in a year
$Income_{by}$	= Average real income per household in base year
$Price_y$	= Average real price of electricity in base year
$Price_{y-1,2,3}$	= Average real price of electricity in previous years
e	= Price elasticity

X Variables: XCool

The construction of the cooling use component is similar to that of the heating use component in that it is dependent upon cooling degree-days, cooling equipment

saturations, cooling equipment operation efficiencies, and average household size, average household income, and electric energy prices. The cooling variable is represented as the product of an annual equipment index and a usage multiplier as illustrated below:

$$XCool_{y,m} = CoolIndex_y * CoolUse_y$$

Where:

$XCool_y$ = Estimated cooling energy use for the year
$CoolIndex_y$ = Annual index of cooling equipment
$CoolUse_y$ = Annual usage multiplier

The Cooling Index variable above is defined as a weighted average across equipment type of equipment saturation levels normalized by operating efficiency levels. Cooling equipment modeled includes heat pumps, room air conditioners, and central air conditioners. Formally, this Cooling equipment index is:

$$CoolIndex_y = \sum_{Type} Wgt^{Type} * \frac{\left[CoolShare^{Type}_{y} \Big/ Eff^{Type}_{y} \right]}{\left[CoolShare^{Type}_{by} \Big/ Eff^{Type}_{by} \right]}$$

Where:

$CoolShare^{Type}_{y}$ = Share of cooling appliance for each year
$CoolShare^{Type}_{by}$ = Share of cooling appliance in base year
Eff^{Type}_{y} = Efficiency of cooling appliance for each year
Eff^{Type}_{by} = Efficiency of cooling appliance in base year
Wgt^{Type} = Base year cooling appliance energy divided by total households in base year

The CoolUse variable defined above is impacted by the following exogenous variables: cooling degree-days, household size, household income, and electric price. As for the HDDs, the cooling degree-days are derived using daily high/low temperature observations against a 65-degree base. The CoolUse variable is defined as:

$$CoolUse_y = \left(\frac{CDD_y}{NormCDD} \right) \left(\frac{HHSize_y}{HHSize_{by}} \right) 0.35 \left(\frac{Income_y}{Income_{by}} \right) 0.20 \left(\frac{Price_y}{Price_{y-1,2,3}} \right) \text{-e}$$

Where:

CDD_y = Cooling Degree days in year and month
NormCDD = Normal value of annual cooling degree days
$HHSize_y$ = Average household size in a year

$HHSize_b$ = Average household size in base year
$Income_y$ = Average real income per household in a year
$Income_{by}$ = Average real price of electricity in base year
$Price_{y-1,2,3}$ = Average real price of electricity in previous years
e = Price elasticity

X Variables: XOther

The "Other" use component is a monthly estimate of non-weather sales and is derived from appliance and equipment saturation levels, appliance efficiency levels, average number of billing days per month, average household size, average household income, and electric prices. The explanatory variable for Other use is defined as follows:

$$XOther_y = OtherIndex_y * OtherUse_y$$

Where:

$XOther_y$ = Estimated heating energy use for the year
$OtherIndex_y$ = Annual index of non heating or cooling equipment
$OtherUse_y$ = Annual usage multiplier

The OtherIndex variable embodies information about appliance saturation levels and efficiency levels. The appliances modeled include electric water heaters, refrigerators, freezers, electric cooking stoves, electric dryers, dishwashers, washing machines, and miscellaneous appliances. The equation is defined as follows:

$$OtherIndex_{y,m} = \sum_{Type} Wgt^{Type} * \frac{\left[Sat^{Type}_{y} / Eff^{Type}_{y} \right]}{\left[Sat^{Type}_{by} / Eff^{Type}_{by} \right]}$$

Where:

Sat^{Type}_{y} = Share of appliance type per year
Sat^{Type}_{b} = Share of appliance type in base year
Eff^{Type}_{y} = Efficiency of appliance per year
Eff^{Type}_{by} = Efficiency of appliance in base year

The OtherUse variable is impacted by the following exogenous variables: billing days, household size, household income and electric price. Billing days are defined as the number of billing days for the year. The OtherUse variable is defined as:

$$OtherUse_{y,m} = \left[\frac{BillingDays_y}{365} \right] \left[\frac{HHSize_y}{HHSize_{by}} \right] 0.46 \left[\frac{Income_y}{Income_{by}} \right] 0.10 \left[\frac{Price_y}{Price_{y-1,2,3}} \right] -e$$

Where:

$BillingDays_y$	= Billing days for the year
$HHSize_y$	= Average household size in a year
$HHSize_{by}$	= Average household size in base year
$Income_y$	= Average real income per household in a year
$Income_{by}$	= Average real income per household in base year
$Price_y$	= Average real price of electricity for the year
$Price_{y-1,2,3}$	= Average real price of electricity in previous years
e	= Price elasticity

Input Data Sources

Developing the 'X' variables for the SAE model is data intensive, and employs inputs from a number of sources. In the 2014 IRP residential forecast models relied on inputs from the Energy Information Administration (EIA) for forecasts of saturations and efficiencies, which are inputs into the Index variables mentioned above. The results of an appliance saturation survey conducted in 2010 provided base-year saturations, as well as demographic variables such as the number of people per household, and structural variables such as dwelling size, age and type (single-family, multi-family, mobile home). Unit Energy Consumption (UEC) values were obtained from the EIA (also an input into the aforementioned Index variables).

Use variables are predominantly functions of weather, demographics, and economics. In the 2014 IRP forecast, data sources include the National Oceanic & Atmospheric Association (NOAA) and Global Insight. The elasticities of demand (i.e., the exponents of each of the components in the Use equations) were created via a discussion with Itron and research by LG&E/KU.