2019
Integrated Resource Plan

Technical Appendix

Volume 1

Load Forecast

REDACTED

EAST KENTUCKY POWER COOPERATIVE

A Touchstone Energy® Cooperative

2018
Load Forecast

Prepared by:
Load Forecasting Department

December 2018

TABLE OF CONTENTS

SECTION 1.0

EXECUTIVE SUMMARY

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Section 1.0
Executive Summary

East Kentucky Power Cooperative Inc. (EKPC) is a generation and transmission electric cooperative located in Winchester, Kentucky. EKPC is owned by 16 owner-member distribution cooperatives (owner-members) that have approximately 538,000 retail meters serving a population of approximately 1,100,000.

EKPC's load forecast is prepared every two years in accordance with EKPC's Rural Utilities Service (RUS) - approved Work Plan. EKPC's "2018 Load Forecast" was prepared pursuant to its "2018-2019 Load Forecast Work Plan" (the Work Plan), which was approved by EKPC's Board of Directors in December 2017 and by RUS in December 2017. The Work Plan details the methodology used to develop the projections. The EKPC Load Forecasting Department works with the staff of each owner-member to prepare its forecast and then aggregates the 16 owner-member forecasts, adding forecasts of own use and losses, and subtracting planned demand-side management to create EKPC's forecast. Owner-members use their load forecasts in developing construction work plans, long-range work plans, and financial forecasts. EKPC uses the load forecast for demand-side management analyses, marketing analyses, transmission planning, power supply planning, and financial forecasting.

EKPC's load forecast projects total energy requirements to increase from 13.4 to 17.7 million MWh, an average of 1.4 percent per year over the 2018 through 2038 period. Net winter and summer peak demands will increase by approximately 477 MW or 0.7 percent and 450 MW or 0.9 percent respectively over weather normalized 2018 to 2038. Annual load factor projections are increasing from 48 percent to approximately 55 percent. Historical and projected total energy requirements, seasonal peak demands, and annual load factor for the EKPC system are presented in Table 1-2. Peak demands are based on coincident hourly-integrated demand intervals. Load factor is calculated using annual net peak demand and energy requirements.

Energy projections for the residential, small commercial, and large commercial classifications indicate that during the 2018 through 2038 period, sales to the residential class will increase by 0.9 percent per year, commercial and industrial sales ≤1000 KVA will increase by 1.0 percent per year, and commercial and industrial sales >1000 KVA will increase by 2.6 percent per year as shown in Table 1-1. Class sales are presented in Table 1-3.

Table 1-1

Growth Rates

	2018-2023	2018-2028	2018-2038
Net Total Energy Requirements	2.8%	1.9%	1.4%
Residential Energy Sales	0.8%	0.9%	0.9%
Commercial and Industrial ≤ 1000 KVA Energy Sales	1.1%	1.0%	1.0%
Commercial and Industrial > 1000 KVA Energy Sales	7.8%	4.4%	2.6%
	2018-2023	**2018-2028**	**2018-2038**
Net Winter Peak Demand	0.8%	0.8%	0.7%
Net Summer Peak Demand	0.8%	0.9%	0.9%

Factors considered in preparing the forecast include national, regional, and local economic performance, population and housing trends, service area industrial development, electric price, household income, appliance saturations and efficiencies, demand-side management programs, and weather. Assumption details are discussed in Section 3.

Table 1-2

Peak Demands and Total Requirements

Historical and Projected

Season	Winter Peak Demand (MW)	Year	Summer Peak Demand (MW)	Year	Total Requirements (MWh)	Load Factor (%)
2006 - 07	2,840	2007	2,481	2007	13,080,367	52.6%
2007 - 08	3,051	2008	2,243	2008	12,948,091	48.3%
2008 - 09	3,152	2009	2,195	2009	12,380,972	44.8%
2009 - 10	2,868	2010	2,443	2010	13,376,292	53.2%
2010 - 11	2,891	2011	2,388	2011	12,666,998	50.0%
2011 - 12	2,481	2012	2,354	2012	12,190,070	55.9%
2012 - 13	2,597	2013	2,199	2013	12,644,590	55.6%
2013 - 14	3,425	2014	2,192	2014	13,163,516	43.9%
2014 - 15	3,507	2015	2,179	2015	12,604,942	41.0%
2015 - 16	2,890	2016	2,293	2016	13,039,953	51.4%
2016 - 17	2,871	2017	2,311	2017	12,680,111	50.4%
2017 - 18	3,437	2018	2,375	2018	13,369,007	44.4%
2018 - 19	3,258	2019	2,341	2019	13,735,980	48.1%
2019 - 20	3,281	2020	2,377	2020	14,354,291	49.8%
2020 - 21	3,323	2021	2,425	2021	15,109,727	51.9%
2021 - 22	3,349	2022	2,448	2022	15,241,723	52.0%
2022 - 23	3,373	2023	2,457	2023	15,373,488	52.0%
2023 - 24	3,401	2024	2,483	2024	15,555,697	52.1%
2024 - 25	3,418	2025	2,505	2025	15,704,283	52.5%
2025 - 26	3,444	2026	2,532	2026	15,862,441	52.6%
2026 - 27	3,468	2027	2,545	2027	16,012,368	52.7%
2027 - 28	3,502	2028	2,576	2028	16,185,645	52.6%
2028 - 29	3,514	2029	2,595	2029	16,292,394	52.9%
2029 - 30	3,531	2030	2,622	2030	16,429,025	53.1%
2030 - 31	3,540	2031	2,639	2031	16,571,785	53.4%
2031 - 32	3,568	2032	2,664	2032	16,752,464	53.5%
2032 - 33	3,585	2033	2,685	2033	16,879,184	53.7%
2033 - 34	3,608	2034	2,709	2034	17,048,653	53.9%
2034 - 35	3,633	2035	2,688	2035	17,218,531	54.1%
2035 - 36	3,665	2036	2,764	2036	17,416,209	54.1%
2036 - 37	3,681	2037	2,786	2037	17,547,441	54.4%
2037 - 38	3,711	2038	2,813	2038	17,708,142	54.5%

Impacts from demand response and energy efficiency programs have been subtracted from the projections.

Table 1-3

Class Sales

Year	Residential Sales (MWh)	Seasonal Sales (MWh)	Small Comm. Sales (MWh)	Public Buildings Sales (MWh)	Large Comm. Sales (MWh)	Public Street / Highway Lighting Sales (MWh)	Total Retail Sales (MWh)
2007	6,998,554	14,679	1,861,952	26,427	3,124,043	8,457	12,034,113
2008	7,055,277	14,531	1,872,811	34,074	3,083,589	9,477	12,069,760
2009	6,789,142	13,080	1,787,112	35,507	2,831,935	9,065	11,465,841
2010	7,388,901	13,959	1,935,479	39,809	2,845,857	9,503	12,233,507
2011	6,967,413	12,774	1,892,090	38,468	2,889,142	9,845	11,809,733
2012	6,577,784	227	1,883,241	35,194	2,901,688	9,600	11,407,734
2013	6,909,853	300	1,917,730	37,215	3,017,925	9,845	11,892,868
2014	7,142,350	370	1,919,198	39,753	3,246,287	9,916	12,357,874
2015	6,781,622	354	1,958,109	38,996	2,979,716	9,890	11,768,687
2016	6,847,090	416	1,951,787	37,627	3,296,495	9,940	12,143,355
2017	6,517,101	534	1,896,475	36,578	3,395,430	9,325	11,855,444
2018	7,055,642	503	1,958,436	39,136	3,398,144	8,912	12,460,774
2019	7,154,796	538	2,000,123	39,560	3,608,750	8,983	12,812,750
2020	7,188,311	574	2,025,733	40,028	4,144,183	9,051	13,407,879
2021	7,175,389	610	2,036,273	40,400	4,874,338	9,118	14,136,129
2022	7,207,766	649	2,052,964	40,819	4,940,304	9,185	14,251,687
2023	7,247,866	686	2,068,392	41,248	5,007,458	9,251	14,374,902
2024	7,333,909	725	2,089,435	41,702	5,071,019	9,333	14,546,124
2025	7,388,926	761	2,103,105	42,085	5,140,502	9,417	14,684,795
2026	7,457,583	797	2,123,423	42,522	5,198,169	9,501	14,831,995
2027	7,532,016	830	2,145,020	42,958	5,240,948	9,575	14,971,348
2028	7,623,433	873	2,170,088	43,422	5,287,182	9,639	15,134,636
2029	7,662,936	907	2,186,914	43,804	5,328,538	9,693	15,232,792
2030	7,712,076	938	2,205,939	44,218	5,389,079	9,742	15,361,992
2031	7,774,578	970	2,224,093	44,613	5,441,597	9,791	15,495,642
2032	7,863,946	1,008	2,246,697	45,039	5,497,115	9,840	15,663,646
2033	7,918,703	1,044	2,263,765	45,401	5,542,559	9,890	15,781,363
2034	7,999,245	1,084	2,285,056	45,797	5,598,527	9,941	15,939,649
2035	8,076,302	1,123	2,305,776	46,186	5,659,157	9,991	16,098,535
2036	8,172,878	1,167	2,330,870	46,618	5,720,395	10,043	16,281,970
2037	8,232,979	1,207	2,348,519	46,985	5,765,292	10,098	16,405,080
2038	8,310,977	1,252	2,370,926	47,384	5,815,131	10,152	16,555,821

Table 1-3 (continued)

Purchased Power and Total Requirements

Year	Total Retail Sales (MWh)	Office Use (MWh)	% Loss	Purchased Power (MWh)	Own Use (MWh)		Losses	Total Requirements (MWh)
2007	12,034,113	10,291	4.3%	12,582,260	7,491	12,589,751	3.9%	13,080,367
2008	12,069,760	10,431	4.5%	12,646,146	7,932	12,654,078	2.3%	12,948,091
2009	11,465,841	10,173	4.2%	11,981,909	8,247	11,990,156	3.3%	12,380,972
2010	12,233,507	10,401	4.4%	12,811,906	8,654	12,820,560	4.3%	13,376,292
2011	11,809,733	9,742	3.8%	12,289,071	10,146	12,299,217	3.0%	12,666,998
2012	11,407,734	9,120	4.4%	11,943,406	8,811	11,952,217	2.0%	12,190,070
2013	11,892,868	9,977	4.0%	12,400,903	8,270	12,409,174	1.9%	12,644,590
2014	12,357,874	10,497	4.1%	12,898,402	8,246	12,906,648	2.0%	13,163,516
2015	11,768,687	10,008	4.3%	12,303,441	8,190	12,311,631	2.4%	12,604,942
2016	12,143,355	10,270	4.1%	12,674,244	8,203	12,682,447	2.8%	13,039,953
2017	11,855,444	9,992	3.9%	12,340,793	8,374	12,349,167	2.7%	12,680,111
2018	12,460,774	10,551	4.6%	13,004,293	8,367	13,012,660	2.6%	13,369,007
2019	12,812,750	10,551	4.6%	13,365,921	8,367	13,374,287	2.6%	13,735,980
2020	13,407,879	10,551	4.6%	13,968,806	8,367	13,977,173	2.6%	14,354,291
2021	14,136,129	10,551	4.6%	14,700,906	8,367	14,709,273	2.6%	15,109,727
2022	14,251,687	10,551	4.6%	14,821,699	8,367	14,830,065	2.6%	15,241,723
2023	14,374,902	10,551	4.6%	14,950,497	8,367	14,958,864	2.6%	15,373,488
2024	14,546,124	10,551	4.6%	15,129,343	8,367	15,137,709	2.6%	15,555,697
2025	14,684,795	10,551	4.6%	15,274,570	8,367	15,282,937	2.6%	15,704,283
2026	14,831,995	10,551	4.6%	15,428,671	8,367	15,437,038	2.6%	15,862,441
2027	14,971,348	10,551	4.6%	15,574,317	8,367	15,582,684	2.6%	16,012,368
2028	15,134,636	10,551	4.6%	15,744,973	8,367	15,753,340	2.6%	16,185,645
2029	15,232,792	10,551	4.6%	15,848,028	8,367	15,856,395	2.6%	16,292,394
2030	15,361,992	10,551	4.6%	15,983,080	8,367	15,991,447	2.6%	16,429,025
2031	15,495,642	10,551	4.6%	16,122,890	8,367	16,131,257	2.6%	16,571,785
2032	15,663,646	10,551	4.6%	16,298,441	8,367	16,306,807	2.6%	16,752,464
2033	15,781,363	10,551	4.6%	16,421,879	8,367	16,430,246	2.6%	16,879,184
2034	15,939,649	10,551	4.6%	16,587,359	8,367	16,595,725	2.6%	17,048,653
2035	16,098,535	10,551	4.6%	16,753,569	8,367	16,761,936	2.6%	17,218,531
2036	16,281,970	10,551	4.6%	16,945,177	8,367	16,953,544	2.6%	17,416,209
2037	16,405,080	10,551	4.6%	17,074,333	8,367	17,082,699	2.6%	17,547,441
2038	16,555,821	10,551	4.6%	17,231,919	8,367	17,240,285	2.6%	17,708,142

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SECTION 2.0

DESCRIPTION OF THE COOPERATIVE

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Section 2.0
Description of the Cooperative

East Kentucky Power Cooperative Inc. (EKPC) is a generation and transmission electric cooperative headquartered in Winchester, Kentucky, and owned by its 16 owner-members:

- Big Sandy RECC
- Blue Grass Energy
- Clark Energy
- Cumberland Valley Electric
- Farmers RECC
- Fleming-Mason Energy
- Grayson RECC
- Inter-County Energy
- Jackson Energy
- Licking Valley RECC
- Nolin RECC
- Owen Electric
- Salt River Electric
- Shelby Energy
- South Kentucky RECC
- Taylor County RECC

EKPC owns a generation fleet of 3,259 MW, including coal, natural gas, oil, and landfill gas units, and an additional 170 MW of hydropower purchases from the Southeastern Power Administration. EKPC also owns more than 2,900 miles of transmission line and approximately 400 substations.

Generation includes:

- Spurlock – 1,346 net MW
- Cooper – 341 net MW
- Smith Combustion Turbine Units
  - Summer – 753 net MW
  - Winter – 989 net MW
- Bluegrass Combustion Turbine Units
  - Summer – 501 net MW
  - Winter – 567 net MW
- Landfill Gas Plants
  - Bavarian – 4.6 net MW
  - Laurel Ridge – 3.0 net MW
  - Green Valley – 2.3 net MW
  - Glasgow – 0.8 net MW
  - Pendleton County – 3.0 net MW
  - Hardin County – 2.3 net MW
- Southeastern Power Administration (SEPA), hydropower – 170 MW

2.1 Owner-Members' Service Territory

EKPC owner-members serve approximately 538,000 retail meters (approximately 1,100,000 customers) in 87 counties in Kentucky and 3 counties in Tennessee, including portions of the Louisville, Cincinnati, Elizabethtown, Lexington, Huntington, and Bowling Green Metropolitan Statistical Areas (MSA). EKPC owner-members serve most of the rural areas, while investorowned and municipal utilities serve most of the cities and towns. Interstates 64, 65, 71, and 75 and several limited-access parkways pass through the area. EKPC owner-members' fixed service territory boundaries are on file with the Kentucky Public Service Commission.

2.2 Customer Overview

In EKPC's service area, electricity is the primary method for water heating and home heating. Around 87 percent of all homes have electric water heating, and about 63 percent have electric heat. In 2017, 55 percent of EKPC's member retail sales were to the residential class (see Figure 2-1) and residential customer use averaged 1,083 kWh per month (see Figure 2-2). As shown in Figure 2-2, appliance efficiency improvements, the economy, and the increasing electricity prices in recent years have had a dampening effect on use per customer and this is expected to continue.

Figure 2-1

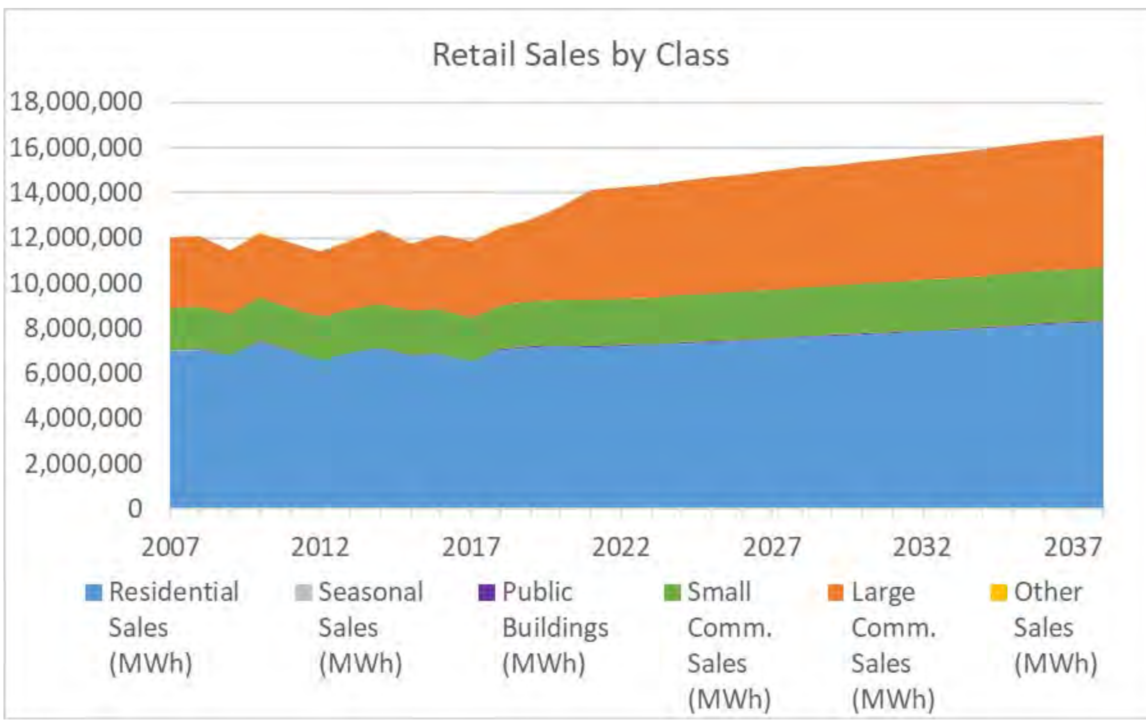
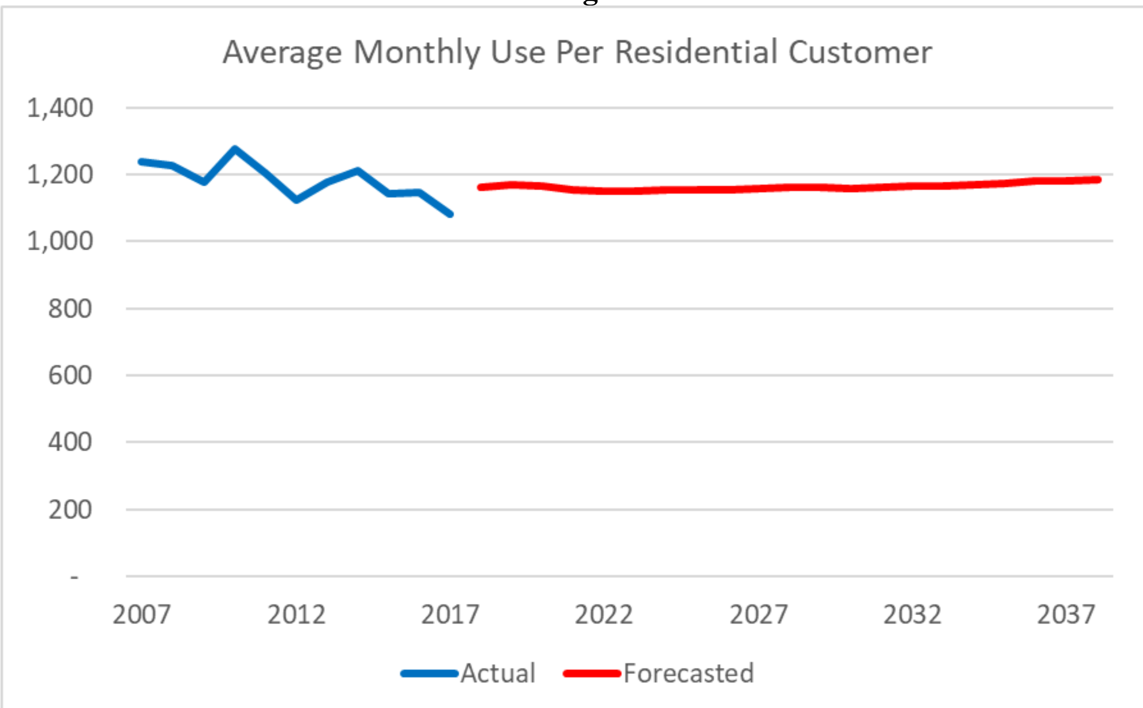


Figure 2-2



2.3 Economic Overview

The economy of EKPC's service area is quite varied. Areas around Lexington and Louisville have a significant amount of manufacturing industry. The region around Cincinnati contains a growing number of retail trade and service jobs. Mining has seen strong decreases due to regulatory changes as well as decreased gas prices, the most notable impacts being in eastern and southeastern regions. Tourism is an important aspect of EKPC's southern and southwestern service area, with Lake Cumberland and Mammoth Cave National Park contributing to jobs in the service and retail trade industries. This area suffered during the recession but is starting to notice an increase in activity in recent years as the economy strengthened and lake levels rose. Kentucky as a whole expects to see growth in the health care sector due to the aging population.

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SECTION 3.0

DESCRIPTION OF THE FORECASTING METHOD

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Section 3.0
Description of the Forecasting Method

3.1 Coordination with Owner-Members

EKPC's "2018 Load Forecast" was prepared pursuant to its "2018-19 Load Forecast Work Plan", which was approved by EKPC's Board of Directors in December 2017 and by RUS in December 2017. Factors considered when preparing the forecast include regional economic growth, electric appliance saturation and efficiency trends, electricity rates, and weather. The EKPC Load Forecasting Department works with the staff of each owner-member to prepare its forecast and then aggregates the 16 owner-member forecasts, adds forecasts of own use and losses, and subtracts planned demand response and energy efficiency to create EKPC's forecast.

EKPC and its owner-members will use the "2018 Load Forecast" for long-term planning, including construction work plans and financial forecasts for the owner-members and transmission, generation, demand response and energy efficiency, and financial planning for EKPC.

The general steps followed by EKPC in developing its load forecast are summarized as follows:

1. EKPC subscribes to IHS Global Insights, Inc. (IHS), in order to analyze regional economic performance. IHS provides EKPC projections for population, employment, and income as well as other variables. Details are provided in Section 4.0.

2. EKPC prepares a preliminary forecast for each of its owner-members for each classification as reported on the RUS Form 7, which contains publicly available retail sales data for owner-members. These include: residential, seasonal, small commercial, public buildings, large commercial, and public street and highway lighting. EKPC's sales to owner-members are then determined by adding distribution losses to total retail sales. EKPC's total requirements are estimated by adding transmission losses to total owner-member sales. Seasonal peak demands are determined by applying load factors for heating, cooling, and water heating to energy. The same methodology is used in developing each of the 16 owner-member forecasts.

3. EKPC meets with each owner-member to discuss their preliminary forecast. Owner-member staff at these meetings includes the President/CEO and other key individuals.

4. The preliminary forecast is revised based on mutual agreement of EKPC staff and owner-member's President/CEO and staff. This final forecast is approved by the Board of Directors of each owner-member.

5. The EKPC forecast is the summation of the forecasts of its 16 owner-members.

There is close collaboration and coordination between EKPC and its owner-members in this process. This working relationship is essential since EKPC has no retail members. Input from owner-members relating to industrial development, subdivision growth, and other specific service area information is crucial to the preparation of accurate forecasts. Review meetings provide opportunities to critique the assumptions and the overall results of the preliminary forecast. The resulting load forecast reflects a combination of EKPC's structured forecast methodology combined with the judgment and experience of the owner-member staff.

3.2 Forecast Model Summary

Models are used to develop the load forecast for each owner-member. A brief overview of each is given in this section. Specifics regarding the models and resulting forecasts are presented in Sections 4 through 8 of this report.

3.3 Regional Economic Model

EKPC has divided its owner-members' service area into seven economic regions with economic activity projected for each. Regional forecasts for population, income and employment are developed and used as inputs to residential customer and small commercial customer and energy forecasts. Therefore, EKPC's economic assumptions regarding its load forecast are consistent. Detail is in section 4.

3.4 Residential Sales

This class of energy sales is forecasted using regression analysis. At the owner-member level, residential energy use per customer is projected using a statistically adjusted end-use model. Variables such as electric price, economic activity, appliance saturations and efficiencies are drivers. The number of residential customers is also projected with regression analysis using economic variables such as population and households. The owner-member results are summed to determine total residential customers and total class sales. System residential energy use per customer is calculated by dividing the forecasted number of customers into the energy sales forecast.

3.5 Small Commercial Sales

Small commercial energy sales forecast results from regression analysis. The number of small commercial customers is forecasted by means of regression analysis on various regional economic data in addition to the resulting residential customer forecast described above. Exogenous variables include real electric price, employment by sector and economic activity. Energy use per customer is calculated by dividing the forecasted number of customers into the energy sales forecast.

3.6 Large Commercial Sales

This class is projected by owner-members and EKPC. Owner-members project usage for existing large loads. EKPC projects new large loads based on historical development, the presence of industrial parks, and the economy of the service territory.

3.7 Seasonal Sales

Seasonal sales are sales to customers with seasonal residences such as vacation homes and weekend retreats. Seasonal sales are relatively small and are reported by only one of EKPC's owner-members.

3.8 Public Building Sales

Public Building sales include sales to accounts such as government buildings and libraries. The sales are relatively small and are reported by only two of EKPC's owner-members.

3.9 Public Street and Highway Lighting Sales

The Public Street and Highway Lighting class is relatively small and is usually projected as a function of residential sales. There are eleven owner-members that report this class.

3.10 Demand Response and Energy Efficiency

For over 30 years, EKPC and its 16 owner-members have promoted the cost-effective use of energy by offering conservation and other marketing programs to the retail customer. These programs were designed to meet the needs of the customer, and to delay the need for additional generating capacity. EKPC considers the programs as part of its overall supply portfolio. To incorporate into the 2018 long term load forecast, a demand response and energy efficiency plan was developed. See Table 3-1 on page 20 for an overview of demand response and energy efficiency projections.

3.11 Peak Demand Forecast and Scenarios

Seasonal peak demands are projected using the summation of monthly energy usages and load factors for the various classes of customers. Residential energy usage components include heating, cooling, water heating, and other usage. Using load factors, demand is calculated for each component and then summed to obtain the residential portion of the seasonal peak. Small commercial and large commercial classes use load factors on the class usage to obtain the class contribution to the seasonal peak. High and low case projections have been constructed around the base case forecast. Weather, customer growth and electric price assumptions are significant inputs to the high and low cases.

Table 3-1
Additional Effect of Demand Response and Energy Efficiency Programs

	Energy (MWH)	Winter Peak (MW)	Summer Peak (MW)
2019	(35,607)	(121)	(120)
2020	(46,475)	(163)	(162)
2021	(71,724)	(261)	(259)
2022	(81,666)	(263)	(261)
2023	(91,642)	(265)	(263)
2024	(91,434)	(265)	(263)
2025	(90,579)	(265)	(263)
2026	(89,909)	(264)	(263)
2027	(88,568)	(264)	(263)
2028	(87,010)	(264)	(262)
2029	(85,125)	(263)	(262)
2030	(84,308)	(263)	(262)
2031	(83,479)	(263)	(262)
2032	(83,536)	(263)	(262)
2033	(83,421)	(263)	(262)
2034	(81,123)	(262)	(261)
2035	(79,451)	(265)	(260)
2036	(78,702)	(264)	(259)
2037	(77,674)	(261)	(258)
2038	(76,240)	(260)	(256)

To avoid double counting, additional effects do not include energy efficiency measures installed prior to 2018. These are assumed to be embedded in the historical data.

3.12 Model Inputs

The following section describes the independent variables used in EKPC's models of consumers and energy sales by consumer class for each owner-member.

3.13 Input Assumptions

Key forecast assumptions used in developing the EKPC and owner-member load forecasts are:

1. Regional population projections are based upon forecasts provided by IHS.
2. EKPC uses an economic model to develop its load forecast. The model uses data for 87 Kentucky counties in seven geographic regions. The economy of these counties will experience modest growth over the next 20 years.
3. Over the forecast period, naturally-occurring appliance efficiency improvements will have a dampening affect on residential retail sales. In addition to lighting, appliances particularly affected are heating, and cooling.
4. Residential customer growth and local area economic activity will be the major determinants of small commercial growth.
5. Forecasted load growth is based on the assumption of normal weather, as defined by the 20 years of historical data (1998 – 2017). Seven different stations are used depending on geographic location of the owner-member.

3.14 Regional Economic Growth

EKPC combines county-level forecasts from IHS into regional economic forecasts based roughly on owner-member service territory boundaries. Owner-members and counties are assigned to regions as follows:

- Central Region:
  Owner-members: Blue Grass Energy
  counties: Anderson, Bourbon, Clark, Fayette, Franklin, Harrison, Jessamine, Madison, Mercer, Scott, and Woodford
- East Region:
  Owner-members: Big Sandy RECC, Cumberland Valley Electric, Jackson Energy and Licking Valley RECC
  counties: Bell, Breathitt, Clay, Estill, Floyd, Harlan, Jackson, Johnson, Knott, Knox, Laurel, Lee, Leslie, Letcher, Magoffin, Martin, Morgan, Owsley, Perry, Pike, Rockcastle, Whitley, and Wolfe
- North Region:
  Owner-members: Owen Electric
  counties: Boone, Bracken, Campbell, Carroll, Gallatin, Grant, Kenton, Owen, and Pendleton
- North Central Region:
  Owner-members: Nolin RECC, Salt River Electric, and Shelby Energy
  counties: Bullitt, Hardin, Henry, Jefferson, Larue, Meade, Nelson, Oldham, Shelby, Spencer, Trimble, and Washington
- North East Region:
  Owner-members: Clark Energy, Fleming-Mason Energy, and Grayson RECC
  counties: Bath, Boyd, Carter, Elliott, Fleming, Greenup, Lawrence, Lewis, Mason, Menifee, Montgomery, Nicholas, Powell, Robertson, and Rowan
- South Region:
  Owner-members: Inter-County Energy, South Kentucky RECC, and Taylor County RECC
  counties: Adair, Boyle, Casey, Garrard, Green, Lincoln, Marion, McCreary, Pulaski, Russell, Taylor, and Wayne
- South Central Region:
  Owner-member: Farmers RECC
  counties: Allen, Barren, Butler, Cumberland, Edmonson, Grayson, Hart, Metcalfe, Monroe, Simpson, and Warren

EKPC utilized a geographic information system named ESRI to define owner-member's territories. This method was used to take the county-level economic data provided by IHS and carve out the owner-member's portion of that data. By doing this we were able to forecast based upon economic data that was more representative of the individual owner-members.

The “2018 Load Forecast” is based on IHS’s county-level economic forecasts released on February 25, 2018.

3.15 Electric Appliance Saturation and Efficiency Trends

Every 2-3 years since 1981, EKPC has surveyed its owner-members’ residential consumers to gather information on electric appliance saturation and other factors affecting electricity demand. EKPC projects these saturations for each owner-member as a function of time. The “2018 Load Forecast” incorporates survey data from EKPC’s “2018 Owner-Member End-Use Survey Report”.

EKPC is a member of Itron’s Energy Forecasting Group and as such, receives from Itron electric appliance efficiency projections for the East South Central U.S. Census Division (which comprises the states of Alabama, Kentucky, Mississippi, and Tennessee) based on information from the Energy Information Administration (EIA). These projections of appliance efficiency were used in the “Twenty-Year Financial Forecast, 2015-2034.”

3.16 Electricity Rates

The wholesale power cost projections used in the “2018 Load Forecast” are based on EKPC’s board approved “Twenty-Year Financial Forecast, 2015-2034.”

3.17 Weather

The forecasts rely on National Oceanic and Atmospheric Administration (NOAA) weather stations located at seven airports in or near the EKPC system. Normals for most owner-members are based on the historic 20 year values (1998-2017). Owner-members are assigned to airports as follows:

- Blue Grass Airport (LEX) in Lexington, KY:
  Owner-members: Blue Grass Energy, Clark Energy, and Inter-County Energy
- Bowling Green/Warren County Regional Airport (BWG) in Bowling Green, KY:
  Owner-members: Farmers RECC and Taylor County RECC
- Cincinnati/Northern Kentucky International Airport (CVG) in Covington, KY:
  Owner-members: Fleming-Mason Energy and Owen Electric
- Huntington Tri-State Airport (HTS) in Huntington, WV:

Owner-member: Grayson RECC

- Julian Carroll Airport (JKL) in Jackson, KY:
  Owner-members: Big Sandy RECC, Cumberland Valley Electric, Jackson Energy, and Licking Valley RECC
- Louisville International Airport (SDF) in Louisville, KY:
  Owner-members: Nolin RECC, Salt River Electric, and Shelby Energy
- Pulaski County Airport (SME) in Somerset, KY:
  Owner-member: South Kentucky RECC

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SECTION 4.0

REGIONAL ECONOMIC MODEL

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Section 4.0
Regional Economic Model

Part of EKPC's load forecast methodology includes regional economic modeling. EKPC subscribes to IHS for analysis regarding regional economic performance. IHS is a widely used consulting firm with expertise in economic analyses. They collect and monitor data, provide forecasts and analyses, and offer consulting advice to clients in business, financial, and government organizations. IHS collects historical Kentucky county level data for many economic variables, develops forecasting models based on the data, and provides the resulting forecasts to EKPC. Consistent regional forecasts are developed. County level historical and projected data provided to EKPC include:

- North American Industry Classification System (NAICS) Employment
  - Total Non-farm, Non-Manufacturing, Service Providing Private, Construction, Manufacturing, Transportation, Trade & Utilities, Information, Financial Activities, Professional & Business Services, Educational & Health Services, Leisure & Hospitality, Other Services, Government, Federal Government, State & Local Government, Military
- Unemployment Rate
- Labor Force
- Personal Income
- Real Personal Income
- Population
- Households

These county level projections combine into regional economic activity. EKPC converts IHS's quarterly county-level projections to monthly values to use in the load forecasting models.

EKPC has divided its owner-members' service areas into seven economic regions based on the owner-member service territorial boundaries. Some natural regions exist within the EKPC territory. For example, the Central Economic Region defined by EKPC fits closely within the Lexington Standard Metropolitan Statistical Area ("SMSA"). The Bureau Economic Analysis (BEA) defines SMSA's as areas of interrelated economic activity that go beyond a single county's boundaries. The Northern Region includes Kentucky counties that border Cincinnati.

Economic models for these seven economic regions provide EKPC with a way of linking the electricity needs of a service area to the rest of the service area's economy in a consistent and reasonable manner. Projections of regional economic activity enhance the sales forecasting and strategic planning of EKPC because changes in regional employment and income are important determinants of customer and sales growth. Tables 4-1 through 4-7 on pages 32 through 38 report regional economic summaries.

4.1 Overview of Key Variables

An important variable that impacts the load forecast is regional population, shown in Figure 4-1. The spreadsheets with the county level data from IHS are provided in Appendix B. Population growth has slowed during the recent recession, but forecasts show population growth to return to pre-recession levels as the economy continues to strengthen.

Figure 4-1
Total Population, All Regions

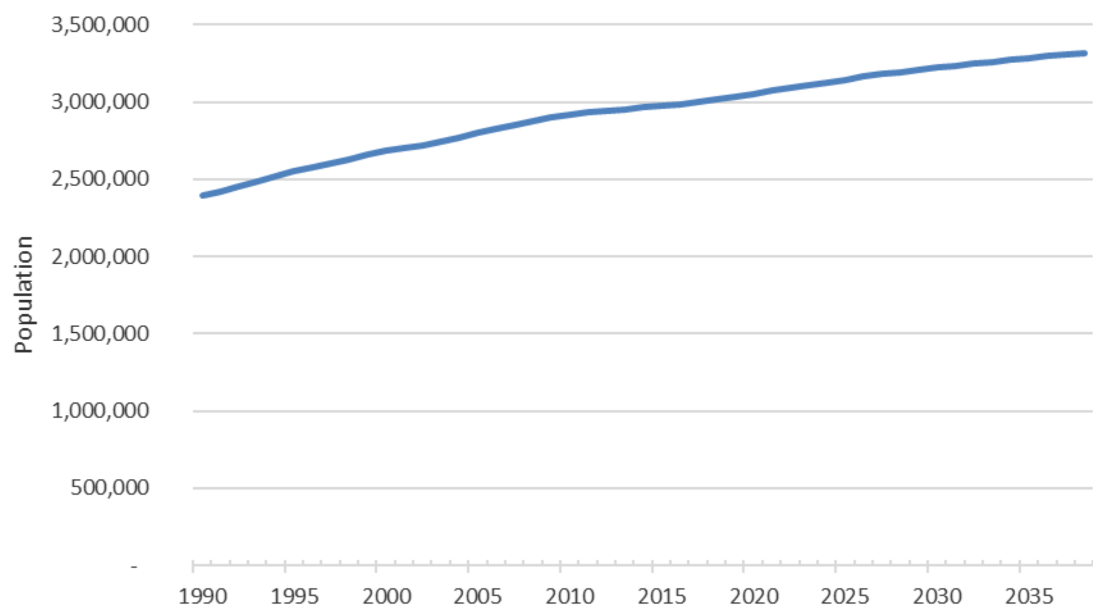
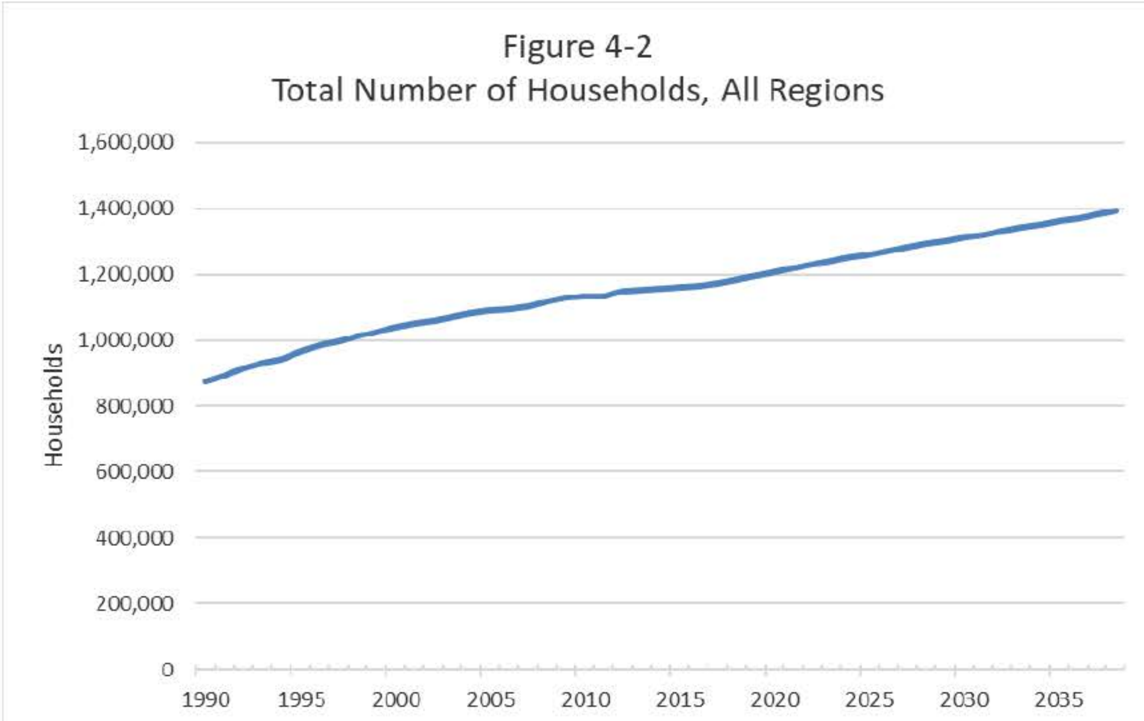


Figure 4-2 depicts historical and projected households. Household growth did slow during the recent recession but it is expected to grow moderately through the forecast period.



Total regional employment is tied closely to the national economy. Throughout the 90s there was strong employment growth. During the recent economic downturn employment fell. However, employment is expected to grow throughout the forecast period. Total non-farm employment growth is represented in Figure 4-3.

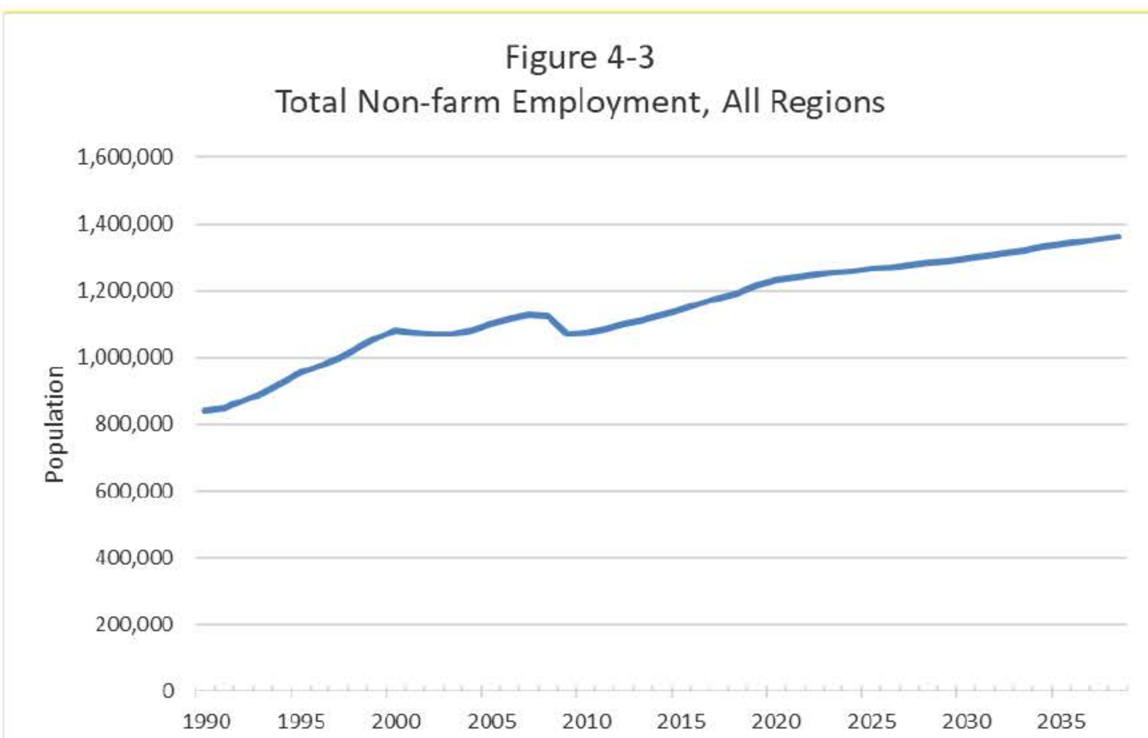


Table 4-1

Central Economic Region Forecast Summary

	Population		**Households**		**Total Employment**	
		(%) Change		**(%) Change**		**(%) Change**
2018	726,236	1.09%	287,329	1.29%	370,067	1.17%
2019	733,423	0.99%	291,264	1.37%	377,389	1.98%
2020	740,429	0.96%	295,169	1.34%	382,941	1.47%
2021	747,631	0.97%	299,017	1.30%	386,177	0.85%
2022	754,537	0.92%	302,607	1.20%	388,783	0.68%
2023	761,574	0.93%	306,112	1.16%	391,206	0.62%
2024	768,281	0.88%	309,482	1.10%	393,405	0.56%
2025	774,988	0.87%	312,810	1.08%	395,206	0.46%
2026	781,195	0.80%	316,068	1.04%	397,148	0.49%
2027	786,899	0.73%	319,186	0.99%	399,340	0.55%
2028	792,122	0.66%	322,207	0.95%	401,370	0.51%
2029	797,143	0.63%	325,139	0.91%	403,530	0.54%
2030	801,925	0.60%	327,877	0.84%	406,301	0.69%
2031	806,474	0.57%	330,588	0.83%	408,609	0.57%
2032	810,906	0.55%	333,353	0.84%	411,148	0.62%
2033	815,351	0.55%	336,222	0.86%	413,734	0.63%
2034	819,685	0.53%	339,133	0.87%	416,571	0.69%
2035	823,893	0.51%	341,946	0.83%	419,205	0.63%
2036	828,129	0.51%	344,752	0.82%	421,886	0.64%
2037	832,334	0.51%	347,610	0.83%	424,803	0.69%
2038	836,515	0.50%	350,497	0.83%	427,761	0.70%

Table 4-2

Eastern Economic Region Forecast Summary

	Population		Households		Total Employment	
		(%) Change		(%) Change		(%) Change
2018	508,030	-0.55%	204,560	0.00%	151,586	1.37%
2019	505,495	-0.50%	204,836	0.14%	153,609	1.33%
2020	503,163	-0.46%	205,106	0.13%	154,774	0.76%
2021	500,961	-0.44%	205,309	0.10%	154,965	0.12%
2022	498,669	-0.46%	205,329	0.01%	154,938	-0.02%
2023	496,503	-0.43%	205,336	0.00%	154,906	-0.02%
2024	494,420	-0.42%	205,357	0.01%	154,785	-0.08%
2025	492,487	-0.39%	205,416	0.03%	154,647	-0.09%
2026	490,545	-0.39%	205,567	0.07%	154,582	-0.04%
2027	488,839	-0.35%	205,884	0.15%	154,647	0.04%
2028	487,436	-0.29%	206,024	0.07%	154,874	0.15%
2029	486,243	-0.24%	206,283	0.13%	155,135	0.17%
2030	485,049	-0.25%	206,477	0.09%	155,617	0.31%
2031	484,022	-0.21%	206,830	0.17%	156,098	0.31%
2032	482,942	-0.22%	207,139	0.15%	156,674	0.37%
2033	481,717	-0.25%	207,476	0.16%	157,193	0.33%
2034	480,267	-0.30%	207,777	0.14%	157,824	0.40%
2035	478,837	-0.30%	208,047	0.13%	158,365	0.34%
2036	477,416	-0.30%	208,267	0.11%	158,871	0.32%
2037	475,960	-0.31%	208,527	0.12%	159,403	0.34%
2038	474,459	-0.32%	208,787	0.12%	159,946	0.34%

Table 4-3
Northern Economic Region Forecast Summary

	Population		Households		Total Employment	
		(%) Change		(%) Change		(%) Change
2018	470,986	0.82%	179,802	1.15%	215,484	1.05%
2019	475,247	0.90%	182,161	1.31%	219,678	1.95%
2020	479,553	0.91%	184,507	1.29%	223,000	1.51%
2021	483,997	0.93%	186,788	1.24%	224,645	0.74%
2022	488,226	0.87%	188,895	1.13%	226,122	0.66%
2023	492,546	0.88%	190,939	1.08%	227,537	0.63%
2024	496,339	0.77%	192,756	0.95%	228,392	0.38%
2025	500,097	0.76%	194,536	0.92%	228,936	0.24%
2026	504,093	0.80%	196,503	1.01%	230,116	0.52%
2027	508,152	0.81%	198,546	1.04%	231,616	0.65%
2028	512,155	0.79%	200,651	1.06%	233,176	0.67%
2029	516,137	0.78%	202,739	1.04%	234,722	0.66%
2030	520,109	0.77%	204,766	1.00%	236,763	0.87%
2031	524,068	0.76%	206,823	1.00%	238,512	0.74%
2032	527,843	0.72%	208,900	1.00%	240,133	0.68%
2033	531,673	0.73%	211,062	1.03%	242,163	0.85%
2034	535,492	0.72%	213,279	1.05%	244,153	0.82%
2035	539,215	0.70%	215,432	1.01%	246,303	0.88%
2036	542,924	0.69%	217,584	1.00%	248,358	0.83%
2037	546,562	0.67%	219,750	1.00%	250,540	0.88%
2038	550,191	0.66%	221,950	1.00%	252,682	0.86%

Table 4-4

Central Northern Economic Region Forecast Summary

	Population		**Households**		**Total Employment**	
		(%) Change		**(%) Change**		**(%) Change**
2018	449,005	0.88%	168,026	1.31%	145,961	1.65%
2019	453,589	1.02%	170,621	1.54%	148,908	2.02%
2020	458,609	1.11%	173,445	1.66%	151,592	1.80%
2021	463,771	1.13%	176,133	1.55%	152,828	0.82%
2022	469,192	1.17%	178,986	1.62%	154,099	0.83%
2023	474,644	1.16%	181,556	1.44%	155,337	0.80%
2024	480,438	1.22%	184,212	1.46%	156,570	0.79%
2025	486,272	1.21%	186,895	1.46%	157,720	0.73%
2026	492,264	1.23%	189,735	1.52%	158,978	0.80%
2027	497,453	1.05%	192,338	1.37%	160,074	0.69%
2028	502,008	0.92%	195,039	1.40%	161,006	0.58%
2029	505,924	0.78%	197,255	1.14%	161,849	0.52%
2030	509,600	0.73%	199,337	1.06%	163,087	0.77%
2031	513,038	0.67%	201,433	1.05%	163,618	0.33%
2032	516,509	0.68%	203,762	1.16%	164,463	0.52%
2033	519,948	0.67%	205,960	1.08%	165,303	0.51%
2034	523,516	0.69%	208,214	1.09%	166,290	0.60%
2035	527,019	0.67%	210,413	1.06%	167,186	0.54%
2036	530,669	0.69%	212,901	1.18%	168,197	0.60%
2037	534,479	0.72%	215,356	1.15%	169,360	0.69%
2038	538,249	0.71%	217,852	1.16%	170,583	0.72%

Table 4-5
North Eastern Economic Region Forecast Summary

	Population		Households		Total Employment	
		(%) Change		(%) Change		(%) Change
2018	272,885	0.20%	107,143	0.50%	89,190	1.30%
2019	273,591	0.26%	107,845	0.65%	90,549	1.52%
2020	274,261	0.24%	108,497	0.60%	91,605	1.17%
2021	274,909	0.24%	109,095	0.55%	92,151	0.60%
2022	275,556	0.24%	109,647	0.51%	92,592	0.48%
2023	276,253	0.25%	110,181	0.49%	92,926	0.36%
2024	276,967	0.26%	110,714	0.48%	93,250	0.35%
2025	277,715	0.27%	111,220	0.46%	93,497	0.26%
2026	278,476	0.27%	111,803	0.52%	93,836	0.36%
2027	279,148	0.24%	112,341	0.48%	94,228	0.42%
2028	279,720	0.20%	112,893	0.49%	94,657	0.46%
2029	280,307	0.21%	113,451	0.49%	95,119	0.49%
2030	280,841	0.19%	113,956	0.45%	95,711	0.62%
2031	281,162	0.11%	114,414	0.40%	96,226	0.54%
2032	281,441	0.10%	114,854	0.38%	96,806	0.60%
2033	281,638	0.07%	115,299	0.39%	97,348	0.56%
2034	281,756	0.04%	115,730	0.37%	97,935	0.60%
2035	281,846	0.03%	116,128	0.34%	98,452	0.53%
2036	281,972	0.04%	116,522	0.34%	98,960	0.52%
2037	282,075	0.04%	116,935	0.35%	99,491	0.54%
2038	282,157	0.03%	117,351	0.36%	100,039	0.55%

Table 4-6
Southern Economic Region Forecast Summary

	Population		Households		Total Employment	
		(%) Change		(%) Change		(%) Change
2018	283,519	0.29%	113,424	0.75%	95,149	1.43%
2019	284,495	0.34%	114,436	0.89%	96,535	1.46%
2020	285,602	0.39%	115,461	0.90%	97,734	1.24%
2021	286,803	0.42%	116,455	0.86%	98,421	0.70%
2022	287,971	0.41%	117,358	0.78%	99,047	0.64%
2023	289,231	0.44%	118,269	0.78%	99,601	0.56%
2024	290,559	0.46%	119,201	0.79%	100,157	0.56%
2025	291,994	0.49%	120,169	0.81%	100,729	0.57%
2026	293,445	0.50%	121,208	0.86%	101,373	0.64%
2027	294,620	0.40%	122,172	0.80%	102,007	0.63%
2028	295,643	0.35%	123,041	0.71%	102,661	0.64%
2029	296,577	0.32%	123,896	0.69%	103,292	0.61%
2030	297,425	0.29%	124,680	0.63%	104,048	0.73%
2031	298,032	0.20%	125,417	0.59%	104,690	0.62%
2032	298,557	0.18%	126,112	0.55%	105,379	0.66%
2033	299,010	0.15%	126,835	0.57%	106,031	0.62%
2034	299,329	0.11%	127,545	0.56%	106,759	0.69%
2035	299,658	0.11%	128,240	0.54%	107,430	0.63%
2036	300,042	0.13%	128,930	0.54%	108,087	0.61%
2037	300,472	0.14%	129,679	0.58%	108,778	0.64%
2038	300,870	0.13%	130,432	0.58%	109,478	0.64%

Table 4-7
Central Southern Economic Region Forecast Summary

	Population		Households		Total Employment	
		(%) Change		(%) Change		(%) Change
2018	309,980	0.68%	123,486	1.08%	126,491	1.46%
2019	311,840	0.60%	124,824	1.08%	128,753	1.79%
2020	313,673	0.59%	126,106	1.03%	130,511	1.37%
2021	315,172	0.48%	127,177	0.85%	131,441	0.71%
2022	316,955	0.57%	128,282	0.87%	132,160	0.55%
2023	318,535	0.50%	129,266	0.77%	132,760	0.45%
2024	320,086	0.49%	130,233	0.75%	133,279	0.39%
2025	321,682	0.50%	131,209	0.75%	133,766	0.37%
2026	323,291	0.50%	132,259	0.80%	134,279	0.38%
2027	324,944	0.51%	133,371	0.84%	134,845	0.42%
2028	326,484	0.47%	134,522	0.86%	135,464	0.46%
2029	327,865	0.42%	135,642	0.83%	136,058	0.44%
2030	329,184	0.40%	136,700	0.78%	136,793	0.54%
2031	330,497	0.40%	137,450	0.55%	137,507	0.52%
2032	331,767	0.38%	138,573	0.82%	138,266	0.55%
2033	332,920	0.35%	139,724	0.83%	138,997	0.53%
2034	334,022	0.33%	140,910	0.85%	139,853	0.62%
2035	335,024	0.30%	142,048	0.81%	140,625	0.55%
2036	335,962	0.28%	143,142	0.77%	141,395	0.55%
2037	336,744	0.23%	144,221	0.75%	142,229	0.59%
2038	337,500	0.22%	145,319	0.76%	143,069	0.59%

SECTION 5.0

RESIDENTIAL CUSTOMER FORECAST

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Section 5.0
Residential Customer Forecast

5.1 Introduction

EKPC's owner-member residential sales account for 55 percent of all retail sales; therefore, the forecast of residential customers has a large impact on the overall load forecast. It is developed as follows:

1. Forecasts of regional households are prepared by modeling population growth and changes in household size.

2. Within each geographic region, there are many electric utilities that serve those customers. The portion of those customers that the owner-member serves is modeled in a 'share' variable. Forecasts of share are made based on historical trends and knowledge about service area development.

3. The regional population and household variables are combined with the share variable to represent the growth for a specific owner-member instead of the entire economic region. These variables are used in a regression equation to produce a forecast of residential customers for each owner-member. Other economic variables from EKPC's Regional Economic Model, such as total employment, or household income, may be used in the equations where appropriate.

4. The variables in the previous equations and their sources are listed below in Table 5-1:

Table 5-1
Variables

Variable	Historical Source	Forecast Source
Population	IHS Global Insight, Inc.	IHS Global Insight, Inc.
Household Size	IHS Global Insight, Inc., EKPC End-Use Surveys	IHS Global Insight, Inc., EKPC End-Use Surveys
Share-The percent of regional households served by owner-members	RUS Form 7	Trend Growth

5. The EKPC system residential customer forecast is the summation of the 16 owner-member forecasts.

5.2 Residential Customer Forecast Results

The average number of residential customers served by EKPC is expected to increase from approximately 501,000 in 2017 to 585,000 in 2038. Population growth is projected to increase at levels similar to recent trends. A summary of the system residential customer projections is shown in Figure 5-1 and Table 5-2. Individual owner-member customer forecasts are reported in Appendix A. Model specifics are provided in Appendix B.

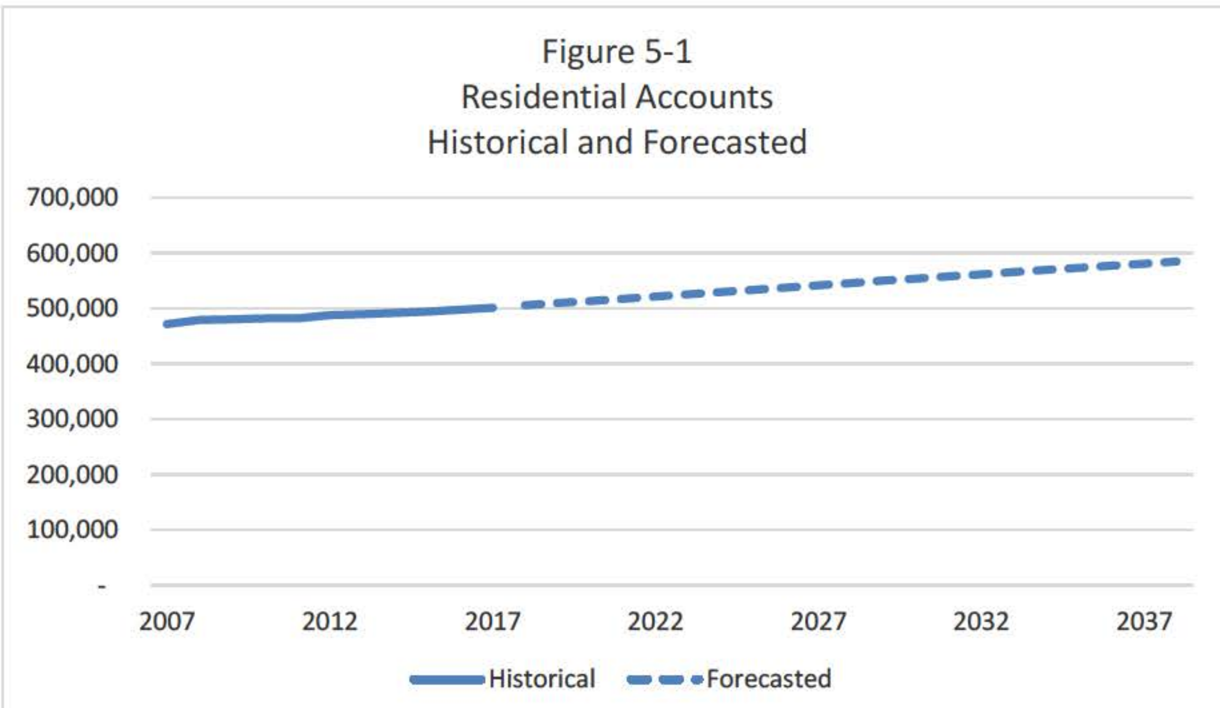

Table 5-2
Residential Class
Customer History and Forecast

Year	Annual Average	Annual Change	% Change
2007	471,585		
2008	479,042	7,457	1.6%
2009	480,527	1,485	0.3%
2010	481,825	1,298	0.3%
2011	482,351	526	0.1%
2012	487,793	5,442	1.1%
2013	489,738	1,945	0.4%
2014	491,776	2,038	0.4%
2015	494,297	2,521	0.5%
2016	497,803	3,506	0.7%
2017	501,421	3,618	0.7%
2018	505,724	4,303	0.9%
2019	509,573	3,849	0.8%
2020	513,553	3,980	0.8%
2021	517,489	3,936	0.8%
2022	521,474	3,985	0.8%
2023	525,475	4,001	0.8%
2024	529,427	3,952	0.8%
2025	533,403	3,976	0.8%
2026	537,486	4,083	0.8%
2027	541,620	4,134	0.8%
2028	545,827	4,207	0.8%
2029	550,018	4,191	0.8%
2030	553,992	3,974	0.7%
2031	557,944	3,952	0.7%
2032	561,901	3,957	0.7%
2033	565,838	3,937	0.7%
2034	569,734	3,896	0.7%
2035	573,548	3,814	0.7%
2036	577,334	3,786	0.7%
2037	581,135	3,801	0.7%
2038	584,988	3,853	0.7%

Beginning in 2008, the City of Monticello became part of South Kentucky RECC, increasing customer count by approximately 3,000.

Beginning in 2018 there is a reclassification from Small Commercial to Residential.

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SECTION 6.0

RESIDENTIAL SALES FORECAST

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Section 6.0
Residential Sales Forecast

6.1 Methodology

EKPC uses statistically adjusted end-use (SAE) models to forecast residential sales. This method of modeling incorporates end-use forecasts and is used to separate the monthly and annual forecasts into end-use components. SAE models offer the structure of end-use models while also using the strength of time-series analysis.

This method, like end-use modeling, requires detailed information about appliance saturation, appliance use, appliance efficiencies, household characteristics, weather characteristics, and demographic and economic data. The SAE approach segments the average household use into end-use components as follows:

$$Use_{y,m} = Heat_{y,m} + Cool_{y,m} + Water\ Heat_{y,m} + Other_{y,m}$$

Where, y=year
m=month

Each component is defined in terms of its end-use structure. For example, the cool index may be defined as a function of appliance saturation, efficiency of the appliance, and usage of the appliance. Annual end-use indices and a usage variable are constructed and used to develop a variable to be used in least squares regression in the model. These variables are constructed for heating, cooling, water heating, and an 'Other' variable, which includes lighting and other miscellaneous usages.

$$CoolIndex_y = \sum_{Type} Wgt^{Type} * \frac{\left(CoolShare_y^{Type} / Eff_y^{Type} \right)}{\left(CoolShare_{98}^{Type} / Eff_{98}^{Type} \right)}$$

$$CoolUse_{y,m} = \left(\frac{CDD_{y,m}}{NormCDD} \right) * \left(\frac{HHSize_y}{HHSize_{by}} \right) * \left(\frac{Income_y}{Income_{by}} \right) * \left(\frac{Price_{y,m}}{Price_{by}} \right)^{-.30}$$

Where, by=base year

$$Cool_{y,m} = CoolIndex_y * CoolUse_{y,m}$$

The Cool, Heat, Water Heat, and Other variables are then used in a least squares regression, which results in estimates for annual and monthly use per household.

Features of EKPC's SAE model are as follows:

1. Over twenty years of End-use Survey historical data are used to forecast saturation of appliances.
2. Appliance efficiencies due to government standards have been accounted for in the model. Indices pertaining to appliance efficiency trends and usage are used to construct energy models based on heating, cooling, water heating and other energy for the residential class. Source: Energy Information Administration Annual Energy Outlook, East South Central region representing Kentucky.
3. Various demographic and socioeconomic factors that affect appliance choice and appliance use are present in the methodology. These include the changing shares of urban and rural customers relative to total customers, number of people living in the household, as well as square footage of the house and the thermal integrity of the house.
4. Future electricity rates are based upon EKPC’s 20 year financial forecast.

Model details of residential sales are provided in Table 6-1. Details by owner-member are provided in Appendix B.

Table 6-1
Residential Sales Forecast - Appliance Usage Projections

Dependent Variable: Appliance Usage	
Model Inputs	***Source***
Residential Customers	Historical customers are taken from Form 7. Future customers are projected by EKPC and owner-members.
Average Real Price of Electricity	Historical price is taken from Form 7. Future prices are projected by EKPC's Pricing Department and owner-members.
Appliance Efficiency Improvements and Appliance Lifetimes	Energy Information Administration Annual Energy Outlook
Household Size (People Per Household)	IHS Global Insight, Inc., Trend Growth, EKPC End-Use Survey
Real Household Income	EKPC Regional Economic Model

6.2 Appliance Saturation Projections

Every two to three years since 1981, EKPC has surveyed the owner-members' residential customers. The most recent survey was conducted in 2018. EKPC gathers appliance, heating and cooling, economic, and demographic data. Appliance holdings of survey respondents are analyzed in order to better understand their electricity consumption and to project future appliance saturations. Based upon this survey:

- 63.0% use electricity as their main source of heat
  - 18.9% use electric furnace
  - 45.9% use electric heat pump
  - 15.8% use portable electric heaters
  - 6.9% use other electric heat
- 84.0% use central air conditioning
  - 19.1% use room air only
  - 2.0% have no air conditioning
- 86.8% use electric water heaters

EKPC is a member of Itron's Energy Forecasting Group and as such, receives from Itron electric appliance efficiency projections for the East South Central U.S. Census Division (which comprises the states of Alabama, Kentucky, Mississippi, and Tennessee) based on information from the Energy Information Administration (EIA). Their projections on appliance efficiency were used in the "2018 Load Forecast." Heating, cooling, and water heater projections remain stable throughout the forecast.

6.3 Residential Class Sales Forecast Results

Sales to the Residential Class are expected to grow 0.8% over the next 20 years. Electric use per customer is increasing. Table 6-2 reports historical and projected use per customer and class sales.

Table 6-2
Residential Class
Customers and Sales

	Customers			*Use Per Customer*			*Class Sales*		
	Annual Average	Annual Change	% Change	Monthly Average (kWh)	Change (kWh)	% Change	Total (MWh)	Annual Change (MWh)	% Change
2007	471,585	6,021	1.3	1,237	65	5.5	6,998,554	450,394	6.9
2008	479,042	7,457	1.6	1,227	-9	-0.8	7,055,277	56,723	0.8
2009	480,527	1,485	0.3	1,177	-50	-4.1	6,789,142	-266,135	-3.8
2010	481,825	1,298	0.3	1,278	101	8.5	7,388,901	599,759	8.8
2011	482,351	526	0.1	1,204	-74	-5.8	6,967,413	-421,487	-5.7
2012	487,793	5,442	1.1	1,124	-80	-6.6	6,577,784	-389,629	-5.6
2013	489,738	1,945	0.4	1,176	52	4.6	6,909,853	332,069	5.0
2014	491,776	2,038	0.4	1,210	35	2.9	7,142,350	232,497	3.4
2015	494,297	2,521	0.5	1,143	-67	-5.5	6,781,622	-360,728	-5.1
2016	497,803	3,506	0.7	1,146	3	0.3	6,847,090	65,468	1.0
2017	501,421	3,618	0.7	1,083	-63	-5.5	6,517,101	-329,989	-4.8
*2018	505,724	4,303	0.9	1,171	88	8.1	7,107,239	590,138	9.1
2019	509,573	3,849	0.8	1,170	-1	-0.1	7,154,796	47,557	0.7
2020	513,553	3,980	0.8	1,166	-4	-0.3	7,188,311	33,515	0.5
2021	517,489	3,936	0.8	1,155	-11	-0.9	7,175,389	-12,921	-0.2
2022	521,474	3,985	0.8	1,152	-4	-0.3	7,207,766	32,377	0.5
2023	525,475	4,001	0.8	1,149	-2	-0.2	7,247,866	40,100	0.6
2024	529,427	3,952	0.8	1,154	5	0.4	7,333,909	86,043	1.2
2025	533,403	3,976	0.8	1,154	0	0.0	7,388,926	55,017	0.8
2026	537,486	4,083	0.8	1,156	2	0.2	7,457,583	68,657	0.9
2027	541,620	4,134	0.8	1,159	3	0.2	7,532,016	74,434	1.0
2028	545,827	4,207	0.8	1,164	5	0.4	7,623,433	91,416	1.2
2029	550,018	4,191	0.8	1,161	-3	-0.2	7,662,936	39,503	0.5
2030	553,992	3,974	0.7	1,160	-1	-0.1	7,712,076	49,140	0.6
2031	557,944	3,952	0.7	1,161	1	0.1	7,774,578	62,502	0.8
2032	561,901	3,957	0.7	1,166	5	0.4	7,863,946	89,369	1.1
2033	565,838	3,937	0.7	1,166	0	0.0	7,918,703	54,756	0.7
2034	569,734	3,896	0.7	1,170	4	0.3	7,999,245	80,543	1.0
2035	573,548	3,814	0.7	1,173	3	0.3	8,076,302	77,056	1.0
2036	577,334	3,786	0.7	1,180	6	0.5	8,172,878	96,576	1.2
2037	581,135	3,801	0.7	1,181	1	0.1	8,232,979	60,101	0.7
2038	584,988	3,853	0.7	1,184	3	0.3	8,310,977	77,998	0.9

Totals may not equal sum of components due to rounding.

Beginning in 2018 there is a reclassification from Small Commercial to Residential.

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SECTION 7.0

COMMERCIAL AND OTHER SALES FORECAST

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Section 7.0
Commercial and Other Sales Forecast

The small and large commercial classes have stabilized in recent years as reflected in the years of actual data. EKPC owner-members serve many of the satellite industrial and commercial customers that produce parts for Toyota and, as a result of the aforementioned circumstances, were negatively impacted. In more recent years Kentucky has experienced more economic recovery from this downturn. Mining had a noticeable decline due to increased regulation and lower gas prices most notably affecting eastern and southeastern regions.

7.1 Small Commercial Sales Forecast

Owner-member cooperatives classify commercial and industrial accounts into two groups. Customers whose annual peak demand is less than 1 MW are classified as small commercial customers and customers whose annual peak demand is greater than or equal to 1 MW are classified as large commercial/industrial customers. In 2017, there were more than 35,000 small commercial customers on the system. Customers are projected to grow to approximately 41,000 by 2038.

EKPC projects class sales by owner-member through regression analysis of historical data. Typical regressions include small commercial customers as a function of residential customers, employment rate, and other economic variables. The sales regression usually includes customers, electric price, and other economic measures as explanatory variables. Historical and projected small commercial sales for EKPC are reported in Table 7-1. Owner-member regression equations are in Appendix B.

7.2 Large Commercial Sales Forecast

In 2017, there were 149 retail customers classified as large commercial customers. The total annual usage was greater than the annual usage of the small commercial class. This class experienced substantial growth from 1995 to 2003; however from 2004 to 2013 there was minimal growth, and sales declined due to the conditions noted above. Approximately half of EKPC's large commercial customers are manufacturing plants.

The Large Commercial Class is forecasted using input from owner-members as well as a modeling approach. New industrial customers that owner-members expect in the next few years are explicitly input into the models. To estimate total new large loads at the system level, a regression approach is used. A probabilistic model is then used to distribute these customers among the 16 owner-members. A load of 1.5 MW and 60% load factor is assumed for these new loads. This methodology for forecasting new large commercial customers and energy provides a robust and defensible projection at the owner-member level as well as the system level. Table 7-2 reports historical and projected large commercial customers and sales. Owner-members are in regular contact with large commercial customers in order to remain current with production and facility expansion plans. Owner-members communicate with local industrial development groups, which keeps them aware of the status of new large commercial customers. EKPC's owner-members are working hard to contribute to local efforts to attract industry.

7.3 Seasonal Sales Forecast

Seasonal sales are sales to customers with seasonal residences such as vacation and weekend homes. Seasonal sales are relatively small and are reported by only one of EKPC's owner-members. Table 7-3 reports historical and projected seasonal sales.

7.4 Public Building Sales Forecast

Public Building sales include sales to accounts such as government buildings and libraries. The sales are relatively small and are reported by only two of EKPC's owner-members. Table 7-4 reports historical and projected public building sales for EKPC.

7.5 Public Street and Highway Lighting Sales Forecast

Public Street and Highway Lighting sales refer mainly to street lighting. Table 7-5 reports historical and projected retail sales for this class. This class is reported by eleven owner-members.

Table 7-1
Small Commercial Class Customers and Sales
Historical and Projected

	Customers			***Use Per Customer***			***Class Sales***		
	Annual Average	Annual Change	% Change	Annual Average (MWh)	Change (MWh)	% Change	Total (MWh)	Annual Change (MWh)	% Change
2007	30,981	788	2.6	60	1	2.1	1,861,952	84,055	4.7
2008	32,036	1,055	3.4	58	-2	-2.7	1,872,811	10,859	0.6
2009	32,380	344	1.1	55	-3	-5.6	1,787,112	-85,699	-4.6
2010	32,552	172	0.5	59	4	7.7	1,935,479	148,367	8.3
2011	32,654	102	0.3	58	-2	-2.5	1,892,090	-43,389	-2.2
2012	33,069	415	1.3	57	-1	-1.7	1,883,241	-8,850	-0.5
2013	33,287	218	0.7	58	1	1.2	1,917,730	34,489	1.8
2014	33,670	383	1.2	57	-1	-1.1	1,919,198	1,468	0.1
2015	34,117	447	1.3	57	0	0.7	1,958,109	38,912	2.0
2016	34,252	135	0.4	57	0	-0.7	1,951,787	-6,322	-0.3
2017	34,594	342	1.0	55	-2	-3.8	1,896,475	-55,312	-2.8
*2018	34,318	-276	-0.8	57	2	4.1	1,958,436	61,961	3.3
2019	34,667	349	1.0	58	1	1.1	2,000,123	41,687	2.1
2020	35,011	344	1.0	58	0	0.3	2,025,733	25,610	1.3
2021	35,336	325	0.9	58	0	-0.4	2,036,273	10,541	0.5
2022	35,659	323	0.9	58	0	-0.1	2,052,964	16,691	0.8
2023	35,972	313	0.9	58	0	-0.1	2,068,392	15,428	0.8
2024	36,274	302	0.8	58	0	0.2	2,089,435	21,043	1.0
2025	36,573	299	0.8	58	0	-0.2	2,103,105	13,670	0.7
2026	36,872	299	0.8	58	0	0.1	2,123,423	20,318	1.0
2027	37,167	295	0.8	58	0	0.2	2,145,020	21,597	1.0
2028	37,477	310	0.8	58	0	0.3	2,170,088	25,068	1.2
2029	37,783	306	0.8	58	0	0.0	2,186,914	16,826	0.8
2030	38,087	304	0.8	58	0	0.1	2,205,939	19,025	0.9
2031	38,387	300	0.8	58	0	0.0	2,224,093	18,154	0.8
2032	38,691	304	0.8	58	0	0.2	2,246,697	22,604	1.0
2033	38,994	303	0.8	58	0	0.0	2,263,765	17,069	0.8
2034	39,299	305	0.8	58	0	0.2	2,285,056	21,291	0.9
2035	39,603	304	0.8	58	0	0.1	2,305,776	20,720	0.9
2036	39,913	310	0.8	58	0	0.3	2,330,870	25,094	1.1
2037	40,223	310	0.8	58	0	0.0	2,348,519	17,649	0.8
2038	40,537	314	0.8	58	0	0.2	2,370,926	22,407	1.0

Totals may not equal sum of components due to rounding.

Beginning in 2018 there is a reclassification from Small Commercial to Residential.

Table 7-2
Large Commercial Class Customers and Sales
Historical and Projected

	Customers			***Use Per Customer***			***Class Sales***		
	Annual Average	Annual Change	% Change	Annual Average (MWh)	Change (MWh)	% Change	Total (MWh)	Annual Change (MWh)	% Change
2007	122	-13	-9.6	25,607	2,961	13.1	3,124,043	66,859	2.2
2008	132	10	8.2	23,361	-2,246	-8.8	3,083,589	-40,454	-1.3
2009	138	6	4.5	20,521	-2,839	-12.2	2,831,935	-251,654	-8.2
2010	125	-13	-9.4	22,767	2,246	10.9	2,845,857	13,922	0.5
2011	128	3	2.4	22,571	-195	-0.9	2,889,142	43,285	1.5
2012	130	2	1.6	22,321	-251	-1.1	2,901,688	12,546	0.4
2013	135	5	3.8	22,355	34	0.2	3,017,925	116,237	4.0
2014	136	1	0.7	23,870	1,515	6.8	3,246,287	228,362	7.6
2015	129	-7	-5.1	23,099	-771	-3.2	2,979,716	-266,571	-8.2
2016	138	9	7.0	23,888	789	3.4	3,296,495	316,779	10.6
2017	149	11	8.0	22,788	-1,100	-4.6	3,395,430	98,935	3.0
2018	152	3	2.0	22,520	-268	-1.2	3,423,062	27,632	0.8
2019	156	4	2.6	23,293	773	3.4	3,633,668	210,606	6.2
2020	160	4	2.6	26,057	2,764	11.9	4,169,101	535,433	14.7
2021	163	3	1.9	30,057	4,000	15.4	4,899,256	730,155	17.5
2022	165	2	1.2	30,092	35	0.1	4,965,222	65,966	1.3
2023	168	3	1.8	29,955	-138	-0.5	5,032,376	67,154	1.4
2024	169	1	0.6	30,153	199	0.7	5,095,937	63,561	1.3
2025	171	2	1.2	30,207	54	0.2	5,165,420	69,483	1.4
2026	175	4	2.3	29,846	-361	-1.2	5,223,087	57,667	1.1
2027	176	1	0.6	29,920	73	0.2	5,265,866	42,779	0.8
2028	178	2	1.1	29,843	-76	-0.3	5,312,100	46,234	0.9
2029	180	2	1.1	29,741	-102	-0.3	5,353,456	41,356	0.8
2030	183	3	1.7	29,585	-157	-0.5	5,413,997	60,541	1.1
2031	186	3	1.6	29,390	-195	-0.7	5,466,515	52,518	1.0
2032	188	2	1.1	29,373	-17	-0.1	5,522,033	55,518	1.0
2033	190	2	1.1	29,303	-70	-0.2	5,567,477	45,444	0.8
2034	193	3	1.6	29,137	-165	-0.6	5,623,445	55,968	1.0
2035	196	3	1.6	29,000	-137	-0.5	5,684,075	60,630	1.1
2036	199	3	1.5	28,871	-129	-0.4	5,745,313	61,238	1.1
2037	201	2	1.0	28,807	-64	-0.2	5,790,210	44,897	0.8
2038	203	2	1.0	28,769	-38	-0.1	5,840,049	49,839	0.9

Totals may not equal sum of components due to rounding.

Table 7-3
Seasonal Class Customers and Sales
Historical and Projected

	Customers			***Use Per Customer***			***Class Sales***		
	Annual Average	Annual Change	% Change	Monthly Average (kWh)	Change (MWh)	% Change	Total (MWh)	Annual Change (MWh)	% Change
2007	4,459	88	2.0	274	10	3.7	14,679	797	5.7
2008	4,463	4	0.1	271	-3	-1.1	14,531	-149	-1.0
2009	4,420	-43	-1.0	247	-25	-9.1	13,080	-1,451	-10.0
2010	4,490	70	1.6	259	12	5.1	13,959	879	6.7
2011	4,518	28	0.6	236	-23	-9.1	12,774	-1,185	-8.5
2012	67	-4,451	-98.5	282	46	19.6	227	-12,547	-98.2
2013	94	27	40.3	266	-16	-5.6	300	73	32.4
2014	115	21	22.3	268	2	0.9	370	70	23.5
2015	120	5	4.3	246	-23	-8.4	354	-17	-4.5
2016	125	5	4.2	277	31	12.8	416	62	17.5
2017	141	16	12.8	316	38	13.8	534	118	28.4
2018	151	10	7.4	277	-39	-12.3	503	-31	-5.8
2019	163	12	7.9	275	-2	-0.8	538	35	7.0
2020	176	12	7.6	272	-3	-0.9	574	36	6.6
2021	188	13	7.2	270	-2	-0.8	610	37	6.4
2022	201	12	6.6	269	-1	-0.2	649	39	6.4
2023	213	12	5.9	269	0	-0.1	686	37	5.7
2024	224	12	5.5	270	1	0.2	725	39	5.7
2025	236	11	5.1	269	-1	-0.2	761	35	4.9
2026	247	11	4.7	269	0	0.1	797	37	4.8
2027	256	10	4.0	270	1	0.2	830	33	4.2
2028	269	12	4.7	271	1	0.4	873	42	5.1
2029	280	11	4.2	270	-1	-0.3	907	34	3.9
2030	290	11	3.8	269	-1	-0.4	938	31	3.4
2031	301	10	3.6	269	0	-0.2	970	32	3.4
2032	312	11	3.7	269	1	0.2	1,008	38	3.9
2033	323	11	3.7	269	0	-0.1	1,044	36	3.5
2034	335	12	3.7	269	0	0.1	1,084	40	3.8
2035	347	12	3.5	270	0	0.2	1,123	40	3.7
2036	359	12	3.5	271	1	0.4	1,167	43	3.8
2037	372	13	3.6	271	0	-0.1	1,207	40	3.5
2038	385	13	3.5	271	1	0.2	1,252	45	3.7

Totals may not equal sum of components due to rounding.

Table 7-4
Public Building Class Customers and Sales
Historical and Projected

	Customers			***Use Per Customer***			***Class Sales***		
	Annual Average	Annual Change	% Change	Monthly Average (kWh)	Change (MWh)	% Change	Total (MWh)	Annual Change (MWh)	% Change
2007	969	38	4.1	2,273	286	14.4	26,427	4,231	19.1
2008	993	24	2.5	2,860	587	25.8	34,074	7,647	28.9
2009	998	5	0.5	2,965	105	3.7	35,507	1,433	4.2
2010	1,046	48	4.8	3,172	207	7.0	39,809	4,301	12.1
2011	1,084	38	3.6	2,958	-213	-6.7	38,468	-1,341	-3.4
2012	1,096	12	1.1	2,676	-282	-9.5	35,194	-3,274	-8.5
2013	1,109	13	1.2	2,796	121	4.5	37,215	2,021	5.7
2014	1,117	8	0.7	2,966	169	6.1	39,753	2,537	6.8
2015	1,132	15	1.3	2,871	-95	-3.2	38,996	-757	-1.9
2016	1,137	5	0.4	2,758	-113	-3.9	37,627	-1,369	-3.5
2017	1,156	19	1.7	2,637	-121	-4.4	36,578	-1,049	-2.8
2018	1,176	20	1.7	2,773	136	5.2	39,136	2,558	7.0
2019	1,197	21	1.8	2,754	-19	-0.7	39,560	424	1.1
2020	1,214	17	1.4	2,748	-5	-0.2	40,028	467	1.2
2021	1,230	17	1.4	2,736	-12	-0.4	40,400	373	0.9
2022	1,246	16	1.3	2,729	-7	-0.3	40,819	419	1.0
2023	1,263	17	1.3	2,721	-8	-0.3	41,248	429	1.1
2024	1,280	16	1.3	2,716	-5	-0.2	41,702	454	1.1
2025	1,296	16	1.3	2,707	-9	-0.3	42,085	383	0.9
2026	1,313	17	1.3	2,699	-7	-0.3	42,522	437	1.0
2027	1,329	16	1.2	2,694	-5	-0.2	42,958	436	1.0
2028	1,345	16	1.2	2,690	-4	-0.1	43,422	464	1.1
2029	1,362	17	1.3	2,680	-10	-0.4	43,804	382	0.9
2030	1,378	16	1.2	2,674	-6	-0.2	44,218	414	0.9
2031	1,394	16	1.2	2,666	-8	-0.3	44,613	395	0.9
2032	1,411	17	1.2	2,659	-7	-0.3	45,039	426	1.0
2033	1,427	16	1.1	2,651	-9	-0.3	45,401	362	0.8
2034	1,443	16	1.1	2,644	-7	-0.3	45,797	395	0.9
2035	1,461	17	1.2	2,635	-9	-0.3	46,186	389	0.8
2036	1,477	16	1.1	2,631	-4	-0.2	46,618	432	0.9
2037	1,493	16	1.1	2,623	-8	-0.3	46,985	368	0.8
2038	1,510	17	1.1	2,616	-7	-0.3	47,384	399	0.8

Totals may not equal sum of components due to rounding.

Table 7-5
Public Street and Highway Lighting Class Customers and Sales
Historical and Projected

	Customers			*Use Per Customer*			*Class Sales*		
	Annual Average	Annual Change	% Change	Annual Average (MWh)	Change (MWh)	% Change	Total (MWh)	Annual Change (MWh)	% Change
2007	434	14	3.3	19	0	-0.6	8,457	221	2.7
2008	441	7	1.6	21	2	10.3	9,477	1,020	12.1
2009	424	-17	-3.9	21	0	-0.5	9,065	-413	-4.4
2010	424	0	0.0	22	1	4.8	9,503	438	4.8
2011	416	-8	-1.9	24	1	5.6	9,845	342	3.6
2012	414	-2	-0.5	23	0	-2.0	9,600	-245	-2.5
2013	412	-2	-0.5	24	1	3.0	9,845	244	2.5
2014	408	-4	-1.0	24	0	1.7	9,916	72	0.7
2015	411	3	0.7	24	0	-1.0	9,890	-26	-0.3
2016	404	-7	-1.7	25	1	2.2	9,940	50	0.5
2017	381	-23	-5.7	24	0	-0.5	9,325	-615	-6.2
2018	385	4	1.0	23	-1	-5.4	8,912	-413	-4.4
2019	386	1	0.3	23	0	0.5	8,983	71	0.8
2020	388	2	0.5	23	0	0.2	9,051	68	0.8
2021	390	2	0.5	23	0	0.2	9,118	67	0.7
2022	392	2	0.5	23	0	0.2	9,185	66	0.7
2023	394	2	0.5	23	0	0.2	9,251	67	0.7
2024	396	2	0.5	24	0	0.4	9,333	82	0.9
2025	399	3	0.8	24	0	0.1	9,417	84	0.9
2026	401	2	0.5	24	0	0.4	9,501	84	0.9
2027	403	2	0.5	24	0	0.3	9,575	74	0.8
2028	404	1	0.2	24	0	0.4	9,639	63	0.7
2029	405	1	0.2	24	0	0.3	9,693	54	0.6
2030	407	2	0.5	24	0	0.0	9,742	50	0.5
2031	408	1	0.2	24	0	0.3	9,791	49	0.5
2032	409	1	0.2	24	0	0.3	9,840	49	0.5
2033	410	1	0.2	24	0	0.3	9,890	50	0.5
2034	412	2	0.5	24	0	0.0	9,941	51	0.5
2035	413	1	0.2	24	0	0.3	9,991	51	0.5
2036	414	1	0.2	24	0	0.3	10,043	52	0.5
2037	416	2	0.5	24	0	0.1	10,098	54	0.5
2038	417	1	0.2	24	0	0.3	10,152	54	0.5

Totals may not equal sum of components due to rounding.

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SECTION 8.0

SCENARIOS

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Section 8.0
Scenarios

8.1 Peak and Energy Scenario Results

In addition to the base case peak demands and energy, high and low scenarios were developed. The same methodology is used to construct two new models: one reflecting assumptions that result in high usage and one with assumptions that result in low usage. Assumptions include:

1. Weather: Based on 15 years of historical heating and cooling degree day (HDD and CDD) data, alternate weather projections were developed based upon the 90th and 10th percentile to reflect extreme and mild weather, respectively. The resulting forecasts reflect cases assuming base case HDD +/-20% and CDD +/-30%.

2. Electric price: The general approach is to use price forecasts that are available and use the growth rates from those forecasts to prepare the high and low growth rates bounding the base case residential price forecast. The growth rate for the electricity rate was estimated by using high and low case forecasts for the forward market prices for energy (source: ACES Power Marketing).

   The high scenario for the residential price forecast is constructed to have a 3.2% compound annual growth rate, while the low scenario is constructed to have a 1.1% compound annual growth rate compared to the base of 2.0%. The relationships between the base case residential class rates and the commercial, industrial and other class rates are maintained in scenario models.

3. Residential customers: In the EKPC base case, the residential growth rate is 0.7%. The basic approach to preparing high and low case scenarios for the future number of residential customers is to determine the magnitude of historical variation between long term average growth rates and higher or lower growth rates during shorter periods of time. The resulting rate of 1.2% was used to produce the high case and 0.3% was used for the low case.

4. Small and Large Commercial customer and energy: Small commercial customer growth is correlated to residential customer growth and this relationship is maintained when developing the high and low cases. The industrial class was not changed.

Adjusting these assumptions leads to different customer forecasts which in turn results in different energy and demand forecasts. The results are shown in Table 8-1 and Figures 8-1 through 8-3 for the following cases:

Low Case - Pessimistic economic assumptions with mild weather
Base Case - Most probable economics assumptions with normal weather
High Case - Optimistic economic assumptions with severe weather

Table 8-1
Scenarios
Peak Demands and Total Requirements

Net Requirements (MWh)				Net Winter Peak (MW)				Net Summer Peak (MW)			
Season	Low Case	Base Case	High Case	Year	Low Case	Base Case	High Case	Year	Low Case	Base Case	High Case
2017-18	12,853,511	**13,393,925**	13,978,835	2018	3,210	**3,234**	3,259	2018	2,357	**2,363**	2,369
2018-19	12,811,892	**13,735,980**	14,710,416	2019	3,235	**3,258**	3,283	2019	2,324	**2,341**	2,359
2019-20	13,353,036	**14,354,291**	15,426,015	2020	3,240	**3,281**	3,323	2020	2,347	**2,377**	2,407
2020-21	14,018,008	**15,109,727**	16,294,035	2021	3,266	**3,323**	3,383	2021	2,383	**2,425**	2,469
2021-22	14,101,417	**15,241,723**	16,494,152	2022	3,275	**3,349**	3,426	2022	2,394	**2,448**	2,504
2022-23	14,187,864	**15,373,488**	16,695,117	2023	3,282	**3,373**	3,469	2023	2,391	**2,457**	2,527
2023-24	14,326,392	**15,555,697**	16,950,423	2024	3,294	**3,401**	3,516	2024	2,404	**2,483**	2,566
2024-25	14,427,616	**15,704,283**	17,172,639	2025	3,294	**3,418**	3,550	2025	2,414	**2,505**	2,603
2025-26	14,532,543	**15,862,441**	17,407,068	2026	3,303	**3,444**	3,596	2026	2,428	**2,532**	2,644
2026-27	14,629,327	**16,012,368**	17,634,408	2027	3,309	**3,468**	3,639	2027	2,428	**2,545**	2,671
2027-28	14,745,669	**16,185,645**	17,890,591	2028	3,325	**3,502**	3,694	2028	2,446	**2,576**	2,718
2028-29	14,803,507	**16,292,394**	18,075,818	2029	3,320	**3,514**	3,726	2029	2,452	**2,595**	2,752
2029-30	14,896,939	**16,429,025**	18,289,937	2030	3,320	**3,531**	3,762	2030	2,466	**2,622**	2,794
2030-31	14,989,061	**16,571,785**	18,514,283	2031	3,313	**3,540**	3,789	2031	2,470	**2,639**	2,825
2031-32	15,110,689	**16,752,464**	18,782,076	2032	3,324	**3,568**	3,837	2032	2,482	**2,664**	2,865
2032-33	15,182,711	**16,879,184**	18,992,448	2033	3,325	**3,585**	3,874	2033	2,490	**2,685**	2,901
2033-34	15,294,220	**17,048,653**	19,250,602	2034	3,331	**3,608**	3,916	2034	2,501	**2,709**	2,940
2034-35	15,409,932	**17,218,531**	19,508,624	2035	3,340	**3,633**	3,962	2035	2,471	**2,688**	2,931
2035-36	15,556,128	**17,416,209**	19,797,596	2036	3,356	**3,665**	4,014	2036	2,530	**2,764**	3,027
2036-37	15,638,860	**17,547,441**	20,014,389	2037	3,356	**3,681**	4,049	2037	2,539	**2,786**	3,064
2037-38	15,746,110	**17,708,142**	20,266,878	2038	3,369	**3,711**	4,100	2038	2,554	**2,813**	3,108

Note: 2017-2018 Winter Peak and 2018 Summer Peak are weather normal actual values.

Figure 8-1
Net Energy Requirements (MWh)

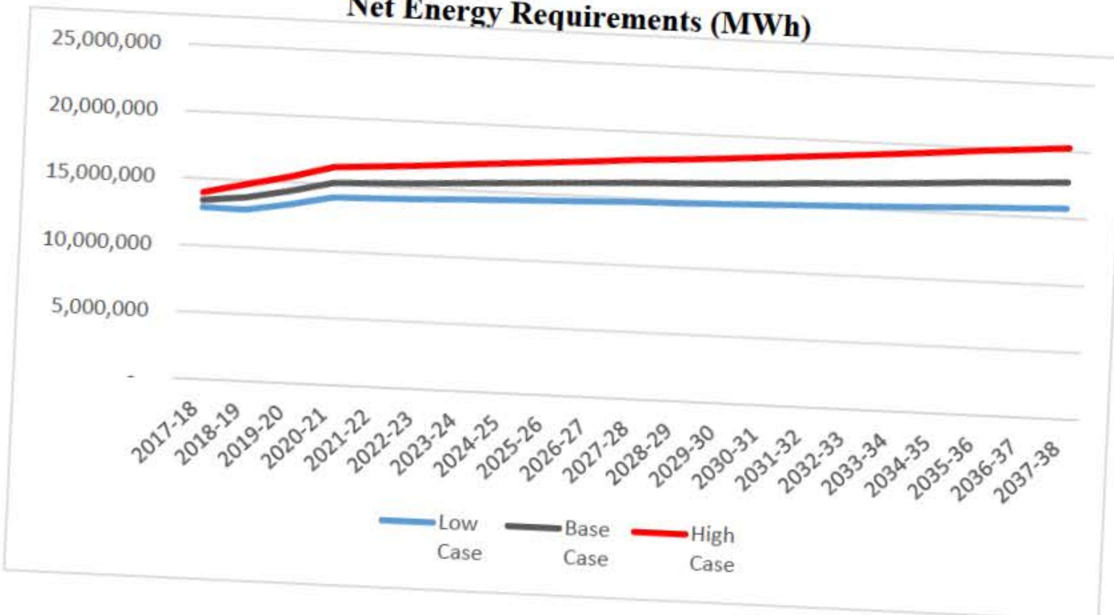


Figure 8-2
Net Winter Peak (MW)

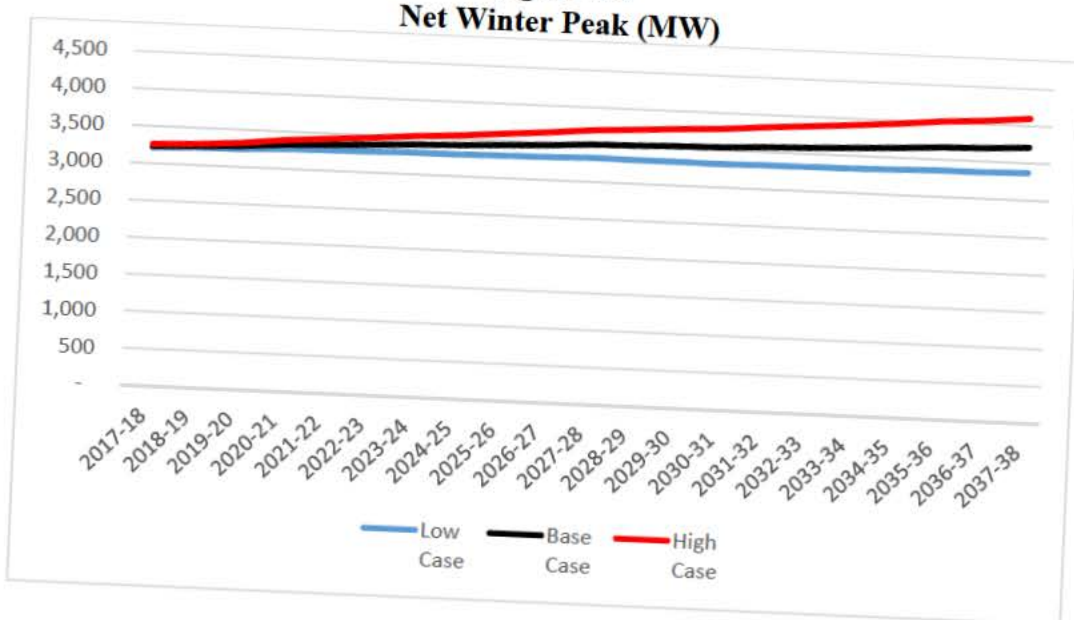
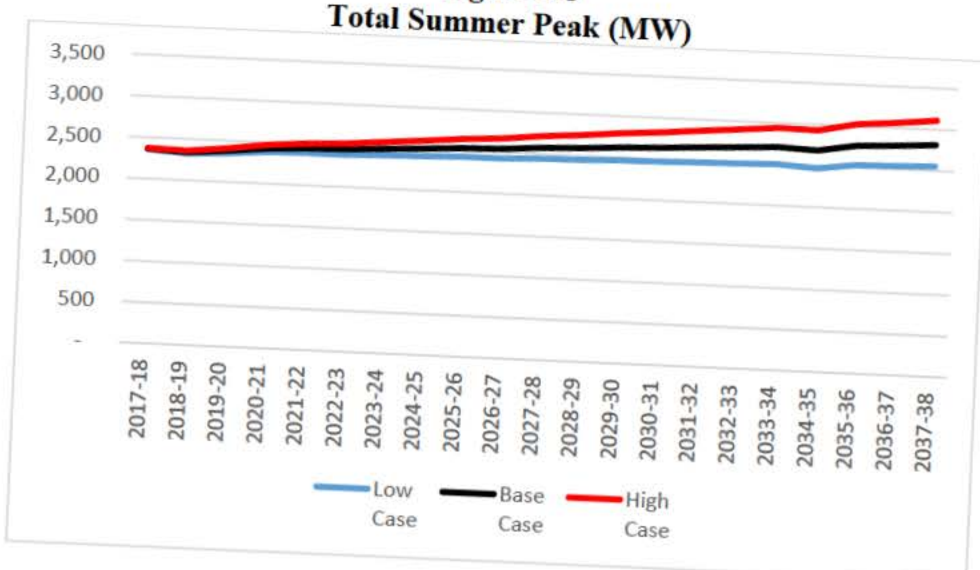


Figure 8-3
Total Summer Peak (MW)



Residential Statistically Adjusted End-Use (SAE) Spreadsheets – 2018 AEO Update

The Residential SAE spreadsheets and models have recently been updated based on the Energy Information Administration's (EIA*) 2018 Annual Energy Outlook (AEO).* The updated spreadsheets reflect the Reference case, which no longer includes the impact of the Clean Power Plan (CPP).

The 2018 residential SAE spreadsheets and *MetrixND* project files include:

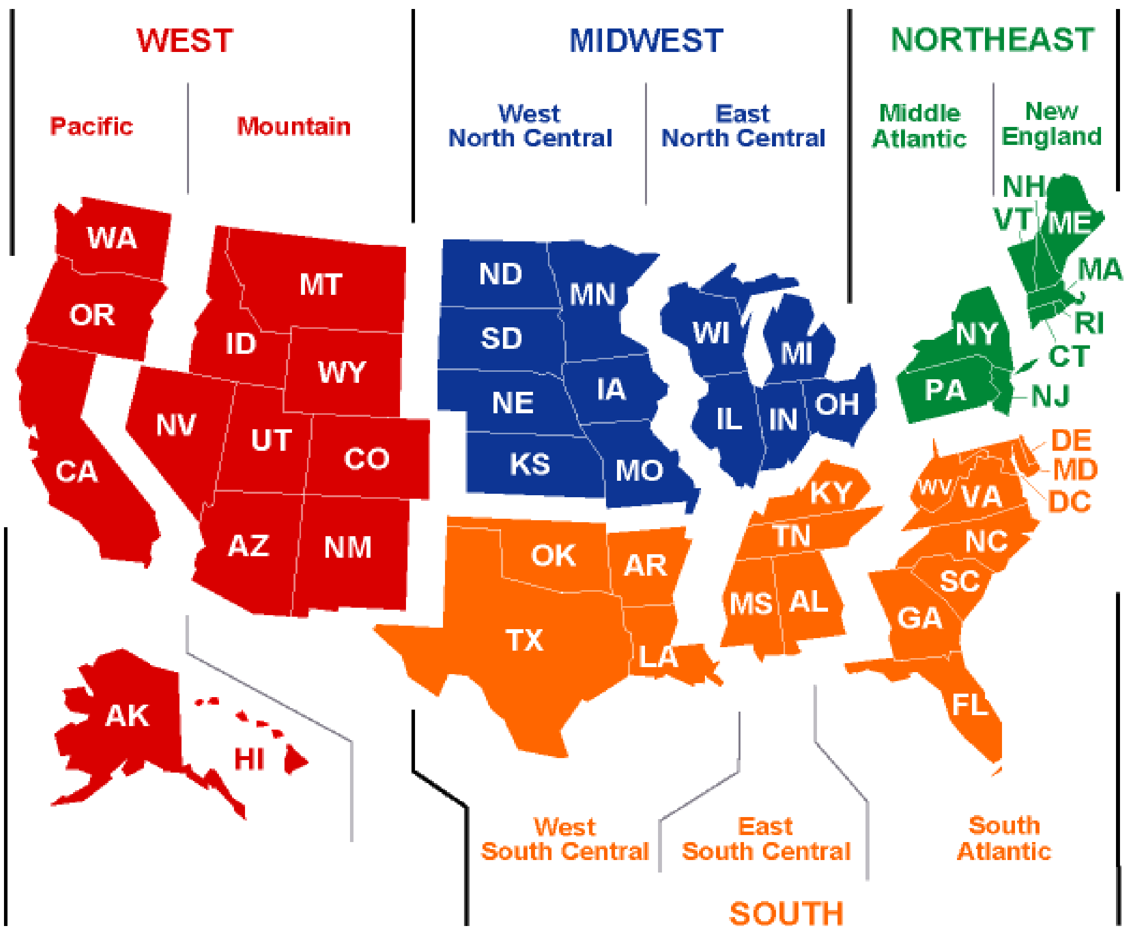
- Updated equipment efficiency trends
- Updated equipment and appliance saturation trends
- Updated structural indices
- Updated annual heating, cooling, water heating, and Non-HVAC indices
- Updated regional sales forecasts

End-use saturation, efficiency, structural changes (building shell efficiency improvements and square footage projections), and base-year end-use energy use are combined to develop historical and projected end-use intensity estimates. Resulting intensities can be used in constructing heating, cooling, and other use variables for residential average use and total sales forecast models.

EIA end-use saturation, efficiency and annual appliance usage (UEC – Unit Energy Consumption) are derived from the National End-Use Model System (NEMS). While NEMS generates detailed end-use data, EIA is primarily concerned with the high-level projection of total energy requirements (measured in Btu) across all end-uses and sectors including transportation. From an electric or natural gas utility forecaster's perspective, it is the underlying end-use and technology level detail that provides insights into how individual residential and commercial customers are using electricity and natural gas, trends in end-use energy consumption, and what these trends imply for future electric and gas usage at the regional level.

EIA provides end-use detail for nine census divisions, depicted in Figure 1.

Figure 1: Forecast Census Divisions



The 2018 AEO forecast base-year is 2009. Base-year end-use UEC, saturations and efficiency are derived from the 2009 Residential Energy Consumption Survey (RECS). The NEMS model, tracks end-use saturation and stock efficiency change over time with changes in customer appliance choices in the new home and replacement markets. Appliance choice decisions are driven by appliance costs, efficiency options and standards, natural gas availability, and fuel prices for electricity and natural gas. Forecasts are developed for three housing types – single family, multi-family, and mobile homes, for twenty end-uses, including:

- Resistance heating/furnaces
- Air-source heat pumps (heating)

- Ground-source heat pumps (heating)
- Secondary heating
- Central air conditioning
- Air-source heat pumps (cooling)
- Ground-source heat pumps (cooling)
- Room air conditioning
- Water heating
- Cooking
- 1st refrigerators
- 2nd refrigerators
- Freezers
- Dishwashers
- Clothes washers
- Clothes dryers
- TVs and related equipment
- Furnace fans
- Lighting
- Miscellaneous

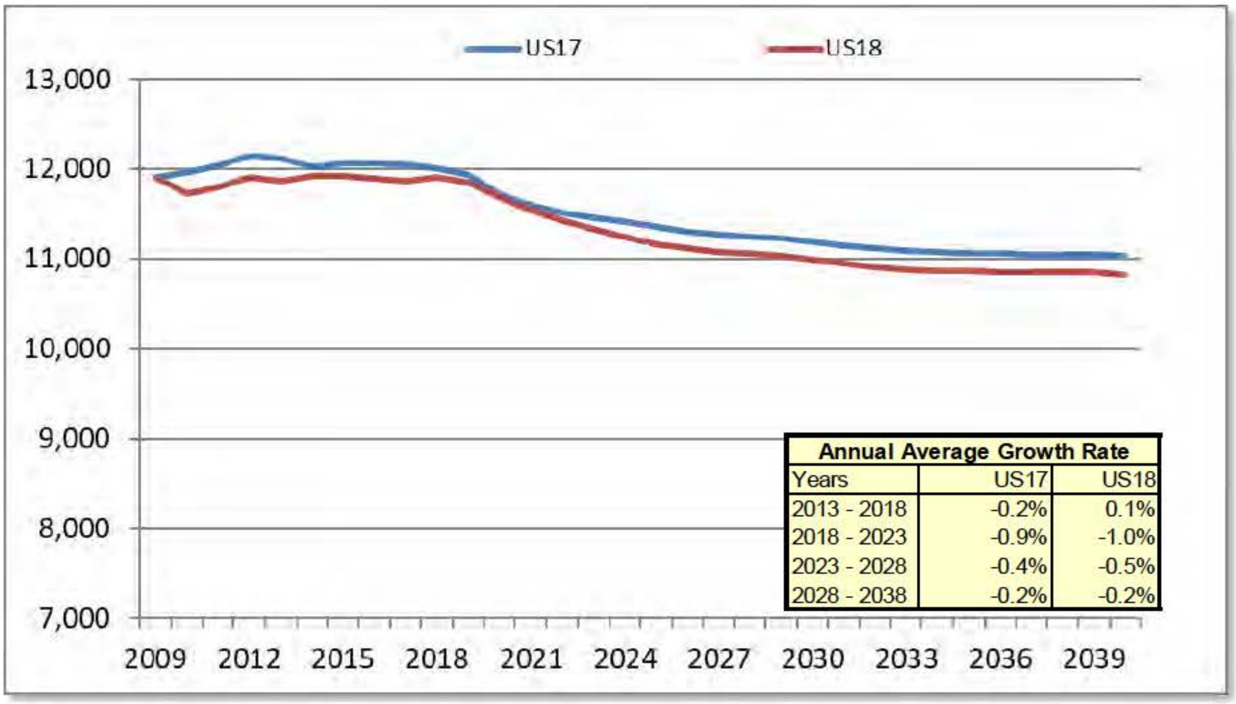
In the Statistically Adjusted End-Use (SAE) model, detailed end-use data derived from the EIA forecasts is used to construct end-use intensities (kWh per household) that are then integrated into monthly heating, cooling, and other use model variables. These variables are then used to forecast utility-level residential and commercial sales through estimated linear regression models. This approach allows utilities to capture the significant improvements in energy efficiency reflected in past usage and to account for expected improvements due to standards, new technologies, as well as state and utility efficiency programs in the future.

To support econometric modeling, Itron maintains and updates historical end-use data trends that are consistent with the 2009 RECS and earlier RECS (such as the 2005 RECS). Doing so sometimes requires adjusting historical end-use saturation and efficiency trends to reflect what EIA believes is the current state of appliance ownership, stock efficiency, and housing characteristics. The 2018 SAE spreadsheets reflect Itron's best estimates of historical end-use saturations, efficiency, and usage given EIA's 2009 base-year starting point and past estimates of end-use stock characteristics. This is the last year the AEO forecast will be based on the 2009 RECS. Going forward, the AEO forecast will be based on the more recent 2015 RECS.

Changes from 2017 Forecast - Electricity

Figure 2 compares the SAE 2017 and SAE 2018 residential total household intensity projections for the U.S. Intensities are measured in kWh per household. Both 2017 and 2018 forecasts exclude CPP adjustments.

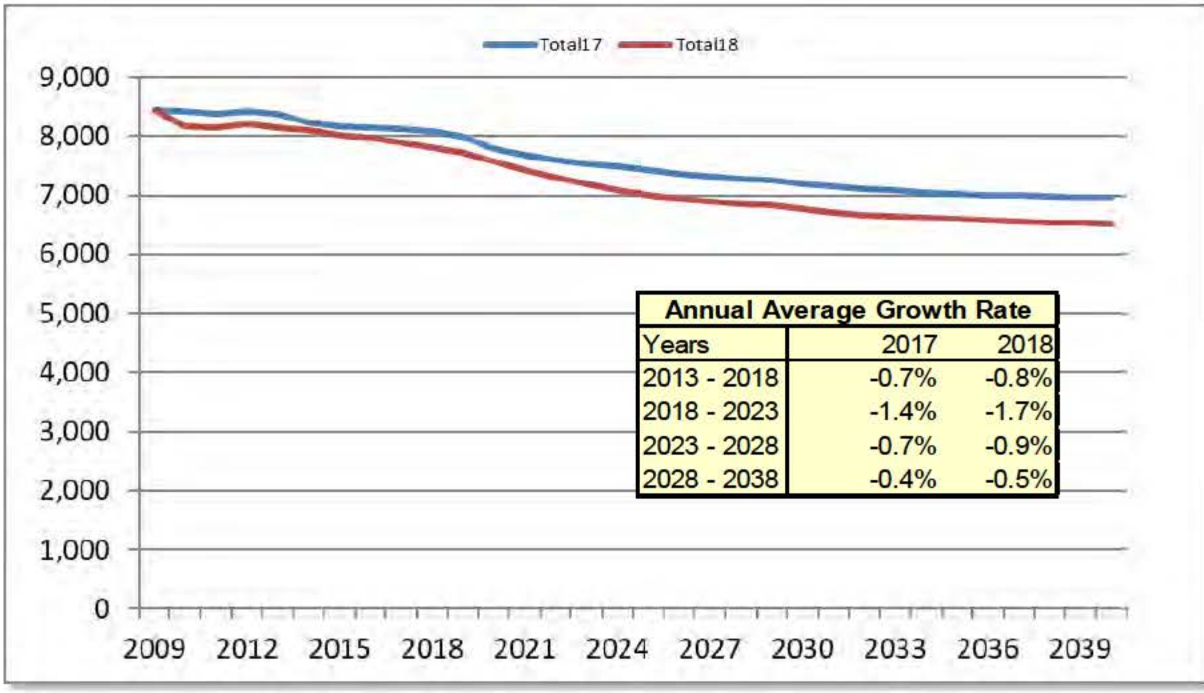
Figure 2: U.S. Residential Total Intensity (kWh/household)



Annual Average Growth Rate		
Years	US17	US18
2013 - 2018	-0.2%	0.1%
2018 - 2023	-0.9%	-1.0%
2023 - 2028	-0.4%	-0.5%
2028 - 2038	-0.2%	-0.2%

The 2008 total intensity is lower on an absolute basis and declines at a slightly faster rate; each year, EIA forecasts lower long-term energy intensities. In the updated forecast, total intensity declines on average 1.0% through 2023 compared with last year's forecast of 0.9% average annual decline. Over the next five years total intensity averages 0.5% decline compared with 0.4% decline in the 2017 forecast. Growth rate differences are even larger across some of the census divisions. Figure 3, for example, compares Mid-Atlantic census division 2017 and 2018 energy intensities.

Figure 3: Mid-Atantic Energy Intensity (kWh/household)



Annual Average Growth Rate		
Years	2017	2018
2013 - 2018	-0.7%	-0.8%
2018 - 2023	-1.4%	-1.7%
2023 - 2028	-0.7%	-0.9%
2028 - 2038	-0.4%	-0.5%

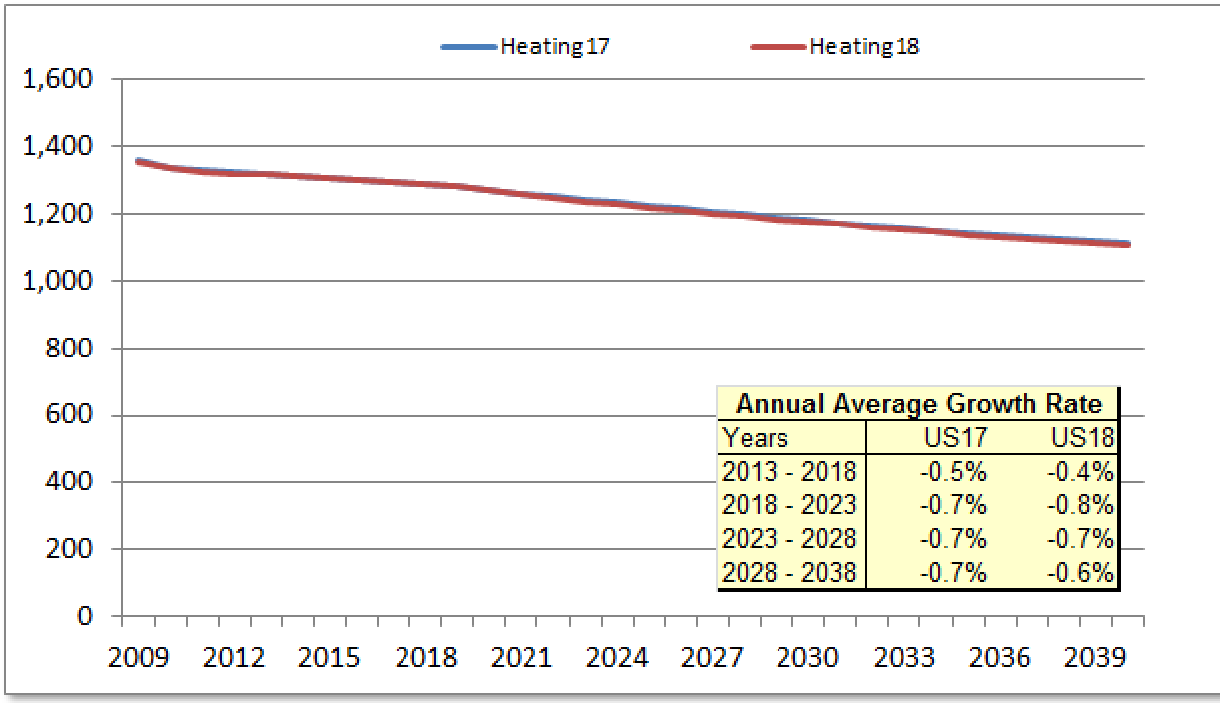
Over the next five years, the 2018 Mid-Atlantic intensity averages 1.7% decline compared with 1.4% average decline in 2017 forecast.

Another factor to note is that the end-use intensity projections include EIA's assumption on future utility efficiency efficiency (EE) spending. EIA intensity estimates also include projected behind the meter (BTM) solar adoption. EIA has provided us with their solar load forecast, so we have been able to back out EIA's solar load forecast from the SAE spreadsheets. EIA has said they will provide EE savings estimates later this summer; we will provide updated SAE 2018 spreadsheets that exclude EE savings estimates once we are able to process this data.

Electric Heating

Electric heating includes resistant electric heat, heat pumps, and furnace fan loads. Figure 4 shows the 2017 and 2018 heating intensity forecasts.

Figure 4: Heating Intensity Projections (kWh/household)

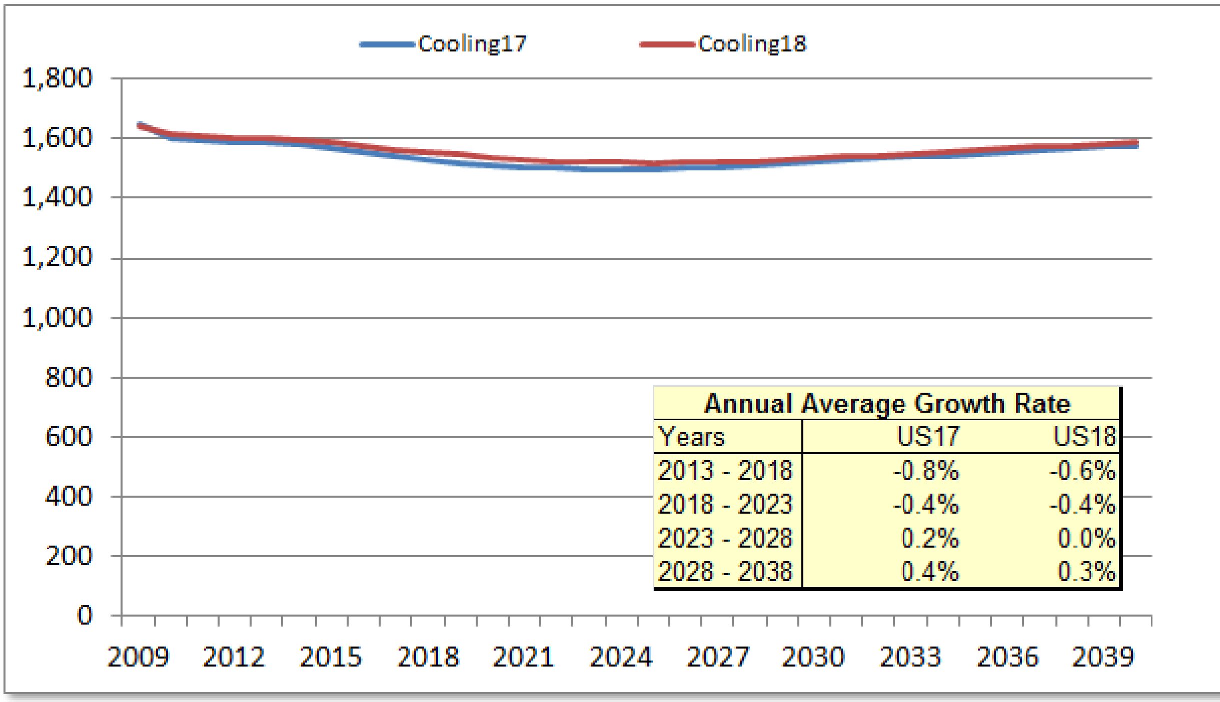


Total heating intensity forecast is only slightly different from the 2017 forecast.

Cooling

Cooling includes central and room air conditioning, and air-source heat pumps. There is also a small amount of cooling load from ground-source heat pumps. Figure 5 compares the 2017 and 2018 cooling intensity projections.

Figure 5: Cooling Intensity Projections (kWh/household)



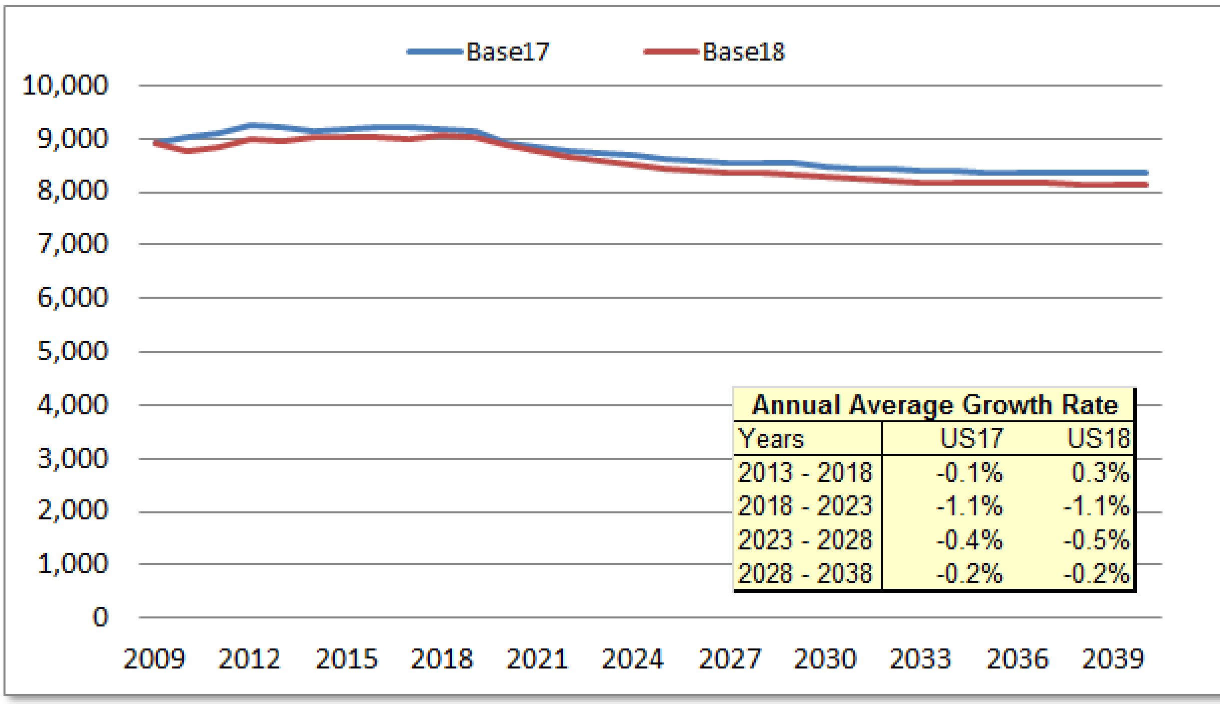
Annual Average Growth Rate		
Years	US17	US18
2013 - 2018	-0.8%	-0.6%
2018 - 2023	-0.4%	-0.4%
2023 - 2028	0.2%	0.0%
2028 - 2038	0.4%	0.3%

Near-term decline in cooling intensity is similar to last year's forecast; overall cooling efficiency increases faster than air conditioning saturation contributing to a -0.4% decline in average annual cooling intensity. Longer term, cooling intensity flattens out and shows some growth as improvements in air conditioning efficiency slows.

Electric Base Use

Electric base-use (loads which are not weather-sensitive) accounts for the largest share of residential electricity use. At the U.S. level, base-use accounts for 75% of residential electricity sales. Figure 6 compares base-use intensity projections.

Figure 6: Base Use Intensity (kWh/household)

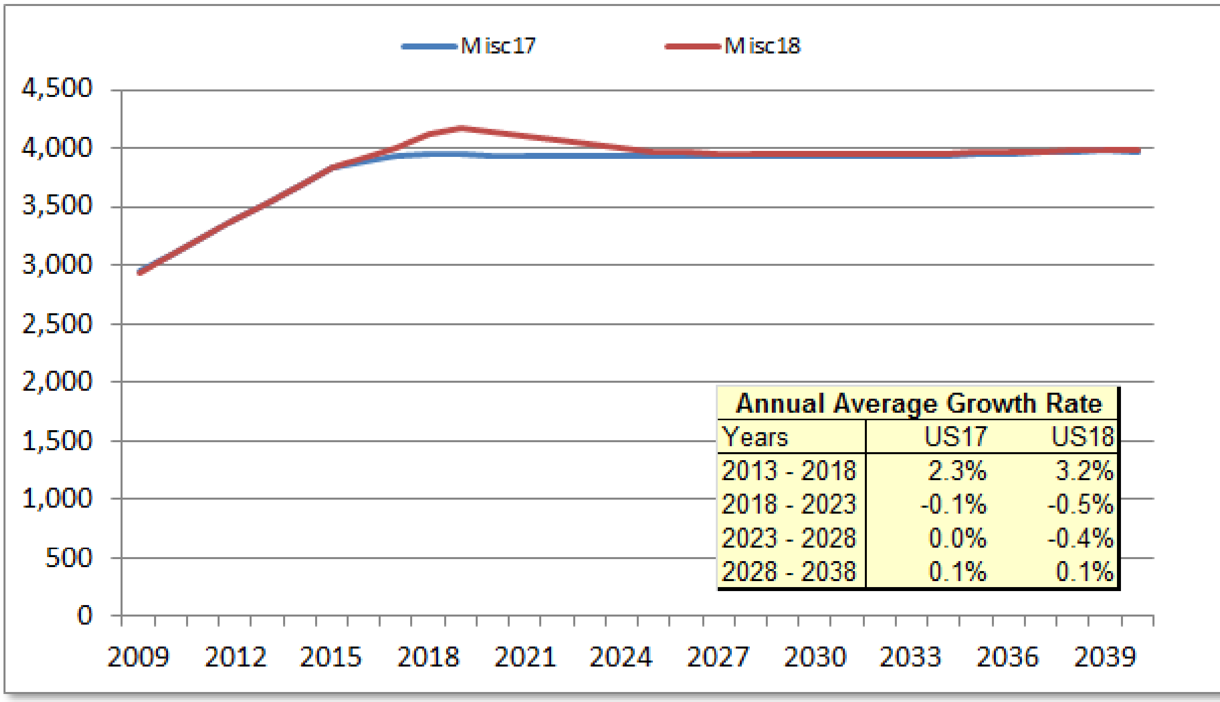


The 2018 base-use intensity is slightly lower in terms of kWh per household than the 2017 forecast, but the forecasted growth rates are similar; average base-use intensity declines through the foreseeable future with the strongest decline over the next five years. While 2018 and 2017 total base-use intensity forecasts follow the same growth projectory, there are significant differences across some of the underlying end-uses. The largest differences are in miscellaneous, water heating, electric dryers, and lighting.

Miscellaneous

Miscellaneous is the largest end-use category accounting for roughly 25% of residential usage, and nearly half of base-use. Miscellaneous includes everything from pool pumps and security systems to smart phones and other plug-in devices. Figure 7 shows EIA's miscellaneous energy intensity forecasts for the current and prior-year forecasts.

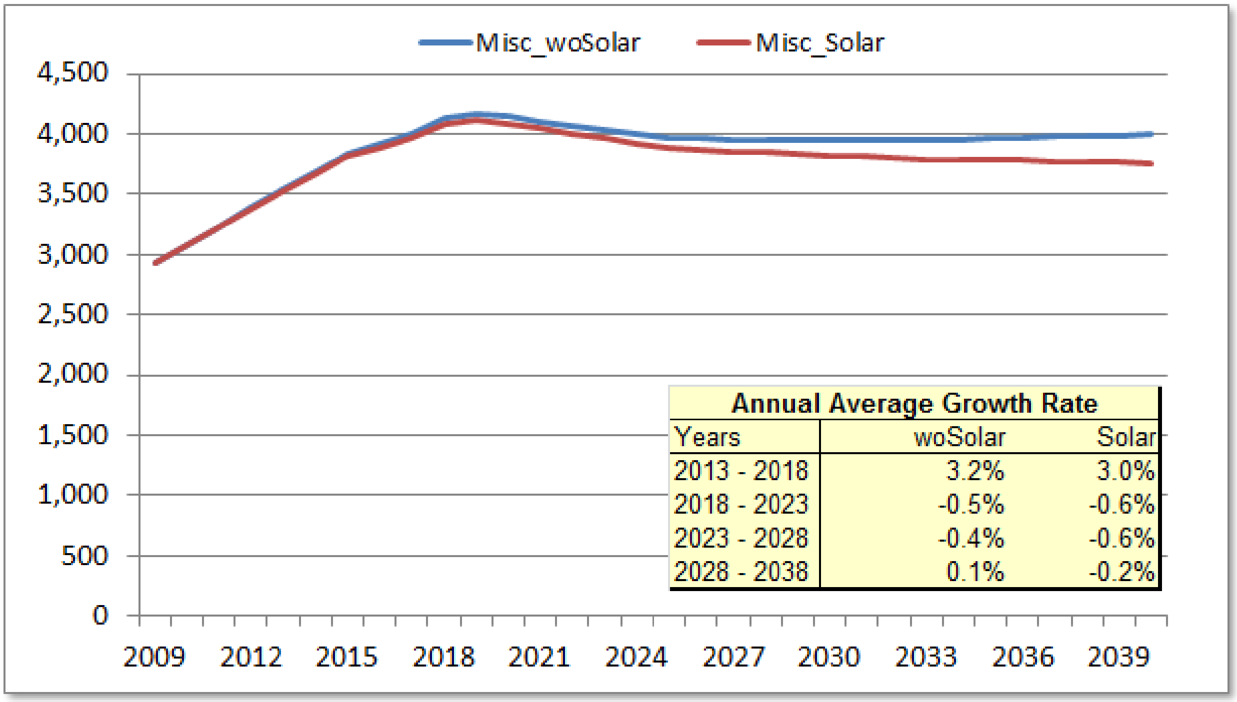
Figure 7: EIA Miscellaneous Intensity Projections (kWh/household)



The 2018 forecast shows an average annual decline of 0.5% through 2023 and continues to decline through 2028. In comparison the 2017 miscellaneous intensity forecast was largely flat through the forecast period. Changes in historical growth are a large contributor to differences in forecasted growth. The 2018 forecast shows 3.2% miscellaneous growth between 2013 and 2018 compared with 2.3% growth in the 2017 forecast. Ultimately, the 2018 and 2017 miscellaneous intensity projections reach the same point in 2027 at roughly 4,000 kWh per household.

The 2018 miscellaneous sales would decline even faster if BTM solar was not backed out of the forecast. Most of EIA's solar load impact rolls through the miscellaneous end-use. Figure 8 compares miscellaneous intensity with and without solar own-use generation.

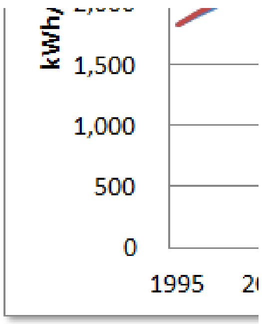
Figure 8: Miscellaneous Solar Adjustment (kWh/household)



Alternative Miscellaneous Intensity Curve

Miscellaneous sales growth like that associated with all new technologies can be expected to slow in the future as saturation growth of home miscellaneous end-uses slows down and efficiency improves. However, we are not entirely comfortable with the idea that miscellaneous energy use (which has been carrying most of residential usage growth for the last ten years) will turn negative over the near-term. Part of the decline may be attributed to embedded EE savings assumptions that we hope to back out later this summer. In the meantime, we have developed an adjusted miscellaneous intensity curve for each census division. The curve is based on a Bass Diffusion model that runs through the 2009 RECS estimate and ultimately reaches the long-term EIA intensity projection. Figure 9 compares adjusted against EIA's miscellaneous projections (excluding solar).

Figure 9: Adjusted Miscellaneous Usage Curve

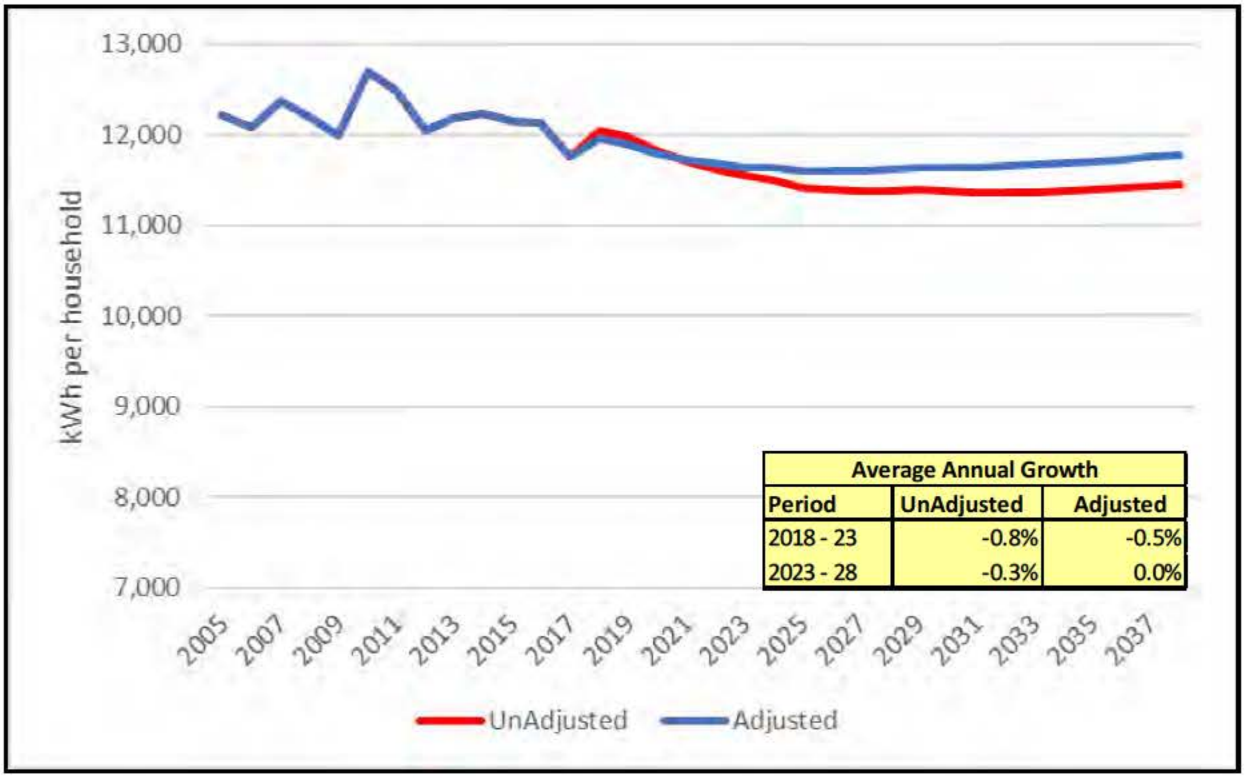


In contrast to EIA estimate, the adjusted miscellaneous intensity continues to increase over the entire forecast period but does so at a slowing rate. The curve fits historical data through 2009 but increases at a slower rate through 2018 than EIA's assumption. As this process impacts historical miscellaneous load estimates as well as the forecast, using the adjusted estimates in SAE models will change model coefficients.

In updating forecasts, we recommend comparing model results and forecasts using the unadjusted and adjusted miscellaneous intensity projections. Should you choose to use the adjusted miscellaneous curve, simply change the miscellaneous link in your MetrixND energy intensity Data Table to point to the "Misc_Adj" instead of "Misc".

Figure 10 shows predicted average use for the U.S. with the unadjusted and adjusted miscelleaneous intensities.

Figure 10: U.S. Average Use with Adjusted Miscellaneous Intensity



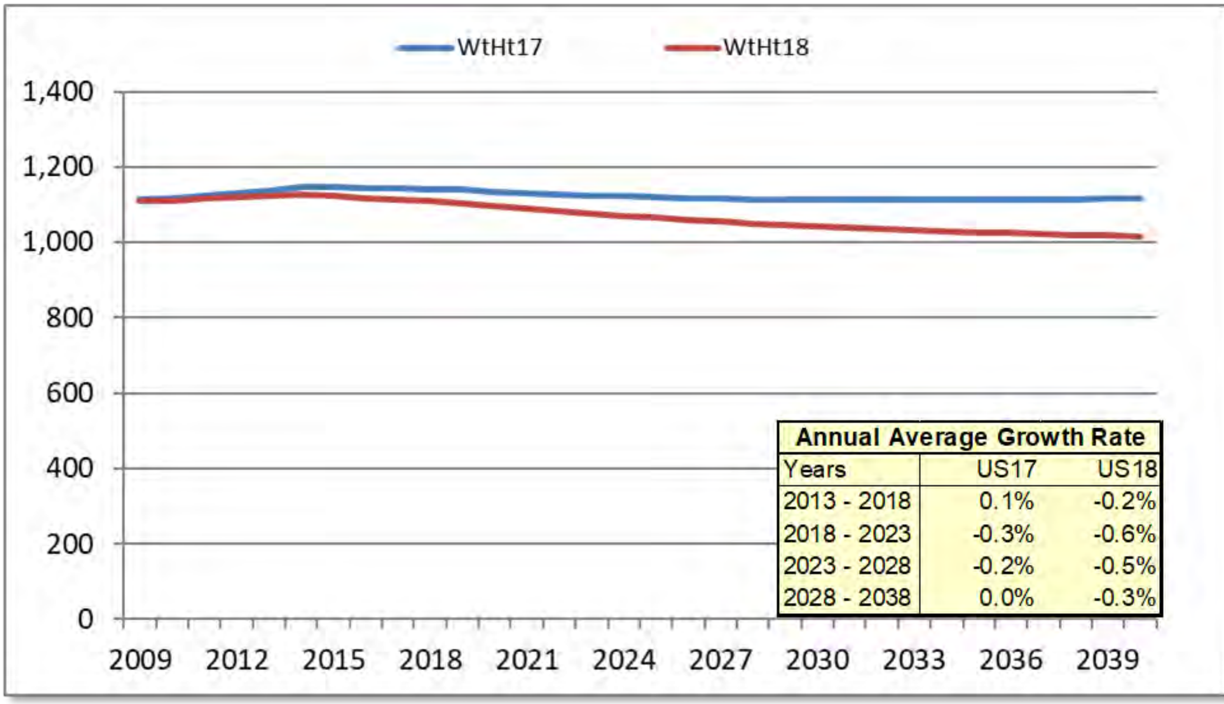
Average Annual Growth		
Period	UnAdjusted	Adjusted
2018 - 23	-0.8%	-0.5%
2023 - 28	-0.3%	0.0%

Using the curve-fitted intensity estimate, U.S. total intensity declines on average 0.5% (adjusted) over the next five years compared with -0.8% using EIA's miscellaneous (unadjusted) intensity projection. Between 2023 and 2028, adjusted miscellenous results in flat average use projection vs. a 0.3% decline with EIA's projection.

Water Heating

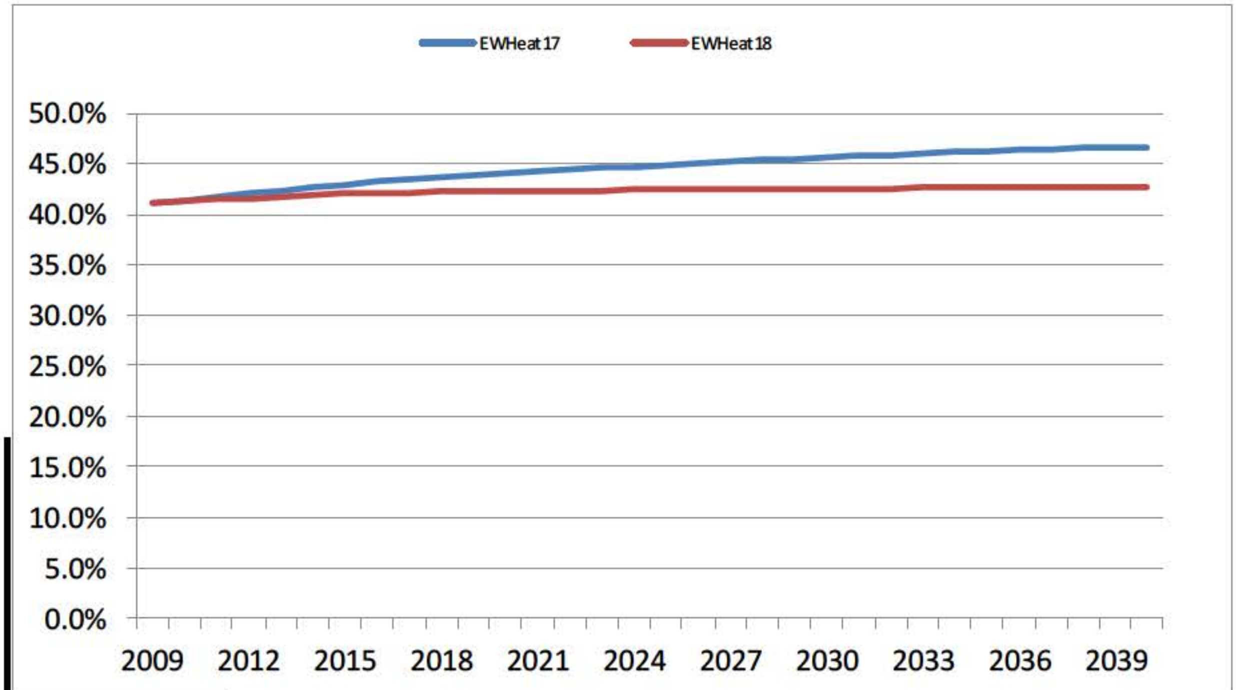
The electric water heating also declines at a faster rate than in the 2017 forecast. Figure 11 compares 2018 and 2017 forecasted water heating intensity.

Figure 11: Electric Water Heating Intensity (kWh/household)



For electric water heating it isn't differences in efficiency that drives the trends, but rather differences in saturation. The 2018 water heating saturation is lower because of lower natural gas prices which in turn results in higher saturation of gas water heating heating. Figure 12 compares electric water heating saturation.

Figure 12: Electric Water Heating Saturation

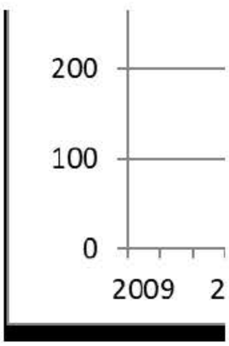


By 2023, electric water heating saturation is three precent lower in the 2018 forecast.

Electric Dryers

The 2018 electric dryer intensity is also lower than last year. Figure 13 compares 2017 and 2018 electric dryer intensities.

Figure 13: Electric Dryer Intensity (kWh/household)

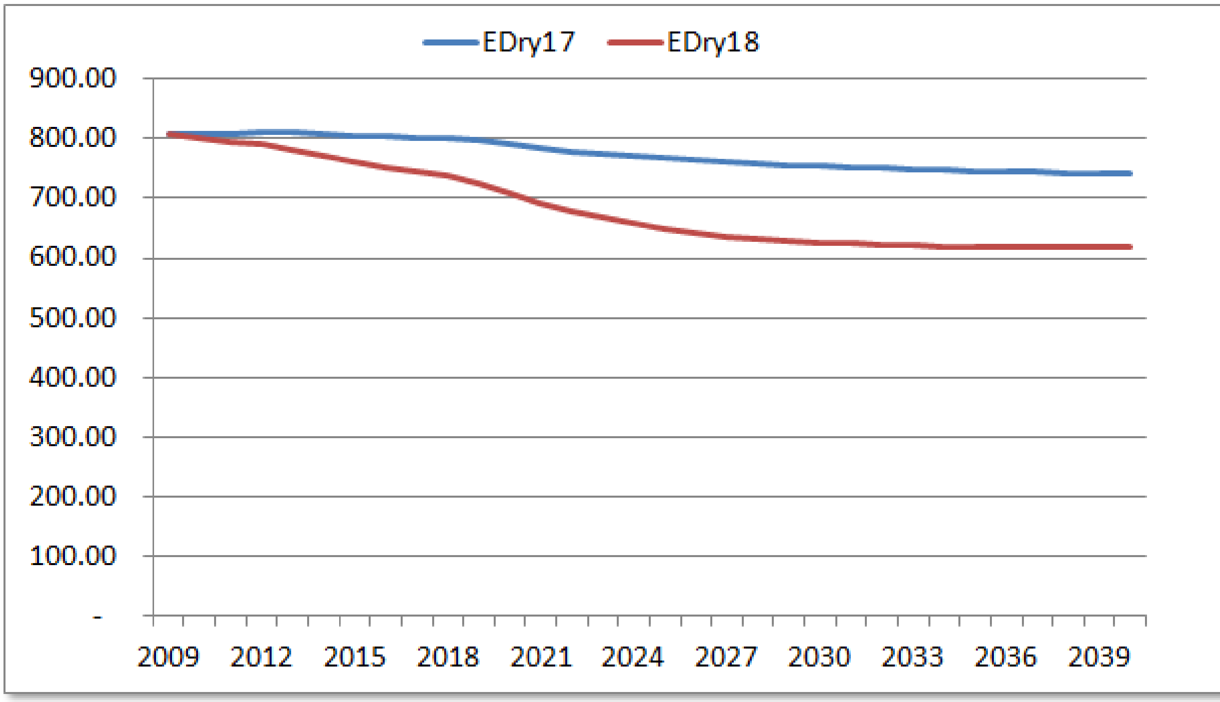


Annual Average Growth Rate		
Years	US17	US18
2013 - 2018	0.3%	-0.9%
2018 - 2023	-0.2%	-1.7%
2023 - 2028	0.0%	-0.9%
2028 - 2038	0.2%	0.0%

While part of the difference is again due to lower electic dryer saturation, the bigger factor is assumed to be the stronger gain electric dryer efficiency.

Part of the difference is again due to lower natural gas prices that translate into lower electric and higher gas dryer saturations. The larger factor though is due to higher electric heat efficiency improvements; part of this may be driven by EIA's EE program assumption. Figure 14 compares electric dryer efficiency forecast.

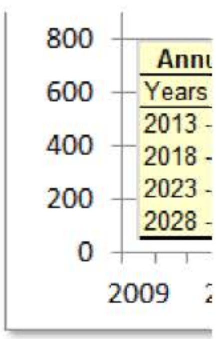
Figure 14: Electric Dryer Efficiency Projections (kWh/year)



Lighting

In 2018 residential lighting was adjusted to better account for historical shipment shares of general service incandescents, CFLs, and LEDs, as well as utility rebate incentives. Figure 15 shows lighting intensity projections.

Figure 15: Lighting Intensity (kWh/household)



The new forecast reflects faster upfront penetration of LED lighting with part of that due to utility lighting incentive programs. Because of earlier LED penetration, the sharp drop due where the new standards go into effect shown in the 2017 forecast are softened in the updated forecast. Lighting intensity flattens out after 2024 with lighting intensity reaching 800 kWh per household by 2030. Slower decline in lighting intensity largely compensates for stronger intensity declines in miscellaneous, water heating, and electric dryers.

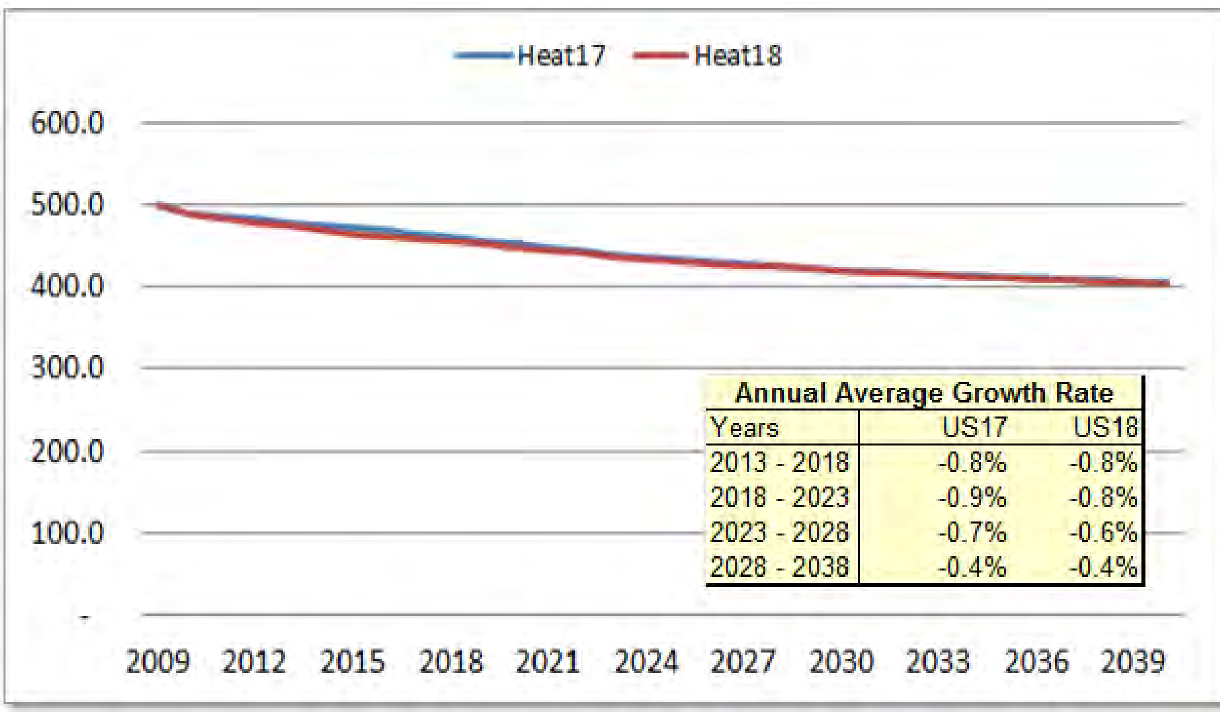
Changes from 2017 – Natural Gas

Space heating and water heating account for 95% of residential natural gas usage, with cooking and clothes dryers accounting for the remainder. At the U.S. level, roughly 50% of households have gas space and water heating. The share of homes with gas space heat has been relatively constant and is expected to increase just slightly over the next 20 years.

Gas Heating

Over the last 10 years, there have been significant improvements in heating system efficiency. With a relatively flat saturation, gas heating use declines as improvements in efficiency continue. Residential gas heat intensity has averaged 0.7% decline over the last 10 years. Figure 16 compares the 2017 and 2018 gas heating intensity projections.

Figure 16: Heating Intensity (Therms/household)

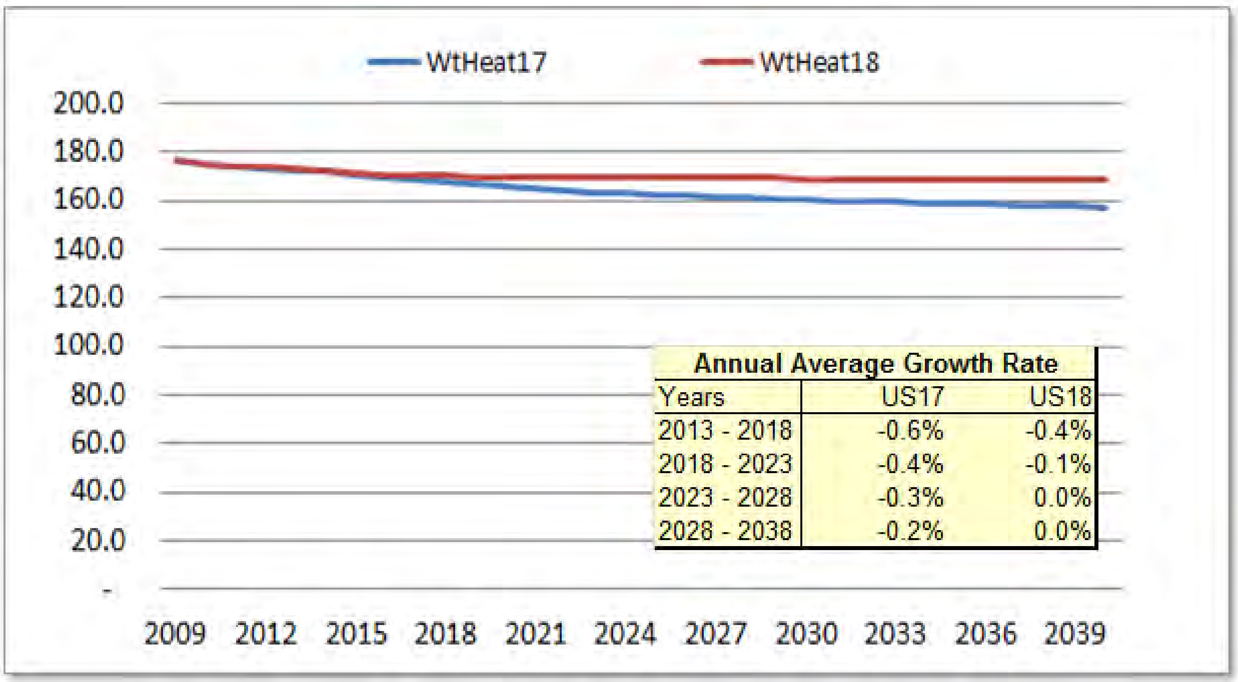


There is little difference in heating usage between the two forecasts.

Water Heating

Water heating is the second largest gas end-use, accounting for approximately 30% of residential natural gas usage. As with furnaces and gas boilers, water heaters have seen significant improvements in energy efficiency. Because efficiency has been increasing while saturation has been flat to declining, gas water heating intensity has also been declining. Figure 17 shows the 2017 and 2018 gas water heating intensity forecast.

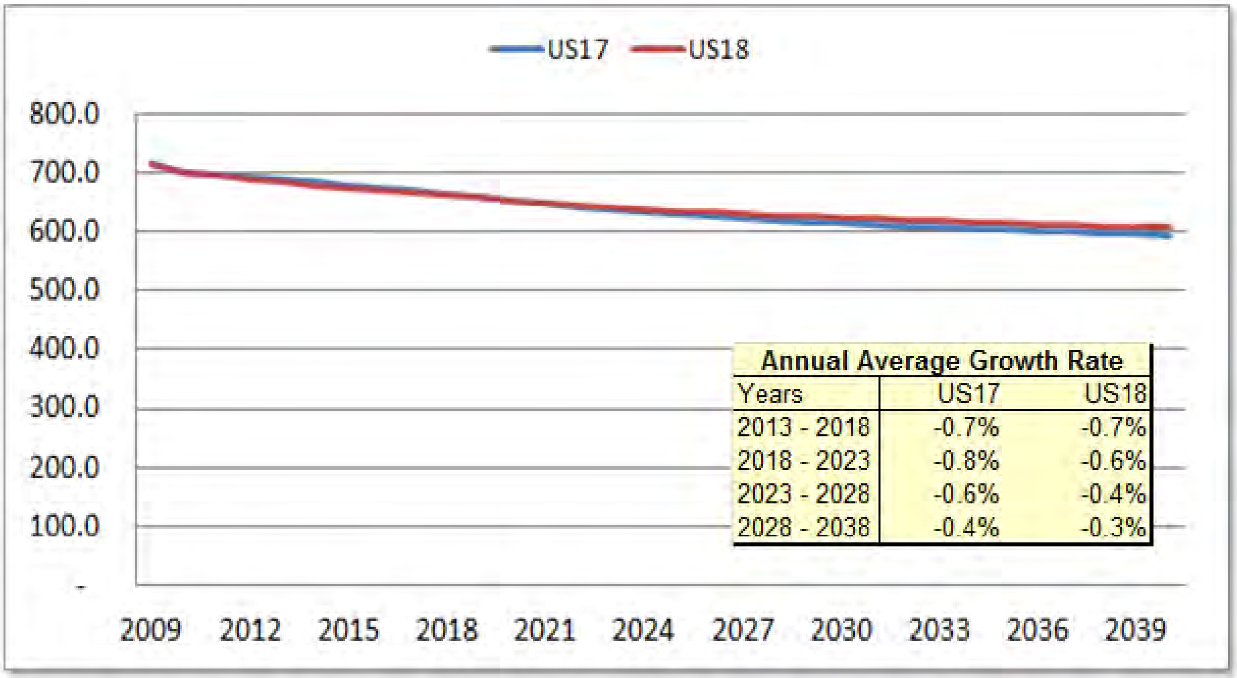
Figure 17: Gas Water Heating Intensity (Therms/household)



The 2017 gas water heating intensities are projected to be largely flat throughout the forecast period due to flat versus declining saturation in 2017.

Gas dryer and cooking energy intensities also decline through the forecast horizon. When all gas appliances are aggregated, total residential gas intensity averages 0.7% annual decline over the next 10 years. This is not significantly different than the previous 10 years and is slightly higher than 2017 forecast. Figure 18 shows total residential gas intensity forecast.

Figure 18: Total Residential Gas Intensity (Therms/household)



Annual Average Growth Rate

Years	US17	US18
2013 - 2018	-0.7%	-0.7%
2018 - 2023	-0.8%	-0.6%
2023 - 2028	-0.6%	-0.4%
2028 - 2038	-0.4%	-0.3%

Summary

EIA's 2018 electric end-use efficiency projections coupled with lower saturations for end-uses that competed with natural gas results in EIA's lowest end-use intensity projections to date. For those that incorporate the end-use intensities into residential SAE models you will likely see lower residential sales forecasts than in prior years. The lower intensities can partly be mitigated by using the adjusted miscellaneous intensity incorporated in the SAE spreadsheets. The 2018 projected intensities will likely be adjusted upwards once we are able to back out the EE program savings assumptions. We plan on a second 2018 release hopefully by the end of the summer.

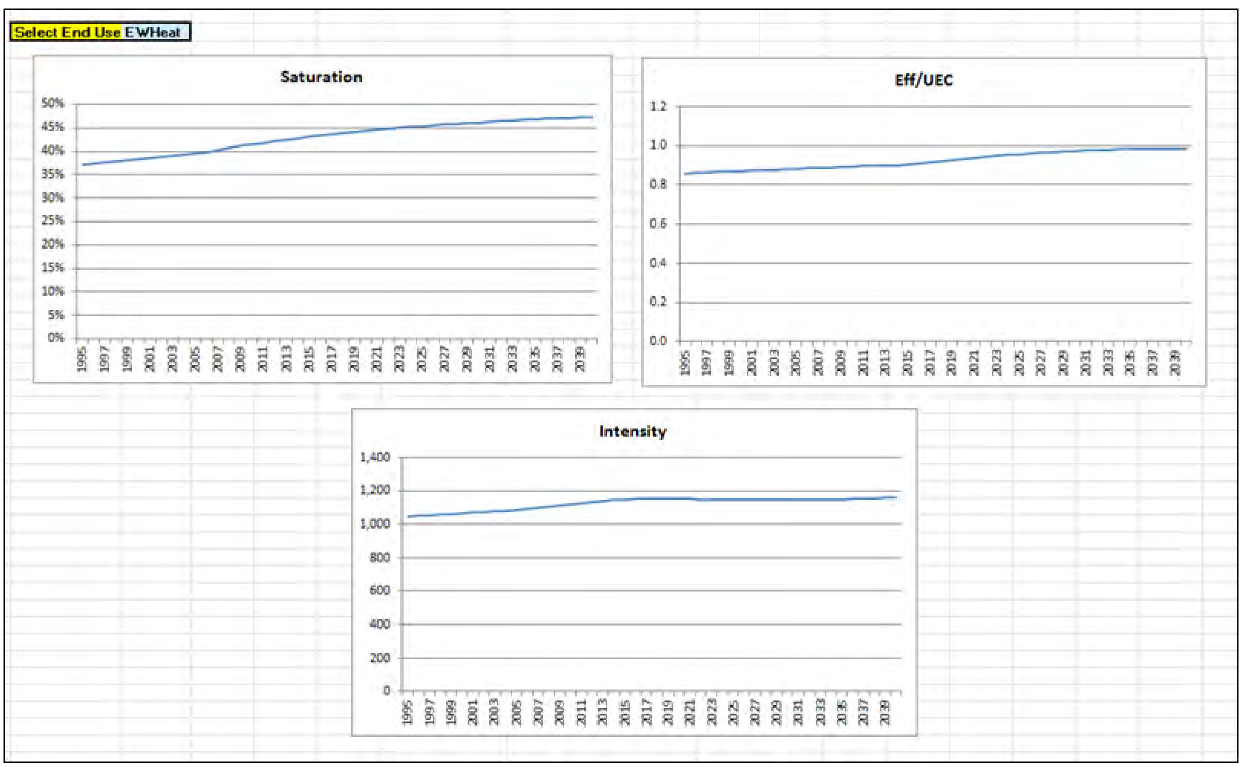
In 2019 we are likely to see another significant change in end-use intensities as EIA updates the long-term forecast to based on the 2015 RECS. This will also require a major effort on our part to integrate past RECS surveys and estimated stock efficiency into a new historical set of saturation, efficiency, and intensites. Given the coming changes, and our concerns with the current 2018 indices, it would not be unreasonable to continue using the 2017 indices in any near-term forecast development work.

Appendix A: Using the SAE Spreadsheets

Updates to the SAE Spreadsheets

Itron continually works to simplify and improve the SAE spreadsheets to allow analysts to view end-use intensity trends, to understand how the indices are calculated, and to customize the SAE inputs (such as end-use saturations and starting UEC) to their own service area. Last year, Itron added a new “graph” tab that allows the analyst to select an end-use and graph the end-use saturation, efficiency/UEC, and calculated intensity. Figure 19 shows this feature for electric water heaters.

Figure 19: SAE Spreadsheet End-Use Graph - Electric Water Heat



SAE Spreadsheet Organization

The SAE spreadsheets are organized to allow the analyst to calibrate end-use intensities to a specific utility service area organization where service area specific saturation and UEC estimates are available. The spreadsheet tabs include:

- **Definitions** provides descriptive information about end-uses, units and brief descriptions of the other worksheets.
- **EIAData** contains EIA efficiency, consumption, equipment stock, household, floor space and price projections.
- **Calibration** provides base year usage information. It can also be used to customize the spreadsheet to the user's service territory. Figure 20 shows the layout of the Calibration worksheet.

Figure 20: Calibration Worksheet

	A	B	C	D	E	F	G	H	I	J	K
1	Base Year (2009)	EFurn	HPHeat	GHPHeat	SecHt	CAC	HPCool	GHPCool	RAC	EWHeat	ECook
2	Consumption (mmBtu)	295,156,965	49,006,093	3,298,852	60,466,462	469,614,726	92,426,664	4,189,994	68,043,412	428,267,637	104,815,834
3	Equipment Stock (units)	29,626,185	9,099,838	699,168	28,312,038	61,707,187	9,099,838	699,168	49,101,682	46,763,693	68,137,629
4	UEC (kWh/unit)	2,920	1,578	1,383	626	2,230	2,977	1,756	406	2,684	451
5	Share (%)	26.0%	8.0%	0.6%	23.4%	54.2%	8.0%	0.6%	43.1%	41.1%	59.9%
6	Raw Intensity (kWh/year)	760	126	8	147	1,209	238	11	175	1,103	270
7	Model-Scaled Intensity (kWh/year)	760	126	8	147	1,209	238	11	175	1,103	270
8											
9	Observed Use Per Customer (kWh/year)	11,909									
10	Adjustment Factor	1.010									
11	Adjusted Intensity (kWh/year)	768	127	9	148	1,222	240	11	177	1,114	273
12											
13	XHeat	1.000									
14	XCool	1.000									
15	XOther	1.000									
16											

Base-year use-per-customer (kWh) for the utility service area is depicted in Row 9 and can be used to calibrate the spreadsheet to the user's service territory. To do this, substitute your weather-normalized average use for the Census Division average-use in Cell B9.

In additional to basic calibration to observed usage, in 2017 we have also added another layer of calibration to better tailor the regional data to utility-specific conditions. In order to get better starting estimates of electric usage by end-use, we have utilized MetrixND models to "true up" EIA estimates to the regions. You can do this on the utlity level by substituting the adjustment factors in cells B13-15 with estimated coefficients on SAE variables in your residential model. Figure 21 below provides an example.

Figure 21: Model-Based Calibration

	A	B	C	D	E	F	G	H	I	J	K
1	Base Year (2009)	EFurn	HPHeat	GHPHeat	SecHt	CAC	HPCool	GHPCool	RAC	EWHeat	ECook
2	Consumption (mmBtu)	295,156,965	49,006,093	3,298,852	60,466,462	469,614,726	92,426,664	4,189,994	68,043,412	428,267,637	104,815,834
3	Equipment Stock (units)	29,626,185	9,099,838	699,168	28,312,038	61,707,187	9,099,838	699,168	49,101,682	46,763,693	68,137,629
4	UEC (kWh/unit)	2,920	1,578	1,383	626	2,230	2,977	1,756	406	2,684	451
5	Share (%)	26.0%	8.0%	0.6%	23.4%	54.2%	8.0%	0.6%	43.1%	41.1%	59.9%
6	Raw Intensity (kWh/year)	760	126	8	147	1,209	238	11	175	1,103	270
7	Model-Scaled Intensity (kWh/year)	1,853	308	21	358	2,389	470	21	346	677	166
8											
9	Observed Use Per Customer (kWh/year)	11,909									
10	Adjustment Factor	0.999									
11	Adjusted Intensity (kWh/year)	1,852	307	21	357	2,387	470	21	346	677	166
12											
13	XHeat	2.438									
14	XCool	1.975									
15	XOther	0.614									
16											

In this case, model-based calibration adjusts heating and cooling starting year usage up based on model coefficients estimated from observed use per customer data. Other usage is adjusted downward.

Resulting end-use intensities are written to the Intensities tab. MetrixND project files can link to the Intensities tab as the source-data for the constructing of SAE model variables.

StructuralVars

This worksheet contains data about the size of homes and their building shell efficiencies. The results of the calculations on this tab are used in the development of energy intensities for heating and cooling end-uses.

Analysts can substitute local household and floor space estimates for the regional estimates to reflect local conditions in the final energy intensities. Total floor space can be modified in Column E and number of households in Column I.

Shares

The Shares tab contains historical saturation estimates and forecasts developed by the EIA. Data from appliance saturation surveys can be used to modify the default saturations. Depending on data availability, these changes can either shift the projections up or down (one survey) or modify the growth rate in the trends (two or more surveys).

Efficiencies

The Efficiencies tab provides historical and forecasted end-use efficiency. UEC estimates are used as a proxy for efficiency where specific technology efficiency data (as central air conditioner SEER) are not available. Efficiency trends can also be modified to reflect the utility service area. As a practical matter however, average efficiency for most equipment varies little between regions.

Intensities

Intensities are per-household end-use energy estimate derived from combining end-use saturation, efficiency, and starting UEC. If the user changes saturation and/or efficiency, the changes are reflected in the end-use intensity calculations.

MonthlyMults

This tab provides seasonal multipliers for non-HVAC end-uses. This allows us to accurately gauge seasonal usage for such non weather-sensitive end-uses as water heating, refrigeration and lighting.

Graphs

The Graphs tab provides an interface to select an end-use and view historical and projected end-use saturation, efficiency (or UEC where an efficiency measure is not available) and resulting end-use intensity.

EV

Electric vehicle load is added to the base (other) end-use in the SAE model. Input data rows are highlighted in red and include:

- **Households** - Historical and forecasted number of households (column B)
- **EVSold** - Number of EV vehicles sold in any given year (column C)
- **EVDecay** - Number of EV vehicles removed (column D)
- **AnnualMiles** - Annual average miles driven (column G)
- **MilePerKwh** - Average vehicle efficiency (column H)

Additional columns include:

- **EVStock** - Calculated as the sum of all new purchases minus vehicle decay (column E).
- **Share** - The share of households with EVs (column F), calculated as *EVStock / Households*.
- **UEC** - The Unit Energy Consumption (kWh) for those households that own an EV. Calculated as the number of miles driven divided by the average vehicle miles per kWh (column I).
- **ShareUEC** - Use per household (column K), calculated by multiplying the vehicle UEC and the share of households that own an EV. The resulting annual EV energy intensity is on a kWh per household basis and can be added to the base or *other use index* in the SAE model.

PV

The SAE spreadsheets also include a worksheet for calculating PV (photovoltaic) energy impacts. Input data rows are highlighted in red and include:

- **Households** - Historical and forecasted Households or customers (column B)
- **PVInstalls** - Number of new PV installations (column C)
- **AvgPVSize** - Average PV kW capacity (column E)
- **PVDecayKW** - PV capacity decay in kW (column G)
- **CapacityFactor** - Capacity Factor (column I)

Additional columns include:

- **PVStockKW** - Estimated PV kW capacity (column H), calculated by summing current and all past PV installed capacity and subtracting the decay, calculated as:

$$(PVInstalls \times AvgPVSize) - PVDecayKW$$

- **PVEnergy** - PV MWh (column J) is derived by applying the capacity factor to the PV Capacity Stock, calculated as:

$$(PVStockKW \times 8760 \times CapacityFactor)/1000$$

- **ShareUEC** - Final PV energy intensity (column K) is derived by dividing *PVEnergy* by total number of households. The estimate is negative, as it represents a load reduction.

Appendix B: Residential SAE Modeling Framework

The traditional approach to forecasting monthly sales for a customer class is to develop an econometric model that relates monthly sales to weather, seasonal variables, and economic conditions. Econometric models are well suited to identifying historical trends and to projecting these trends into the future. In contrast, end-use models are able to identify and isolate the end-use factors that are driving energy use. By incorporating end-use structure into an econometric model, the statistically adjusted end-use (SAE) modeling framework exploits the strengths of both approaches.

There are several advantages to this approach.

- The equipment efficiency and saturation trends, dwelling square footage, and thermal integrity changes embodied in the long-run end-use forecasts are introduced explicitly into the short-term monthly sales forecast. This provides a strong bridge between the two forecasts.
- By explicitly incorporating trends in equipment saturations, equipment efficiency, dwelling square footage, and thermal integrity levels, it is easier to explain changes in usage levels and changes in weather-sensitivity over time.
- Data for short-term models are often not sufficiently robust to support estimation of a full set of price, economic, and demographic effects. By bundling these factors with equipment-oriented drivers, a rich set of elasticities can be incorporated into the final model.

This section describes this approach, the associated supporting SAE spreadsheets, and the *MetrixND* project files that are used in the implementation. The main source of the SAE spreadsheets is the 2017 Annual Energy Outlook (AEO) database provided by the Energy Information Administration (EIA).

Statistically Adjusted End-Use Modeling Framework

The statistically adjusted end-use modeling 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,

$$\mathrm{USE}_{y,m} = \mathrm{Heat}_{y,m} + \mathrm{Cool}_{y,m} + \mathrm{Other}_{y,m} \quad (1)$$

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.

$$\mathrm{USE}_{m} = a + b_1 \times \mathrm{XHeat}_{m} + b_2 \times \mathrm{XCool}_{m} + b_3 \times \mathrm{XOther}_{m} + \varepsilon_{m} \quad (2)$$

$XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, dwelling data, 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.

Constructing XHeat

As represented in the 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
- Thermal integrity and footage of homes
- Average household size, household income, and energy prices

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

$$XHeat_{y,m} = HeatIndex_{y,m} \times HeatUse_{y,m} \quad (3)$$

Where:

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

The heating equipment index is defined as a weighted average across equipment types of equipment saturation levels normalized by operating efficiency levels. Given a set of fixed weights, the index will change over time with changes in equipment saturations (*Sat*), operating efficiencies (*Eff*), building structural index (*StructuralIndex*), and energy prices. Formally, the equipment index is defined as:

$$HeatIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} / Eff_y^{Type} \right)}{\left(Sat_{09}^{Type} / Eff_{09}^{Type} \right)} \quad (4)$$

The *StructuralIndex* is constructed by combining the EIA's building shell efficiency index trends with surface area estimates, and then it is indexed to the 2009 value:

$$StructuralIndex_y = \frac{BuildingShellEfficiencyIndex_y \times SurfaceArea_y}{BuildingShellEfficiencyIndex_{09} \times SurfaceArea_{09}} \quad (5)$$

The *StructuralIndex* is defined on the *StructuralVars* tab of the SAE spreadsheets. Surface area is derived to account for roof and wall area of a standard dwelling based on the regional average square footage data obtained from EIA. The relationship between the square footage and surface area is constructed assuming an aspect ratio of 0.75 and an average of 25% two-story and 75% single-story. Given these assumptions, the approximate linear relationship for surface area is:

$$SurfaceArea_y = 892 + 1.44 \times Footage_y \quad (6)$$

In Equation 4, 2009 is used as a base year for normalizing the index. As a result, the ratio on the right is equal to 1.0 in 2009. In other years, it will be greater than 1.0 if equipment saturation levels are above their 2009 level. This will be counteracted by higher efficiency levels, which will drive the index downward. The weights are defined as follows.

$$Weight^{Type} = \frac{Energy_{09}^{Type}}{HH_{09}} \times HeatShare_{09}^{Type} \tag{7}$$

In the SAE spreadsheets, these weights are referred to as *Intensities* and are defined on the *EIAData* tab. With these weights, the *HeatIndex* value in 2009 will be equal to estimated annual heating intensity per household in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

For electric heating equipment, the SAE spreadsheets contain two equipment types: electric resistance furnaces/room units and electric space heating heat pumps. Examples of weights for these two equipment types for the U.S. are given in Table 1.

Table 1: Electric Space Heating Equipment Weights

Equipment Type	Weight (kWh)
Electric Resistance Furnace/Room units	760
Electric Space Heating Heat Pump	126

Data for the equipment saturation and efficiency trends are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets. The efficiency for electric space heating heat pumps are given in terms of Heating Seasonal Performance Factor [BTU/Wh], and the efficiencies for electric furnaces and room units are estimated as 100%, which is equivalent to 3.41 BTU/Wh.

Price Impacts. In the 2007 version of the SAE models and thereafter, the Heat Index has been extended to account for the long-run impact of electric and natural gas prices. Since the Heat Index represents changes in the stock of space heating equipment, the price impacts are modeled to play themselves out over a 10-year horizon. To introduce price effects, the Heat Index as defined by Equation 4 above is multiplied by a 10-year moving-average of electric and gas prices. The level of the price impact is guided by the long-term price elasticities:

$$HeatIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \big/ Eff_y^{Type} \right)}{\left(Sat_{09}^{Type} \big/ Eff_{09}^{Type} \right)} \times$$

$$(TenYearMovingAverageElectric\,Price_{y,m})^{\phi} \times (TenYearMovingAverageGas\,Price_{y,m})^{\gamma}$$

(8)

Since the trends in the Structural index (the equipment saturations and efficiency levels) are provided exogenously by the EIA, the price impacts are introduced in a multiplicative form. As a result, the long-run change in the Heat Index represents a combination of adjustments to the structural integrity of new homes, saturations in equipment and efficiency levels relative to what was contained in the base EIA long-term forecast.

Heating system usage levels are impacted on a monthly basis by several factors, including weather, household size, income levels, prices, and billing days. The estimates for space heating equipment usage levels are computed as follows:

$$HeatUse_{y,m} = \left(\frac{WgtHDD_{y,m}}{HDD_{09}} \right) \times \left(\frac{HHSize_y}{HHSize_{09}} \right)^{0\ 25} \times \left(\frac{Income_y}{Income_{09}} \right)^{0\ 20} \times \left(\frac{Elec\,Price_{y,m}}{Elec\,Price_{09,7}} \right)^{\lambda} \times \left(\frac{Gas\,Price_{y,m}}{Gas\,Price_{09,7}} \right)^{\kappa} \quad (9)$$

Where:

- *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 2009
- *HHSize* is average household size in a year (*y*)
- *Income* is average real income per household in year (*y*)
- *ElecPrice* is the average real price of electricity in month (*m*) and year (*y*)
- *GasPrice* is the average real price of natural gas in month (*m*) and year (*y*)

By construction, the $HeatUse_{y,m}$ variable has an annual sum that is close to 1.0 in the base year (2009). 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 1.0 in the base year. In other years, the values will reflect changes in the economic drivers, as transformed through the end-use elasticity parameters. The price impacts captured by the Usage equation represent short-term price response.

Constructing 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
- Thermal integrity and footage of homes
- Average household size, household income, and energy prices

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

$$XCool_{y,m} = CoolIndex_{y} \times CoolUse_{y,m} \tag{10}$$

Where

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

As with heating, the cooling equipment index is defined as a weighted average across equipment types of equipment saturation levels normalized by operating efficiency levels. Formally, the cooling equipment index is defined as:

$$CoolIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \big/ Eff_y^{Type} \right)}{\left(Sat_{09}^{Type} \big/ Eff_{09}^{Type} \right)} \quad (11)$$

Data values in 2009 are used as a base year for normalizing the index, and the ratio on the right is equal to 1.0 in 2009. In other years, it will be greater than 1.0 if equipment saturation levels are above their 2009 level. This will be counteracted by higher efficiency levels, which will drive the index downward. The weights are defined as follows.

$$Weight^{Type} = \frac{Energy_{09}^{Type}}{HH_{09}} \times CoolShare_{09}^{Type} \quad (12)$$

In the SAE spreadsheets, these weights are referred to as *Intensities* and are defined on the *EIAData* tab. With these weights, the *CoolIndex* value in 2009 will be equal to estimated annual cooling intensity per household in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

For cooling equipment, the SAE spreadsheets contain three equipment types: central air conditioning, space cooling heat pump, and room air conditioning. Examples of weights for these three equipment types for the U.S. are given in Table 2.

Table 2: Space Cooling Equipment Weights

Equipment Type	Weight (kWh)
Central Air Conditioning	1,209
Space Cooling Heat Pump	238
Room Air Conditioning	175

The equipment saturation and efficiency trends data are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets. The efficiency for space cooling heat pumps and central air conditioning (A/C) units are given in terms of Seasonal Energy Efficiency Ratio [BTU/Wh], and room A/C units efficiencies are given in terms of Energy Efficiency Ratio [BTU/Wh].

Price Impacts. In the 2007 SAE models and thereafter, the Cool Index has been extended to account for changes in electric and natural gas prices. Since the Cool Index represents changes in the stock of space heating equipment, it is anticipated that the impact of prices will be long-term in nature. The Cool Index as defined Equation 11 above is then multiplied by a 10-year moving average of electric and gas prices. The level of the price impact is guided by the long-term price elasticities.

$$CoolIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \Big/ Eff_y^{Type} \right)}{\left(Sat_{09}^{Type} \Big/ Eff_{09}^{Type} \right)} \times \quad (13$$

$$(TenYearMovingAverageElectric\,Price_{y,m})^{\phi} \times (TenYearMovingAverageGas\,Price_{y,m})^{\gamma}$$

)

Since the trends in the Structural index, equipment saturations and efficiency levels are provided exogenously by the EIA, price impacts are introduced in a multiplicative form. The long-run change in the Cool Index represents a combination of adjustments to the structural integrity of new homes, saturations in equipment and efficiency levels. Without a detailed end-use model, it is not possible to isolate the price impact on any one of these concepts.

Cooling system usage levels are impacted on a monthly basis by several factors, including weather, household size, income levels, and prices. The estimates of cooling equipment usage levels are computed as follows:

$$CoolUse_{y,m} = \left(\frac{WgtCDD_{y,m}}{CDD_{09}} \right) \times \left(\frac{HHSize_y}{HHSize_{09}} \right)^{0.25} \times \left(\frac{Income_y}{Income_{09}} \right)^{0.20} \times \left(\frac{Elec\,Price_{y,m}}{Elec\,Price_{09}} \right)^{\lambda} \times \left(\frac{Gas\,Price_{y,m}}{Gas\,Price_{09}} \right)^{\kappa} \quad (14)$$

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 2009.

By construction, the *CoolUse* variable has an annual sum that is close to 1.0 in the base year (2009). 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 1.0 in the base year. In other years, the values will change to reflect changes in the economic driver changes.

Constructing 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:

- Appliance and equipment saturation levels
- Appliance efficiency levels
- Average number of days in the billing cycle for each month
- Average household size, real income, and real prices

The explanatory variable for other uses is defined as follows:

$$XOther_{y,m} = OtherEqpIndex_{y,m} \times OtherUse_{y,m} \qquad (15)$$

The first term on the right hand side of this expression ($OtherEqpIndex_y$) embodies information about appliance saturation and efficiency levels and monthly usage multipliers. The second term (*OtherUse*) captures the impact of changes in prices, income, household size, and number of billing-days on appliance utilization.

End-use indices are constructed in the SAE models. A separate end-use index is constructed for each end-use equipment type using the following function form.

$$ApplianceIndex_{y,m} = Weight^{Type} \times \frac{\left(\dfrac{Sat_y^{Type}}{\dfrac{1}{UEC_y^{Type}}} \right)}{\left(\dfrac{Sat_{09}^{Type}}{\dfrac{1}{UEC_{09}^{Type}}} \right)} \times MoMult_m^{Type} \times \qquad (16)$$

$$(TenYearMovingAverageElectric\,Price)^{\lambda} \times (TenYearMovingAverageGas\,Price)^{\kappa}$$

Where:

- *Weight* is the weight for each appliance type
- *Sat* represents the fraction of households, who own an appliance type
- $MoMult_m$ is a monthly multiplier for the appliance type in month (m)
- *Eff* is the average operating efficiency the appliance
- *UEC* is the unit energy consumption for appliances

This index combines information about trends in saturation levels and efficiency levels for the main appliance categories with monthly multipliers for lighting, water heating, and refrigeration.

The appliance saturation and efficiency trends data are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets.

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

$$ApplianceUse_{y,m} = \left(\frac{BDays_{y,m}}{30.44} \right) \times \left(\frac{HHSize_y}{HHSize_{09}} \right)^{0\,46} \times \left(\frac{Income_y}{Income_{09}} \right)^{0\,10} \times \left(\frac{Elec\,Price_{y,m}}{Elec\,Price_{09}} \right)^{\phi} \times \left(\frac{Gas\,Price_{y,m}}{Gas\,Price_{09}} \right)^{\lambda} \qquad (17)$$

The index for other uses is derived then by summing across the appliances:

$$OtherEqpIndex_{y,m} = \sum_k ApplianceIndex_{y,m} \times ApplianceUse_{y,m} \qquad (18)$$

Supporting Spreadsheets and MetrixND Project Files

The SAE approach described above has been implemented for each of the nine Census Divisions. A mapping of states to Census Divisions is presented in Figure 22. This section describes the contents of each file and a procedure for customizing the files for specific utility data. A total of 18 files are provided. These files are listed in Table 3.

Figure 22: Mapping of States to Census Divisions

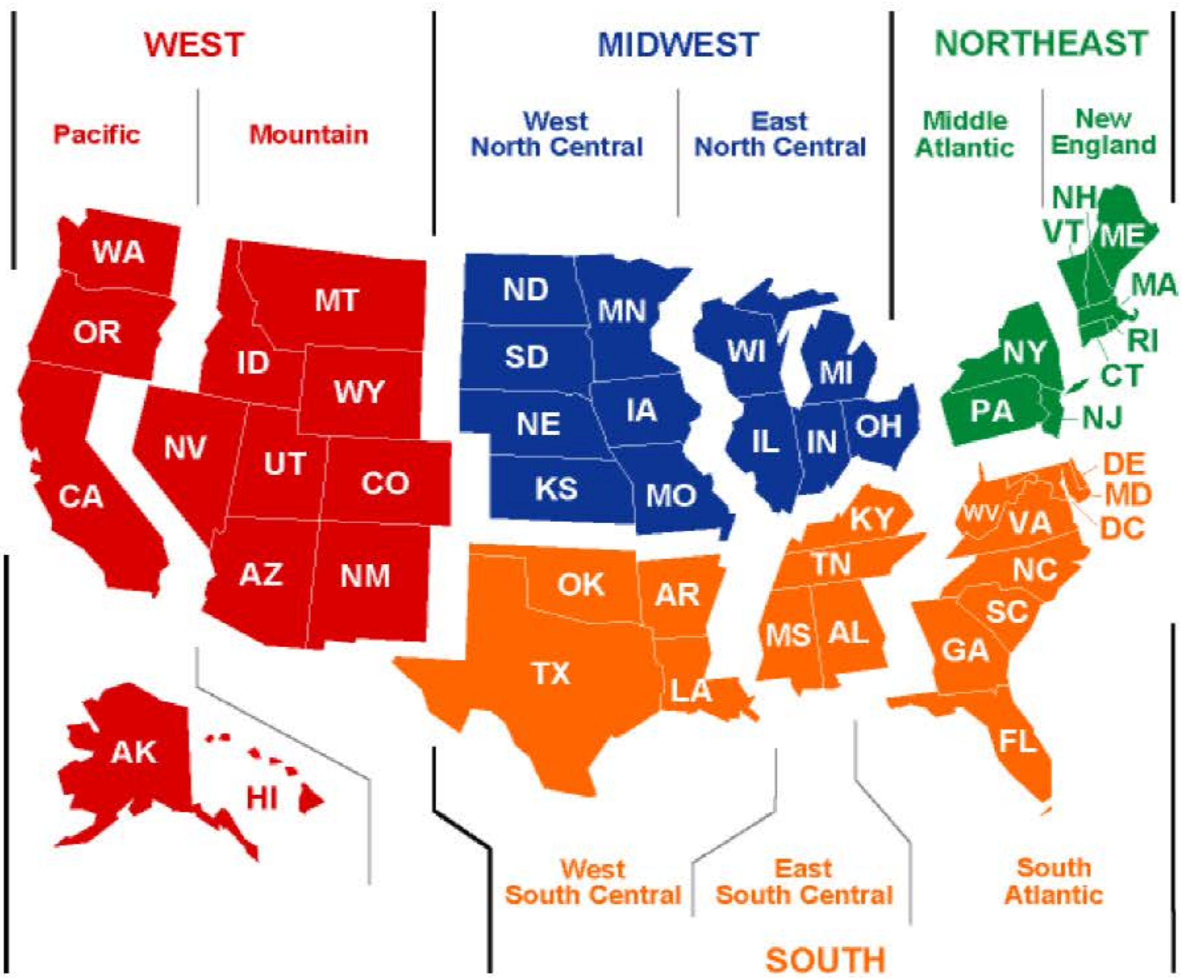


Table 3: List of SAE Files

Spreadsheet	*MetrixND* Project File
NewEngland.xls	SAE NewEngland.ndm
MiddleAtlantic.xls	SAE MiddleAtlantic.ndm
EastNorthCentral.xls	SAE EastNorthCentral.ndm

WestNorthCentral.xls	SAE_WestNorthCentral.ndm
SouthAtlantic.xls	SAE_SouthAltantic.ndm
EastSouthCentral.xls	SAE_EastSouthCentral.ndm
WestSouthCentral.xls	SAE_WestSouthCentral.ndm
Mountain.xls	SAE_Mountain.ndm
Pacific.xls	SAE_Pacific.ndm

As defaults, the SAE spreadsheets include regional data, but utility data can be entered to generate the *Heat*, *Cool*, and *Other* equipment indices used in the SAE approach. The *MetrixND* project files link to the data in these spreadsheets. These project files calcualte the end-use *Usage* variables are constructed and the estimated SAE models.

Each of the nine SAE spreadsheets contains the following tabs:

- **Definitions -** Contains equipment, end use, worksheet, and Census Division definitions.
- **Intensities -** Calculates the annual equipment indices.
- **Shares -** Contains historical and forecasted equipment shares. The default forecasted values are provided by the EIA. The raw EIA projections are provided on the *EIAData* tab.
- **Efficiencies -** Contains historical and forecasted equipment efficiency trends. The forecasted values are based on projections provided by the EIA. The raw EIA projections are provided on the *EIAData* tab.
- **StructuralVars -** Contains historical and forecasted square footage, number of households, building shell efficiency index, and calculation of structural variable. The forecasted values are based on projections provided by the EIA.
- **Calibration -** This tab contains calculations of the base year *Intensity* values used to weight the equipment indices.
- **EIAData -** Contains the raw forecasted data provided by the EIA.
- **MonthlyMults -** Contains monthly multipliers that are used to spread the annual equipment indices across the months.
- **EV -** Worksheet for incorporating electric vehicle (EV) impacts.
- **PV -** Worksheet for incorporating photovoltaic battery (PV) impacts.

The *MetrixND* Project files are linked to the *AnnualIndices*, *ShareUEC*, and *MonthlyMults* tabs in the spreadsheets. Sales, economic, price and weather information for the Census Division is provided in the linkless data table *UtilityData*. In this way, utility specific data and the equipment indices are brought into the project file. The *MetrixND* project files contain the objects described below.

Parameter Tables

- **Elas.** This parameter table includes the values of the elasticities used to calculate the *Usage* variables for each end-use. There are five types of elasticities included on this table.

  - Economic variable elasticities
  - Short-term own price elasticities
  - Short-term cross price elasticities
  - Long-term own price elasticities
  - Long-term cross price elasticities

  The short-term price elasticities drive the end-use usage equations. The long-term price elasticities drive the Heat, Cool and other appliance indices. The combined price impact is an aggregation of the short and long-term price elasticities. As such, the long-term price elasticities are input as incremental price impact. That is, the long-term price elasticity is the difference between the overall price impact and the short-term price elasticity.

Data Tables

- **AnnualEquipmentIndices** links to the *AnnualIndices* tab for heating and cooling indices, and *ShareUEC* tab for water heating, lighting, and appliances in the SAE spreadsheet.
- **UtilityData** is a linkless data table that contains sales, price, economic and weather data specific to a given Census Division.
- **MonthlyMults** links to the corresponding tab in the SAE spreadsheet.

Transformation Tables

- **EconTrans** computes the average usage, and household size, household income, and price indices used in the usage equations.
- **WeatherTrans** computes the HDD and CDD indices used in the usage equations.
- **ResidentialVars** computes the *Heat*, *Cool* and *Other Usage* variables, as well as the *XHeat*, *XCool* and *XOther* variables that are used in the regression model.
- **BinaryVars** computes the calendar binary variables that could be required in the regression model.
- **AnnualFcst** computes the annual historical and forecast sales and annual change in sales.
- **EndUseFcst** computes the monthly sales forecasts by end uses.

Models

- **ResModel** is the Statistically Adjusted End-Use Model.

Steps to Customize the Files for Your Service Territory

The files that are distributed along with this document contain regional data. If you have more accurate data for your service territory, you are encouraged to tailor the spreadsheets with that information. This section describes the steps needed to customize the files.

Minimum Customization

- Save the *MetrixND* project file and the spreadsheet into the same folder
- Select the spreadsheet and *MetrixND* project file from the appropriate Census Division
- Open the spreadsheet and navigate to the *Calibration* tab
- In cell “B9”, replace base year Census Division use-per-customer with observed use-per-customer for your service territory
- Save the spreadsheet and open the *MetrixND* project file
- Click on the *Update All Links* button on the *Menu* bar
- Review the model results

Further Customization of Starting Usage Levels

In addition to the minimum steps listed above, you can also utilize model-based calibration process described above on pages 15-16 to further fine-tune starting year usage estimates to your service territory.

Customizing the End-use Share Paths

You can also install your own share history and forecasts. To do this, navigate to the *Share* tab in the spreadsheet and paste in the values for your region. Make sure that base year shares on the *Calibration* tab reflect changes on the *Shares* tab.

Customizing the End-use Efficiency Paths

Finally, you can override the end-use efficiency paths that are contained on the *Efficiencies* tab of the spreadsheet.

Kentucky

James Kelly, Economist II

[redacted]

Economic Performance Summary
Kentucky

	Level				Annual Percent Change					
	2017	Rank	2022	Rank	2015-2017	Rank	2017-2019	Rank	2019-2022	Rank
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Note: Rankings are out of 50 states and the District of Columbia
Source: IHS Markit

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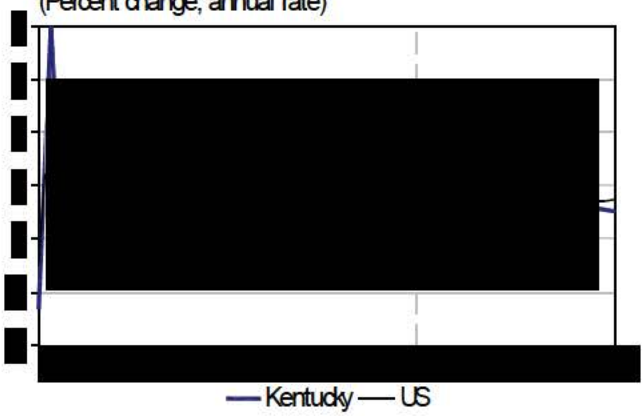
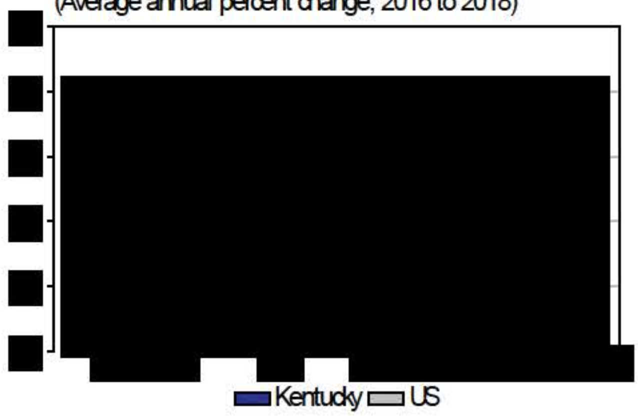
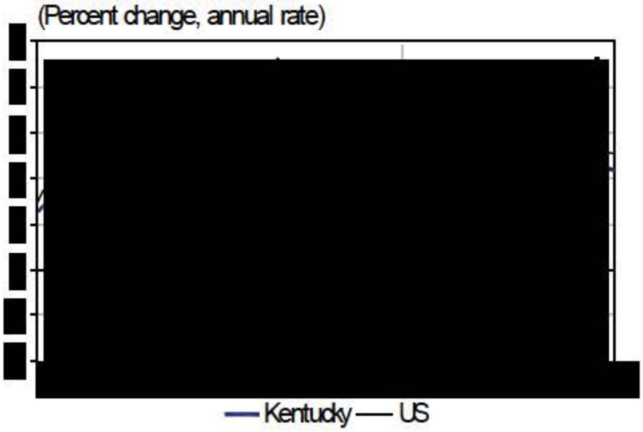
Total Employment
(Percent change, annual rate)



Growth Relative to the US Average
(Average annual percent change, 2016 to 2018)

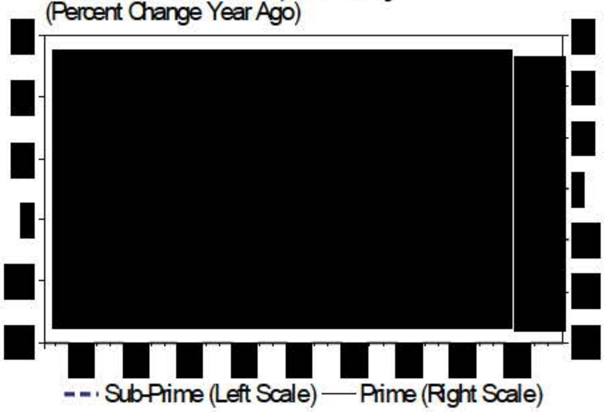


Real Personal Income
(Percent change, annual rate)



Housing Affordability
(Higher index reading = more affordable)

Loans in Foreclosure, Kentucky
(Percent Change Year Ago)



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[redacted]

Kentucky outlook over the next four quarters

		Baseline Scenario			Pessimistic			Optimistic		
		Level	Percent	Rank	Level	Percent	Rank	Level	Percent	Rank
[redacted]										
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]										
	[redacted]	[redacted]		[redacted]	[redacted]		[redacted]	[redacted]		[redacted]

Source: IHS Markit

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[redacted]

[redacted]

[redacted]

Export Trends

Total Exports
(Percent change, annual rate)

[redacted]

Kentucky — US

Merchandise Exports as a Percent of Total GSP

[redacted]

Economic Structure

Business Monitor for Kentucky

[redacted]

Note: For definitions, please see appendix at back of book.

Source: IHS Markit

Key Industries in Kentucky
(Employment, Thousands)

	2017 Level	2017 Share (%)**
[redacted]	[redacted]	[redacted]

** The Manufacturing sector shares are of Total Manufacturing
** All other shares are of Total Employment

Source: IHS Markit

[redacted]

[redacted]

Short Term Outlook for Kentucky
November 2017 Forecast

	2017Q1	2017Q2	2017Q3	2017Q4	2018Q1	2018Q2	2018Q3	2016	2017	2018	2019	2020
Personal Income (Billions $)												
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: IHS Markit

Short Term Outlook for Kentucky
November 2017 Forecast

	2017Q1	2017Q2	2017Q3	2017Q4	2018Q1	2018Q2	2018Q3	2016	2017	2018	2019	2020

[redacted]

Source: IHS Markit

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