VOLUME 3

LOAD ANALYSIS AND LOAD FORECASTING

KANSAS CITY POWER & LIGHT COMPANY (KCP&L)

INTEGRATED RESOURCE PLAN

4 CSR 240-22.030

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HIGHLIGHTS

- KCP&L expects energy consumption to grow 0.57% and peak demand to grow 0.45% annually from 2017-2037.
- Residential energy consumption is expected to provide the most growth over the next 20 years.
- KCP&L customers are expected to grow 0.7% annually from 2017-2037.
- Key forecast uncertainties include the impact of rising prices, technological advancement in renewable energy sector, adoption of new consumer products and energy efficiency.

PURPOSE: This rule sets minimum standards for the maintenance and updating of historical data, the level of detail required in analyzing loads, and the purposes to be accomplished by load analysis and by load forecast models. The load analysis discussed in this rule is intended to support both demand-side management efforts of 4 CSR 240-22.050 and the load forecast models of this rule. This rule also sets the minimum standards for the documentation of the inputs, components, and methods used to derive the load forecasts.

SECTION 1: SELECTING LOAD ANALYSIS METHODS

The utility may choose multiple methods of load analysis if it deems doing so is necessary to achieve all of the purposes of load analysis and if the methods are consistent with, and calibrated to, one another. The utility shall describe and document its intended purposes for load analysis methods, why the selected load analysis methods best fulfill those purposes, and how the load analysis methods are consistent with one another and with the endues consumption data used in the demand-side analysis as described in 4 CSR 240-22.050. At a minimum, the load analysis methods shall be selected to achieve the following purposes:

1.1 PURPOSE: IDENTIFICATION OF END-USE MEASURES

(A) To identify end-use measures that may be potential demand-side resources, generally, those end-use measures with an opportunity for energy and/or demand savings;

1.2 PURPOSE: DERIVATION OF DATA SET OF HISTORICAL VALUES

(B) To derive a data set of historical values from load research data that can be used as dependent and independent variables in the load forecasts;

1.3 PURPOSE: ANALYSIS OF IMPACTS OF IMPLEMENTED DSM AND DEMAND-SIDE RATES ON LOAD FORECASTS

(C) To facilitate the analysis of impacts of implemented demand-side programs and demand-side rates on the load forecasts and to augment measurement of the effectiveness of demand-side resources necessary for 4 CSR 240-22.070(8) in the evaluation of the performance of the demand-side programs or rates after they are implemented; and

1.4 PURPOSE: PRESERVATION OF LOAD ANALYSIS IN HISTORICAL DATABASE

(D) To preserve, in a historical database, the results of the load analysis used to perform the demand-side analysis as described in 4 CSR 240-22.050, and the load forecasting described in 4 CSR 240-22.030.

SECTION 2: HISTORICAL DATABASE FOR LOAD ANALYSIS

The utility shall develop and maintain data on the actual historical patterns of energy usage within its service territory. The following information shall be maintained and updated on an ongoing basis and described and documented in the triennial compliance filings:

2.1 CUSTOMER CLASS DETAIL

(A) Customer Class Detail. At a minimum, the historical database shall be maintained for each of the major classes;

KCP&L maintains a historical database of its loads for each major class, which are Residential, Small General Service (SGS), Medium General Service (MGS), Large General Service (LGS), Large Power (LP), Lighting and Sales for Resale (SFR). In addition, SGS, MGS, LGS and LP are split into the subclasses commercial and industrial. This data begins in May 2005 for KCP&L and will be maintained with at least 10 years of history going forward. Beginning with the 2015 IRP filling, KCP&L forecasts its loads for each major class, which are Residential, Commercial Small General Service (SGS), Commercial Big (The sum of MGS, LGS, and LP), Industrial (The sum of SGS, MGS, LGS, and LP), Lighting, and Sales for Resale (SFR).

2.2 LOAD DATA DETAIL

(B) The historical load database shall contain the following data:

2.2.1 ACTUAL AND WEATHER NORMALIZED ENERGY, AND NUMBER OF CUSTOMERS

1. For each jurisdiction for which it prepares customer and energy and demand forecasts, for each major class, to the actual monthly energy usage and number of customers and weather-normalized monthly energy usage;

MetrixND files are used to maintain this data for each subclass listed in 22.030 (2) (A). These files also contain the models used to forecast the number of customers and weather-normalize and forecast monthly energy sales.

2.2.2 ACTUAL AND WEATHER NORMALIZED DEMANDS

2. For each jurisdiction and major class, estimated actual and weather-normalized demands at the time of monthly system peaks; and

Actual and weather-normalized coincident demands are provided in Appendix 3B and MetrixLT projects MO_SystemLoad.ltm and KS_SystemLoad.ltm. This data is available beginning in May 2004 at which time the load research sample converted from revenue class to CCOS. Class level hourly loads are currently weather normalized when a rate case is prepared. Jurisdiction level peaks are weather normalized annually when forecasting peak demand for the triennial IRP or IRP update.

2.2.3 ACTUAL AND WEATHER NORMALIZED SYSTEM PEAK DEMANDS

3. For the system, actual and weather normalized hourly net system load;

Actual and weather-normalized Net System Input (NSI) is contained in the MetrixLT files.

2.3 LOAD COMPONENT DETAIL

(C) The historical database for major class monthly energy usage and demands at time of monthly peaks shall be disaggregated into a number-of-units component and a use-per-unit component, for both actual and weather-normalized loads.

2.3.1 UNITS COMPONENT

1. The number-of-units component shall be the number of customers, square feet, devices, or other units as appropriate to the customer class and the load analysis method selected by the utility. The utility shall select the units component with the intent of providing meaningful load analysis for demand-side analysis and maintaining the integrity of the database over time.

The number-of-units is the number of customers for residential and SGS commercial. For the other subclasses, mWh sales are modeled because it is more stable than kWh sales per customer and the model fit statistics are higher. In the big commercial and Industrial customer classes, the size of customers varies more than in the smaller classes and use per customer can vary substantially as customers enter or exit the class.

2.3.2 UPDATE PROCEDURE

2. The utility shall develop and implement a procedure to routinely measure and regularly update estimates of the effect of departures from normal weather on class and system electric loads. The estimates of the effect of weather on historical major class and system loads shall incorporate the nonlinear response of loads to daily weather and seasonal variations in loads.

KCP&L has developed a MetrixND model for each subclass of kWh sales that weather normalizes sales or sales per unit. These models will update weather normalized sales at the subclass level whenever these models are updated. This procedure is automatic. Major class level demands are currently weather normalized only for a rate case and this process is not automatic as it requires many manual steps. Heating and cooling degree days calculated with different base temperatures were tested and kept in the models if statistically significant so that nonlinear weather response functions could be represented.

2.3.3 WEATHER MEASURES AND ESTIMATION OF WEATHER EFFECTS DESCRIPTION AND DOCUMENTATION

3. The utility shall describe and document the methods used to develop weather measures and the methods used to estimate the effect of weather on electric loads. If statistical models are used, the documentation shall include at least: the functional form of the models; the estimation techniques employed; and the relevant statistical results of the models, including parameter estimates and tests of statistical significance. The data used to estimate the models, including the development of model input data from basic data, shall be included in the workpapers supplied at the time the compliance report is filed;

In this IRP filing, KCP&L used different methods to model the effects of weather for normalization and for forecasting. One reason for using different methods is that the sample period for WN needed to cover the entire period that historical data was available so that data could be WN. On the other hand, the forecasting models often need a more recent shorter sample period since the focus is on calibrating an end-use forecast to recent data. The method of WN used in this IRP filing is different than that used in the rate cases because it is designed to WN many years of data whereas the rate case models are based on only two years of data. Also, the method used here is much less labor intensive and can be updated more routinely.

Degree days computed at different base temperatures were tested in explaining the effects of weather on sales and system load. Degree days computed with more than one base temperature were tested in the same model to determine if the load response is nonlinear. The statistical results of model estimation in the weather normalization models of monthly sales are presented in this section. Additional information is available in the MetrixND model files that are included in the electronic workpapers. This additional information includes formulas that define the explanatory variables, plots and tables of residuals, plots and tables of actual, weather-normalized and predicted values, plots and tables of explanatory variables and model statistics and coefficients. The model coefficients were estimated using ordinary least squares regression in MetrixND. The estimation period generally includes January 2005 to June 2017 for all classes.

Table 1: WN Model for MO Residential Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	21.947	0.816	26.906	0.00%	
mWthrRevPD.HDD55	0.648	0.013	49.749	0.00%	
mWthrRevPD.CDD65	1.560	0.061	25.391	0.00%	
mWthrRevPD.CDD75	0.563	0.160	3.524	0.07%	
mBin.Feb	-0.836	0.330	-2.535	1.29%	
mBin.Jul12	-2.914	0.941	-3.098	0.26%	
mBin.TrendVar	-0.202	0.033	-6.040	0.00%	

Table 2: WN Model for MO Small GS Commercial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	29.469	1.396	21.108	0.00%	
mWthrRevPD.HDD55	0.423	0.033	12.758	0.00%	
mWthrRevPD.CDD65	1.169	0.045	26.236	0.00%	
mBin.Jan	1.662	0.795	2.090	3.95%	
mBin.Feb	3.395	0.757	4.486	0.00%	
mBin.Mar	1.865	0.587	3.178	0.20%	
mBin.Aug	2.838	0.655	4.336	0.00%	
mBin.Sep	2.941	0.570	5.160	0.00%	
mBin.Oct	3.087	0.540	5.721	0.00%	
ComSmlAvgUsePD.Dec11toDec14	-1.911	0.286	-6.685	0.00%	
mBin.TrendVar	0.198	0.057	3.494	0.08%	
ComSmlAvgUsePD.Jul09	4.604	1.426	3.229	0.17%	
ComSmlAvgUsePD.Feb15	-4.402	1.454	-3.027	0.32%	

Table 3: WN Model for MO Big GS Commercial Sales (MGS, LGS and LP)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	10257524.237	172455.566	59.479	0.00%	
mWthrRevPD.HDD55	65659.072	2752.179	23.857	0.00%	
mWthrRevPD.CDD60	162314.315	4346.422	37.344	0.00%	
mBin.TrendVar	-44084.269	6865.427	-6.421	0.00%	
ComBigSalesPD.Jun16	-436446.089	172116.134	-2.536	1.29%	
mBin.Mar	320718.927	61318.385	5.230	0.00%	
mBin.May	163564.644	66666.643	2.453	1.60%	
mBin.Aug	261782.923	79089.699	3.310	0.13%	
mBin.Sep	318762.619	70865.332	4.498	0.00%	
mBin.Oct	539888.622	67983.784	7.941	0.00%	

Table 4: WN Model for MO Industrial Sales (SGS, MGS, LGS and LP)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	4010938.461	37885.860	105.869	0.00%	
mWthrRevPD.CDD60	30246.302	4046.485	7.475	0.00%	
IndSalesPD.Feb09	-1452720.978	281217.342	-5.166	0.00%	
IndSalesPD.Mar09	1565038.735	281052.922	5.568	0.00%	
IndSalesPD.Feb10	-1294141.557	281217.342	-4.602	0.00%	
IndSalesPD.Mar10	2001268.472	281214.368	7.117	0.00%	
IndSalesPD.Jun09	-791018.174	280613.627	-2.819	0.59%	
IndSalesPD.Jul09	828896.462	282934.536	2.930	0.43%	
IndSalesPD.Dec15	-908582.730	281212.149	-3.231	0.17%	

Table 5: WN Model for KS Residential Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	27.200	0.800	34.007	0.00%	
mWthrRevPD.HDD55	0.735	0.014	52.735	0.00%	
mWthrRevPD.CDD60	1.533	0.043	35.287	0.00%	
mWthrRevPD.CDD75	0.687	0.142	4.834	0.00%	
mBin.Mar	-1.011	0.327	-3.090	0.26%	
mBin.Sep	-2.012	0.356	-5.654	0.00%	
mBin.Dec	1.480	0.344	4.307	0.00%	
mBin.Aug12	-3.546	1.045	-3.395	0.10%	
mBin.TrendVar	-0.312	0.032	-9.687	0.00%	
ResAvgUsePD.Oct15	-2.757	0.946	-2.914	0.44%	
ResAvgUsePD.Jul11	3.780	0.960	3.940	0.02%	

Table 6: WN Model for KS Small GS Commercial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	32.850	0.384	85.467	0.00%	
mWthrRevPD.HDD55	0.365	0.019	18.975	0.00%	
mWthrRevPD.CDD65	0.992	0.072	13.862	0.00%	
mBin.TrendAfterYr12	1.011	0.145	6.988	0.00%	
mBin.AfterYr12	-23.922	3.676	-6.508	0.00%	
mBin.Mar	-1.217	0.496	-2.453	1.61%	
mBin.Apr	-1.616	0.507	-3.190	0.20%	
mBin.Jul	2.386	0.877	2.721	0.78%	
mBin.Aug	2.875	0.916	3.137	0.23%	
mBin.Sep	1.872	0.698	2.682	0.87%	
mBin.Dec	-1.182	0.524	-2.257	2.65%	
ComSmlAvgUsePD.Oct11	-3.766	1.364	-2.761	0.70%	
ComSmlAvgUsePD.Oct13	-3.908	1.384	-2.824	0.59%	

Table 7: WN Model for KS Big GS Commercial Sales (MGS and LGS)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	6429149.800	64006.666	100.445	0.00%	
mWthrRevPD.HDD55	51448.951	2966.263	17.345	0.00%	
mWthrRevPD.CDD60	131991.321	4039.849	32.672	0.00%	
mBin.Apr	133572.897	59070.263	2.261	2.61%	
mBin.May	277779.809	61851.500	4.491	0.00%	
mBin.Oct	253708.977	60251.864	4.211	0.01%	
mBin.Nov	151866.117	62451.103	2.432	1.69%	
mBin.AfterYr12	-1045170.305	355823.741	-2.937	0.42%	
mBin.TrendAfterYr12	44739.291	14043.031	3.186	0.20%	

Table 8: WN Model for KS Industrial Sales (SGS, MGS and LGS)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	1398315.958	141139.857	9.907	0.00%	
mWthrRevPD.CDD60	9285.408	1001.914	9.268	0.00%	
IndSalesPD.Mar09	232840.421	36579.565	6.365	0.00%	
IndSalesPD.Mar10	209788.364	36429.443	5.759	0.00%	
mBin.TrendVar	-24788.279	6066.709	-4.086	0.01%	
AR(1)	0.742	0.065	11.370	0.00%	

2.4 ASSESSMENTS

(D) For each major class specified pursuant to subsection (2)(A), the utility shall provide, on a seasonal and annual basis for each year of the historical period—

For the current KCP&L filing, historical sales and customers broken out by class cost of service for residential and industrial customers were available beginning in January 2000. Commercial class cost of service data was available beginning May 2005. Going forward, KCP&L will maintain this data for at least the previous 10 years.

2.4.1 HISTORIC END-USE DRIVERS OF ENERGY USAGE AND PEAK DEMAND

1. Its assessment of the historical end-use drivers of energy usage and peak demand, including trends in numbers of units and energy consumption per unit;

Historical plots of customers and kwh/customer for energy usage and peak demand can be found in *Appendix 3A.*

Residential customer growth for KCP&L was 1% or higher during the late 1990s and the housing boom of the early 2000s. Beginning in 2007, customer growth slowed to below 1% and slow growth continued until growth in housing development began to occur in 2013. A catch-up effect has resulted in rapid customer growth in 2016 and 2017 of about 1.4%.

KCP&L SGS Commercial customer growth was flat (average of 0.2%) in the late 2000s and early 2010s, but has risen since 2012, largely due to customer migrations from other classes. Growth from 2012 to 2016 averaged 1.3%.

Commercial Big (MGS, LGS, LP) saw rapid customer growth in the late 2000s, averaging 2.4% from 2006 to 2010, but has been flat thereafter, averaging -0.2% since 2010. This is largely due to customers migrating to the small general service class such that all the commercial customer growth has been realized in the small class.

Industrial customers have gradually declined through the recent couple decades, averaging -1.4% growth since 2006.

Residential MWh use per customer reveal a downward trend in summer usage and flat trend in non-summer usage following a period of modest growth in non-summer use per customer in the late 2000s. The downward trend in summer usage is due to increasing efficiency of air conditioning units. The flat trend in non-summer use per customer is due to increasing saturation of electric space heat offset by increasing efficiency of base load appliances such as refrigerators, lighting, computers, etc.

For Commercial SGS, both summer (-1.3%) and non-summer (-0.9%) use per customer declined from 2007 to 2012 on an annual basis. From 2012 to 2016, use per customer saw annual growth for both summer (1.9%) and non-summer (2.0%) due to the impact of customer migrations between classes.

Commercial Big (MGS, LGS, LP) use per customer declined 2007 to 2012 at an annual rate of -2.0% during the summer months and -1.5% during the non-summer months. Use per customer increased at an annual rate of 0.5% for summer months and 0.3% for non-summer months due to the impact of customer migrations between classes.

From 2007 to 2012 Industrial use per customer declined at an annual rate of -2.7% for summer and -1.8% for non-summer months. Since 2012 Industrial use per customer has increased for both summer (2.4%) and non-summer (1.7%) on an annual basis from 2012 to 2016, while customers and employment have steadily declined. This points to an increase in equipment use over labor use amongst area manufacturers.

2.4.2 WEATHER SENSITIVITY OF ENERGY AND PEAK DEMAND

2. Its assessment of the weather sensitivity of energy and peak demand.

The following plots illustrate the weather response function of daily energy and peak demand for each major class. This data is weather normalized in the rate case process during which the weather response function is represented with an equation estimated with statistical regression analysis for the time period of January 2015 through June 2017. The blue symbols in the plot represent weekdays and the red symbols represent weekends.

Figure 1: MO Residential Daily Energy vs Average Temp

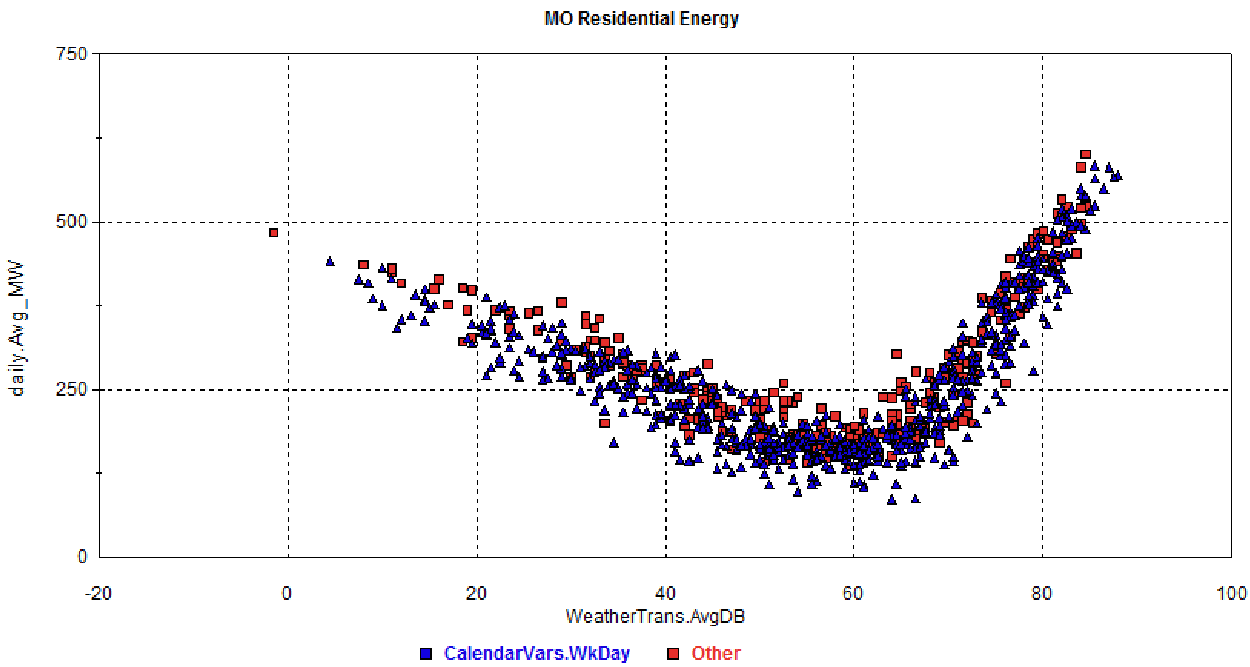


Figure 2: MO Residential Daily Peak Demand vs Average Temp

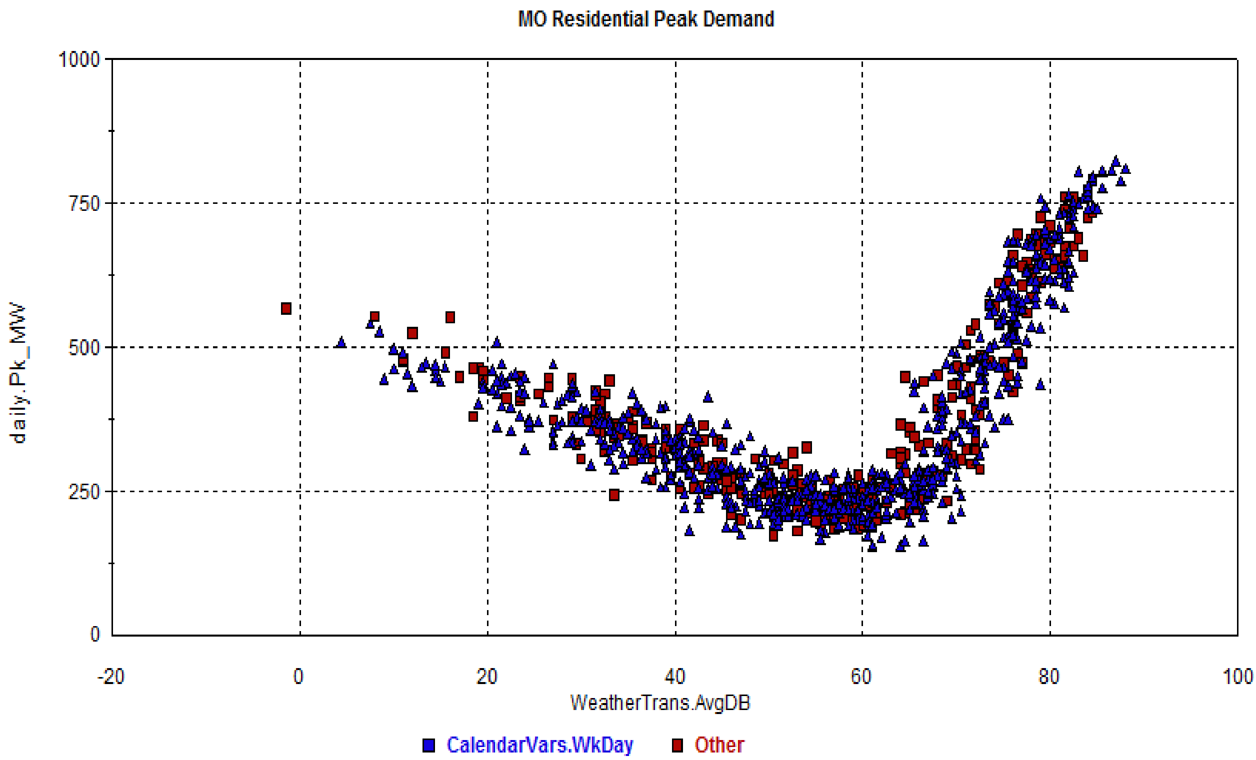


Figure 3: MO Small General Service Daily Energy vs Average Temp

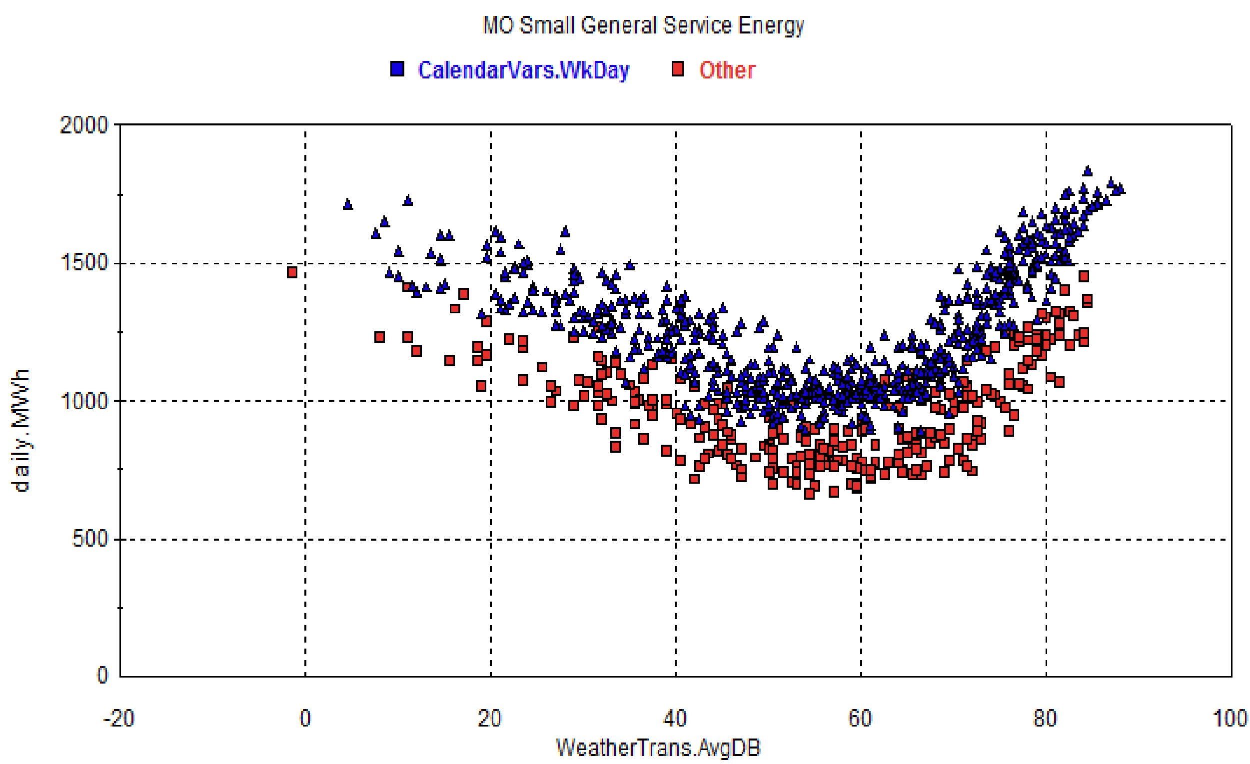


Figure 4: MO Small General Service Daily Peak vs Average Temp

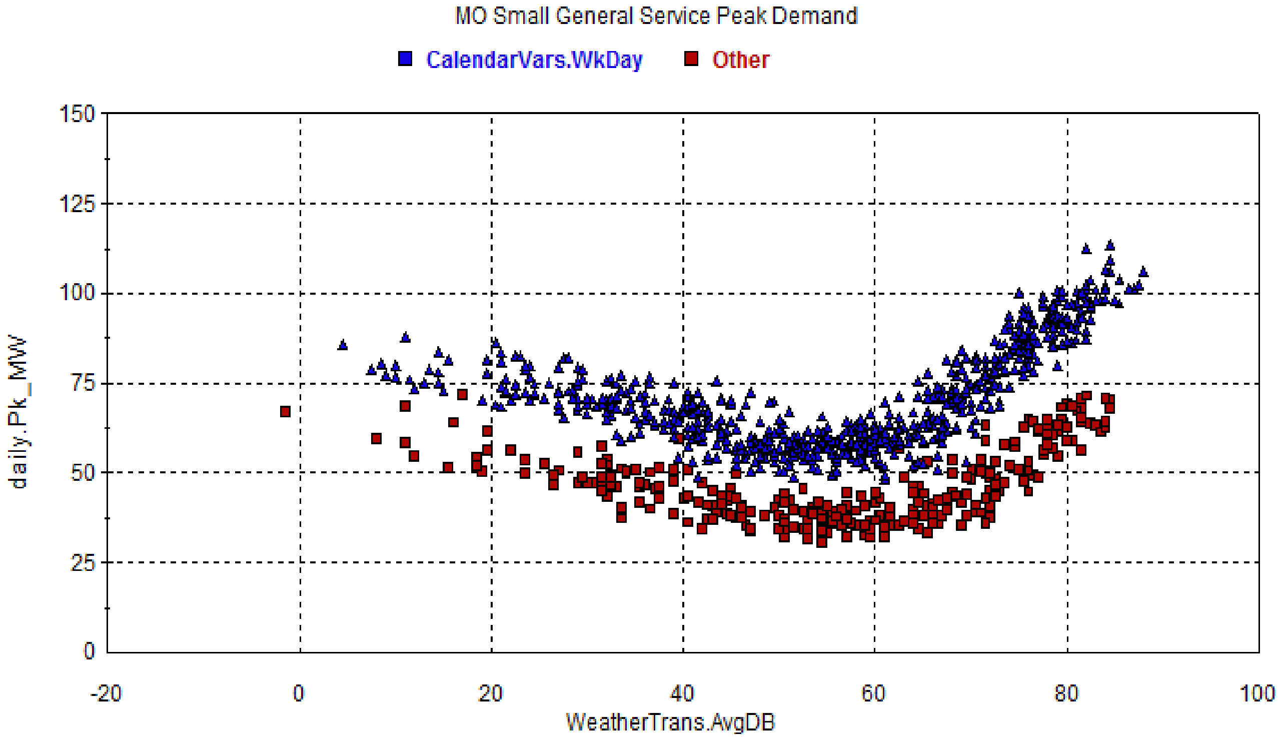


Figure 5: MO Medium General Service Daily Energy vs Average Temp

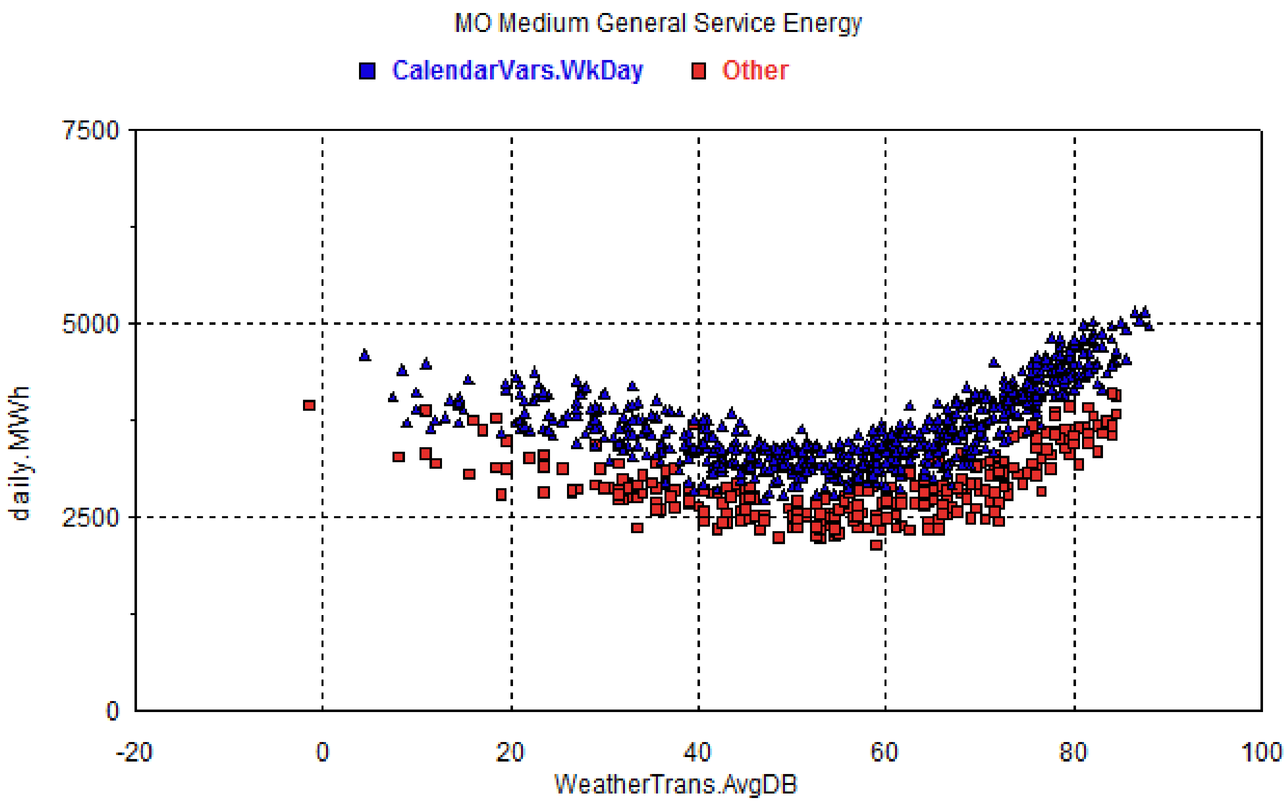


Figure 6: MO Medium General Service Daily Peak Demand vs Average Temp

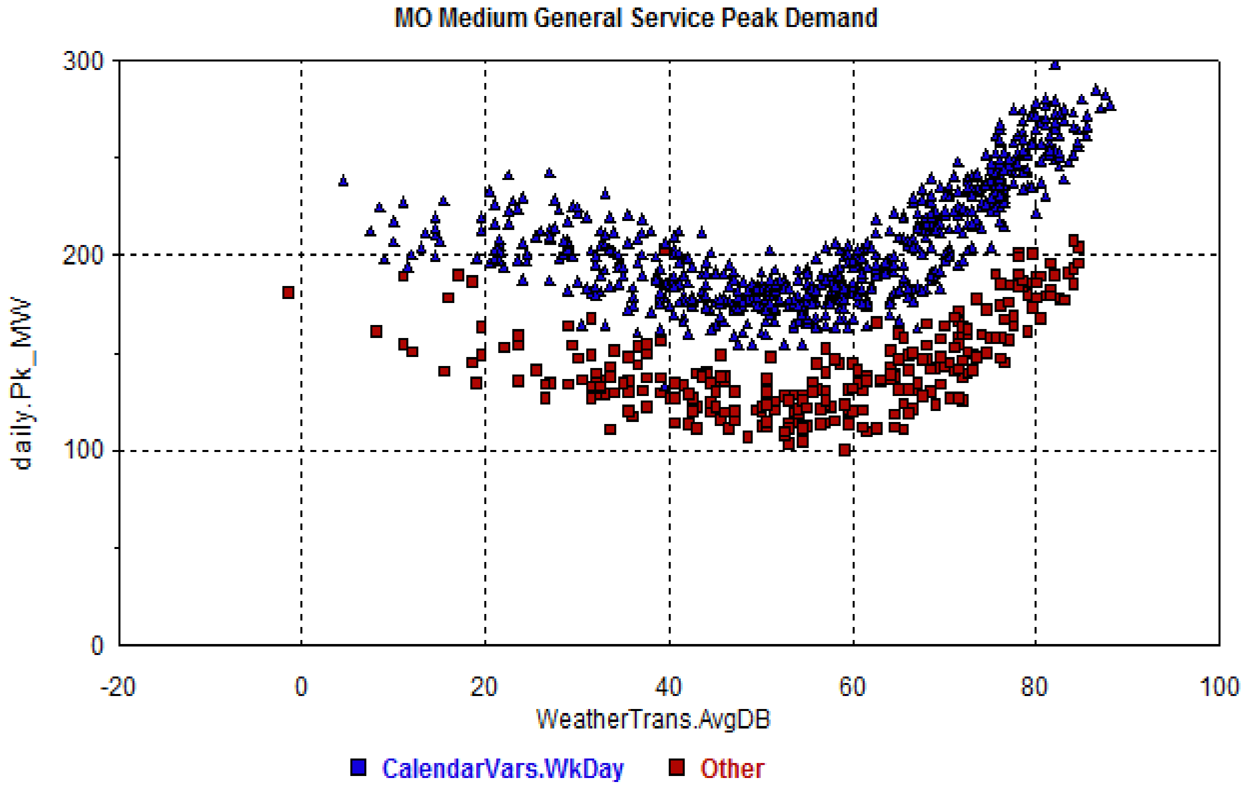


Figure 7: MO Large General Service Daily Energy vs Average Temp

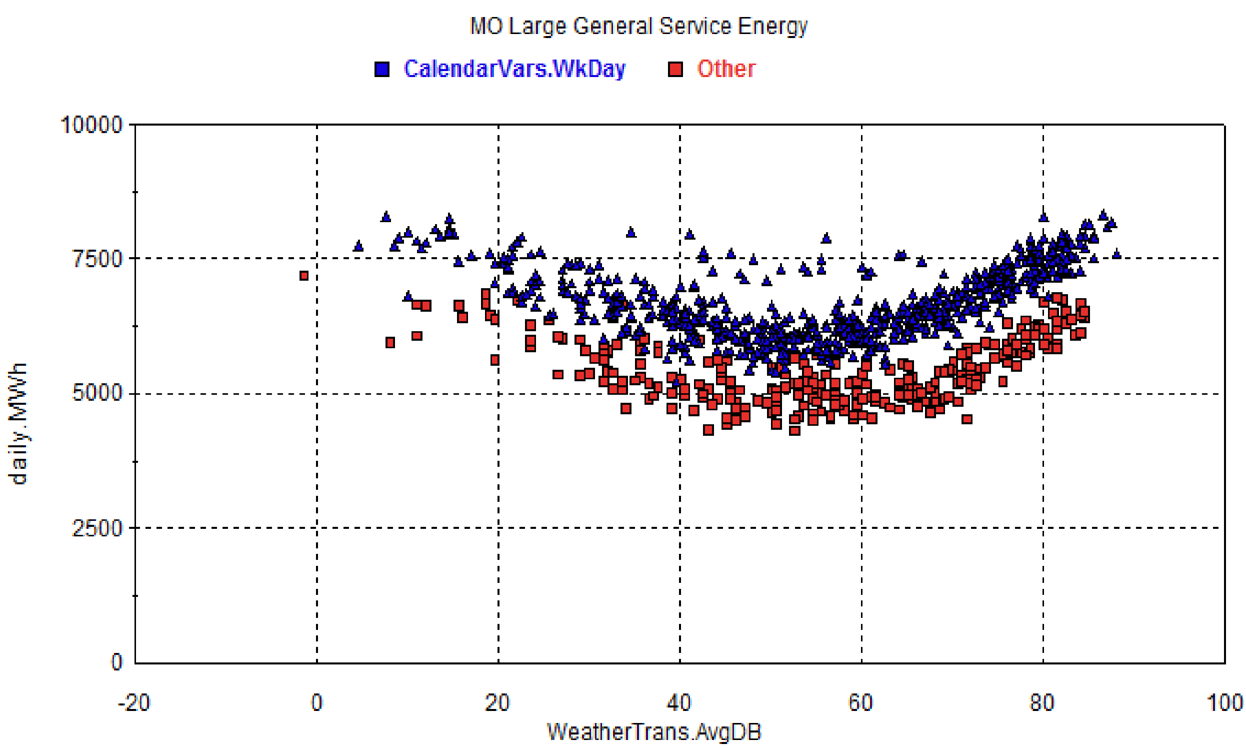


Figure 8: MO Large General Service Daily Peak Demand vs Average Temp

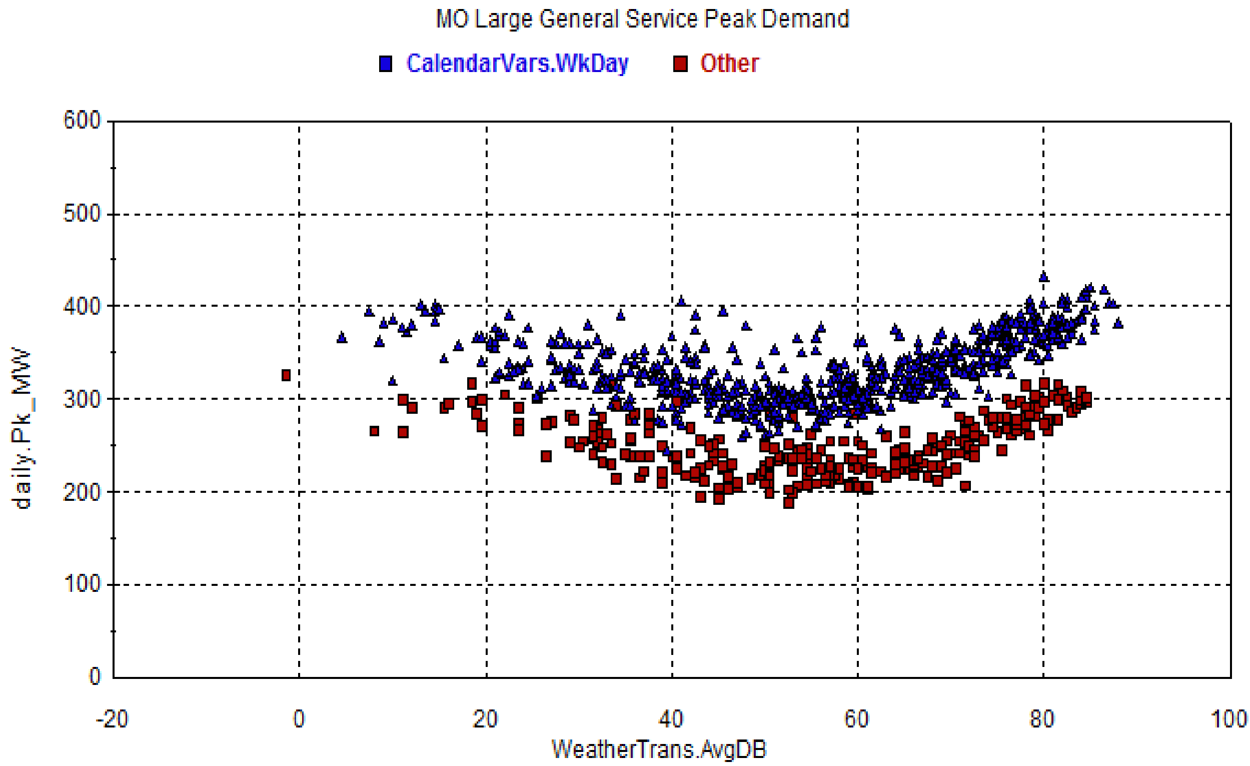


Figure 9: MO Large Power Daily Energy vs Average Temp

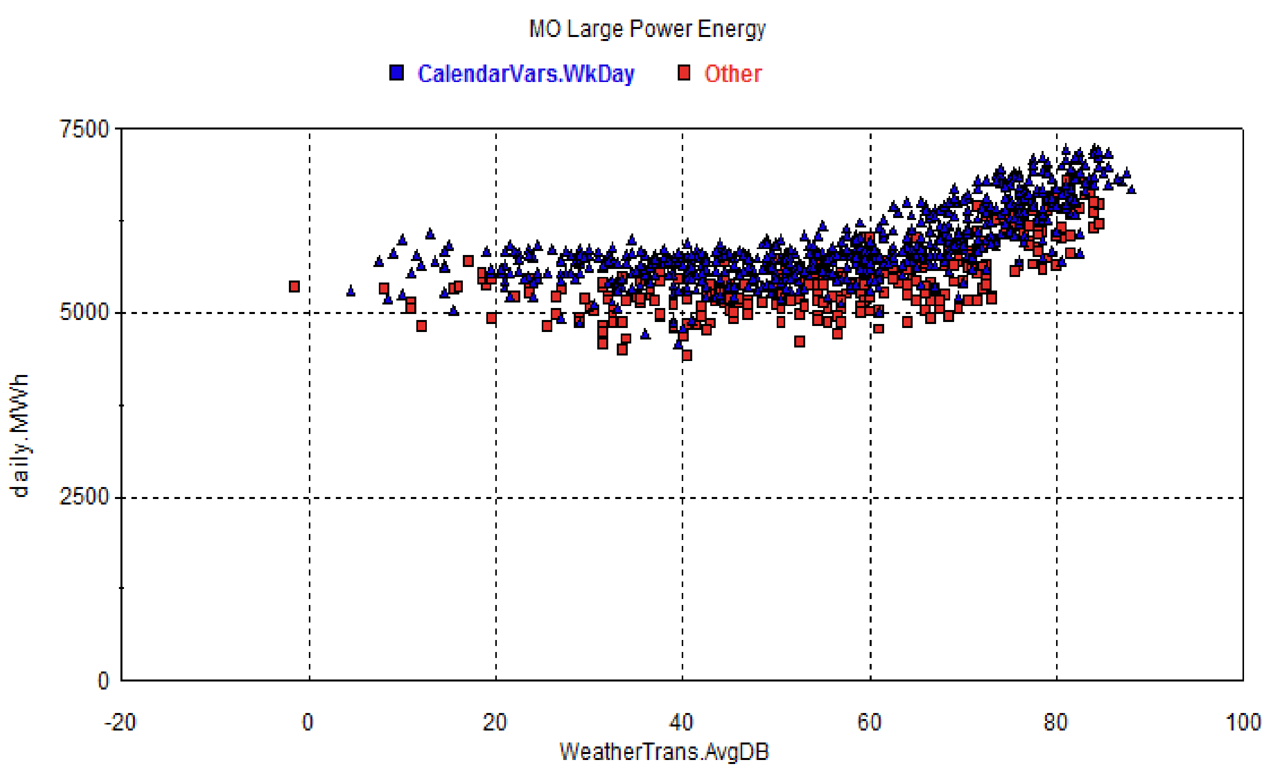


Figure 10: MO Large Power Daily Peak Demand vs Average Temp

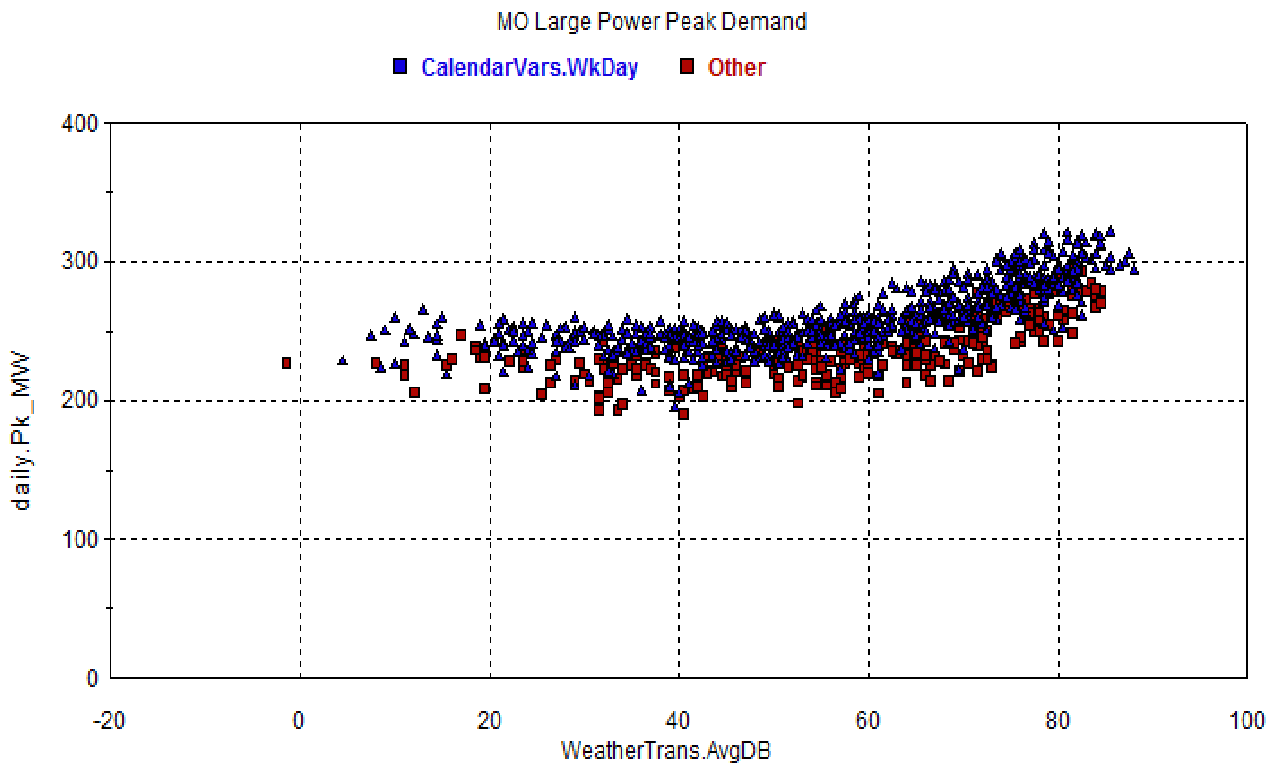


Figure 11: MO Sales for Resale Daily Energy vs Average Temp

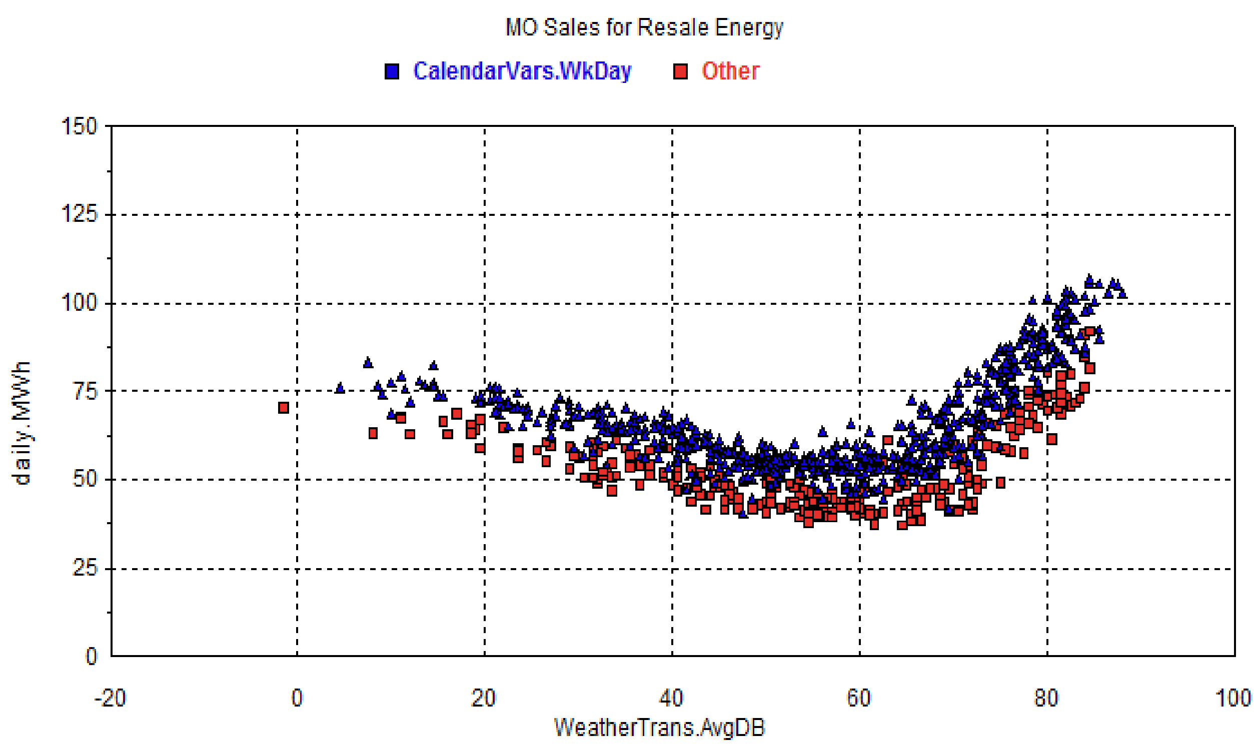


Figure 12: MO Sales for Resale Daily Peak Demand vs Average Temp

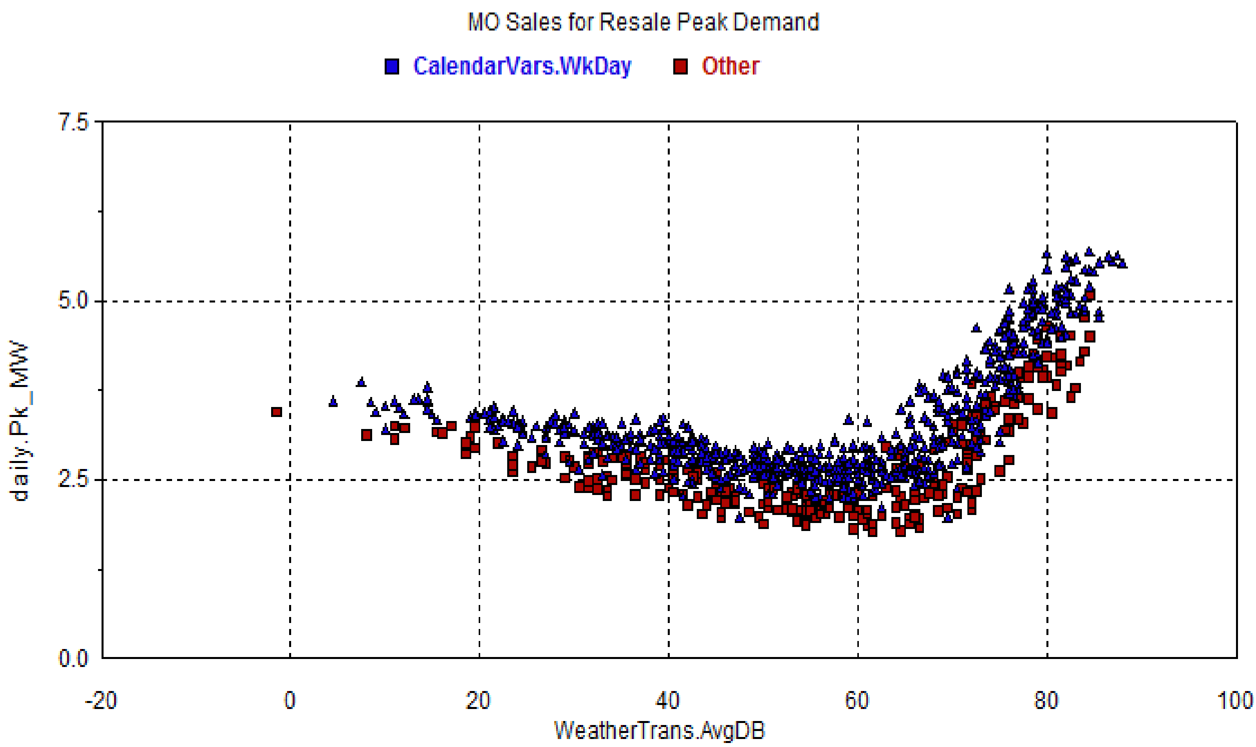


Figure 13: KS Residential Daily Energy vs Average Temp

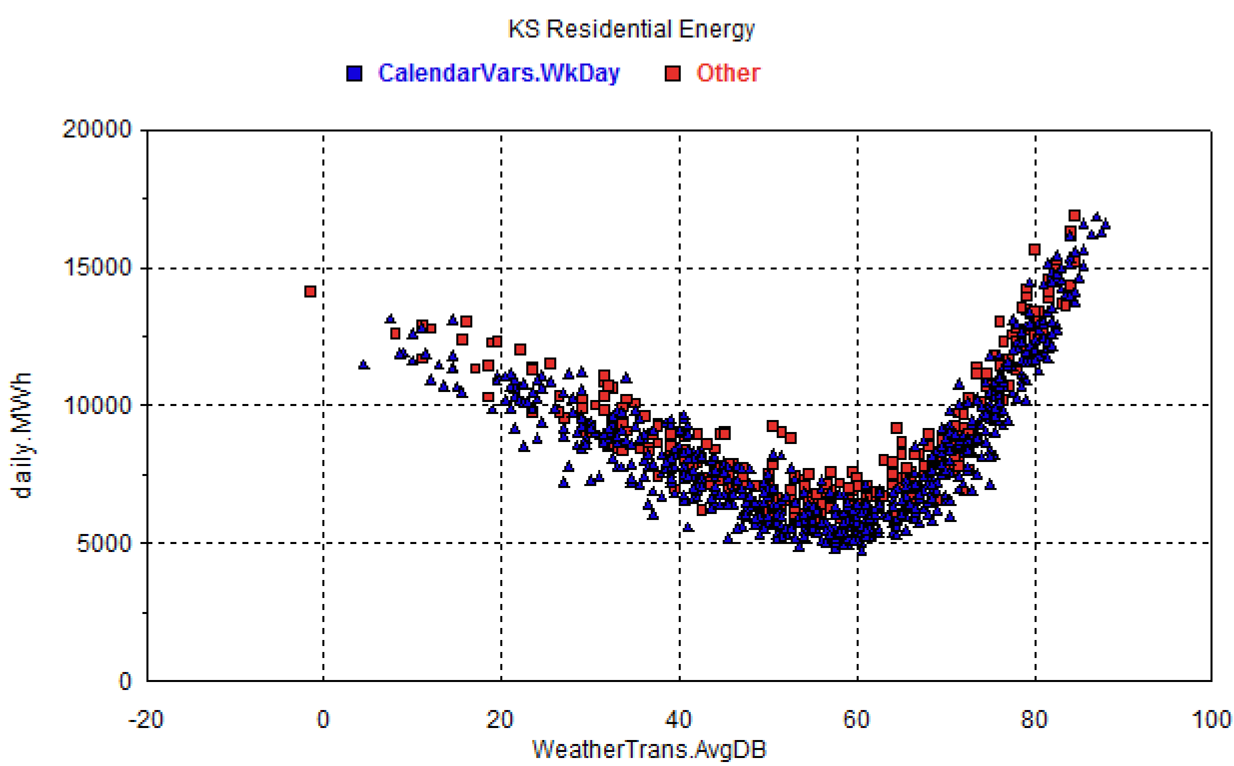


Figure 14: KS Residential Daily Peak Demand vs Average Temp

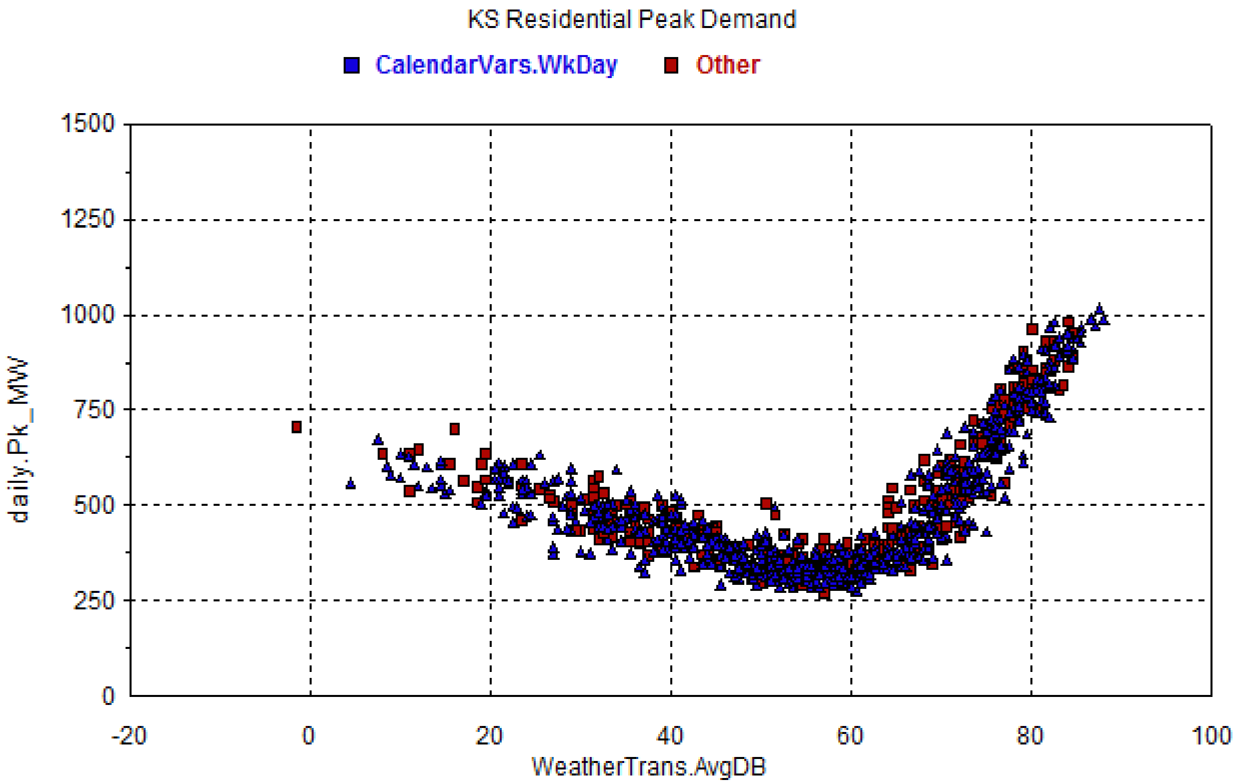


Figure 15: KS Small General Service Daily Energy vs Average Temp

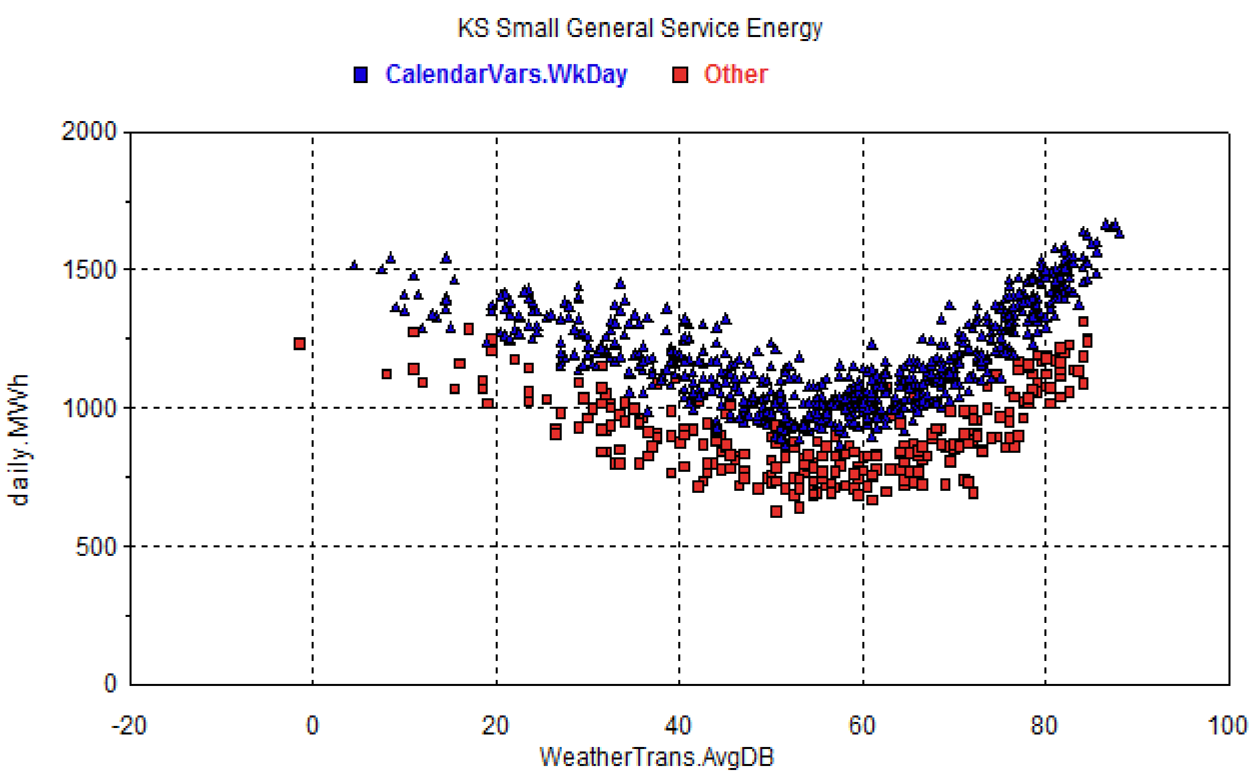


Figure 16: KS Small General Service Daily Peak Demand vs Average Temp

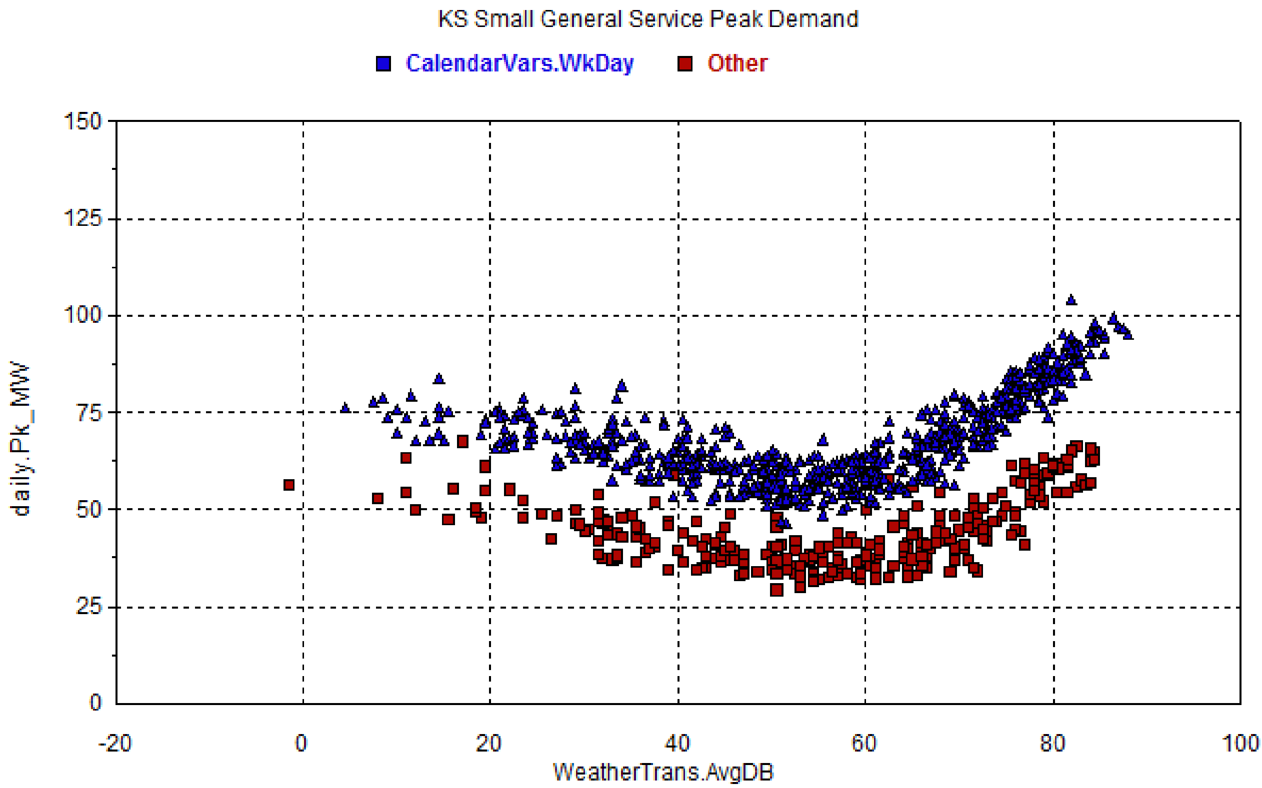


Figure 17: KS Medium General Service Daily Energy vs Average Temp

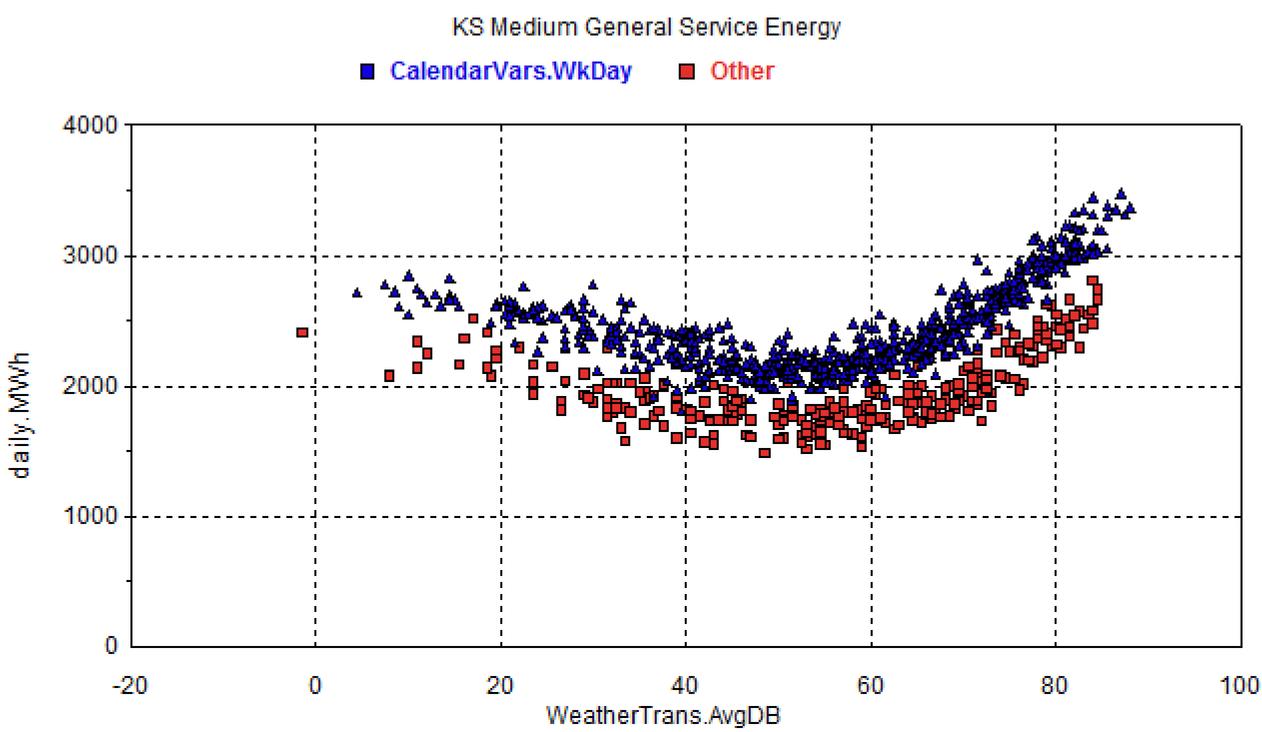


Figure 18: KS Medium General Service Daily Peak Demand vs Average Temp

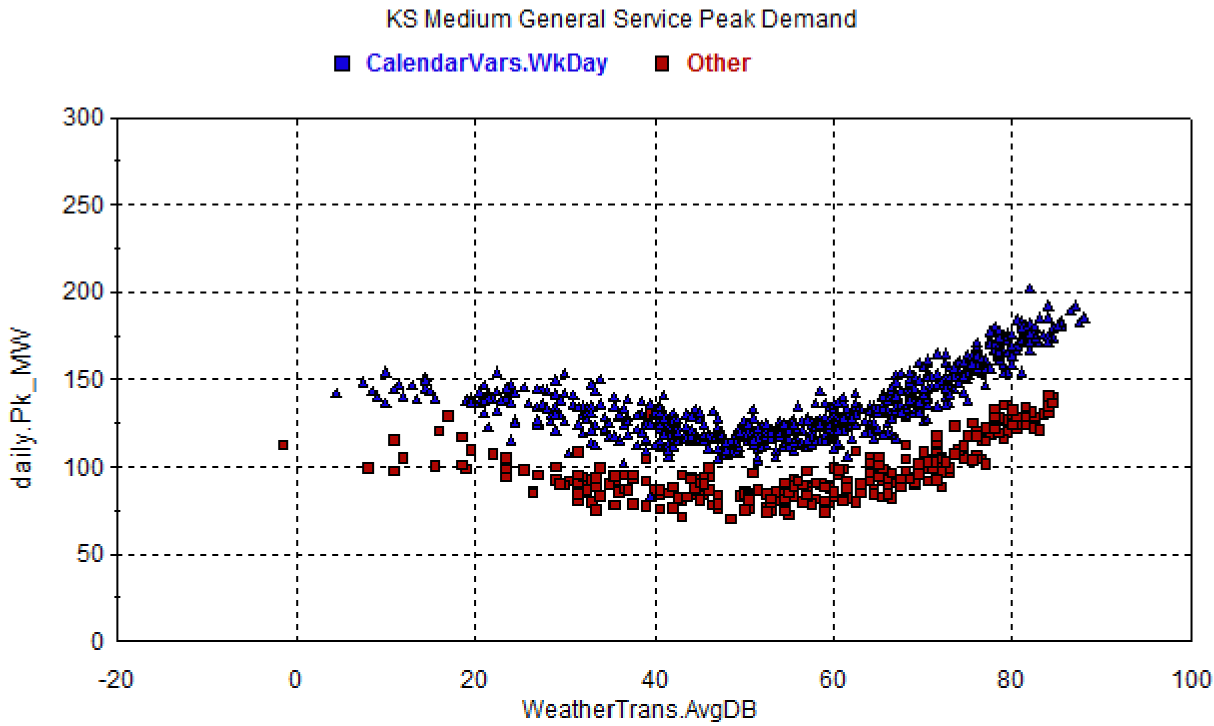


Figure 19: KS Large General Service Daily Energy vs Average Temp

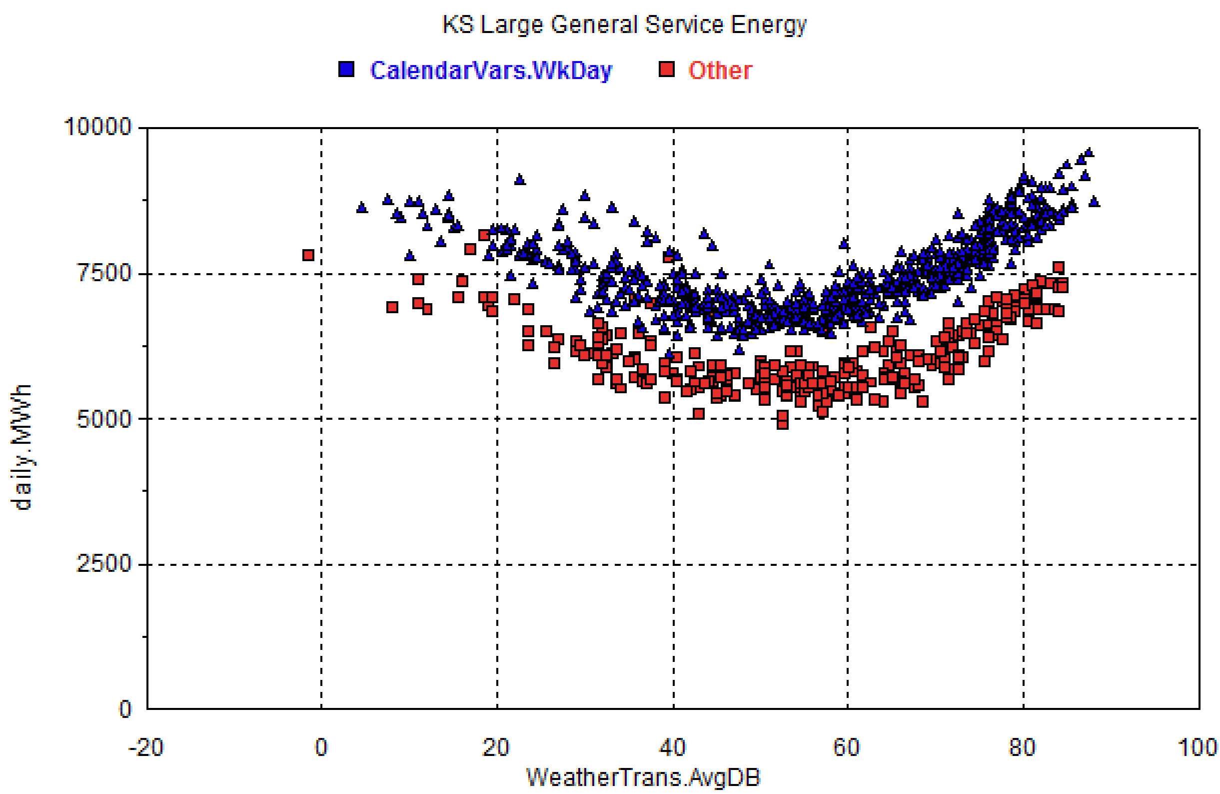


Figure 20: KS Large General Service Daily Peak Demand vs Average Temp

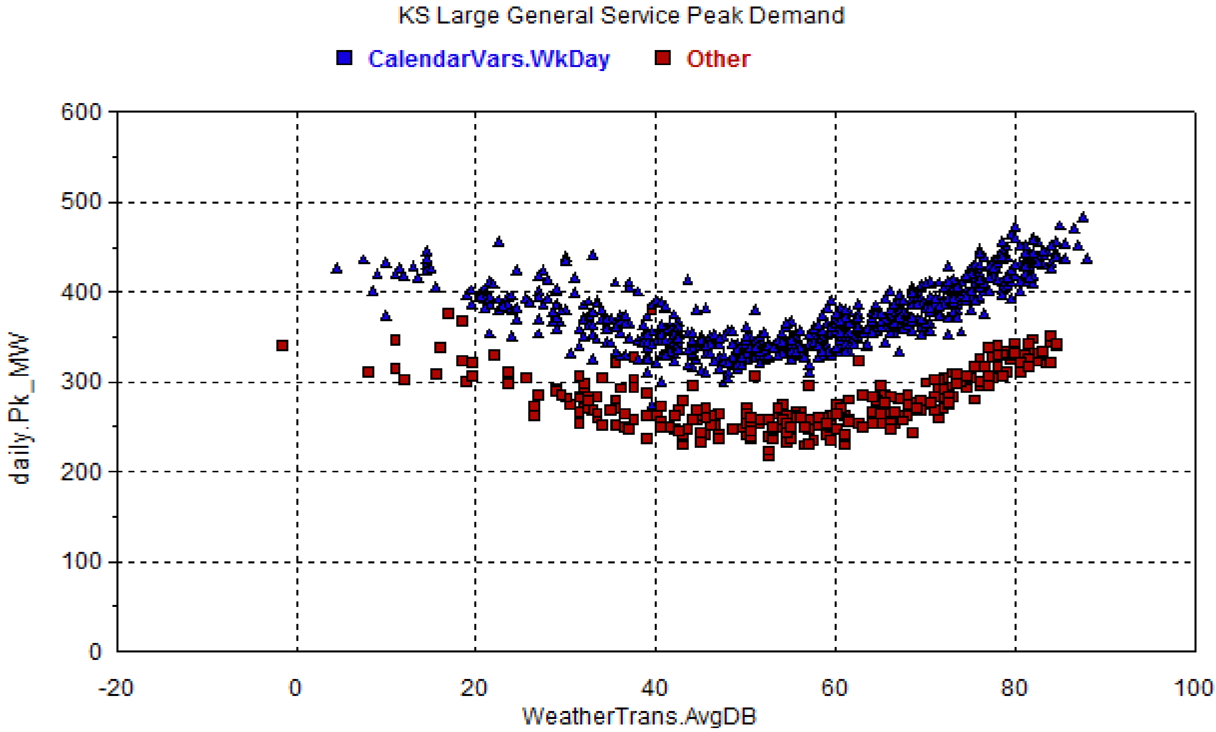


Figure 21: KS Sales for Resale Daily Energy vs Average Temp

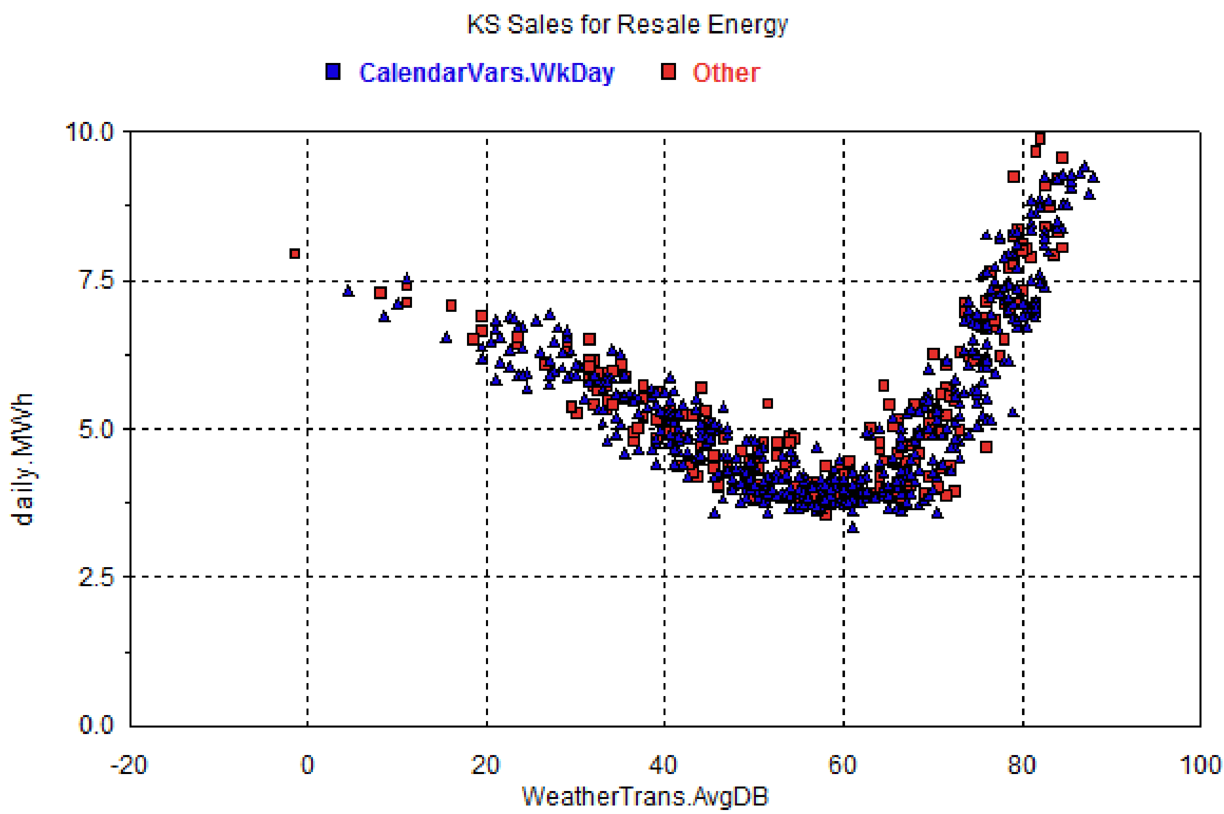
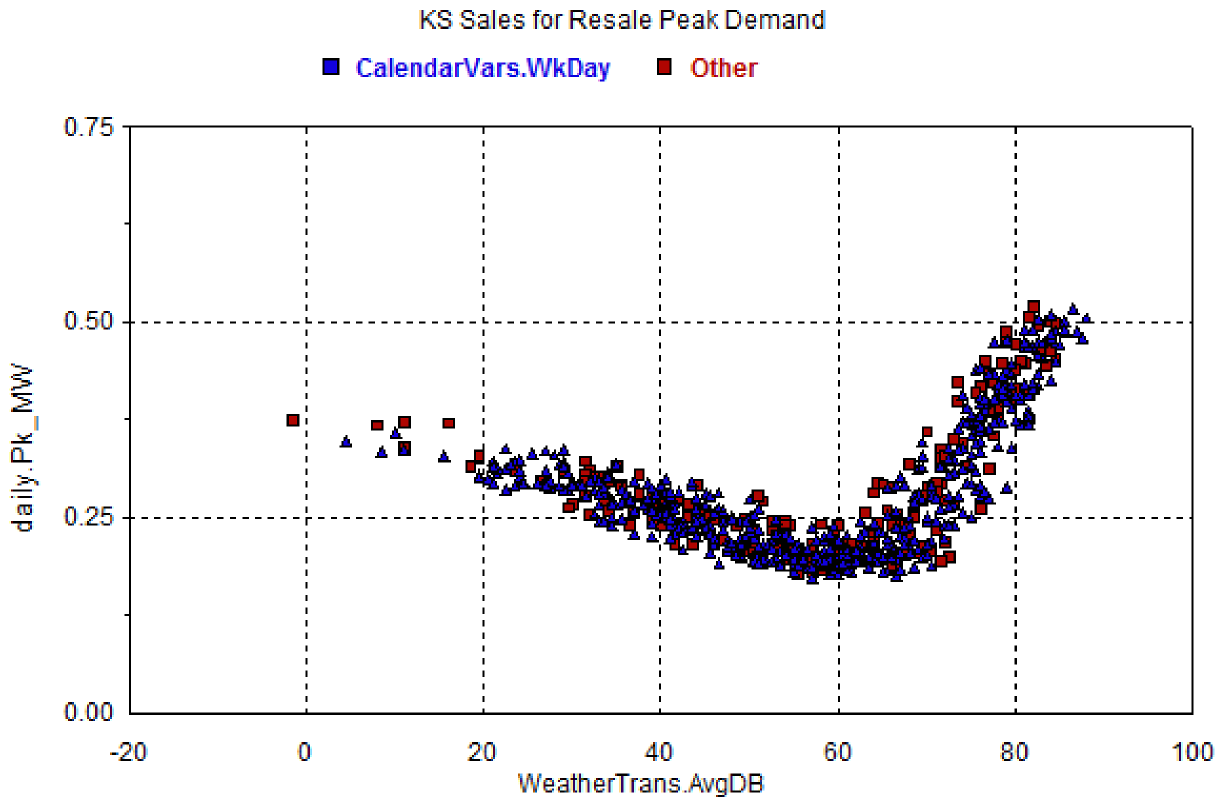


Figure 22: KS Sales for Resale Daily Energy vs Average Temp



KCP&L-KS has zero Sales for Resale customers as of July 2017.

3. Plots illustrating trends materially affecting electricity consumption over the historical period.

Historical class plots of customers, kwh, average use and peak are provided in *Appendix 3A1* and were discussed in the section for rule (2) (D) 1*.*

2.5 ADJUSTMENTS TO HISTORICAL DATA DESCRIPTION AND DOCUMENTATION

(E) The utility shall describe and document any adjustments that it made to historical data prior to using it in its development or interpretation of the forecasting models; and

KCP&L used binary variables in regression models to explain outliers rather than adjust the data.

2.6 LENGTH OF HISTORICAL DATABASE

(F) Length of Historical Database. The utility shall develop and retain the historical database over the historical period.

For KCP&L, historical sales and customers broken out by class cost of service for residential and industrial customers were available beginning in January 2000. Commercial class cost of service data was available beginning May 2005. Going forward, KCP&L will maintain this data for at least the previous 10 years.

SECTION 3: ANALYSIS OF NUMBER OF UNITS

For each major class, the utility shall describe and document its analysis of the historical relationship between the number of units and the economic and/or demographic factors (explanatory variables) that affect the number of units for that major class. The analysis may incorporate or substitute the results of secondary analyses, with the proviso that the utility analyze and verify the applicability of those results to its service territory. If the utility develops primary analyses, or to the extent they are available from secondary analyses, these relationships shall be specified as statistical or mathematical models that relate the number of units to the explanatory variables.

3.1 IDENTIFICATION OF EXPLANATORY VARIABLES

(A) Choice of Explanatory Variables. The utility shall identify appropriate explanatory variables as predictors of the number of units for each major class. The critical assumptions that influence the explanatory variables shall also be identified and documented.

A forecast of the number of households in the KC metro area from Moody's Analytics was the driver for the number of residential customers of KCP&L. The KC metro area is the same as the Metropolitan Statistical Area (MSA) defined by the US Census Bureau and it includes some counties in both states that are not served by KCP&L. Also, KCP&L's service area includes some counties that are not included in the MSA. Despite these inconsistencies in geographic areas, the number of households in the metro area is a good driver to predict the number of our residential customers because the metro area functions economically as a single entity and the metro area includes the vast majority of our customers. Many people live on one side of the state line and work on the other side. Many people shop on both sides of the state line. And many companies each year move from one side of the state line to the other. Documentation for Moody's forecast of economic activity is provided in the workpapers in the folder *\models\KCP&L Base Case\Data\Economics* and Documentation\Economics.

KCP&L tested the use of county level forecasts from Moody's several years ago, but saw no improvement in forecasting accuracy. This might be because it is difficult to forecast economic activity for a small geographic area, or because economic activity crosses county lines in the metro area.

The residential customer models where test with both households and population used as drivers and the one with the best fit was chosen. If neither was significant or had a positive coefficient, the driver was tested without a constant term in the model, and if still insignificant, a driver was not used. Typically, households had the best fit.

The main driver for the number of small general service customers was the number of residential customers or households. These drivers were chosen because they have worked well in the past and because most small commercial customers exist to serve households and residences and these customers will increase in areas where there are new housing developments. Examples of small commercial customers that serve households are medical offices, grocery stores, drug stores, restaurants, churches, schools, hair salons, and movie theaters.

In the models for Big (Medium GS, Large GS and Large Power) commercial customers, non-manufacturing employment and non-manufacturing gross metro product were tested as drivers, as well as population and households. The log of population produced the best fit and was chosen as the primary driver.

3.2 STATISTICAL MODEL DOCUMENTATION

(B) Documentation of statistical models shall include the elements specified in subsection (2)(C) of this rule. Documentation of mathematical models shall include a specification of the functional form of the equations if the utility develops primary analyses, or to the extent they are available if the utility incorporates secondary analyses.

The following tables show the statistics for the variables in the regression models. Additional statistics and residual plots are available in the Metrix ND model files and a word document located in KCPL\KCPL Model Statistics.docx.

Table 9: MO Residential Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
Economics.Households	297.673	4.695	63.400	0.00%	Thousand
RES_Cust.Feb06	1226.203	303.744	4.037	0.01%	
RES_Cust.Nov09	911.565	305.437	2.984	0.32%	
RES_Cust.Jun11	-1138.379	310.169	-3.670	0.03%	
RES_Cust.Jul14	-1076.882	346.110	-3.111	0.22%	
RES_Cust.Nov15	912.297	340.407	2.680	0.80%	
RES_Cust.Jul16	1656.941	385.550	4.298	0.00%	
mBinary.Aug11	-684.620	322.387	-2.124	3.50%	
mBinary.Feb	723.283	166.442	4.346	0.00%	
mBinary.Oct	-481.387	171.273	-2.811	0.55%	
mBinary.Dec	-615.221	171.053	-3.597	0.04%	
AR(1)	0.979	0.009	105.418	0.00%	
SMA(1)	0.477	0.072	6.600	0.00%	
SMA(2)	0.514	0.073	7.051	0.00%	

Table 10: MO Small GS Commercial Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
Economics.Total_Households	30.393	0.396	76.699	0.00%	Thousand
SML_Cust.Jun12	-200.699	90.521	-2.217	2.85%	
SML_Cust.Nov13	-175.068	92.076	-1.901	5.97%	
SML_Cust.Oct13	284.512	92.153	3.087	0.25%	
SML_Cust.Oct16	-349.772	91.078	-3.840	0.02%	
AR(1)	0.983	0.006	155.760	0.00%	
MA(1)	-0.619	0.077	-8.011	0.00%	

Table 11: MO Big Commercial Customers (MGS, LGS and LP)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mEcon.Population_log	796.336	0.748	1064.408	0.00%	
mBinary.BeforeJul08	-446.243	9.451	-47.215	0.00%	
mBinary.Oct13	-129.987	35.754	-3.636	0.04%	
mBinary.Dec09	97.495	35.147	2.774	0.64%	
mBinary.Mar10	88.309	34.694	2.545	1.22%	
mBinary.TrendYR08_09	0.001	0.000	4.907	0.00%	
mBinary.TrendYR13	-0.001	0.000	-2.189	3.05%	
mBinary.YR14	-39.745	11.795	-3.370	0.10%	
mBinary.TrendAfter15	-0.002	0.000	-5.351	0.00%	
mBinary.TrendAfter14	-0.001	0.000	-4.510	0.00%	
BIG_Cust.YR06	-118.510	13.100	-9.047	0.00%	
BIG_Cust.Jul08	-116.718	35.125	-3.323	0.12%	
BIG_Cust.Dec08	146.326	35.132	4.165	0.01%	
BIG_Cust.Dec11	77.062	34.695	2.221	2.82%	
BIG_Cust.Apr12	-85.505	34.696	-2.464	1.51%	
BIG_Cust.Jun14	-90.841	35.746	-2.541	1.23%	

The variable ending with month and year, shown in the table above, is defined as 1 for that month and 0 for all other months.

Table 12: MO Industrial Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	3.217	8.297	0.388	69.86%	
IND_Cust.LagDep(1)	0.996	0.008	131.027	0.00%	
IND_Cust.Jul03	60.137	11.214	5.363	0.00%	
IND_Cust.Aug03	-66.450	11.195	-5.936	0.00%	
IND_Cust.Aug08	40.031	10.425	3.840	0.02%	
IND_Cust.May14	35.654	10.383	3.434	0.08%	
IND_Cust.Aug09	-36.168	10.521	-3.438	0.07%	
AR(1)	-0.417	0.071	-5.897	0.00%	

Table 13: KS Residential Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
Economics.Households	265.434	0.796	333.276	0.00%	Thousand
RES_Cust.Jul06	855.372	280.763	3.047	0.28%	
RES_Cust.Nov09	682.275	282.012	2.419	1.68%	
RES_Cust.Jul16	1893.473	281.876	6.717	0.00%	
mBinary.Jan	-430.556	83.871	-5.134	0.00%	
mBinary.Mar	-248.357	83.745	-2.966	0.36%	
mBinary.Oct	-516.341	86.315	-5.982	0.00%	
mBinary.Dec	-507.786	86.722	-5.855	0.00%	
AR(1)	0.975	0.020	48.537	0.00%	
MA(1)	-0.614	0.087	-7.068	0.00%	
MA(2)	0.224	0.085	2.615	0.99%	

Table 14: KS Small GS Commercial Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
ResCustomers.RU_Cust	0.066	0.010	6.581	0.00%	Count
Economics.Emp_NonMan	8.691	2.285	3.804	0.02%	Thousand
SML_Cust.Jun_Aug06	0.000	0.000	0.000	100.00%	
SML_Cust.Mar07	-163.614	85.042	-1.924	5.69%	
SML_Cust.Jul10	292.476	86.713	3.373	0.10%	
SML_Cust.Oct11	-254.615	88.611	-2.873	0.49%	
SML_Cust.Nov11	-217.768	88.074	-2.473	1.49%	
mBinary.Aug11	434.625	85.683	5.072	0.00%	
SML_Cust.Feb13	-347.149	85.001	-4.084	0.01%	
SML_Cust.BeforeMar14	-285.362	87.559	-3.259	0.15%	
SML_Cust.Jul16	-1298.375	89.239	-14.549	0.00%	
SML_Cust.Aug16	-489.763	87.630	-5.589	0.00%	
mBinary.Apr	-80.919	25.761	-3.141	0.22%	
AR(1)	0.943	0.036	26.192	0.00%	
MA(1)	-0.476	0.104	-4.602	0.00%	

Table 15: KS Big GS Commercial Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mEcon.Population_log	65.544	20.029	3.272	0.14%	
BIG_Cust.Jul08	122.394	38.046	3.217	0.17%	
BIG_Cust.Sep11	228.125	41.075	5.554	0.00%	
BIG_Cust.Oct11	281.645	44.460	6.335	0.00%	
BIG_Cust.Nov11	-243.769	43.956	-5.546	0.00%	
BIG_Cust.Mar13	83.196	38.480	2.162	3.27%	
BIG_Cust.Apr17	189.396	40.430	4.685	0.00%	
BIG_Cust.May17	-186.080	40.673	-4.575	0.00%	
BIG_Cust.LagDep(1)	0.903	0.030	30.447	0.00%	
AR(1)	-0.459	0.085	-5.420	0.00%	

Table 16: KS Industrial Customers

Variable	Coefficient	StdErr	T-Stat	P-Value
Simple	0.411	0.080	5.157	0.000
Trend	-0.084	0.003	-24.497	0.000
Damp Factor	0.997	0.001	1606.618	0.000

No economic drivers were significant in the model for industrial customers in Kansas.

SECTION 4: USE PER UNIT ANALYSIS

For each major class, the utility shall describe and document its analysis of historical use per unit by end use.

4.1 END-USE LOAD DETAIL

(A) End-Use Load Detail. For each major class, use per unit shall be disaggregated, where information permits, by end-uses that contribute significantly to energy use or peak demand.

4.1.1 END-USE LOAD INFORMATION

1. The utility shall consider developing information on at least the following end-use loads:

4.1.1.1 Residential Sector

A. For the residential sector: lighting, space cooling, space heating, ventilation, water heating, refrigerators, freezers, cooking, clothes washers, clothes dryers, television, personal computers, furnace fans, plug loads, and other uses;

The list of residential enduses that KCP&L maintains the number of units and energy use per unit include electric furnaces, heat pumps with electric resistance backup, heat pumps with natural gas backup, ground source heat pumps, central air conditioning without a heat pump, window or wall AC units, electric water heaters, electric ovens, cook tops and ranges, full-sized refrigerators, small refrigerators and wine coolers, freezers, dishwashers, clothes washers, electric dryers, TVs, air cleaners, computers, video game systems, hot tubs, swimming pools, electric vehicles and miscellaneous uses.

4.1.1.2 Commercial Sector

B. For the commercial sector: space heat, space cooling, ventilation, water heat, refrigeration, lighting, office equipment, cooking equipment, and other uses; and

KCP&L maintains information on saturations per square foot of floor space and energy use per square foot (EUI) for enduses including heating, cooling, ventilation, electric water heating, electric cooking, refrigeration, outdoor lighting, indoor lighting, and office equipment and miscellaneous uses. In this filing, secondary data from the U.S. DOE for the West North Central region was adopted for both KCP&L Kansas and Missouri. The region includes the states of North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas and Missouri. The results are combined across building types using building type weights. The building types include assembly (theaters, libraries, churches etc.), education, food sales, food service, health care, lodging, small office, large office, mercantile/service, warehouse and other. This data is maintained in *ComIndices_MO.xls* and *ComIndices_KS.xls*. The building types are defined in NEMS to NAICS Mapping*.xls*. These spreadsheets were provided to KCP&L by Itron Inc. through the Energy Forecasting Group (EFG). The spreadsheets are documented in *2017_CommercialSAE.pdf*. These files are provided in the workpapers.

4.1.1.3 Industrial Sector

C. For the industrial sector: machine drives, space heat, space cooling, ventilation, lighting, process heating, and other uses.

KCP&L has a relatively small industrial sector, accounting for approximately 12% of retail sales. KCP&L lacks the concentration of heavy industry that some utilities have. As such, we have modeled our industrial sector with a statistically adjusted employment-based intensity model. Major end-uses are cooling and other.

4.1.2 MODIFICATION OF END-USE LOADS

2. The utility may modify the end-use loads specified in paragraph (4)(A)1.

4.1.2.1 Removal or Consolidation of End-Use Loads

A. The utility may remove or consolidate the specified end-use loads if it determines that a specified end-use load is not contributing, and is not likely to contribute in the future, significantly to energy use or peak demand in a major class.

In the last few years, KCP&L has dropped several enduses from its residential survey including VCRs, DVD players, printers, fax machines, copier/scanners and attic fans since these do not contribute significantly to energy use or peak demand.

4.1.2.2 <u>Additions to End-Use Loads</u>

B. The utility shall add to the specified end-use loads if it determines that an end-use load currently not specified is likely to contribute significantly to energy use or peak demand in a major class.

In 2011 KCP&L added electric vehicles (including PHEVs) to our database. In the 2017 base year forecast we incorporated preliminary EV adoption forecasts produced in an ongoing study of KCP&L service territory EV usage conducted in partnership with the Electric Power Research Institute.

Starting with the 2013 base year forecast, we began tracking solar installations and merged that tracking with the EIA forecast estimate in 2015 to start generating a solar end-use intensity forecast for use in our residential and commercial forecasts.

4.1.2.3 <u>Modification of End-Use Documentation</u>

C. The utility shall provide documentation of its decision to modify the specified end-use loads for which information is developed, as well as an assessment of how the modifications can be made to best preserve the continuity and integrity of the end-use load database.

KCP&L dropped the enduses listed in the previous section A because VCRs, DVD players, printers, fax machines and copier/scanners are mainly plug loads that do not contribute significantly to energy use. We added well pumps, video game systems and mini\wine refrigerators because these use substantial amounts of energy and we believed that these had a significant saturation in our service areas.

A preliminary study and projection of electric vehicle utilization and load impact was incorporated as an end-use in the current forecast. The study suggests that electric vehicle utilization is likely to significantly impact our energy load in the future. The available resources underlying the study results are included in our work-papers.

4.1.3 SCHEDULE FOR ACQUIRING END-USE LOAD INFORMATION

3. For each major class and each end-use load, including those listed in paragraph (4)(A)1., if information is not available, the utility shall provide a schedule for acquiring this end-use load information or demonstrate that either the expected costs of acquisition were found to outweigh the expected benefits over the planning horizon or that gathering the end-use load information has proven to be infeasible.

KCP&L completed a DSM potential study in 2016. The study collected detailed end-use saturation and efficiency data from our customers in the residential, commercial and industrial sectors. KCP&L provided copies of the completed study to stakeholders' group.

4.1.4 WEATHER EFFECTS ON LOAD

4. The utility shall determine the effect that weather has on the total load of each major class by disaggregating the load into its cooling, heating, and non-weather-sensitive components. If the cooling or heating components are a significant portion of the total load of the major class, then the cooling or heating components of that load shall be designated as enduses for that major class.

KCP&L used statistical regression analysis applied to the load research data to develop HELM like hourly load profiles for each month, for three different day types and for base, heating and cooling loads. The three-day types are weekdays, weekends and peak days. Daily temperature was used in the regression models to identify the heating and cooling portions of the loads. The profiles were developed for each CCOS. The regressions were performed in MetrixND projects MO_BaseHeatCool16.NDM, MO_LoadEndUse16.NDM, KS_BaseHeatCool.NDM, KS_LoadEndUse.NDM using 2012-2015 load research data.

These load profiles are used in this IRP filing to allocate base, heating and cooling energy to each hour on an annual and monthly basis. These profiles are stored in *MO_SystemLoad.ltm and KS_SystemLoad.ltm.*

4.2 END-USE DEVELOPMENT

(B) The database and historical analysis required for each end use shall be developed from a utility-specific survey or other primary data. The database and analysis may incorporate or substitute the results of secondary data, with the proviso that the utility analyze and verify the applicability of those results to its service territory. The database and historical analysis required for each end use shall include at least the following:

4.2.1 MEASURES OF THE STOCK OF ENERGY-USING CAPITAL GOODS

1. Measures of the stock of energy-using capital goods. For each major class and end-use load identified in subsection (4)(A), the utility shall implement a procedure to develop and maintain adequate data on the energy-related characteristics of the building, appliance and equipment stock including saturation levels, efficiency levels, and sizes, where applicable. The utility shall update the data before each triennial compliance filing; and

KCP&L has conducted a residential appliance saturation survey every 2-3 years for many decades. The surveys have been conducted by mail historically and recently by a mix of mail and internet methods. The last survey was conducted in the second quarter of 2016 in conjunction with the 2016 potential study. Questionnaires were sent to at least 5,000 residential premises in each jurisdiction resulting in 793 and 790 responses received from residential customers in Missouri and Kansas respectively. The survey responses were matched with each customers' billing records for the previous 12 months and with heating and cooling degree days computed for the billing period and the combined data was used in a conditional demand study to estimate the energy used by each type of appliance.

KCP&L conducted a DSM potential study that was completed in 2016. This study collected detailed end-use saturation and efficiency data from our customers in the residential, commercial and industrial sectors. KCP&L provided copies of the final report to the Stakeholders' group.

A commercial and industrial (C&I) saturation survey was conduct in 2016 in addition to the residential appliance saturation survey. The C&I survey was conducted as a single jurisdictional survey due to the sample size. The survey targeted a sample of 800 surveys which was allocated across strata and by SIC segment (Office, Retail, Restaurant, Grocery, College, Schools, Health, Lodging, Warehouse, Misc., Energy Intensive Mfg., Non-Intensive Mfg., Other Industrial, and Unknow). Of the 800 surveys, there were 40 onsite interviews and 760 telephone interviews.

The C&I survey captured information about a wide range of features of customer business facilities, including the following:

- Business / building characteristics
- Heating and cooling systems (fuel type, primary /secondary, controls, and % of space)
- Water heating (type, fuel, and size)
- Lighting (number by type, controls, and operating hours)
- Electronic equipment
- Other end uses (electronics, kitchens, warehouse space, motors, etc.)
- Energy efficiency-related improvements

4.2.3 <u>END-USE ENERGY AND DEMAND ESTIMATES</u>

2. Estimates of end-use energy and demand. For the end-use loads identified in subsection (4)(A), the utility shall estimate monthly energies and demands at the time of monthly system peaks and shall calibrate these energies and demands to equal the weather-normalized monthly energies and demands at the time of monthly peaks for each major class for the most recently available data.

Monthly energies for the end-uses that are included in our SAE models are calibrated in the SAE models to monthly billed sales for each CCOS. The coefficients for the base, heating and cooling loads calibrate those loads and the coefficient for the base load raises or lowers all the components of the base load when the base load is calibrated to monthly billed sales.

Monthly demand for the major end-uses that are included in our SAE models are calibrated to the time of the monthly system peaks. This is done in the models by taking the hourly system demands and matching them to the hourly class end-use demands. This computes the coincident peak by class and end-use. To calibrate class end-use demands to the weather normalized system peak, the system peak and weather normalized peaks are used to develop a calibration factor that is applied to each class and end-use. This process is done for both Missouri and Kansas. This process is completed in an Excel worksheet which is provided in the workpapers.

SECTION 5: SELECTING LOAD FORECASTING MODELS

The utility shall select load forecast models and develop the historical database needed to support the selected models. The selected load forecast models will include a method of end-use load analysis for at least the residential and small commercial classes, unless the utility demonstrates that end-use load methods are not practicable and provides documentation that other methods are at a minimum comparable to end-use methods. The utility may choose multiple models and methods if it deems doing so is necessary to achieve all of the purposes of load forecasting and if the methods and models are consistent with, and calibrated to, one another. The utility shall describe and document its intended purposes for load forecast models, why the selected load forecast models best fulfill those purposes, and how the load forecast models are consistent with one another and with the end-use usage data used in the demand-side analysis as described in 4 CSR 240-22.050. As a minimum, the load forecast models shall be selected to achieve the following purposes:

5.1 CONSUMPTION DRIVERS AND USAGE PATTERNS

(A) Assessment of consumption drivers and customer usage patterns—to better understand customer preferences and their impacts on future energy and demand requirements, including weather sensitivity of load;

KCP&L uses the Statistically Adjusted End-use (SAE) method to forecast energy sales and demand for all classes except lighting and sales for resale. The SAE method creates a forecast of sales at the end-use level and then for each class aggregates the forecasts into base, heating and cooling energy and then calibrates these loads to monthly billed sales using statistical regressions.

Our end-use level forecasts are developed using both primary data collected by KCP&L and secondary data and projections produced by the U.S. Department of Energy (DOE) for the West North Central region of the U.S. DOE projections used in our models include projections of saturations for household appliances and equipment used in commercial buildings and projections of efficiencies for appliances, buildings and equipment. DOE has a large professional staff that is responsible for constructing and maintaining energy demand models and for managing contractors. The contractors survey households, businesses and buildings on a regular schedule. Contractors are also used to conduct special studies. DOE's projections are designed to account for changes in consumer preferences, technology and building design practices. Their projections also account for the impacts of appliance and equipment standards. DOE updates its projections at least once a year and we use the most recently available projections whenever we update our models.

KCP&L calibrates DOE appliance saturation projections to the saturation numbers that we obtain from our residential surveys. We also calibrate DOE's projections of unit energy consumption (UEC) for appliances to the results of our conditional demand study.

Itron hosts an annual meeting for the Energy Forecasting Group (EFG), which supports utilities that use the SAE method to forecast their sales. DOE staff attends the meeting of the EFG (which we attend) to explain changes in the assumptions, data and methods that have occurred during the previous year. Their slide decks provided during these meetings for the past several years are included in our workpapers. On their website, DOE provides detailed documentation and computer code for their models and assumptions.

5.2 LONG-TERM LOAD FORECASTS

(B) Long-term load forecasts—to serve as a basis for planning capacity and energy service needs. This can be served by any forecasting method or methods that produce reasonable projections (based on comparing model projections of loads to actual loads) of future demand and energy loads;

KCP&L believes that the SAE methodology is the best available for producing our load forecasts. REEPS, COMMEND and INFORM are no longer supported and never were supported as well as the DOE projections. DOE forecasts the impacts of all appliance and equipment standards most of which will substantially increase efficiency.[i] DOE also models trends in appliance ownership and utilization.

The Annual Energy Outlook for 2017 (AEO2017) differed from the previous year's forecast for both the residential and commercial outlooks. The residential outlook had changes for the following:

- Updated housing stock formation and decay
- Residential photovoltaic (PV)
- Lighting intensity was scaled to the 2009 Residential Energy Consumption Survey (RECS) base year, though slope was unchanged
- Miscellaneous electric loads (MEL)

Total Residential intensity is follows a growth trajectory very similar to the previous Annual Energy Outlook, though growth in 2016-2021 is lightly less negative (-0.8% compared to -1.0%). The reason for this change is the assumptions driving Miscellaneous Electric Load. The prior outlook included a period of negative growth in MEL (a departure from previous projections), while the latest estimate is a flat trajectory.

For the commercial outlook, changes were made for the following:

- Incorporation of the 2012 Commercial Buildings Energy Consumption Survey (CBECS)
- Floor stock projections
- End-use energy intensity projections
- End-use efficiency projections
- Revised historical saturations and efficiencies

The majority of the end-uses decreased in intensity in the 2017 outlook compared to the previous outlook, with cooling being a notable exception.

5.3 POLICY ANALYSIS

(C) Policy analysis—to assess the impact of legal mandates, economic policies, and rate designs on future energy and demand requirements. The utility may use any load forecasting method or methods that it demonstrates can adequately analyze the impacts of legal mandates, economic policies, and rate designs.

KCP&L believes that the SAE approach is the best available method to incorporate the impacts of appliance and equipment efficiency standards because the DOE is the best qualified institution to estimate these impacts. DOE will also incorporate any federal legal impacts into its forecasts. For example, DOE has incorporated CAFÉ regulations into its forecasts of electric vehicle unit sales, which in turn impacts kWh sales for recharging EVs.

Table 17: Residential Product Categories Covered by DOE Standards[ii]

Product Covered	Initial Legislation	Last Standard Published	Compliance Date	Issued By	Proposed Standards Due	New Final Standard Due	Potential Compliance Date	States With Standard
Battery Chargers	EPACT 2005	2016	2018	DOE	2022	2024	2026	CA, OR
Boilers	NAECA 1987	2016	2021	DOE	2022	2024	2029	
Ceiling Fans	EPACT 2005	2017	2020	DOE	2023	2025	2028	
Central Air Conditioners and Heat Pumps	NAECA 1987	2017	2023	DOE	2023	2025	2030	
Clothes Dryers	NAECA 1987	2011	2015	DOE	2017	2019	2022	
Clothes Washers	NAECA 1987	2012	2018	DOE	2018	2020	2024	
Compact Audio Equipment								CA, CT, OR
Computers and Computer Systems				N/A				CA
Cooking Products	NAECA 1987	2009	2012	DOE		2017	2020	
Dehumidifiers	EPACT 2005	2016	2019	DOE	2022	2024	2027	
Direct Heating Equipment *	NAECA 1987	2016	None	DOE	2019	2021	2024	
Dishwashers *	NAECA 1987	2016	None	DOE	2019	2021	2024	
DVD Players and Recorders								CA, CT, OR
External Power Supplies	EPACT 2005	2014	2016	DOE		2021		CA
Faucets	EPACT 1992	1992	1994	Congress				CA, CO
Furnace Fans	EPACT 2005	2014	2019	DOE	2020	2022	2025	
Furnaces	NAECA 1987	2007	2015	DOE		2016		
Game Consoles				N/A				
Hearth Products				N/A				
Microwave Ovens	NAECA 1987	2013	2016	DOE	2019	2021	2024	
Miscellaneous Refrigeration Products		2016	2019	DOE	2022	2024	2027	CA
Pool Heaters	NAECA 1987	2010	2013	DOE	2016	2018	2021	
Pool Pumps		2017	2021	DOE	2023	2025	2028	AZ, CA, CT, WA
Portable Air Conditioner	NAECA 1987		None	DOE				
Portable Electric Spas								AZ, CA, CT, OR, WA
Refrigerators and Freezers	NAECA 1987	2011	2014	DOE	2017	2019	2022	
Room Air Conditioners	NAECA 1987	2011	2014	DOE	2017	2019	2022	
Set-top Boxes				N/A				
Showerheads	EPACT 1992	1992	1994	Congress				CA, CO
Televisions	NAECA 1987			N/A				CA, CT, OR
Toilets	EPACT 1992	1992	1994	Congress				CA, CO, GA, TX
Water Heaters	NAECA 1987	2010	2015	DOE	2016	2018	2023	

Table 18: Commercial/Industrial Product Categories Covered by DOE Standards[iii]

Product Covered	Initial Legislation	Last Standard Published	Compliance Date	Issued By	Proposed Standards Due	New Final Standard Due	Potential Compliance Date	States With Standard
Automatic Commercial Ice Makers	EPACT 2005	2015	2018	DOE	2021	2023	2026	
Boilers, Commercial	EPACT 1992	2009	2012	DOE				
Clothes Washers, Commercial	EPACT 2005	2014	2018	DOE	2020	2022	2025	
Commercial CAC and HP (65,000 Btu/hr to 760,000 Btu/hr)	EPACT 1992	2016	2018	DOE	2022	2024	2029	
Commercial CAC and HP (<65,000 Btu/hr)	EPACT 1992	2015	2017	DOE	2021	2023	2026	
Commercial CAC and HP (Water- and Evaporatively-Cooled)	EPACT 1992	2012	2013	DOE	2018	2020	2023	
Commercial Refrigeration Equipment	EPACT 2005	2014	2017	DOE		2020	2023	
Commercial Warm Air Furnaces	EPACT 1992	2016	2023	DOE	2022	2024	2029	
Commercial Water Heaters	EPACT 1992	2001	2003	DOE		2018	2021	
Compressors	EPACT 1992			N/A				
Computer Room Air Conditioners	EPACT 1992	2012	2013	DOE		2018	2021	
Distribution Transformers: Liquid-Immersed	EPACT 1992	2013	2016	DOE	2019	2021	2024	
Distribution Transformers: Low-Voltage Dry-Type	EPACT 2005	2013	2016	DOE	2019	2021	2024	
Distribution Transformers: Medium-Voltage Dry-Type	EPACT 1992	2013	2016	DOE	2019	2021	2024	
Electric Motors	EPACT 1992	2014	2016	DOE	2020	2022	2025	
Fans and Blowers	EPACT 1992			N/A				
Hot Food Holding Cabinets								CA, CT, DC, MD, NH, OR, RI, WA
Packaged Terminal AC and HP	EPACT 1992	2015	2017	DOE	2021	2023	2026	
Pre-Rinse Spray Valves	EPACT 2005	2016	2019	DOE	2022	2024	2027	
Pumps, Commercial and Industrial	EPACT 1992	2016	2020	DOE	2022	2024	2027	
Single Package Vertical Air Conditioners and Heat Pumps	EPACT 1992	2015	2019	DOE	2021	2023	2026	
Small Electric Motors	EPACT 1992	2010	2015	DOE	2016	2018	2021	
Unit Heaters	EPACT 2005	2005	2008	Congress				
Urinals	EPACT 1992	1992	1994	Congress				CA, CO, TX
Vending Machines	EPACT 2005	2016	2019	DOE	2022	2024	2027	
Walk-In Coolers and Freezers	EISA 2007	2014	2017	DOE		2020	2023	
Water Dispensers								CA, CT, DC, MD, NH, OR, RI, WA
Water-Source Heat Pumps	EPACT 1992	2015	2015	DOE	2021	2023	2026	

Table 19: Lighting Product Categories Covered by DOE Standards[iv]

Product Covered	Initial Legislation	Last Standard Published	Compliance Date	Issued By	Proposed Standards Due	New Final Standard Due	Potential Compliance Date	States With Standard
Candelabra & Intermediate Base Incandescent Lamps		2007	2012	Congress				
Ceiling Fan Light Kits	EPACT 2005	2016	2019	DOE	2022	2024	2027	
Compact Fluorescent Lamps	EPACT 2005	2005	2006	Congress				
Deep-Dimming Fluorescent Ballasts								CA
Fluorescent Lamp Ballasts	NAECA 1988	2011	2014	DOE	2017	2019	2022	
General Service Fluorescent Lamps	EPACT 1992	2015	2018	DOE	2021	2023	2026	
General Service Lamps	EISA 2007	2007	2012	Congress		2022	2025	
HID Lamps	EPACT 1992	2015		DOE	2018	2020	2023	
High Light Output Double-Ended Quartz Halogen Lamps								OR
Illuminated Exit Signs	EPACT 2005	2005	2006	Congress				
Incandescent Reflector Lamps	EPACT 1992	2015	None	DOE	2021	2023	2026	
Incandescent Reflector Lamps (includes certain BR and Other Exempted IRLs)	EPACT 1992			N/A				
Luminaires	EPACT 1992			N/A				
Mercury Vapor Lamp Ballasts	EPACT 2005	2005	2008	Congress				
Metal Halide Lamp Fixtures	EISA 2007	2014	2017	DOE		2019	2022	
Small-Diameter Directional Lamps								CA
Torchiere Lighting Fixtures	EPACT 2005	2005	2006	Congress				
Traffic Signals	EPACT 2005	2005	2006	Congress				

SECTION 6: LOAD FORECASTING MODEL SPECIFICATIONS

6.1 DESCRIPTION AND DOCUMENTATION

(A) For each load forecasting model selected by the utility pursuant to section 4 CSR 240-22.030(5), the utility shall describe and document its—

6.1.1 DETERMINATION OF INDEPENDENT VARIABLES

1. Determination of appropriate independent variables as predictors of energy and peak demand for each major class. The critical assumptions that influence the independent variables shall also be identified.

In the models of residential use per customer, the independent variables were appliance saturations, appliance UECs, the real price of electricity, real per capita income and persons per household. The appliance saturations and UEC forecasts were adopted from DOE's forecast for the west north central region. The critical assumptions influencing the forecasts of saturations and UECs are discussed in workpapers located in documentation/SAE/assumptions and describes the model assumptions, computational methodology, parameter estimation techniques. These forecasts incorporate appliance ownership trends, trends in efficiency, updated building standards and technological change.

The forecasts of real per capita income and persons per household were produced by Moody's analytics for the KC metro area. Moody's documents its methodology in *micromodel_methodology.pdf*, *State Model Methodology.pdf* and Metro_Model_Methodology*.pdf*, which are supplied in the workpapers. These independent variables were used to construct an end-use forecast of residential use per customer for three major enduses: heating, cooling and other, and these were then calibrated to monthly billed sales per customer in a linear regression. This is described in *Appendix B: Residential SAE Modeling Framework* in the file *Res2017SAEUpdate.pdf*.

In the models of commercial sales and use per customer, the independent variables were equipment saturations and EUIs, the real price of electricity and economic variables. Economic variables were non-manufacturing employment or non-manufacturing GMP. The forecasts from DOE incorporate trends in equipment saturations, equipment efficiencies, equipment standards, building standards and technological change. These independent variables were used to construct an end-use forecast of commercial use for three major enduses: heating, cooling and other, and these were then calibrated to monthly billed sales or sales per customer in a linear regression. This is described in *Appendix A: Commercial Statistically Adjusted End-Use Model* in the file *2017CommercialSAE.pdf*.

In the models of industrial sales, the independent variables were EUIs on an industry and employment basis, the real price of electricity and economic variables. Economic variables were manufacturing employment or manufacturing GMP.

The forecasts from DOE incorporate trends in equipment saturations, equipment efficiencies, equipment standards, building standards and technological change. These independent variables were used to construct an intensity forecast of aggregated across industrial segments and these were then calibrated to monthly billed sales or sales per customer in a linear regression. This is described in *Appendix A: Commercial Statistically Adjusted End-Use Model* in the file *2017CommercialSAE.pdf*.

A. The utility shall assess the applicability of the historical explanatory variables pursuant to subsection (3)(A) to its selected forecast model.

The explanatory variables used by KCP&L in its forecasting models incorporate the most important drivers of energy use. These drivers are energy standards, building standards, trends in saturations and equipment efficiency, economic growth at the sector level and existing company energy efficiency and DSM programs.

B. To the extent that the independent variables selected by the utility differ from the historical explanatory variables, the utility shall describe and document those differences;

KCP&L has used the SAE approach since 2004 to forecast its loads. The economic drivers for the residential sector have been the number of households in the KC metro area during this time period. This is the second triennial filling that KCP&L has modeled small commercial (SGS), big commercial (MGS, LGS, and LP) and industrial sales (SGS, MGS, LGS, and LP) using the statistically adjusted end-use method.

For this filing, we are using updated projections from DOE for 2017 and a June 2017 vintage economic forecast of the KC metro area from Moody's Analytics.

2. Development of any mathematical or statistical equations comprising the load forecast models, including a specification of the functional form of the equations; and

Table 20: MO Residential kWh per Customer

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat55_RES	0.888	0.016	56.066	0.00%	kWh/cust
mStrucVars.XCool65_RES	1.038	0.013	81.317	0.00%	kwh/cust
mStrucVars.XOther_RES	1.053	0.011	92.519	0.00%	kWh/cust
RES_AvgUse.YR07	-40.994	6.575	-6.234	0.00%	
RES_AvgUse.Yr08	-36.277	6.526	-5.559	0.00%	
mBinary.May	-15.921	7.514	-2.119	3.64%	
mBinary.Jun	-47.608	7.041	-6.761	0.00%	
mBinary.Aug	29.162	9.110	3.201	0.18%	
mBinary.Nov	-27.600	8.022	-3.441	0.08%	
mBinary.Dec	12.939	7.535	1.717	8.88%	
RES_AvgUse.Aug07	-104.552	22.744	-4.597	0.00%	
RES_AvgUse.Nov09	66.959	21.500	3.114	0.24%	
RES_AvgUse.Aug10	-64.159	21.860	-2.935	0.41%	
RES_AvgUse.Apr12	-58.532	20.903	-2.800	0.61%	
RES_AvgUse.Jul12	-55.302	22.107	-2.502	1.39%	
RES_AvgUse.Jul13	-43.948	21.017	-2.091	3.89%	
RES_AvgUse.Dec16	-61.366	21.499	-2.854	0.52%	
RES_AvgUse.Apr08	50.217	21.569	2.328	2.18%	

Table 21: MO Small GS Commercial kWh per Customer

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat55_SML	1.327	0.085	15.610	0.00%	kWh
mStrucVars.XCool60_SML	2.292	0.080	28.663	0.00%	Kwh
mStrucVars.XOther_SML	0.960	0.013	74.233	0.00%	kWh
SML_AvgUse.TrendCalib	-0.002	0.000	-4.933	0.00%	
mBinary.Nov08	-195.759	57.205	-3.422	0.09%	
mBinary.Dec08	-278.597	57.716	-4.827	0.00%	
SML_AvgUse.Jan09	-101.251	58.279	-1.737	8.50%	
SML_AvgUse.Dec11	-176.432	56.899	-3.101	0.24%	
mBinary.JanFebMarAfter12	123.060	17.794	6.916	0.00%	
mBinary.Before15	-95.728	13.525	-7.078	0.00%	
mBinary.Jun	-41.706	18.785	-2.220	2.84%	
mBinary.Aug	39.013	22.651	1.722	8.77%	

Table 22: MO Big GS Commercial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat55_BIG	480.801	52.916	9.086	0.00%	kWh
mStrucVars.XCool60_BIG	1177.427	51.607	22.815	0.00%	Kwh
mStrucVars.XOther_BIG	970.341	5.611	172.951	0.00%	kWh
BIG_Sales.TrendCalib	22342.926	1819.001	12.283	0.00%	
mBinary.CalibBig	-918850397.962	72923937.512	-12.600	0.00%	
BIG_Sales.YR12	-8299834.229	2839452.472	-2.923	0.42%	
BIG_Sales.Feb07	-18584818.639	5666762.207	-3.280	0.14%	
BIG_Sales.Jan08	-25144421.395	5642306.493	-4.456	0.00%	
BIG_Sales.Dec12	-19050175.903	5862510.597	-3.249	0.16%	
BIG_Sales.Mar15	19205977.757	5415898.455	3.546	0.06%	
BIG_Sales.Dec_08_10	-10966068.394	3558994.196	-3.081	0.26%	
mBinary.Jan	-8561808.433	3001137.484	-2.853	0.52%	
mBinary.Feb	-4238665.938	2414482.045	-1.756	8.21%	
mBinary.Apr	-7851073.014	1608120.348	-4.882	0.00%	
mBinary.Jul	9560455.905	2665816.533	3.586	0.05%	
mBinary.Aug	13967650.864	3203892.307	4.360	0.00%	
mBinary.Sep	8700546.173	2455063.523	3.544	0.06%	
mBinary.Nov	-21285621.659	1952780.733	-10.900	0.00%	
mBinary.Dec	-19351436.974	2780882.595	-6.959	0.00%	
MA(1)	0.330	0.098	3.375	0.10%	

Table 23: MO Industrial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XCool60_IND	34706831.561	2566439.966	13.523	0.00%	
mStrucVars.XOther_IND	79173633.422	404574.105	195.696	0.00%	
mBinary.Bef09	11083130.309	707322.915	15.669	0.00%	
mBinary.May12toApr13	-5641411.967	1161971.318	-4.855	0.00%	
mBinary.Jan	-5713527.394	1230955.853	-4.642	0.00%	
mBinary.Mar	5588228.167	1166154.079	4.792	0.00%	
mBinary.Aug	6337832.239	1474793.559	4.297	0.00%	
mBinary.Sep	-2415940.353	1286681.181	-1.878	6.26%	
mBinary.Dec	-7224788.656	1234397.956	-5.853	0.00%	
mBinary.Aug05	-25095644.686	3926030.195	-6.392	0.00%	
mBinary.Feb14	9491020.265	3780676.834	2.510	1.32%	
mBinary.Jan15	-10362701.476	3894708.446	-2.661	0.87%	
mBinary.May07	13208922.925	3779256.173	3.495	0.07%	
IND_Sales.Jul15	9082729.585	3831824.949	2.370	1.92%	
IND_Sales.YR10	3839203.962	1162564.185	3.302	0.12%	

Table 24: KS Residential kWh per Customer

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat55_RES	0.662	0.015	42.838	0.00%	kWh/cust
mStrucVars.XCool65_RES	1.073	0.018	61.023	0.00%	kwh/cust
mStrucVars.XOther_RES	1.047	0.010	105.631	0.00%	kWh/cust
RES_AvgUse.YR07	-30.200	8.286	-3.645	0.04%	
RES_AvgUse.Sep07	-126.077	29.865	-4.222	0.01%	
RES_AvgUse.Jul11	129.793	27.528	4.715	0.00%	
RES_AvgUse.SummerCalib	-46.655	10.005	-4.663	0.00%	
mBinary.Jan	39.534	10.914	3.622	0.04%	
mBinary.Mar	-24.864	9.093	-2.734	0.73%	
mBinary.May	28.770	8.993	3.199	0.18%	
mBinary.Jun	114.429	10.490	10.908	0.00%	
mBinary.Jul	103.848	13.619	7.625	0.00%	
mBinary.Aug	62.794	14.258	4.404	0.00%	
mBinary.Dec	31.295	9.804	3.192	0.18%	

Table 25: KS Small GS Commercial kWh per Customer

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat55_SML	1.087	0.064	16.851	0.00%	kWh
mStrucVars.XCool60_SML	2.219	0.051	43.440	0.00%	Kwh
mStrucVars.XOther_SML	0.950	0.012	78.105	0.00%	kWh
mBinary.CalibSml	44.371	18.812	2.359	1.99%	
SML_AvgUse.YR11	-145.715	18.671	-7.804	0.00%	
SML_AvgUse.YR12	-124.081	18.520	-6.700	0.00%	
SML_AvgUse.YR13	-69.539	18.383	-3.783	0.02%	
SML_AvgUse.YR14	-42.708	18.090	-2.361	1.98%	
SML_AvgUse.Dec05	-124.681	36.534	-3.413	0.09%	
mBinary.Dec_06_08	-76.965	21.476	-3.584	0.05%	
mBinary.Oct13	-200.176	36.628	-5.465	0.00%	
mBinary.Jun14	-152.977	36.467	-4.195	0.01%	
mBinary.Oct11	-153.256	36.598	-4.188	0.01%	
mBinary.Feb16	142.007	36.754	3.864	0.02%	
mBinary.Apr12	-115.787	36.392	-3.182	0.19%	
SML_AvgUse.TrendBefore11	-0.004	0.000	-10.390	0.00%	
SML_AvgUse.YR_07_08	-76.173	12.381	-6.152	0.00%	
SML_AvgUse.Jan17	197.117	36.837	5.351	0.00%	
SML_AvgUse.Apr17	-135.782	36.614	-3.708	0.03%	
SML_AvgUse.Jun17	-115.724	39.274	-2.947	0.38%	
MA(1)	0.316	0.090	3.517	0.06%	

Table 26: KS Big GS Commercial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat55_BIG	24.647	2.297	10.729	0.00%	kWh
mStrucVars.XCool60_BIG	90.527	2.021	44.798	0.00%	Kwh
mStrucVars.XOther_BIG	62.146	0.412	150.979	0.00%	kWh
BIG_Sales.TrendBefore11	-113.805	29.945	-3.801	0.02%	
mBinary.After13	13950276.832	1058158.209	13.184	0.00%	
BIG_Sales.YR07	-15753131.610	1489383.330	-10.577	0.00%	
BIG_Sales.Yr08	-7361521.269	1487002.165	-4.951	0.00%	
BIG_Sales.YR13	8214244.238	1436022.392	5.720	0.00%	
BIG_Sales.Jan07	-16698785.665	4371116.270	-3.820	0.02%	
BIG_Sales.Jan08	-16258343.842	4436178.489	-3.665	0.04%	
BIG_Sales.Feb14	14317539.093	4255505.779	3.364	0.11%	
BIG_Sales.Oct15	-9606633.908	4172392.496	-2.302	2.32%	
BIG_Sales.Aug16	11453955.348	4227441.438	2.709	0.78%	
BIG_Sales.Jan17	9568882.316	4209187.172	2.273	2.50%	
mBinary.Mar	-2822572.528	1423130.550	-1.983	4.99%	
mBinary.Apr	-2800884.520	1452800.620	-1.928	5.65%	
mBinary.Nov	-8852190.340	1553414.340	-5.699	0.00%	
mBinary.Dec	-10635751.764	1534859.673	-6.929	0.00%	

Table 27: KS Industrial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XCool_IND	2221139.995	72453.172	30.656	0.00%	
mStrucVars.XOther_IND	1314949.442	243612.792	5.398	0.00%	
IND_Sales.Nov06	1559132.045	612456.961	2.546	1.20%	
mBinary.Feb10	4144040.662	613930.371	6.750	0.00%	
mBinary.Jun10	-1624334.141	596077.956	-2.725	0.73%	
mBinary.Aug10	1515319.894	606916.343	2.497	1.37%	
IND_Sales.After13	1270662.962	640892.852	1.983	4.94%	
IND_Sales.Oct13	1333616.895	622230.979	2.143	3.39%	
mBinary.Feb	734345.530	179283.678	4.096	0.01%	
mBinary.Sep	445046.150	185802.336	2.395	1.80%	
mBinary.Oct	1099939.495	198901.319	5.530	0.00%	
mBinary.Nov	1056067.610	210015.857	5.029	0.00%	
mBinary.Dec	979264.046	235600.282	4.156	0.01%	
AR(1)	0.998	0.002	461.974	0.00%	
MA(1)	-0.524	0.082	-6.388	0.00%	

3. Assessment of the applicability of any load forecast models or portions of models that were utilized by the utility but developed by others, including a specification of the functional forms of any equations or models, to the extent they are available.

The load forecasting models rely on a forecast of economic activity for the KC metro area that was produced by Moody's Analytics. The KC metro area is the same as the Metropolitan Statistical Area (MSA) defined by the US Census Bureau and it includes some counties in both states that are not served by KCP&L. Also, KCP&L's service area includes some counties that are not included in the MSA. Despite these inconsistencies in geographic areas, there are reasons why this forecast is representative of our service areas. Many people live on one side of the state line and work on the other side. Many people shop on both sides of the state line. And many companies each year move from one side of the state line to the other. Documentation for Moody's forecast of economic activity is provided in the workpapers in the folder \KCPL Base Case\Data\Economics.

The load forecasting models also rely on saturation and appliance and equipment utilization forecasts from the DOE. The advantages of the projections from these models is 1) DOE's Forecasting and Analyst staff includes dozens of experts and maintains a large budget for data collection and consultants, 2) DOE has a focus on measuring the impacts of appliance and equipment standards and legal mandates and 3) DOE is very transparent, making available its work and computer code on its website.[v] KCP&L also relies on the staff that developed and maintained some of EPRI's end-use models recommended and developed the SAE approach for KCP&L and many other utilities. EPRI no longer maintains its end-use forecasting models.

A potential downside of these projections for KCP&L is that the data and models developed by DOE are developed at a regional level rather than specifically for KCP&L, although this can be an advantage when one service area or region has insufficient variation to measure the impact of a variable such as electric price. Cross sectional variation in the data can be an advantage in situations where price or income elasticities are being modeled.

(B) If the utility selects load forecast models that include end-use load methods, the utility shall describe and document any deviations in the independent variables or functional forms of the equations from those derived from load analysis in sections (3) and (4).

KCP&L is not aware of any such deviations.

(C) Historical Database for Load Forecasting. In addition to the load analysis database, the utility shall develop and maintain a database consistent with and as needed to run each forecast model utilized by the utility. The utility shall describe and document its load forecasting historical database in the triennial compliance filings. As a minimum, the utility shall—

1. Develop and maintain a data set of historical values for each independent variable of each forecast model. The historical values for each independent variable shall be collected for a period of ten (10) years, or such period deemed sufficient to allow the independent variables to be accurately forecasted over the entire planning horizon;

The independent variables acquired from Moody's are available back to 1990. Historical economic and demographic data are updated each time KCP&L acquires a new forecast as revisions are common.

The independent variables acquired from DOE are available starting in 1995; as in the case of economic data, these historical estimates are subject to revision and are updated each time KCP&L receives data with an updated forecast. New studies or data can revise historical estimates of efficiencies and saturations.

The independent variables for natural gas prices of local utilities are maintained back to 1991.

Temperature data is maintained back to 1971 when the Kansas City International Airport.

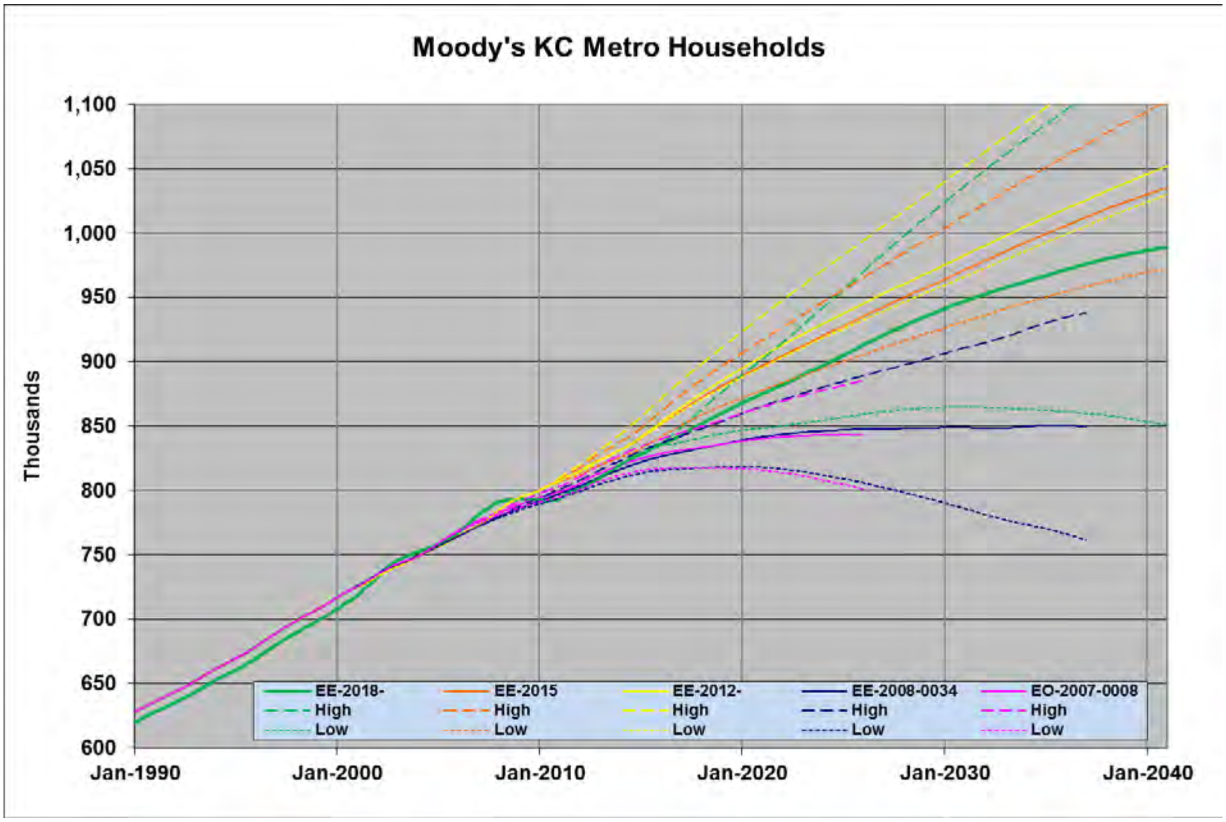
2. Explain any adjustments that it made to historical data prior to using it in its development of the forecasting models;

KCP&L staff is not aware of any adjustments made to independent variables used in its load forecasting models.

3. Archive previous projections of all independent variables used in the energy usage and peak load forecasts made in at least the past ten (10) years and provide a comparison of the historical projected values in prior plan filings to actual historical values and to projected values in the current compliance filing; and

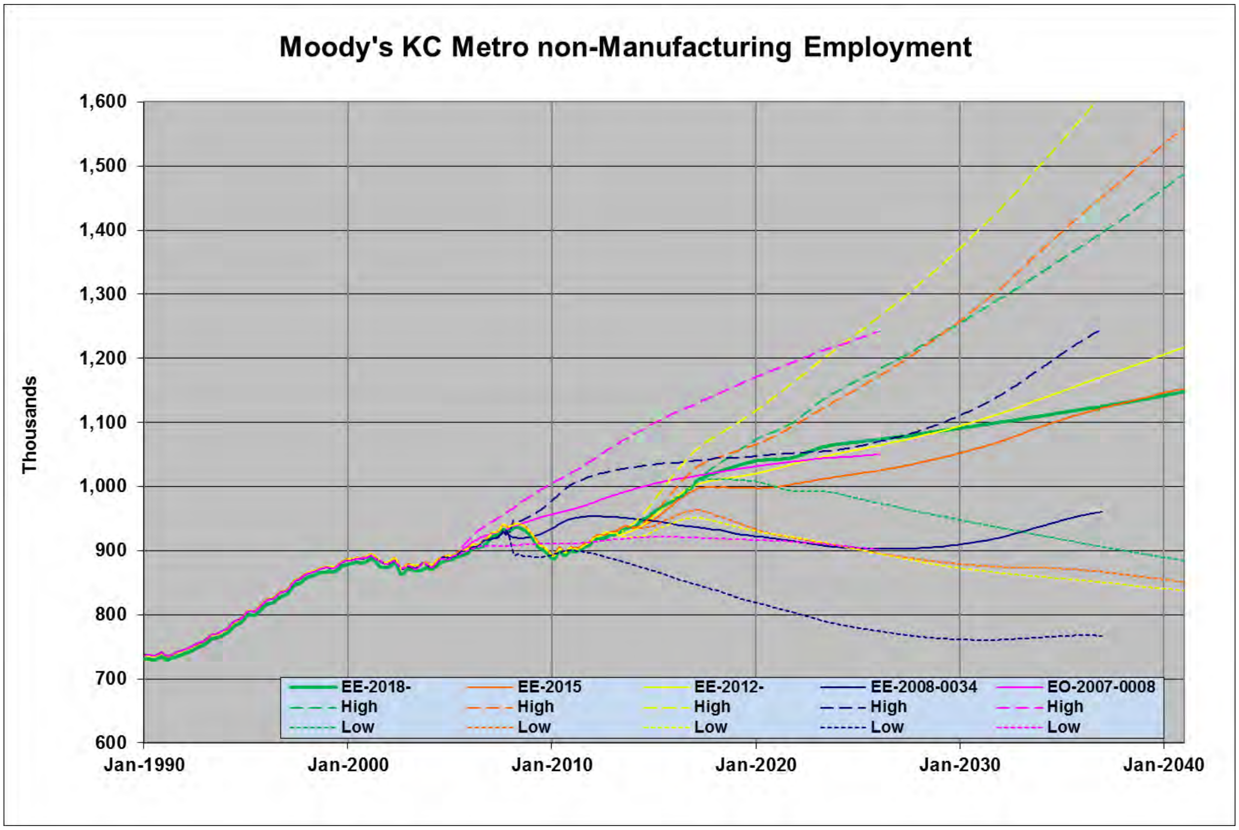
KCP&L still possesses the electronic files that it received with the independent variables used in producing energy and peak forecasts during the last ten years. Below we plot the base, high and low bands for the most important economic and demographic independent variables used in the current and two previous IRP filings.

Figure 23: Households



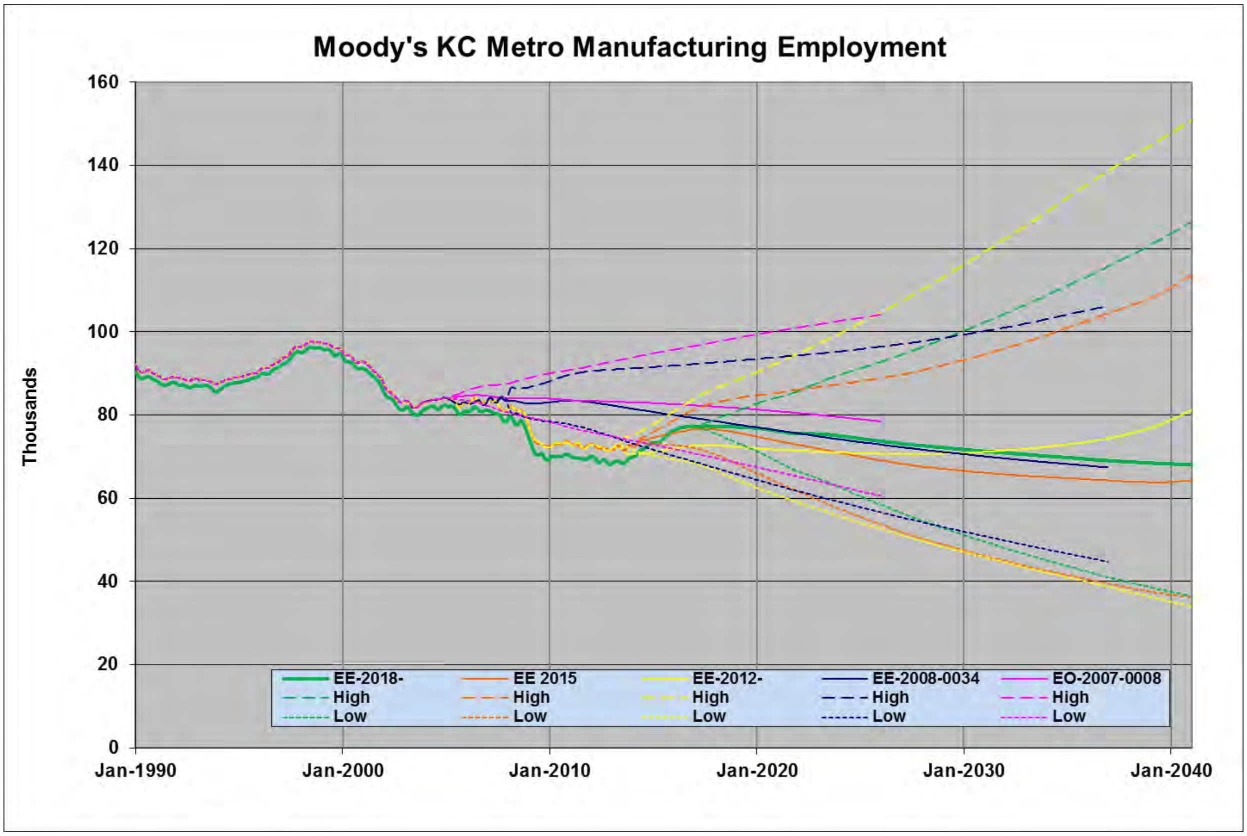
The current forecast for households is significantly lower than previous forecasts; however, it is due to some of the historical data being restated. The slope of the forecast is very similar to the 2015 forecast until about 2035 when it decelerates. The range for the high and low bands is significantly wider than previous reflecting both (1) an increase in the historical variance due to the restated household figures and (2) widening the high and low range to two standard deviations rather than 1 standard deviation.

Figure 24: Employment Non-Manufacturing



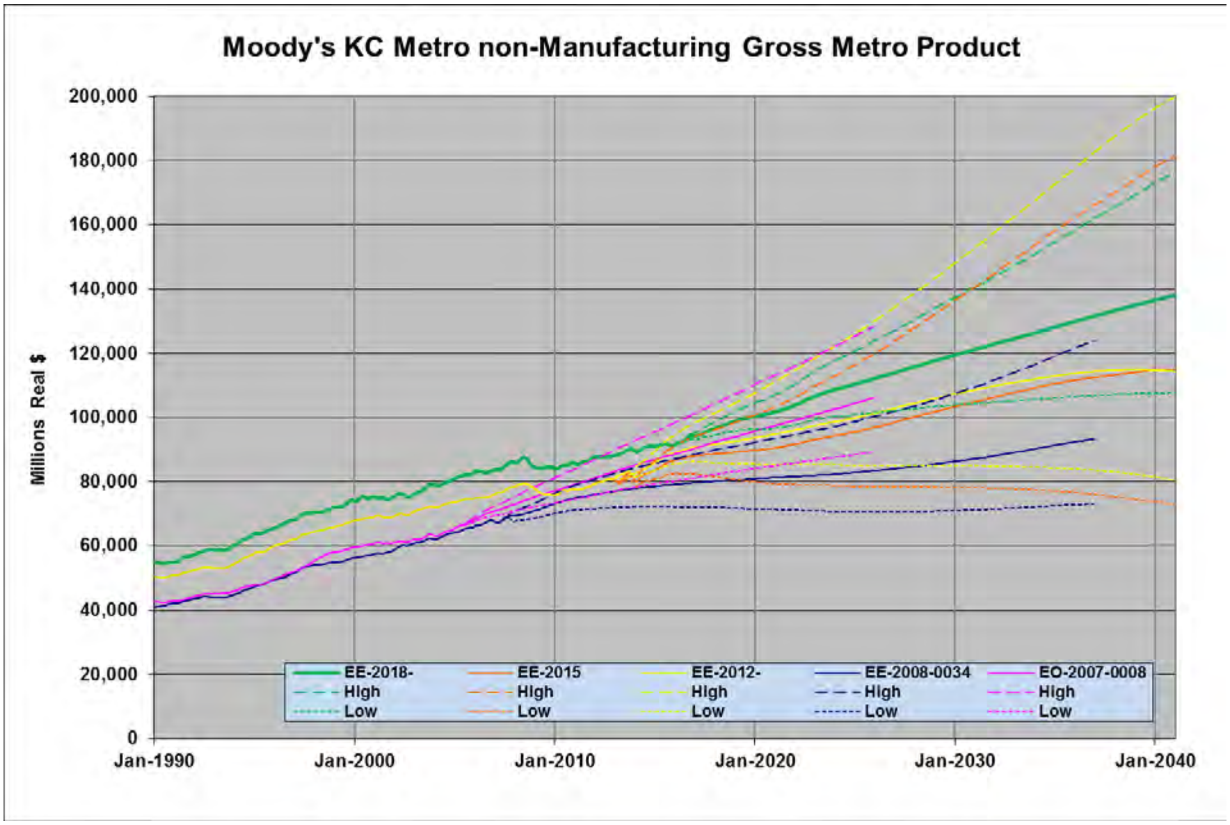
The 2018 forecast of non-manufacturing employment shows stronger growth than previous forecasts through 2020, but slower growth thereafter. The 2012 and 2015 forecast of non-manufacturing employment shows a substantial drop during and several years after the last recession, then a rapid rebound and then steady robust growth. The 2008 forecast shows only a small drop and no increases until the mid-20s.

Figure 25: Employment Manufacturing



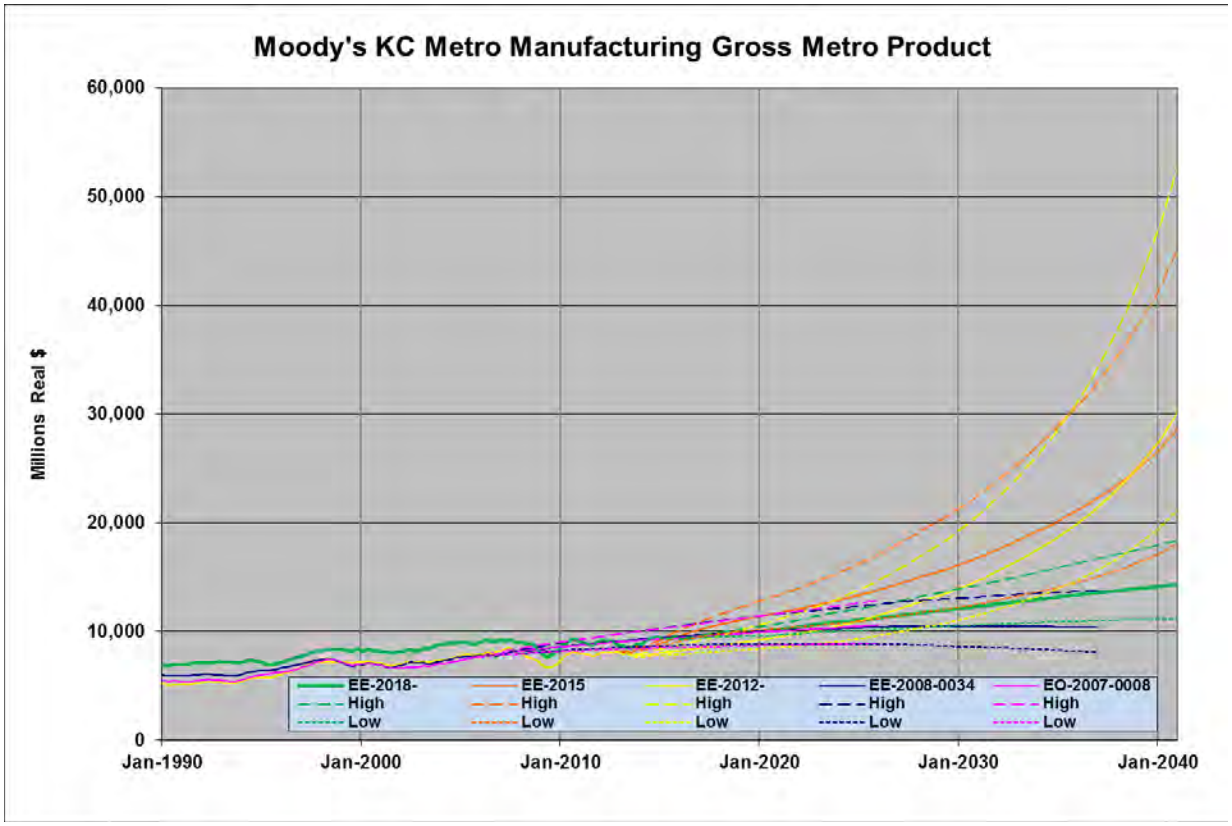
Manufacturing employment shows a large decline following the 2008 recession. It climbed from a 2013 low until stalling in 2016 and is projected to slowly decline throughout the forecast period. Moody's indicates that the decline in employment for manufacturing workers is due to increased productivity from the workers, as manufacturing becomes more automated. The decline in manufacturing employment for the forecast horizon is also consistent with the observed downward trend dating back to the 1990s.

Figure 26: Gross Metro Product Non-Manufacturing



Real non-manufacturing GMP is growing much faster than employment in all three scenarios. The current forecast is higher than previously forecasted due to revised historical figures; the positive growth trajectory is slower in the short-term, but faster in the long-term.

Figure 27: Gross Metro Product Manufacturing



The current forecast for Manufacturing Gross Metro Product shows slow growth throughout the forecast period. Previous Economic forecasts showed rapid growth for two reasons: (1) growth in manufacturing employment in the long run and (2) a competitive advantage for the area in manufacturing leading to faster growth compared to the national average. In contrast, the current forecast has a continuous decline in manufacturing employment and a production growth trajectory are similar to the US as a whole. These assumptions lead to modest growth throughout the forecast period for real manufacturing GMP, as opposed to the previous rapid growth in the long-term.

4. Archive all previous forecasts of energy and peak demand, including the final data sets used to develop the forecasts, made in at least the past ten (10) years. Provide a comparison of the historical final forecasts to the actual historical energy and peak demands and to the current forecasts in the current triennial compliance filing.

KCP&L maintains an archive of the electronic files associated with our previous forecasts of energy use and peak demand for at least the last ten years. The graphs below compare our previous long-run forecasts of NSI and peak demand. The most recent forecast is very similar to the prior four forecasts (starting with 2014) reflecting the significant slowdown in economic growth that began in 2008, expectations for modest economic growth, the impact of currently enforced energy efficiency standards and the anticipated impact of recently enacted energy efficiency standards.

Figure 28: Net System Input (NSI) Historical and Forecasts

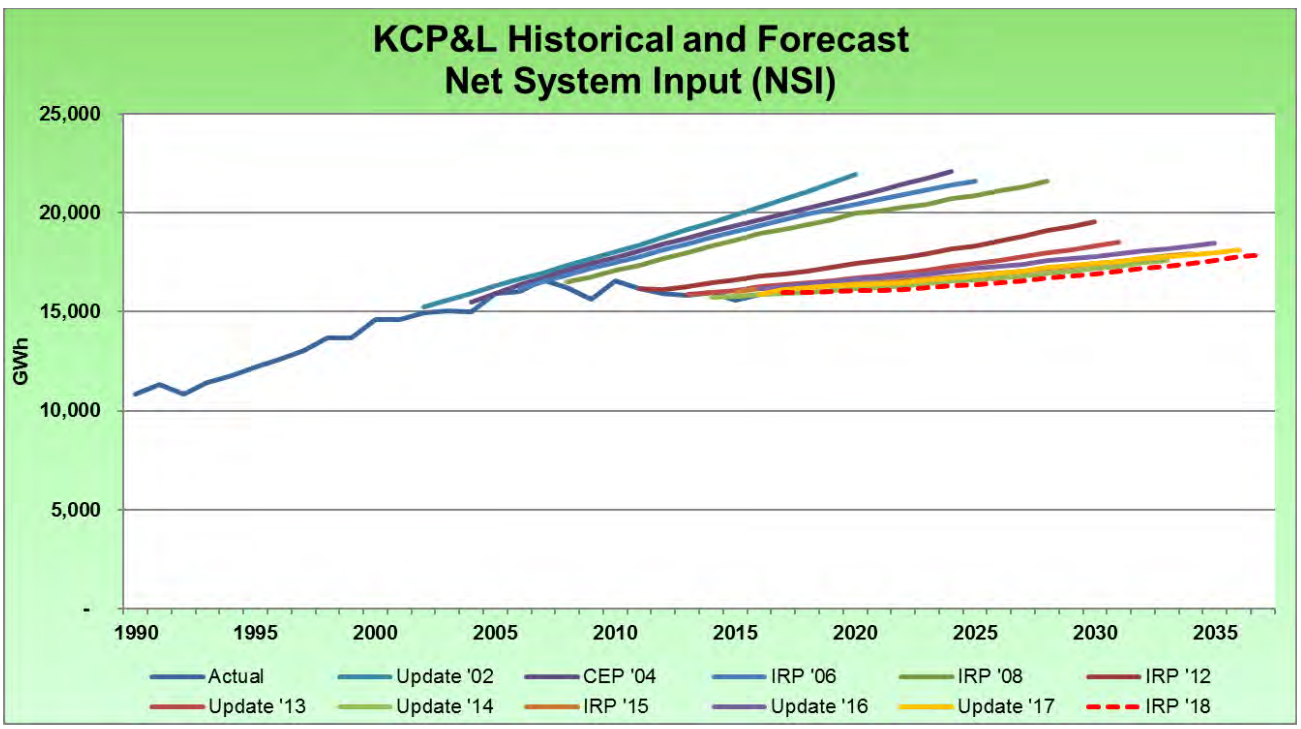
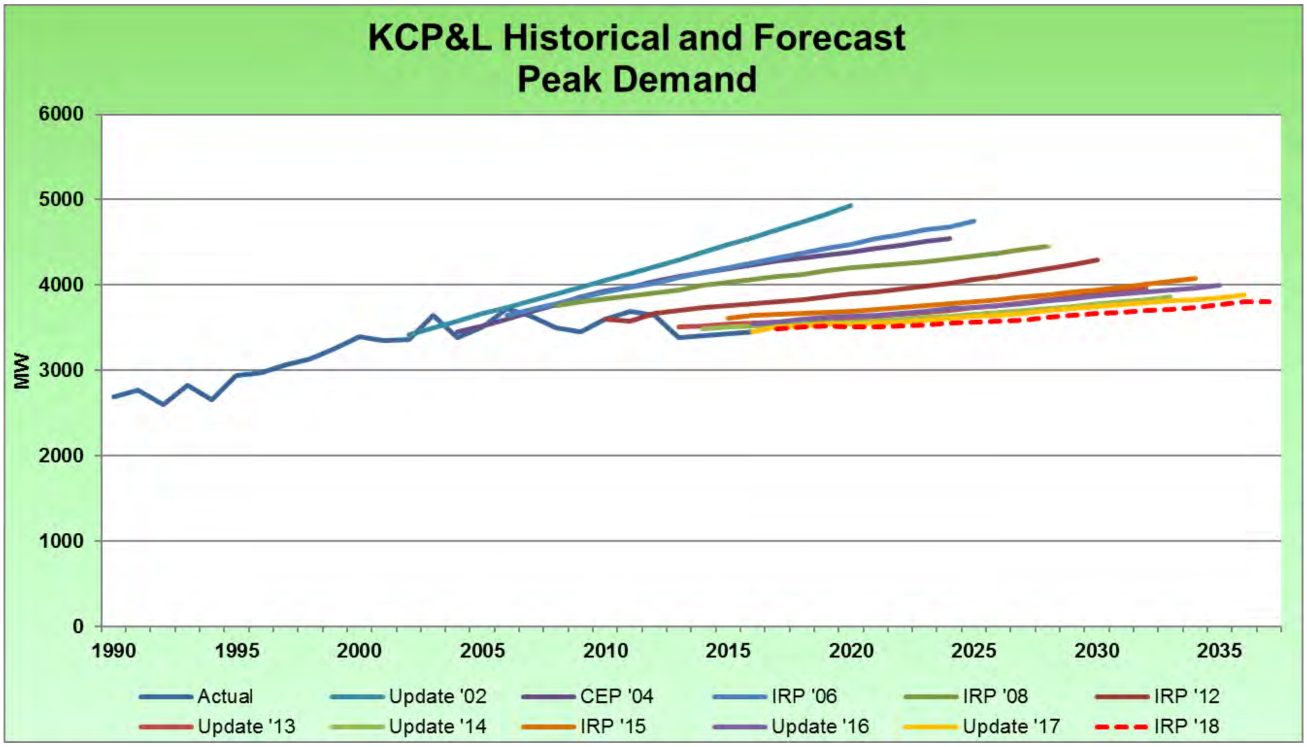


Figure 29: Peak Demand Historical and Forecasts



SECTION 7: BASE-CASE LOAD FORECAST

The utility's base-case load forecast shall be based on projections of the independent variables that utility decision-makers believe to be most likely. All components of the base-case load forecast shall assume normal weather conditions. The load impacts of implemented demand-side programs and rates shall be incorporated in the base-case load forecast, but the load impacts of proposed demand-side programs and rates shall not be included in the base-case forecast.

KCP&L's base-case forecast was produced with a base-case economic forecast from Moody's Analytics obtained in June 2017. The forecast included the impacts of KCP&L's implemented energy efficiency and DSM programs on NSI and peak load. The forecast was produced using normal weather.

7.1 MAJOR CLASS AND TOTAL LOAD DETAIL

(A) Major Class and Total Load Detail.

The utility shall produce forecasts of monthly energy usage and demands at the time of the summer and winter system peaks by major class for each year of the planning horizon, and shall describe and document those forecasts in its triennial compliance filings. Where applicable, these major class forecasts shall be separated into their jurisdictional components.

7.1.1 DESCRIBE AND DOCUMENT RELEVENT ECONOMIC AND DEMOGRAPHICS

1. The utility shall describe and document how the base-case forecasts of energy usage and demands have taken into account the effects of real prices of electricity, real prices of competitive energy sources, real incomes, and any other relevant economic and demographic factors. If the methodology does not incorporate economic and demographic factors, the utility shall explain how it accounted for the effects of these factors.

KCP&L accounted for the effects of real electricity prices in two ways. First, the prices of electricity and natural gas were used in the models that forecast the saturations of electric space heating for residential and commercial customers. These models are described in the section of this document for rule 7.B.1. Second, KCP&L assumes a price elasticity of -0.15 in each model of sales or sales per customer. These elasticities are close to the default values in the ERPI models REEPS and COMEND, which ITRON used in the original SAE models that they delivered to KCP&L in 2004. Since, then KCP&L has made some small changes to these values to improve the fit of the models.

In the residential models of kWh per customer, KCP&L assumes an income elasticity of 0.2 for heating and cooling and 0.2 for other uses and a person's-per-household elasticity of 0.2. Moody's forecast of households for the KC metro area were used in the models of residential customers as was described previously in the section for rule 3.B.

7.1.2 DESCRIBE AND DOCUMENT EFFECTS OF LEGAL MANDATES

2. The utility shall describe and document how the forecasts of energy usage and demands have taken into account the effects of legal mandates affecting the consumption of electricity.

KCP&L uses the SAE methodology to forecast kWh sales for residential, commercial and industrial sales. This methodology relies on DOE forecasts of UECs and EUIs, which account for appliance efficiency standards and building codes.[vi]

7.1.3 DESCRIBE AND DOCUMENT CONSISTENCY

3. The utility shall describe and document how the forecasts of energy usage and demands are consistent with trends in historical consumption patterns, end uses, and end-use efficiency in the utility's service area as identified pursuant to sections 4 CSR 240-22.030(2), (3), and (4).

KCP&L forecasts incorporate and thus are consistent with the following trends:

- Electric space heating models explain the rapid rise of electric space heating saturations in the residential and commercial sector as a function of the relative costs of using electricity and natural gas. These costs depend on electricity and natural gas prices and the efficiencies of heat pumps and natural gas furnaces.

- Forecasts of UECs and EUIs used in our models reflect the impacts of energy standards in both the past and the future.

- Forecasts of appliance and equipment saturations reflect the penetration of new devices such as CFL/LED Light Bulbs, HDTVs and the limitations of further increases for appliances that are reaching equilibrium such as dishwashers and central air conditioners.

7.1.4 DESCRIBE AND DOCUMENT WEATHER NORMALIZED CLASS LOADS

4. For at least the base year of the forecast, the utility shall describe and document its estimates of the monthly cooling, heating, and non-weather-sensitive components of the weather-normalized major class loads.

The estimates are shown below. Details for the full 20 years forecast can be found in MO_SystemLoad.ltm and KS_SystemLoad.ltm in the ENDUse_Energy Frequency Transforms.

Figure 30: Estimates of MO Residential Monthly Cooling, Heating, and Base

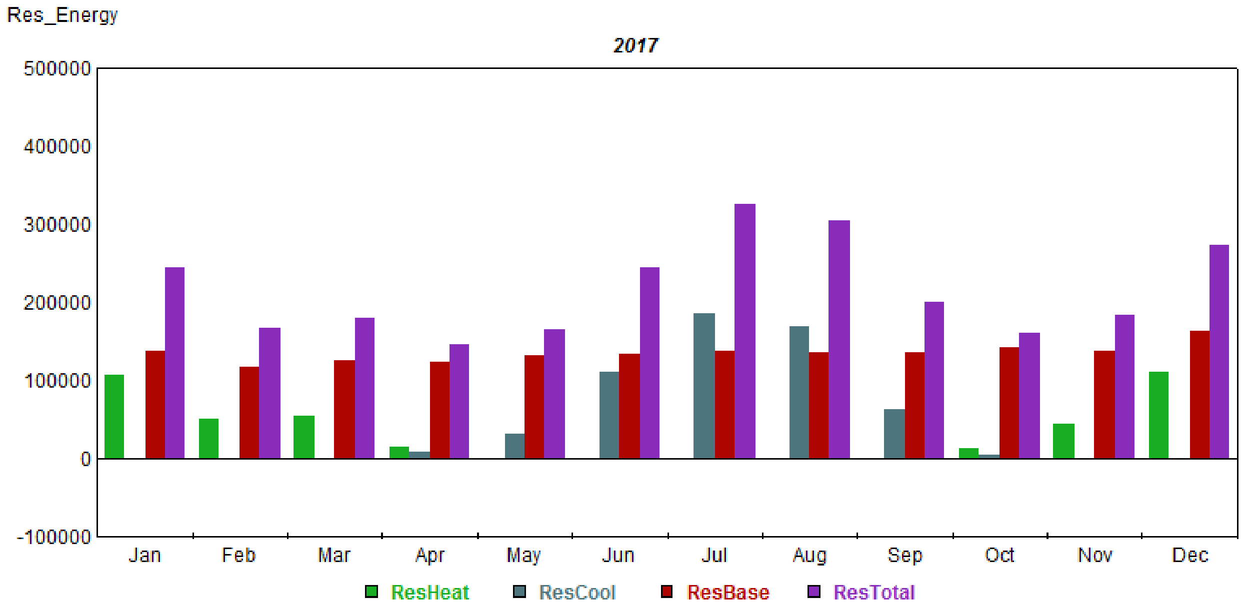


Table 28: Data Table of MO Residential Monthly Cooling, Heating, and Base

Date	ResHeat	ResCool	ResBase	ResTotal
Jan-17	106,236	0	137,619	243,855
Feb-17	49,409	0	117,724	167,133
Mar-17	54,202	847	125,379	180,427
Apr-17	14,279	8,043	123,841	146,162
May-17	1,268	32,493	131,599	165,360
Jun-17	0	111,263	133,186	244,449
Jul-17	0	186,298	138,494	324,792
Aug-17	0	169,415	135,151	304,566
Sep-17	544	63,921	136,576	201,041
Oct-17	13,105	5,401	142,622	161,127
Nov-17	44,535	1,154	137,546	183,235
Dec-17	110,281	0	162,460	272,741

Figure 31: Estimates of MO Commercial Small General Service Monthly Cooling, Heating, and Base

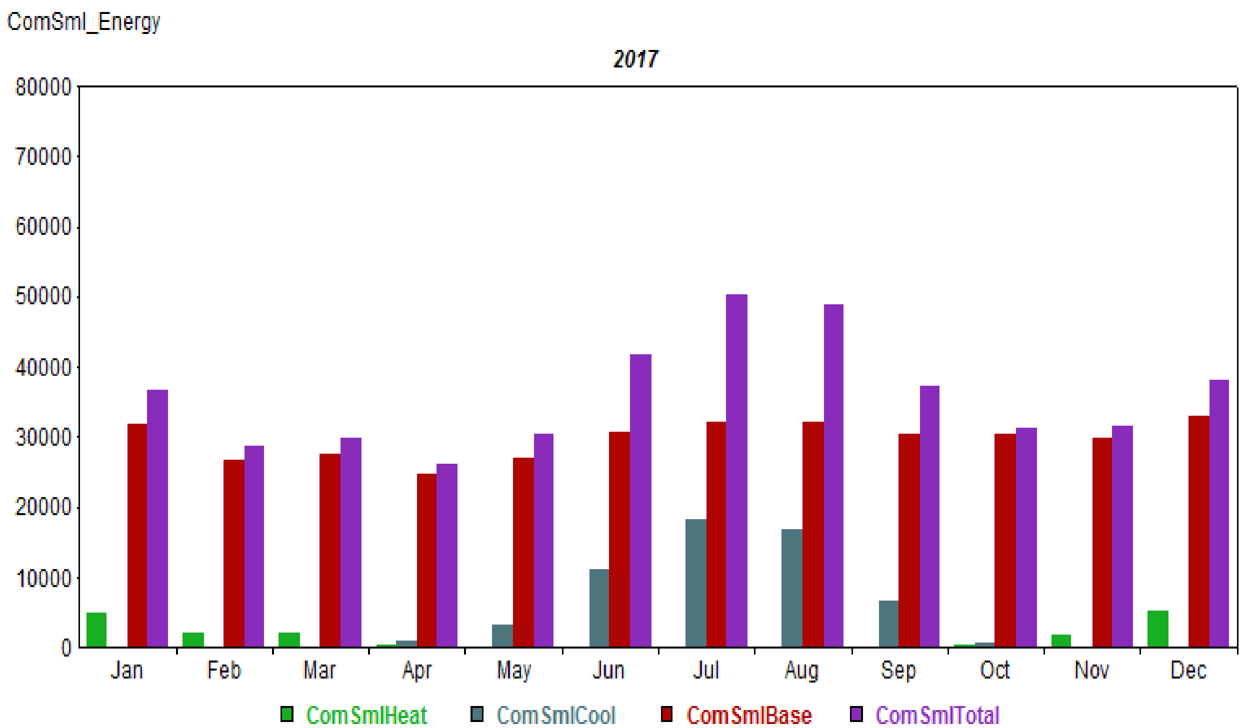


Table 29: Data Table of MO Commercial Small General Service Monthly Cooling, Heating, and Base

Date	ComSmlHeat	ComSmlCool	ComSmlBase	ComSmlTotal
Jan-17	4,936	0	31,793	36,729
Feb-17	2,144	0	26,700	28,844
Mar-17	2,103	93	27,739	29,935
Apr-17	370	881	24,833	26,084
May-17	14	3,319	27,062	30,394
Jun-17	0	11,073	30,615	41,688
Jul-17	0	18,172	32,016	50,187
Aug-17	0	16,693	32,032	48,725
Sep-17	0	6,772	30,572	37,345
Oct-17	320	596	30,338	31,254
Nov-17	1,715	126	29,835	31,676
Dec-17	5,105	0	33,130	38,236

Figure 32: Estimates of MO Commercial Big (MGS, LGS & LP) Monthly Cooling, Heating, and Base

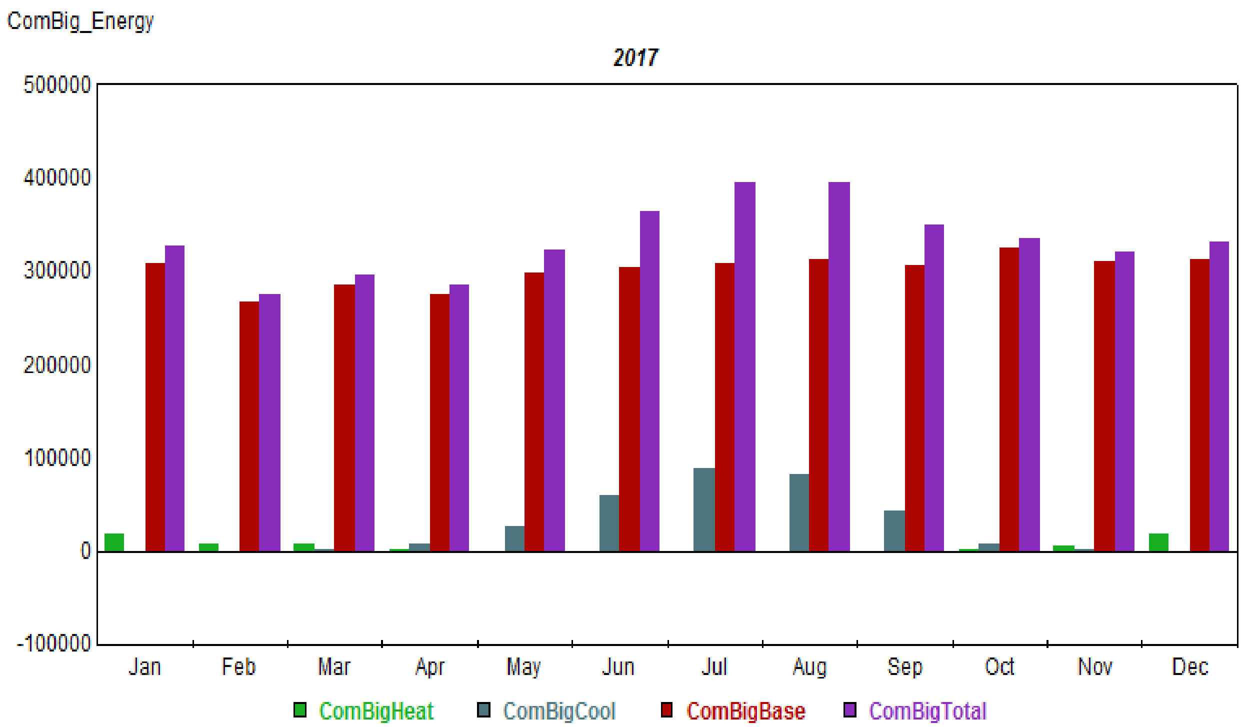


Table 30: Data Table of MO Commercial Big (MGS, LGS & LP) Monthly Cooling, Heating, and Base

Date	ComBigHeat	ComBigCool	ComBigBase	ComBigTotal
Jan-17	18,236	0	308,208	326,444
Feb-17	8,108	589	266,540	275,237
Mar-17	8,266	2,185	285,811	296,263
Apr-17	1,710	7,864	274,795	284,369
May-17	106	25,305	296,650	322,061
Jun-17	0	60,235	304,612	364,848
Jul-17	0	87,759	307,951	395,710
Aug-17	0	82,242	312,881	395,123
Sep-17	29	43,326	305,344	348,700
Oct-17	1,510	6,951	325,771	334,233
Nov-17	6,733	2,422	311,010	320,164
Dec-17	18,838	343	311,867	331,048

Figure 33: Estimates of MO Industrial Monthly Cooling, Heating, and Base

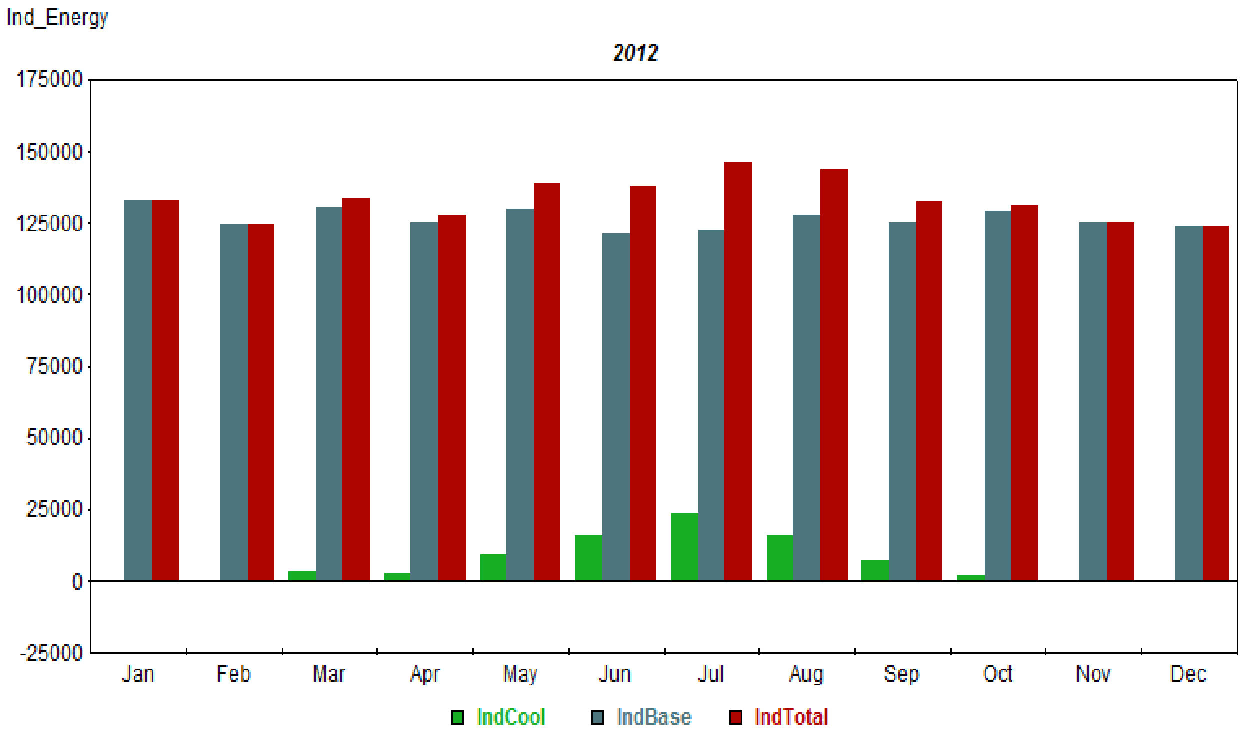


Table 31: Data Table of MO Industrial Monthly Cooling, Heating, and Base

Date	IndCool	IndBase	IndTotal
Jan-17	0	128,152	128,152
Feb-17	112	111,234	111,346
Mar-17	486	119,589	120,074
Apr-17	1,750	116,092	117,842
May-17	5,905	124,510	130,415
Jun-17	12,883	126,677	139,560
Jul-17	17,756	128,082	145,838
Aug-17	16,247	128,430	144,677
Sep-17	8,840	126,030	134,870
Oct-17	2,304	133,908	136,213
Nov-17	232	128,386	128,618
Dec-17	7	126,148	126,154

Figure 34: Other MO Load (SFR & Lighting)

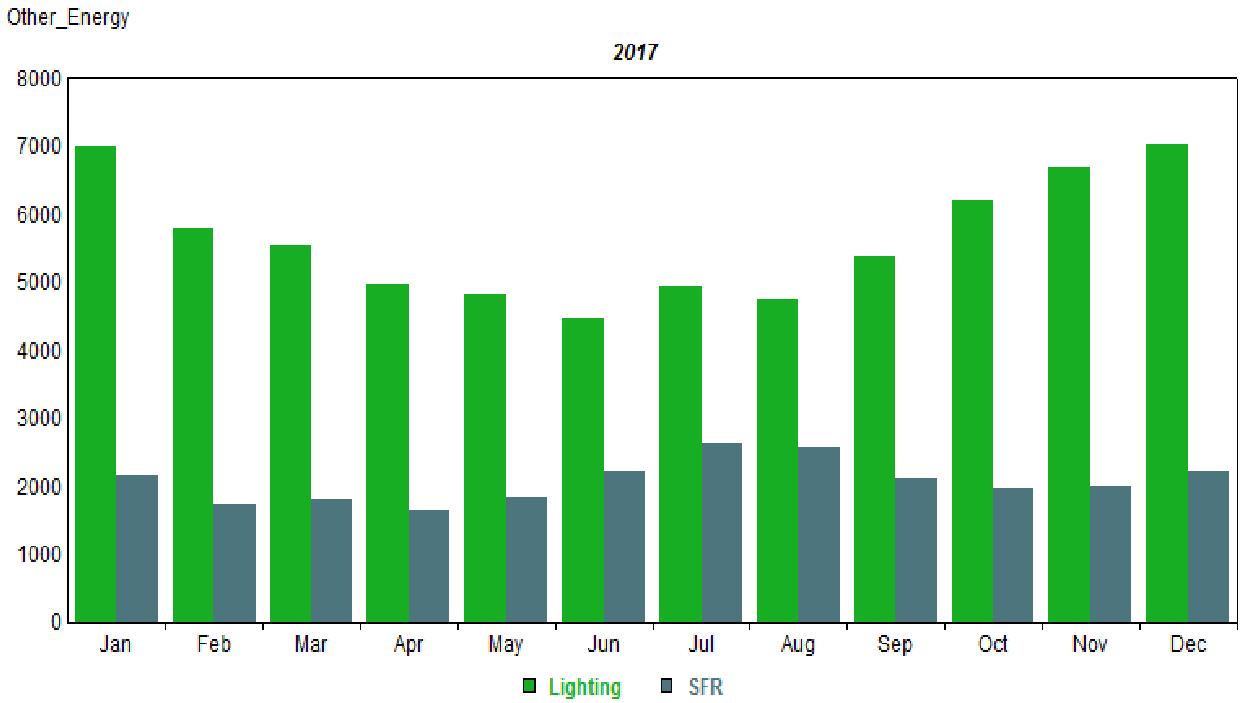


Table 30: Data Table Other MO Load (SFR & Lighting)

Date	Lighting	SFR
Jan-17	7,001	2,161
Feb-17	5,800	1,727
Mar-17	5,536	1,817
Apr-17	4,956	1,653
May-17	4,831	1,849
Jun-17	4,471	2,235
Jul-17	4,938	2,621
Aug-17	4,752	2,590
Sep-17	5,390	2,100
Oct-17	6,199	1,990
Nov-17	6,694	1,998
Dec-17	7,030	2,220

Figure 35: Estimates of KS Residential Monthly Cooling, Heating, and Base

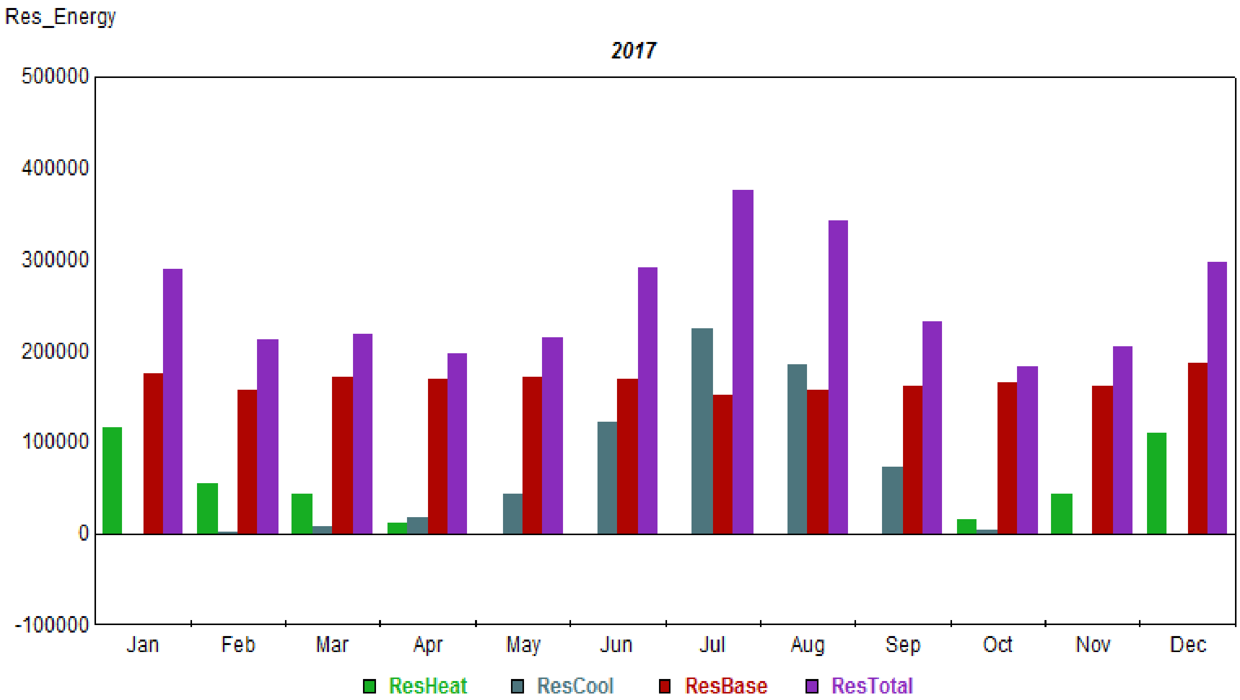


Table 31: Data Table of KS Residential Monthly Cooling, Heating, and Base

Date	ResHeat	ResCool	ResBase	ResTotal
Jan-17	114,415	0	173,690	288,105
Feb-17	54,927	1,117	156,730	212,775
Mar-17	42,008	6,202	170,036	218,246
Apr-17	10,586	16,904	168,173	195,663
May-17	166	41,686	171,103	212,955
Jun-17	0	121,797	168,106	289,903
Jul-17	0	224,345	151,315	375,660
Aug-17	0	185,100	156,782	341,882
Sep-17	0	71,893	160,497	232,390
Oct-17	15,080	2,901	163,980	181,961
Nov-17	42,814	0	160,840	203,655
Dec-17	108,982	0	187,002	295,983

Figure 36: Estimates of KS Commercial Small General Service Monthly Cooling, Heating, and Base

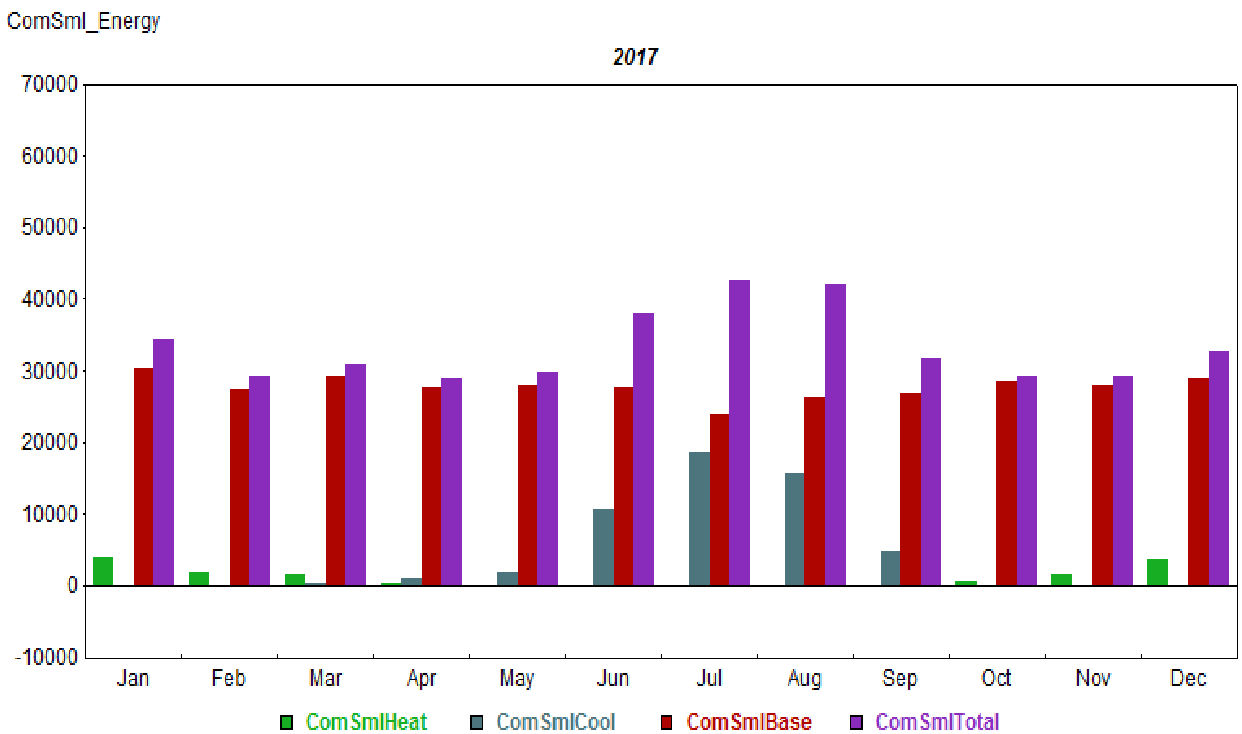


Table 32: Data Table of KS Commercial Small General Service Monthly Cooling, Heating, and Base

Date	ComSmlHeat	ComSmlCool	ComSmlBase	ComSmlTotal
Jan-17	3,972	0	30,252	34,224
Feb-17	1,914	0	27,243	29,157
Mar-17	1,461	222	29,254	30,937
Apr-17	368	1,000	27,586	28,955
May-17	6	1,878	27,959	29,843
Jun-17	0	10,573	27,496	38,070
Jul-17	0	18,605	24,017	42,622
Aug-17	0	15,677	26,415	42,092
Sep-17	0	4,859	26,789	31,648
Oct-17	508	38	28,532	29,077
Nov-17	1,472	0	27,777	29,249
Dec-17	3,746	0	28,838	32,583

Figure 37: Estimates of KS Commercial Big General Service (MGS and LGS) Monthly Cooling, Heating, and Base

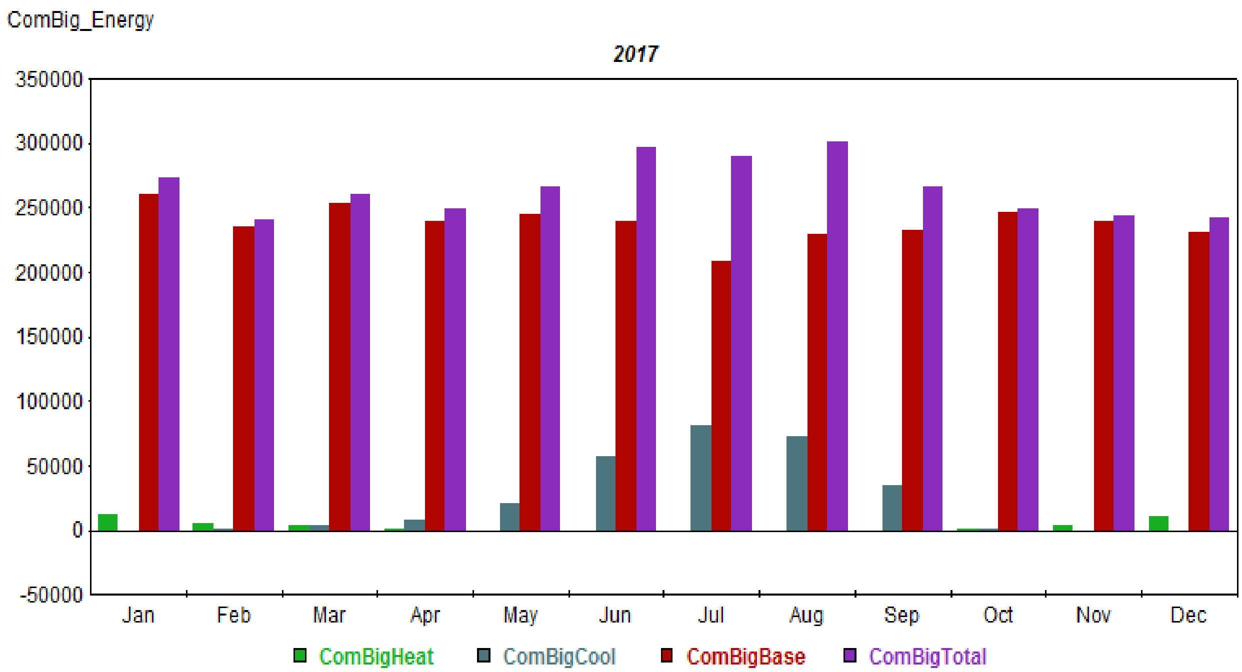


Table 33: Data Table of KS Commercial Big General Service (MGS and LGS) Monthly Cooling, Heating, and Base

Date	ComBigHeat	ComBigCool	ComBigBase	ComBigTotal
Jan-17	11,553	0	261,071	272,624
Feb-17	5,573	555	235,285	241,414
Mar-17	4,253	3,116	253,624	260,993
Apr-17	1,071	8,514	240,216	249,801
May-17	17	20,650	244,798	265,465
Jun-17	0	56,798	240,105	296,902
Jul-17	0	81,103	209,277	290,380
Aug-17	0	72,254	228,999	301,253
Sep-17	0	34,001	232,809	266,810
Oct-17	1,456	1,369	246,885	249,709
Nov-17	4,261	0	239,539	243,800
Dec-17	10,848	0	231,024	241,872

Figure 38: Estimates of KS Industrial Monthly Cooling, Heating, and Base

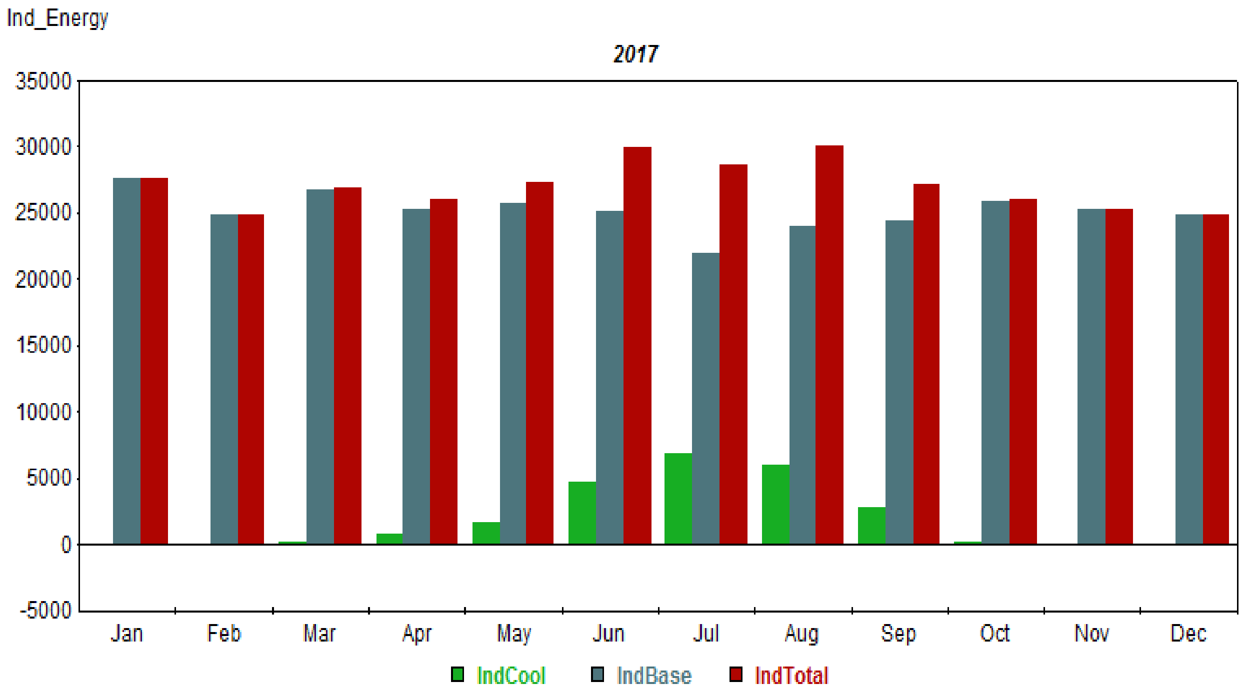


Table 34: Data Table of KS Industrial Monthly Cooling, Heating, and Base

Date	IndCool	IndBase	IndTotal
Jan-17	0	27,586	27,586
Feb-17	44	24,839	24,883
Mar-17	251	26,675	26,926
Apr-17	694	25,320	26,014
May-17	1,671	25,691	27,362
Jun-17	4,712	25,171	29,882
Jul-17	6,805	21,882	28,687
Aug-17	6,044	23,990	30,033
Sep-17	2,789	24,434	27,224
Oct-17	109	25,913	26,022
Nov-17	0	25,332	25,332
Dec-17	0	24,894	24,894

Figure 39: Other KS Load (SFR & Lighting)

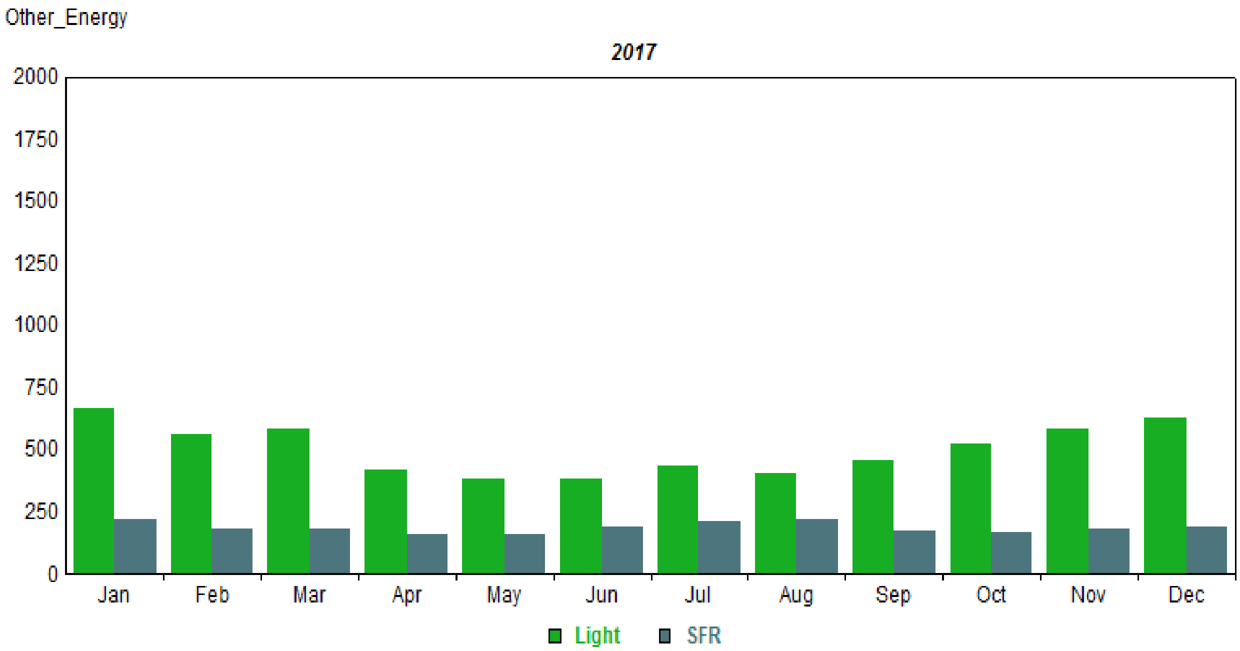


Table 35: Data Table Other KS Load (SFR & Lighting)

Date	Light	SFR
Jan-17	664	219
Feb-17	563	177
Mar-17	583	177
Apr-17	418	156
May-17	383	154
Jun-17	379	184
Jul-17	430	213
Aug-17	407	215
Sep-17	452	173
Oct-17	524	168
Nov-17	584	180
Dec-17	623	189

KCP&L-KS has zero customers as of July 2017; however, the energy forecast was completed prior to the removal of the Sales for Resale customer.

7.1.5 DESCRIBE AND DOCUMENT MODIFICATION OF MODELS

5. Where judgment has been applied to modify the results of its energy and peak forecast models, the utility shall describe and document the factors which caused the modification and how those factors were quantified.

No outside-the-model modifications were made to the forecasted values resulting from the energy and peak forecast models.

7.1.6 PLOTS OF CLASS MONTHLY ENERGY AND COINCIDENT PEAK DEMAND

6. For each major class specified pursuant to subsection (2)(A), the utility shall provide plots of class monthly energy and coincident peak demand at the time of summer and winter system peaks. The plots shall cover the historical database period and the forecast period of at least twenty (20) years. The plots of coincident peak demands for the historical period shall include both actual and weather-normalized peak demands at the time of summer and winter system peaks. The plots of coincident peak demand for the forecast period shall show the class coincident demands for the base-case forecast at the time of summer and winter system peaks.

Plots for class monthly energy and coincident peak demand at the time of summer and winter system loads are provided in *Appendix 3B*. Energy plots by jurisdiction and system are provided in the file *IRP_7.1.6_KCPL_MWh.xlsx* and peak plots are in the file *IRP_7.1.6_KCPL_Peaks.xlsx*.

7.1.7 PLOTS OF NET SYSTEM LOAD PROFILES

7. The utility shall provide plots of the net system load profiles for the summer peak day and the winter peak day showing the contribution of each major class. The plots shall be provided in the triennial filing for the base year of the forecast and for the fifth, tenth, and twentieth years of the forecast. Plots for all years shall be included in the workpapers supplied at the time of the triennial filing.

The figures below show the load profiles for the base, fifth, tenth, and twentieth years broken out by summer and winter peak days for each major class in Missouri, Kansas and for the system. The plots with data tables are provided in *Appendix 3C*. Plots for additional years can be found in the MetrixLT files (*MO_SystemLoad*, *KS_SystemLoad*, and *SysShape*) included in the workpapers.

Figure 40: Base Year (2017) Net System Load Profiles for MO, KS, and System

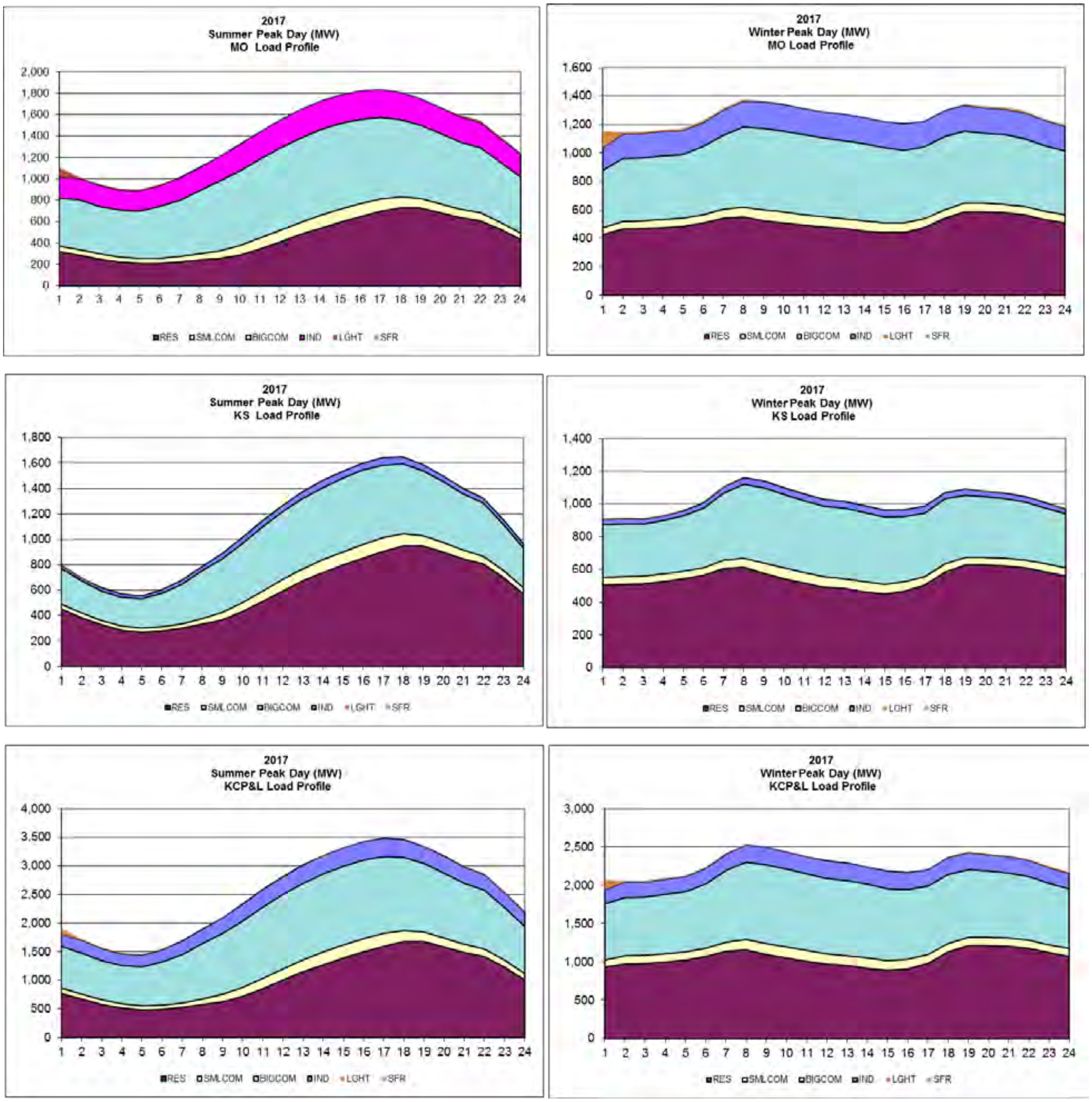


Figure 41: Fifth Year (2022) Net System Load Profiles for MO, KS, and System

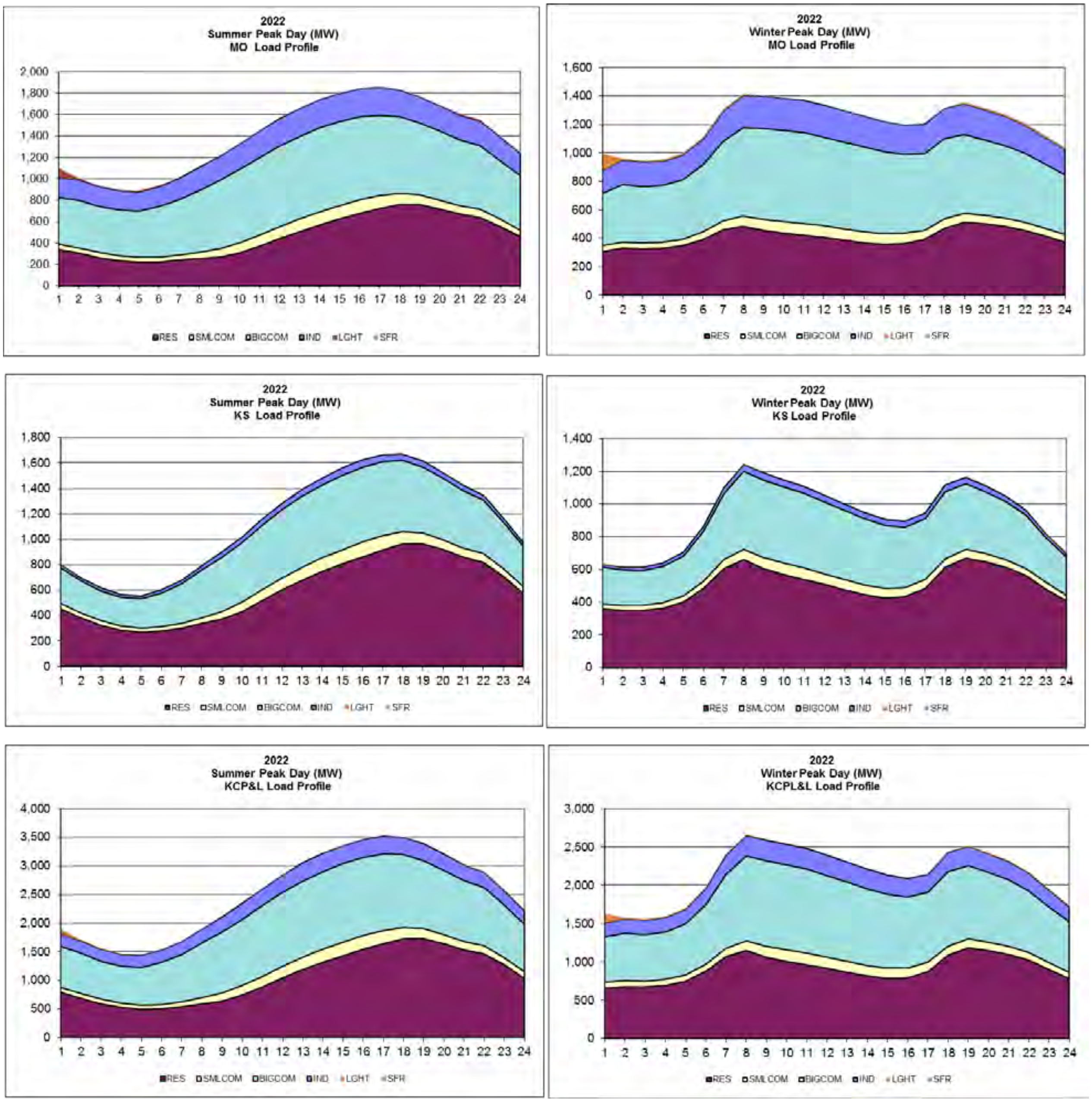


Figure 42: Tenth Year (2027) Net System Load Profiles for MO, KS, and System

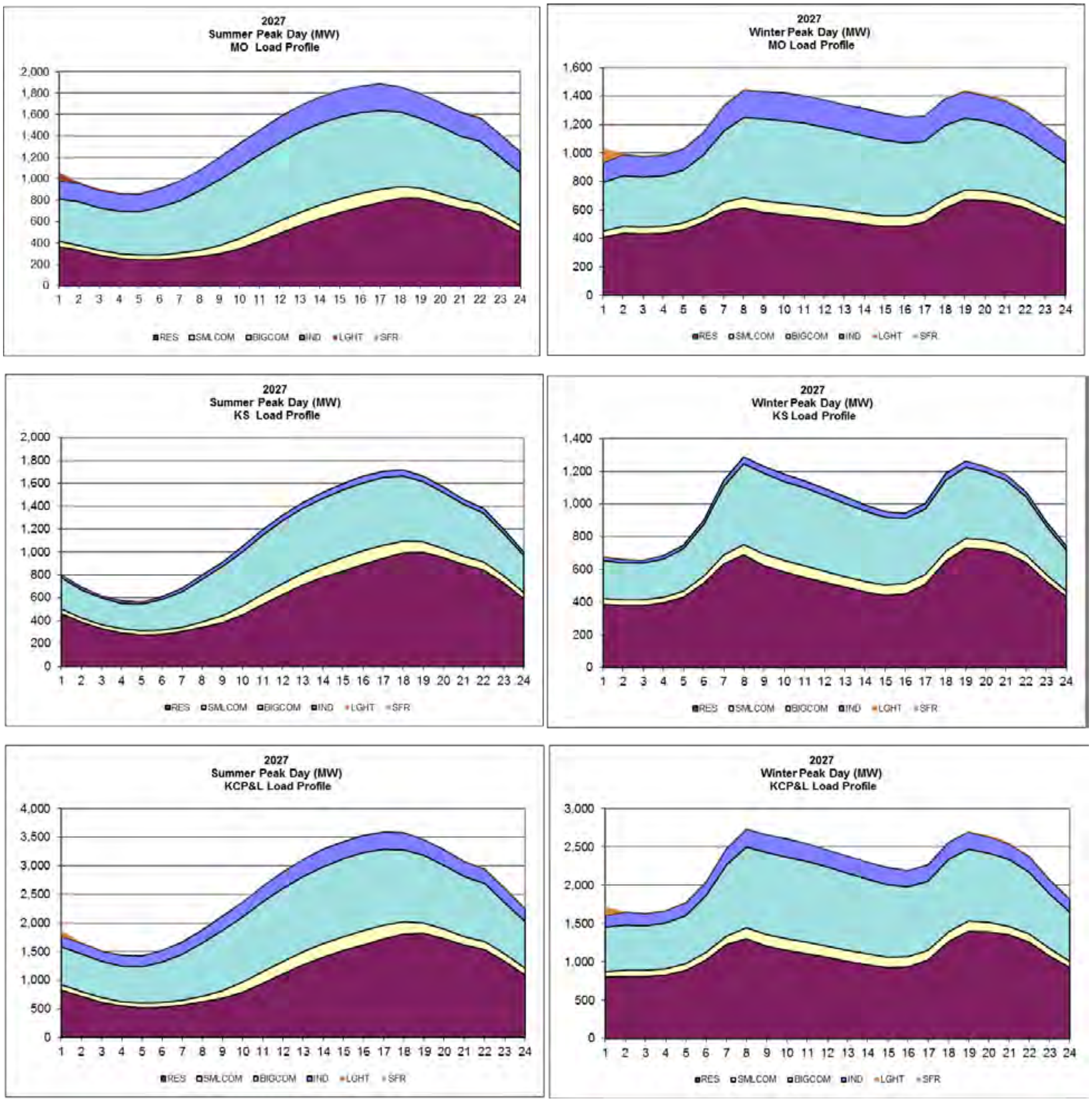
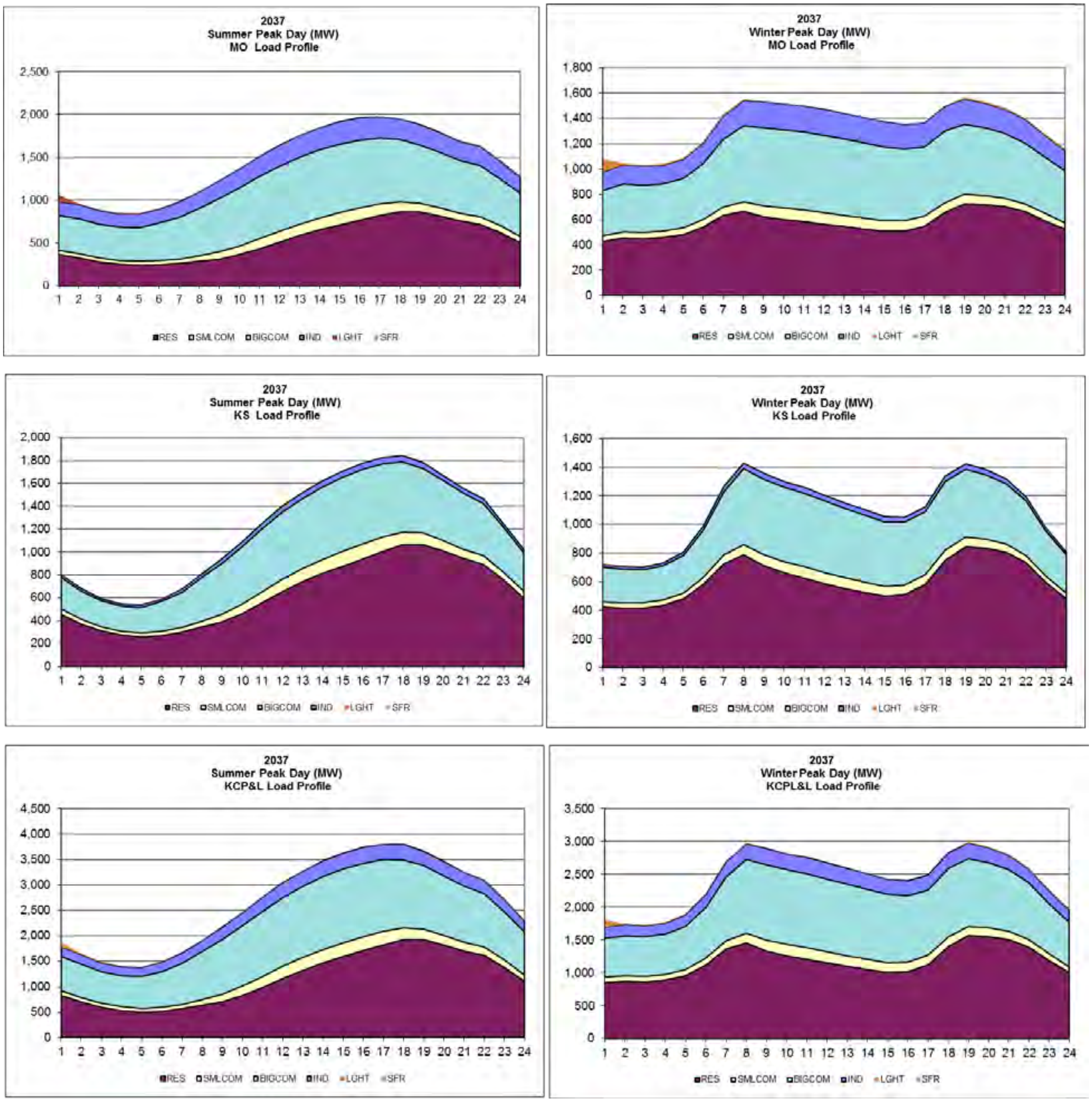


Figure 43: Twentieth Year (2037) Net System Load Profiles for MO, KS, and System



7.3 DESCRIBE AND DOCUMENT FORECASTS OF INDEPENDENT VARIABLES

(B) Forecasts of Independent Variables.

The forecasts of independent variables shall be specified, described, and documented.

The forecasts of independent variables were described above in the section for rule 6.C.3 and below in the section for rule for 7.B.3.

7.3.1 DOCUMENTATION OF MATHEMATICAL MODELS

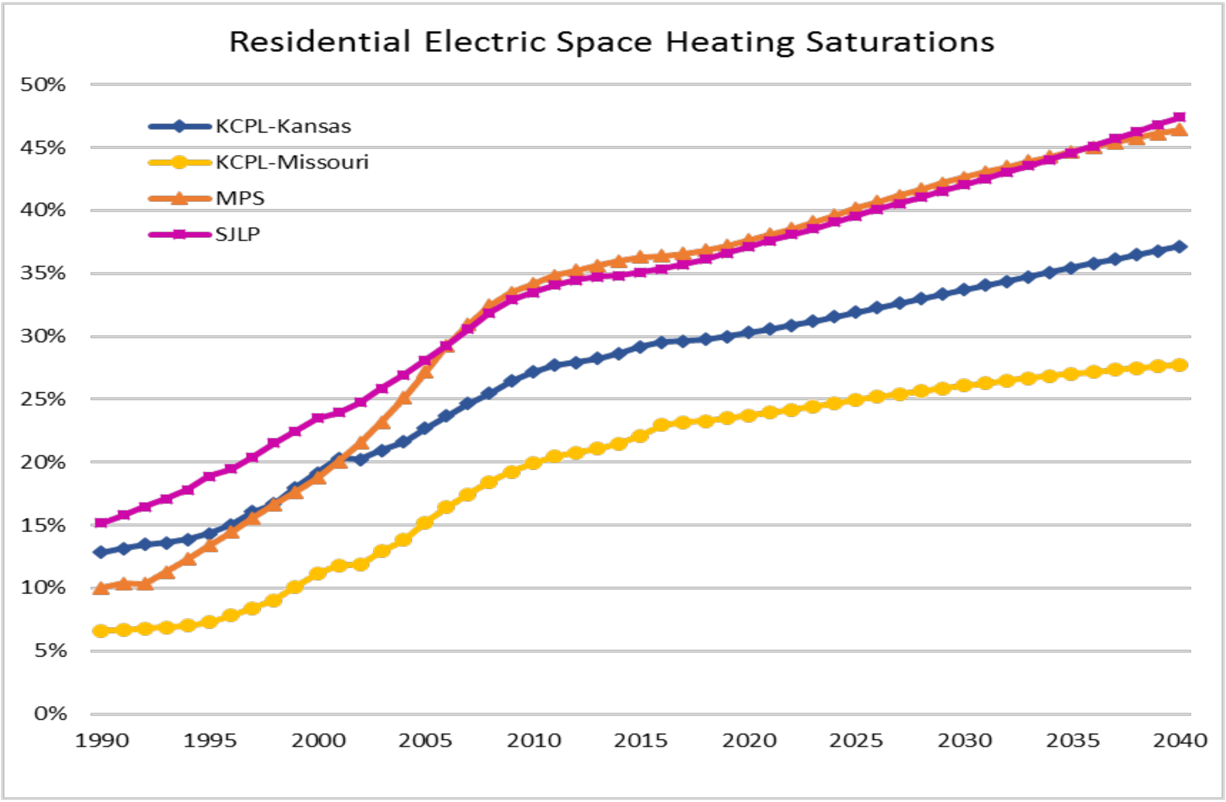
1. Documentation of mathematical models developed by the utility to forecast the independent variables shall include the reasons the utility selected the models as well as specification of the functional form of the equations.

KCP&L acquired forecasts of independent variables from Moody's and DOE as described previously. KCP&L developed its own models to forecast the saturation of electric space heating for residential and commercial customers (SpaceHeat.ndm). KCP&L has specific tariffs for customers that have electric space heating and the percentage of customers on these tariffs is used as a measure of electric space heating saturations. The models predict the penetration rate of electric space heating residential and commercial customers. The independent variables for residential include electric price with forecast, KC Metro area natural gas price with forecast and lag of residential electric space heat saturation. The independent variables for commercial class include electric price, West North Central census division natural gas price index and lag of commercial electric space heat saturation.

The coefficients were estimated with least squares regression separately for residential and commercial in each jurisdiction.

The forecasts for KCP&L and GMO are compared in the figure below.

Figure 44: Residential Space Heating Saturations



7.3.2 DOCUMENTATION OF ADOPTED FORECASTS DEVELOPED BY ANOTHER ENTITY

2. If the utility adopted forecasts of independent variables developed by another entity, documentation shall include the reasons the utility selected those forecasts, an analysis showing that the forecasts are applicable to the utility's service territory, and, if available, a specification of the functional form of the equations used to forecast the independent variables.

KCP&L used a forecast of economic and demographic variables for the KC metro area that was developed by Moody's Analytics. The reasons for using this forecast, the applicability to KCP&L's service area and documentation for the forecast were discussed in the sections for rules 22.030(3)(A) and 22.030(6)(A)3.

KCP&L used forecasts of saturations, UECs, EUIs and building efficiencies from DOE. The reasons for using these forecasts, the applicability to KCP&L's service area and documentation for the forecast were discussed in the sections for rules 22.030(3)(A), (4)(A)1. 22.030(B), 22.030(5)(A), 22.030(5)(B) and 22.030(6)(A)3.

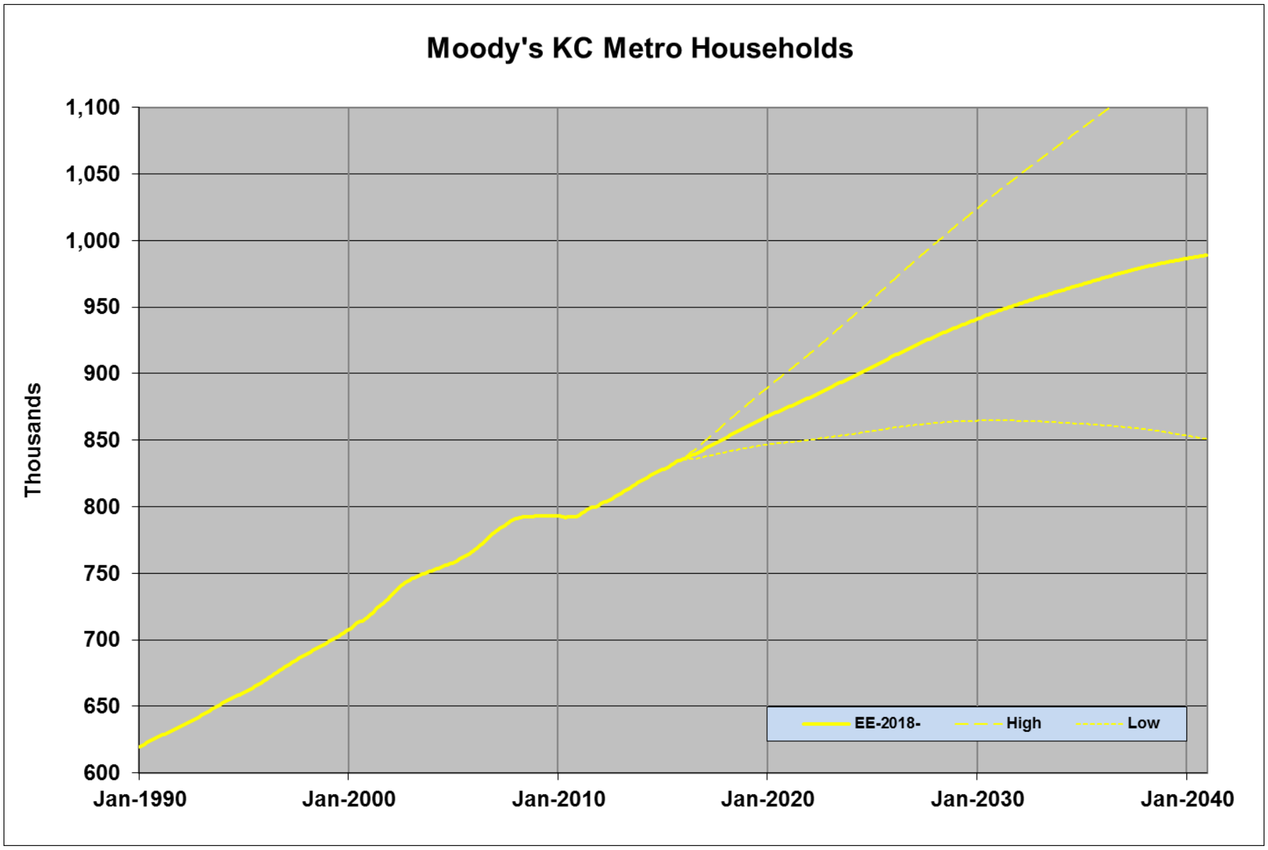
7.3.3 COMPARISON OF FORECAST FROM INDEPENDENT VARIABLES TO HISTORICAL TRENDS

3. These forecasts of independent variables shall be compared to historical trends in the variables, and significant differences between the forecasts and long-term and recent trends shall be analyzed and explained.

Table 36: Economic Growth Rates for KC Metro Area **

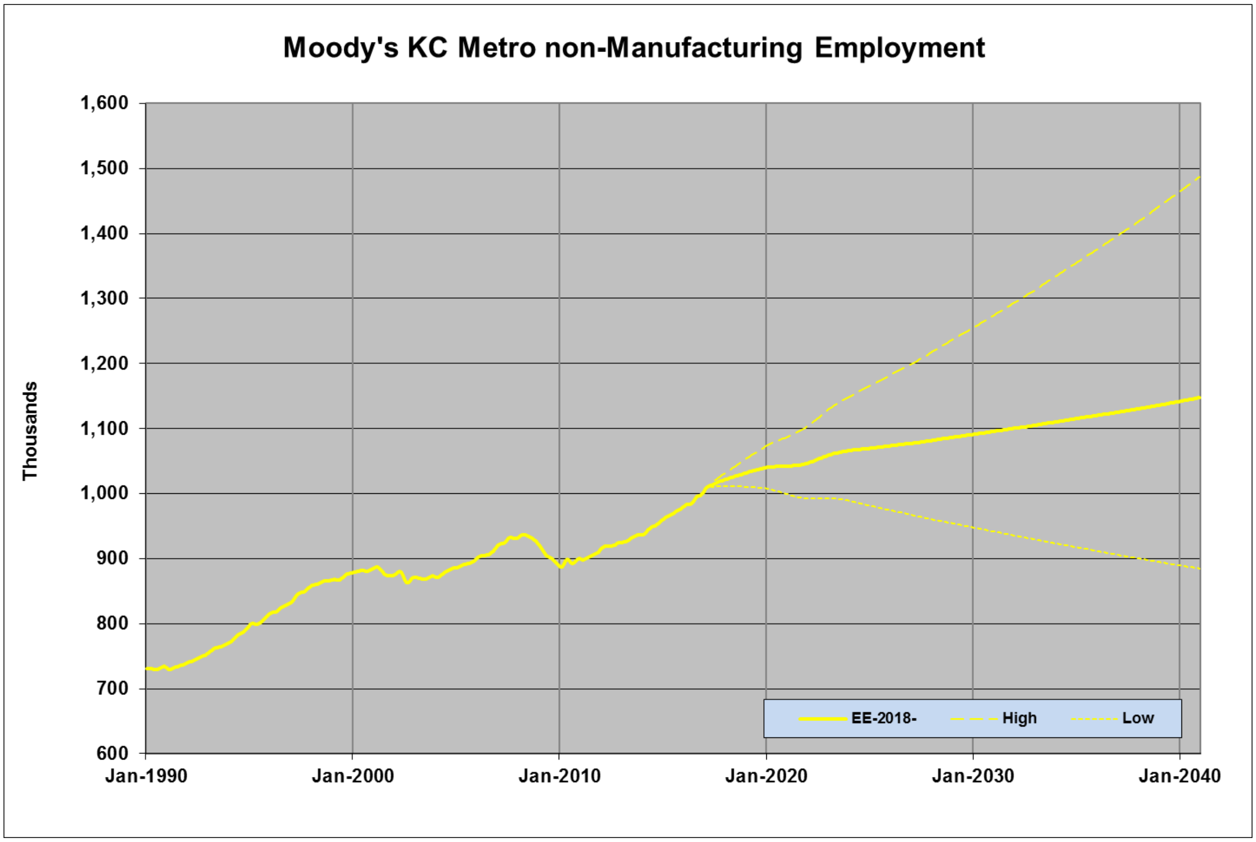
	Households	Employment Non-Manufacturing	Employment Manufacturing	Gross Product Non-Manufacturing	Gross Product Manufacturing
2000	1.4%	1.9%	0.3%	3.2%	1.7%
2010	1.0%	0.2%	-2.6%	1.3%	1.1%
2020	1.0%	1.5%	0.8%	1.7%	1.1%
2030	0.8%	0.5%	-0.7%	1.8%	1.9%
2040	0.4%	0.5%	-0.5%	1.3%	1.5%

Figure 45: KC Metro Households



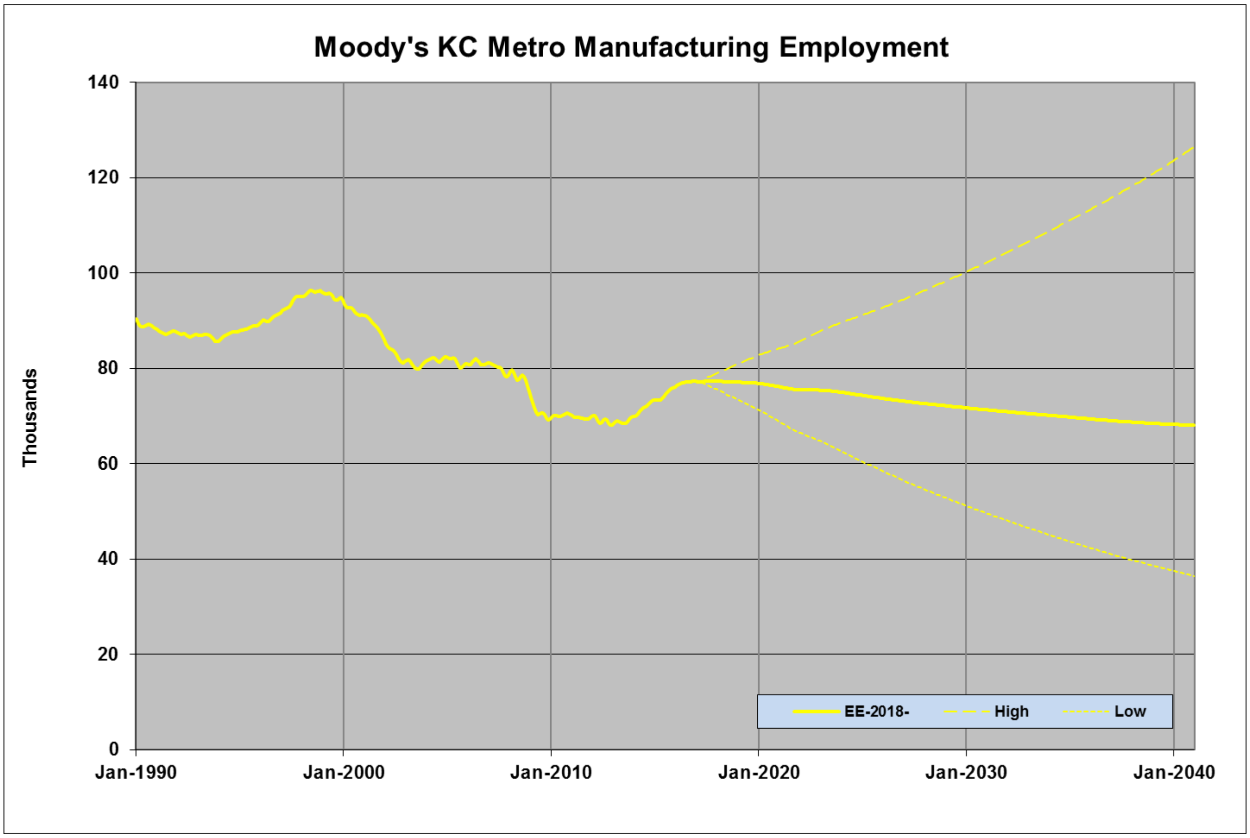
The household data and projection shows robust growth from 1990 until the beginning of the last recession at the end of 2007, at which time growth slowed substantially. Housing stock has expanded since 2012 and the growth is expected to continue at a slowly decelerating pace until 2030 when the pace begins to decelerate more rapidly.

Figure 46: KC Metro Employment Non-Manufacturing



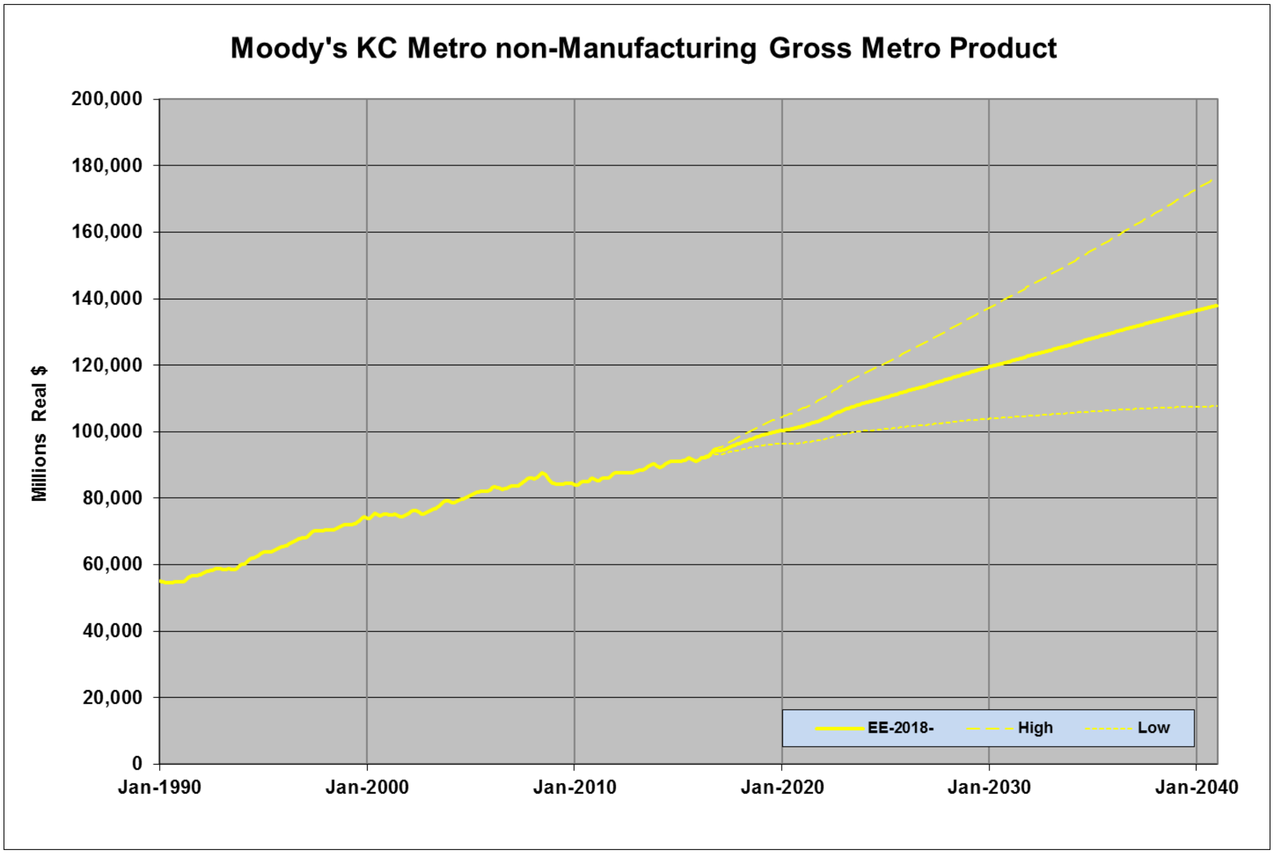
Non-manufacturing employment showed very strong growth in the 1990s, 1.9% per year, then stalled after the 2001 recession, picked up strongly in 2004 and then turned negative during the last recession. Growth returned in 2012 and grew stronger starting in 2015. Moody's expects continued growth though at a slower pace.

Figure 47: KC Metro Employment Manufacturing



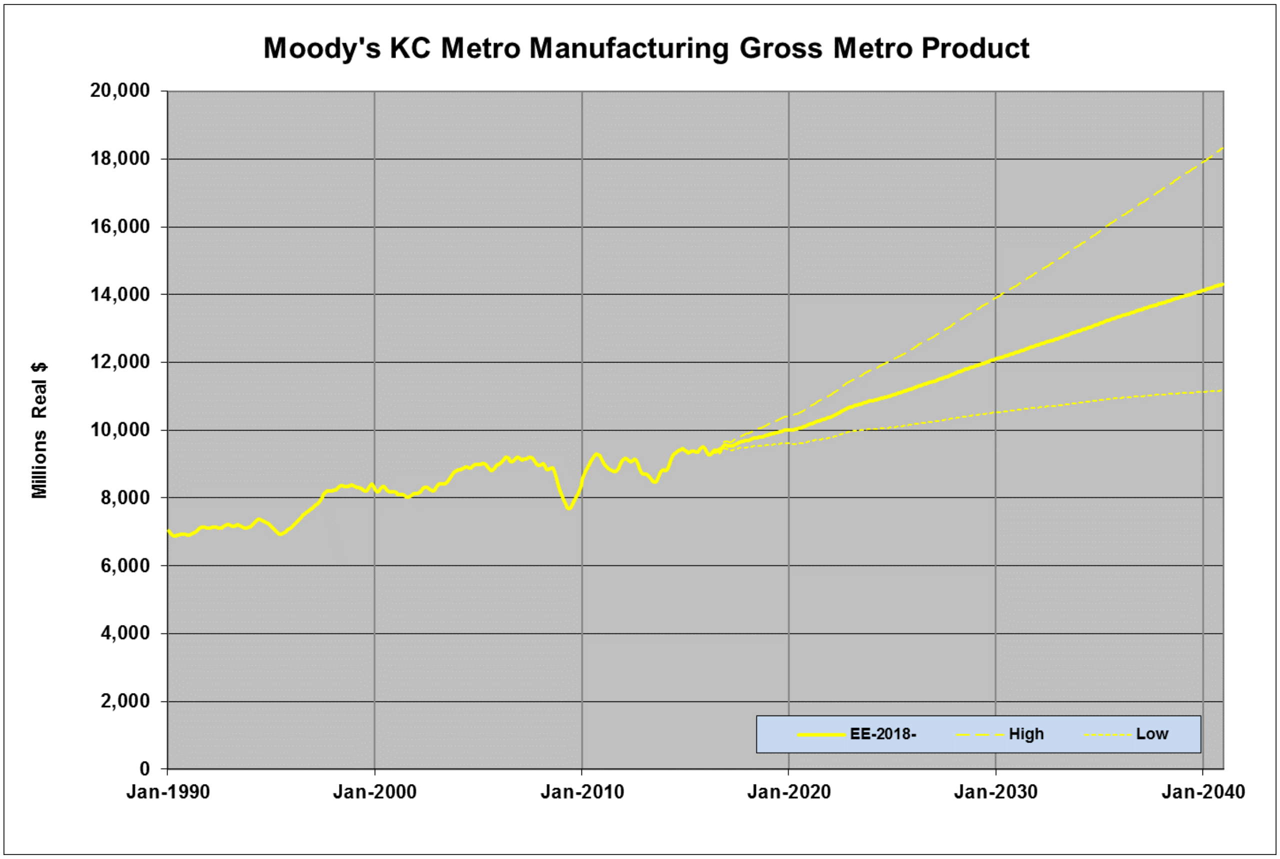
Manufacturing employment peaked in the late 1990s and has fallen since. It fell precipitously between 1999 and 2003 and again during the last recession. After regaining some of the jobs lost in the aftermath of the last recession, Moody's expects employment to resume its historical decline.

Figure 48: KC Metro Gross Metro Product Non-Manufacturing



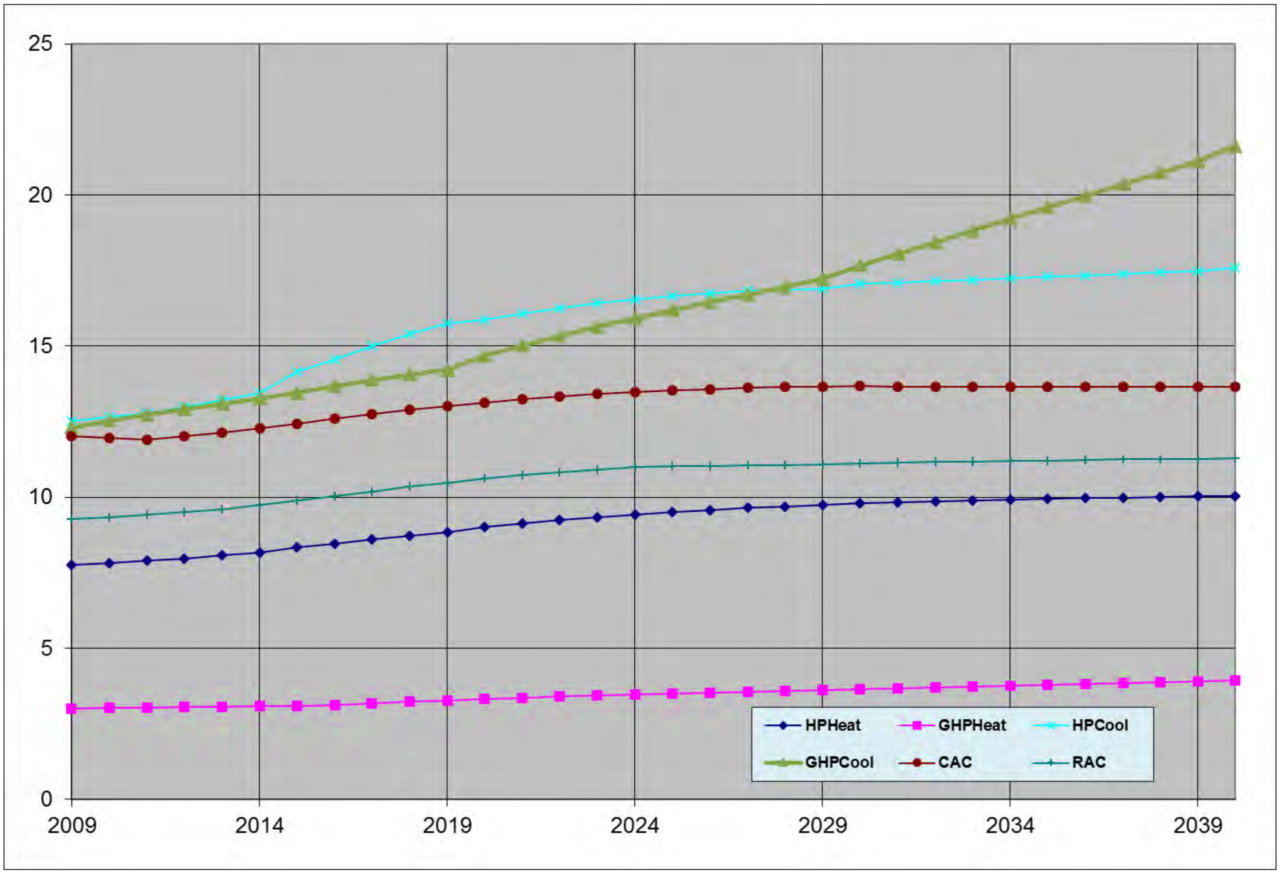
Real non-manufacturing gross metro product grew 3% per year during the 1990s, slowed down a bit after that and then declined during the last recession. GMP is growing faster than employment because of increasing productivity, a trend seen nationally and across many service sectors. Moody's expects above trend growth in the short-term and return to trend growth after that.

Figure 49: Gross Metro Product Manufacturing



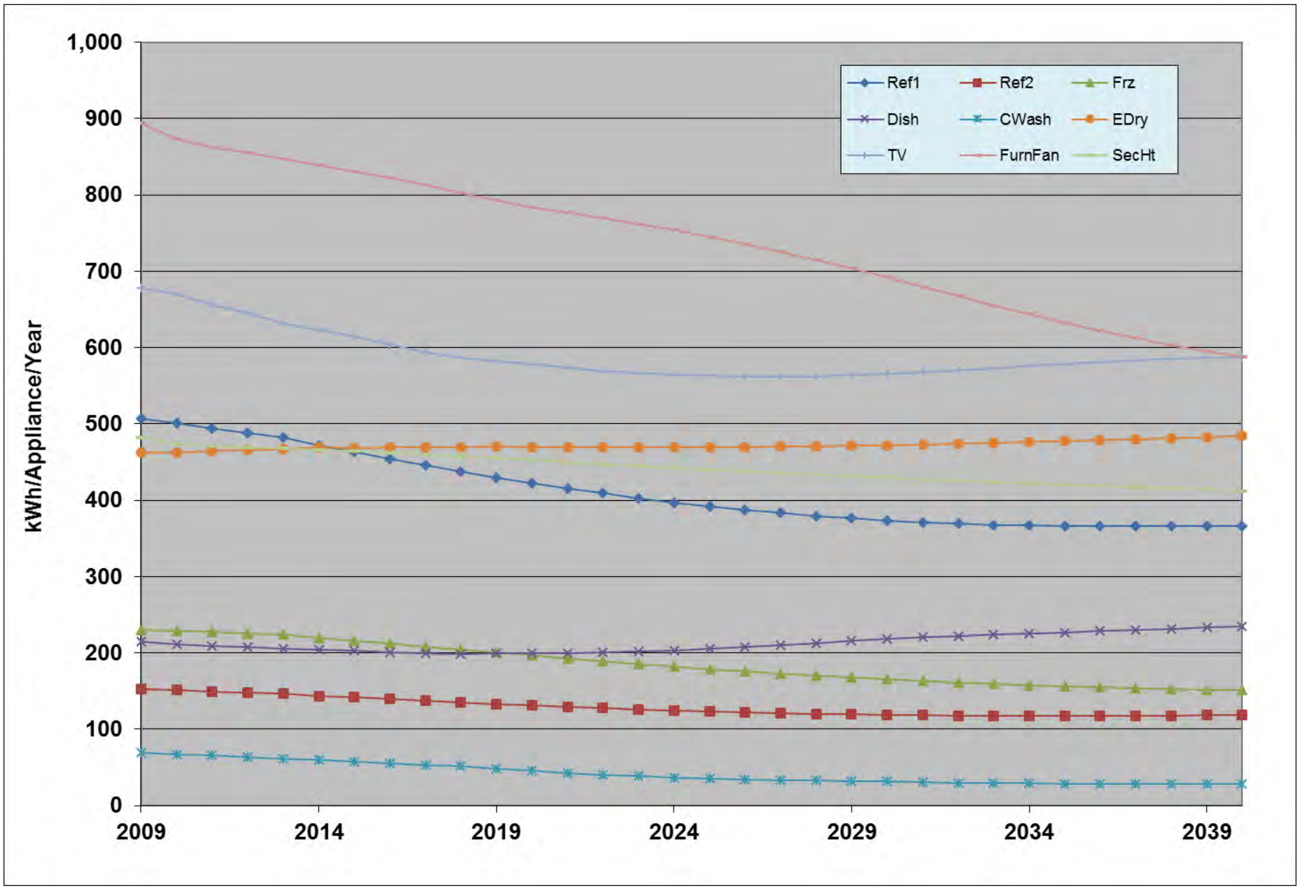
Real gross metro product from the manufacturing sector grew strongly during the 1990s and then fell flat until it plunged during the last recession. Growth has been somewhat volatile since 2008, but positive in total. Moody's expects growth in line with the recent historical trend. GMP for this sector is growing while employment is flat or declining because of increasing productivity, automation of the manufacturing processes and because many of the labor-intensive portions of production have moved overseas where labor cost is lower.

Figure 50: DOE Stock Average Appliance Efficiency Projections



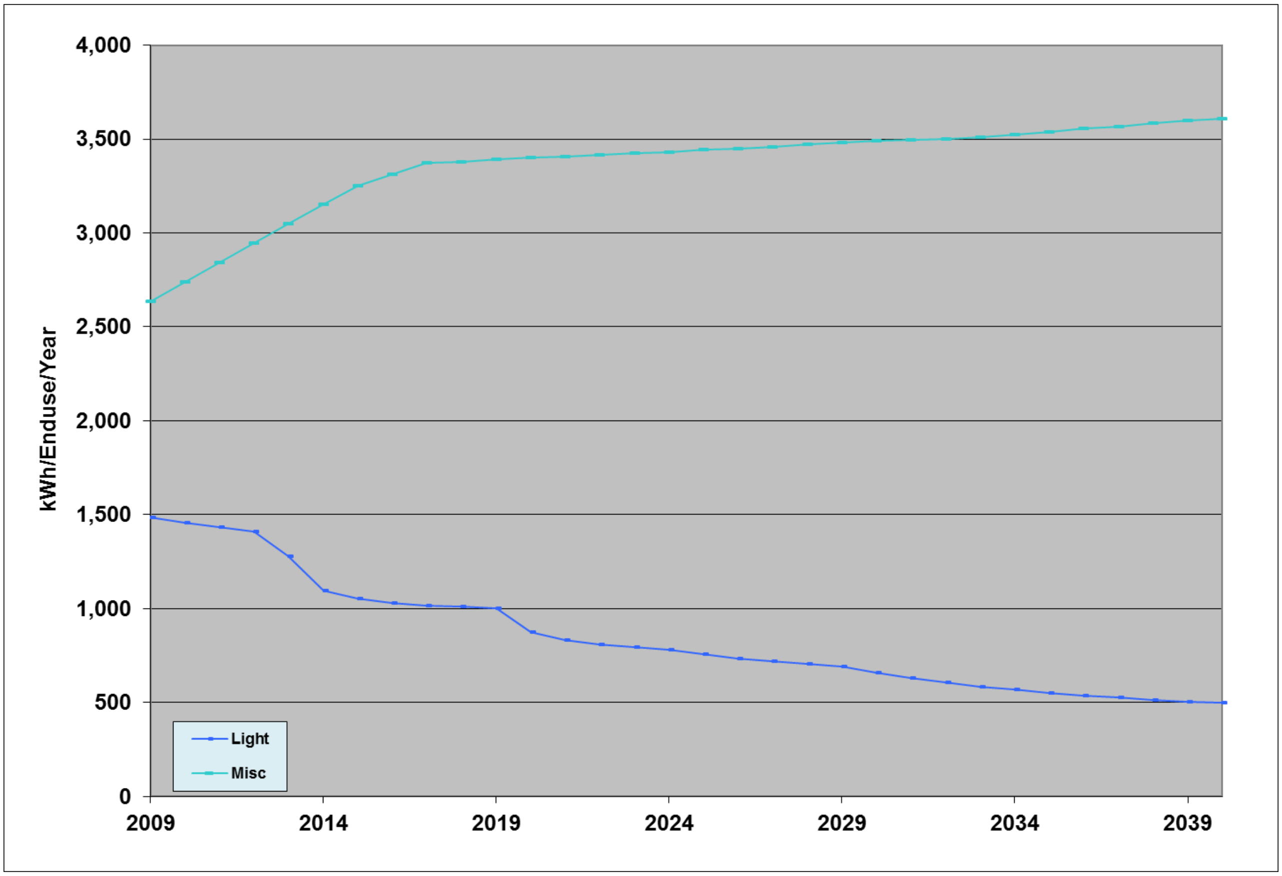
DOE is expecting increases in the stock average appliance efficiencies for residential heating and cooling equipment. This is resulting from appliance standards. In January 2006, a new standard raised the SEER standard by 30 percent for central air conditioners and has resulted in increasing efficiency since that time. This standard impacts the stock average efficiency both due to new construction and replacement units.

Figure 51: DOE UEC Projections (<1000 kWh/year)



The decline in UEC for refrigerators and freezers is expected to continue for another decade before beginning to level. TV UEC has fallen sharply in recent years but is expected to flatten beginning in 2018. Furnace fans are expected to continue to see a sharp decline in UEC. Dishwashers and electric dryers are expected to see slight increases in UEC due to increasing saturation levels.

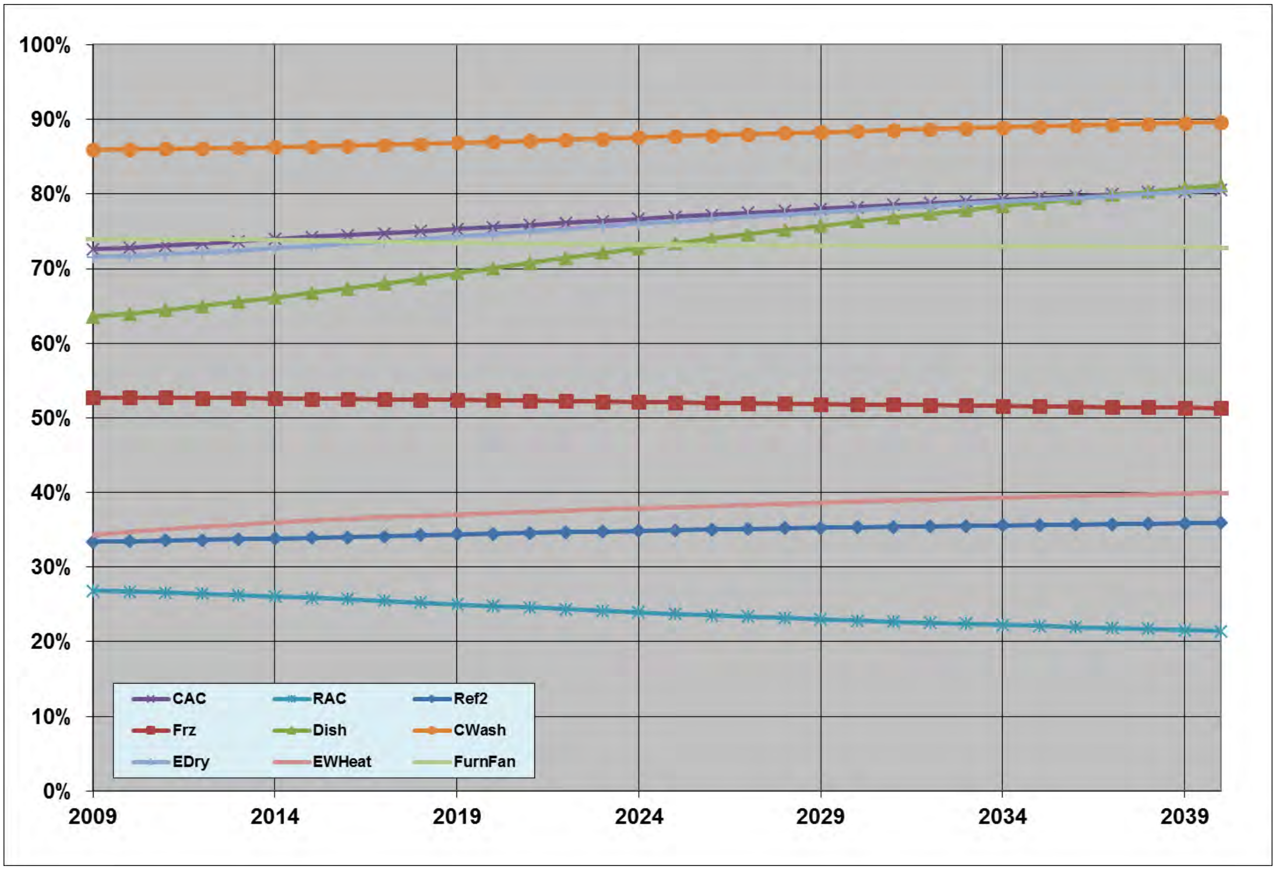
Figure 52: DOE UEC Projections (>1000 kWh/year)



The UEC for lighting is expected to continue declining due to increased saturation of CFL and LED light bulbs. Lighting standards initially began in 2012 will take full effect in 2020 and result in further declines in UEC.

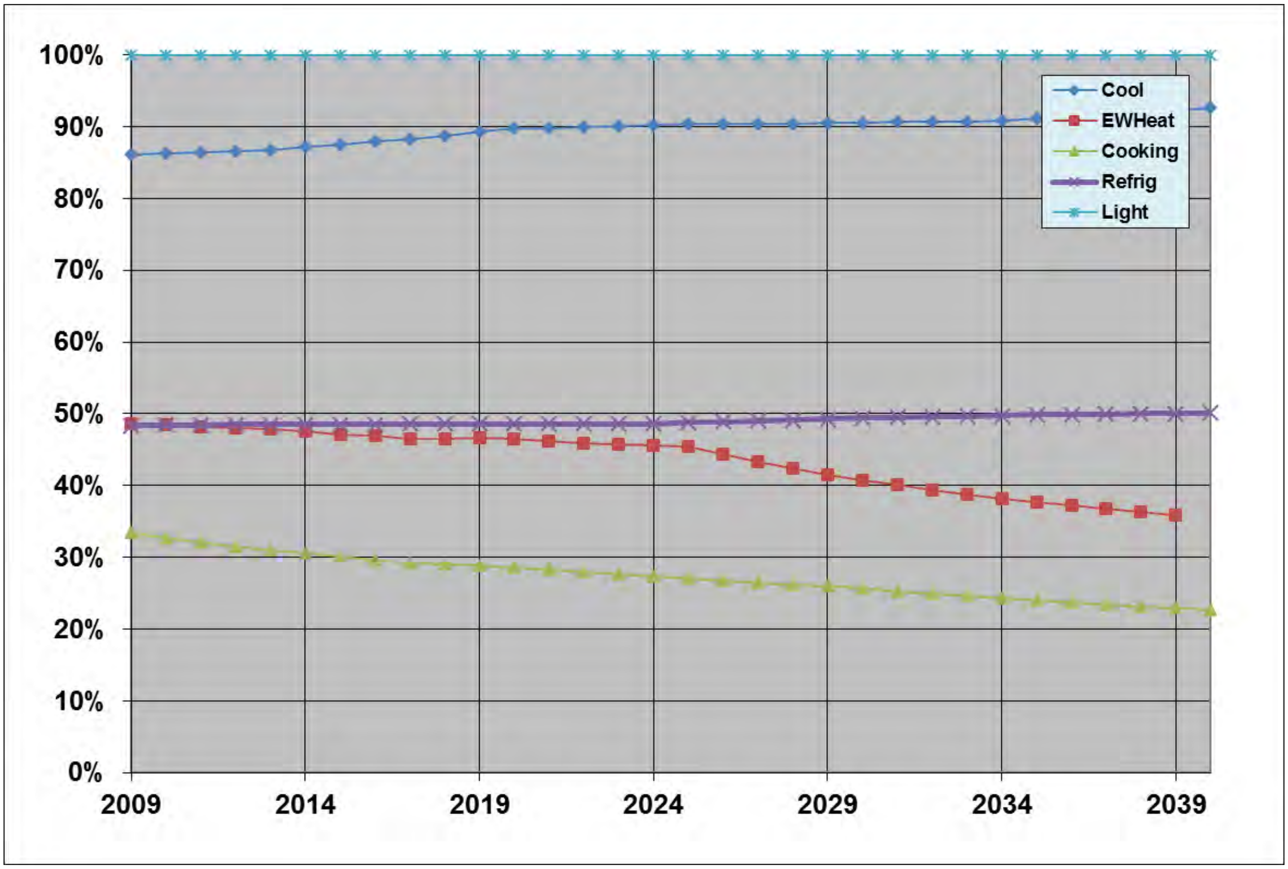
Miscellaneous UEC grew rapidly in the late 1990s and early 2000s before decelerating (from 5% to 3%) in 2006 and then again decelerating in 2016. The EIA expects miscellaneous UEC to again decelerate and grow slowly at about 0.3% per year going forward.

Figure 53: DOE Electric Appliance Saturation Projections (< 100%)



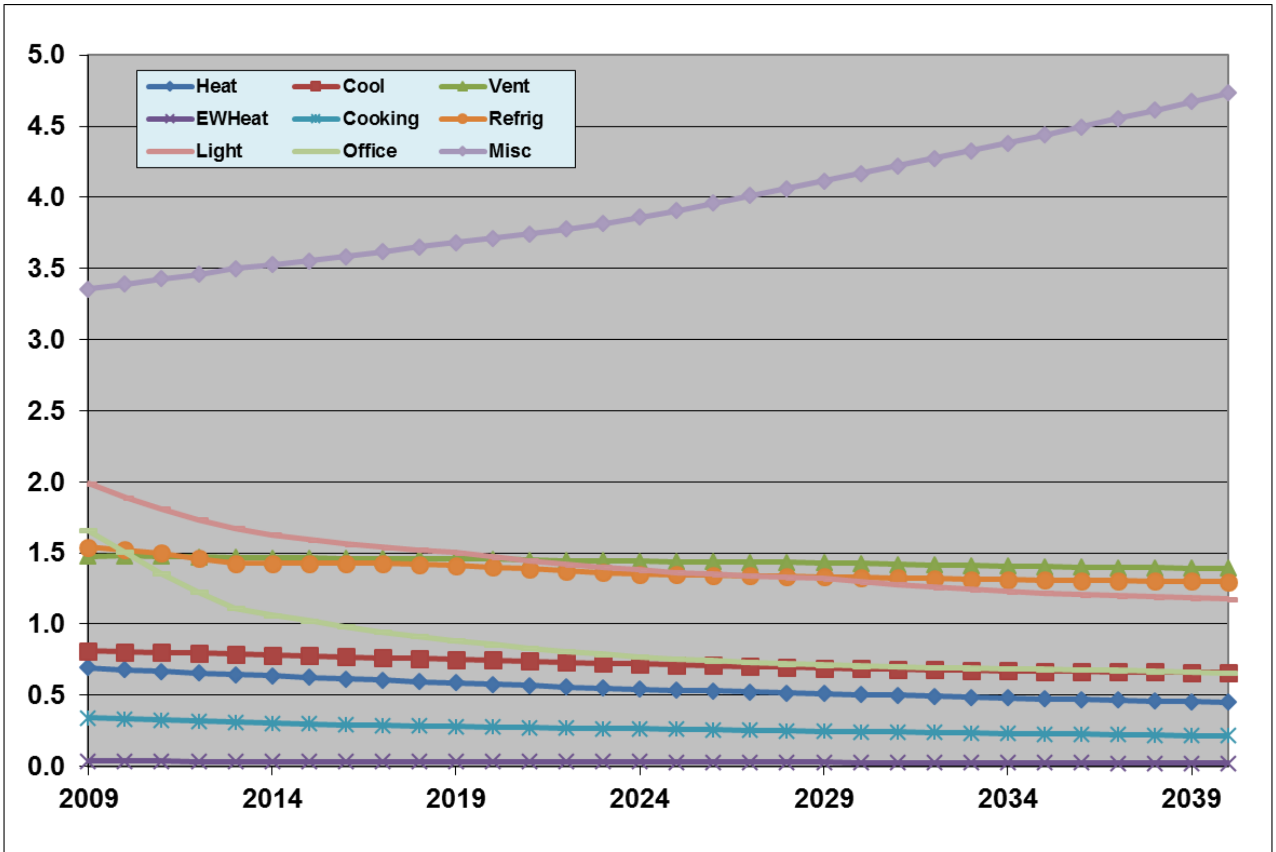
DOE saturation projections shown above are in line with recent historical trends.

Figure 54: DOE Commercial Equipment Saturation Projections (Average over all Commercial Building Types)



DOE commercial sector saturations are mostly in line with trends in recent historical data. Electric water heat saturation is projected to decline sharply starting in 2027, departing from its recent gradual decline. Electric cooking saturations are expected to fall in line with currently observed decline.

Figure 55: DOE Commercial EUI Projections
(Average over all Commercial Building Types)



DOE estimates of the EUI for lighting has been declining since 1995 and started falling more rapidly in 2005, due to the use of CFLs, especially for lodging and in recessed fixtures in offices. The refrigeration EUI has been declining historically and started a more rapid decline in 2009, which continues with the projection. New standards for commercial refrigeration equipment went into effect at the beginning of 2010 and updated in 2012. New refrigeration standards will become effective in 2017.[vii] The heating EUI is declining and expected to further decline. A new standard for commercial heating and cooling equipment became effective in April 2007 and November 2004 and updated in 2010.[viii] The EUI for miscellaneous equipment has been rising rapidly and is expected to continue that trend, though it is lower than previous outlooks due to the incorporation of the 2012 CBECS. One of the prominent end uses in the miscellaneous equipment category is medical equipment. Expansion in the health care sector and expanded use of medical equipment explain part of the intensity growth for miscellaneous equipment.

7.3.4 <u>SPECIFICATION AND QUANTIFICATION OF FACTORS</u>

4. Where judgment has been applied to modify the results of a statistical or mathematical model, the utility shall specify the factors which caused the modification and shall explain how those factors were quantified.

KCP&L used the forecasts of economic and demographic variables as is from Moody's Analytics.

The projections of appliance saturations from DOE were calibrated to the results of our Residential Appliance Saturation. An additional calibration was made to lighting to account for the KCP&L lighting program that had been in place prior to the implementation of the 2013 federal lighting standard. The adjustment slows the rate of decline.

7.4 <u>NET SYSTEM LOAD FORECAST</u>

(C) Net System Load Forecast. The utility shall produce a forecast of net system load profiles for each year of the planning horizon. The net system load forecast shall be consistent with the utility's forecasts of monthly energy and peak demands at time of summer and winter system peaks for each major class.

KCP&L has produced an hourly forecast for each major class and the sum of these forecasts is the hourly forecast of NSI.

SECTION 8: LOAD FORECAST SENSITIVITY ANALYSIS

(8) Load Forecast Sensitivity Analysis.

The utility shall describe and document its analysis of the sensitivity of the dependent variables of the base-case forecast for each major class to variations in the independent variables identified in subsection 4 CSR 240-22.030(8).

To perform a sensitivity analysis, we are using a method that was suggested by the Missouri Public Service Commission Staff for KCP&L's IRP. For each customer class, mwh sales were regressed on important driver variables and degree days and the standardized variables are used to show the relative importance of each explanatory variable. We also show the elasticity for each driver variable as measured by the statistical regression. The sensitivity analysis was first run using the class cost of service groups. Unfortunately, there was not enough data to obtain statically significant results since this data was available only from 2005. The analysis was repeated using revenue classes, residential, commercial and industrial with monthly data available from 2001 to 2017.

Table 37 displays the results for MO residential customers. Among the driving variables, the cooling degree days' variable has the largest standardized coefficient, followed by the heating degree days variable. Note that the base temperature for the cooling degree days' variable was 65^0 F and the base temperature for the heating degree days variable was 55^0 F. The variable hddPriceRatio variable is heating degree days with a base temperature of 55^0 F times the price of natural gas for MGE's residential customers divided by the price of electricity. The purpose of this variable is to measure the impact of gas and electric prices on electric space heating loads. The trends in both heating degree day response and cooling degree day response are significant as well. The variable BDays is the number of billing days averaged over each billing cycle. The regression periods used for these regressions are monthly from January 2001 to June 2017, with the exception of KCPL-MO Industrial and KCPL-KS Commercial, which used January 2002 – June 2017.

Table 37: Missouri Residential

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
BDays	4,066,212	87.4	0.59
hddPriceRatio	14,291,092	5.0	0.05
resCusCDD65	65,955,098	73.4	0.24
resCusHdd55	33,002,710	12.9	0.13
HDDtrend	12,513,701	9.1	-0.02
CDDtrend	-2,917,806	-3.6	0.00

Table 38provides the results for Missouri commercial customers. The variable with the largest standardized coefficient is cooling degree days. The heating degree day base temperature for the commercial model was the same as the residential model, but the cooling degree day base temperature was 60^0 F. Heating degree days, trend in heating degree days and the HDDpriceRatio variable all had similar impact for commercial customers. Several economic drivers were tested and the number of households was more significant than non-manufacturing employment or GMP.

Table 38: Missouri Commercial

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
Total_Households	4,196,078	5.5	0.27
BDays	6,859,182	11.8	0.59
HDDpriceRatio	13,580,340	5.1	0.03
comCusCDD60	40,584,925	39.7	0.10
comCusHdd55	11,167,074	4.5	0.03
Jun02	-1,702,267	-3.1	0.00
Apr03	-1,926,191	-3.5	0.00
HddTrend	11,457,458	8.1	-0.01
EffTrend	-3,969,414	-4.0	-0.01

The Missouri industrial model results are shown in. The cooling degree variable has the largest standardized coefficient, followed by manufacturing employment of the economic variables, the manufacturing employment variable was the most significant. Using industrial customers as a variable was also statistically significant.

Table 39: Missouri Industrial

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
Emp_Man	4,383,866	5.6	0.60
indCus	3,209,977	4.1	0.41
prElecCus	-488,788	-0.9	-0.05
indCusCDD60	5,314,635	8.5	0.04
Aug03	-712,037	-2.0	0.00
Aug05	-1,681,597	-4.9	0.00
Nov12	-851,986	-2.5	0.00

Table 40 shows the results for residential customers in Kansas. The variables with the largest standardized coefficients are degree days followed by the hddPriceRatio. The hddPriceRatio variable is the same formula used for the same named variables in the Missouri models.

Table 40: Kansas Residential

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
BDays	7,411,809	12.4	0.99
resCus	-4,078,751	-4.7	-0.37
hddPriceRatio	8,291,170	2.1	0.03
resCusCDD65	71,503,872	69.4	0.24
resCusHdd55	32,792,542	9.1	0.12
hddTrend	6,212,414	3.3	-0.01

Table 41 shows the results for commercial customers in Kansas. Again, the degree day variables represented the variables with the largest coefficients.

Table 41: Kansas Commercial

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
GP_Non_Man	4,745,164	7.3	0.31
BDays	4,630,652	12.7	0.55
HDDpriceRatio	6,572,870	2.6	0.02
comCusCDD60	28,902,047	42.0	0.10
comCusHdd55	9,457,411	4.1	0.03
HDDtrend	5,042,222	4.5	0.00
Oct08	1,003,170	2.9	0.00

Table 42 reports the results of the sensitivity analysis for manufacturing customers in Kansas. The manufacturing employment economic variable had the largest coefficient closely followed by the cooling degree variable. The next largest coefficient was from the prElecCus variable, which had the same formula as the same named variable in the Missouri models.

Table 42: Kansas Industrial

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
Emp_Man	2,836,073	20.0	1.07
prElecCus	-570,471	-3.3	-0.14
indCusCDD60	2,403,431	17.1	0.07
Sep00	-194,086	-3.5	0.00
Dec00	124,452	2.3	0.00
Feb01	-120,079	-2.2	0.00

8.1 TWO ADDITIONAL NORMAL WEATHER LOAD FORECASTS

(A) The utility shall produce at least two (2) additional normal weather load forecasts (a high-growth case and a low-growth case) that bracket the base-case load forecast. Subjective probabilities shall be assigned to each of the load forecast cases. These forecasts and associated subjective probabilities shall be used as inputs to the risk analysis required by 4 CSR 240-22.060.

KCP&L used two additional economic forecasts from Moody's Analytics to produce high-growth and low-growth load forecast scenarios. These additional scenarios represent economic growth of two standard deviations above and below the base case forecast.

In addition to these two scenarios, KCP&L produced an additional scenario representing significant loss of customer.

KCP&L constructed this scenario by subtracting the energy and peak demand from the largest customer in both Kansas and Missouri from the results for the base case scenario. The most recent 12 billing records from each customer were used and the energy and peak from each month was used for that particular month in the forecast. Losses were added to the energy and peak demands.

The corresponding figures below show the base-case, low-case, high-case, and significant loss forecasts for energy and demand. The impact of the last recession and the economic malaise since then are evident in the plot for energy. Growth in the forecast is lower than it was prior to the last recession and this is primarily because U.S. growth prior to the recession was fueled by circumstances that will not be repeated in the forecast horizon such as extremely lax lending standards.

Figure 56: Base, Low, High and Significant Loss Net System Input Forecast

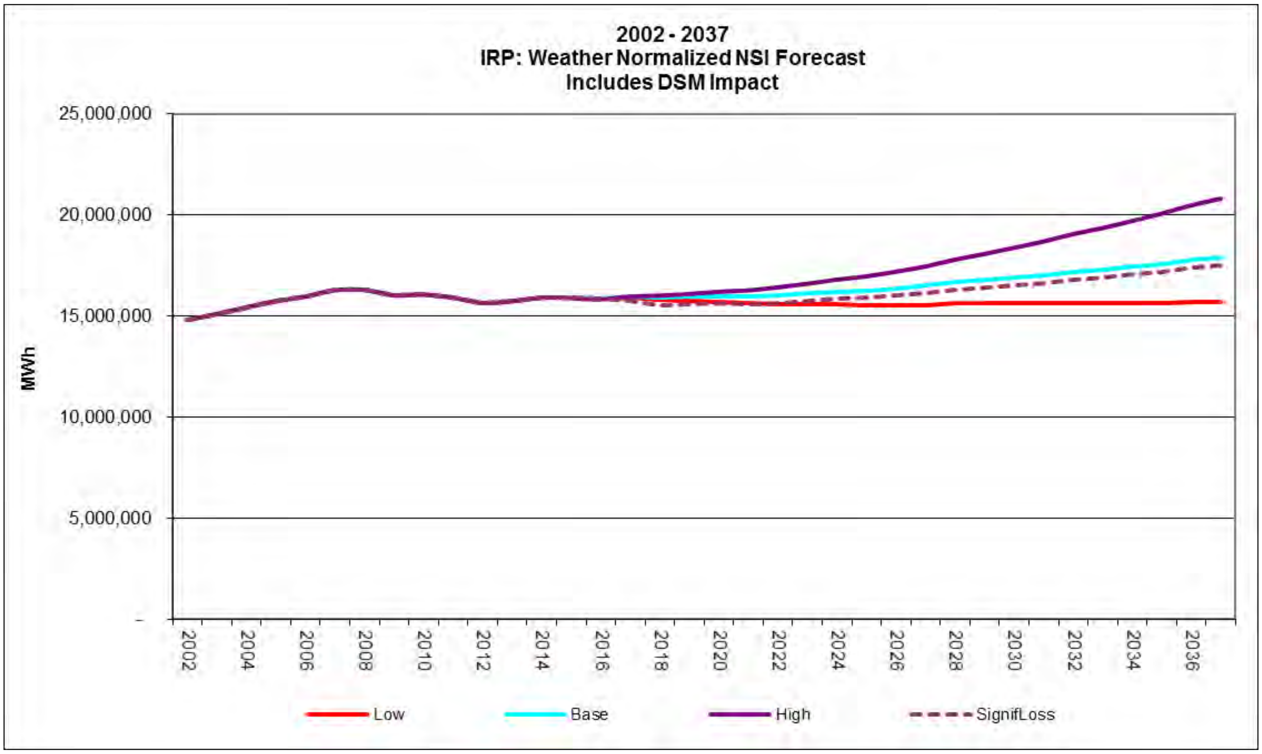
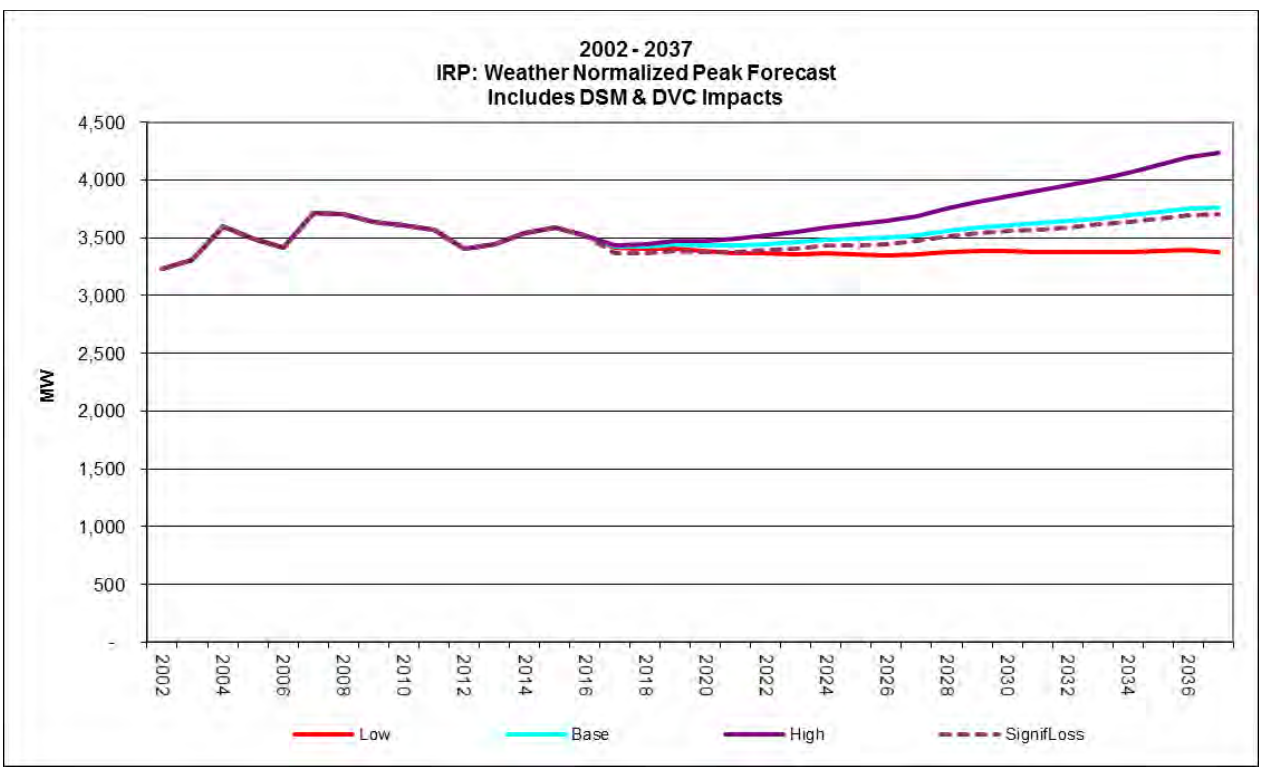


Figure 57: Base, Low, High and Significant Loss Peak Demand Forecast



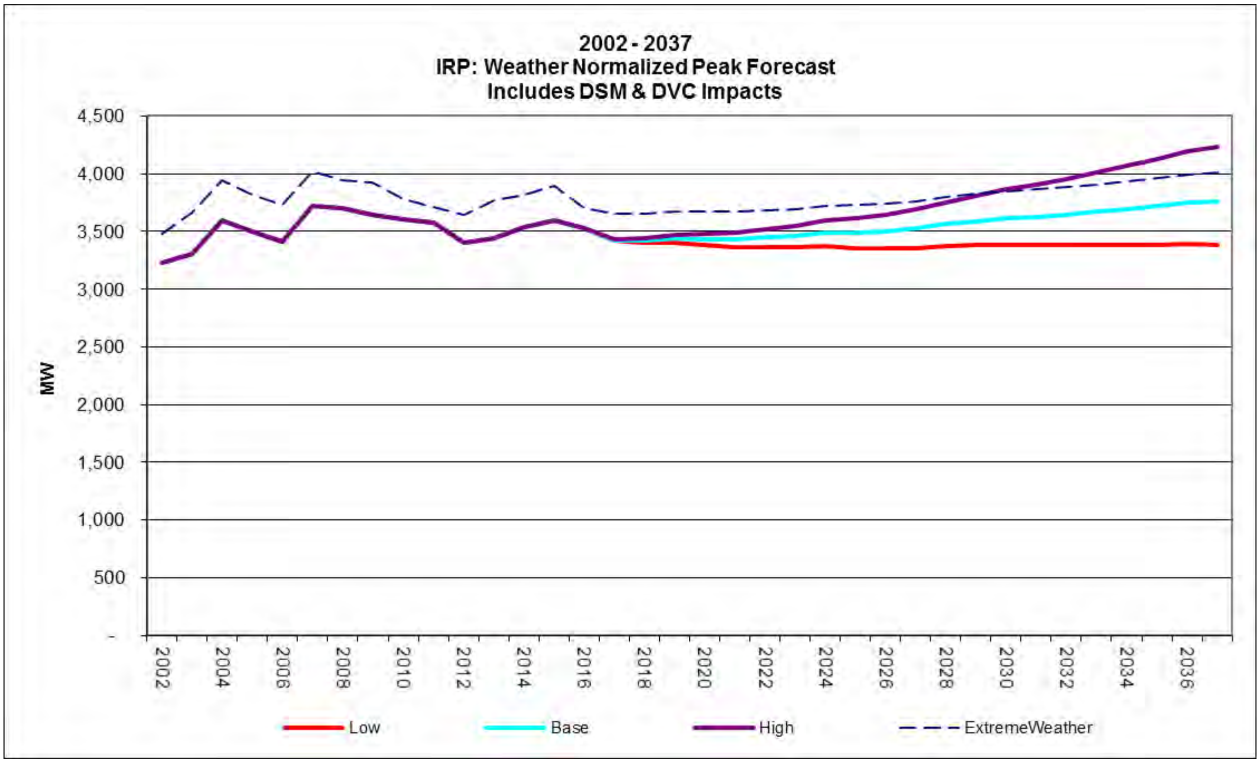
8.2 ESTIMATE OF SENSITIVITY OF SYSTEM PEAK LOAD FORECASTS TO EXTREME-WEATHER

(B) The utility shall estimate the sensitivity of system peak load forecasts to extreme weather conditions. This information shall be considered by utility decision-makers to assess the ability of alternative resource plans to serve load under extreme weather conditions when selecting the preferred resource plan pursuant to 4 CSR 240-22.070(1).

KCP&L created a forecast scenario using the base case economic scenario and weather from the 4 warmest years in terms of cooling degree days at KCI. These years were 1980, 1988, 2006 and 2012. The number of cooling degree days those years were 1,746, 1,724, 1,724 and 1,839. The scenario was created by running our computer programs with normal weather computed with those four years instead of with 30 years. In 2017, the peak rose from 3,434 mW in the base case scenario to 3,667 mW in the extreme weather scenario. In 2022, the peak increased from 3,464 (base case) to 3,699 extreme weather scenario. The complete set of results is in a file, *KCPL NSI_Peak Monthly_Annual.xls.* This file contains monthly NSI and peak load for all forecast scenarios.

The corresponding figures below show the base-case, low-case, high-case, and extreme weather forecasts for energy and demand.

Figure 58: Base, Low, High, and Extreme Weather Peak Demand Forecast



8.4 ENERGY USAGE AND PEAK DEMAND PLOTS

(C) The utility shall provide plots of energy usage and peak demand covering the historical database period and the forecast period of at least twenty (20) years.

1. The energy plots shall include the summer, non-summer, and total energy usage for each calendar year. The peak demand plots shall include the summer and winter peak demands.

The figures below represent actual and weather normalized Net System Input (Energy) for summer, non-summer, and total year for the base case forecast. Corresponding tables can be found in *Appendix 3D* and in the file *IRP_8C_KCPL_NSI_Peak.xls*. Weather normalization significantly smooths out the energy plots.

Figure 59: Base Case Actual and Weather Normalized Summer Energy Plots

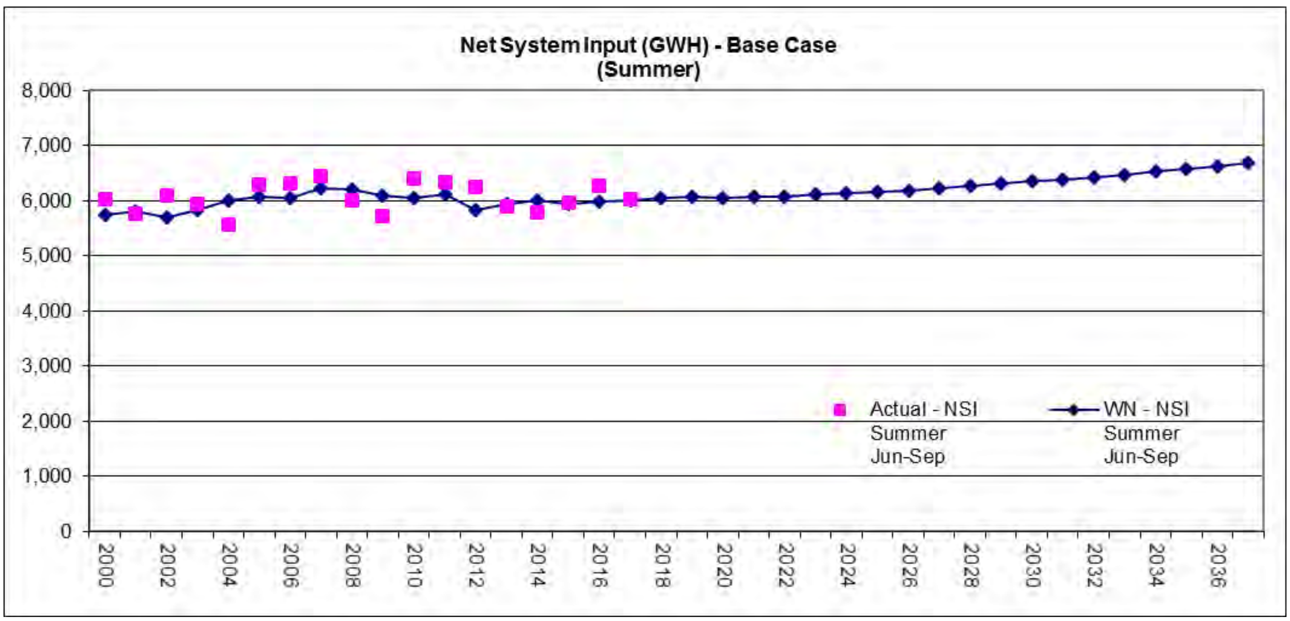


Figure 60: Base Case Actual and Weather Normalized Non-Summer Energy Plots

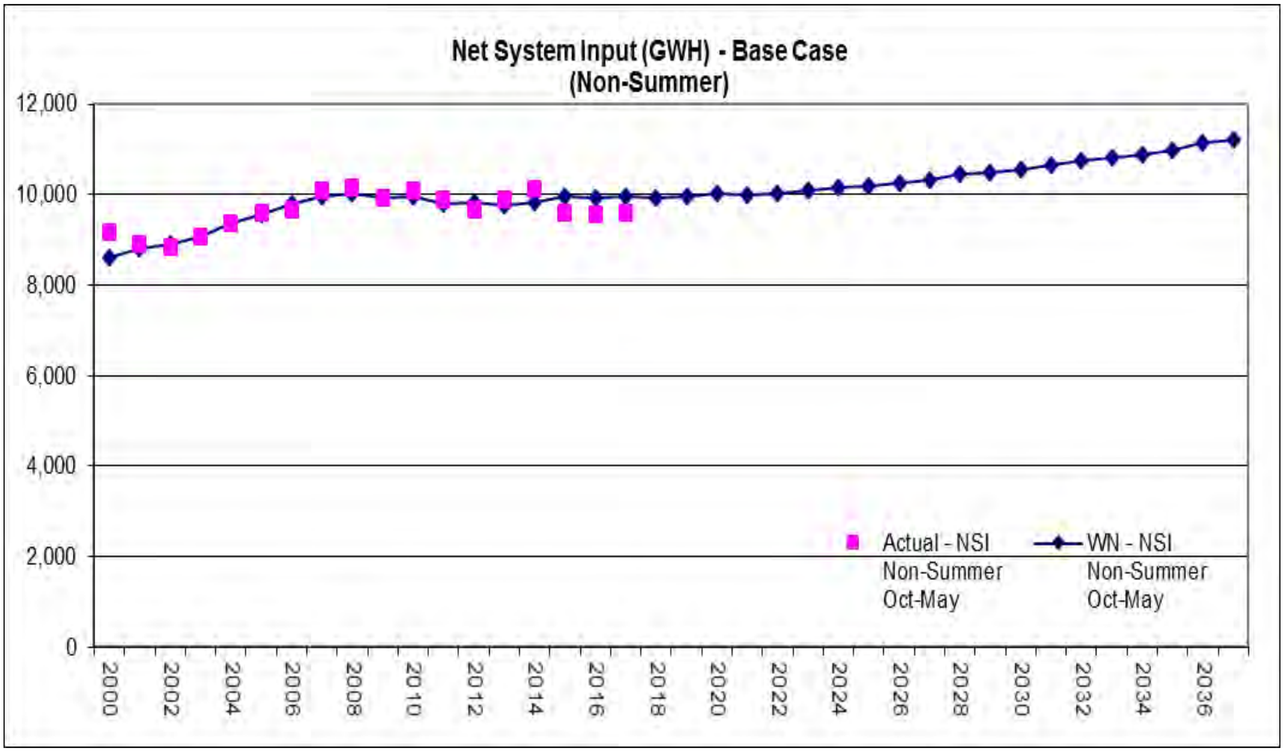
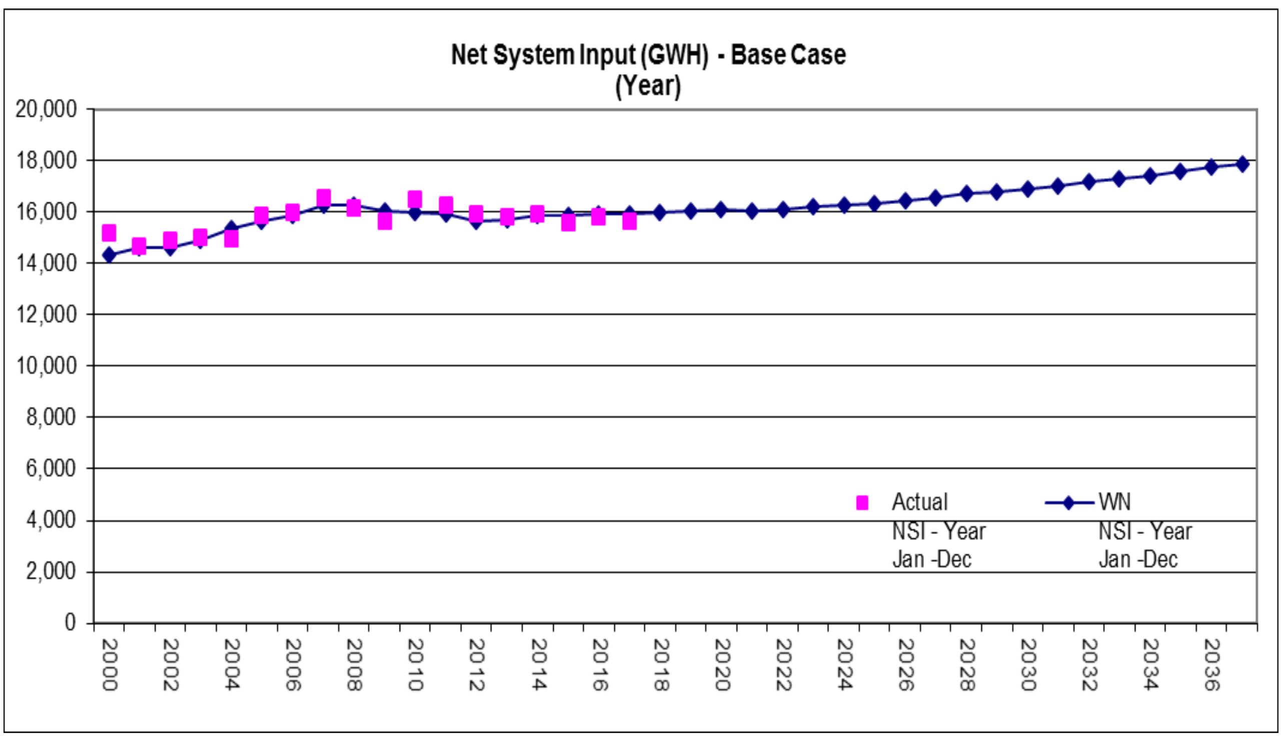


Figure 61: Base Case Actual and Weather Normalized Total Energy Plots



The figures below represent actual and weather normalized peak demand for summer and non-summer for the base case forecast. Annual peak demand plots are not shown, since they are the same as summer demand plots. Corresponding tables can be found in *Appendix 3D* and the file *IRP_8C_KCPL_NSI_Peak.xls*.

Figure 62: Base Case Actual and Weather Normalized Summer Peak Demand Plots

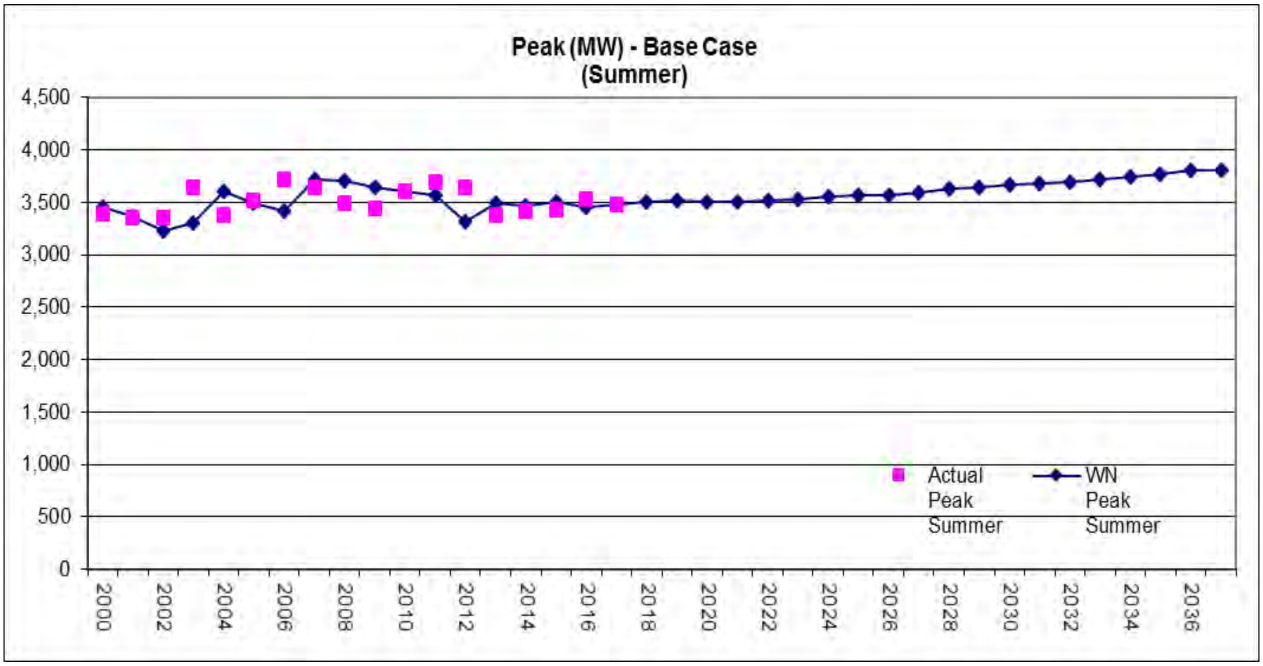
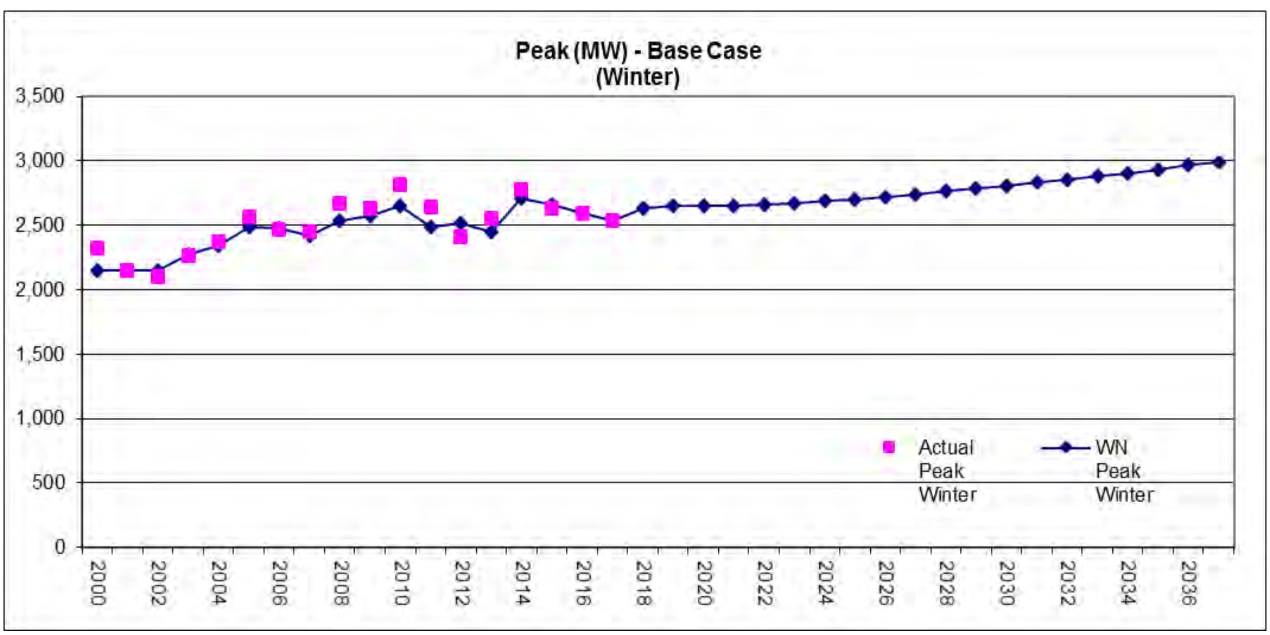


Figure 63: Base Case Actual and Weather Normalized Winter Peak Demand Plots



2. The historical period shall include both actual and weather-normalized values. The forecast period shall include the base-case, low-case, and high-case forecasts.

The figures below represent Net System Input (energy) for summer, non-summer, and the whole year for the base, low and high scenario forecasts. Corresponding tables can be found in *Appendix 3D* and the file *IRP_8C_KCPL_NSI_Peak.xls*.

Figure 64: Base-Case, Low-Case, and High-Case Summer Energy Plots

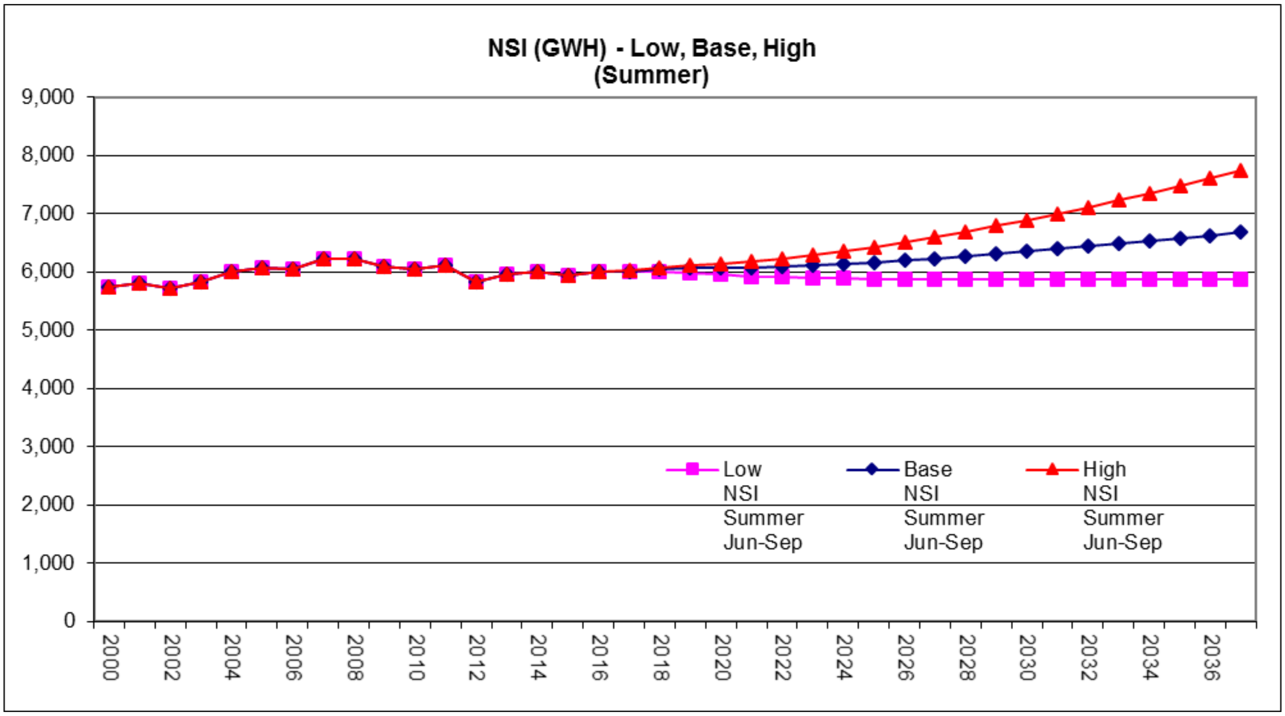


Figure 65: Base-Case, Low-Case, and High-Case Non-Summer Energy Plots

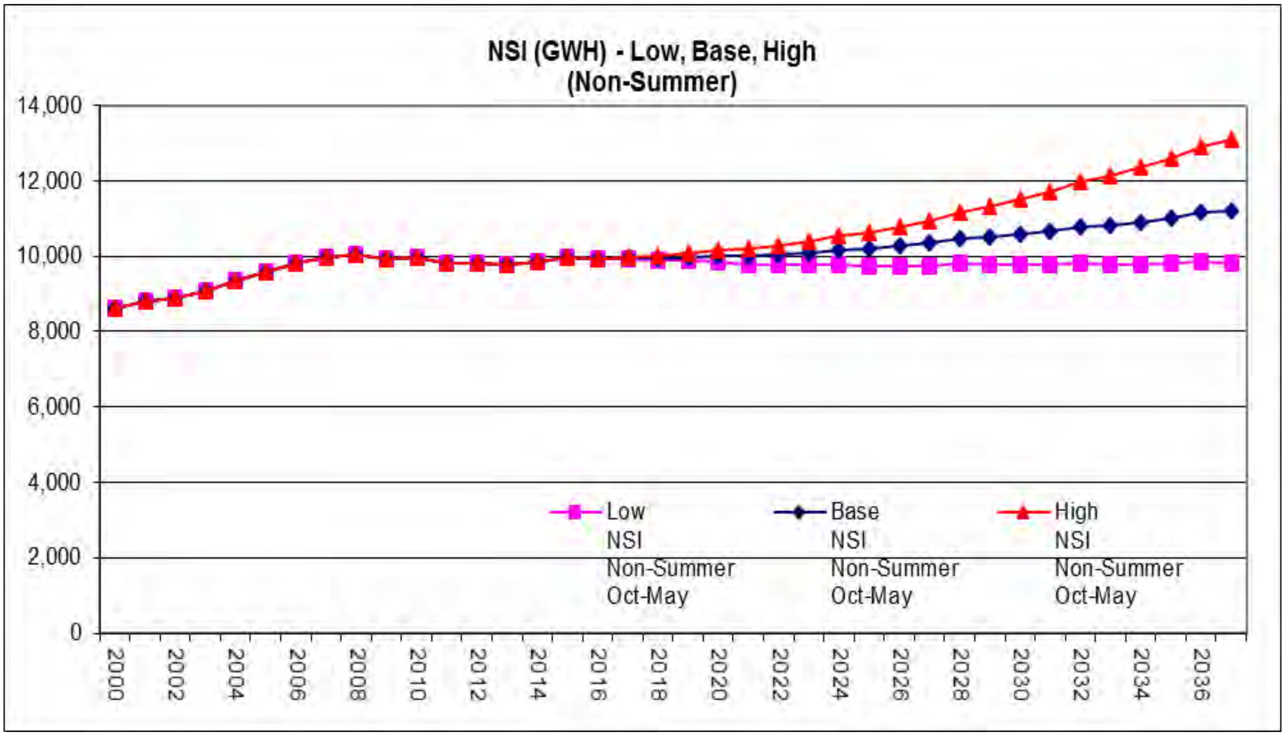
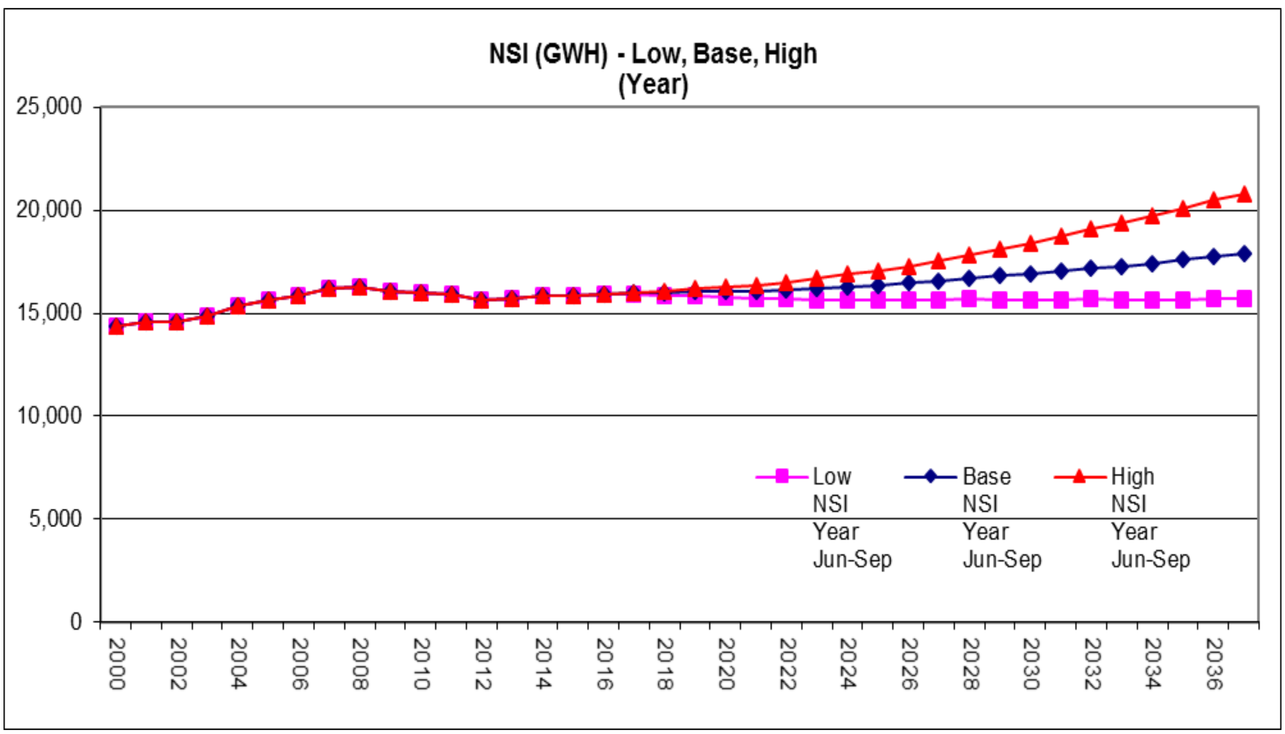


Figure 66: Base-Case, Low-Case, and High-Case Total Energy Plots



The figures below represent peak demand for summer and non-summer for the base, low, and high scenario forecasts. Annual peak demand plots are not shown, since they are the same as summer demand plots. Corresponding tables can be found in *Appendix 3D* and in the file *IRP_8C_KCPL_NSI_Peak.xls*.

Figure 67: Base-Case, Low-Case, and High-Case Summer Peak Demand Plots

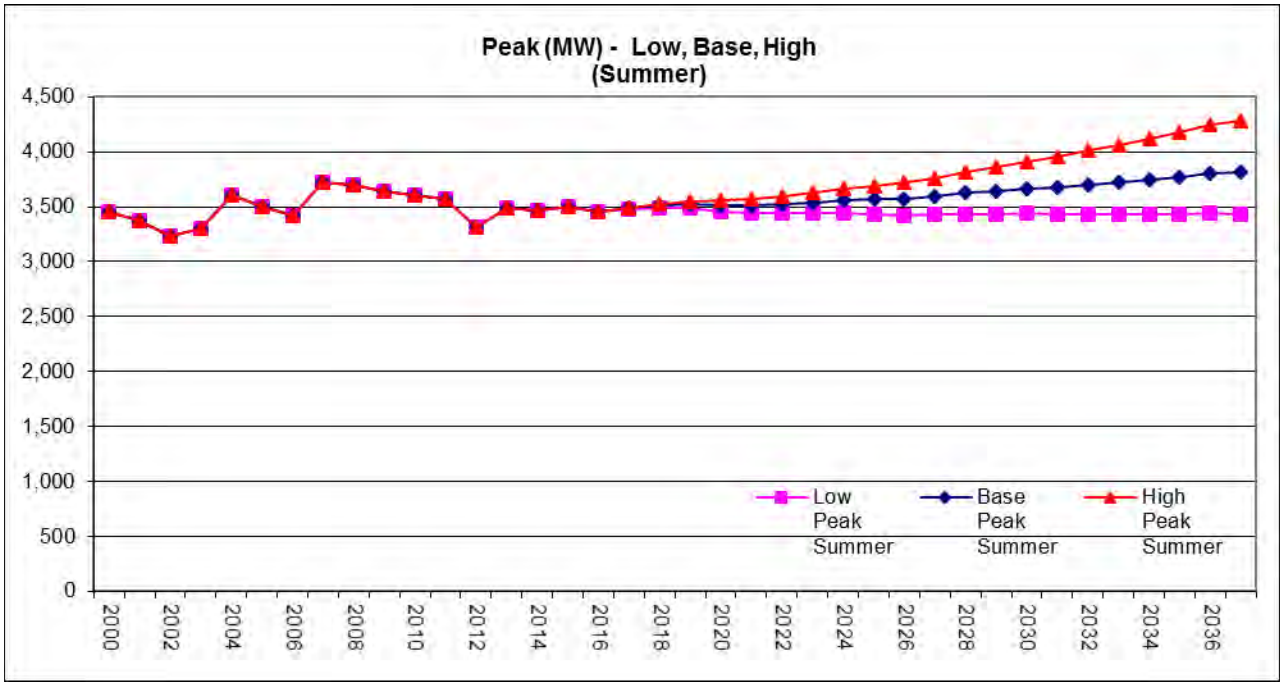
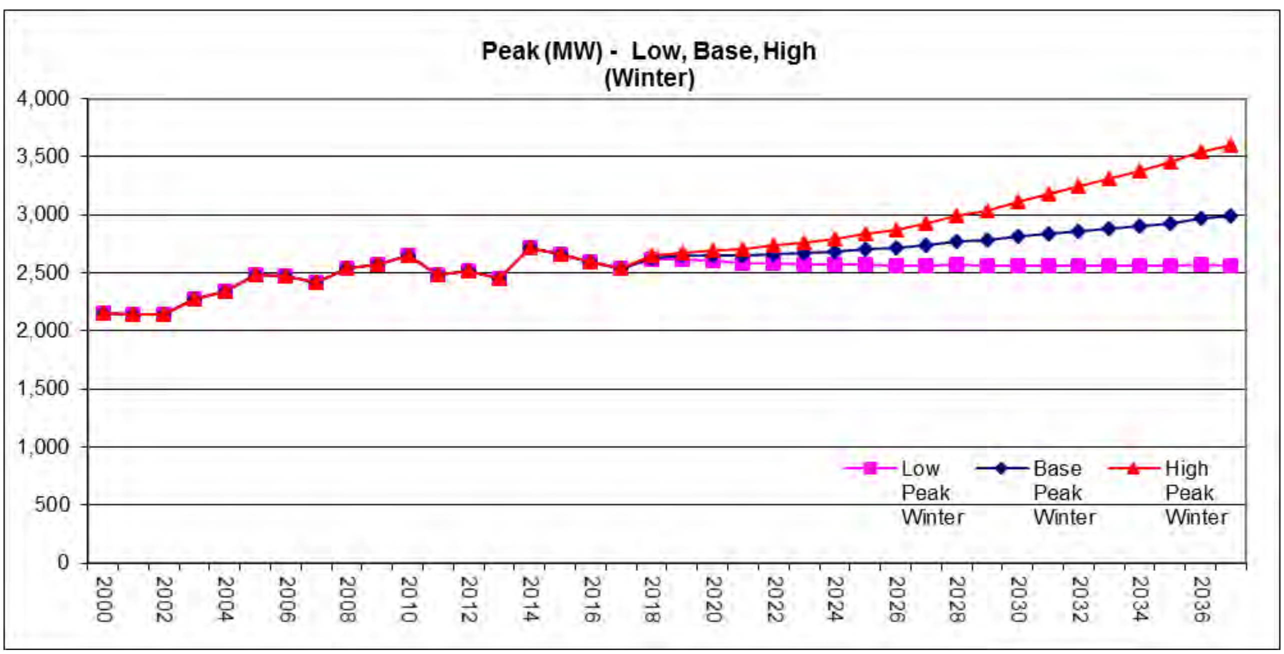


Figure 68: Base-Case, Low-Case, and High-Case Winter Peak Demand Plots



[i] http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html
[ii] Appliance and Equipment Standards Program, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. https://appliance-standards.org/products-and-links.
[iii] Appliance and Equipment Standards Program, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. https://appliance-standards.org/products-and-links.
[iv] Appliance and Equipment Standards Program, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. https://appliance-standards.org/products-and-links.
[v] http://www.eia.gov/analysis/model-documentation.cfm
[vi] See regulatory_programs_mypp.pdf .
[vii] www1.eere.energy.gov/buildings/appliance_standards/commercial/refrig_equip_final_rule.html and www1.eere.energy.gov/buildings/appliance_standards/commercial/automatic_ice_making_equipment.html
[viii] www1.eere.energy.gov/buildings/appliance_standards/commercial/ashrae_products_docs_meeting.html