VOLUME 3

LOAD ANALYSIS AND LOAD FORECASTING

KCP&L GREATER MISSOURI OPERATIONS COMPANY (GMO)

INTEGRATED RESOURCE PLAN

4 CSR 240-22.030

APRIL, 2018

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VOLUME 3 – LOAD ANALYSIS AND LOAD FORECASTING

HIGHLIGHTS

- GMO expects energy consumption to grow 0.9% and peak demand to grow 0.6% annually from 2017-2037.
- Residential energy consumption is expected to provide the most growth over the next 20 years.
- GMO 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;

GMO maintains a historical database of its loads for each major class, which are Residential, Small General Service (SGS), Large General Service (LGS), Large Power (LP), Lighting and Sales for Resale (SFR). In addition, SGS, LGS and LP are split into the subclasses Commercial and Industrial. This data begins in January 1996 for GMO and will be maintained with at least 10 years of history going forward. Beginning with the 2015 IRP filling, GMO forecasts its loads for each major class, which are Residential, Commercial Small General Service (SGS), Commercial Big (The sum of LGS, and LP), Industrial (The sum of SGS, 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 GMO_SystemLoad.ltm. This data is available beginning in 2003 for GMO. Some earlier years are also available. 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 maintained 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.

GMO 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, GMO 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.

Table 1: WN Model for GMO Residential Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	21.312	0.221	96.260	0.00%	
mWthrRevPD.HDD55	0.875	0.012	73.763	0.00%	
mWthrRevPD.CDD65	1.830	0.022	83.109	0.00%	
mBin.May10ToJan11	-0.759	0.379	-2.001	4.75%	
mBin.AfterMay11	-1.077	0.191	-5.644	0.00%	
mBin.Jun06	-3.844	1.060	-3.627	0.04%	

Table 2: WN Model for GMO Small GS Commercial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	161.700	6.068	26.647	0.00%	
mWthrRevPD.CDD65	4.089	0.154	26.599	0.00%	
mWthrRevPD.HDD55	0.873	0.085	10.267	0.00%	
mBin.Feb10	16.882	5.614	3.007	0.32%	
mBin.TrendVar	1.164	0.273	4.271	0.00%	
mBin.Feb2011	15.722	5.692	2.762	0.66%	
AR(1)	0.393	0.081	4.880	0.00%	

Table 3: WN Model for GMO Big GS Commercial Sales (SGS, LGS, & LP)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	161.700	6.068	26.647	0.00%	
mWthrRevPD.CDD65	4.089	0.154	26.599	0.00%	
mWthrRevPD.HDD55	0.873	0.085	10.267	0.00%	
mBin.Feb10	16.882	5.614	3.007	0.32%	
mBin.TrendVar	1.164	0.273	4.271	0.00%	
mBin.Feb2011	15.722	5.692	2.762	0.66%	
AR(1)	0.393	0.081	4.880	0.00%	

Table 4: WN Model for GMO Industrial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	95094.212	1758.611	54.073	0.00%	
mBin.TrendVar	-347.152	78.031	-4.449	0.00%	
mBin.Mar	2657.972	865.358	3.072	0.27%	
mBin.May	2187.496	865.308	2.528	1.28%	
mBin.Aug	2731.467	831.639	3.284	0.14%	
mBin.Oct	2736.719	830.092	3.297	0.13%	
mBin.Nov	3237.856	865.371	3.742	0.03%	
mBin.Jan09	-19972.222	2664.066	-7.497	0.00%	
mBin.Feb09	24670.487	2664.067	9.260	0.00%	
mBin.Nov10	-7719.689	2694.587	-2.865	0.49%	
mBin.Jun08ToSep09	1883.579	767.778	2.453	1.56%	

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 GMO filing, historical sales and customers broken out by class cost of service and commercial and industrial customers was available beginning in January 2000. Going forward, GMO 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 GMO was near 2% during the housing boom of the early 2000s. Beginning in 2008, customer growth slowed to below 1% and slow growth has continued throughout the last 10 years.

GMO SGS Commercial customer growth was negative (-0.5%) in the late 2000s, but has risen slightly since 2012. Growth from 2012 to 2016 averaged 0.4%.

Commercial Big (MGS, LGS, LP) saw rapid customer growth in the late 2000s, averaging 1.9% from 2005 to 2010, but modest growth thereafter, averaging 0.8% since 2010.

Industrial customer growth has largely flat over the last 10 years, averaging 0.2% since 2006.

Residential MWh use per customer reveal a downward trend in both summer (-0.5%) and non-summer usage (-0.7%) since 2010. During the 2000s, summer use per customer was slightly negative at 0.2%, while non-summer use per customer grew 1.7%. The positive trend in non-summer usage was due increasing saturation of electric heat as well as some base load appliances. The current downward trend in summer and non-summer use per customer is due to increasing efficiency of air conditioning units, electric space heat and base load appliances such as refrigerators, lighting, computers, etc.

Commercial SGS has seen a mild decline in use per customer over the last 10 years, for both summer (-0.6%) and non-summer (-0.3%) months.

Commercial Big (MGS, LGS, LP) use per customer been flat since 2006, with summer use per customer growing an average of 0.1% and non-summer use per customer growing 0.2%.

Industrial use per customer few modestly from 2006 to 2010 at a rate of 0.9% during summer months and 0.5 during non-summer. However, use per customer has declined slightly since then for both summer (-0.5%) and non-summer (-0.1%) as industrial production growth has been inconsistent in the GMO service territory.

2.4.2 WEATHER SENSITIVITY OF ENERGY AND PEAK DEMAND

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

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 2016 through June 2017. The blue symbols in the plot represent weekdays and the red symbols represent weekends.

Figure 1: GMO Residential Daily Energy vs Average Temp

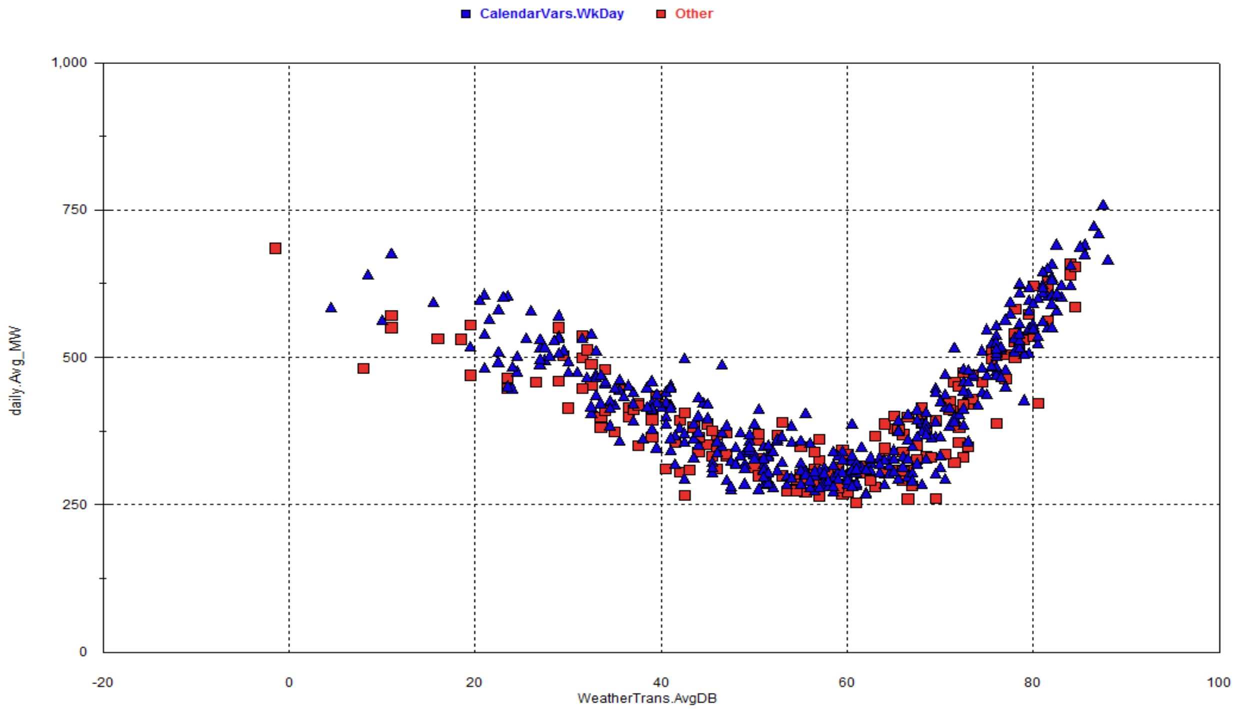


Figure 2: GMO Residential Daily Peak Demand vs Average Temp

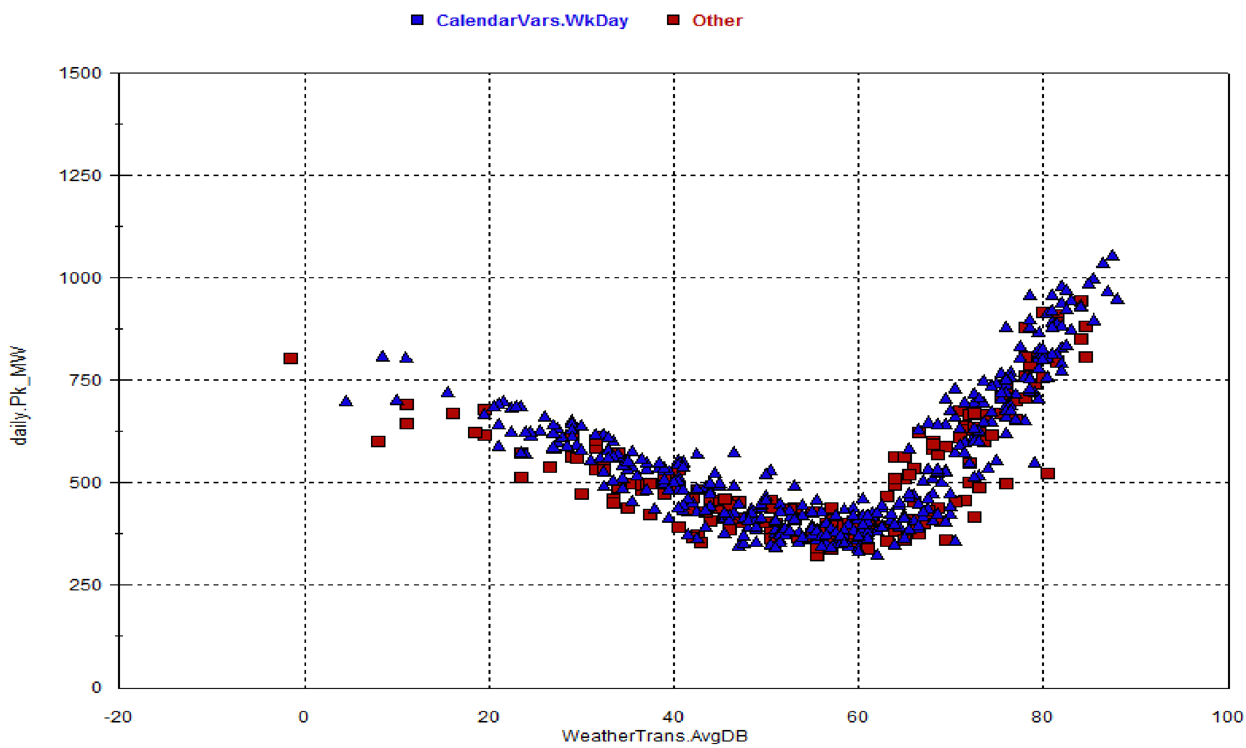


Figure 3: GMO Small General Service Daily Energy vs Average Temp

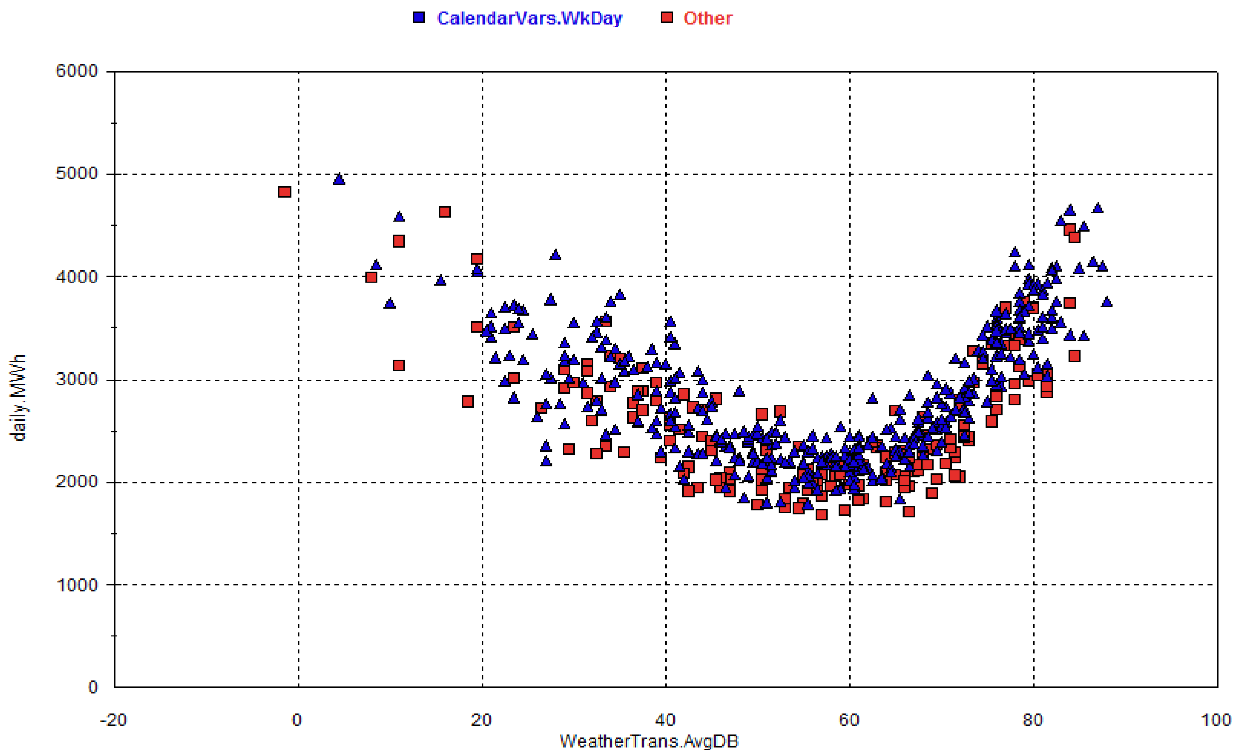


Figure 4: GMO Small General Service Daily Peak vs Average Temp

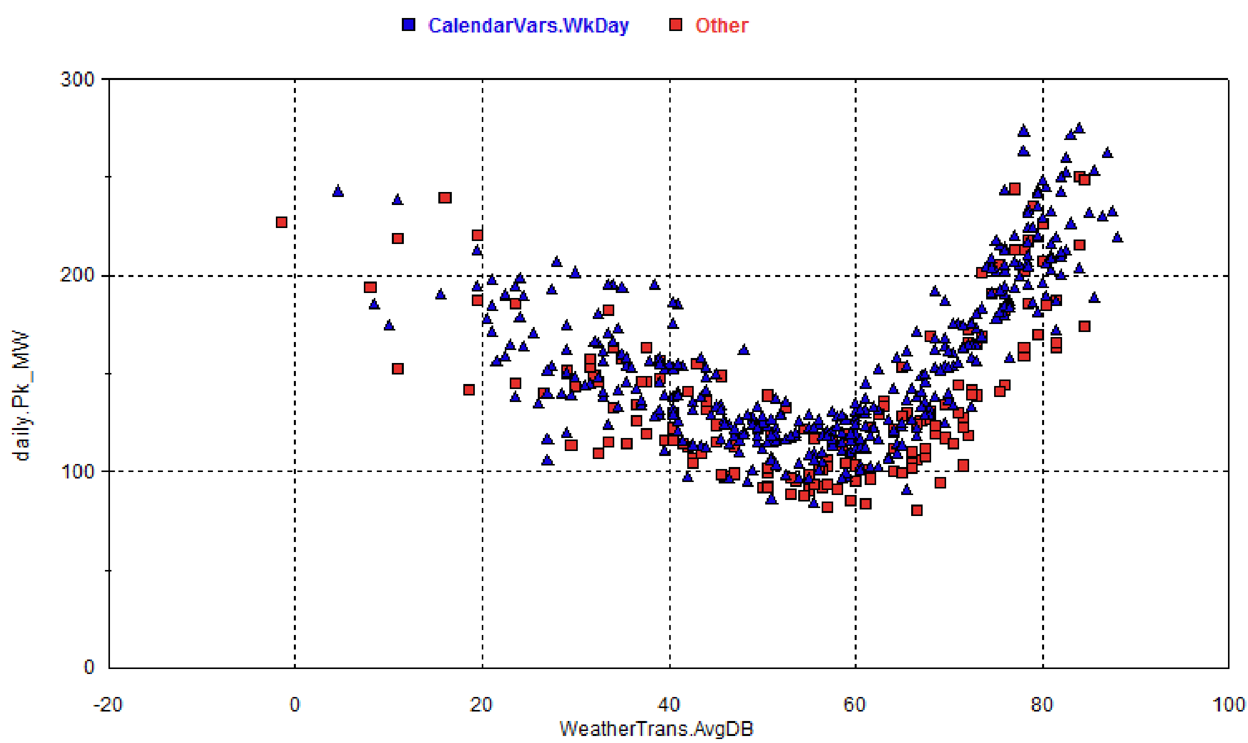


Figure 5: GMO Large General Service Daily Energy vs Average Temp

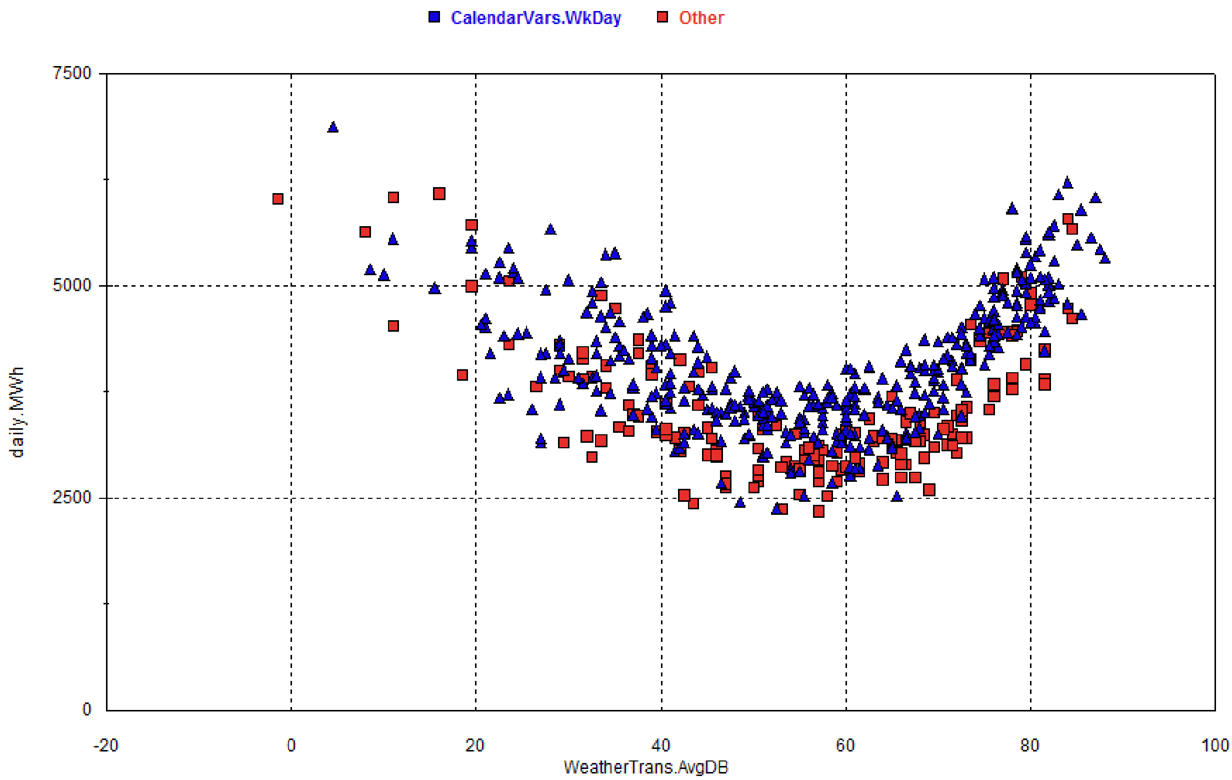


Figure 6: GMO Large General Service Daily Peak Demand vs Average Temp

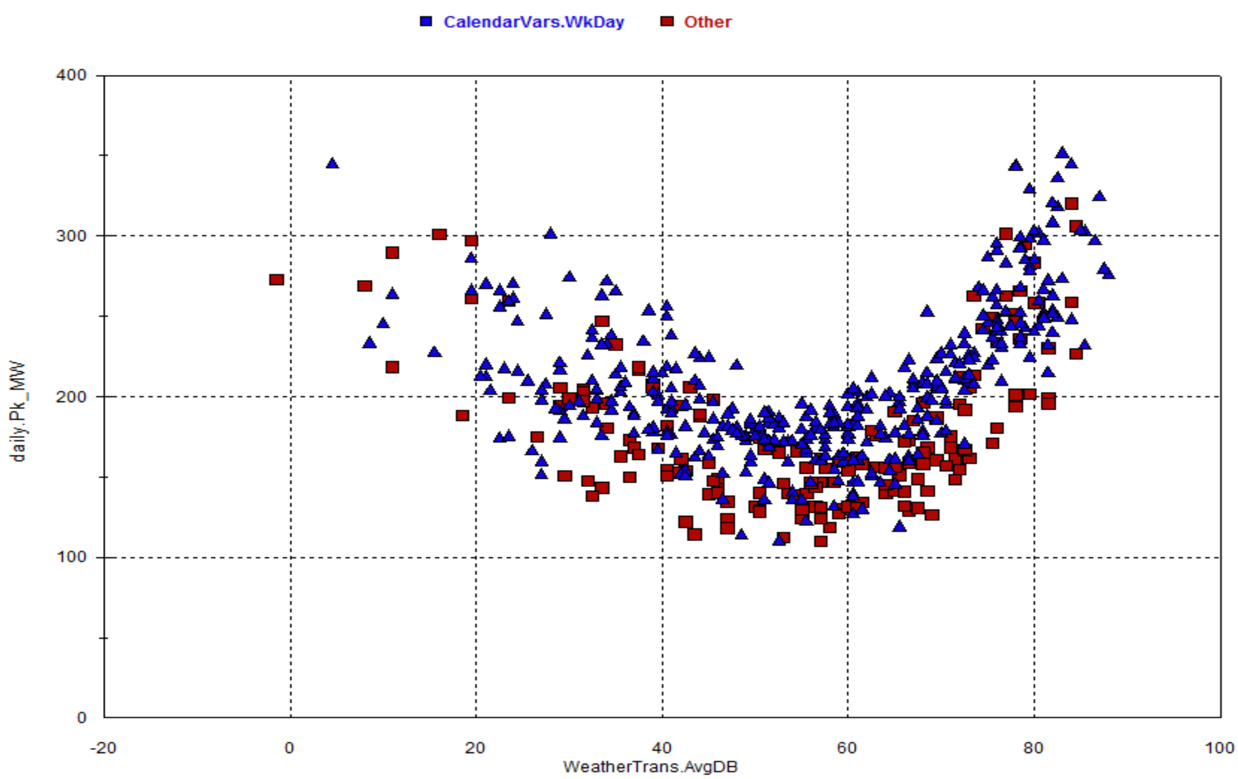


Figure 7: GMO Large Power Daily Energy vs Average Temp

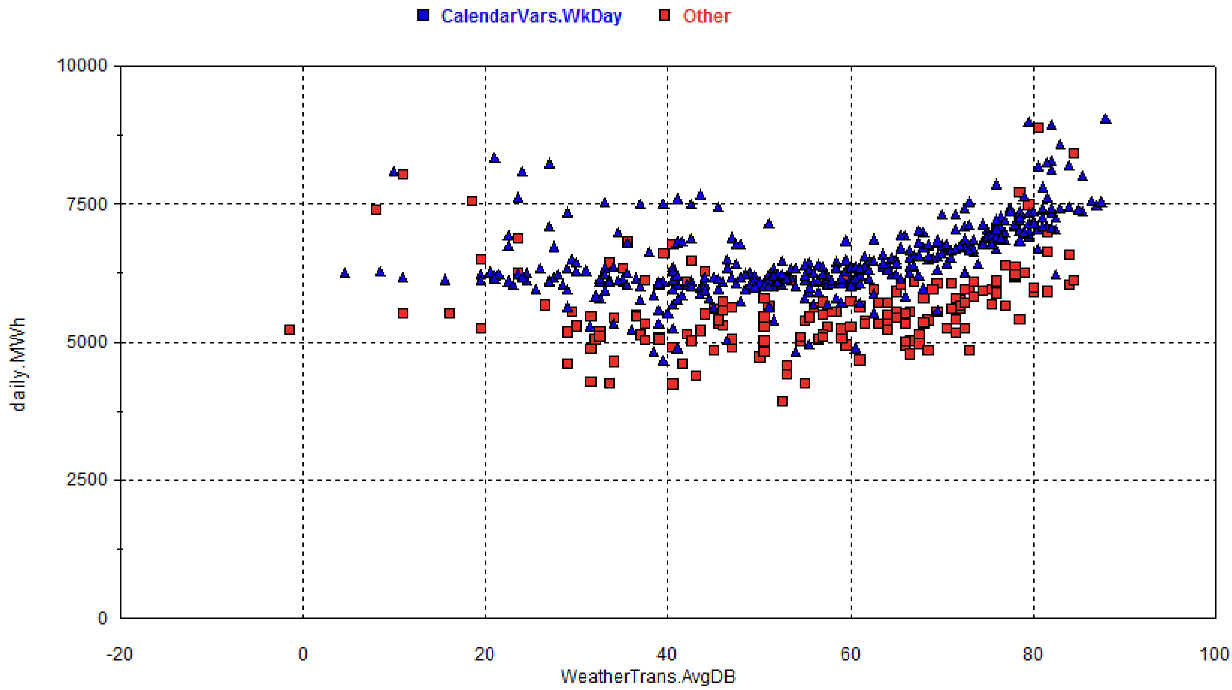


Figure 8: GMO Large Power Daily Peak Demand vs Average Temp

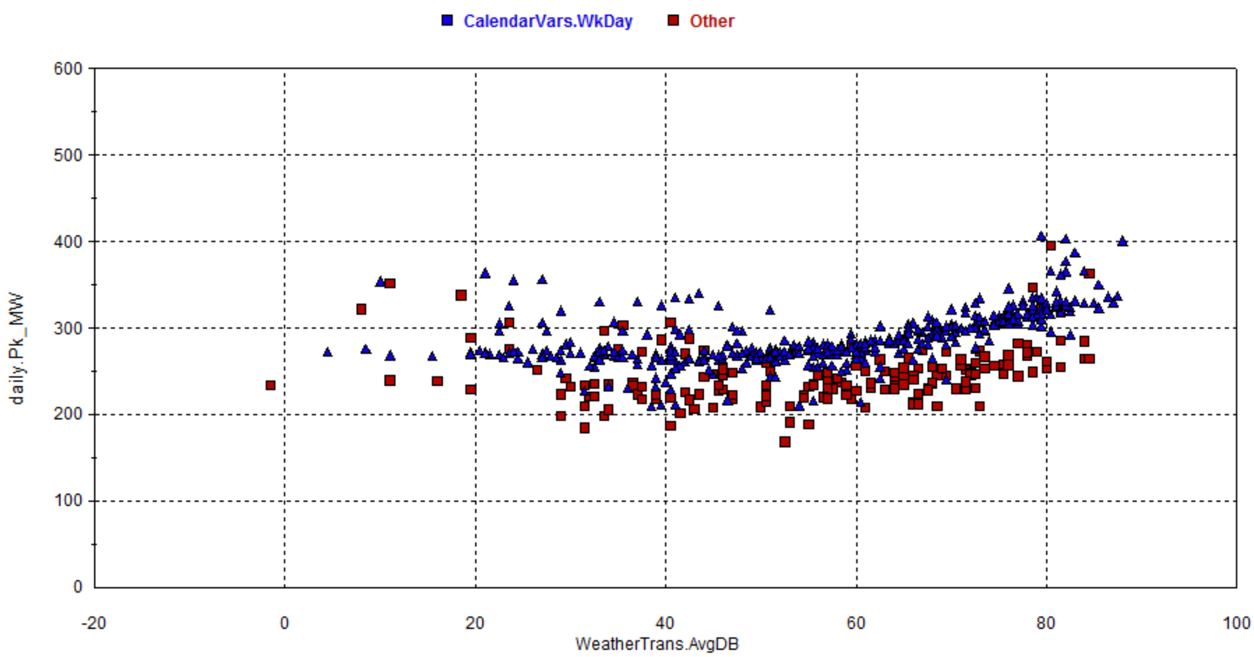


Figure 9: GMO Sales for Resale Daily Energy vs Average Temp

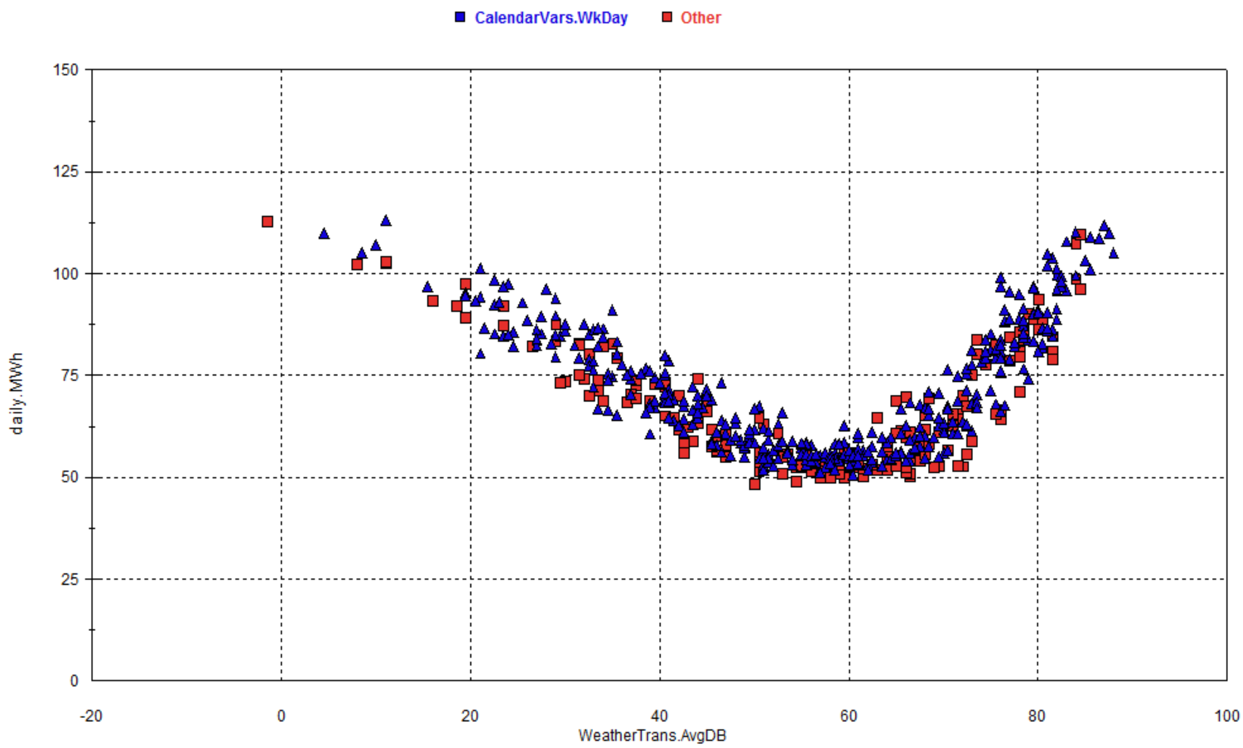
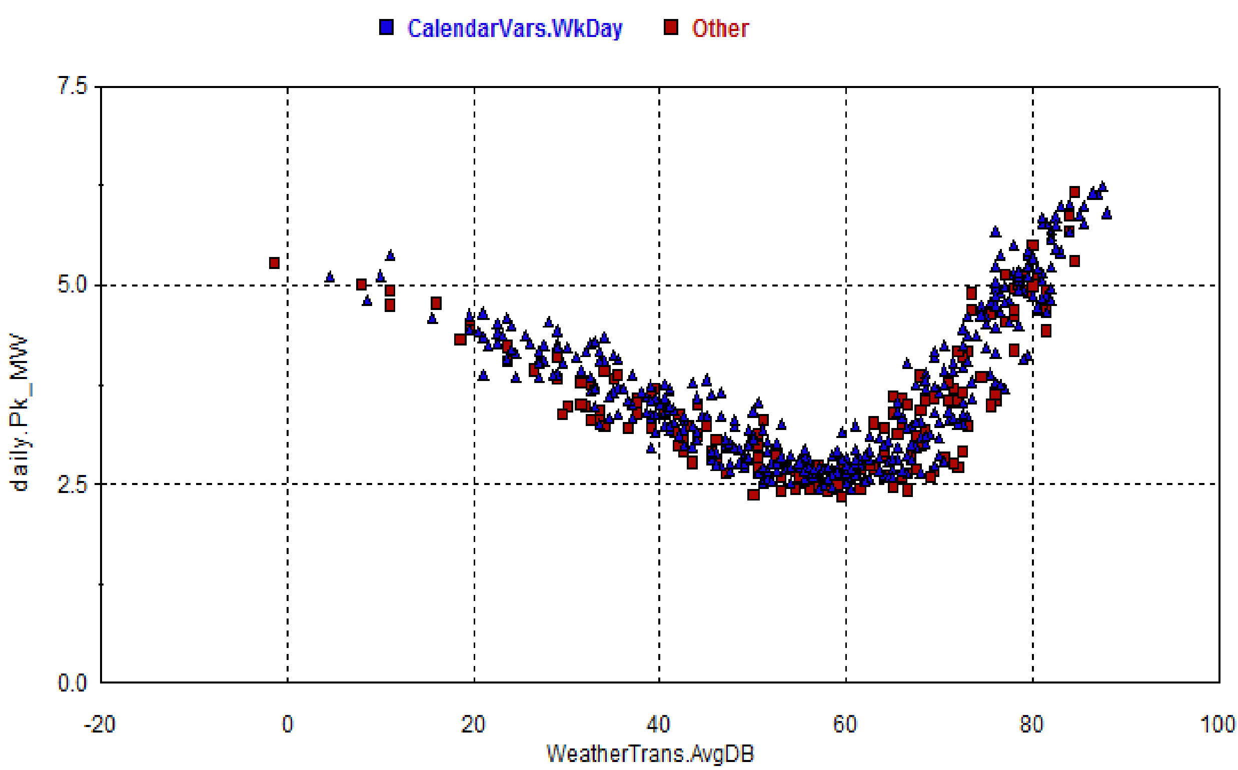


Figure 10: GMO Sales for Resale Daily Peak Demand vs Average Temp



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

GMO 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 GMO, historical sales and customers broken out by class cost of service and commercial and industrial customers was available beginning in January 2000. Going forward, GMO 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 and SJ metro areas from Moody's Analytics was the driver for the number of residential customers of GMO. The KC and SJ metro areas are the same as the Metropolitan Statistical Areas (MSA) defined by the US Census Bureau for KC and SJ and it includes some counties that are not served by GMO. Also, GMO's service areas includes some counties that are not included in the MSA. Despite these inconsistencies in geographic areas, the number of households in the metro areas is a good driver to predict the number of our residential customers because the metro areas each functions economically as a single entity and the metro areas 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\GMO Base Case\Data\Economics and Documentation\Economics*.

GMO 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. This driver was chosen because it has worked well in the past and because most small commercial customers exist to serve households 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, both non-manufacturing employment and non-manufacturing gross metro product were tested 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.

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 GMO\GMO Model Statistics.docx.

Table 5: GMO Residential Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
Economics.Households	318.215	4.560	69.787	0.00%	Thousand
RES_Cust.Dec2007	2001.221	532.055	3.761	0.03%	
RES_Cust.Jan2008	-1509.729	532.052	-2.838	0.53%	
RES_Cust.Jul2008	2091.029	460.923	4.537	0.00%	
AR(1)	0.983	0.019	52.826	0.00%	

Table 6: GMO Small GS Commercial Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	21558.266	1342.816	16.055	0.00%	
ResCustomers.RES_Cust	0.048	0.005	9.816	0.00%	N/A
SML_Cust.Jan14	522.020	239.153	2.183	3.08%	
mBinaryVars.GMOConsolidation	1634.590	126.380	12.934	0.00%	

Table 7: GMO Big GS Commercial Customers (SGS, LGS, & LP)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
Economics.Population	1.226	0.005	246.393	0.00%	Thousand
mBinaryVars.GMOConsolidation	-1397.970	11.938	-117.104	0.00%	
BIG_Cust.July08	-53.808	12.760	-4.217	0.01%	
BIG_Cust.Feb14	-45.824	13.035	-3.515	0.06%	
BIG_Cust.may15	-28.869	12.756	-2.263	2.55%	
BIG_Cust.Feb2017	-330.748	14.076	-23.497	0.00%	
BIG_Cust.Jan2014	57.025	13.029	4.377	0.00%	
BIG_Cust.June2014	-45.946	12.839	-3.579	0.05%	
AR(1)	0.946	0.019	50.261	0.00%	
MA(1)	-0.592	0.080	-7.363	0.00%	

In the model for big commercial customers of GMO, the intercept term dropped since it wasn’t statistically significant. 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 8: GMO Industrial Customers

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	208.723	15.064	13.856	0.00%	
Economics.GP_Non_Man	0.000	0.000	2.456	1.57%	MDollars
IND_Customer.May2012	-17.145	3.234	-5.301	0.00%	
mBinary.Year2013	-5.227	1.596	-3.275	0.14%	
IND_Customer.Expr1	9.633	3.252	2.962	0.38%	
AR(1)	0.382	0.088	4.338	0.00%	

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 end uses for which GMO 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

GMO maintains information on saturations per square foot of floor space and energy use per square foot (EUI) for end uses 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 MPS and SJLP. 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_GMO.xls*. The building types are defined in NEMS to NAICS Mapping*.xls*. The building types are defined in NEMS to NAICS Mapping*.xls*. These spreadsheets were provided to GMO 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 <u>Industrial Sector</u>

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

GMO has a relatively small industrial sector, accounting for approximately 16% of retail sales. GMO lacks the concentration of heavy industry that some utilities have. As such, have modeled our industrial sector with a statistically adjusted employment-based intensity model. Major end uses are heating, cooling and other.

4.1.2 <u>MODIFICATION OF END-USE LOADS</u>

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

4.1.2.1 <u>Removal or Consolidation of End-Use Loads</u>

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, GMO 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 Additions to End-Use Loads

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 GMO 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 GMO 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 Modification of End-Use Documentation

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.

GMO dropped the end uses 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. GMO added well pumps, video game systems and mini\wine refrigerators because these use substantial amounts of energy and GMO 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 <u>SCHEDULE FOR ACQUIRING END-USE LOAD INFORMATION</u>

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.

GMO 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. GMO provided copies of the completed study to stakeholders' group.

4.1.4 <u>WEATHER EFFECTS ON LOAD</u>

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 end uses for that major class.

GMO 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 GMO_BaseHeatCool16.NDM and GMO_LoadEndUse16.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 G*MO_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

GMO has conducted a residential appliance saturation survey every other year since its acquisition by KCP&L. 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 1,623 GMO responses received from residential customers in Missouri. 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.

GMO 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. GMO 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 END-USE ENERGY AND DEMAND ESTIMATES

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 GMO Consolidated. 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;

GMO 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 GMO 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 GMO use the most recently available projections whenever we update our models.

GMO calibrates DOE appliance saturation projections to the saturation numbers that GMO obtain from our residential surveys. GMO 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 GMO attends) 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;

GMO 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.

GMO 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 9: Residential Product Categories Covered by DOE Standards [ii]

Product Covered	Initial Legislation	Last Standard Published	Complianc e 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 10: 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 11: Lighting Product Categories Covered by DOE Standards

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 and SJ metro areas. 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 end uses: heating, cooling and other, and these were then calibrated to monthly billed sales per customer in a linear regression. This is described in *Residential SAE Modeling Framework* in the file *Res2014SAEUpdate.pdf*.

In the models of commercial and 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 or 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 end-use forecast of commercial use for three major end uses: 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 GMO 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;

GMO has used the SAE approach since 2009 to forecast its loads. The economic drivers for the residential sector have been the number of households in the KC and SJ metro areas during this time period. This is the second filling that GMO 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, GMO is using updated projections from DOE for 2017 and June 2017 vintage economic forecasts of the KC and SJ metro areas 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 12: GMO Residential kWh per Customer

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat55_RES	1.092	0.025	43.861	0.00%	
mStrucVars.XCool65_RES	1.212	0.020	62.055	0.00%	Index
mStrucVars.XOther_RES	1.030	0.012	85.078	0.00%	Index
mBinaryVars.Calib	-35.239	8.313	-4.239	0.00%	
RES_AvgUse.Jun06	-109.999	31.390	-3.504	0.06%	
mBinaryVars.Jan	-47.096	23.144	-2.035	4.40%	
mBinaryVars.Aug	32.573	12.685	2.568	1.14%	
mBinaryVars.Sep	32.695	11.287	2.897	0.45%	
mBinaryVars.Nov	-83.787	31.456	-2.664	0.88%	
mBinaryVars.Dec	-61.592	11.397	-5.404	0.00%	
RES_AvgUse.Jan	35.217	24.257	1.452	14.91%	
RES_AvgUse.Nov	40.388	32.510	1.242	21.65%	
AR(1)	0.239	0.092	2.609	1.02%	

Table 13: GMO Small GS Commercial kWh per Customer

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
mStrucVars.XHeat50_SML	0.994	0.052	19.298	0.00%	kWh
mStrucVars.XCool60_SML	1.718	0.047	36.498	0.00%	Kwh
mStrucVars.XOther_SML	0.739	0.008	91.748	0.00%	kWh
mBinaryVars.GMOConsolidation	394.057	52.594	7.492	0.00%	
SML_AvgUse.Calib	-133.562	31.550	-4.233	0.00%	
mBinaryVars.Feb	43.017	17.943	2.397	1.81%	
SML_AvgUse.Expr1	90.347	56.255	1.606	11.10%	
AR(1)	0.547	0.083	6.585	0.00%	

Table 14: GMO Big GS Commercial kWh per Customer (SGS, LGS, & LP)

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	73308175.702	13990588.335	5.240	0.00%	
mStrucVars.XHeat45_BIG	255.781	38.738	6.603	0.00%	kWh
mStrucVars.XCool55_BIG	1177.361	58.453	20.142	0.00%	Kwh
mStrucVars.XOther_BIG	368.829	55.139	6.689	0.00%	kWh
mBinaryVars.GMOConsolidation	-14023185.487	5960129.392	-2.353	2.03%	
BIG_Sales.May2017	-30950550.849	6463784.597	-4.788	0.00%	
BIG_Sales.Expr1	19720598.532	8236643.291	2.394	1.83%	
BIG_Sales.Expr2	-21842182.721	5104291.837	-4.279	0.00%	
mBinaryVars.Jul	-4837587.870	1670962.256	-2.895	0.45%	
BIG_Sales.Expr3	13952110.496	5186270.821	2.690	0.82%	
AR(1)	0.689	0.067	10.332	0.00%	

Table 15: GMO Industrial Sales

Variable	Coefficient	StdErr	T-Stat	P-Value	Units
CONST	82448006.291	7397566.404	11.145	0.00%	
mStrucVars.XCool60_IND	2159.133	2147.531	1.005	31.70%	
mStrucVars.XOther_IND	4667.430	1441.956	3.237	0.16%	
mBinary.year2009	-6182819.645	952528.371	-6.491	0.00%	
IND_Sales.Jan2010	-14428724.749	2944331.183	-4.901	0.00%	
IND_Sales.Feb2010	12223151.407	3044765.065	4.014	0.01%	
IND_Sales.Jun12	10762714.101	3056707.426	3.521	0.06%	
IND_Sales.Jan15	7652212.129	2946578.658	2.597	1.07%	
mBinary.Feb	3777206.081	1105386.855	3.417	0.09%	
mBinary.Apr	2793485.906	1054274.867	2.650	0.93%	
mBinary.May	3640142.896	1213984.866	2.999	0.34%	
mBinary.Jun	7720813.998	2148786.930	3.593	0.05%	
mBinary.Jul	10998324.193	3346576.973	3.286	0.14%	
mBinary.Aug	13559922.753	3538217.188	3.832	0.02%	
mBinary.Sep	9445994.358	2813917.596	3.357	0.11%	
mBinary.Oct	6759267.214	1538440.833	4.394	0.00%	
mBinary.Nov	5819414.438	1127801.198	5.160	0.00%	
IND_Sales.Calib	-3507431.144	752985.584	-4.658	0.00%	
IND_Sales.Jul09	-9523688.547	3179022.609	-2.996	0.34%	

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 and SJ metro areas that was produced by Moody's Analytics. The metro areas are 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 GMO. Also, GMO'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 \GMO 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.[iv] GMO also relies on the staff that developed and maintained some of EPRI's end-use models recommended and developed the SAE approach for GMO and many other utilities. EPRI no longer maintains its end-use forecasting models.

A potential downside of these projections for GMO is that the data and models developed by DOE are developed at a regional level rather than specifically for GMO, 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).

GMO 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 GMO 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 GMO 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.

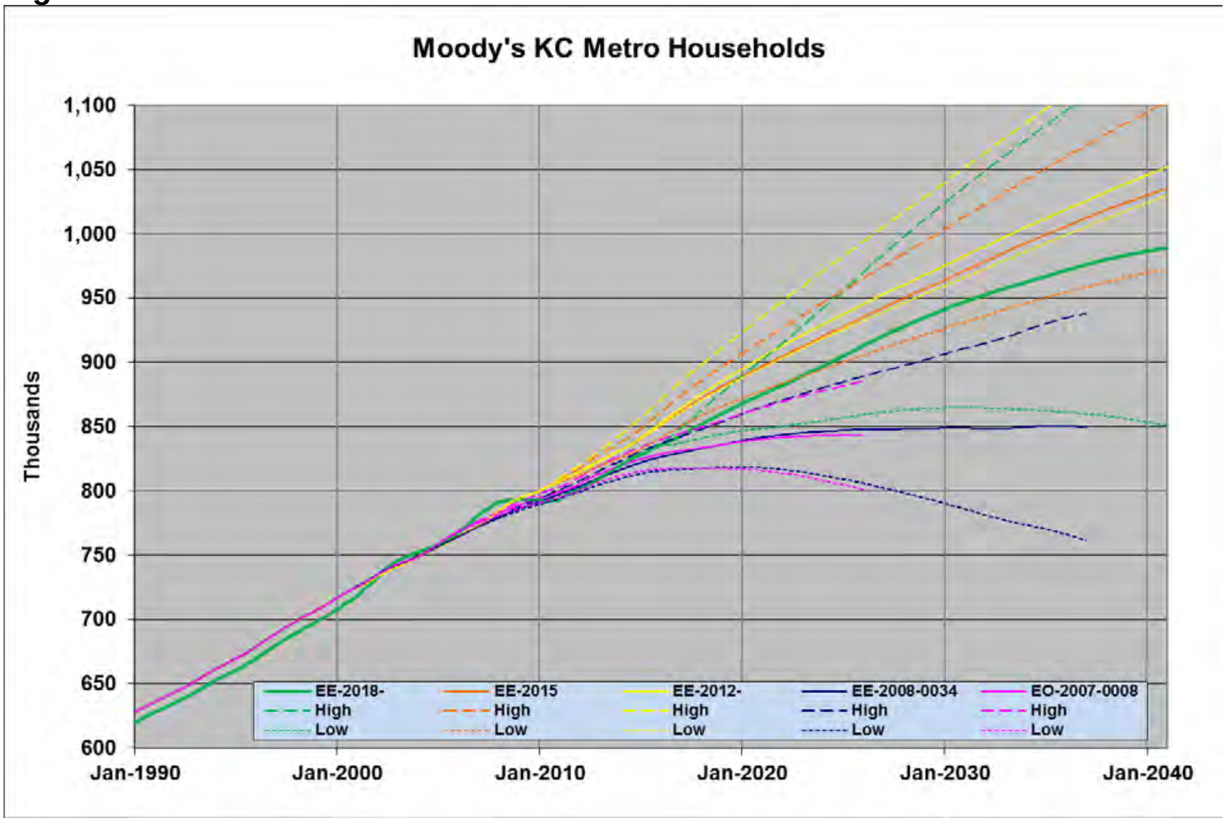
2. Explain any adjustments that it made to historical data prior to using it in its development of the forecasting models;

GMO 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

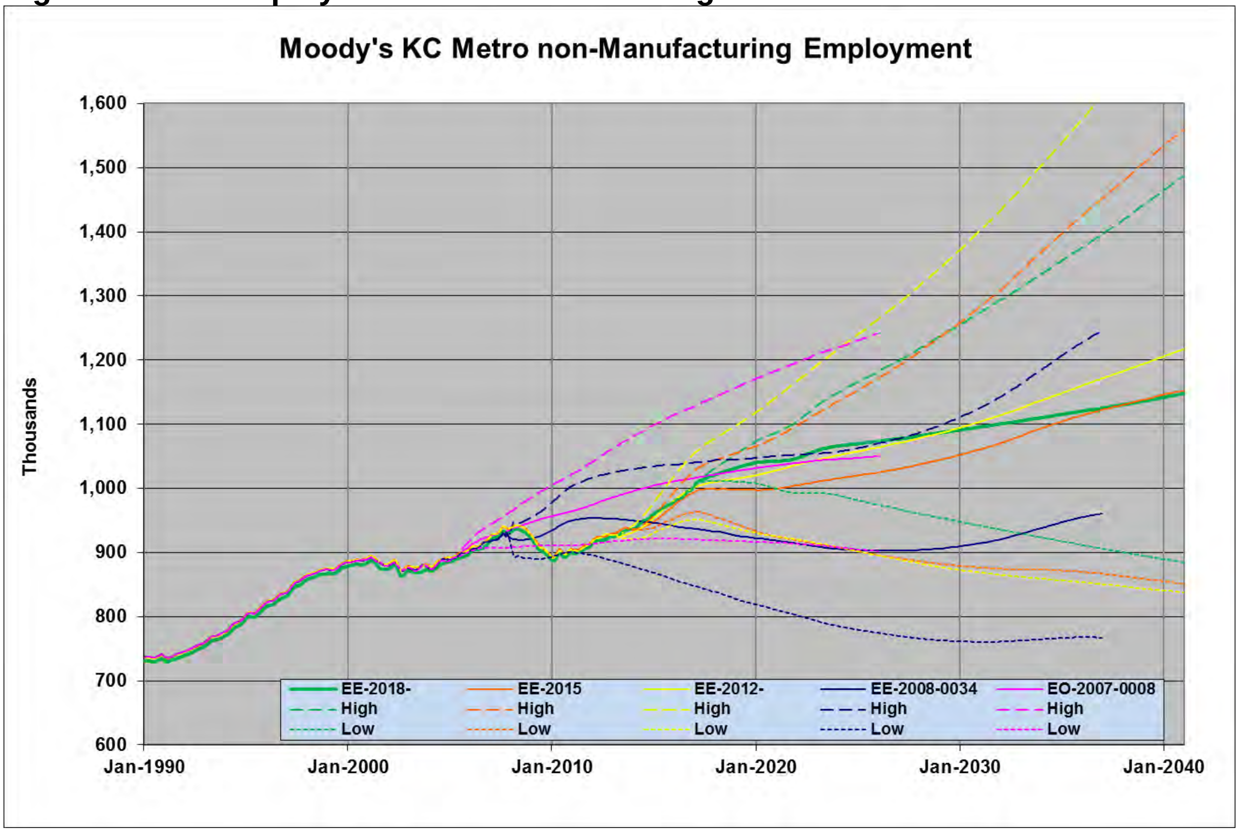
GMO still possesses the electronic files that it received with the independent variables used in producing energy and peak forecasts during the last ten years. Below GMO plots the base, high and low bands for the most important economic and demographic independent variables used in the current and two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

Figure 11: KC Households



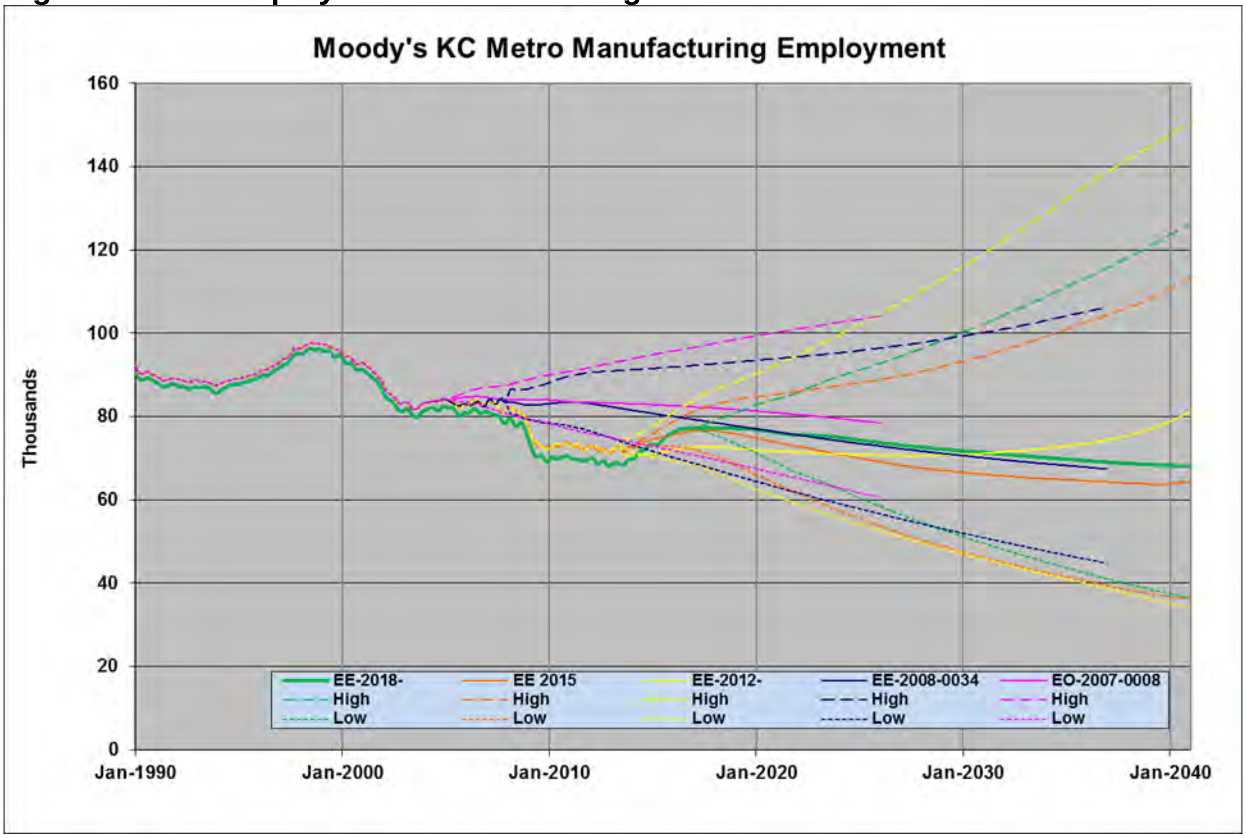
The current forecast for households is significantly lower than previous forecasts; however, it is due to some of the historical data being restated. The slope of the forecast is very similar to the 2015 forecast until about 2035 when it decelerates. The range for the high and low bands is significantly 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 12: KC Employment Non-Manufacturing



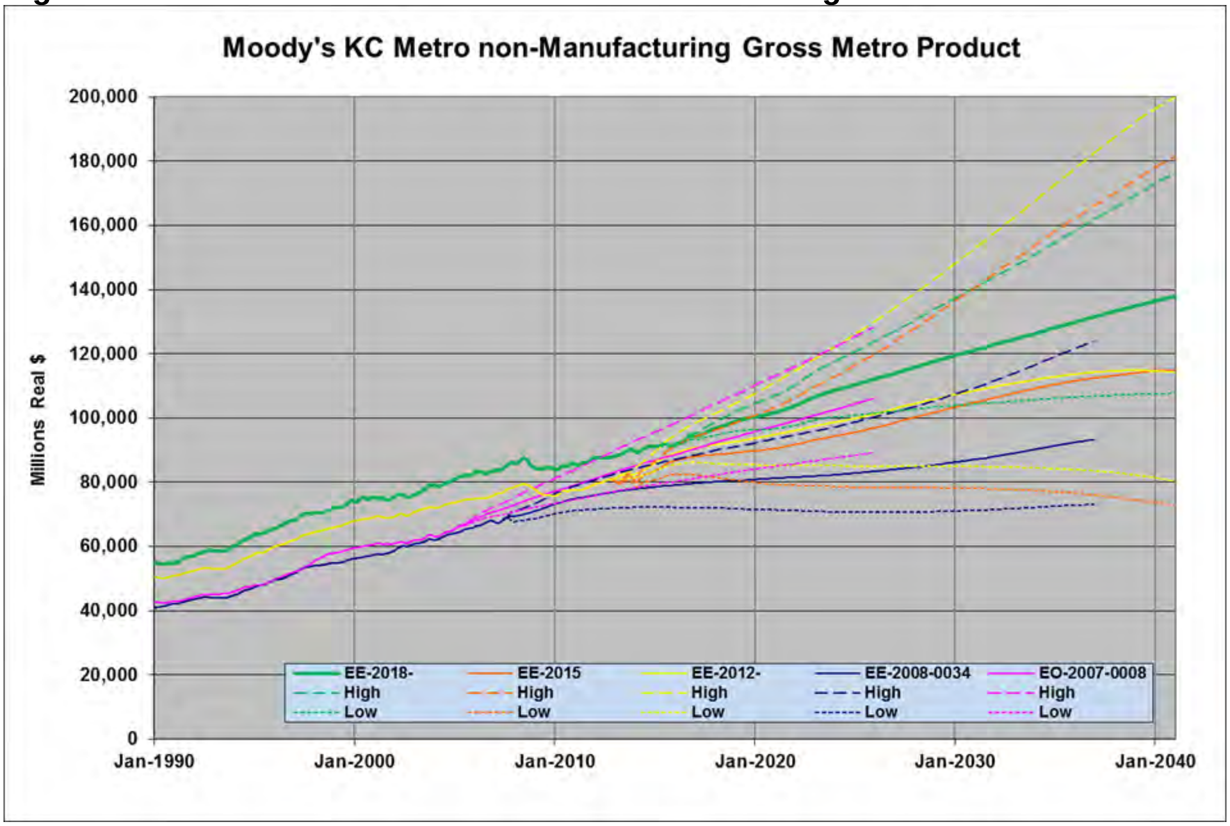
The 2018 forecast of non-manufacturing employment shows stronger growth than previous forecasts through 2020, but slower growth thereafter. The 2012 and 2015 forecast of non-manufacturing employment shows a substantial drop during and several years after the last recession, then a rapid rebound and then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

Figure 13: KC Employment Manufacturing



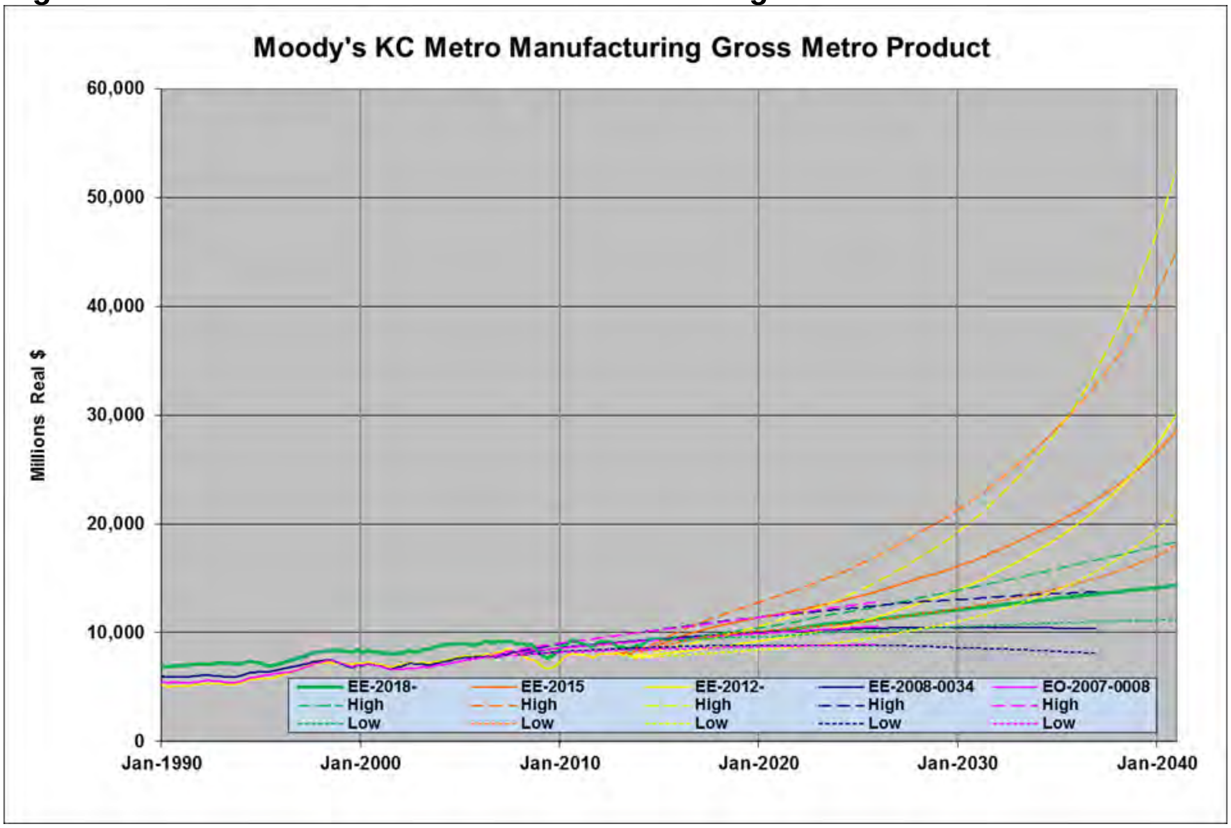
Manufacturing employment shows a large decline following the 2008 recession. It climbed from a 2013 low until stalling in 2016 and is projected to slowly decline throughout the forecast period. Moody's indicates that the decline in employment for manufacturing workers is due to increased productivity 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 14: KC Gross Metro Product Non-Manufacturing



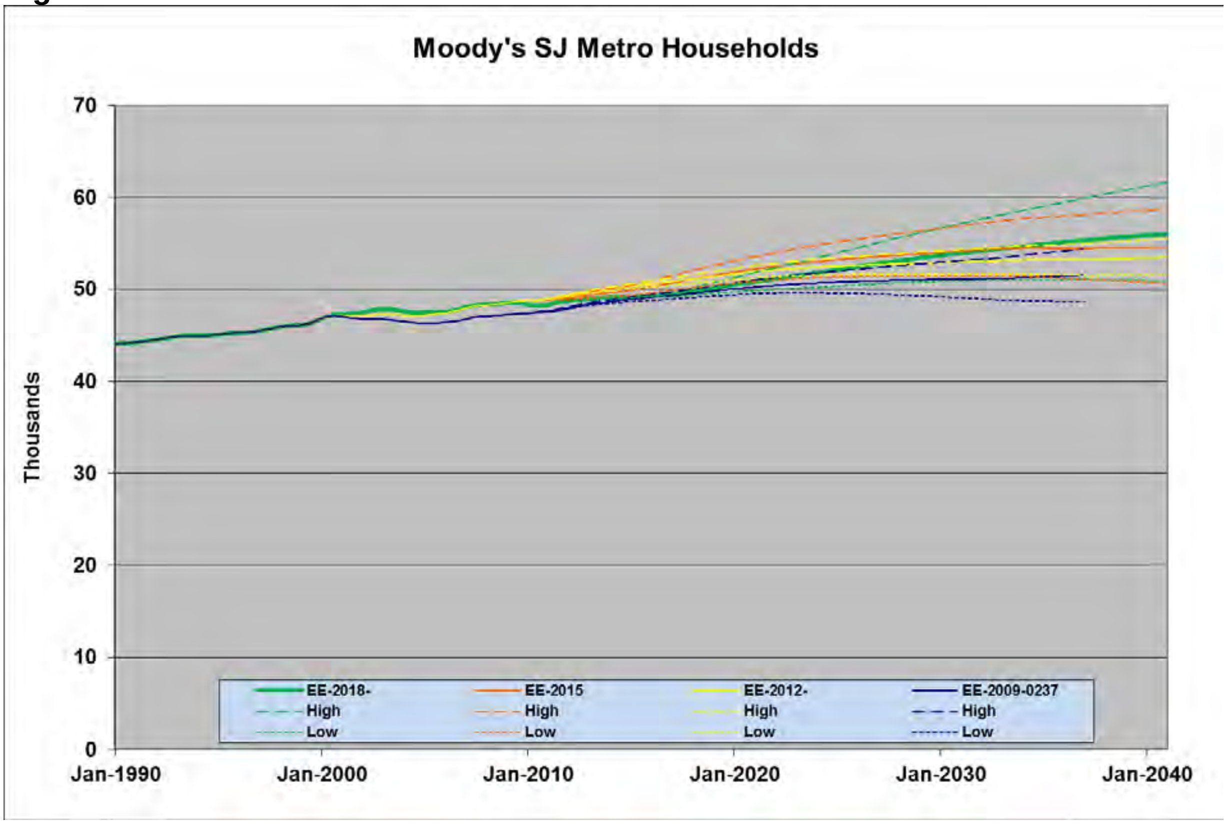
Real non-manufacturing GMP is growing much faster than employment in all three scenarios. The current forecast is higher than previously forecasted due to revised historical figures; the positive growth trajectory is slower in the short-term, but faster in the long-term.

Figure 15: KC Gross Metro Product Manufacturing



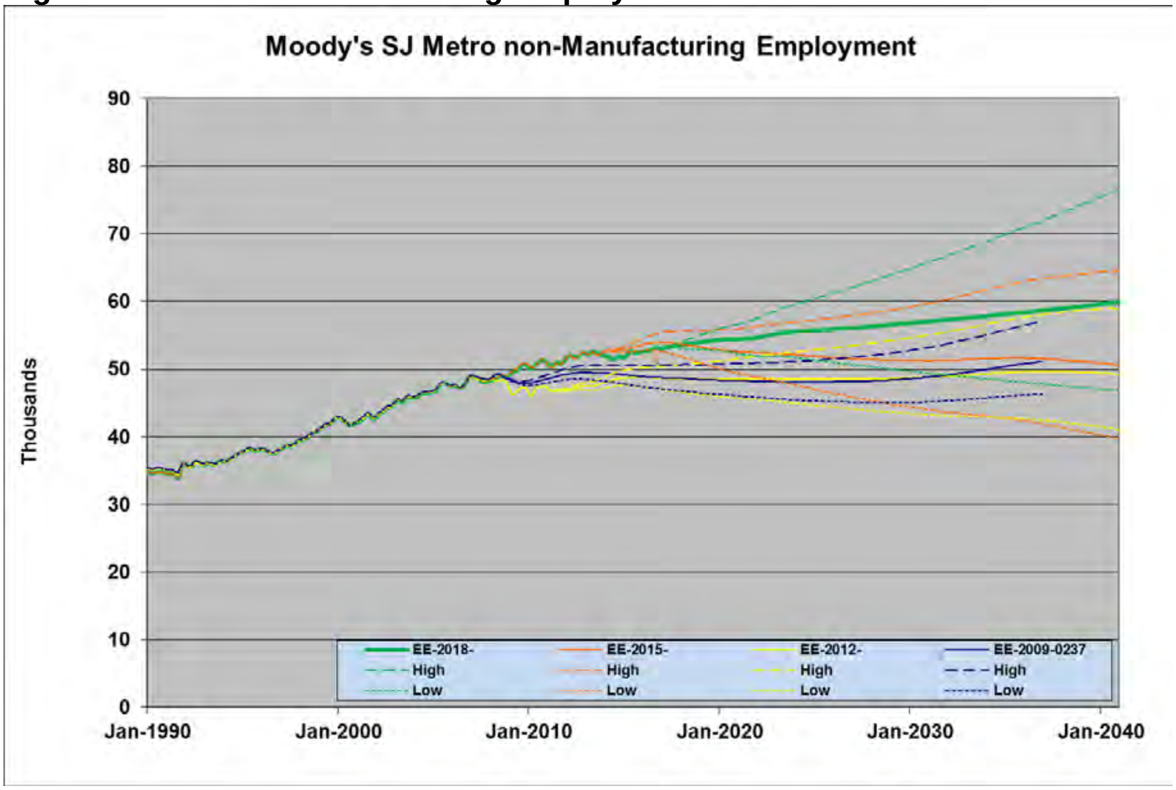
The current forecast for Manufacturing Gross Metro Product shows slow growth throughout the forecast period. Previous Economic forecasts showed rapid growth for two reasons: (1) growth in manufacturing employment in the long run and (2) a competitive advantage for the area in manufacturing leading to 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.

Figure 16: SJ Households



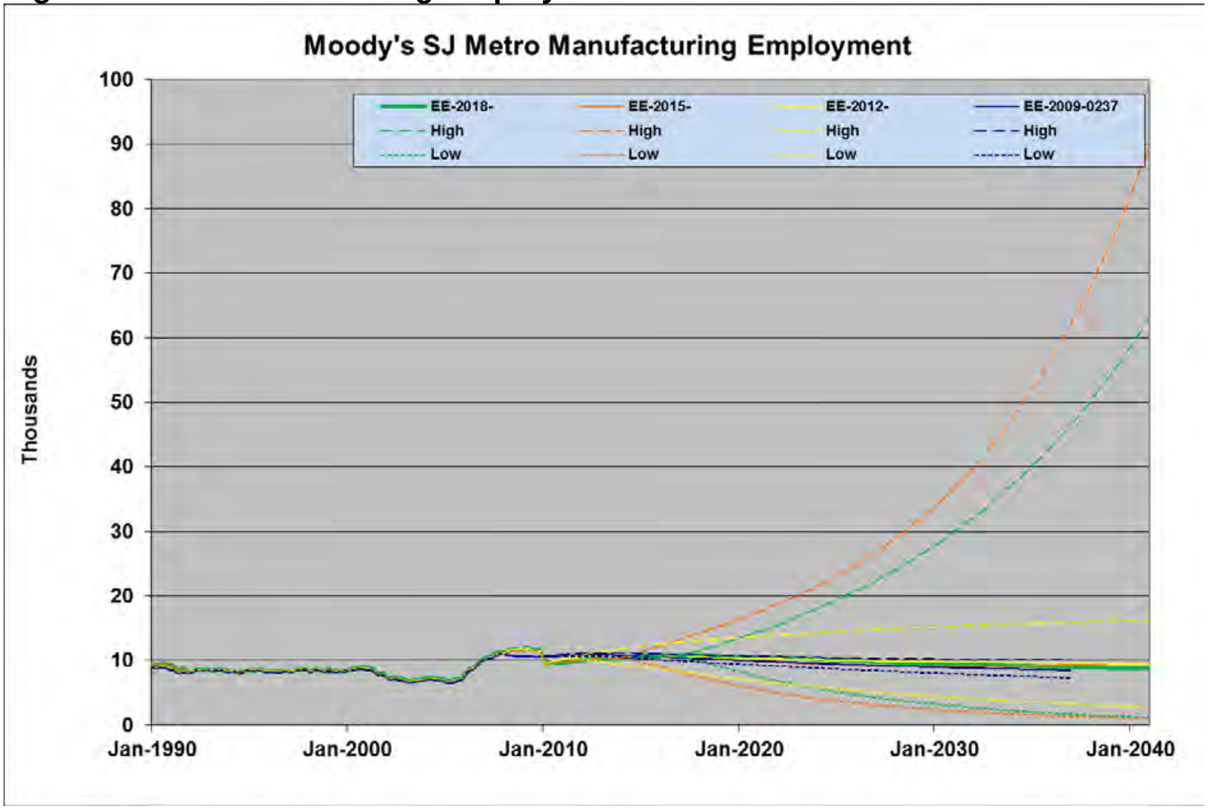
The historical data was restated beginning the year 2000. The number of households is lower than previously forecast through 2030. The growth of households accelerates after 2030. The slope of the forecast is very similar to the 2015 forecast until about 2025 when it accelerates. The range for the high 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 17: SJ non-Manufacturing Employment



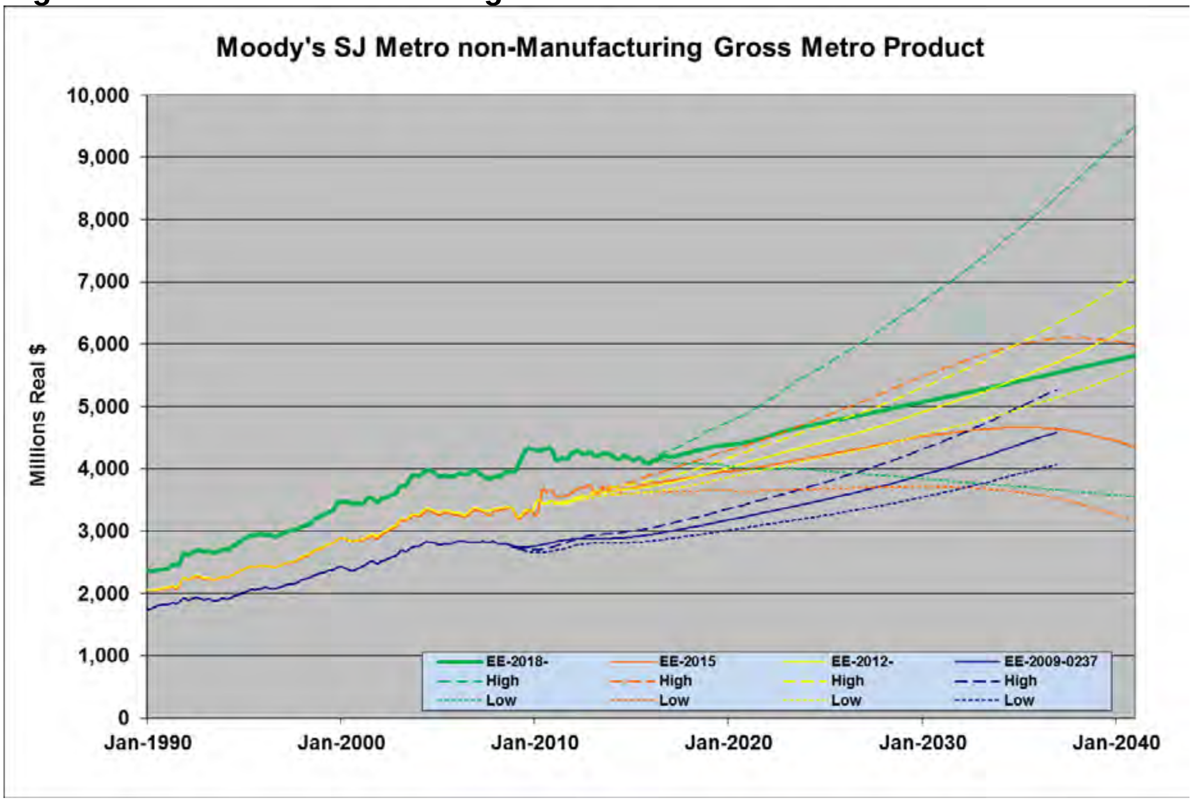
The 2018 forecast of non-manufacturing employment shows stronger growth than previous forecasts through the forecast period. The 2012 and 2015 forecast of non-manufacturing employment shows a substantial drop during and several years after the last recession, then a rapid rebound and then steady robust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

Figure 18: SJ Manufacturing Employment



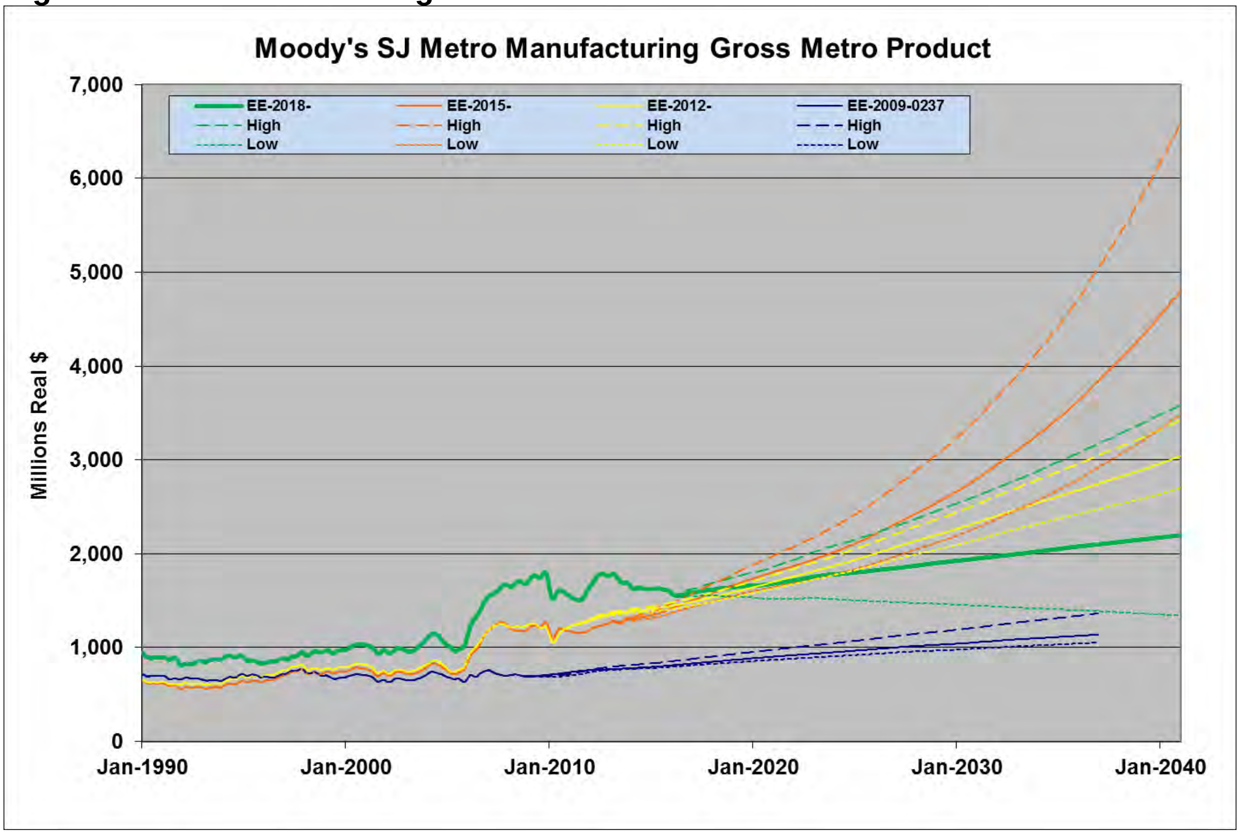
Manufacturing employment is projected to slowly decline throughout the forecast period. Moody's indicates that the decline in employment for manufacturing workers is due to increased productivity from the workers, as manufacturing becomes more automated. The decline in manufacturing employment for the forecast horizon is also consistent with the observed trend dating back to the 1990s.

Figure 19: SJ non-Manufacturing Gross Metro Product



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 20: SJ Manufacturing Gross Metro Product



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.

GMO 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 reflects a significant slowdown in economic growth that 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 21: GMO Net System Input (NSI) Historical and Forecasts

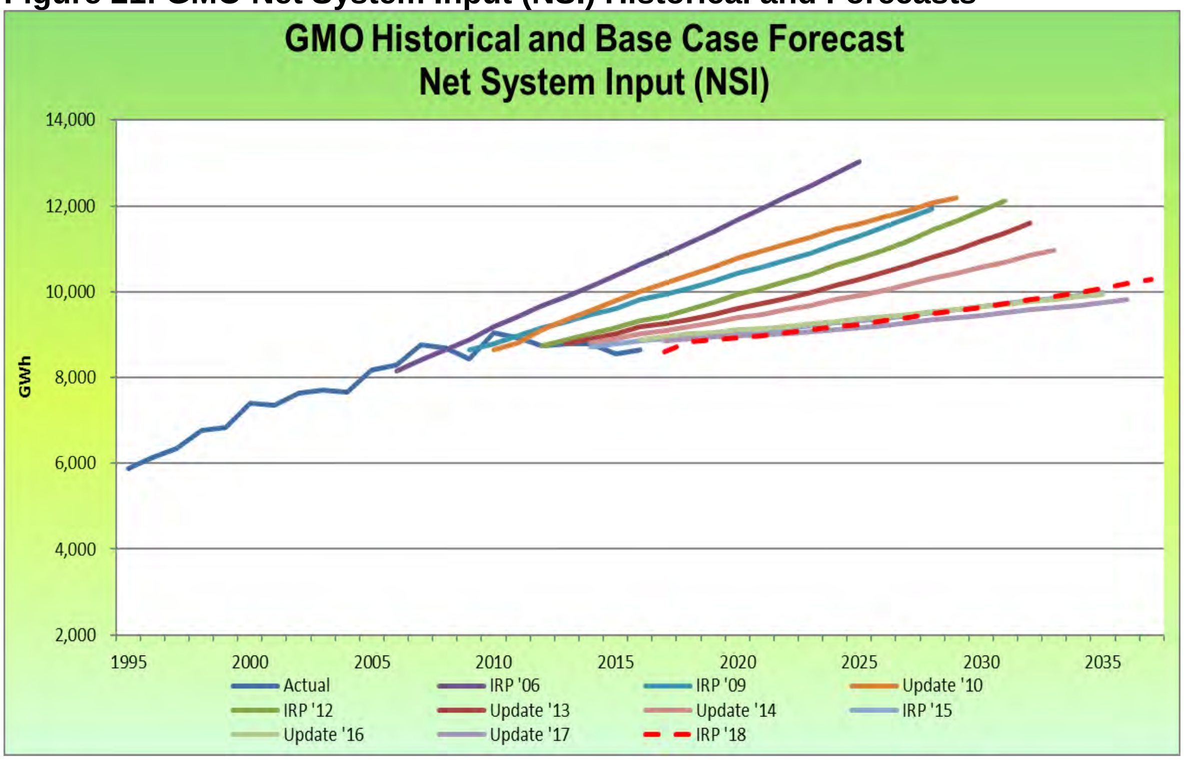
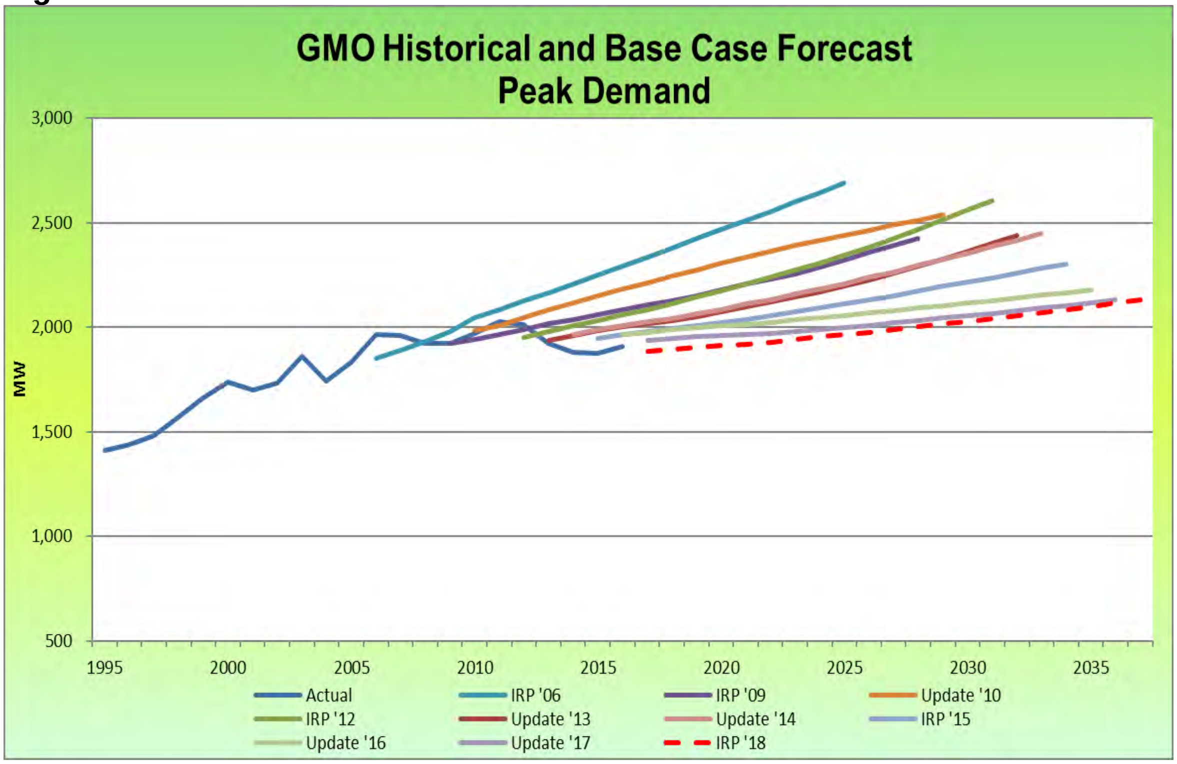


Figure 22: GMO Peak Demand Historical and Forecasts



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.

GMO'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 GMO'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.

GMO 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, GMO 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 GMO has made some small changes to these values to improve the fit of the models.

In the residential models of kWh per customer, GMO 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 and SJ metro areas was 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.

GMO 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.[v]

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).

GMO 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 <u>DESCRIBE AND DOCUMENT WEATHER NORMALIZED CLASS LOADS</u>

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 can be found in the GMO_SystemLoad in the ENDUse_Energy Frequency Transforms.

Figure 23: Estimates of GMO Residential Monthly Cooling, Heating, and Base

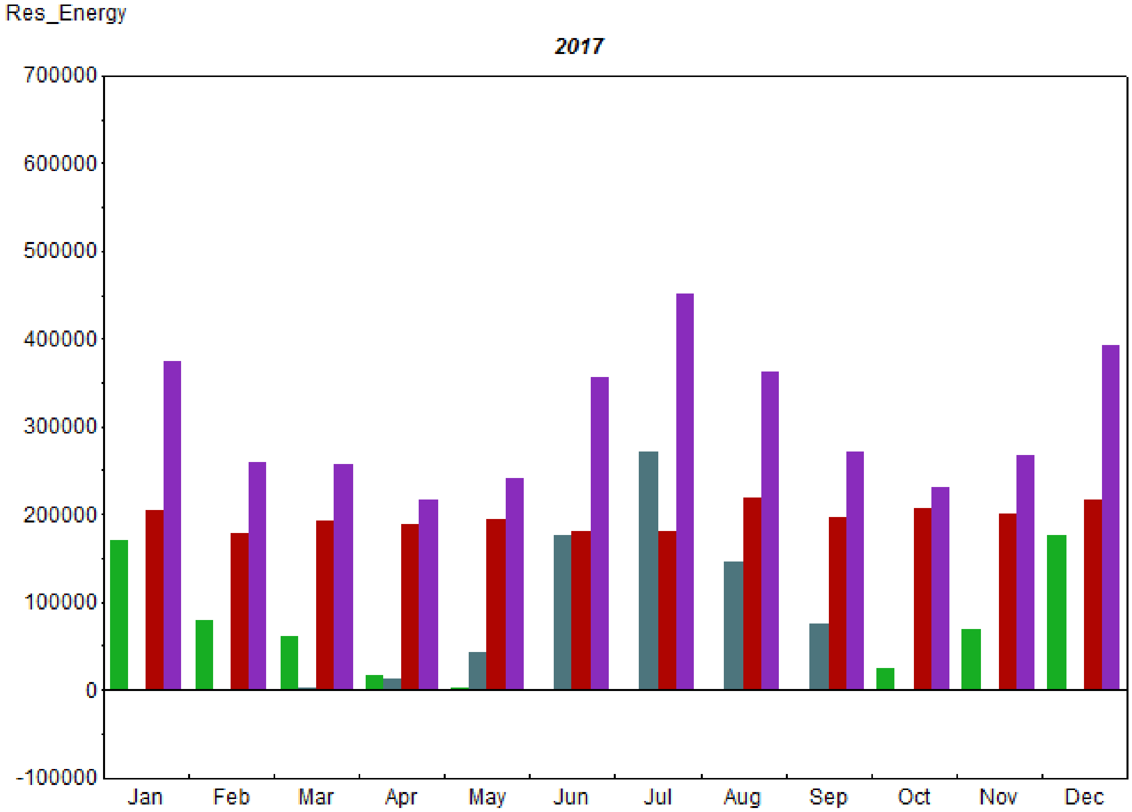


Table 16: Data Table of GMO Residential Monthly Cooling, Heating, and Base

Date	ResHeat	ResCool	ResBase	ResTotal
Jan-17	169,567	0	204,217	373,783
Feb-17	79,644	13	179,144	258,800
Mar-17	61,685	3,143	192,284	257,112
Apr-17	15,590	13,057	187,222	215,869
May-17	3,215	41,950	195,230	240,395
Jun-17	0	175,260	179,920	355,181
Jul-17	0	271,335	180,407	451,743
Aug-17	0	145,149	217,602	362,751
Sep-17	0	74,728	196,442	271,170
Oct-17	24,046	623	205,386	230,055
Nov-17	67,970	4	199,517	267,490
Dec-17	176,949	-4	215,750	392,695

Figure 24: Estimates of GMO Commercial Small General Service Monthly Cooling, Heating, and Base

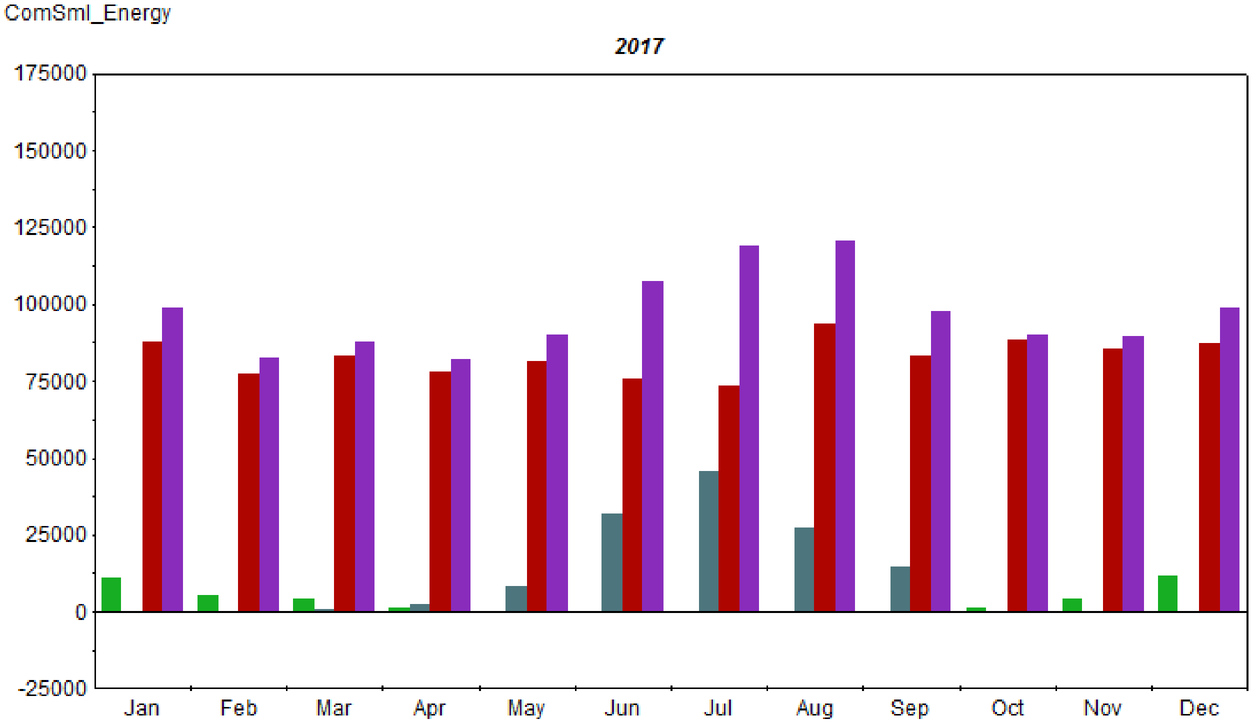


Table 17: Data Table of GMO Small General Service Monthly Cooling, Heating, and Base

Date	ComSmlHeat	ComSmlC	ComSmlB	ComSmlTotal
Jan-17	10,924	0	87,640	98,564
Feb-17		0	77,279	82,428
Mar-17	5,148	630	83,092	87,706
Apr-17	3,984	2,641	78,111	81,757
May-17	1,006	8,244	81,451	89,902
Jun-17	207	31,552	75,792	107,344
Jul-17	0	45,541	73,352	118,893
Aug-17	0	27,213	93,380	120,593
Sep-17	0	14,365	83,133	97,498
Oct-17	1,528	116	88,580	90,224
Nov-17	4,361	0	85,321	89,682
Dec-17	11,355	0	87,238	98,593

Figure 25: Estimates of GMO Big Commercial (SGS, LGS, & LP) Monthly Cooling, Heating, and Base

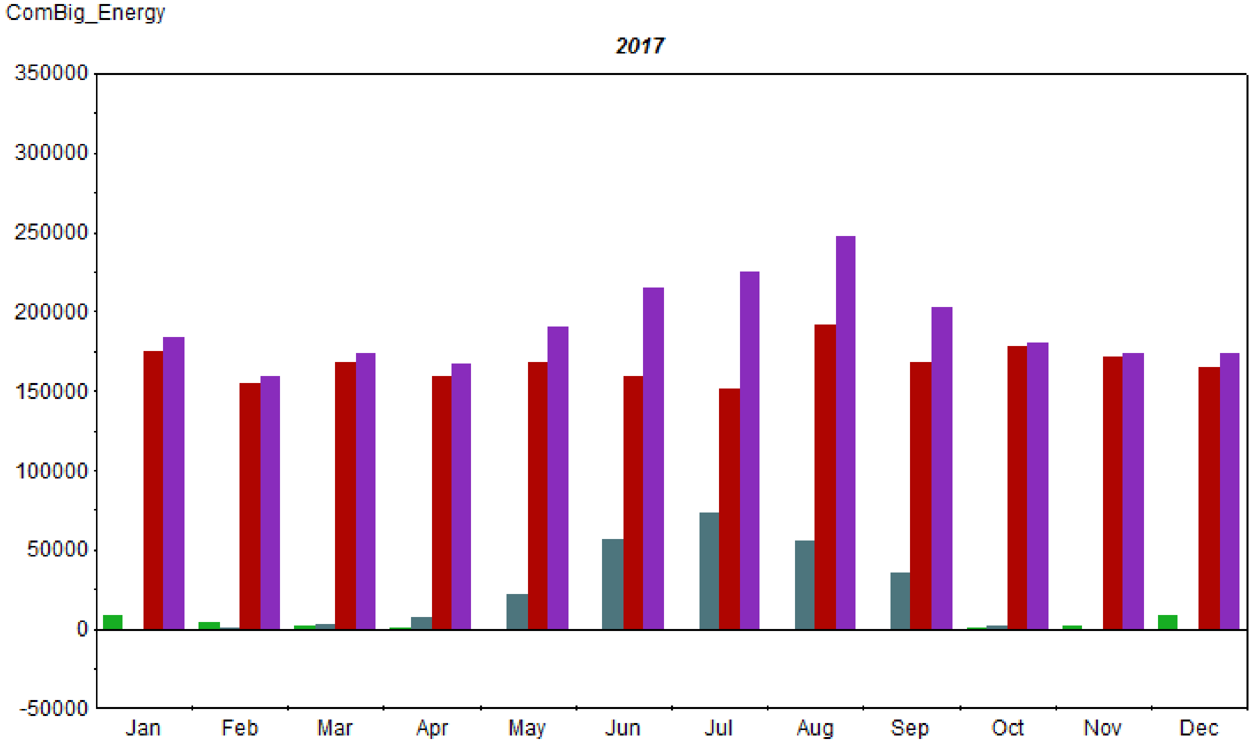


Table 18: Data Table of GMO Big Commercial (SGS, LGS, & LP) Monthly Cooling, Heating, and Base

Date	ComBigHeat	ComBigCool	ComBigBase	ComBigTotal
Jan-17	8,249	0	175,201	183,449
Feb-17	3,624	554	155,150	159,327
Mar-17	2,322	3,059	167,985	173,366
Apr-17	217	7,938	158,802	166,958
May-17	28	22,167	167,745	189,940
Jun-17	0	56,479	158,615	215,094
Jul-17	0	72,907	151,831	224,737
Aug-17	0	54,981	191,888	246,869
Sep-17	0	35,510	167,595	203,105
Oct-17	554	1,481	178,357	180,391
Nov-17	2,074	0	171,445	173,519
Dec-17	8,635	0	164,629	173,264

Figure 26: Estimates of GMO Industrial Monthly Cooling, Heating, and Base

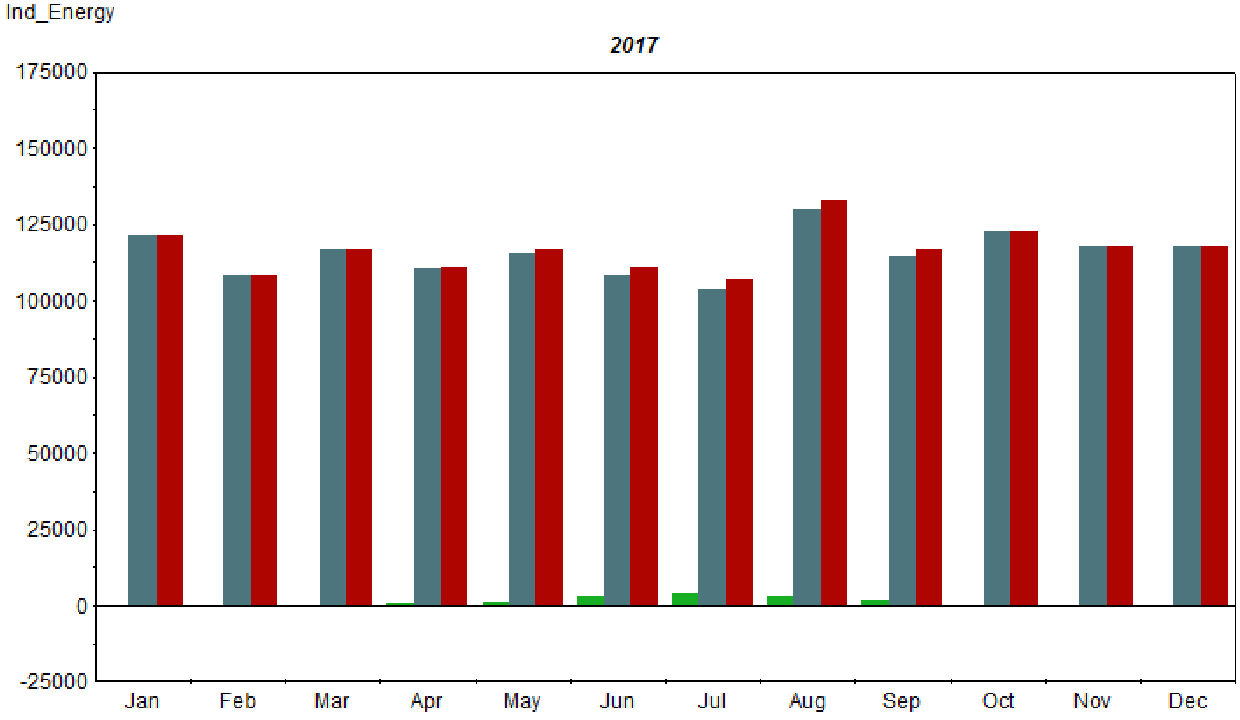


Table 19: Data Table of GMO Industrial Monthly Cooling, Heating, and Base

Date	IndCool	IndBase	IndTotal
Jan-17	0	121,668	121,668
Feb-17	29	108,026	108,055
Mar-17	160	116,614	116,774
Apr-17	415	110,690	111,104
May-17	1,157	115,684	116,842
Jun-17	2,950	107,954	110,904
Jul-17	3,805	103,310	107,115
Aug-17	2,866	130,068	132,933
Sep-17	1,848	114,755	116,603
Oct-17	77	122,664	122,741
Nov-17	0	118,147	118,147
Dec-17	0	118,194	118,194

Figure 27: Other GMO Load (SFR & Lighting)

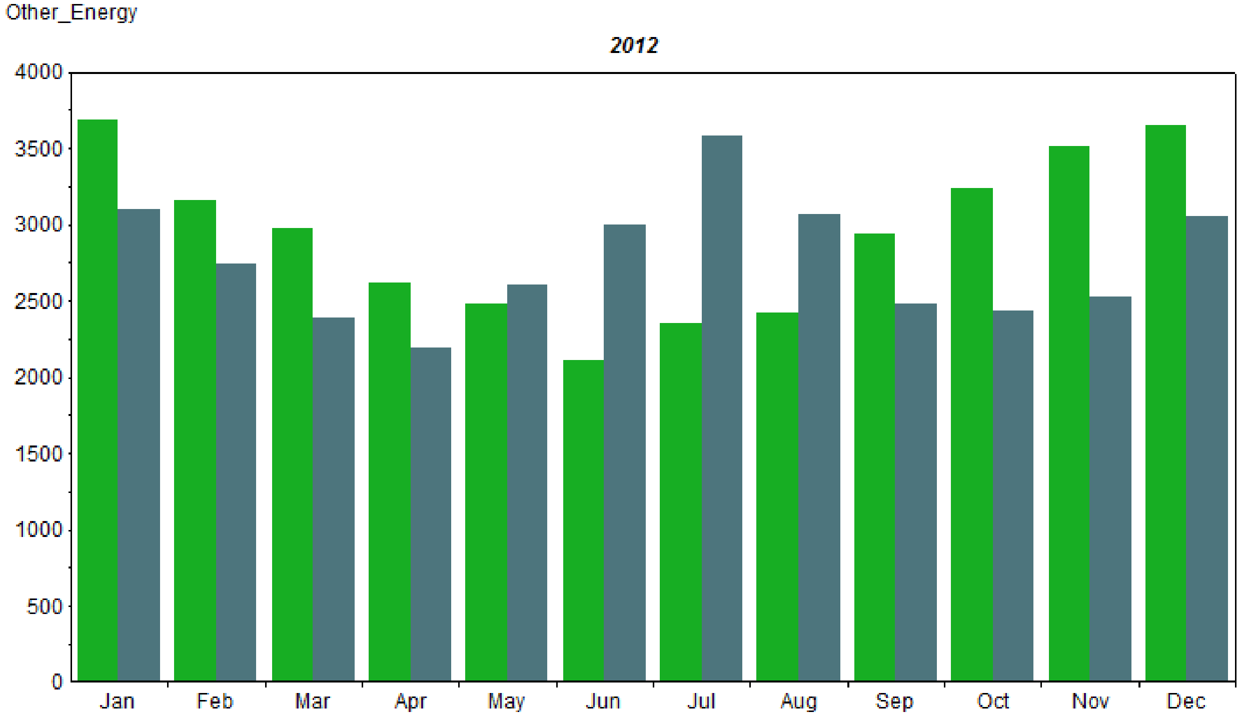


Table 20: Data Table Other GMO Load (SFR & Lighting)

Date	Lighting	SFR
Jan-17	3,516	2,901
Feb-17	2,987	2,187
Mar-17	2,845	2,231
Apr-17	2,519	1,954
May-17	2,367	2,077
Jun-17	1,991	2,412
Jul-17	2,072	2,705
Aug-17	2,416	2,713
Sep-17	2,474	2,228
Oct-17	2,990	2,157
Nov-17	3,286	2,328
Dec-17	3,321	2,921

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.

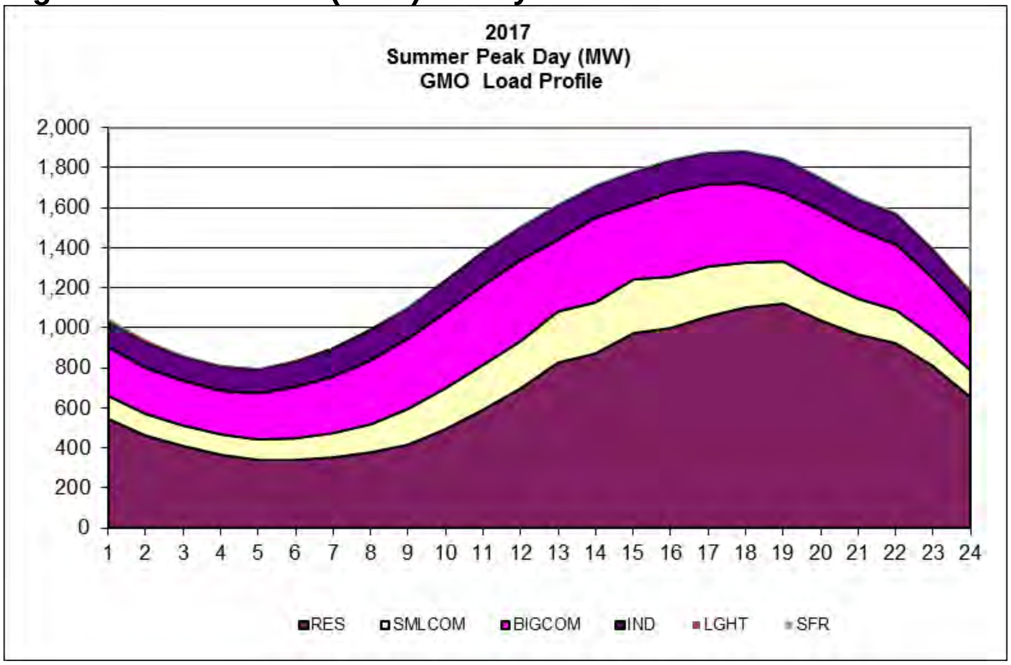
Plots for class monthly energy and coincident peak demand at the time of summer and winter system loads are provided in *Appendix 3B*. Energy plots by jurisdiction and system are provided in the file *IRP_7.1.6_GMO_MWh.xlsx* and peak plots are in the file *IRP_7.1.6_GMO_Peaks.xlsx*.

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 of GMO 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 (*GMO_SystemLoad* and *SysShape*) included in the workpapers.

Figure 28: Base Year (2017) Net System Load Profiles for GMO



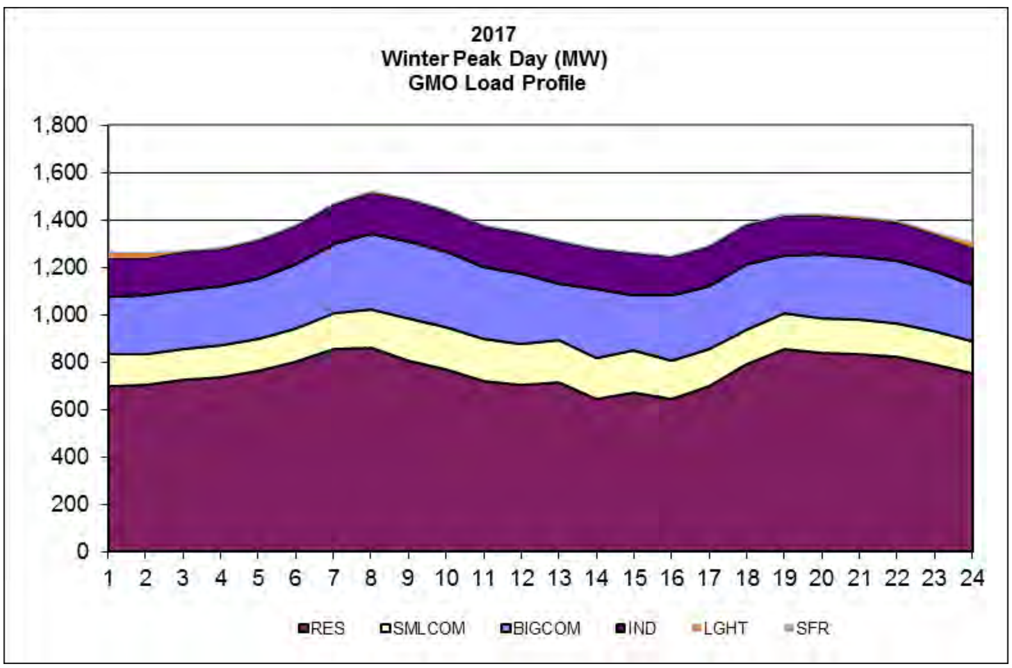
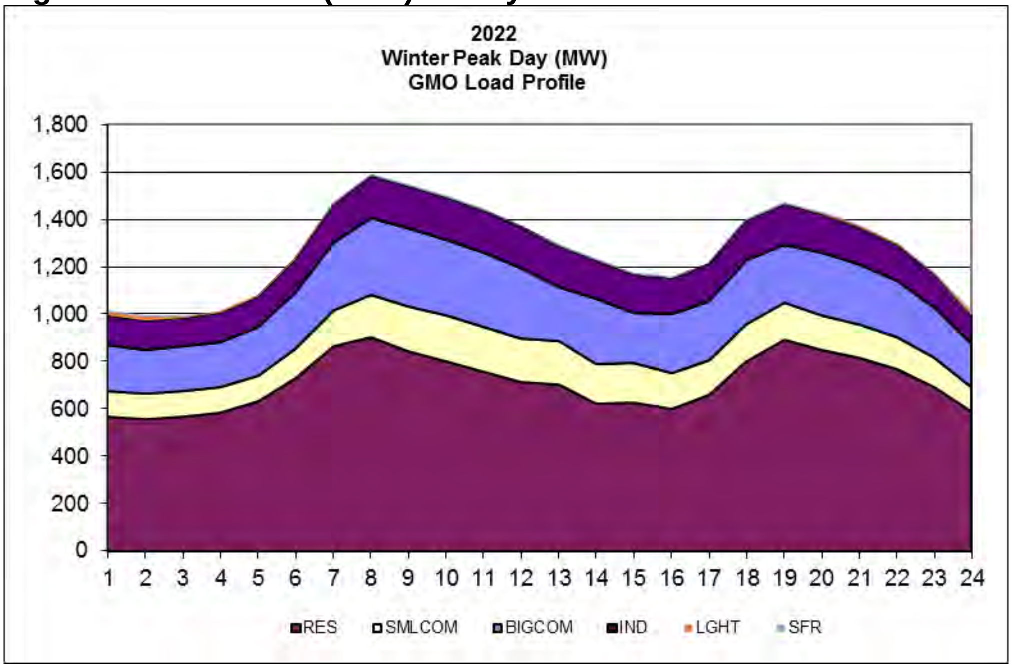


Figure 29: Fifth Year (2022) Net System Load Profiles for GMO



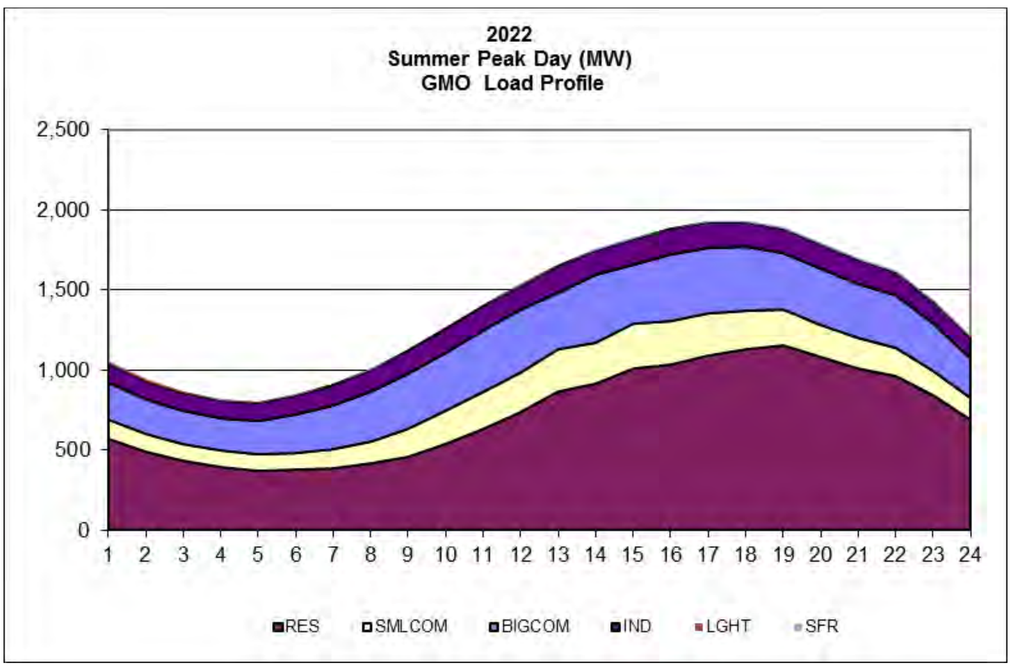
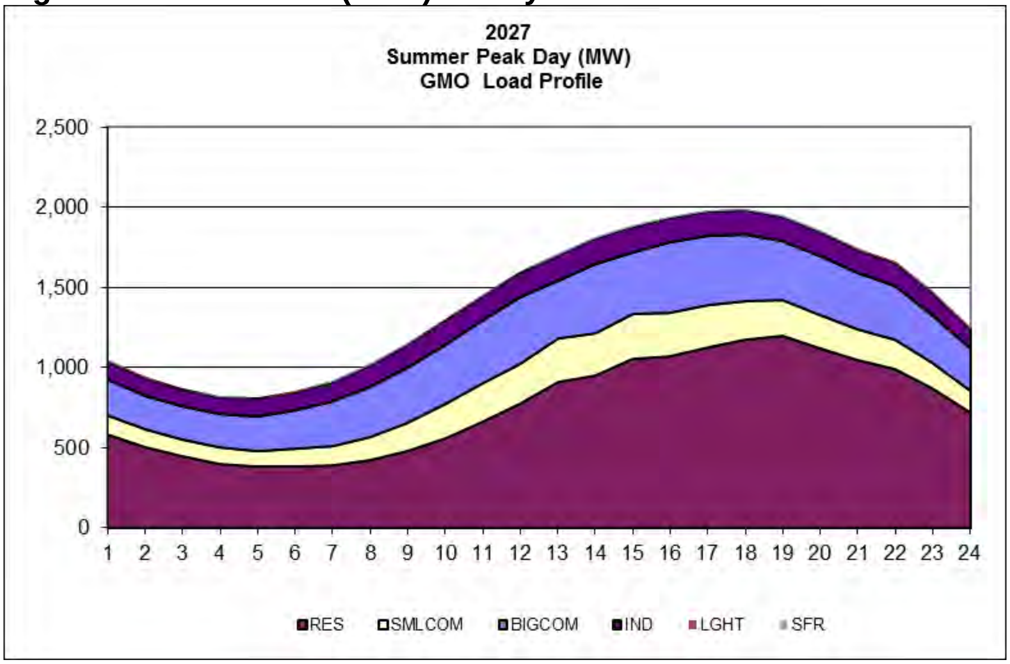


Figure 30: Tenth Year (2027) Net System Load Profiles for GMO



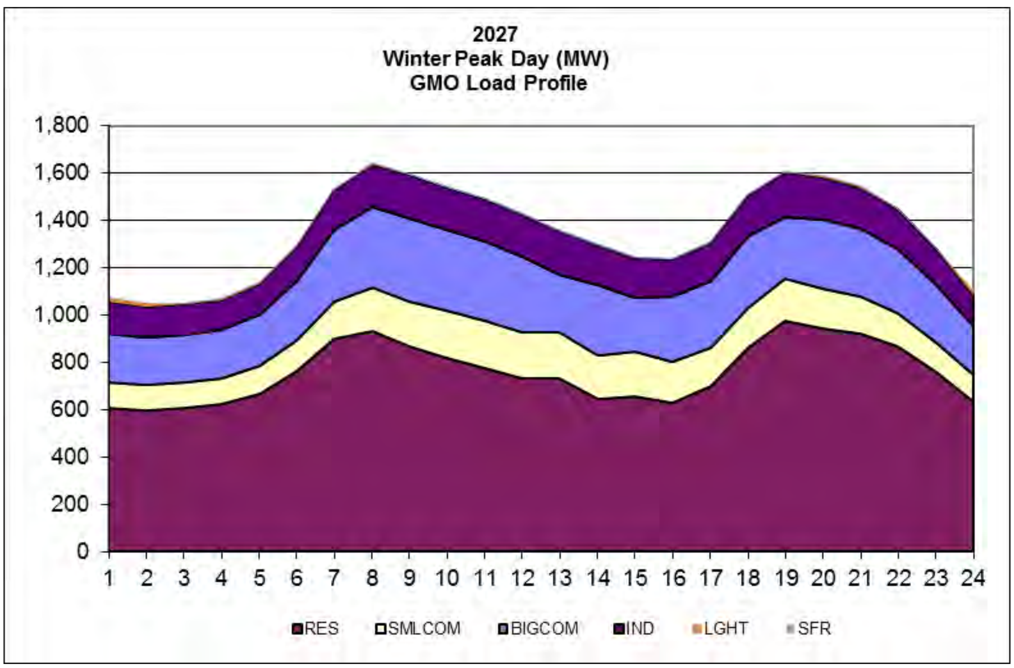
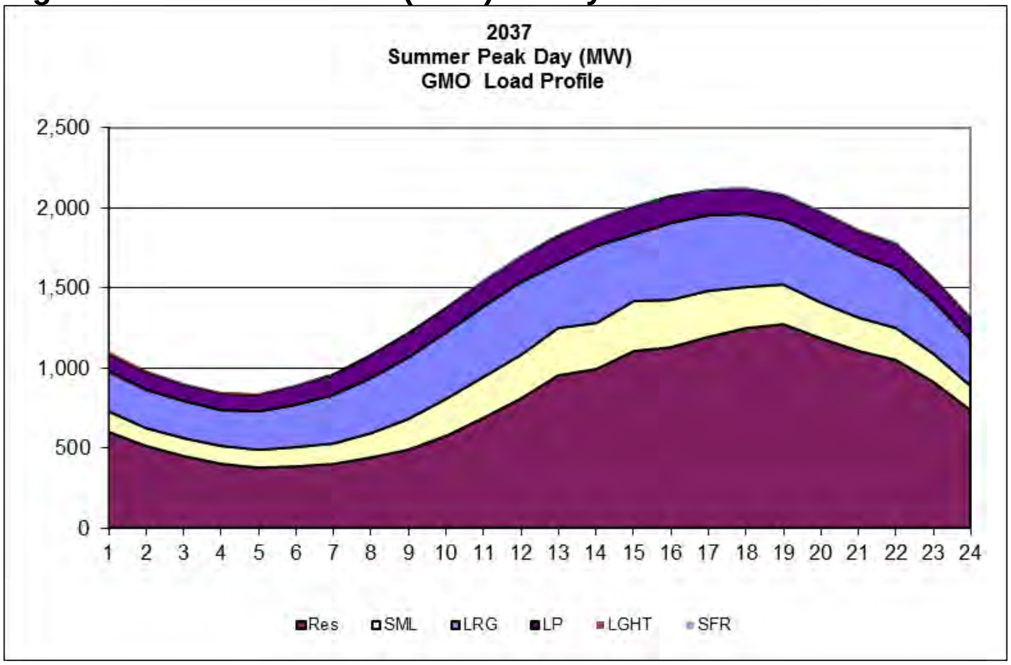
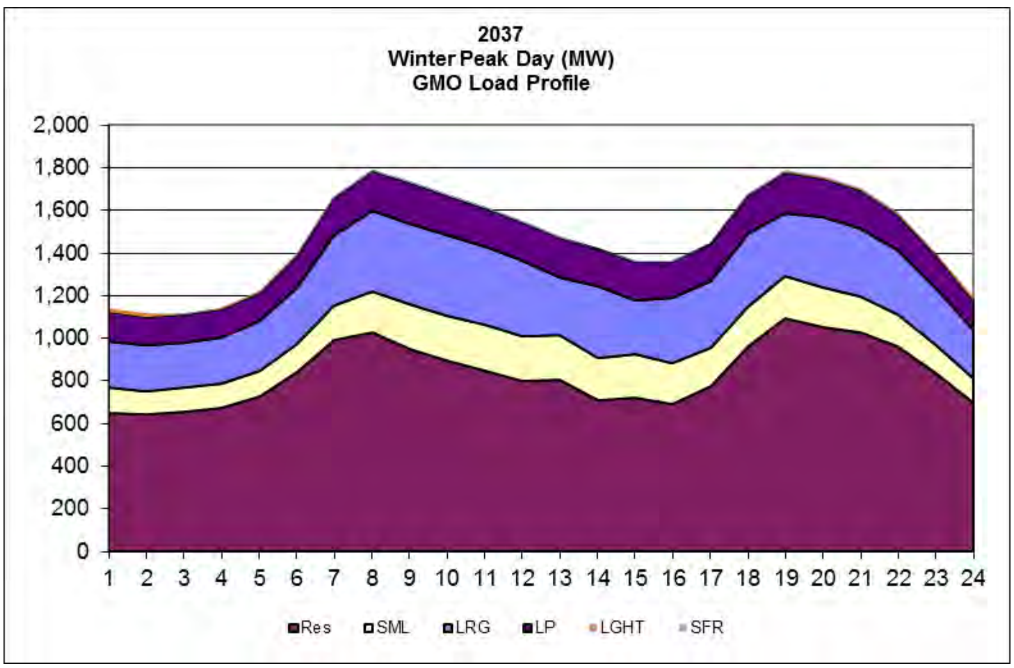


Figure 31: Twentieth Year (2037) Net System Load Profiles for GMO





7.2 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.

7.2.1 DOCUMENTATION OF MATHEMATICAL MODELS

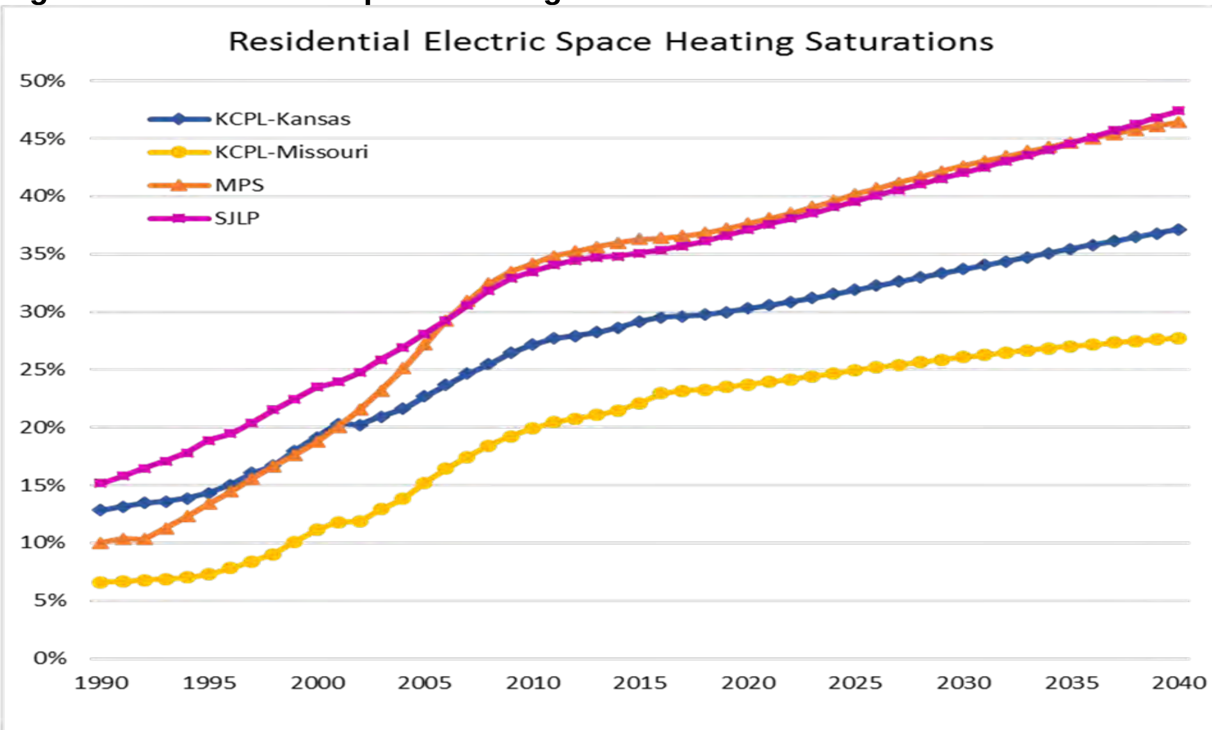
1. Documentation of mathematical models developed by the utility to forecast the independent variables shall include the reasons the utility selected the models as well as specification of the functional form of the equations.

GMO acquired forecasts of independent variables from Moody's and DOE as described previously. GMO developed its own models to forecast the saturation of electric space heating for residential customers (SpaceHeat.ndm). GMO 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 ~~both~~ 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 32: Residential Space Heating Saturations



7.2.2 <u>DOCUMENTATION OF ADOPTED FORECASTS DEVELOPED BY ANOTHER ENTITY</u>

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.

GMO 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 GMO's service areas and documentation for the forecast were discussed in the sections for Rules 22.030(3)(A) and 22.030(6)(A)3.

GMO used forecasts of saturations, UECs, EUIs and building efficiencies from DOE. The reasons for using these forecasts, the applicability to GMO'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.

7.2.3 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.

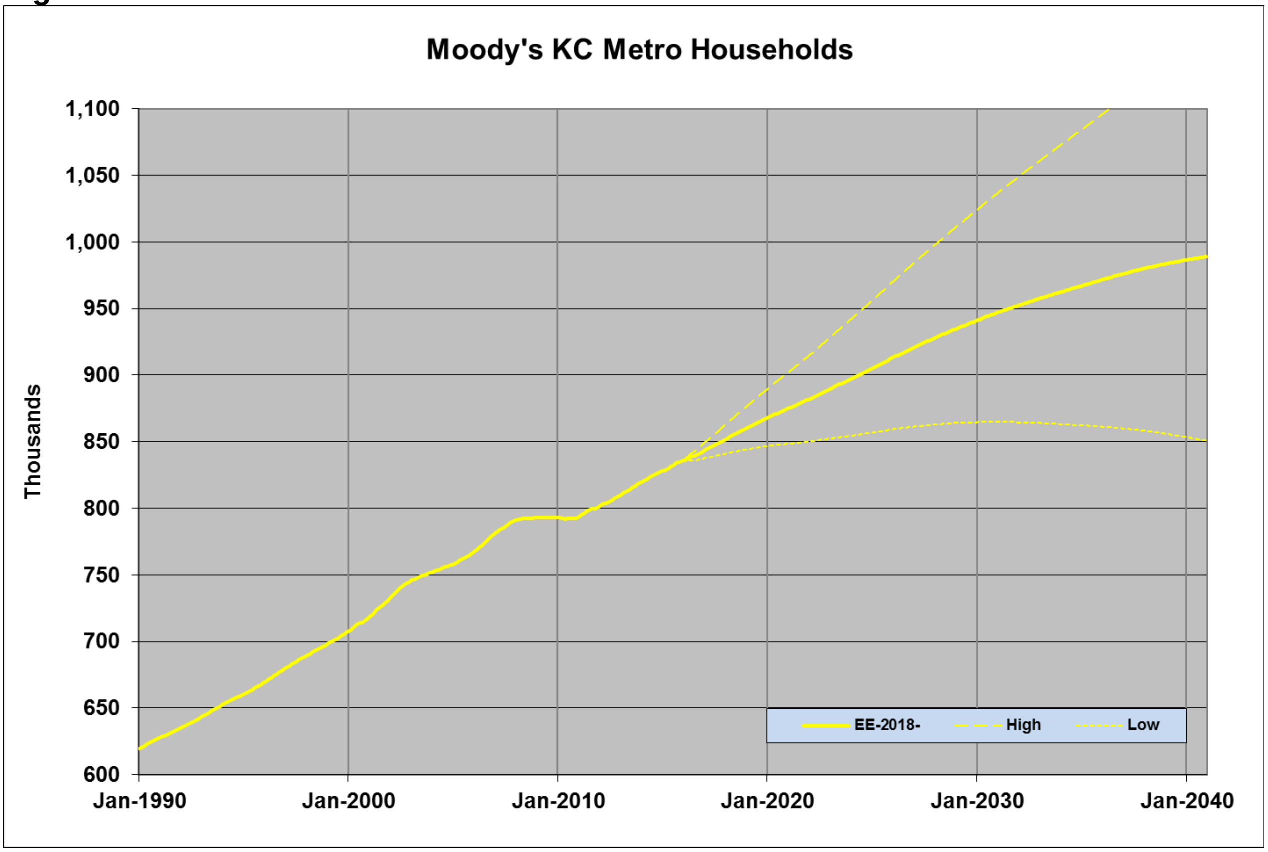
Table 21: Economic Growth Rates for KC Metro Area **

	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%

Table 22: Growth Rates for SJ Metro Area **

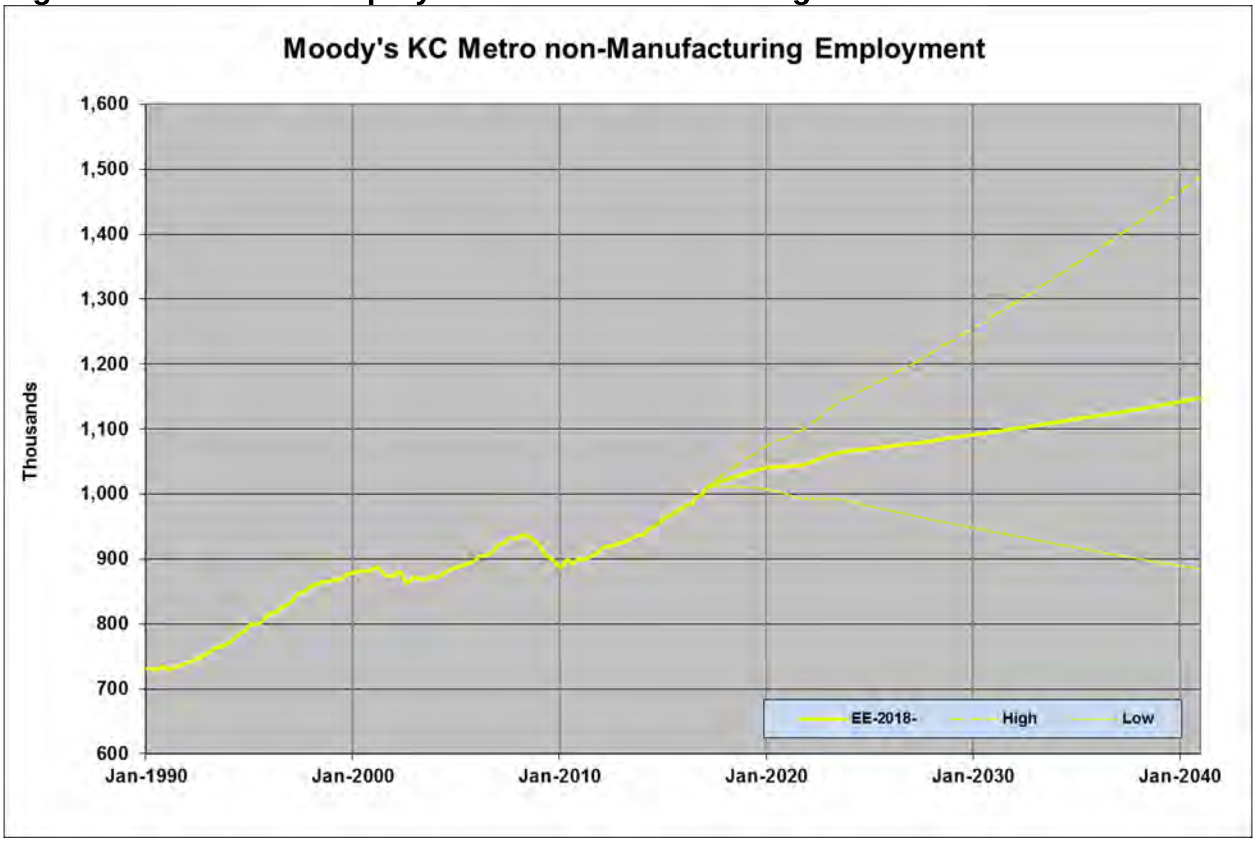
	Households	Employment Non-Manufacturing	Employment Manufacturing	Gross Product Non-Manufacturing	Gross Product Manufacturing
2000	0.7%	2.0%	-0.5%	3.7%	1.4%
2010	0.2%	1.9%	0.9%	2.1%	4.2%
2020	0.5%	0.7%	0.7%	0.4%	0.8%
2030	0.6%	0.5%	-1.0%	1.5%	1.5%
2040	0.4%	0.5%	-0.8%	1.3%	1.2%

Figure 33: 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 34: KC Metro Employment Non-Manufacturing

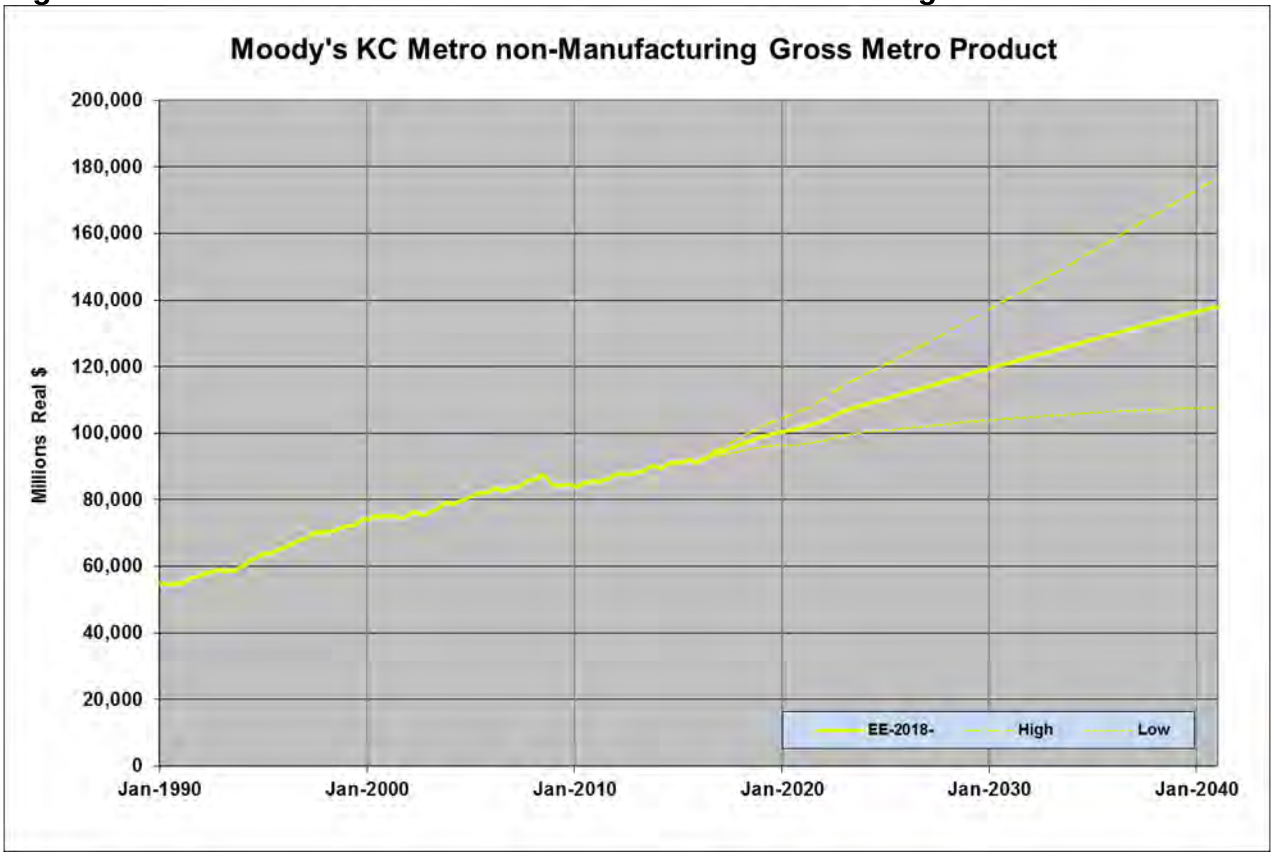


Non-manufacturing employment showed very strong growth in the 1990s, 1.9% per year, then stalled after the 2001 recession, picked up strongly in 2004 and then turned negative during the last recession. Growth returned in 2012 and grew stronger starting in 2015. Moody's expects continued growth though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

Figure 35: KC Metro Employment Manufacturing

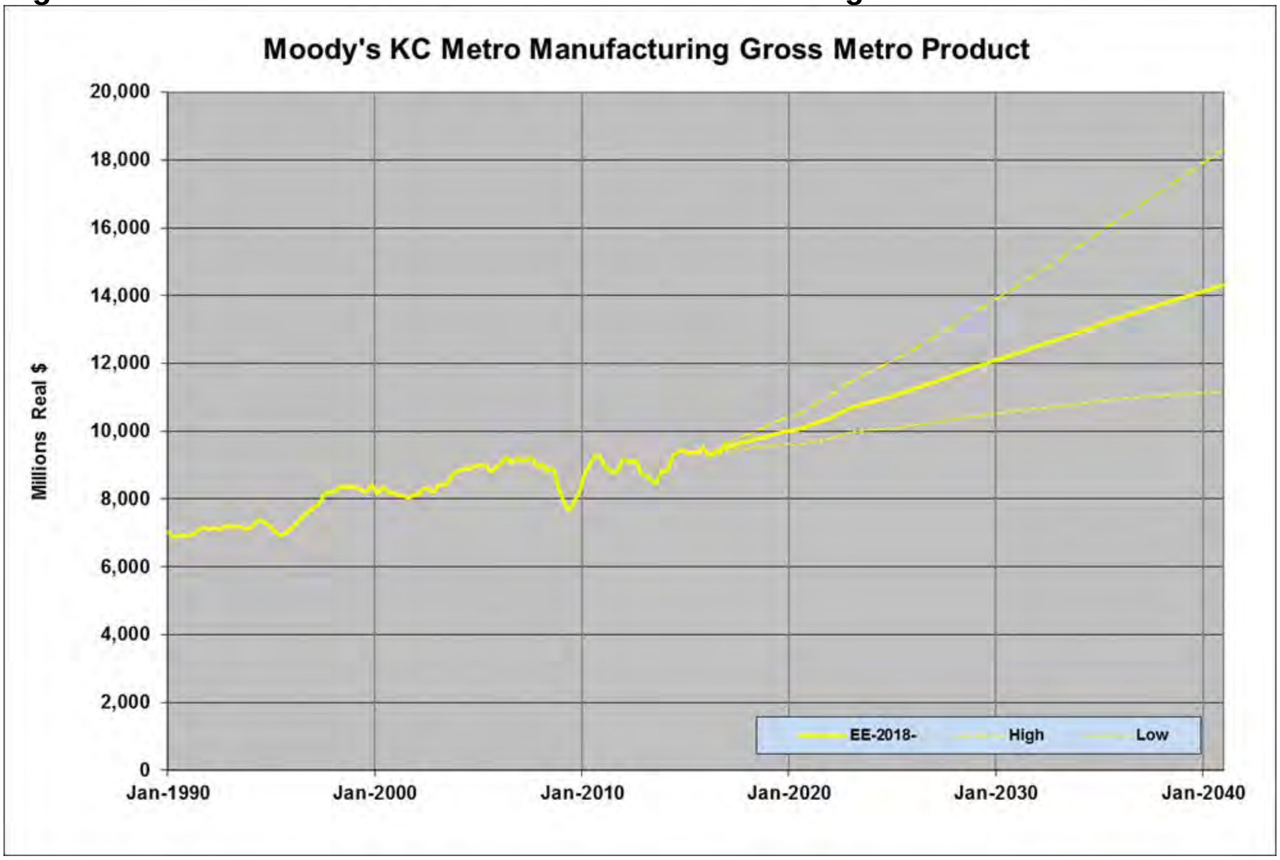
Manufacturing employment peaked in the late 1990s and has fallen since. It fell precipitously between 1999 and 2003 and again during the last recession. After regaining some of the jobs lost in the aftermath of the last recession, Moody's expects employment to resume its historical decline.

Figure 36: 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 37: KC Metro 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 38: SJ Metro Households

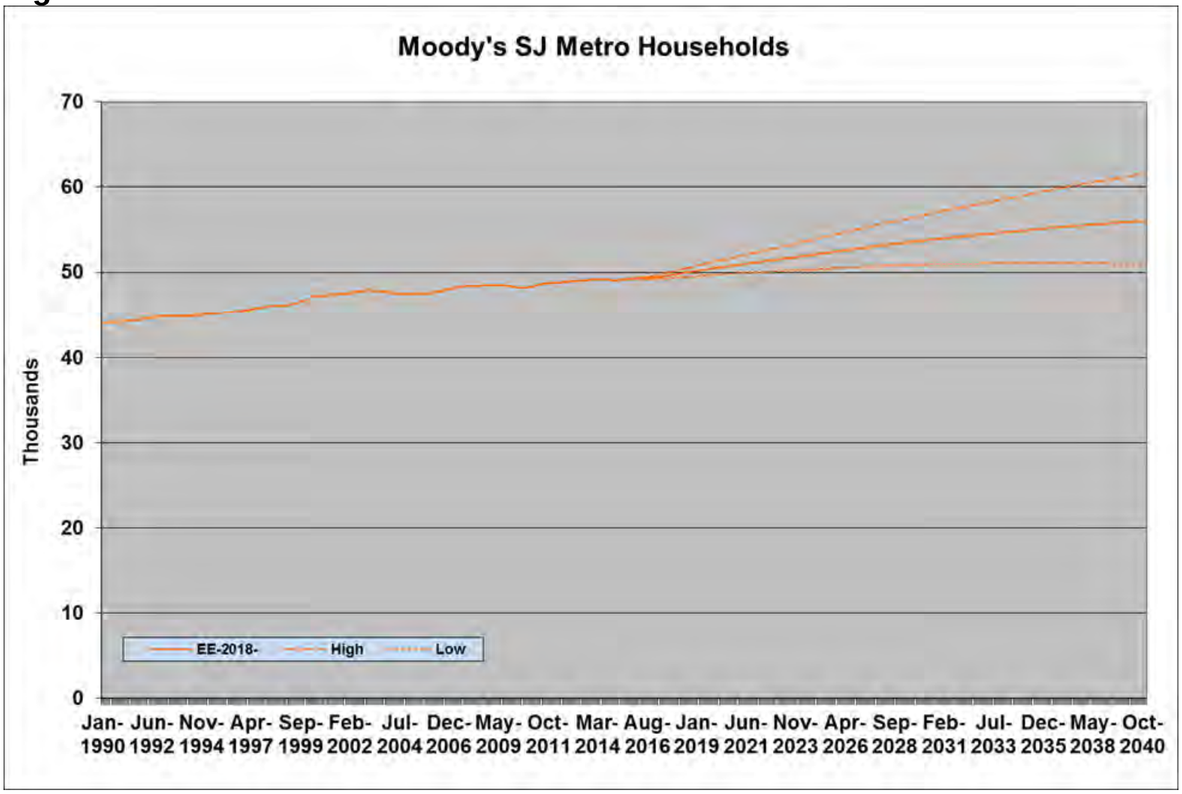


Figure 39: SJ Metro Non-Manufacturing Employment

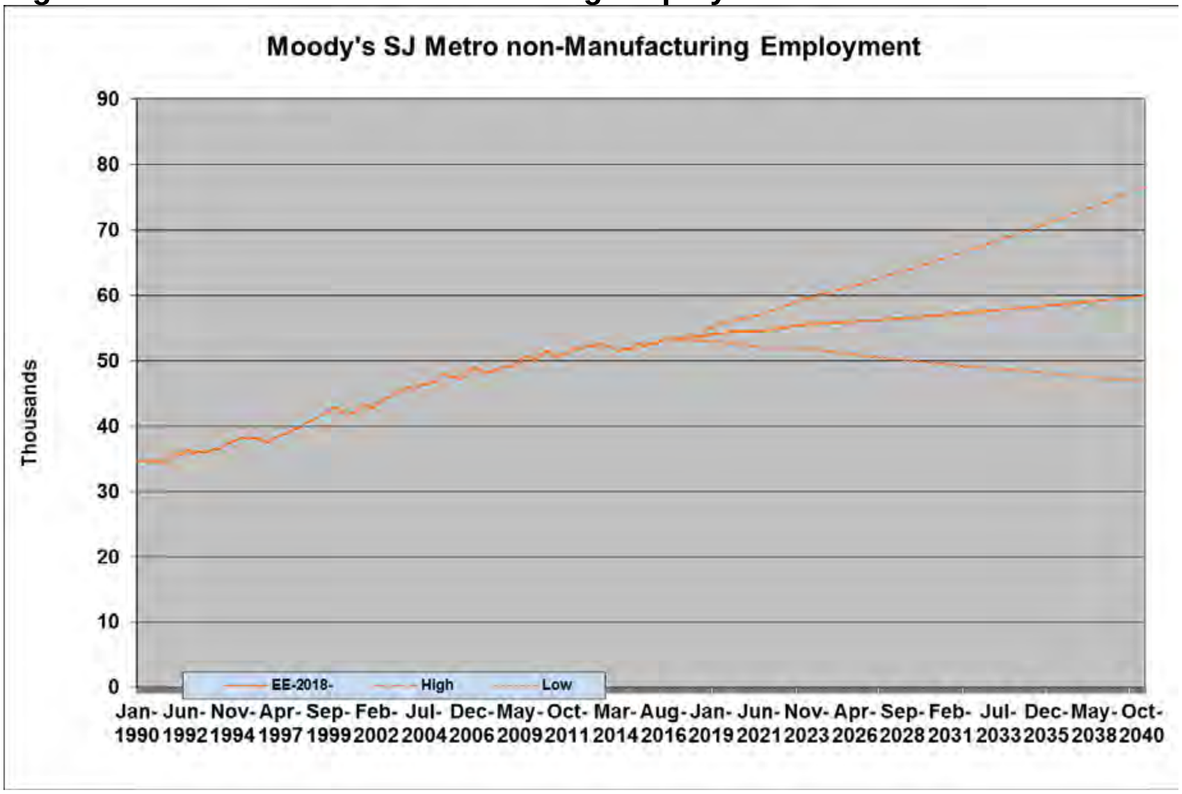


Figure 40: SJ Metro Manufacturing Employment

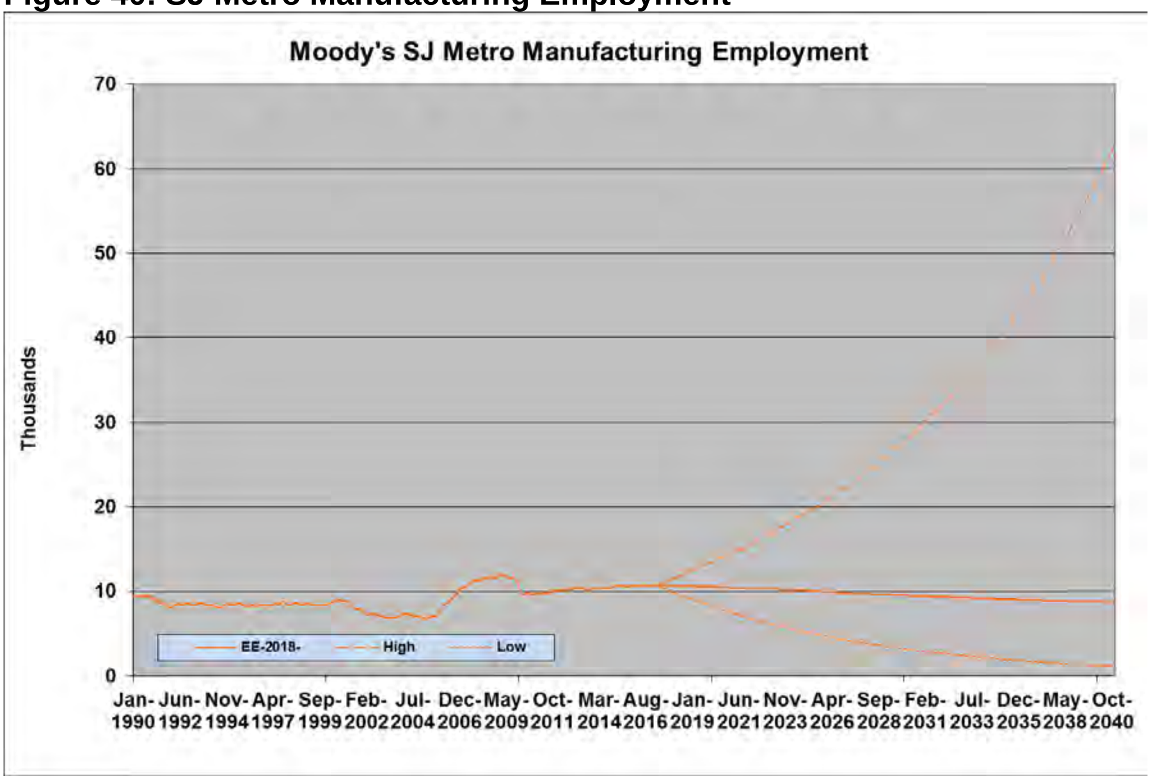


Figure 41: SJ Metro Non-Manufacturing Gross Metro Product

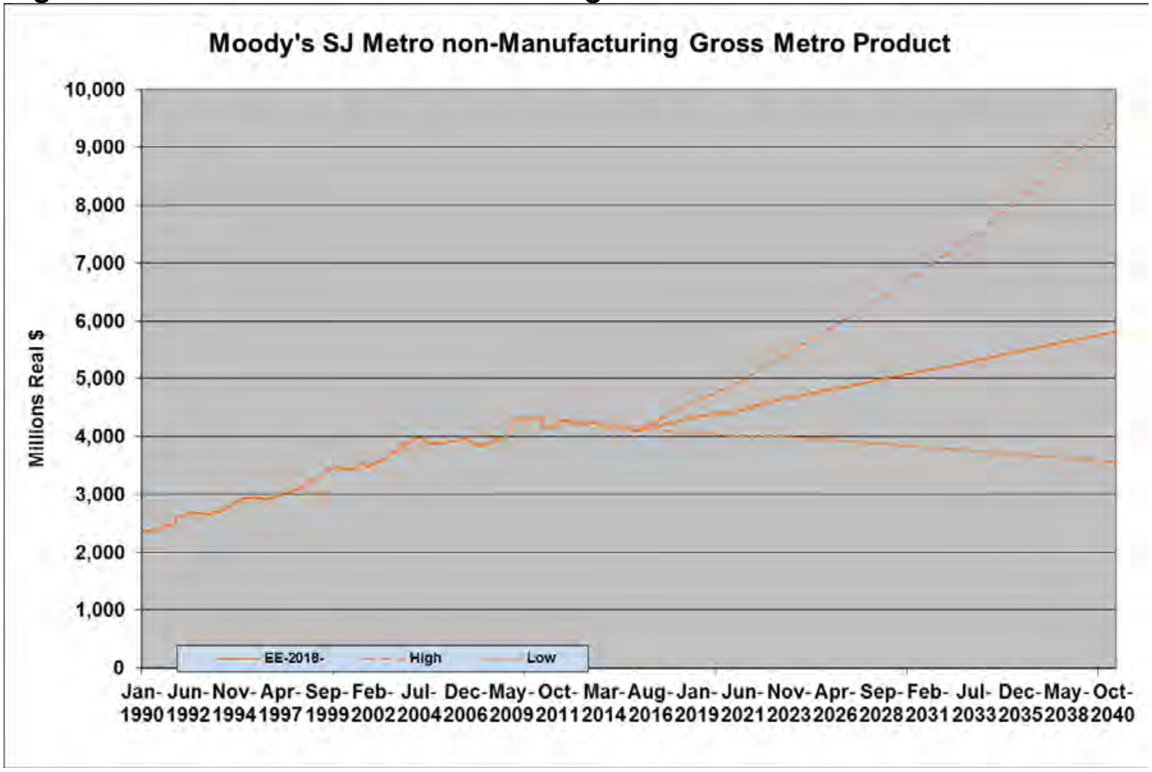
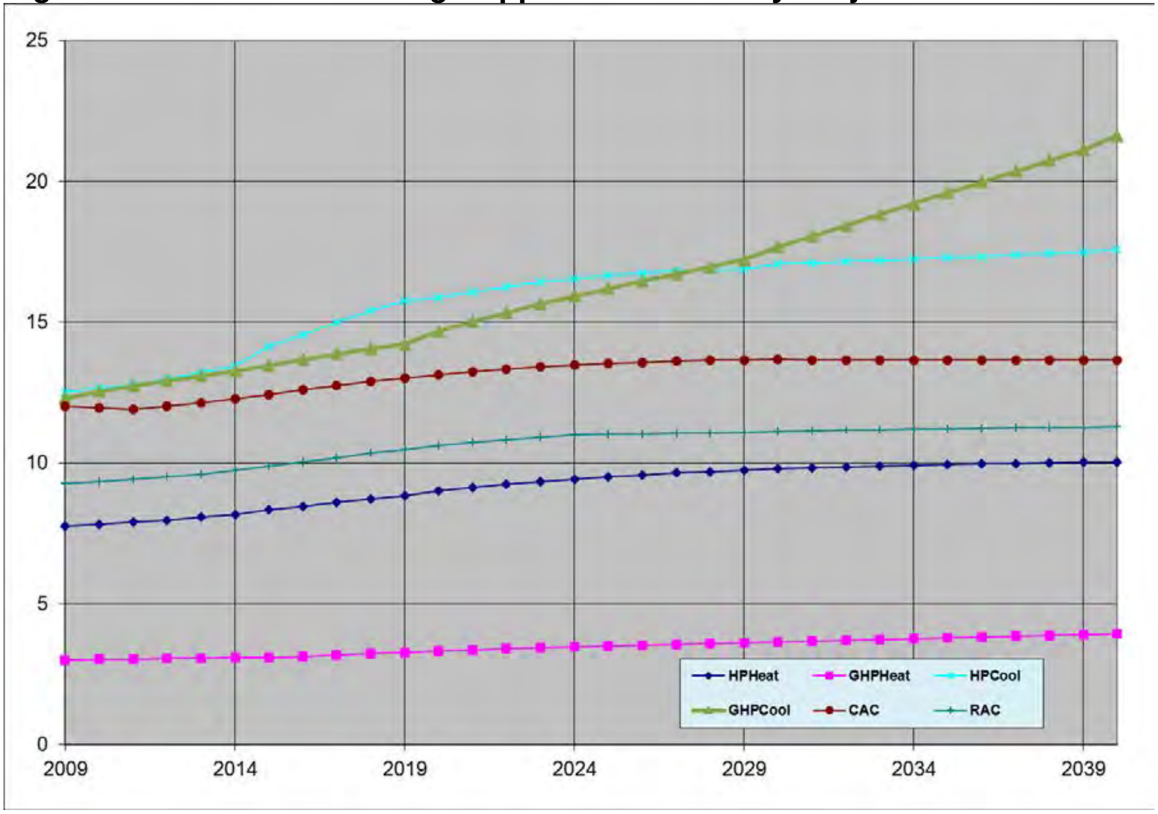


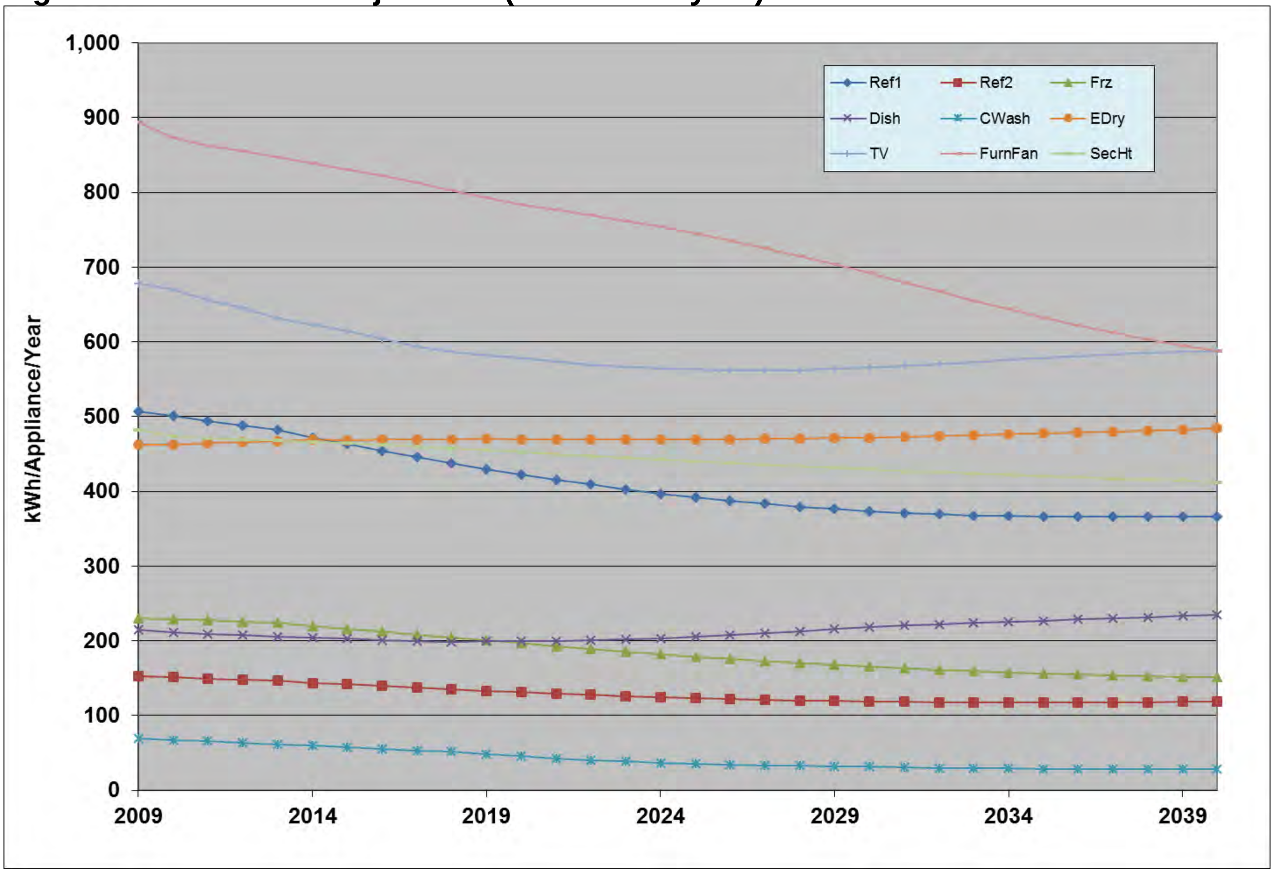
Figure 42: SJ Metro Manufacturing Gross Metro Product

Figure 43: DOE Stock Average Appliance Efficiency Projections



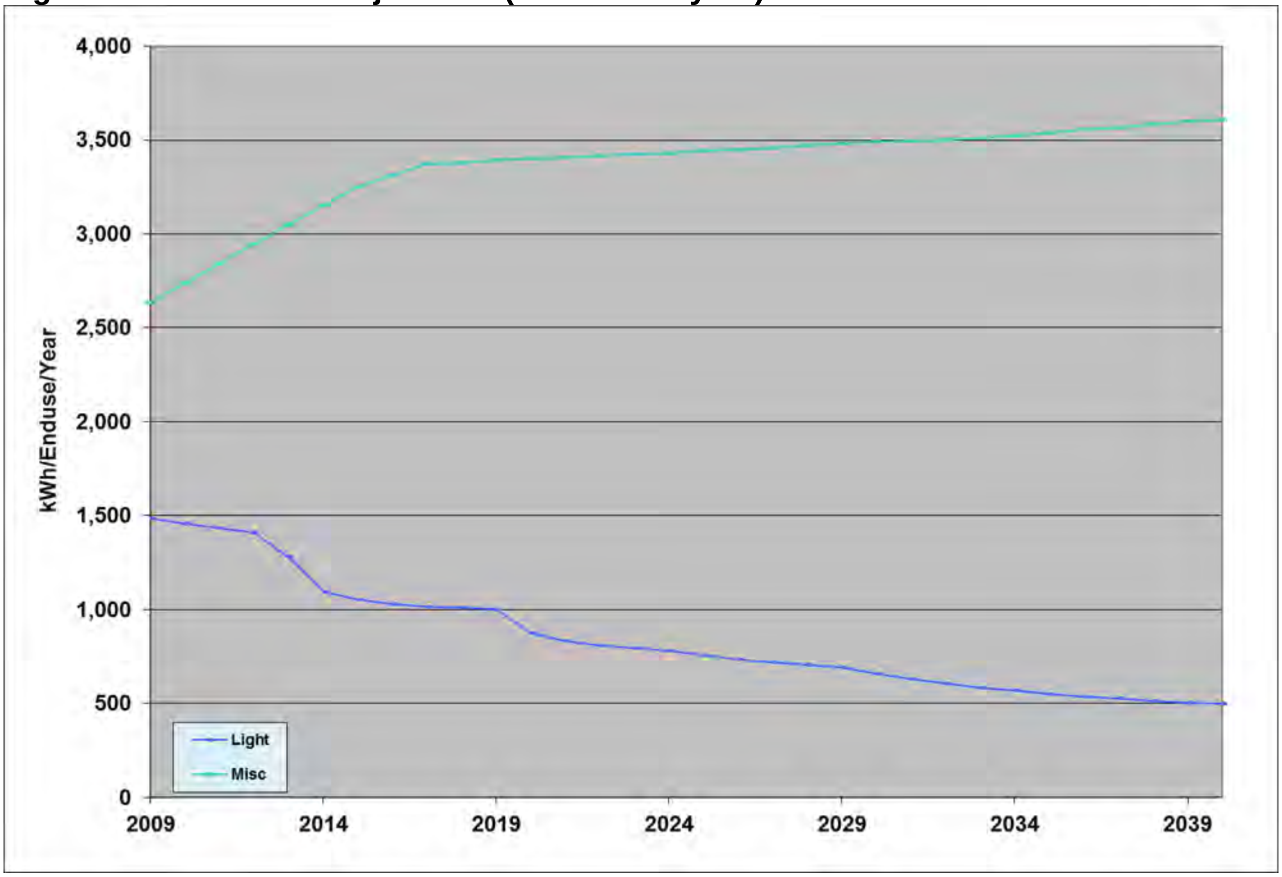
DOE is expecting increases in the stock average appliance efficiencies for residential heating and cooling equipment. This is resulting from appliance standards. In January 2006, a new standard raised the SEER standard by 30 percent for central air conditioners and has resulted in increasing efficiency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

Figure 44: 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.

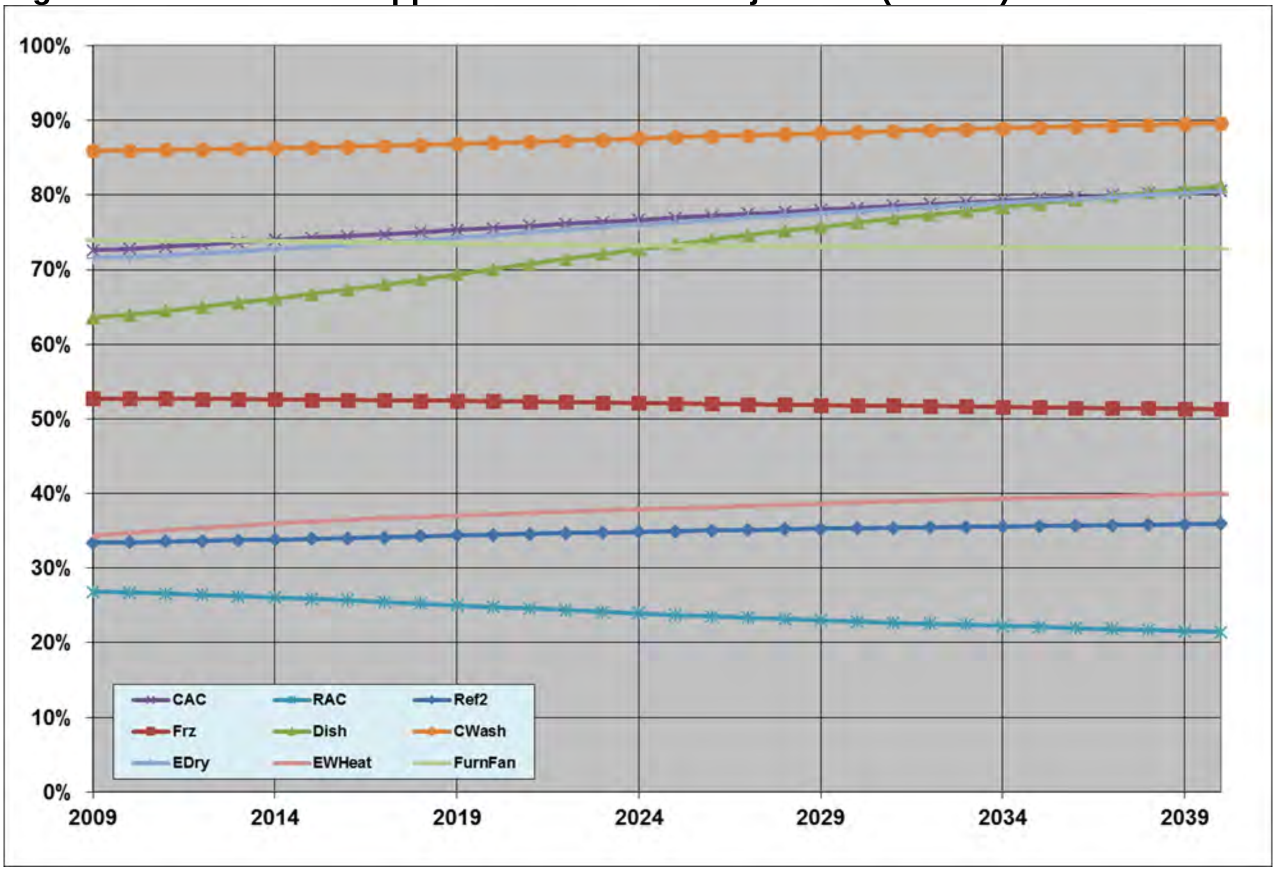
Figure 45: DOE UEC Projections (>1000 kWh/year)



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.

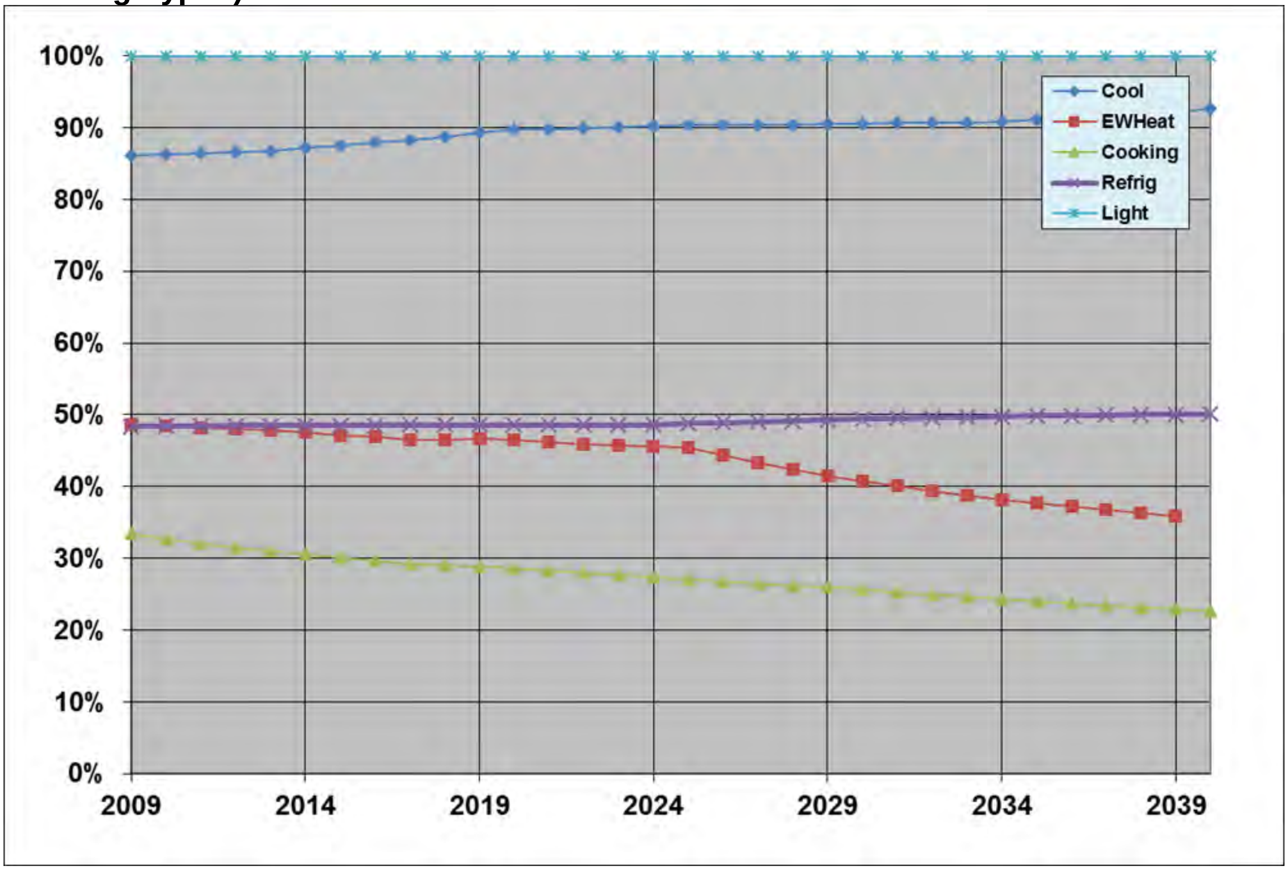
Miscellaneous UEC grew rapidly in the late 1990s and early 2000s before decelerating (from 5% to 3%) in 2006 and then again decelerating in 2016. The EIA expects miscellaneous UEC to again decelerate and grow slowly at about 0.3% per year going forward.

Figure 46: DOE Electric Appliance Saturation Projections (< 100%)



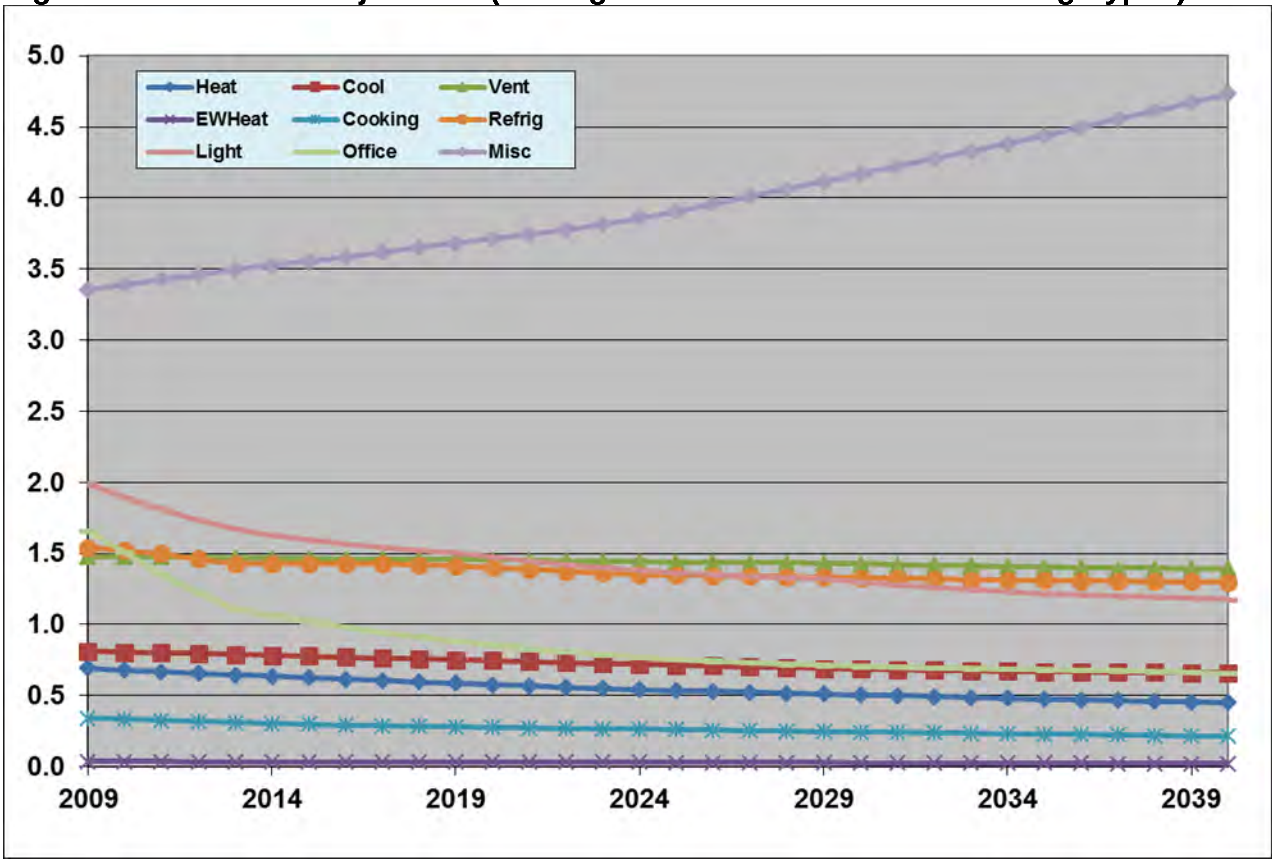
DOE saturation projections shown above are in line with recent historical trends.

Figure 47: DOE 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 48: DOE 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.[vi] 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.[vii] 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.

7.2.4 SPECIFICATION AND QUANTIFICATION OF FACTORS

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.

GMO 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 GMO lighting program that had been in place prior to the implementation of the 2013 federal lighting standard. The adjustment slows the rate of decline.

7.3 NET SYSTEM LOAD FORECAST

(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.

GMO 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, GMO utilized a method that was suggested by the Missouri Public Service Commission Staff for GMO's IRP. For each major 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 22: displays the results for GMO 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,

Table 23: GMO Residential

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
BDays	6,244,054	77.8	0.60
hddPriceRatio	21,516,474	4.1	0.06
resCusCDD65	78,235,845	67.5	0.21
resCusHdd55	49,678,561	10.7	0.15
hddTrend	16,516,950	6.9	-0.01
Jan05	3,889,367	5.7	0.00
Sep06	1,563,086	2.3	0.00
EffTrend	-2,556,916	-1.8	0.00

. 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 600 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 23: provides the results for GMO 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 24: GMO Commercial

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
resCus	9,421,603	29.0	0.79
prElecCus	3,499,192	2.4	0.07
HDDpriceRatio	10,634,668	5.0	0.03
comCusCDD60	29,564,843	20.7	0.10
comCusHdd55	6,984,599	3.6	0.02
cddTrend	5,222,481	6.3	-0.01
HddTrend	10,577,295	11.1	-0.01
Feb02	-1,662,426	-2.8	0.00
Aug07	1,394,155	2.4	0.00
EffTrend	-2,320,625	-3.3	0.00

The Missouri industrial model results are shown in Table 24. 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 25: GMO Industrial

VARIABLE	Standardized Coefficient	t-Statistic	Elasticity
GP_Man	3,162,860	12.5	0.71
prElecCus	-1,101,984	-1.9	-0.05
indCusCDD60	5,784,882	10.4	0.05
Jan10	-757,965	-2.2	0.00
Feb10	1,291,347	3.9	0.00
Mar05	-2,016,066	-5.9	0.00
indCus	1,228,260	5.6	0.29
binary	1,306,002	3.7	0.00
EffTrend	-1,636,657	-4.2	-0.01

8.2 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.

GMO 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 two standard deviation above and below the base case forecast.

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

GMO constructed this scenario by subtracting the energy and peak demand from the largest customer 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 49: GMO Base, Low, High and Significant Loss Energy (NSI) Forecast

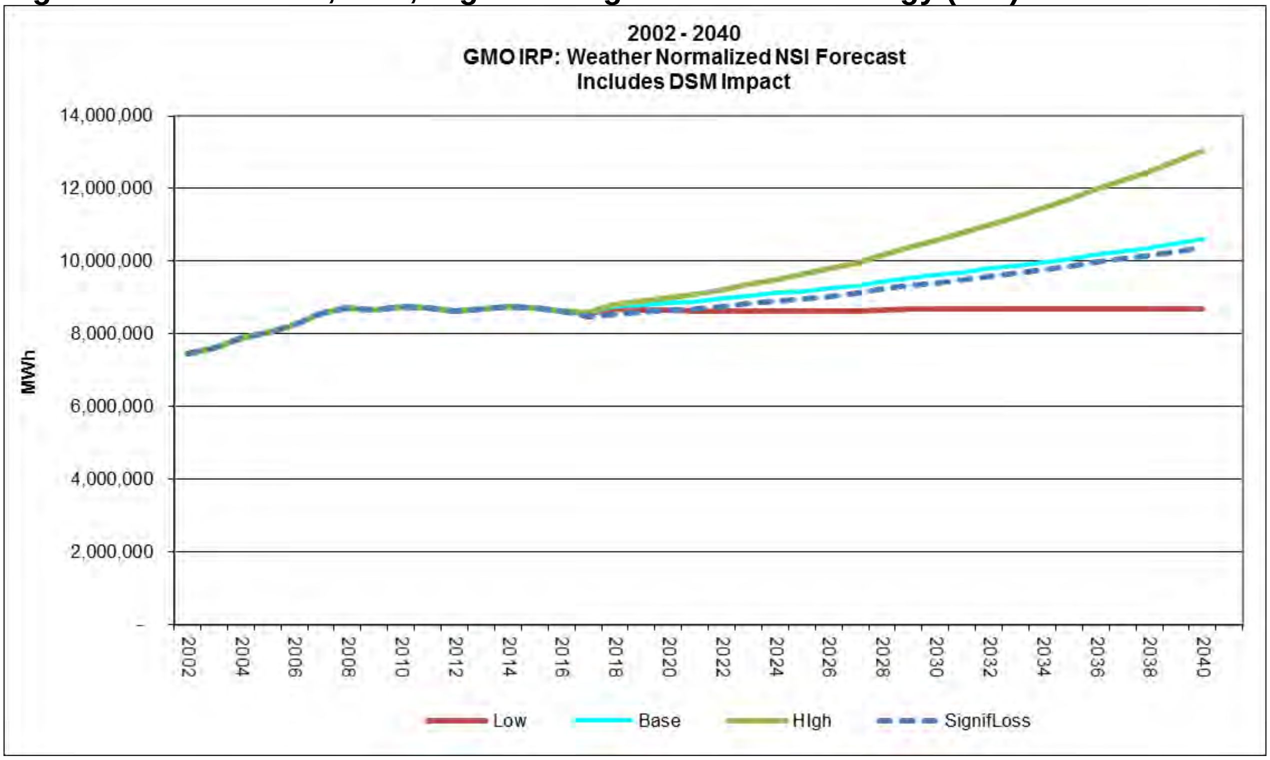
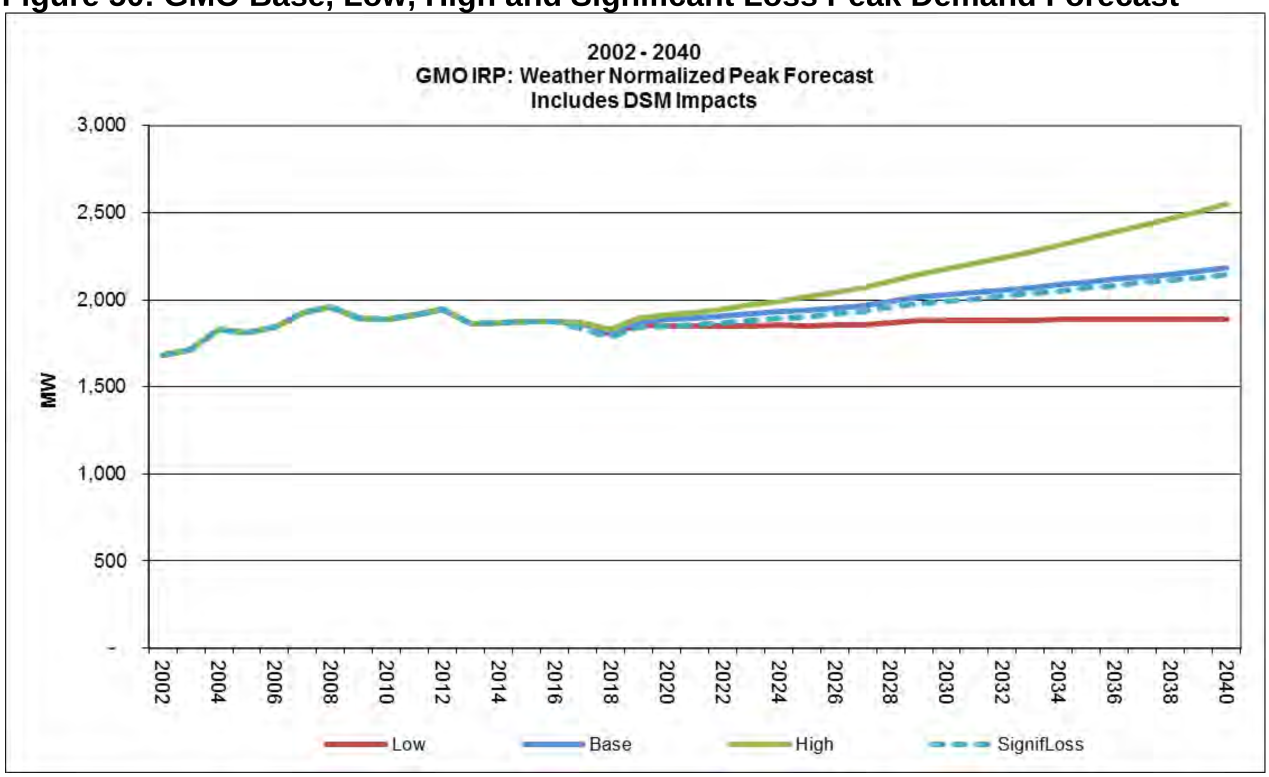


Figure 50: GMO Base, Low, High and Significant Loss Peak Demand Forecast



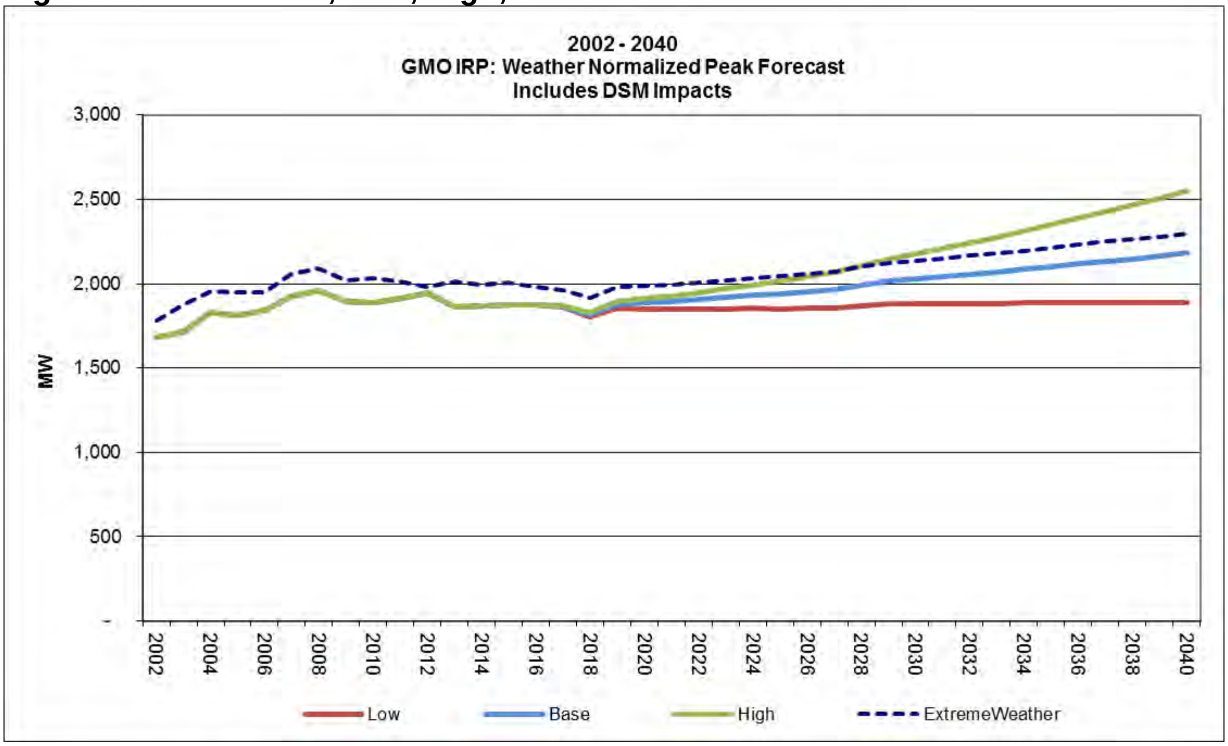
8.3 ESTIMATE OF SENSITIVITY OF SYSTEM PEAK LOAD FORECASTS TO EXTREME-WEATHER

(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).

GMO 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, *GMO 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 51: GMO 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_GMO_NSI_Peak.xls*. Weather normalization significantly smooths out the energy plots.

Figure 52: GMO Base Case Actual and Weather Normalized Summer Energy Plots

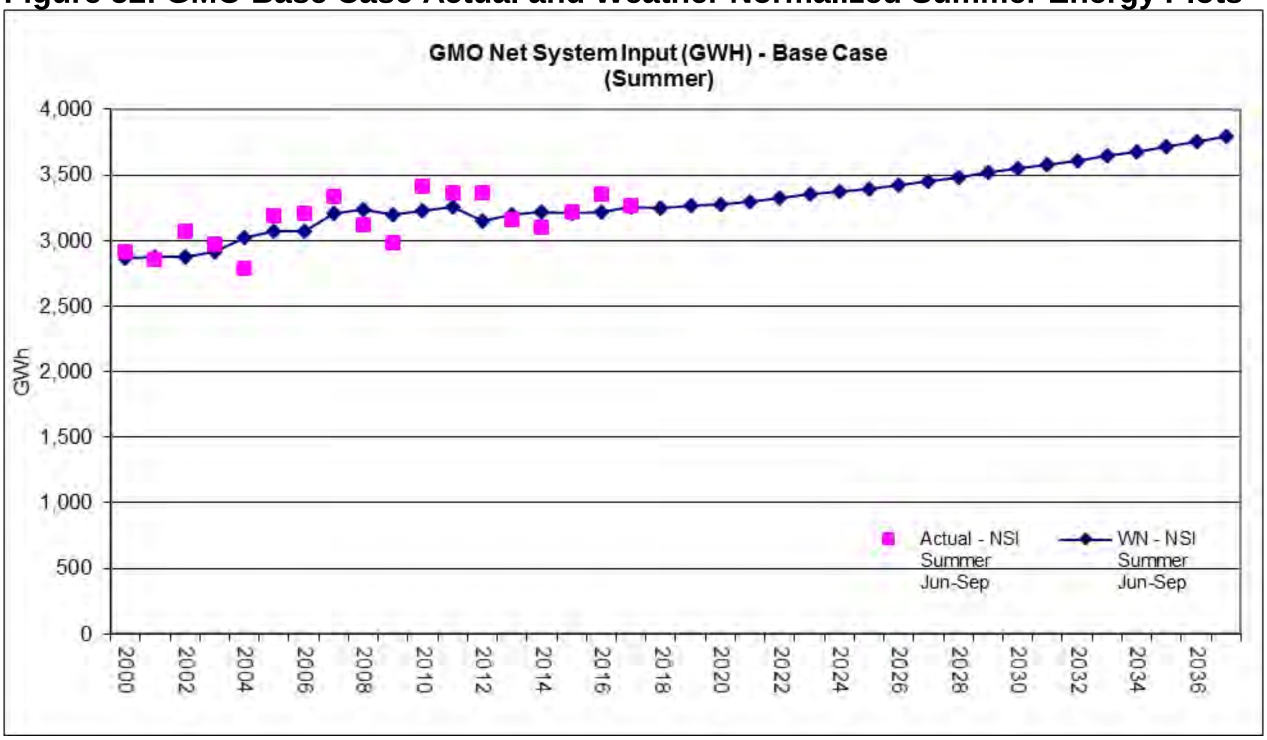


Figure 53: GMO Base Case Actual and Weather Normalized Non-Summer Energy Plots

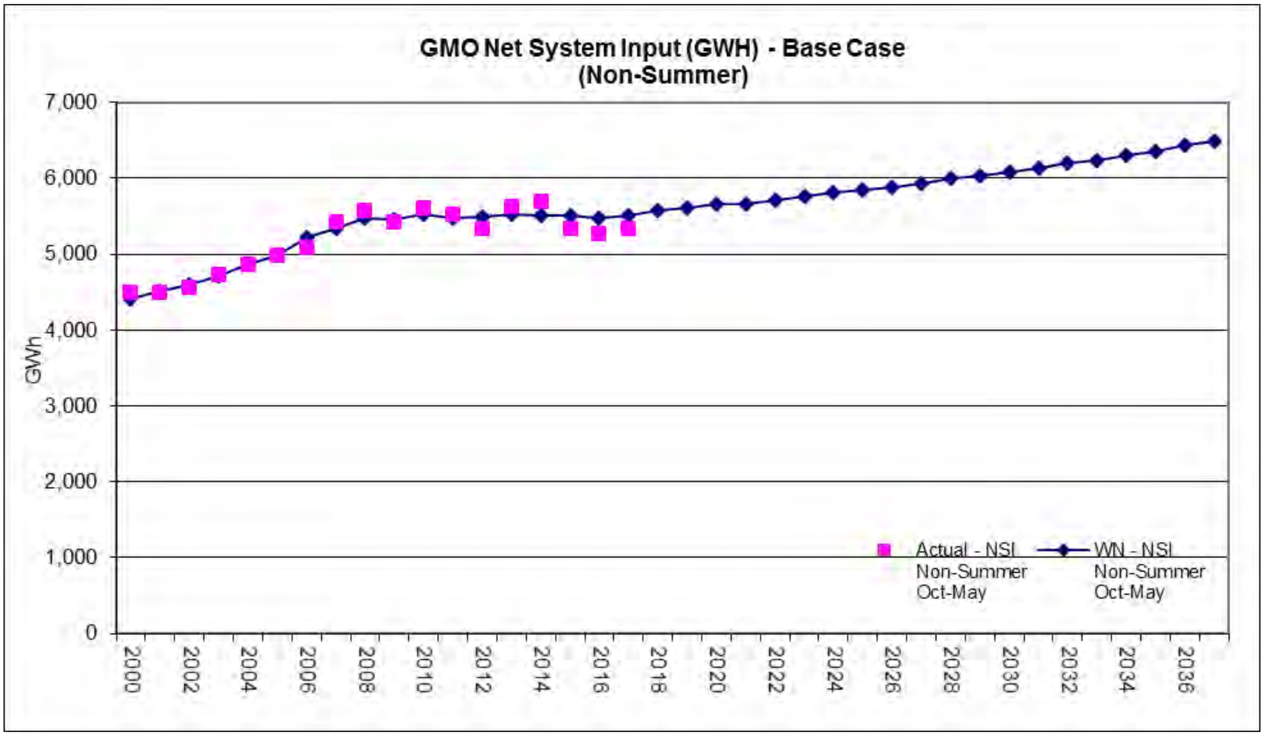
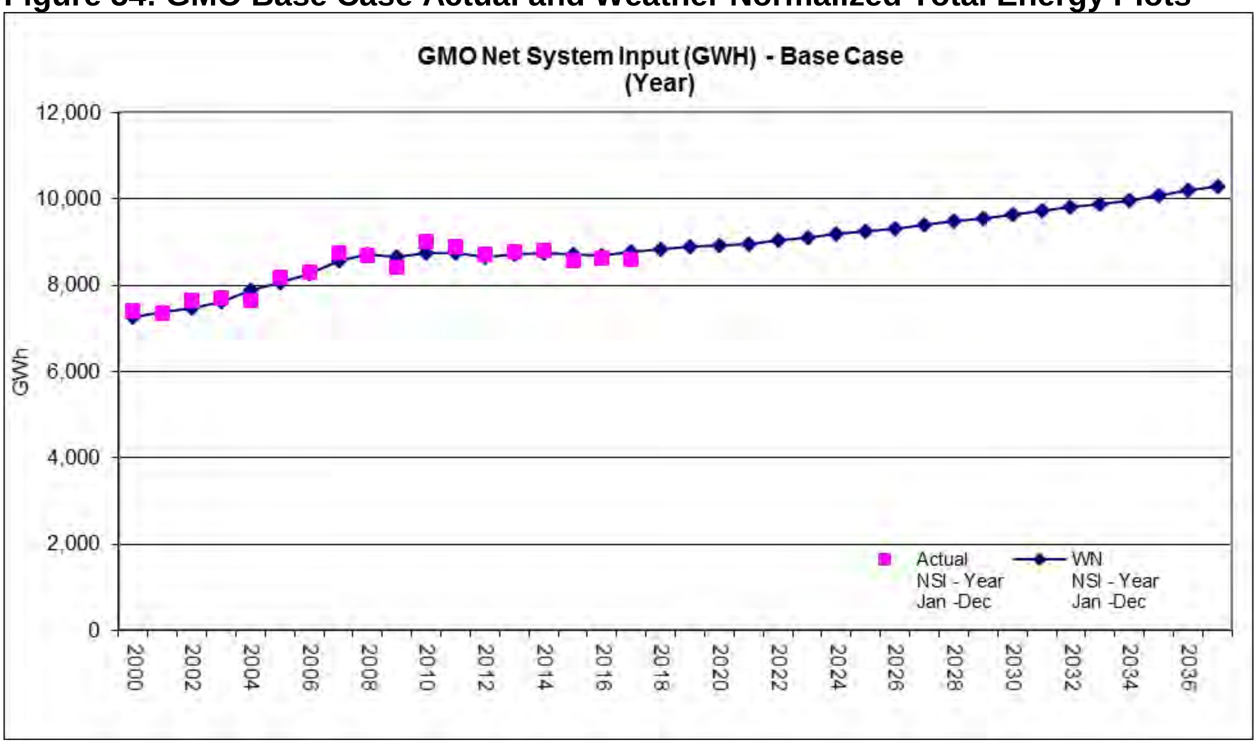


Figure 54: GMO Base Case Actual and Weather Normalized Total Energy Plots



The figures below represent actual and weather normalized peak demand for summer and non-summer for the base case forecast. Annual demand charts are not shown, since they are the same as summer demand charts. Corresponding tables can be found in *Appendix 3D* and the file *IRP_8C_GMO_NSI_Peak.xls*.

Figure 55: GMO Base Case Actual and Weather Normalized Summer Peak Demand Plots

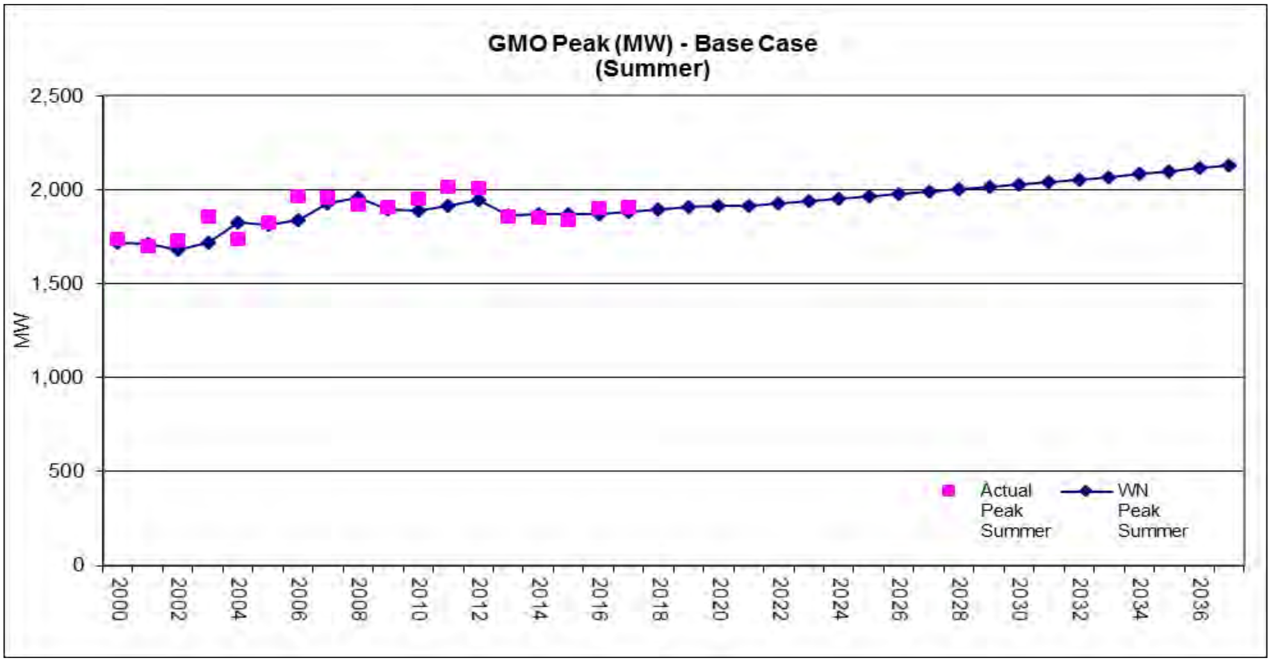


Figure 56: GMO Base Case Actual and Weather Normalized Winter Peak Demand Plots

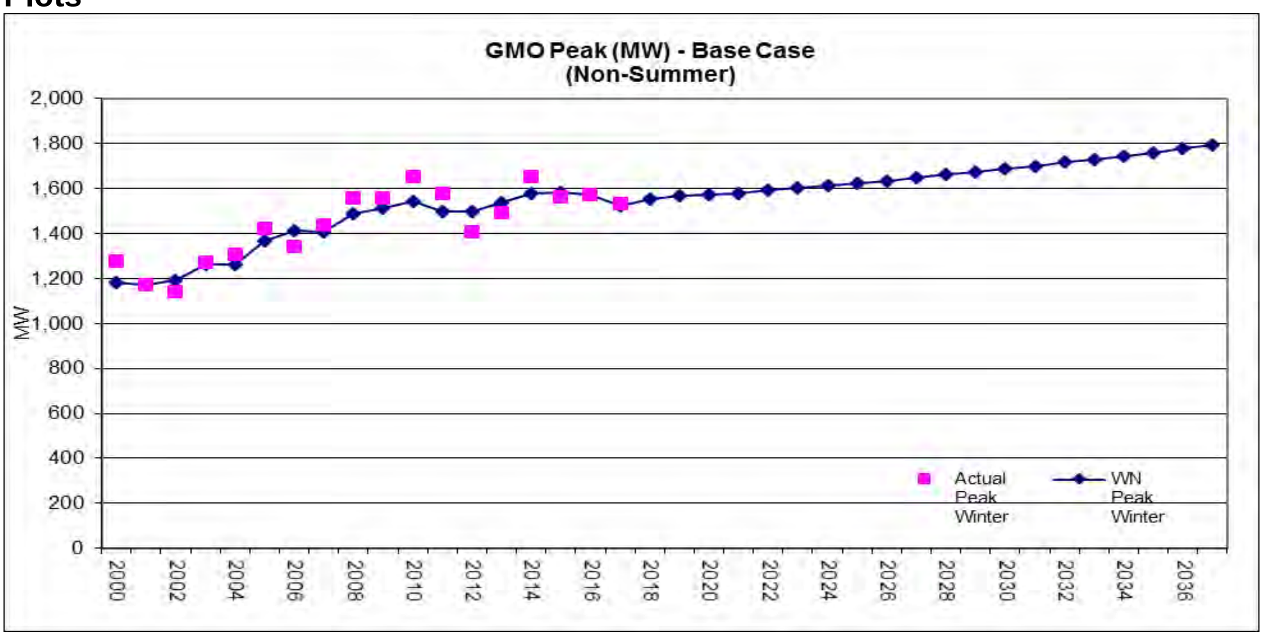
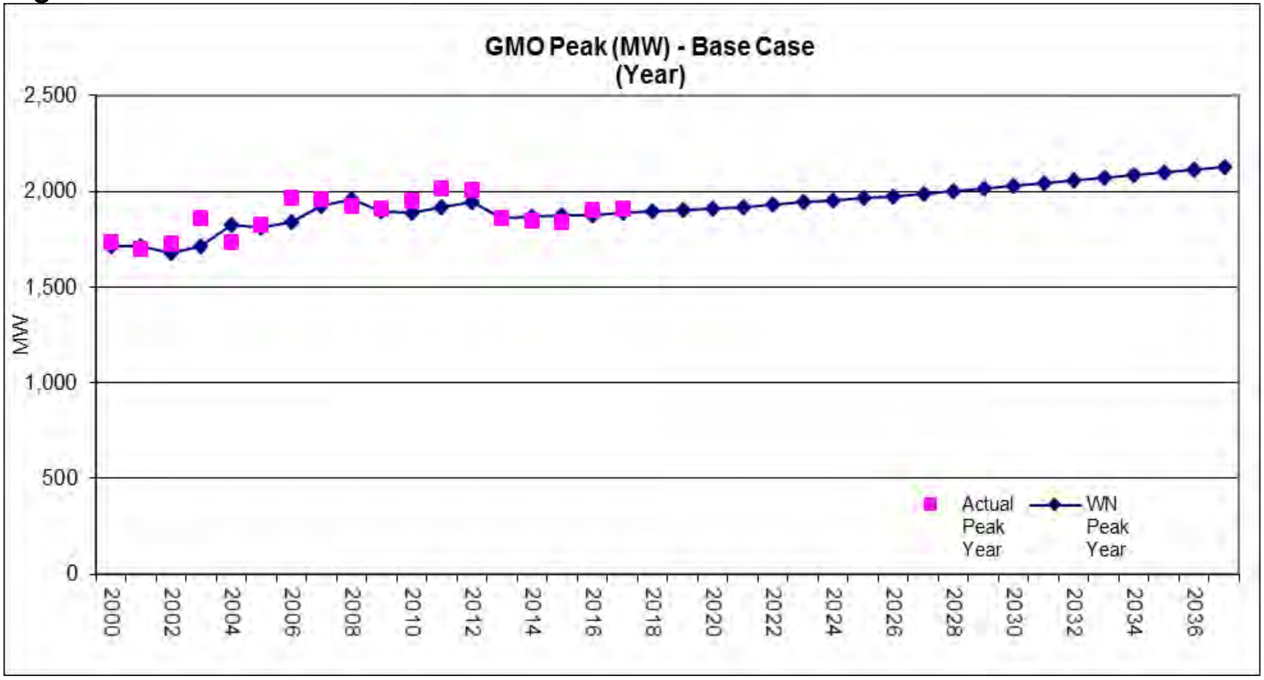


Figure 57: GMO Base Case Actual and Weather Normalized Total Peak Demand Plots



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_GMO_NSI_Peak.xls*.

Figure 58: GMO Base-Case, Low-Case, and High-Case Summer Energy Plots

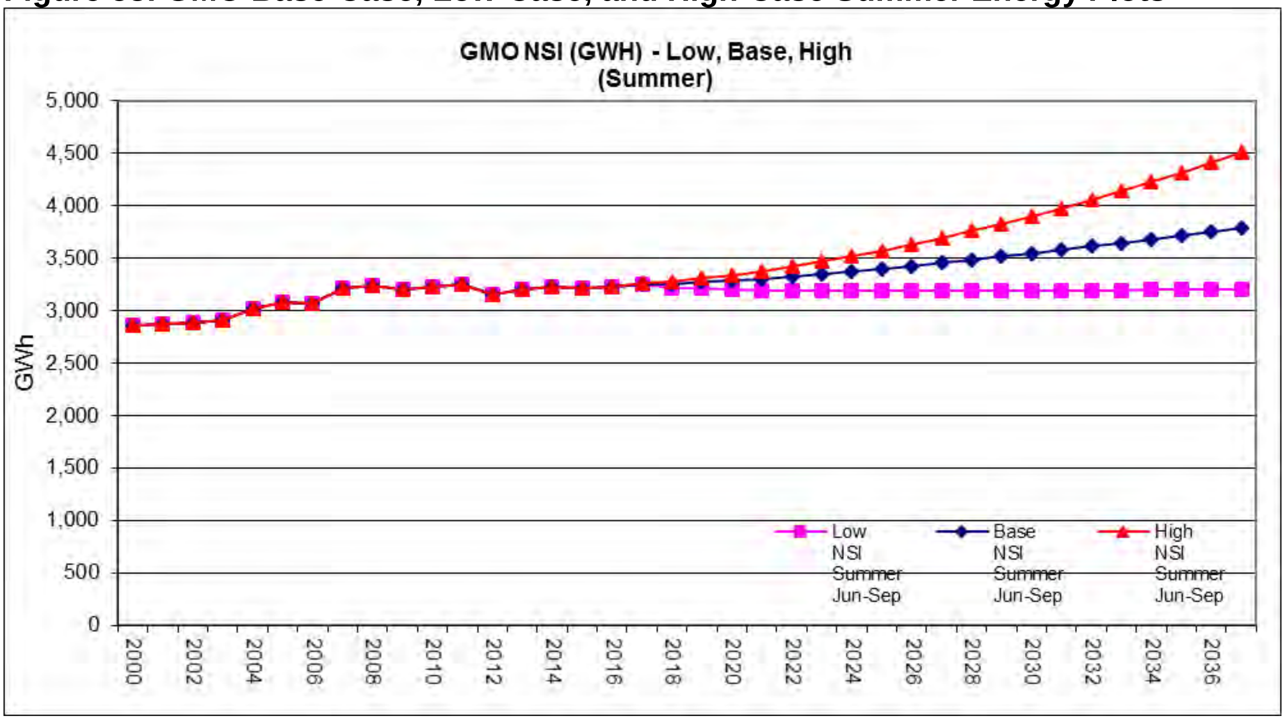


Figure 59: GMO Base-Case, Low-Case, and High-Case Non-Summer Energy Plots

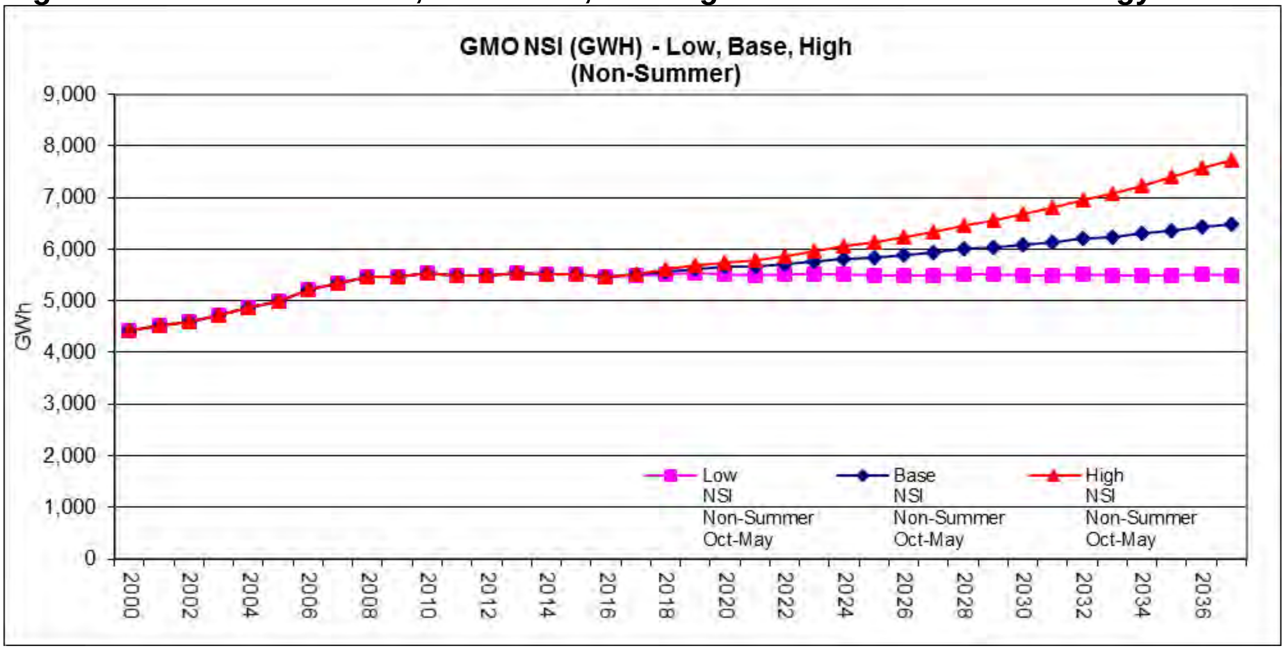
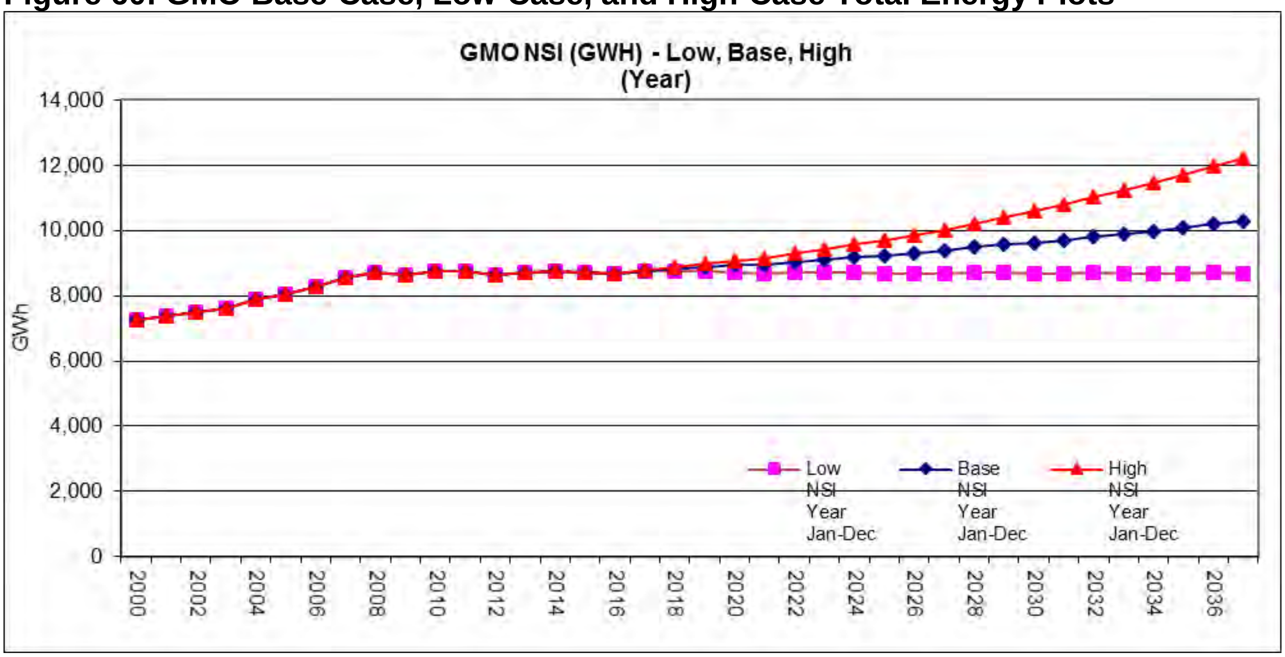


Figure 60: GMO Base-Case, Low-Case, and High-Case Total Energy Plots



The figures below represent peak demand for summer and non-summer for the base, low, and high scenario forecasts. Annual demand charts are not shown, since they are the same as summer demand charts. Corresponding tables can be found in *Appendix 3D* and in the file *IRP_8C_GMO_NSI_Peak.xls*.

Figure 61: GMO Base-Case, Low-Case, and High-Case Summer Peak Demand Plots

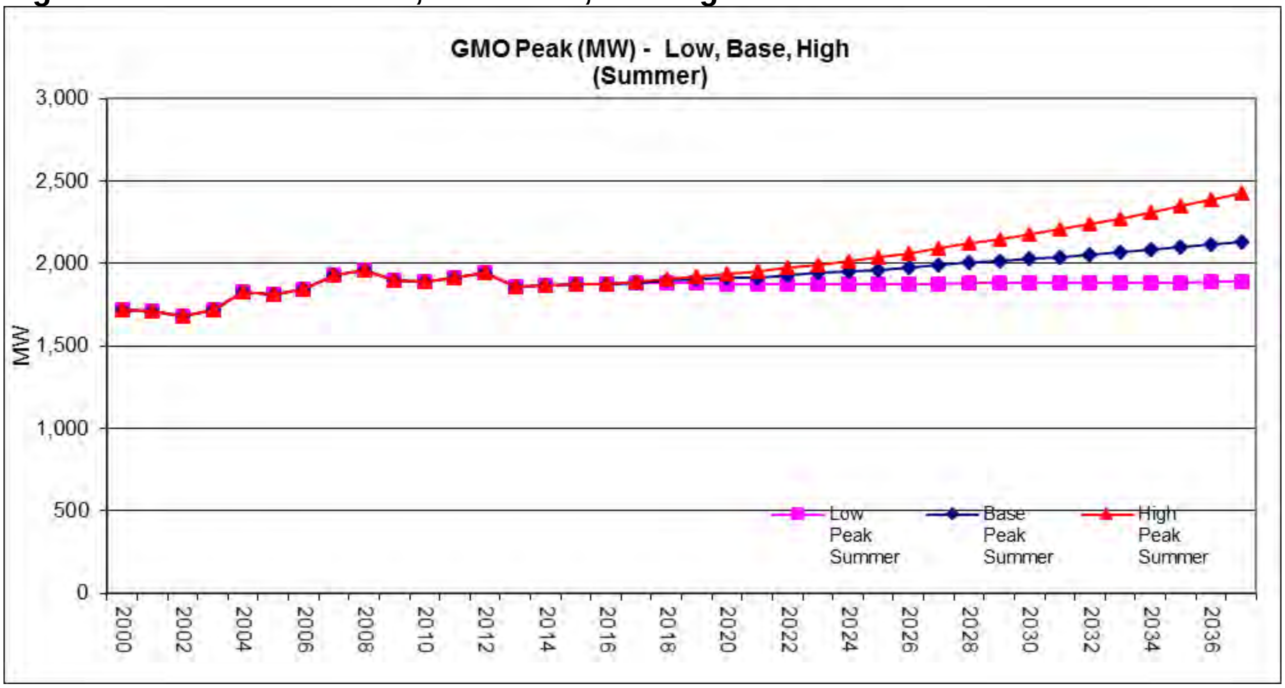


Figure 62: GMO Base-Case, Low-Case, and High-Case Winter Peak Demand Plots

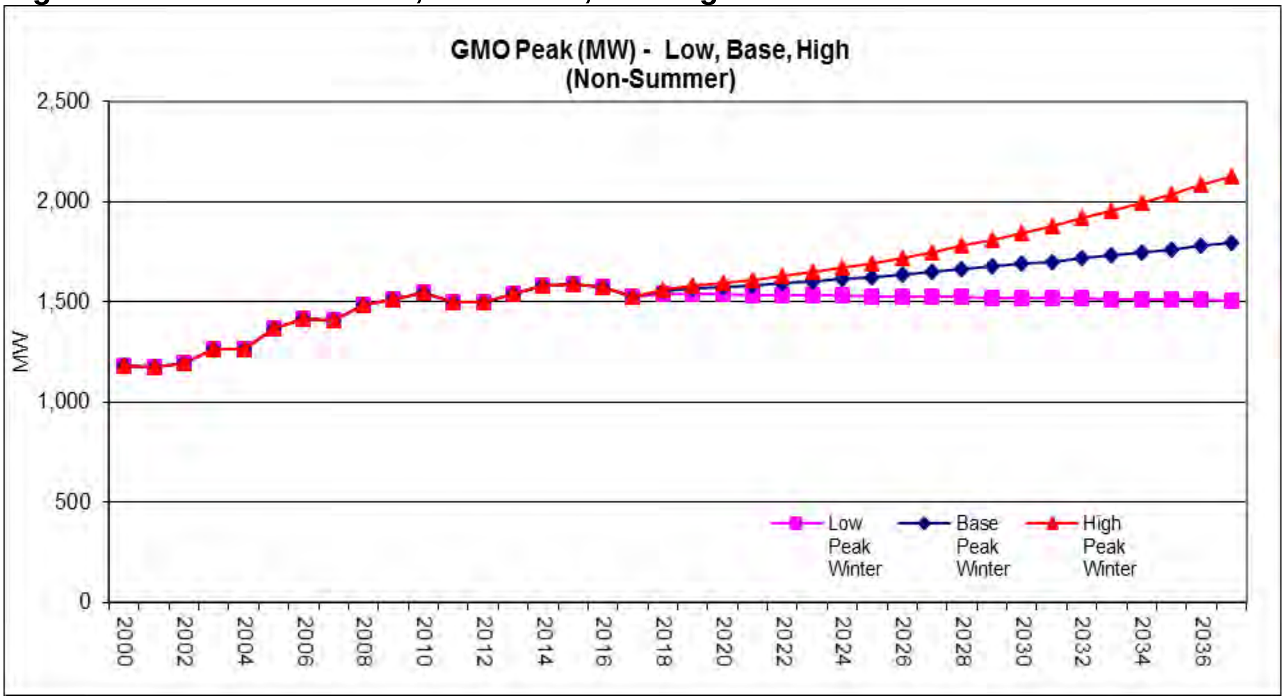
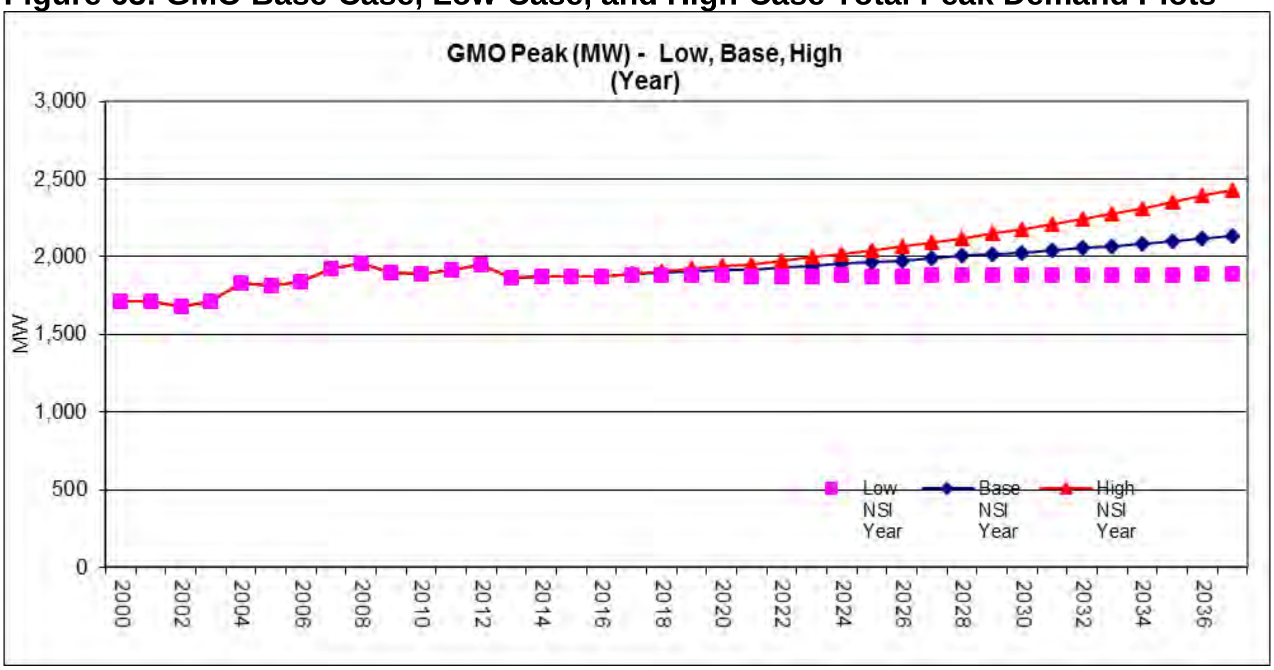


Figure 63: GMO Base-Case, Low-Case, and High-Case Total Peak Demand Plots



[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] See regulatory_programs_mypp.pdf .
[vi] 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
[vii] www1.eere.energy.gov/buildings/appliance_standards/commercial/ashrae_products_docs_meeting.html