MEMO TO: PREPA IRP Team

FROM: Siemens PTI/EBA

DATE: August 21, 2018

SUBJECT: PREPA IRP Load Forecast

The aim of this section is to present and discuss the gross electricity demand forecast (e.g. before any adjustments for future energy efficiency, demand response or distributed generation, which will be modeled separately and are provided in another memo), prepared as required for the development of the Integrated Resource Plan (IRP) for PREPA. This includes a concise presentation of the data used, a description of the methodology and the necessary assumptions, and finally the resulting load forecast. The forecast has been prepared for the IRP study horizon of fiscal year (FY) 2019-2038 (July 1, 2018 – June 30, 2038).

Data, Assumptions and Methodology

Historical Energy Sales

Siemens used monthly historical energy sales provided by PREPA for the econometric model used to develop the load forecast. Siemens used data for fiscal years (FY) 2000-2018 (July 1999 - June 2018) broken down into six customer classes; residential, commercial, industrial, agriculture, public lighting, and other. The commercial is the largest sector accounting for 47% of the total sales in FY 2017, followed by residential (38%) and industrial (13%). Overall, the combined sales to residential, commercial, and industrial customers represented 98% of the total in FY 2017, with the remaining 2% of sales coming mostly from the public lightning sector.

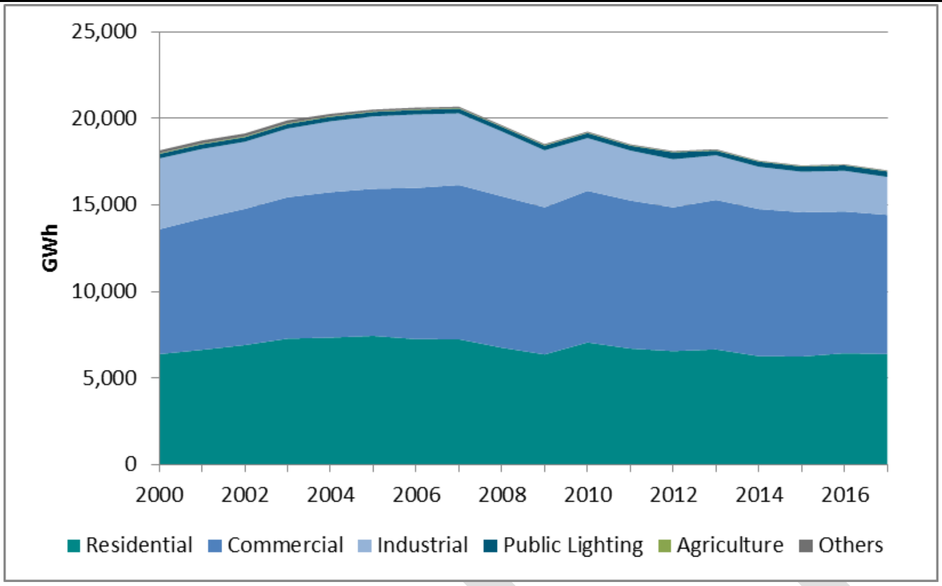
Electricity sales in Puerto Rico declined 18% since the Great Recession due to a structural decline in the economy and net migration of people out of the island with GNP and population falling by at least a percentage point annually since 2007[1]. For FY 2018, total sales declined 22%, reflecting the disruption in the transmission and distribution networks due to the hurricanes as well as customer billing delays[2].

Industrial sales declined 47% in FY 2007-2017, while residential and commercial fell 12% and 10%, respectively. Industrial share of the total demand declined from 20% in FY 2007 to 13% in FY 2017. In contrast, the share of commercial sales increased by 4 percentage points during the same period. Exhibit 1 shows historical energy sales for fiscal years 2000-2017 by customer class, as reported by PREPA.

[1] The prior six years 2000 to 2006 saw an average growth in the GNP of 1.4% yearly while the broader US economy saw a growth of 2.6%.

[2] Based on preliminary data provided by PREPA

Exhibit 1: Historical PREPA Annual Sales by Customer Class (GWh)

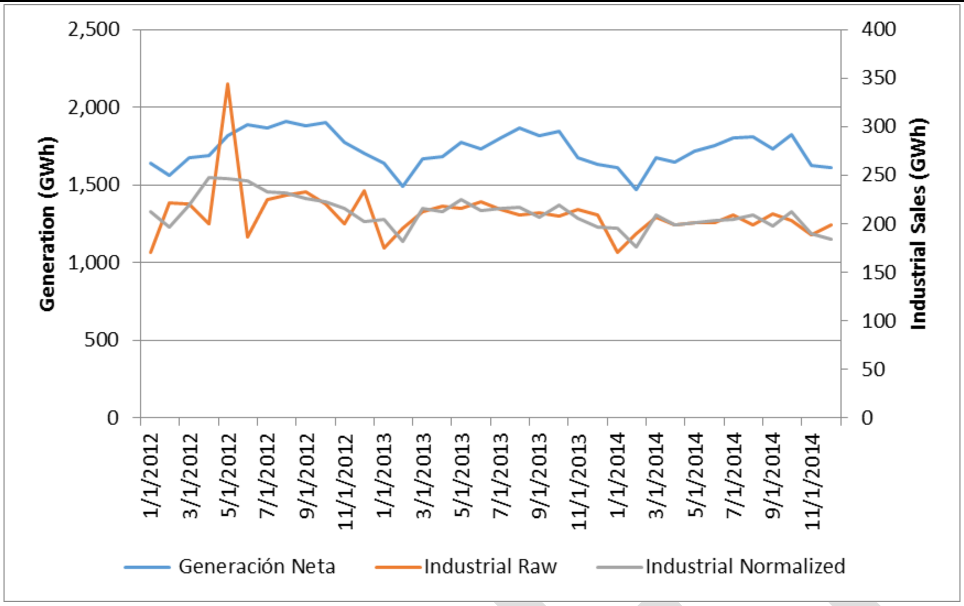


Source: PREPA

Energy sales were normalized for each of the six customer classes. PREPA indicated that historical sales can be affected by billing issues (delays, incorrect reporting, etc.), which might explain high volatility for some months, not in line with changes in monthly generation on a system wide basis. The volatility is particularly notorious after hurricanes Irma and Maria struck Puerto in the fall of 2017, with extreme volatility and low or even negative energy monthly sales numbers reported after September 2017. PREPA indicated, the Company is still in the process of validating data and making corrections for reported sales post Maria. For this reason, Siemens did not include historical numbers for fiscal year 2019 as part of the econometric regression analysis.

To correct for abnormal data volatility and avoid biases embedded in the forecast results, Siemens normalized the sales data by customer class using historic monthly generation and the relative share of each class to the total net generation reported. Exhibit 2 shows the normalization for the industrial customer class compared to the raw data and the net system generation for 2012-2014. The chart shows the normalization technique eliminated unexplained volatility in months such as May or June 2012, and the rise or fall in monthly sales not following net generation levels. The normalized data was used for the econometric regression analysis described next.

Exhibit 2: Historical Normalized data for the Industrial Customer Class



Load Forecast Methodology

The applied methodology considered mathematical models using statistical and econometric tools to develop forecast series of monthly energy sales for the three largest customer classes, residential, commercial and industrial. The gross energy demand forecast is developed using a Classical Linear Regression Model (CLRM) in which the dependent variable, energy sales, is expressed as a linear combination of the independent variables. For Puerto Rico, 15 variables were used including a weather variable (cooling degree days), two economic variables (population and GNP), and 12 month specific dummy variables (one for each month of the year) to capture the seasonality of energy demand on a monthly basis. For industrial demand, manufacturing employment was also included as an explanatory variable instead of the population in the regression analysis. Population was found not to have statistical significance with industrial growth expected to drive future population growth, not vice versa.

The econometric model uses the ordinary least-squares regression technique in MATLAB. This approach is widely used to develop long-term load forecasts by independent system operators like PJM in the U.S. or the California Energy Commission in their annual load forecast studies. Siemens used monthly historical data for FY 2000 through FY 2017 to estimate the regression coefficients applied to the forecast, with 210 observations for each variable.

The coefficients that are produced, unique to each independent variable, are used to develop the gross energy forecast along with projections of the independent variables (weather, GNP, population and manufacturing employment). The 12 month dummy binary variables were included in the forecast formulation to capture monthly seasonality in demand. The sum product of the coefficients and variables on a monthly basis result in the gross energy forecast shown below:

$$Demand = C_1 * V_1 + C_2 * V_2 \ldots \ldots \ldots C_{17} * V_{17} + b$$

In the equation above, C_x is the coefficient corresponding to each independent variable V_x, and b represents the constant.

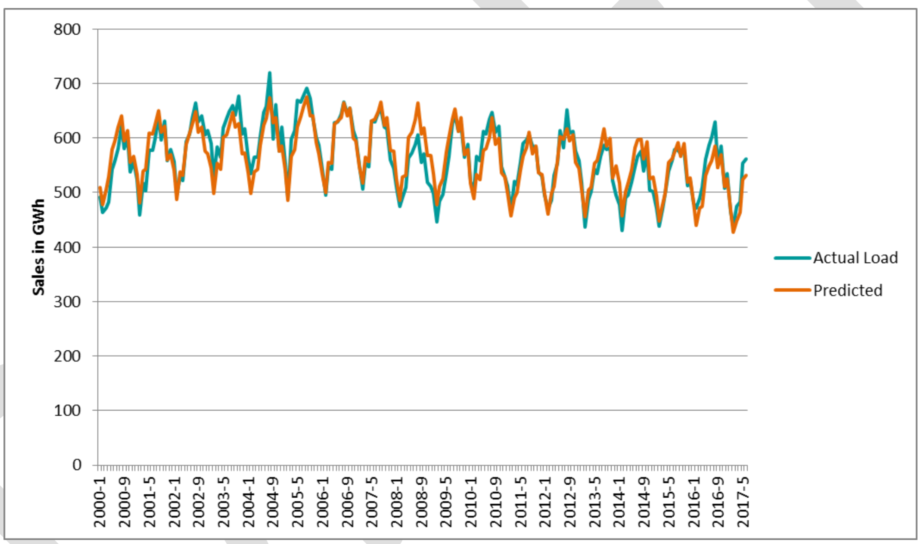
Exhibit 3 illustrates the variables used to develop the forecast for each of three largest classes.

Exhibit 3: Independent variables for Each Customer Classes

Residential	Commercial	Industrial
• CDD • GNP • Population • 12 month variables	• CDD • Population • 12 month variables	• CDD • GNP • Manufacturing Employment • 12 month variables

The statistical significance of the explanatory variables and predicted fit of the model for each class was robust, as shown in Exhibit 4 for the residential class. The predicted values followed monthly historical sales to a great extent. The regression coefficients, adjusted R^2s, and F-stats from the econometric model for each class are shown in Appendix A.

Exhibit 4: Residential Class Predicted Fit vs. Actuals



Source: PREPA, Siemens

For the smaller customer classes (agriculture, lighting and other) the overall fit of the CLRM model was not as robust with the economic and weather fundamental variables providing a much lower explanatory value on the energy demand for each class. For these customer classes, Siemens developed the forecast based on their historical seasonality and using a simpler extrapolation technique with the expectation that each class follow similar growth rates to the overall system.

Fundamental Drivers for the Load Forecast

In line with the econometric model, Siemens used population, GNP, CDD and the monthly dummy variables as explanatory variables to develop the load forecast by customer class for FY 2019-2038. Other economic data was considered, including disposable income, income per-capita, and the heat index for weather but they were not included due to its high correlation to other variables already incorporated in the analysis such as CDD (highly correlated to the heat index) or the GNP (highly correlated to disposable income), diluting their predictive value.

For weather data, Siemens found Cooling Degree Days as the most statistically significant variable to predict the impact of weather on load, despite Puerto Rico having a tropical climatic zone with warm temperatures all year round averaging 80°F (27°C) in low elevation areas, and 70°F (21°C) in the lush central mountains of the island. Although temperature variation is relatively modest throughout the year, the overall heat level drives cooling load trends (demand for air conditioning). Weather data was sourced from the National Oceanic and Atmospheric Association (NOAA) for the San Juan station, as a representative for the overall island temperature and rainfall trends. Higher elevation locations were not found to have a significant impact on overall load changes.

Customer rates were considered in the analysis, in particular industrial rates, but they were found not to have a strong historic correlation to demand and explanatory power. In 2000 to 2017, there were periods where industrial demand fell along with declining industrial rates or the opposite. The expectation would be an inverse relationship with lower demand as a consequence of rising industrial rates. The manufacturing sector in Puerto Rico, mostly comprised of pharmaceutical, textiles, petrochemicals, and electronics; appears to be less responsive to changes in customer rates compared to other manufacturing industries such as steel or aluminum, which are highly sensitive (high elasticity). The residential sector is traditionally a sector with low response to changes in retail rates and to some extend the commercial customers. However, sustained high retail rates could change customer behavior and create more incentives for implementation of energy efficiency programs.

Siemens compiled and reviewed macroeconomic data (historical and forecasts) from several sources including Moody's Analytics, the International Monetary Fund, World Bank, the U.S. Census Bureau, Federal Reserve of Economic Data of St. Louis (FRED) and Puerto Rico's Federal Management Oversight Board (FOMB), among others.

Exhibit 5 below shows the historical annual values for the independent variables used in the regression analysis.

Exhibit 5: Historical Population, Macroeconomic, and Weather Variables

Year	Population (thousands)	GNP (Real Million US dollars)	Cooling Degree Days (Monthly Average)	Manufacturing Employment (thousands)
2000	3,815	6,773	453	143
2001	3,822	6,873	476	132
2002	3,825	6,850	477	121
2003	3,827	6,991	472	118
2004	3,825	7,178	461	118
2005	3,814	7,315	478	115
2006	3,794	7,351	473	110
2007	3,772	7,262	489	106
2008	3,750	7,054	467	101
2009	3,733	6,784	499	92
2010	3,702	6,542	491	87
2011	3,656	6,432	462	84
2012	3,615	6,466	506	82
2013	3,566	6,458	496	76
2014	3,504	6,348	519	75
2015	3,441	6,312	513	74
2016	3,372	6,209	506	74
2017	3,190	6,060	504	72

Source: FOMB (GNP), Moody's (Population), NOAA (weather), FRED (Manufacturing Employment)

Before the hurricane, Puerto Rico's economy was in structural decline, with GNP and population falling by at least a percentage point a year since 2006, the last year when the GNP saw an increase. Puerto Rico's GNP shrunk 8% in the decade after the Great Recession with GNP reaching $6 billion dollars in 2017 (real dollars).

Population declined 15% since 2007 with Maria and Irma accounting for 4 percentage points of this decline in population (182 thousand people in 2017) due to the combined impact of migration and the death toll after the storm, estimated at over 4,100 people[3].

Macroeconomic and Weather Projections

Historical monthly NOAA data was retrieved (2000-2016) to develop expected monthly Cooling Degree Days (CDD) under normal weather conditions for the forecast. Exhibit 6 shows the normalized CDD used for the forecast.

Exhibit 6: Weather Variables

Month	Cooling Degree Days (CDD)
January	391
February	361
March	427
April	454
May	511
June	547
July	567
August	572
September	552
October	552
November	466
December	427

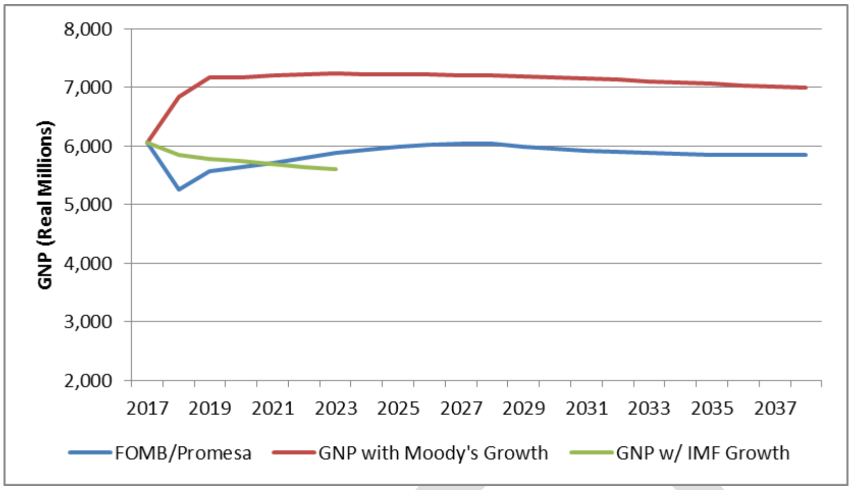
Source: NOAA, Siemens

To be consistent with the Financial Oversight and Management Board, Siemens used their forecast for GNP and population in 2019-2038. According to FOMB, the GNP is estimated to decline 13% for fiscal year (FY) 2018, reflecting the impact of hurricanes Maria and Irma on the economy. For FY 2019, GNP is projected to grow at 6.1%. FOMB forecast shows a relatively fast recovery from Maria's impact, driven by the effect of the Disaster Relief Fund spending program. In the medium-term GNP is projected to increase at 1.6% per-year in 2019-2027. After 2027, GNP growth is projected to soften to -0.3% per-year. The structural reforms are projected to enhanced economic growth, including a reform of the electrical grid, enhanced fiscal transparency and a labor reform aimed to bring Puerto Rican labor law into closer alignment with U.S. law. The offset in economic growth is expected to come from the proposed fiscal consolidation plan which could bring significant austerity over the next few years to reduce Puerto Rico's public debt.

Siemens considered other outlooks as well, including Moody's and the IMF, as shown on Exhibit 7. Moody's projects the GDP to recoup much of its hurricane-related losses and to remain relatively stable throughout the forecast horizon. The IMF shows a more pessimistic forecast through 2023 with GDP not recovering from the aftermath of hurricane Maria in 2017.

[3] Per a study from the Harvard T.H. Chan School of Public Health, published in New England Journal of Medicine, May 2018

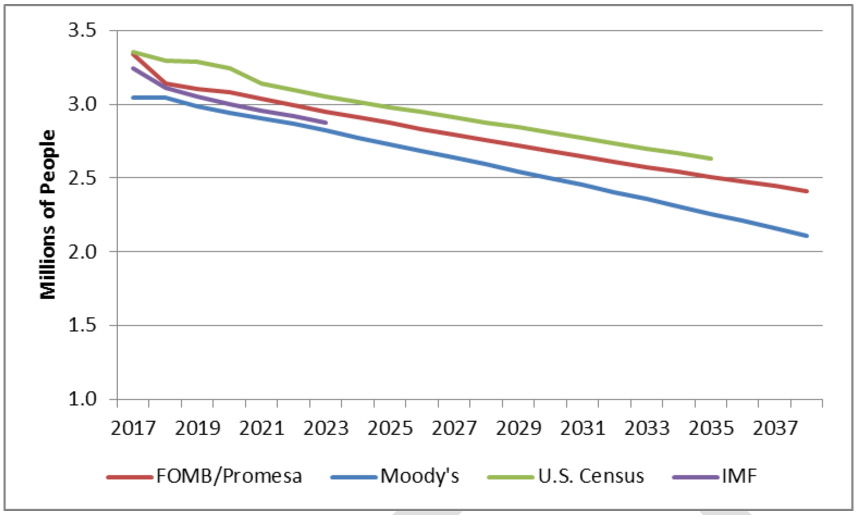
Exhibit 7: Puerto Rico GNP Forecasts



Note: The forecast have been standardized for comparison purposes using the implied growth rates. Moody's GNP forecast is based on real 2009$ and the IMF based on real 1954$.
Sources: Moody's June 2018 Forecast, IMF April 2018 WEO, Financial Oversight and Managing Board of Puerto Rico, Fiscal Plan April 2018

The FOMB forecast for population shows a decline of 5.8% in FY2018 due to hurricanes fatalities and net migration out of the island. Over the study period, FOMB projects population to decline at 1.3% per-year in 2019-2038. Population in Puerto Rico is projected to fall by over 900 thousand people by 2038. Moody's projects a faster pace of population loss over the next decade, compared to FOMB, as the island gets increasingly dragged into a negative feedback loop whereby out-migration undermines the tax base and the provision of public services (which deteriorated since Hurricane Maria), will engender more out-migration. The U.S. Census (prior to Maria) projects higher population levels but still with a falling trend through the forecast. The IMF provides a forecast in between the projections from FOMB and Moody's.

Exhibit 8: Puerto Rico Population Forecast



Sources: Moody's June 2018 Forecast, IMF April 2018 WEO, US Census Bureau August 2017

Exhibit 9 shows the long-term economic forecast used in the load forecast.

Exhibit 9: Macroeconomic Long Term Forecast

Fiscal Year	Population (thousands of people)	GNP (Real Millions US dollars)	Manufacturing Employment (thousands of people)
2018	3,143	5,251	70
2019	3,104	5,573	69
2020	3,084	5,632	70
2021	3,039	5,707	70
2022	2,995	5,792	70
2023	2,951	5,873	70
2024	2,910	5,941	71
2025	2,871	5,991	71
2026	2,833	6,029	71
2027	2,794	6,041	72
2028	2,756	6,038	72
2029	2,718	5,984	73
2030	2,681	5,949	73
2031	2,644	5,922	74
2032	2,609	5,897	74
2033	2,575	5,877	75
2034	2,541	5,862	75
2035	2,508	5,852	76
2036	2,476	5,847	77
2037	2,445	5,846	77
2038	2,414	5,849	78

Source: FOMB (population and GNP), Siemens for Manufacturing employment

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Long Term Energy Forecast

Exhibit 10 shows gross energy sales by customer class forecasted by Siemens. The forecast does not include any future energy efficiency and/or demand response programs and distributed generation (DG) in addition to current programs in place. The impact of those programs will be addressed and modeled separately. The forecast does include the impact of naturally occurring energy efficiency savings such as more efficient household appliances in as much it is included in the historical data used to create the model.

Gross energy sales are projected to increase 15% in fiscal year 2019 due to the projected recovery in the economy. However, over the study period, gross energy sales are projected to decline at 0.23% per-year driven by the long-term decline in population and softening of the GNP growth after 2027. Among customer classes, the industrial class is projected to have the strongest growth at 1.4% per-year over the study period, primarily driven by the projected economic growth through 2026. In contrast, the residential and commercial classes are projected to decline at 0.6% and 0.3% per-year, mostly driven by the long-term decline in population.

Agriculture, public lightning and "other" are projected to decline in line with the overall system at -0.23% per year. The public lighting forecast shown below does not include the impact of a large replacement of current oil-based public lightning with LED light bulbs. That will be addressed in a separate memo along with all other future energy efficiency programs.

Exhibit 10: Gross Sales Demand by Customer Class

Fiscal Year	Residential Sales (GWh)	Commercial Sales (GWh)	Industrial Sales (GWh)	Agricultural Sales (GWh)	Public Lighting Sales (GWh)	Other Sales (GWh)	Total Sales (GWh)
2019	5,472	7,962	1,491	26	315	35.6	15,301
2020	5,480	7,948	1,551	26	316	35.8	15,357
2021	5,473	7,917	1,635	26	317	35.9	15,403
2022	5,473	7,886	1,730	26	318	36.0	15,470
2023	5,470	7,856	1,822	27	320	36.2	15,530
2024	5,464	7,827	1,900	27	320	36.3	15,574
2025	5,451	7,801	1,960	27	321	36.3	15,595
2026	5,431	7,774	2,008	27	321	36.3	15,596
2027	5,396	7,747	2,028	27	320	36.2	15,554
2028	5,353	7,721	2,032	26	319	36.1	15,487
2029	5,284	7,695	1,984	26	316	35.7	15,341
2030	5,223	7,669	1,956	26	313	35.5	15,223
2031	5,168	7,644	1,937	26	311	35.2	15,120
2032	5,115	7,619	1,921	26	309	35.0	15,025
2033	5,065	7,596	1,910	26	307	34.8	14,939
2034	5,020	7,572	1,905	25	306	34.6	14,862
2035	4,978	7,549	1,905	25	304	34.5	14,796
2036	4,940	7,527	1,911	25	303	34.3	14,741
2037	4,905	7,506	1,921	25	302	34.2	14,694
2038	4,873	7,484	1,935	25	302	34.1	14,654
CAGR	-0.61%	-0.32%	1.38%	-0.23%	-0.23%	-0.23%	-0.23%

Note: The sales forecasts reflect gross energy sales inclusive of existing EE programs. It does not include loses, PREPA's own use and auxiliary demand neither any future incremental EE and/or demand response programs.

Exhibit 11 illustrates the gross demand for generation inclusive of the generation auxiliary loads, technical and non-technical loses, and PREPA's own use. The first column, gross energy sales reflects the totals from Exhibit 10. PREPA's own use is assumed to stay constant through the forecast. No auxiliary generation is assumed to be retired. However, for the portfolio scenario analysis of the Integrated Resource Plan, future retirements will be incorporated into the forecast and their corresponding impact on demand.

Exhibit 11: Gross Energy Demand for Generation

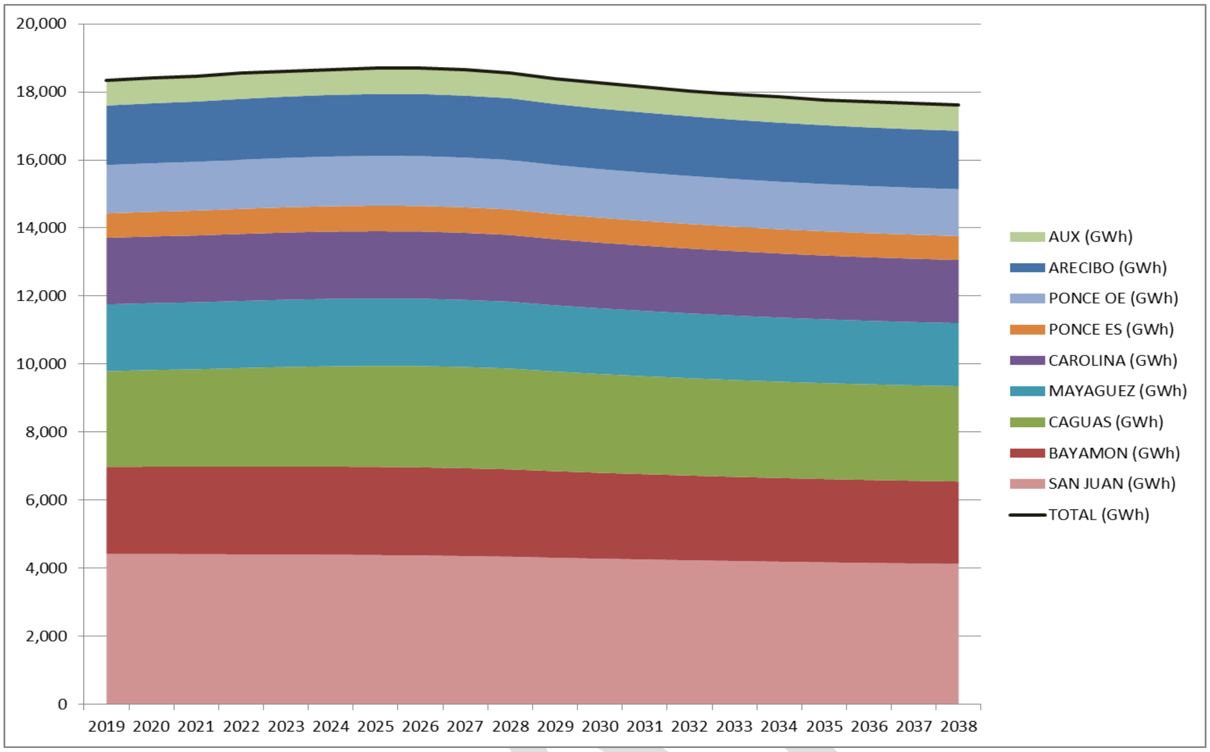
Fiscal Year	Gross Energy Sales (GWh)	Technical Losses (GWh)	Non-Technical Losses (GWh)	Auxiliary (GWh)	PREPA Own Use (GWh)	Total Energy Demand (GWh)
2019	15,301	1,438	827	751	34	18,351
2020	15,357	1,444	830	751	34	18,415
2021	15,403	1,448	832	751	34	18,469
2022	15,470	1,454	836	751	34	18,545
2023	15,530	1,460	839	751	34	18,613
2024	15,574	1,464	841	751	34	18,665
2025	15,595	1,466	842	751	34	18,689
2026	15,596	1,466	843	751	34	18,690
2027	15,554	1,462	840	751	34	18,642
2028	15,487	1,456	837	751	34	18,565
2029	15,341	1,442	829	751	34	18,397
2030	15,223	1,431	822	751	34	18,261
2031	15,120	1,421	817	751	34	18,144
2032	15,025	1,412	812	751	34	18,034
2033	14,939	1,404	807	751	34	17,935
2034	14,862	1,397	803	751	34	17,848
2035	14,796	1,391	799	751	34	17,772
2036	14,741	1,386	796	751	34	17,708
2037	14,694	1,381	794	751	34	17,654
2038	14,654	1,377	792	751	34	17,608
CAGR	-0.23%	-0.23%	-0.23%	0.00%	0.00%	-0.22%

To assess the geographical location of the demand above as necessary for the modeling of the system, PREPA provided the composition of the load in term of customer classes (residential, commercial, industrial, etc.) by County which was used to map the forecast to each of the areas into which the system is modeled. Exhibit 12 and Exhibit 13show the resulting allocation of the Energy Demand for Generation above in tabular and graphic form.

Exhibit 12: Gross Energy Demand for Generation by Area

Fiscal Year	ARECIBO (GWh)	BAYAMON (GWh)	CAGUAS (GWh)	CAROLINA (GWh)	MAYAGUEZ (GWh)	PONCE ES (GWh)	PONCE OE (GWh)	SAN JUAN (GWh)	AUX (GWh)	TOTAL (GWh)
2,019	1,748	2,558	2,818	1,956	1,961	719	1,422	4,417	751	18,351
2,020	1,759	2,566	2,840	1,961	1,966	724	1,429	4,418	751	18,415
2,021	1,771	2,571	2,866	1,965	1,969	729	1,436	4,411	751	18,469
2,022	1,787	2,579	2,898	1,970	1,974	736	1,445	4,406	751	18,545
2,023	1,801	2,585	2,927	1,975	1,978	742	1,453	4,401	751	18,613
2,024	1,813	2,590	2,951	1,978	1,981	746	1,460	4,394	751	18,665
2,025	1,820	2,591	2,968	1,979	1,981	750	1,464	4,385	751	18,689
2,026	1,824	2,589	2,978	1,978	1,979	751	1,466	4,374	751	18,690
2,027	1,821	2,581	2,975	1,971	1,972	750	1,462	4,357	751	18,642
2,028	1,815	2,569	2,965	1,962	1,963	747	1,457	4,337	751	18,565
2,029	1,794	2,544	2,930	1,945	1,945	739	1,442	4,307	751	18,397
2,030	1,779	2,524	2,903	1,930	1,931	732	1,430	4,280	751	18,261
2,031	1,766	2,506	2,882	1,917	1,918	727	1,420	4,256	751	18,144
2,032	1,755	2,490	2,862	1,905	1,905	722	1,411	4,233	751	18,034
2,033	1,744	2,475	2,845	1,894	1,894	717	1,403	4,211	751	17,935
2,034	1,736	2,461	2,831	1,885	1,884	714	1,396	4,191	751	17,848
2,035	1,728	2,449	2,820	1,876	1,875	710	1,390	4,172	751	17,772
2,036	1,723	2,439	2,812	1,868	1,867	708	1,385	4,155	751	17,708
2,037	1,719	2,430	2,806	1,862	1,860	706	1,381	4,139	751	17,654
2,038	1,715	2,422	2,802	1,856	1,854	705	1,378	4,124	751	17,608

Exhibit 13: Graph of Gross Energy Demand for Generation by Area



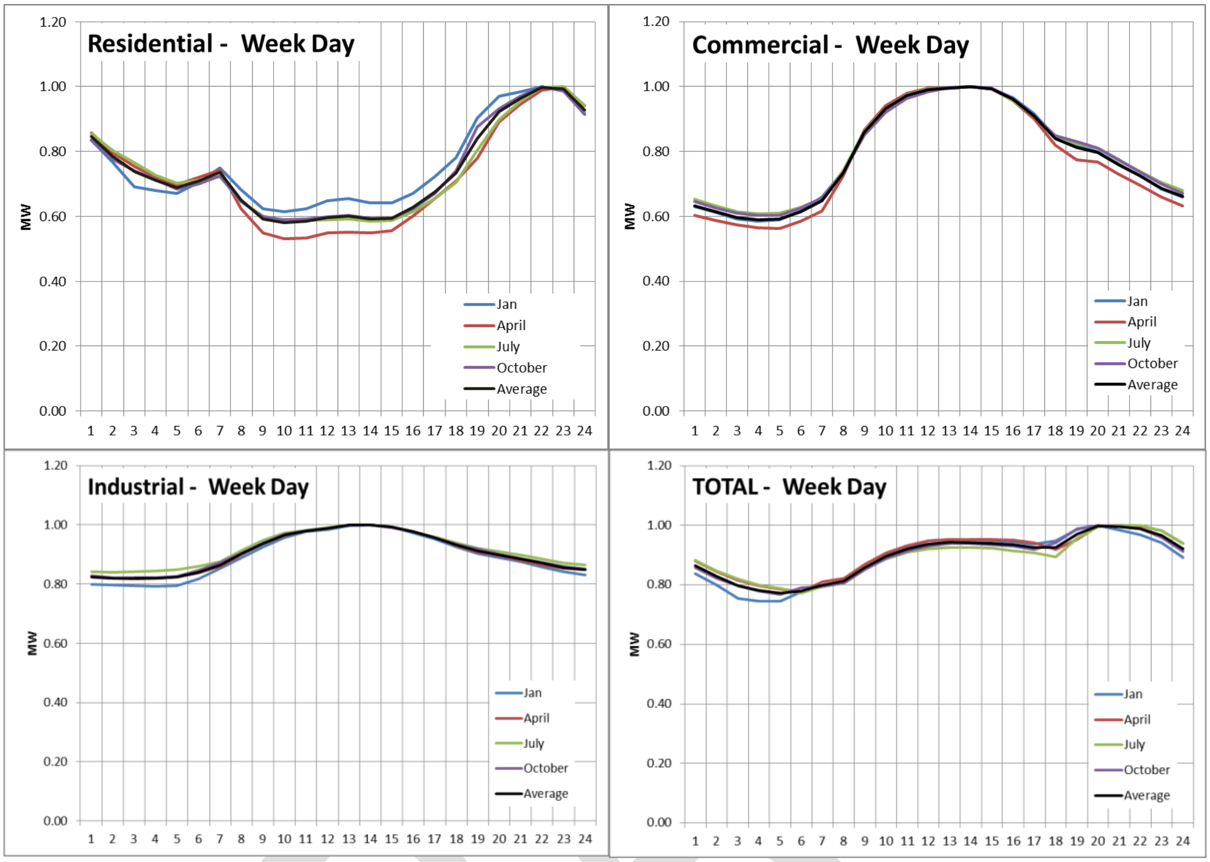
Source: Siemens

Long Term Peak demand Forecast

To estimate the peak demand associated with the energy forecast it is necessary to determine for each customer class their expected load factors (i.e. the ratio of average demand to the peak demand) and the percentage of their peak demand that occurs at the time of the system peak (called Customer Class Coincidence Factor – CCCF - or Contribution to the Peak Factor). These factors in principle should be determined monthly in line with the monthly granularity of the energy forecast. However single values equal to the average of the determined monthly values was preferred due to the fact that: a) there is not a significant change in the hourly load shapes for the relevant customer classes across the year, b) the load factor can be volatile unless averages are made due to its dependence on the measured peak and c) only one year worth of hourly load data by customer class was available.

Exhibit 14 shows the normalized load shapes for the main customer classes (Residential, Commercial and Industrial) that make up most of the energy consumption as well as the system total. As can be observed, unlike the mainland US where there are large changes in the shape from summer to winter, in Puerto Rico the shapes are largely the same (residential shows the greater variation) and an average load factor can be used to represent each customer class. We also note in the Exhibit below that there are two peaks a day time peak driven by commercial and industrial loads and a night peak driven by the residential load and this is the higher of the two. Thus the residential customers peak at the same time as the system (CCCF =1) while the industrial and commercial customers have a lower peak at this time (CCCF < 1).

Exhibit 14: Normalized Load Shapes for main Customer Classes and System Total



Source: Siemens

Based on the hourly information provided Siemens estimated the load factors and Customer Class Coincidence Factors (% of the Customer Class peak at the time of the System Peak) shown in Exhibit 15.

Exhibit 15: Selected Load Factors and Customer Class Coincidence Factor

Customer Class	Load Factor %	Customer Class CF %
Residential	66.9%	100%
Commercial	70.2%	70%
Industrial	81.2%	85%
Lighting	49.3%	100%
Other	73.6%	80%
Agriculture	46.8%	32%

Source: Siemens

Using the values above and the forecasted energy consumption by customer class, the peaks demand and the demand at the time of system peak can be determined. To this peak the following is added: a) effect of the technical transmission and distribution technical loses using a correction to convert energy losses into capacity losses based on the load factor[4], b) non-technical loses using same values as the residential load, c) PREPA own consumption using an estimated load factor based on historical values and b) finally the effect of the consumption of the generating plants auxiliary services.

[4] Capacity Losses % = (Energy Losses %) / (0.3+0.7*LF)

Exhibit 16 shows the gross average and peak demand for generation, inclusive of the factors indicated above (technical and non-technical losses, auxiliary demand and PREPA's own use). Exhibit 16 does not include the impact of future energy efficiency and/or demand response programs or DG, which are modeled and addressed separately.

Peak demand is projected to decline at 0.24% per year. The lower rate of peak growth relative to the energy demand is a consequence of more modest growth in residential demand compared to commercial demand in the long-term and the corresponding contribution of each class to peak demand. Commercial load peaks during the day, while the residential peaks at night (sometimes very late), the last driving the system peak. A reduction in residential load results in a reduction in the night peak and an increase in the overall system load factor.

Exhibit 16: Gross Average and Peak Demand for Generation

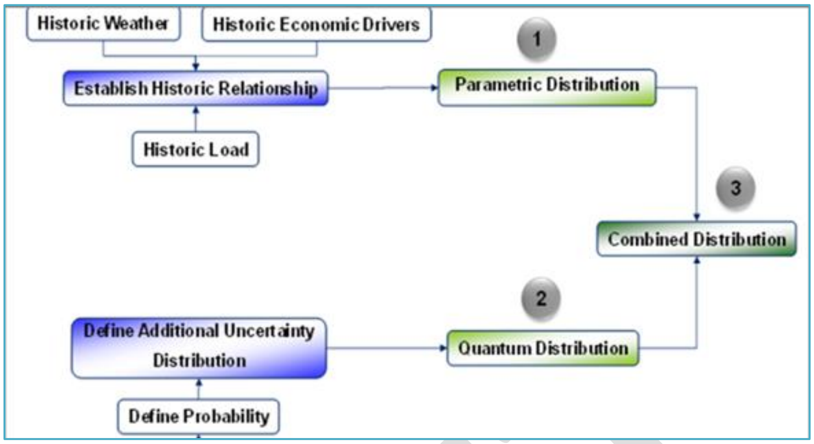
Fiscal Year	Average Demand (MW)	Peak Demand (MW)	Load Factor (%)
2019	2,095	2,791	75.1%
2020	2,102	2,799	75.1%
2021	2,108	2,805	75.2%
2022	2,117	2,815	75.2%
2023	2,125	2,823	75.3%
2024	2,131	2,829	75.3%
2025	2,133	2,831	75.3%
2026	2,134	2,830	75.4%
2027	2,128	2,822	75.4%
2028	2,119	2,810	75.4%
2029	2,100	2,785	75.4%
2030	2,085	2,765	75.4%
2031	2,071	2,748	75.4%
2032	2,059	2,731	75.4%
2033	2,047	2,716	75.4%
2034	2,037	2,703	75.4%
2035	2,029	2,692	75.4%
2036	2,021	2,682	75.4%
2037	2,015	2,673	75.4%
2038	2,010	2,666	75.4%
CAGR	**-0.22%**	**-0.24%**	

Note: Forecast includes technical and non-technical losses, auxiliary demand and PREPA's own use. The forecast does not include the impact of future energy efficiency and/or demand response programs.

Stochastic Distribution

To generate scenarios for load growth, Siemens developed statistical distributions based on the deterministic load forecasts. The process involves two steps, the first one, encompasses developing parametric distributions around the key fundamental variables that could present more volatility in the future (weather and economic performance in Puerto Rico) utilizing historical data to develop 2,000 scenarios for weather and GDP that are feed into the econometric regression model to determine 2,000 iterations of average and peak load. The second step involves developing Quantum distributions, which incorporate future uncertainties not captured by the historical data. The overall process is summarized by the flow chart in Exhibit 17 below.

Exhibit 17: Stochastic Process



Parametric Distributions

To produce load distributions, Siemens propagates three independent random paths: CDD, GDP, and a residual. The development of stochastics is based on building probability distributions around the deterministic forecast.

- To produce reasonable weather data projections, Siemens samples 17-year monthly historical weather data based on CDD for 2000-2017.
- GDP is assumed to follow a Geometric Brownian Motion. This means that there exists a normal distribution with constant mean and variance that describes how the GDP could behave at any time in the future. The process is developed using historical quarterly GDP data for 2000-2017.
- Finally, to account for unexplained variation in the observed data, Siemens adds a normally distributed residual with mean zero and standard deviation equal to the root mean squared error from a stepwise regression.

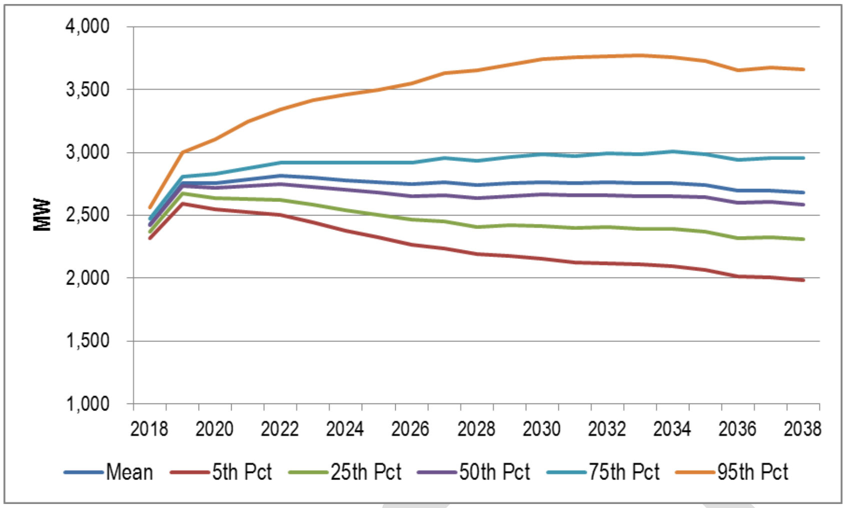
Based on historical volatility, 2,000 distributions of these variables are developed and used in the stepwise regression model to develop an intermediate distribution of average and peak load distributions for the forecast time period.

Quantum Distribution: Additional Variability

It is Siemens' opinion that future power demand may differ substantially from past power demand. To accommodate for this possibility, we add an additional "Quantum Distribution" to our empirically derived distribution. The 5^{th} percentile of this distribution reflects a low growth scenario (i.e. higher degree of DSM and DG penetration). The upper tail of this distribution (95^{th} Percentile) is weighted to match Siemens' analysis of historical high periods of load growth or to capture other events such as higher penetration of air conditioning loads and rising demand from electric vehicles. Using this high and low growth scenarios, Siemens generates a distribution using statistical techniques. This distribution is super imposed on the parametric distribution obtained in the step discussed above. The resulting distribution is considered the final average and peak load distribution (2,000 iterations).

Exhibit 18 shows an illustrative stochastic distribution for the peak demand for generation for planning purposes.

Exhibit 18: Illustrative Peak Demand for Generation Stochastic Distribution (to be updated upon consensus on base forecast)



Note: Forecast reflects peak demand inclusive of loses, auxiliary demand and PREPA's own use (system wide peak). Forecast does not include energy efficiency and/or demand response programs additional to existing programs.

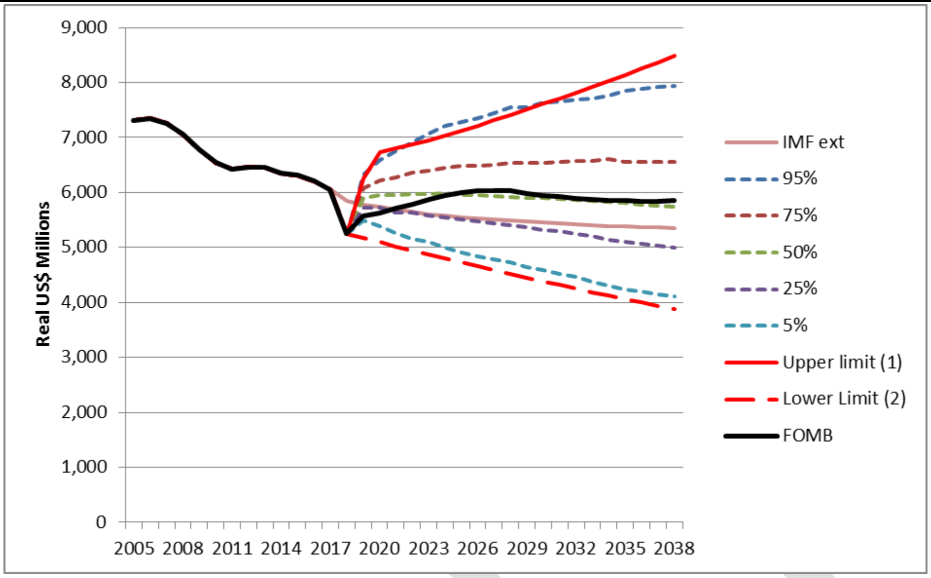
The mean load path corresponds to the average of 2,000 iterations of combinations of the stochastic input drivers. The percentile bands are not load paths but instead represent the likelihood that the peak demand could be at or below that level in a given year. For example, in 2025 there is a 95% likelihood that peak demand will be at or below 3,497 MW. Also in 2025, there is a 5% chance that peak demand will be at or below 2,323 MW.

In addition to the above and to provide some rationale on the factors that could give rise to the high and low forecasts mathematically obtained above, Siemens developed and "Upper Limit" or optimistic scenario and a "Lower Limit" or pessimistic scenario for the macroeconomic parameters driving the forecast: GNP and population.

The Upper Limit assumes that the structural reforms in Puerto Rico are highly successful and the GNP after hitting a low in 2018 bounces back at a rate 50% faster than Moody's forecast for two years as federal funds are invested in the island. From 2020 onwards the Puerto Rico economy recovers to its pre-2006 potential and the GNP grows at 75% of the US GDP forecast growth rate – see Exhibit 19. Consistent with this economic outlook there is initially a drop in population following the US Census forecast until 2019 and from 2020 onwards, as the Puerto Rico economy starts to grow, the population outflow reduces to only 25% of the yearly attrition in the US Census forecast – see Exhibit 20.

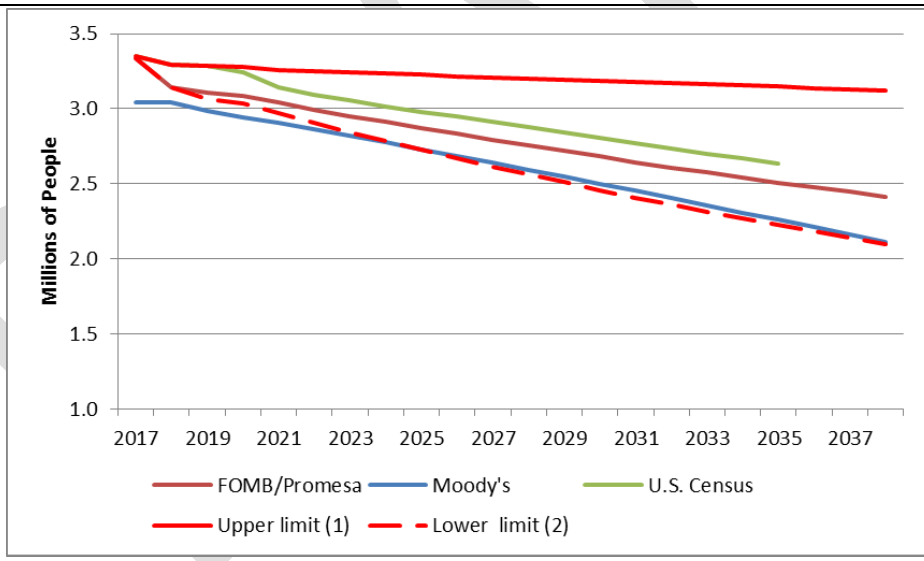
The Lower Limit on the other hand, assumes that the structural reforms do not take place and there is limited federal funds invested in the island, resulting in a continuation of the GNP decline at 1% per year in line with the historical post 2006 decline. Consistent with this outlook the population decline accelerates and after an initial drop in line with FOMB forecasts, from 2019 onwards it declines at 1.5 times yearly attrition in this forecast.

Exhibit 19: GNP Scenarios



Source: Siemens

Exhibit 20: Population Scenarios



Source: Siemens

The resulting gross sales forecasts for the Upper and Lower limits are shown in Exhibit 21. In the high case scenario, gross energy sales increase at 1.34% per-year, with sales reaching 20,672 GWh by 2038 – 41% higher than the reference case. In the low case scenario, gross energy sales decline at 1.50% per-year reaching 11,033 GWh by 2038, 75% below the reference case level. The industrial customer class has the most upside or downside potential driven by changes in the GNP and or population from all three classes, with sales growing at 5.6% per-year in the high case, or declining at 5.2% per-year in the low case.

Exhibit 21: Gross Sales Forecast Scenarios – Resulting Upper and Lower Limits

Fiscal Year	Gross Energy Sales Reference (GWh)	Gross Energy Sales UPPER Limit (GWh)	Gross Energy Sales LOWER Limit (GWh)
2019	15,301	16,043	14,703
2020	15,357	17,400	14,470
2021	15,403	17,869	14,257
2022	15,470	17,976	14,015
2023	15,530	18,102	13,776
2024	15,574	18,239	13,545
2025	15,595	18,385	13,325
2026	15,596	18,540	13,112
2027	15,554	18,699	12,901
2028	15,487	18,863	12,695
2029	15,341	19,030	12,498
2030	15,223	19,200	12,304
2031	15,120	19,372	12,118
2032	15,025	19,547	11,939
2033	14,939	19,725	11,765
2034	14,862	19,906	11,597
2035	14,796	20,091	11,439
2036	14,741	20,280	11,295
2037	14,694	20,474	11,160
2038	14,654	20,672	11,033
CAGR	-0.23%	1.34%	-1.50%

Source: Siemens

Appendix A

Econometric Model Regression Coefficients by Customer Class

Residential		
Variable	Coefficient	Statistical Significance
Constant	-227.36	
CDD	0.366	Yes
GNP	0.047	Yes
Population	91.083	Yes
Jan	-50.592	Yes
Feb	-84.916	Yes
Mar	-64.889	Yes
Apr	-67.875	Yes
May	-36.025	Yes
Jun	-32.552	Yes
Jul	-22.369	Yes
Aug	0.000	Yes
Sep	-31.389	Yes
Oct	-15.618	Yes
Nov	-42.071	Yes
Dec	-26.040	Yes
Adjusted R^2	0.822	
F-Stat	824.8	

Commercial		
Variable	Coefficient	Statistical Significance
Constant	278.1	
CDD	0.456	Yes
Population	57.583	Yes
Jan	-23.315	Yes
Feb	-43.672	Yes
Mar	-2.185	Yes
Apr	-22.364	Yes
May	-13.705	Yes
Jun	-25.823	Yes
Jul	-26.560	Yes
Aug	0.000	Yes
Sep	-26.452	Yes
Oct	15.459	Yes
Nov	-10.917	Yes
Dec	1.679	Yes
Adjusted R^2	0.587	
F Stat	23.9	

Industrial		
Variable	Coefficient	Statistical Significance
Constant	-532.88	
CDD	0.11	Yes
GNP	0.09	Yes
Jan	-13.98	Yes
Feb	-25.86	Yes
Mar	-4.49	No
Apr	1.21	No
May	11.30	Yes
Jun	-0.31	No
Jul	1.32	No
Aug	2.89	No
Sep	-11.79	Yes
Oct	-3.09	No
Nov	-9.52	Yes
Dec	0.42	No
Manufacturing Employment	1.62	Yes
Adjusted R^2	0.969	
F Stat	434.71	