5

2017 PSE Integrated Resource Plan

Demand Forecasts

The system-level demand forecast that PSE develops for the IRP is an estimate of energy sales, customer counts and peak demand over a 20-year period. These forecasts are designed for use in long-term resource planning.

Contents

1. OVERVIEW

Overall, the 2017 IRP Electric Base Demand Forecast before conservation for both energy and peak is lower than the 2015 IRP forecast. For energy, the average annual growth rate forecast in 2017 is 1.4 percent, compared to 1.7 percent in 2015. For peak demand, the average annual growth rate forecast in 2017 is 1.3 percent, compared to 1.6 percent in 2015. The forecast also shows higher near-term loads due to several large customers coming on line, and a lower forecast in later years, which reflects slower customer growth and the inclusion of 2015's unusually warm weather in the calculation of "normal"[1] weather assumptions.

The 2017 IRP Gas Base Demand Forecast before conservation for energy and peak loads is also lower than in the 2015 IRP. For energy, the average annual growth forecast in 2017 is 1.2 percent, compared to 1.7 percent in 2015. For peak demand, the the average annual growth rate forecast in 2017 is 1.4 percent, compared to 1.8 percent in 2015. Slower population growth has resulted in fewer new gas customers, and the inclusion of the 2015's unusually warm weather in calculating normal weather assumptions also reduced demand.

Base Forecast At 2037	Before DSR	After DSR
Electric Load (MW)	3,461	2,879
Electric Peak (MW)	6,511	5,664
Gas Load (Mdth)	120,970	113,100
Gas Peak (Mdth)	1,311	1,229

Demand is reduced significantly when forward projections of conservation savings are applied. However, it is necessary to start with forecasts that do not already include forward projections of conservation savings in order to identify the most cost-effective amount of conservation to include in the resource plan. Throughout this chapter, charts labeled "before DSR" include only demand-side resource (DSR) measures implemented ***before the study period begins in 2018***. Charts labeled "after applying DSR" include the cost-effective amount of DSR identified in the 2017 IRP.

To model a range of potential economic conditions, weather conditions and potential modeling errors in the IRP analysis, PSE also prepares Low and High forecasts in addition to the Base Forecast. The Low forecast models reduced population and economic growth compared to the Base Forecast; the High Forecast models higher population and economic growth compared to the Base Forecast.

1 / For the IRP analysis, normal weather is defined as the average monthly weather recorded at NOAA's Sea-Tac Airport station over the 30 years ending in 2015.

2. ELECTRIC DEMAND FORECAST

Highlights of the base, high and low demand forecasts that PSE developed for the electric service area are presented below in Figures 5-1 through 5-4. The population and employment assumptions for all three forecasts are summarized beginning on page 5-32, and explained in detail in Appendix E, Demand Forecasting Models.

Only DSR measures implemented through December 2017 are included, since the demand forecast itself helps to determine the most cost-effective amount of conservation to include in the portfolio.

Electric Load Growth

In the 2017 IRP Base Demand Forecast, total load before DSR is expected to grow at a rate of 1.3 percent annually from 2018 to 2027 and 1.4 percent annually from 2027 to 2037, for an average annual growth rate of 1.4 percent over the 20-year study period. Total load is expected to grow from 2,681 aMW in 2018 to 3,461 aMW in 2037.

Residential and commercial loads are driving this growth; they represent 49 percent and 44 percent of load in 2016, respectively. On the residential side, use per customer is relatively flat, so growth in this category is being driven by the increase in the number of customers. On the commercial side, both use per customer and rising customer counts are driving growth.

The 2017 IRP High Demand Forecast projects an average annual growth rate of 1.7 percent; the Low Demand Forecast projects 1.1 percent.

Figure 5-1: Electric Demand Forecast before DSR
Base, High and Low Scenarios (aMW)

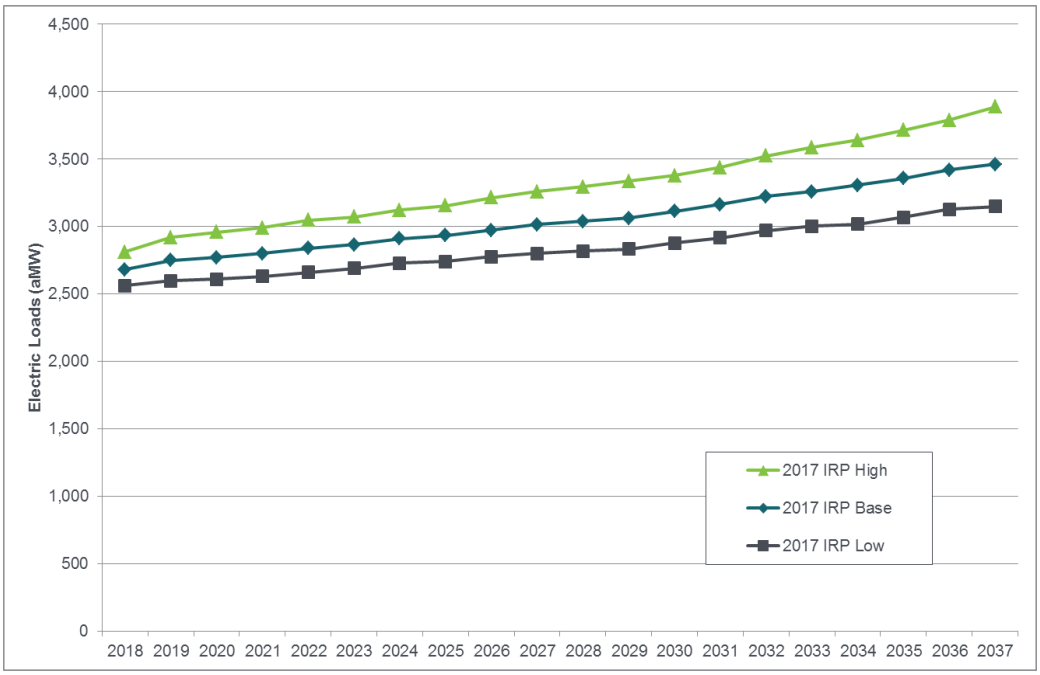


Figure 5-2: Electric Demand Forecast before DSR (Table)
Base, High and Low Scenarios

ELECTRIC DEMAND FORECAST SCENARIOS (aMW)						
Scenario	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
2017 IRP Base Demand Forecast	2,681	2,837	3,013	3,221	3,461	1.4%
2017 IRP High Demand Forecast	2,812	3,048	3,257	3,525	3,886	1.7%
2017 IRP Low Demand Forecast	2,561	2,660	2,800	2,970	3,148	1.1%

Electric Peak Demand

The normal electric peak hour load is modeled using 23 degrees Fahrenheit as the design temperature. Since PSE is still a winter peaking utility, this peak usually occurs in December. The 2017 IRP Base Demand Forecast shows an average annual peak load growth of 1.3 percent and an increase in peak load from 5,098 MW to 6,511 MW between 2018 and 2037.

The 2017 IRP High Demand Forecast shows an average annual peak load growth of 1.6 percent, and the Low Demand Forecast shows a 1.1 percent annual peak load growth rate.

Figure 5-3: Electric Peak Demand Forecast before DSR
Base, High and Low Scenarios, Hourly Annual Peak (23 Degrees, MW)

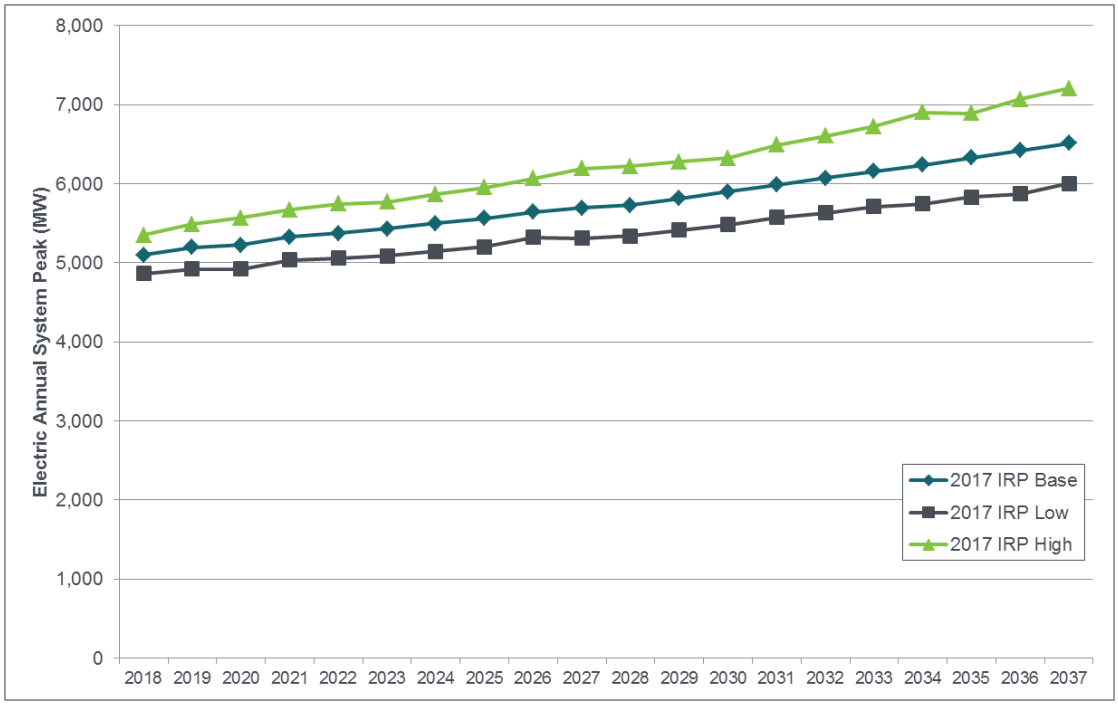


Figure 5-4: Electric Peak Demand Forecast before DSR (Table)
Base, High and Low Scenarios, Hourly Annual Peak (23 Degrees, MW)

ELECTRIC PEAK DEMAND FORECAST SCENARIOS (MW)						
Scenario	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
2017 IRP Base Demand Forecast	5,098	5,374	5,695	6,072	6,511	1.3%
2017 IRP High Demand Forecast	5,348	5,749	6,194	6,606	7,208	1.6%
2017 IRP Low Demand Forecast	4,867	5,062	5,308	5,629	6,001	1.1%

Peak demand in the 2017 IRP Electric Base Demand Forecast is lower than the 2015 IRP Base Demand Forecast due primarily to the lower population forecast which led to a lower customer forecast, and to higher retail rates leading to lower customer usage.

Figure 5-5: Electric Peak Demand Forecast before DSR,
2017 IRP Base Scenario versus 2015 IRP Base Scenario
Hourly Annual Peak (23 Degrees, MW)

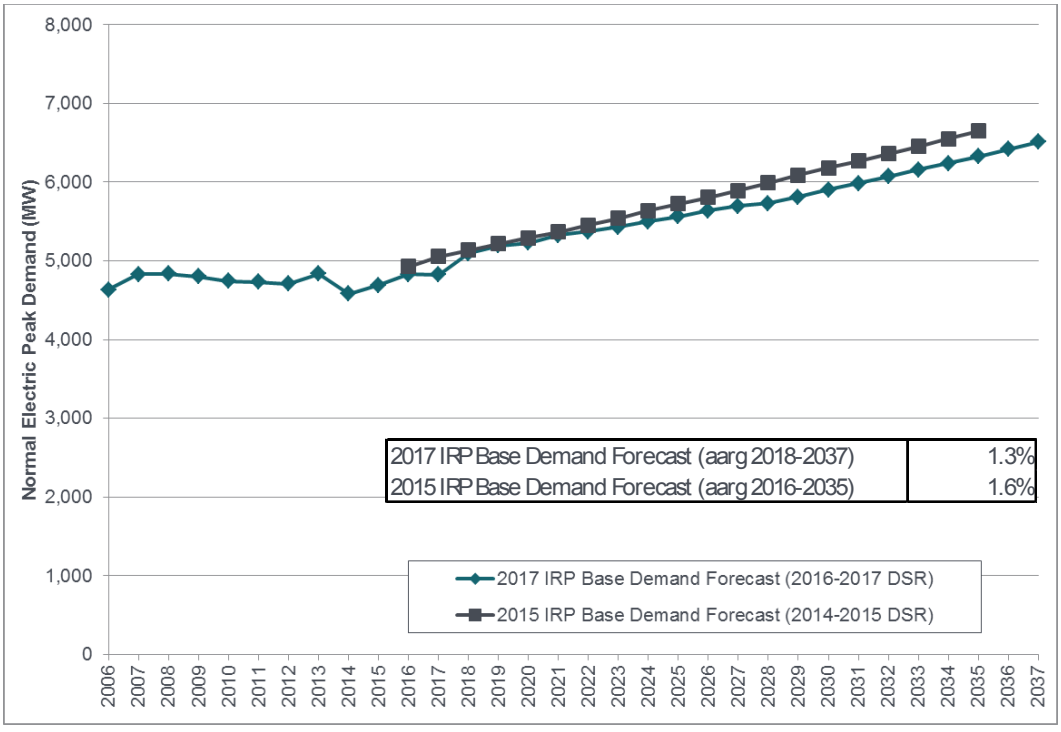


Illustration of Conservation Impacts

The system-level demand forecasts shown above apply only the energy efficiency measures targeted for 2016 and 2017, because those forecasts serve as the starting point for identifying the most cost-effective amount of demand-side resources for the portfolio from 2018 to 2037.

However, we also examine the effects of conservation on the system load and peak forecasts over the 20-year planning horizon. The load forecast net of conservation is used internally at PSE for financial planning and for transmission and distribution system planning. We apply the cost-effective demand-side resources identified in this IRP[2] to the Base Scenario load and peak forecasts for 2018 to 2037. To account for the 2013 general rate case Global Settlement, an additional 5 percent of conservation is also applied for that period. The result is illustrated in Figures 5-6 and 5-7, below.

DSR IMPACT ON LOAD: When the DSR bundles chosen in the 2017 IRP portfolio analysis are applied to the load forecast:

- Total system demand is 2,657 aMW in 2018 increasing to 2,879 aMW in 2037, or an 0.4 percent growth rate per year.
- Average annual growth is -0.3 percent from 2018 to 2027 and 1.1 percent from 2027 to 2037. Load grows more slowly in the first half of the forecast because that is when the majority of the demand-side measures are expected to be implemented.

DSR IMPACT ON PEAK: When the DSR bundles chosen in the portfolio analysis are applied to the peak forecast:

- The system peak is 5,060 MW in 2018 increasing to 5,664 MW in 2037, or a 0.6 percent growth per year.
- From 2018 to 2027 peak loads are flat (average annual growth is 0.0 percent), and from 2027 to 2037 average annual growth is 1.1 percent. Again, peak load grows more slowly in the first 10 years when DSR is more heavily concentrated.

2 / For demand-side resource analysis, see Chapter 6, Electric Analysis, and Appendix J, Conservation Potential Assessment.

Figure 5-6: 2017 IRP Electric Base Demand Forecast (aMW), before DSR and after applying DSR

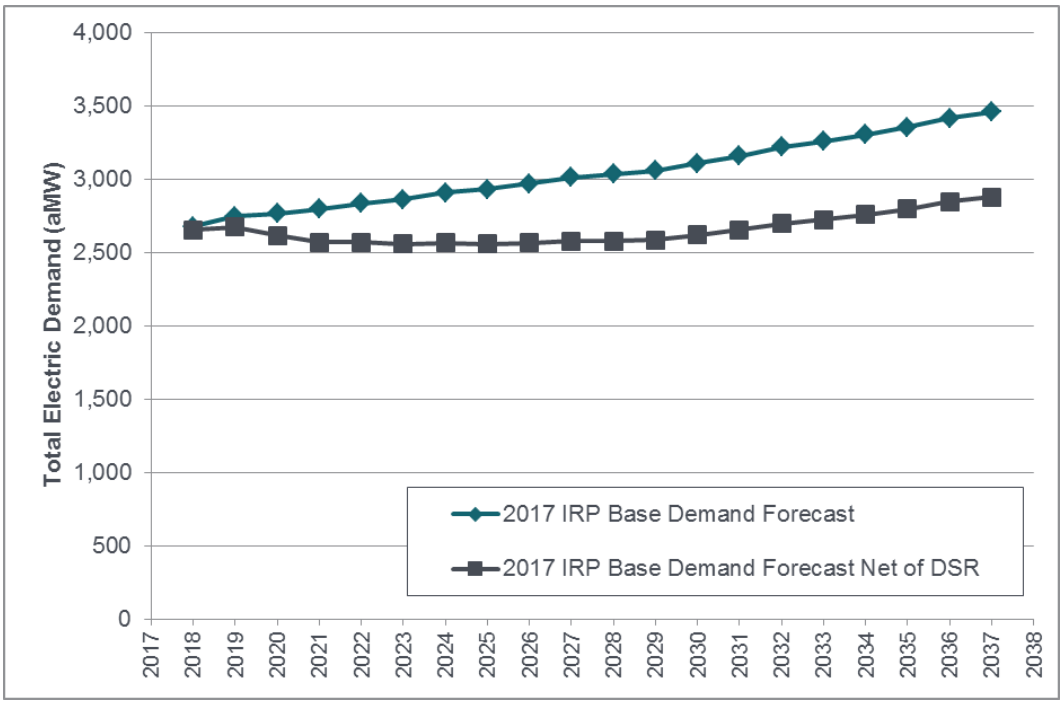
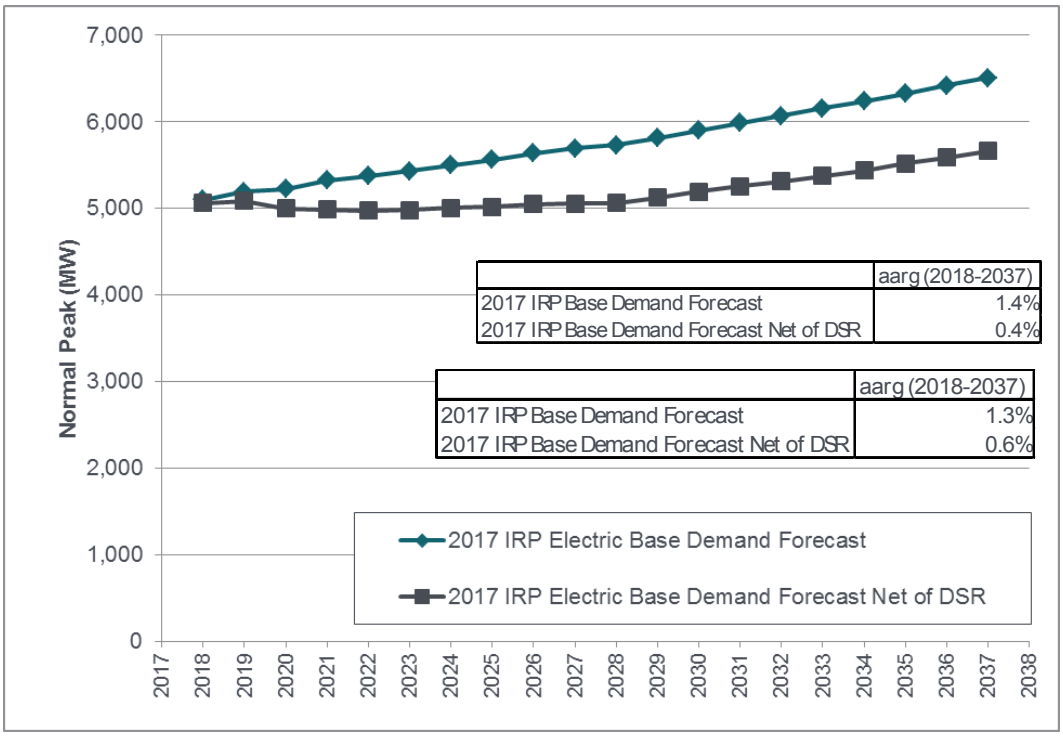


Figure 5-7: Electric Peak Base Demand Forecast (MW), before DSR and after applying DSR



Details of Electric Forecast

Electric Customer Counts

System-level customer counts are expected to grow by 1.2 percent per year on average, from 1.15 million customers in 2018 to 1.45 million customers in 2037. This is slightly lower than the average annual growth rate of 1.5 percent projected in the 2015 IRP Base Demand Forecast due to the lowered population forecast.

Residential customers are driving the customer count increase; they represent 88 percent of the PSE's electric customers in 2018. The next largest group, commercial customers, is expected to grow at an annual rate of 1.6 percent from 2018 to 2037. Industrial customer counts are expected to decline, following a historical trend. These trends are expected to continue as the economy in PSE's service territory grows more commercial and less industrial.

Figure 5-8: December Electric Customer Counts by Class, 2017 IRP Base Demand Forecast

DECEMBER ELECTRIC CUSTOMER COUNTS BY CLASS, BASE DEMAND FORECAST						
Class	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
Total	1,150,954	1,213,022	1,291,755	1,369,925	1,446,944	1.2%
Residential	1,011,079	1,064,616	1,131,808	1,197,449	1,261,057	1.2%
Commercial	130,424	139,048	150,671	163,279	176,764	1.6%
Industrial	3,366	3,277	3,172	3,069	2,971	-0.7%
Other	6,085	6,081	6,104	6,128	6,152	0.1%

Electric Load by Class

Over the next 20 years, the commercial sector is expected to contribute most to the total growth of system loads (60 percent). This is driven by the growth of commercial employment in the high tech sectors, which serve not only local but national and international markets. As the population increases, the need for commercial services such as health care, retail, education and other public services also increases.

Figure 5-9: Electric Demand by Class, 2017 IRP Base Demand Forecast before DSR

ELECTRIC LOAD BY CLASS, BASE DEMAND FORECAST (aMW)						
Class	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
Total	2,681	2,837	3,013	3,221	3,461	1.4%
Residential	1,194	1,258	1,336	1,414	1,499	1.2%
Commercial	1,133	1,231	1,323	1,445	1,586	1.8%
Industrial	150	132	126	120	117	-1.3%
Other	10	9	8	7	7	-1.8%
Losses	196	207	220	235	253	1.4%

Electric Use per Customer

Residential use per customer before conservation is expected to be flat in the future, absent the impacts of demand-side resources. Multifamily housing growth and the increasing use of natural gas for space and water heating will tend to reduce electric use per customer, but this should be balanced by growth in plug loads and declining real electric rates. As the economy continues to grow steadily, commercial use per customer is expected to rise slowly due to higher employment levels and lower vacancy rates in the near term.

Figure 5-10: Electric Use per Customer, 2017 IRP Base Demand Forecast before DSR

ELECTRIC USE PER CUSTOMER, BASE DEMAND FORECAST (MWh)						
Type	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
Residential	10.4	10.4	10.4	10.4	10.5	0.04%
Commercial	76.1	78.1	77.4	78.0	79.1	0.20%
Industrial	389	353	348	342	343	-0.66%

Electric Customer Count and Load Shares by Class

Customer counts as a percent of PSE's total electric customers are shown in Figure 5-11. Load shares by class are shown in Figure 5-12. These tables show the flat growth trajectory of residential classes compared to the robust growth of commercial classes.

Figure 5-11: December Electric Customer Count Shares by Class, 2017 IRP Base Demand Forecast

ELECTRIC CUSTOMER COUNT SHARES BY CLASS, BASE DEMAND FORECAST		
Class	**Share in 2018**	**Share in 2037**
Residential	87.8%	87.2%
Commercial	11.3%	12.2%
Industrial	0.3%	0.2%
Other	0.5%	0.4%

Figure 5-12: Electric Load Shares by Class, 2017 IRP Base Demand Forecast

ELECTRIC LOAD SHARES BY CLASS, BASE DEMAND FORECAST		
Class	**Share in 2018**	**Share in 2037**
Residential	44%	43%
Commercial	42%	46%
Industrial	6%	3%
Other	0.4%	0.2%
Losses	7%	7%

Figure 5-13: PSE Electric Service Territory

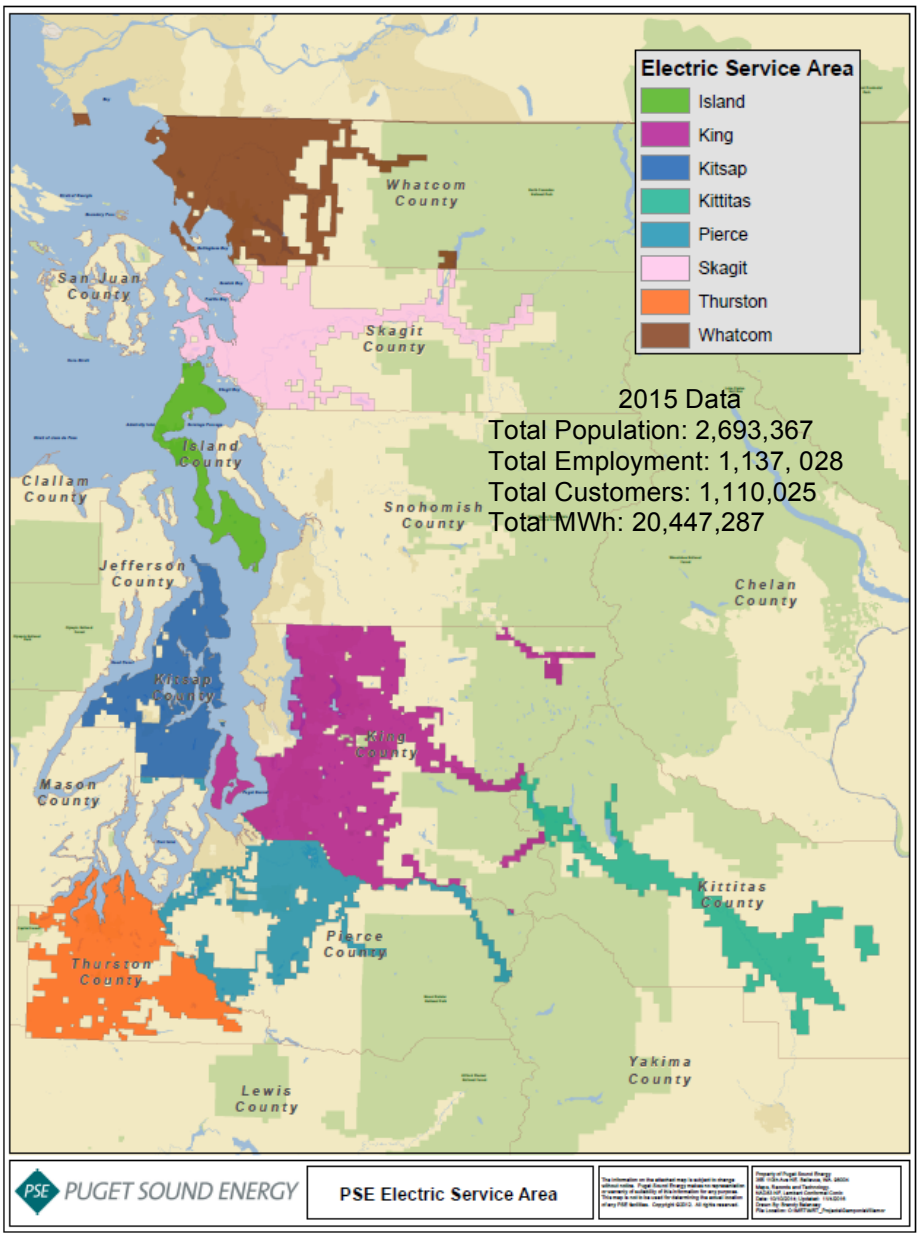


Figure 5-14: Electric Service Area, County Share as a Percent of PSE Total, 2015 Data

COUNTY	POPULATION	EMPLOYMENT	CUSTOMERS	SALES
King	48%	58%	49%	53%
Thurston	10%	10%	11%	11%
Pierce	15%	10%	10%	10%
Kitsap	10%	8%	11%	9%
Whatcom	8%	8%	9%	8%
Skagit	4%	4%	5%	6%
Island	3%	1%	3%	2%
Kittitas	2%	1%	1%	1%

3. GAS DEMAND FORECAST

Highlights of the base, high and low demand forecasts developed for PSE's gas sales service are presented below. The population and employment assumptions for all three forecasts are summarized on page 5-34, and explained in detail in Appendix E, Demand Forecasting Models.

Only demand-side resources implemented through December 2017 are included, since the demand forecast itself helps to determine the most cost-effective level of DSR to include in the portfolio.

Gas Load Growth

The 2017 IRP Gas Base Demand Forecast is a forecast of both firm and interruptible loads, because this is the volume of natural gas that PSE is responsible for securing and delivering to customers. For distribution planning, however, transport loads must be included in total load; transport customers purchase their own natural gas, but contract with PSE for delivery.

In the 2017 IRP Base Demand Forecast, gas load is projected to grow 1.2 percent per year on average from 2018 to 2037; this would increase load from 96,808 Mdth in 2018 to 120,970 Mdth in 2037. This is lower than the annual growth rate of 1.7 percent in the 2015 IRP Base Demand Forecast.

The 2017 IRP High Gas Demand Forecast projects an average annual growth rate of 1.7 percent; the Low Demand Forecast projects a growth rate of 0.5 percent per year.

Figure 5-15: Gas Demand Forecast before DSR
Base, High and Low Scenarios, without Transport Load (Mdth)

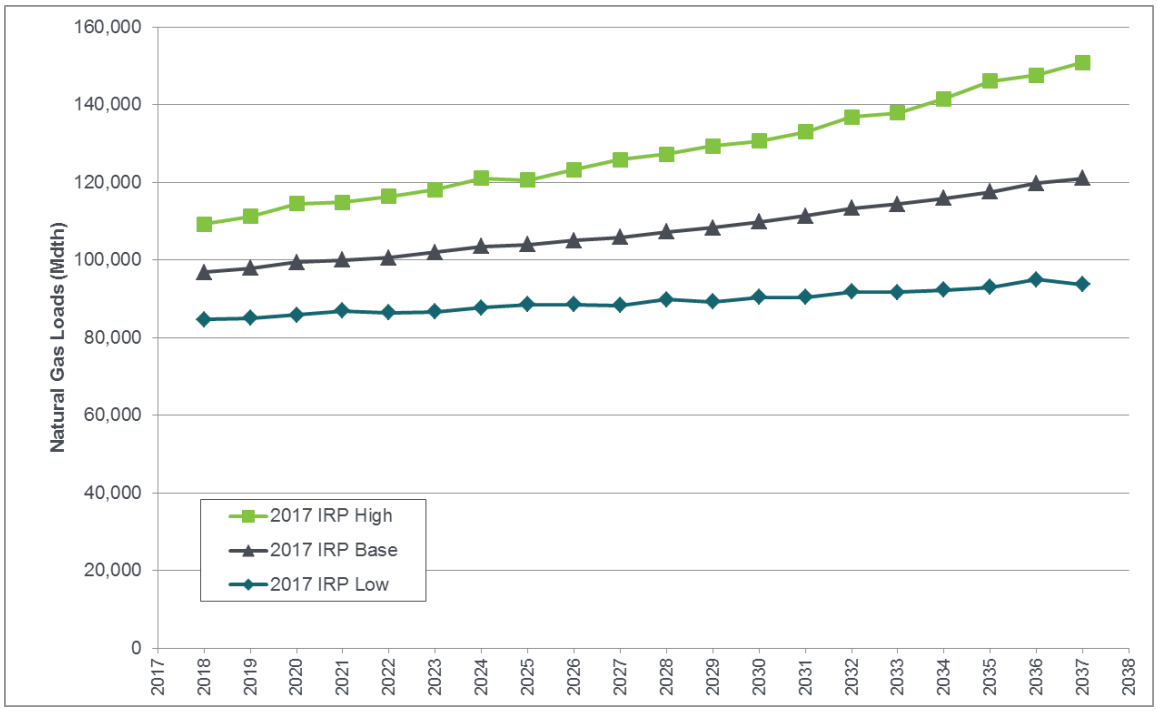


Figure 5-16: Gas Demand Forecast before DSR (Table)
Base, High and Low Scenarios without Transport Load (Mdth)

GAS LOAD FORECAST SCENARIOS (Mdth), WITHOUT TRANSPORT						
Scenario	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
2017 IRP Base Demand Forecast	96,808	100,612	105,806	113,288	120,970	1.2%
2017 IRP High Demand Forecast	109,228	116,376	125,840	136,868	150,861	1.7%
2017 IRP Low Demand Forecast	84,673	86,395	88,275	91,779	93,603	0.5%

Gas Peak Demand

The gas design peak day is modeled at 13 degrees Fahrenheit average temperature for the day. Only firm sales customers are included when forecasting peak gas loads; transportation and interruptible customers are not included.

For peak gas demand, the 2017 IRP Base Demand Forecast projects an average increase of 1.4 percent per year for the next 20 years; peak demand would rise from 1,010 Mdth in 2018 to 1,311 Mdth in 2037. The High Demand Forecast projects a 1.7 percent annual growth rate, and the Low Demand Forecast projects 1.1 percent.

Gas peak day growth rates are slightly higher than the rates for load growth because the classes that contribute most to peak demand (the weather-sensitive residential and commercial sectors) are growing faster than the classes that don't contribute to peak demand. Rising baseloads are also contributing to peak demand because gas is increasingly being used for purposes other than heating (such as cooking, clothes drying and fireplaces). This effect is slightly offset by higher appliance and home efficiencies.

Figure 5-17: Gas Peak Day Demand Forecast before DSR
Base, High and Low Scenarios (13 Degrees, Mdth)

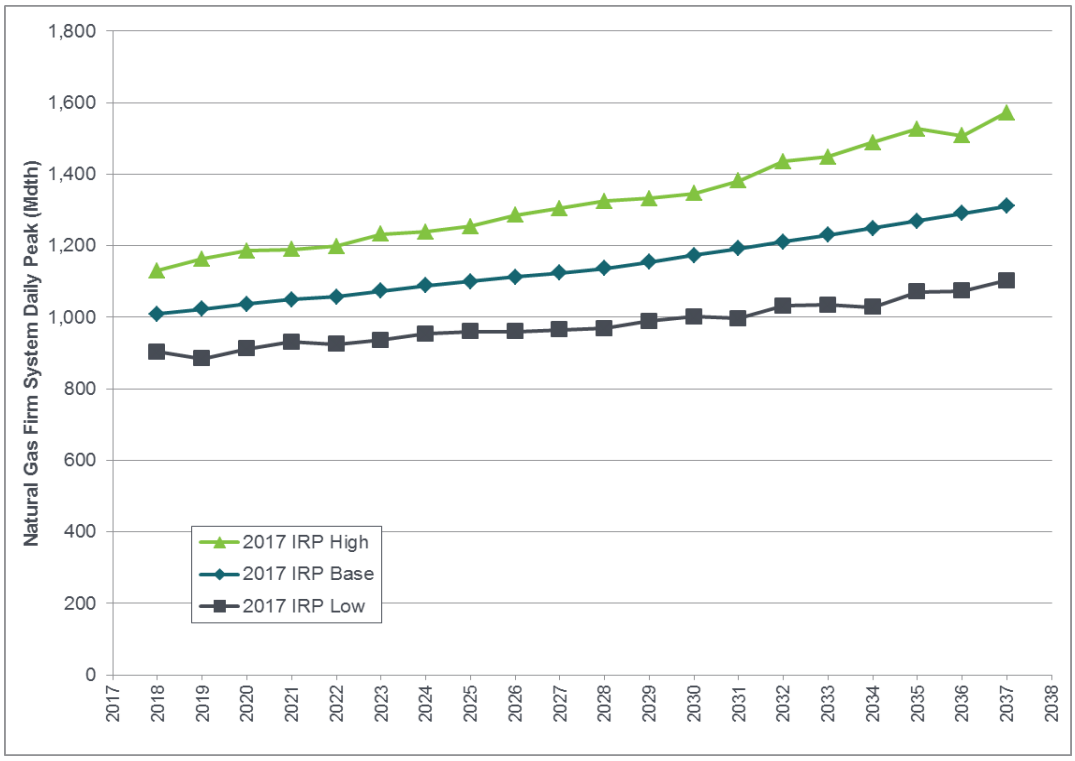


Figure 5-18: Gas Peak Day Demand Forecast before DSR (Table)
Base, High and Low Scenarios (13 Degrees, Mdth)

FIRM GAS PEAK DAY FORECAST SCENARIOS (Mdth)						
Scenario	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
2017 IRP Base Demand Forecast	1,010	1,058	1,123	1,211	1,311	1.4%
2017 IRP High Demand Forecast	1,130	1,199	1,304	1,435	1,571	1.7%
2017 IRP Low Demand Forecast	903	925	965	1,031	1,102	1.1%

The 2017 IRP Base Demand growth rate is lower than the 2015 IRP Base Demand growth rate of 1.8 percent (2016 to 2035), mainly due to the lower customer count forecast.

Figure 5-19: Firm Gas Peak Day Forecast before DSR
2017 IRP Base Scenario versus 2015 IRP Base Scenario
Daily Annual Peak (13 Degrees, Mdth)

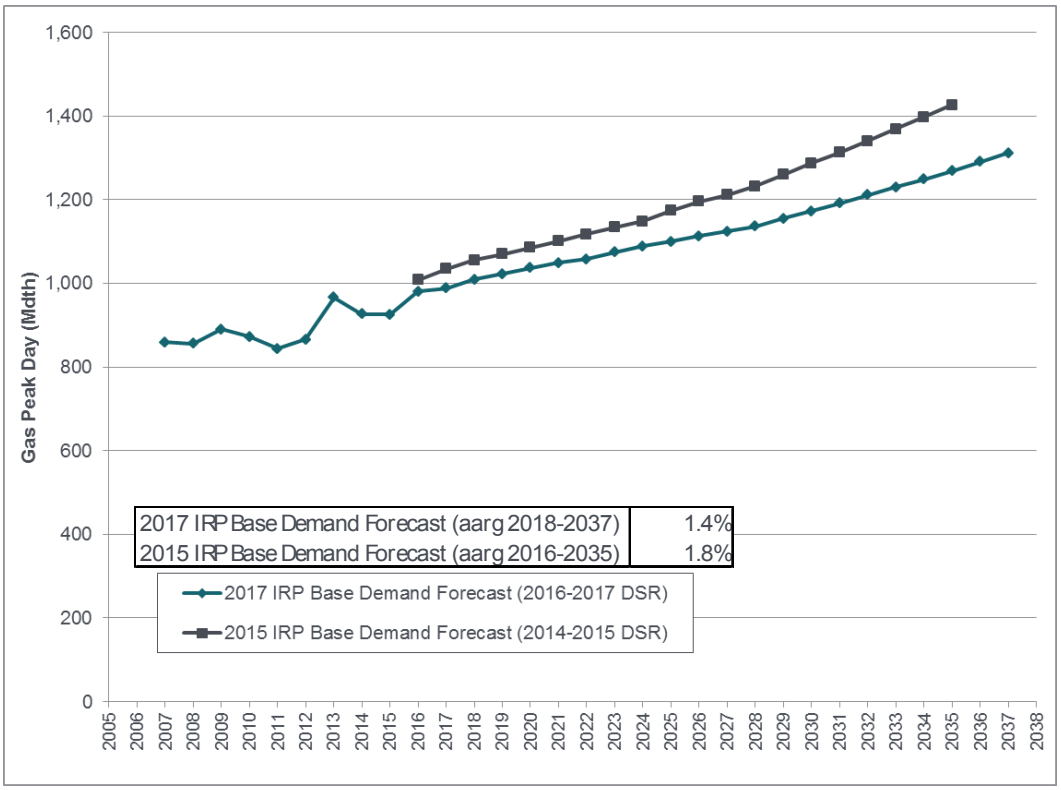


Illustration of Conservation Impacts

As explained at the beginning of the chapter, the gas demand forecasts include only demand-side resources implemented through December 2017, since the demand forecast itself helps to determine the most cost-effective level of DSR to include in the portfolio. To examine the effects of conservation on the system load and peak forecasts, the cost-effective amount of DSR determined in this IRP[3] is applied to the system load (without transport loads) and peak forecast for 2018 to 2037. This forecast is used internally at PSE for financial and system planning decisions.

3 / For demand-side resource analysis, see Chapter 7, Gas Analysis, and Appendix J, Conservation Potential Assessment.

When the DSR bundles chosen in the 2017 IRP portfolio analysis are applied:

- System load (without transport but with losses) grows at an average annual rate of 0.6 percent from 2018 to 2027 and 1.1 percent from 2027 to 2037, or 0.8 percent per year over the next 20 years; volume rises from 96,808 Mdth in 2018 to 113,100 Mdth in 2037. Load grows more slowly in the first half of the forecast because that's when the majority of the demand-side measures are expected to be implemented.
- The design system peak is expected grow at an average annual rate of 0.8 percent from 2018 to 2027 and 1.3 percent from 2027 to 2037, or 1.1 percent per year over the next 20 years; volume rises from 1,008 Mdth in 2018 to 1,229 Mdth in 2037. Again, peak load grows more slowly in the first half of the forecast because that is when the majority of the demand-side measures are expected to be implemented.

Figure 5-20: 2017 IRP Gas Base Demand Forecast, before DSR and after applying DSR

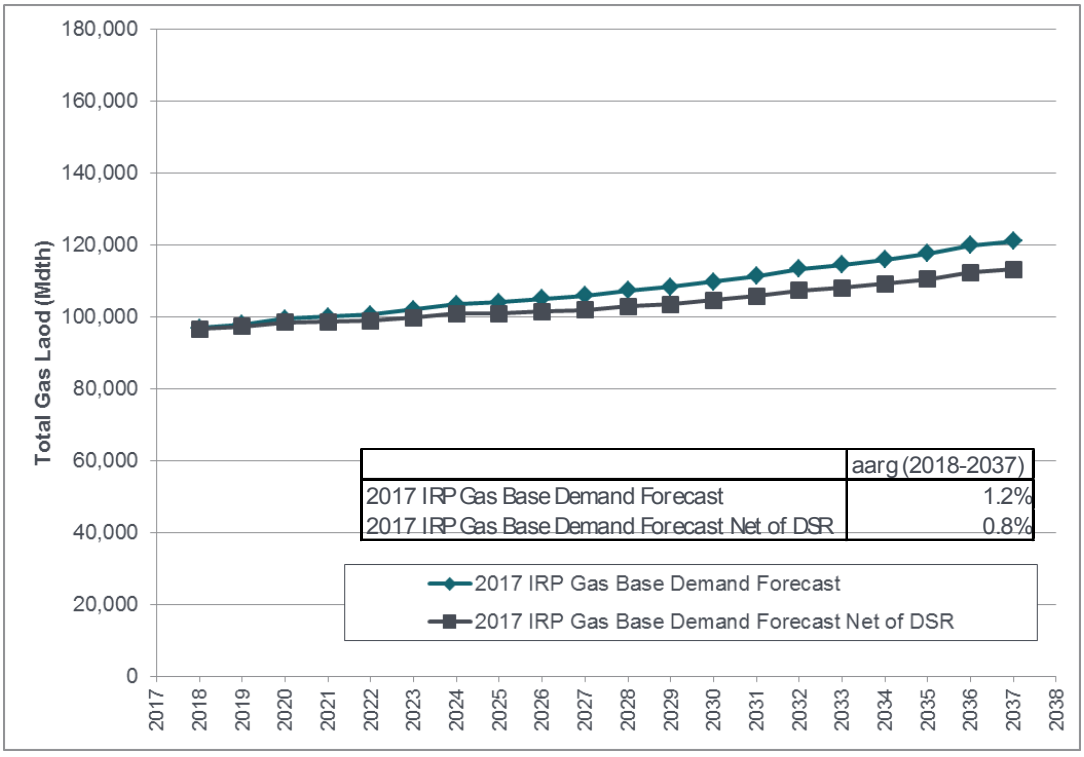
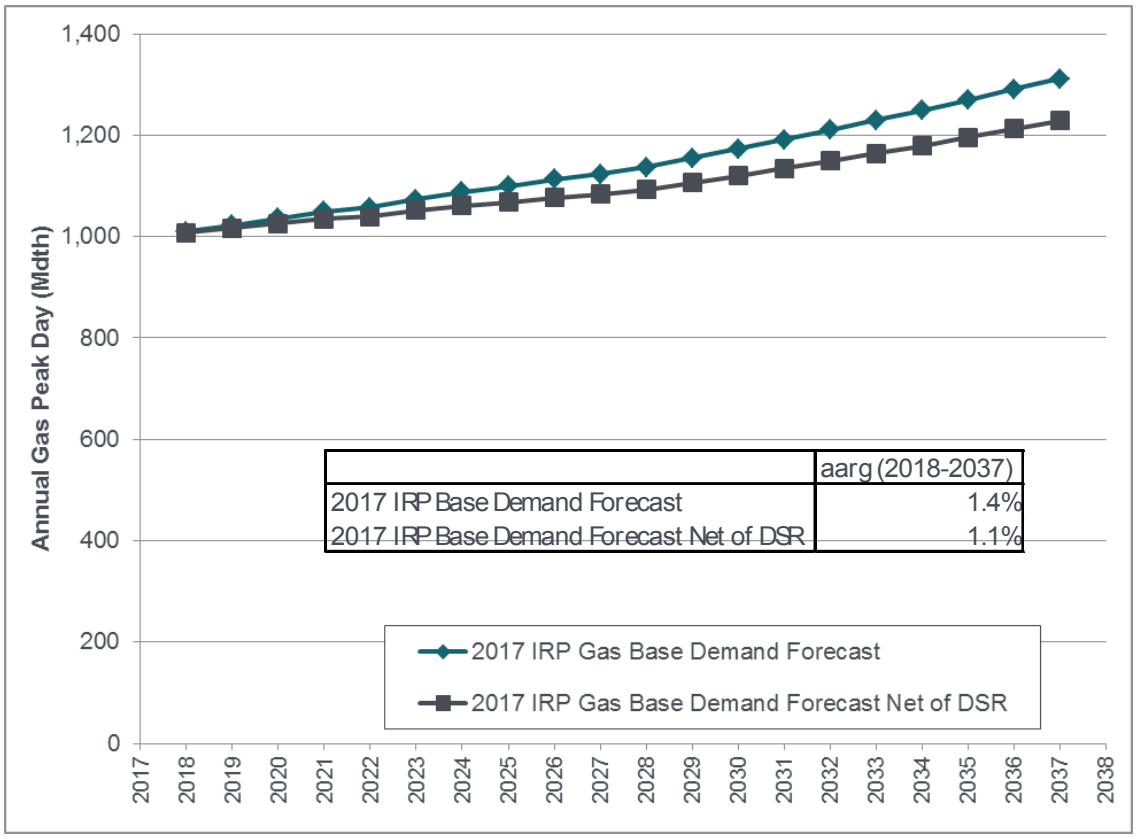


Figure 5-21: 2017 IRP Gas Peak Day Base Demand Forecast, Before DSR and after applying DSR



Details of Gas Forecast

Gas Customer Counts

The Base Demand Forecast projects natural gas customer counts will increase at a rate of 1.3 percent per year on average between 2018 and 2037, reaching almost 1.06 million customers by the end of the forecast period for the system as a whole. A lower population forecast has resulted in a lower growth rate than the 1.9 percent growth rate projected in the 2015 IRP (2016 to 2035).

Residential customer counts drive the growth in total customers, since this class makes up 93 percent of PSE's gas sales customers. The next largest group, commercial customers, is expected to grow at an annual rate of 1.5 percent from 2018 to 2037. Industrial and interruptible customer classes are expected to continue to shrink, consistent with historical trends.

Figure 5-22: December Gas Customer Counts by Class, from 2017 IRP Base Demand Forecast

DECEMBER GAS CUSTOMER COUNTS BY CLASS FROM 2017 IRP BASE DEMAND FORECAST						
Customer Type	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
Residential	768,811	811,203	865,093	921,391	982,574	1.3%
Commercial	56,374	59,802	64,263	69,027	74,146	1.5%
Industrial	2,313	2,201	2,071	1,947	1,832	-1.2%
Total Firm	827,499	873,206	931,427	992,365	1,058,551	1.3%
Interruptible	266	235	206	184	167	-2.4%
Total Firm & Interruptible	827,765	873,441	931,633	992,549	1,058,718	1.3%
Transport	224	224	224	224	224	0.0%
System Total	827,989	873,665	931,857	992,773	1,058,942	1.3%

Gas Use per Customer

Residential use per customer before conservation is declining slightly, showing a -0.2 percent average annual growth for the forecast period. Commercial use per customer is expected to rise 0.4 percent annually over the forecast horizon. Industrial use per customer has been declining in recent years and is expected to decline at an annual rate of -0.3 percent.

Figure 5-23: Gas Use per Customer, 2017 IRP Gas Base Demand Forecast before DSR

USE PER CUSTOMER (THERMS) FROM 2017 IRP GAS BASE DEMAND FORECAST						
Customer	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
Residential	798	783	765	761	762	-0.2%
Commercial	4,887	4,958	5,032	5,166	5,313	0.4%
Industrial	11,296	10,264	10,948	11,007	10,761	-0.3%

Gas Load by Class

Total system load, including transport load, is expected to increase at a rate of 0.8 percent annually between 2018 and 2037. Residential loads, which represent 51 percent of load in 2018, are expected to increase by 1.0 percent annually during the forecast period. Commercial loads, which represent 23 percent of 2018 load, are expected to increase 1.9 percent annually.

Population growth and electric-to-gas conversions are driving residential load growth. Commercial load growth is driven by increases in both customer counts and use per customer. Some sectors, among them industrial, interruptible and transport, are expected to decline slightly, continuing a more than decade-long trend of slowing manufacturing employment.

Figure 5-24: Gas Loads by Class (Mdth), 2017 IRP Gas Base Demand Forecast before DSR

LOAD (Mdth) BY CLASS FROM 2017 IRP GAS BASE DEMAND FORECAST						
Class	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
Residential	61,449	63,571	66,264	70,476	74,846	1.0%
Commercial	27,930	30,058	32,717	36,162	39,708	1.9%
Industrial	2,632	2,288	2,294	2,176	1,999	-1.4%
Total Firm	92,011	95,917	101,275	108,814	116,553	1.3%
Interruptible	4,313	4,192	4,002	3,907	3,812	-0.6%
Total Firm and Interruptible	96,324	100,109	105,277	112,722	120,365	1.2%
Transport	23,859	22,522	20,822	20,134	19,555	-1.0%
System Total before Losses	120,183	122,630	126,099	132,856	139,920	0.8%
Losses	604	616	634	668	703	0.8%
System Total	120,787	123,247	126,732	133,523	140,623	0.8%

Gas Customer Count and Load Shares by Class

Customer counts as a percent of PSE's total gas customers are shown in Figure 5-25. Load shares by class are shown in Figure 5-26.

Figure 5-25: Gas Customer Count Shares by Class, 2017 IRP Base Demand Forecast

GAS CUSTOMER COUNT SHARES BY CLASS, BASE DEMAND FORECAST		
Class	**Share in 2018**	**Share in 2037**
Residential	92.8%	92.8%
Commercial	6.8%	7.0%
Industrial	0.3%	0.2%
Interruptible	0.03%	0.02%
Transport	0.03%	0.02%

Figure 5-26: Gas Load Shares by Class, 2017 IRP Base Demand Forecast

GAS LOAD SHARES BY CLASS, BASE DEMAND FORECAST		
Class	**Share in 2018**	**Share in 2037**
Residential	50.9%	53.2%
Commercial	23.1%	28.2%
Industrial	2.2%	1.4%
Interruptible	3.6%	2.7%
Transport	19.8%	13.9%
Losses	0.5%	0.5%

Figure 5-27: PSE Gas Service Territory

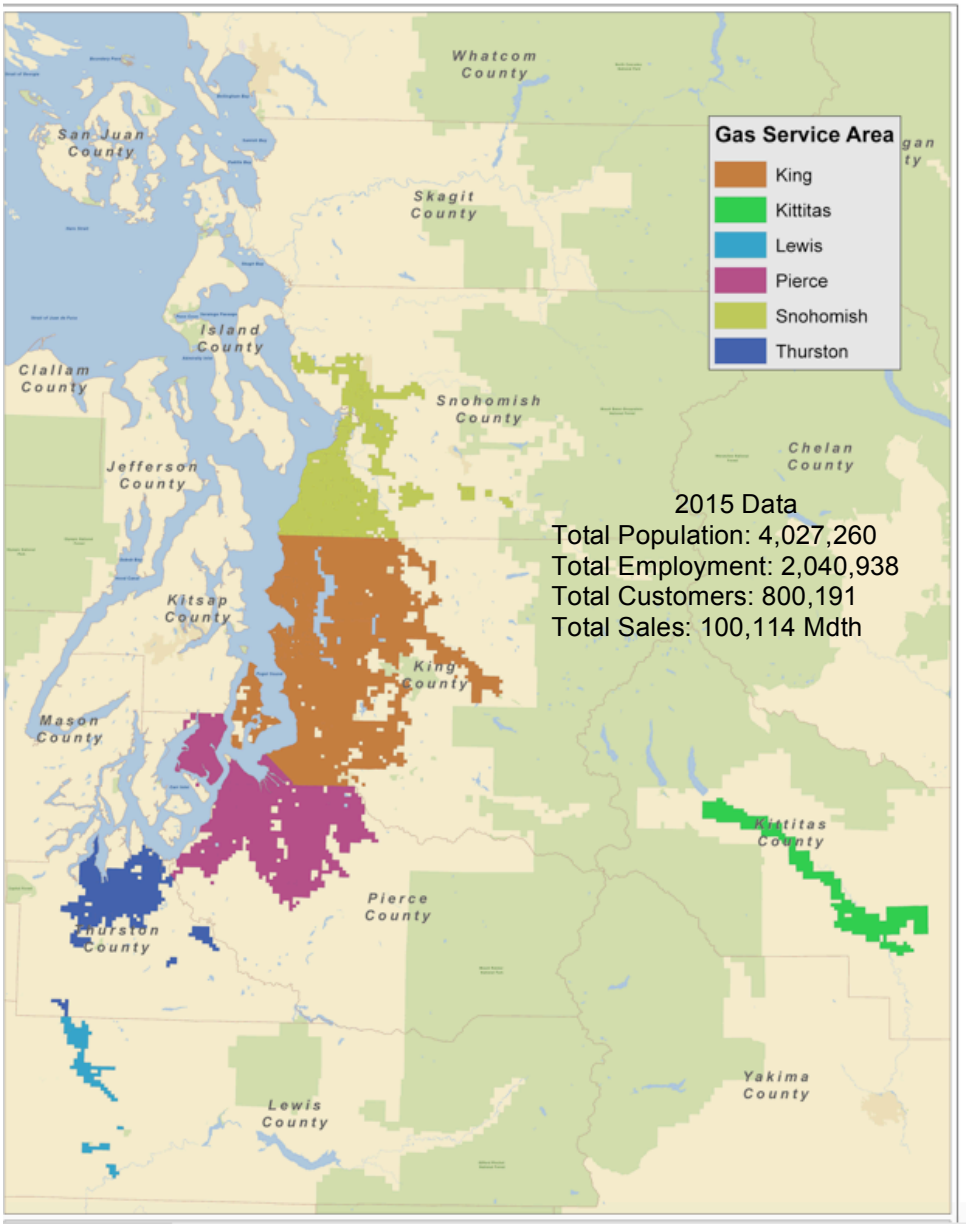


Figure 5-28: Gas Service Territory, County Share as a Percent of PSE Total, 2015 Data

COUNTY	POPULATION	EMPLOYMENT	CUSTOMERS	SALES
King	51%	64%	57%	57%
Pierce	21%	15%	19%	22%
Snohomish	19%	14%	17%	15%
Thurston	7%	5%	6%	5%
Lewis	2%	1%	1%	1%
Kittitas	1%	1%	<1%	<1%

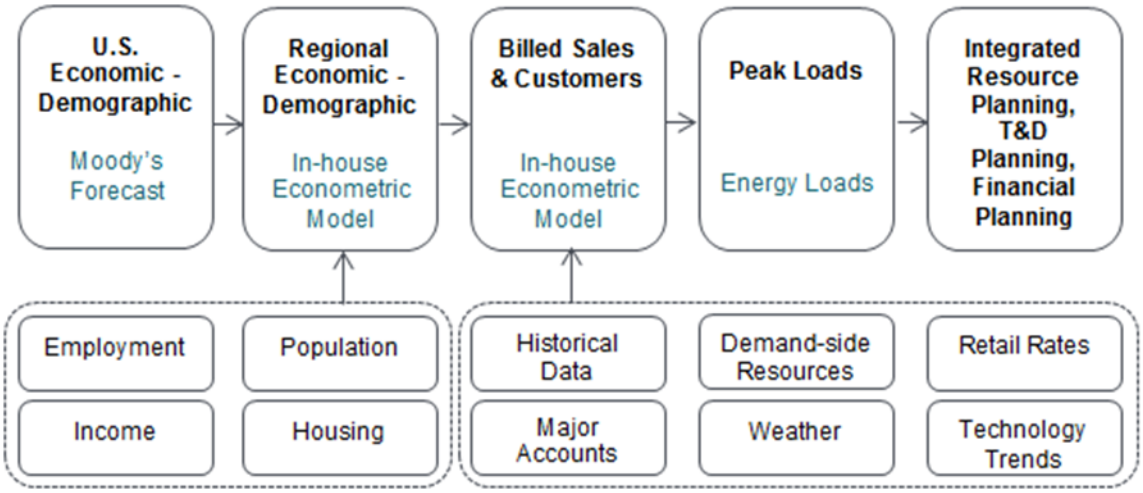
4. METHODOLOGY

Forecasting Process

PSE has made significant updates to the load forecast inputs and equations since the 2015 IRP, which enable us to make more accurate projections of customer counts, use per customer and load shapes. These innovations and updates are described starting on page 5-28.

PSE's regional economic and demographic model uses both national and regional data to produce a forecast of total employment, types of employment, unemployment, personal income, population, households, consumer price index (CPI) and building permits for both the PSE electric and gas service territories. The regional economic and demographic data used in the model are built up from county-level or MSA (metropolitan statistical area)-level information from various sources. This economic and demographic information is combined with other PSE internal information to produce energy and peak load forecasts for the service territory. The load-forecasting process is illustrated in Figure 5-29, and the input data sources are listed in Figure 5-30.

Figure 5-29: PSE Load Forecasting Process



Electricity and natural gas are inputs into different end uses.

- For residential customers, typical energy uses include space heating, water heating, lighting, cooking, refrigeration, dish washing, laundry washing, televisions, computers and various other plug loads.
- Commercial and industrial customers use energy for production processes; space heating, ventilation and air conditioning (HVAC); lighting; computers; and other office equipment.

To forecast energy sales and customer counts, customers are divided into classes and service levels that use energy for similar purposes and at comparable retail rates. The different classes are modeled separately using variables specific to their usage patterns.

- Electric customer classes include residential, commercial, industrial, streetlights, resale and transport (customers purchasing their power not from PSE but from third-party suppliers).
- Gas customer classes include firm (residential, commercial, industrial, commercial large volume and industrial large volume), interruptible (commercial and industrial), and transport (commercial firm, commercial interruptible, industrial firm and industrial interruptible).

Transport Customers

"Transport" in the natural gas industry has historically referred to customers that acquire their own natural gas from third-party suppliers and rely on the gas utility for distribution service. It does not refer to natural gas fuel for vehicles.

Econometric/regression equations are used to forecast the number of customers by class as well as the use per customer (UPC) by class. These are multiplied together to arrive at the billed sales forecast. The main drivers of these equations include population or households, housing permits, unemployment rates, retail rates, personal income, weather, total employment and manufacturing employment. Weather inputs are based on temperature readings from Sea-Tac Airport. Peak system loads are also projected by examining the historical relationship between actual peaks, temperature at peaks, and also the economic and demographic impacts on system loads.

For detailed technical descriptions of the econometric methodologies used to forecast billed energy sales, customer counts, peak loads for electricity and natural gas, hourly distribution of electric loads and forecast uncertainty, see Appendix E, Demand Forecasting Models.

High and Low Scenarios

PSE also develops high and low growth scenarios by performing 250 stochastic simulations of PSE's economic and demographic model combined with stochastic draws of weather. These simulations reflect variations in key regional economic and demographic variables such as population, employment and income, and also a historic weather scenario instead of "normal weather." For the IRP analysis, normal weather is defined as the average monthly weather recorded at NOAA's Sea-Tac Airport station over the 30 years ending in 2015. The historic weather scenarios in each of the 250 simulations use 20 years of continuous historic weather randomly drawn between 1929 and 2015. The low and high scenarios represent the 5th and 95th percentile of the 250 simulations, respectively. More detailed discussion of the stochastic simulations is presented in Appendix E, Demand Forecasting Models.

Figure 5-30: Sources for U.S. and Regional Economic and Demographic Data

DATA USED IN ECONOMIC AND DEMOGRAPHIC MODEL	
County-level Data	**Source**
Labor force, employment, unemployment rate	U.S. Bureau of Labor Statistics (BLS) www.bls.gov Puget Sound Regional Council (PSRC) www.psrc.org
Total non-farm employment, and breakdowns by type of employment	WA State Employment Security Department, using data from Quarterly Census of Employment and Wages https://fortress.wa.gov/
Personal income	U.S. Bureau of Economic Analysis (BEA) www.bea.gov
Wages and salaries	
Population	U.S. Bureau of Economic Analysis (BEA) / WA State Office of Financial Management (OFM) www.ofm.wa.gov
Households, single- and multi-family	U.S. Census www.censtats.census.gov
Household size, single- and multi-family	
Housing permits, single- and multi-family	U.S. Census / Puget Sound Regional Council (PSRC) / City Websites / Building Industry Association of Washington (BIAW) www.biaw.com
Aerospace employment	Puget Sound Economic Forecaster www.economicforecaster.com
US-level Data	**Source**
GDP	Moody's Analytics www.economy.com
Industrial Production Index	
Employment	
Unemployment rate	
Personal income	
Wages and salary disbursements	
Consumer Price Index (CPI)	
Housing starts	
Population	
Conventional mortgage rate	
T-bill rate, 3 months	

Updates to Inputs and Equations

PSE has made significant updates to the load forecast inputs and equations since the 2015 IRP. These updates are summarized below.

MODEL SELECTION TOOL. In conjunction with a University of Washington econometric consultant, PSE developed a model selection tool to develop a set of key drivers that contribute most to explaining the changes in use per customer or customer additions in the historical period. For example, the model selection tool was used to test different base temperatures for the heating degree day (HDD) and cooling degree day (CDD), economic and demographic variables, seasonal or monthly variables, dummy variables, autoregressive moving average (ARMA) terms, and polynomial distributed lag terms and orders.

SERVICE TERRITORY POPULATION AND EMPLOYMENT. The 2015 IRP used county-level population, employment and housing permit growth to predict customer additions and load growth for counties within the service territory. The 2017 IRP removes population and employment from non-PSE areas within those counties to reflect actual PSE service territory population and employment growth more accurately.

RESIDENTIAL ELECTRIC CUSTOMER ADDITIONS. The 2017 IRP uses total households as an explanatory variable for residential electric customer additions instead of total single- and multi-family housing permits, as in the 2015 IRP. The amount of multi-family housing permits in PSE's service territory has increased, but the monthly number of multi-family housing permits can be quite volatile, and therefore add more volatility to the customer forecast. At this time, growth in total households is a more stable indicator of long-term growth.

GAS CUSTOMER ADDITIONS. The 2017 IRP calculates gas customer additions using single-family housing permits as an explanatory variable instead of using total housing permits (single- and multi-family). Most of the new gas customers in PSE's service territory are still in single-family houses, but growth in small commercial customers also needs to be monitored.

RETAIL ELECTRIC FORECAST. The 2017 IRP smooths the retail rates forecast for the electric forecast to the rolling 12-month average of retail rates. This reflects the fact that while customers experience seasonal fluctuations in their retail rate, they tend to respond more to their total bill than the actual electric rates. This also removes the impact of seasonality on price per kWh.

MONTHLY BILLING CYCLE DEGREE DAY CALCULATION. The 2015 IRP used a generic degree day calculation to match up billing cycle data with the weather that occurred during that monthly billing cycle. The 2017 IRP uses PSE's actual 21 billing cycles to calculate a more precise degree day for each monthly billing cycle. The 2017 IRP also uses historical data to weight the degree day calculation based on the amount of load that occurs in each cycle within each month.

MONTHLY LOAD SHAPE. In the 2017 IRP, the monthly load shape is only applied to the years 2016 to 2018. Beyond 2018 the load shape is not applied. This allowed for shaping trends based on the historical data to be incorporated in the long-term forecast.

CONDITIONED SALES. Billing errors or back-billing can be present in recorded or "booked" billed sales. "Conditioned" sales correct for errors in billing and reallocate sales into the month where they occurred. The 2017 IRP uses conditioned sales instead of booked sales to create a better correlation between temperature, economic factors, and amount of energy or natural gas used.

LARGE VOLUME AND FIRM TRANSPORT GAS CUSTOMERS. The 2013 update to PSE's billing system made it difficult to determine the number of customers that had firm gas service in addition to interruptible or transport gas service. These customers are now counted based on usage in the last 6 months, instead of estimating their number based on historical data.

5. KEY ASSUMPTIONS

To develop PSE's demand forecasts, assumptions must be made about economic growth, energy prices, weather and loss factors, including certain system-specific conditions. These and other assumptions are described below.

Economic Growth

Economic activity has a significant effect on long-term energy demand. While the energy component of the national GDP has been declining over time, energy is still an essential input into various residential end uses such as space heating/cooling, water heating, lighting, cooking, dishwashing/clothes washing and various electric plug loads. The growth in residential building stock therefore directly impacts the demand for energy over time. Commercial and industrial sectors also use energy for space heating and cooling, water heating, lighting and for various plug loads. Energy is also in important input into many industrial production processes. Economic activities in the commercial and industrial sectors are therefore important indicators for the overall trends in energy consumption.

National Economic Outlook

Because the Puget Sound region is a major commercial and manufacturing center with strong links to the national economy, PSE's IRP forecast begins with assumptions about what is happening in the broader U.S. economy. The U.S. economy has established a steady, positive growth path; however, recovery from the effects of the 2008 recession has been modest compared to the strong recovery cycles experienced after prior recessions. Relative to the 2015 IRP economic forecasts, the U.S. economy is expected to grow steadily but more modestly in the 2017 IRP as a result of modest international economic growth and slowing U.S. population growth in the long term. Near term, however, the employment growth rate is expected to be slightly more robust relative to the 2015 IRP projections, leading to slightly faster near-term employment growth in parts of the PSE service territory.

We rely on Moody's Analytics U.S. Macroeconomic Forecast, a long-term forecast of the U.S. economy, for both economic and population growth rates. The March 2016 Moody's forecast was used for this IRP.

Moody's forecast calls for:

- U.S. GDP to continue growing modestly from the past recession, reaching 3 percent in 2017. This is a slower economic recovery than the Moody's forecast used in the 2015 IRP of nearly 4 percent GDP growth by 2015. Moody's forecasts of economic recovery have been tempered over the last few years by lower GDP growth rates.
- Average annual population growth of 0.66 percent for 2018-2037. This is down from the 0.76 percent growth rate Moody's forecast in the 2015 IRP for 2016-2035.

Slower population growth is attributed to lower birth rates due to an aging population and lower international migration now that developing countries' economies are growing faster than they have in the past.

Economic growth could slow if demand from China and Euro Zone economies continues to slow; if the Federal Reserve becomes aggressive in its interest rate setting; if international trade policies become more protectionist; or if geopolitical tensions increase, especially in Eastern Europe or the Middle East. Alternatively, if U.S. and international growth rates continue to diverge, the U.S. could be more attractive to domestic investors. Low oil prices could spur spending in the short term but weigh on U.S. oil companies in the long term. However, many believe that the U.S. economy will be able to withstand these threats and continue to follow a steady, positive growth path.

Regional Economic Outlook

PSE is the largest investor owned utility in Washington; it and provides gas services to almost 60 percent of state's population and electric services to about 40 percent of the state's population. Within PSE's service territory, demand growth is uneven. Most of the economic growth is driven by the growth in the high tech or information technology sectors, and this growth is concentrated in King County, which accounts for half or more of the system's electric and gas sales demand today. Other counties are growing, but slowly; most have yet to reach their pre-recession population or employment growth rates.

PSE prepares regional economic and demographic forecasts using econometric models whose primary inputs are the macroeconomic forecasts of the United States plus historical economic data for the counties in PSE's service area.

Electric Scenario Outlooks

BASE SCENARIO OUTLOOK. The following forecast assumptions are used in the 2017 IRP Base Electric Demand Forecast scenario.

- Employment is expected to grow at an average annual rate (aarg) of 0.8 percent between 2018 and 2037, which is slightly faster than the annual growth rate of 0.7 percent forecasted in the 2015 IRP.
- Local employers are expected to create about 320,000 total jobs between 2018 and 2037 as compared to about 297,000 jobs forecasted in the 2015 IRP, mainly driven by growth in the commercial sectors.
- Manufacturing employment is expected to decline by 0.3 percent annually on average between 2018 and 2037 due to the outsourcing of manufacturing processes to lower wage states or countries, and also due to the continuing trend of capital investments that create increases in productivity.
- An inflow of more than 590,000 new residents (by birth or migration) is expected to increase PSE's electric service territory population to more than 4.6 million by 2037, for an average annual growth rate of 0.7 percent. This is lower than the 2015 IRP forecast, which projected an average annual population growth of 0.9 percent, which would have resulted in almost 4.8 million service territory residents by 2035.

In the region, long-term growth is driven by a diverse group of employers that includes Microsoft, Amazon, Costco, REI, Boeing and Starbucks among others. Also, other prominent high technology companies are beginning to establish or have already established their presence in the Puget Sound area. Boeing's strong historical employment growth is not necessarily expected to continue, due to outsourcing and an increase in the number of planes assembled in other states.

HIGH SCENARIO OUTLOOK. For the High Electric Demand Forecast scenario, population grows by 0.8 percent annually from 2018 to 2037, and employment grows by 1.3 percent per year during that period.

LOW SCENARIO OUTLOOK. For the Low Electric Demand Forecast scenario, population grows by 0.6 percent annually from 2018 to 2037. Employment grows 0.3 percent annually from 2018 to 2037.

The Base, High and Low population and employment forecasts for PSE's electric service area are compared in Figures 5-31 and 5-32.

Figure 5-31: Population Growth, Electric Service Area

POPULATION GROWTH, ELECTRIC SERVICE AREA (1,000s)						
Scenario	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
2017 IRP Base Demand Forecast	4,031	4,187	4,363	4,509	4,622	0.7%
2017 IRP High Demand Forecast	4,033	4,214	4,414	4,571	4,698	0.8%
2017 IRP Low Demand Forecast	3,961	4,096	4,250	4,375	4,471	0.6%

Figure 5-32: Employment Growth, Electric Service Area

EMPLOYMENT GROWTH, ELECTRIC SERVICE AREA (1,000s)						
Scenario	**2018**	**2022**	**2027**	**2032**	**2037**	**AARG 2018-2037**
2017 IRP Base Demand Forecast	2,089	2,156	2,236	2,320	2,409	0.8%
2017 IRP High Demand Forecast	2,193	2,336	2,476	2,619	2,784	1.3%
2017 IRP Low Demand Forecast	1,973	1,989	2,000	2,040	2,105	0.3%

Gas Scenario Outlooks: Base, High and Low

BASE SCENARIO OUTLOOK. In the Base Gas Demand Forecast scenario, population grows by 1.0 percent annually from almost 4.2 million people in 2018 to 5 million people by 2037. Employment is expected to grow by 1.3 percent annually from 2018 to 2037.

HIGH SCENARIO OUTLOOK. For the High Gas Demand Forecast scenario, population grows by 1.1 percent annually from 2018 to 2037, and employment grows by 1.9 percent per year during that period.

LOW SCENARIO OUTLOOK. For the Low Gas Demand Forecast scenario, population grows by 0.9 percent annually from 2018 to 2037. Employment grows 0.7 percent annually from 2018 to 2037.

The Base, High and Low population and employment forecasts for PSE's gas sales service area are compared in Figures 5-33 and 5-34.

Figure 5-33: Population Growth, Gas Service Area

POPULATION GROWTH, GAS SERVICE AREA (1,000s)						
Scenario	2018	2022	2027	2032	2037	AARG 2018-2037
2017 IRP Base Demand Forecast	4,189	4,392	4,633	4,852	5,049	1.0%
2017 IRP High Demand Forecast	4,213	4,442	4,713	4,967	5,203	1.1%
2017 IRP Low Demand Forecast	4,155	4,330	4,541	4,722	4,887	0.9%

Figure 5-34: Employment Growth, Gas Service Area

EMPLOYMENT GROWTH, GAS SERVICE AREA (1,000s)						
Scenario	2018	2022	2027	2032	2037	AARG 2018-2037
2017 IRP Base Demand Forecast	2,187	2,313	2,467	2,628	2,801	1.3%
2017 IRP High Demand Forecast	2,265	2,460	2,694	2,960	3,266	1.9%
2017 IRP Low Demand Forecast	2,133	2,200	2,272	2,354	2,431	0.7%

Energy Prices

Retail energy prices – what customers pay for energy – are included as explanatory variables in the demand forecast models, because in the long run, they affect customer choices about the efficiency level of newly acquired appliances, how they are used, and the type of energy source used to power them. The energy price forecasts draw on information obtained from internal and external sources.

Electric Retail Prices

PSE projects that between 2018 and 2037, nominal retail electric rates will grow at an average annual rate of 2.1 percent, which is higher than the 1.1 to 1.3 percent rate increase modeled in the 2015 IRP. However, the growth of retail electric rates is expected to trail inflation rates of 2.5 percent per year.

In the near term, the retail price forecast assumes rate increases resulting from PSE's general and power cost only rate cases. Long-term retail rates were derived from PSE's internal financial model, which showed higher power costs compared to the 2015 IRP, hence the higher growth rate assumed here.

Gas Retail Prices

PSE expects nominal retail gas rates to rise between 2.8 percent and 3.1 percent per year between 2018 and 2037, depending on the customer class. This is slightly more than the long-term inflation rate of 2.5 percent. Gas prices for residential and commercial customers are higher in this forecast compared to the forecast in the 2015 IRP; interruptible and transport classes have similar or slightly higher retail rates and industrial rates are slightly lower.

Two components make up gas retail rates: the cost of gas and the cost of distribution, known as the distribution margin. The near-term forecast of gas rates includes PSE's purchased gas adjustment and general rate case considerations. Forecast gas costs reflect Kiodex gas prices for the 2016 to 2020 period as of September 18, 2015 and inflation projections beyond. The distribution margin is based on PSE's projection for the near term and inflation projections for the longer term.

Other Assumptions

Weather

The billed sales forecast is based on normal weather, defined as the average monthly weather recorded at NOAA's Sea-Tac Airport station over the 30 years ending in 2015. While the climate may change during the 20-year planning horizon, reliable forecasts for these changes are not yet available. Future IRPs will incorporate new climate information as it becomes available.

Loss Factors

The electric loss factor is 7.3 percent, compared to 6.9 percent in the 2015 IRP. The gas loss factor in this IRP is 0.5 percent, compared to 0.8 percent in the 2015 IRP.

Block Load Additions from Major Accounts

Beyond typical economic change, the demand forecast also takes into account known major load additions and deletions, using information from PSE's system planners. These adjustments add 291 MW to demand over the next 7 years for the electric system as a whole. King County has the most additions.

Block load additions are ramped into the forecast and then ramped out when population and employment have grown enough to account for these additions. This avoids double counting block load additions.

The electric forecast includes the following load additions:

- 109 MW of commercial load additions are expected between 2016 and 2018, and 67 MW between 2019 and 2022. Approximately 2.1 MWs of these additions are expected for horticultural lighting.
- Residential additions are expected to be 36 MW between 2016 and 2018, and 18 MW between 2019 and 2022.
- Expected industrial additions are 56 MW before 2019 and 5 MW between 2019 and 2022.

The gas forecast includes the following block load additions:

- 0.6 Mdth per day is added for transport customers.
- 1.5 Mdth per day is added for commercial customers.

Compressed Natural Gas Vehicles

Compressed natural gas (CNG) vehicles were added to the 2017 IRP Gas Base Demand Forecast. CNG vehicles include marine vessels, buses, light-duty vehicles, medium-duty vehicles and heavy-duty vehicles. In 2017, this adds 27.6 Mdth to the forecast. This load is expected to grow at an average annual rate of 2.0 percent, based on the Annual Energy Outlook 2015 published by the U.S. Department of Energy.

Distributed Generation/Electric Vehicles

Distributed generation, including customer-level generation via solar panels, was not included in the load forecast; this energy production is captured in the IRP scenario modeling process. Electric vehicle loads, which are expected to increase in the future, will also be treated in the IRP modeling process.

Interruptible Loads

PSE has 163 electric interruptible customers; five of these are commercial and industrial customers and 158 are schools. The school contracts limit the time of day when energy can be curtailed. The other customers represent 7 MW of coincident peak load. Since this 7 MW is so small compared to PSE's peak load, it was included in the firm load forecast. For a number of gas customers, all or part of their volume is interruptible volume. The curtailment of interruptible gas volumes was included when forecasting peak gas loads.