Exh. EPM-7
Docket UG-240008
Witness: Eric P. Martuscelli

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. CASCADE NATURAL GAS CORPORATION, Respondent.	DOCKET UG-240008

CASCADE NATURAL GAS CORPORATION

SIXTH EXHIBIT TO THE
DIRECT TESTIMONY OF ERIC P. MARTUSCELLI

March 29, 2024

Chapter 3

Demand Forecast

Overview

Each year Cascade develops a 20-year forecast of customers, therm sales, and peak requirements for use in short-term (annual budgeting) and long-term (distribution and integrated resource planning) planning processes. For this IRP, Cascade is extending its forecast to 28 years in order to better align with emissions modeling. Sources of this forecast include historic data, market intelligence (ie building code changes), and regional economic data from Woods & Poole. This forecast is a robust portfolio of estimates created by expanding a single best-estimate forecast, which includes various potential economic, demographic, and marketplace eventualities, into scenarios such as low, expected, and high growth. The scenarios are used for distribution system enhancement planning and as inputs in optimization models to determine the reasonable least cost, least risk mix of supply and energy efficiency resources, revenue budgeting, and load forecasts associated with the purchased gas cost process.

Key Points

- Cascade extended its forecast analyses of demand areas, HDDs, and wind from 20 years to 28 years to better align with emissions modeling.
- Peak day is analyzed stochastically using 10,000 Monte Carlo simulated draws for each weather zone.
- Cascade added a price regressor to the Use-Per-Customer forecast.
- The Company utilizes dynamic regression modeling techniques for customer and annual demand forecasts.
- High and low scenarios are included and alternative forecasting assumptions were considered.
- Cascade expects system load growth to average 1.10% per year over the 28-year planning horizon.
- For methodological changes from previous IRPs, please refer to the "Methodological Changes…" section of this chapter.
- Uncertainties in the future, such as economic and long-term weather conditions, as well as future legislation, may cause differences from the Company's forecast.

Demand Areas

For the 2023-2050 planning horizon, Cascade continued to forecast at both the citygate and rate class levels. Cascade has a total of 76 citygates of which nine citygates feed only non-core customers and the remaining 67 serve at least one core customer. Of the 67 citygates that serve core customers, 22 are grouped into nine different citygate loops. Therefore, Cascade forecasts a total of 57 areas. Each of these areas contain multiple rate classes, resulting in approximately 200 individual dynamic regression models. Each citygate is assigned to a weather location. For this IRP, the Company assigned the citygates to the closest weather location by distance. The citygate results are rolled up into zones and districts which segregate Cascade's system based on pipelines and weather, as shown in Appendix B. Figure 3-1 provides a cross reference for the demand areas.

Figure 3-1: Demand Areas

Citygate	Loop	State	Weather Location	Zone
7TH DAY SCHOOL		WA	Yakima	10
A/M RENDERING	Sumas SPE Loop	WA	Bellingham	30-W
ACME		WA	Bellingham	30-W
ARLINGTON		WA	Bellingham	30-W
ATHENA		OR	Pendleton	ME-OR
BAKER		OR	Baker City	24
BELLINGHAM 1 (FERNDALE)	Sumas SPE Loop	WA	Bellingham	30-W
BEND	Bend Loop	OR	Redmond	GTN
BREMERTON (SHELTON)		WA	Bremerton	30-S
BURBANK HEIGHTS	Burbank Heights Loop	WA	Walla Walla	20
CASTLE ROCK		WA	Bremerton	26
CHEMULT		OR	Redmond	GTN
DEHAWN DAIRY		WA	Yakima	10
DEMING		WA	Bellingham	30-W
EAST STANWOOD	East Stanwood Loop	WA	Bellingham	30-W
FINLEY		WA	Walla Walla	20
GILCHRIST		OR	Redmond	GTN
GRANDVIEW		WA	Yakima	10
HERMISTON		OR	Pendleton	ME-OR
HUNTINGTON		OR	Baker City	24
KALAMA #1		WA	Bremerton	26
KALAMA #2		WA	Bremerton	26
KENNEWICK	Kennewick Loop	WA	Walla Walla	20
LA PINE		OR	Redmond	GTN
LAWRENCE		WA	Bellingham	30-W
LDS CHURCH		WA	Bellingham	30-W
LONGVIEW-KELSO	Longview South Loop	WA	Bremerton	26
LYNDEN	Sumas SPE Loop	WA	Bellingham	30-W
MADRAS		OR	Redmond	GTN
MCCLEARY (ABERDEEN/HOQUIAM)		WA	Bremerton	30-S
MILTON-FREEWATER		OR	Walla Walla	ME-OR
MISSION TAP		OR	Pendleton	ME-OR
MOSES LAKE		WA	Yakima	20
MOUNT VERNON	Sedro-Woolley Loop	WA	Bellingham	30-W
MOXEE (BEAUCHENE)		WA	Yakima	11
NORTH BEND		OR	Redmond	GTN
NORTH PASCO	Burbank Heights Loop	WA	Walla Walla	20
NYSSA-ONTARIO		OR	Baker City	24
OAK HARBOR/STANWOOD	East Stanwood Loop	WA	Bellingham	30-W

Citygate	Loop	State	Weather Location	Zone
OTHELLO		WA	Walla Walla	20
PASCO	Burbank Heights Loop	WA	Walla Walla	20
PATTERSON		WA	Yakima	26
PENDLETON		OR	Pendleton	ME-OR
PRINEVILLE		OR	Redmond	GTN
PRONGHORN		OR	Redmond	GTN
PROSSER		WA	Yakima	10
QUINCY		WA	Yakima	11
REDMOND		OR	Redmond	GTN
RICHLAND (Richland Y)	Kennewick Loop	WA	Walla Walla	20
SEDRO/WOOLLEY	Sedro-Woolley Loop	WA	Bellingham	30-W
SELAH	Yakima Loop	WA	Yakima	11
SOUTHRIDGE	Kennewick Loop	WA	Walla Walla	20
SOUTH BEND	Bend Loop	OR	Redmond	GTN
SOUTH LONGVIEW	Longview South Loop	WA	Bremerton	26
STANFIELD		OR	Pendleton	GTN
STEARNS (SUNRIVER)		OR	Redmond	GTN
SUNNYSIDE		WA	Yakima	10
UMATILLA		OR	Pendleton	ME-OR
WALLA WALLA LOOP		WA	Walla Walla	ME-WA
WALLULA		WA	Walla Walla	ME-WA
WCT-CNG INTERCONNECT	Sumas SPE Loop	WA	Bellingham	30-W
WENATCHEE		WA	Yakima	11
WOODLAND		WA	Bremerton	26
YAKIMA CHIEF RANCH		WA	Yakima	10
YAKIMA TRAINING CENTER		WA	Yakima	11
YAKIMA/UNION GAP	Yakima Loop	WA	Yakima	11
ZILLAH (TOPPENISH)		WA	Yakima	10

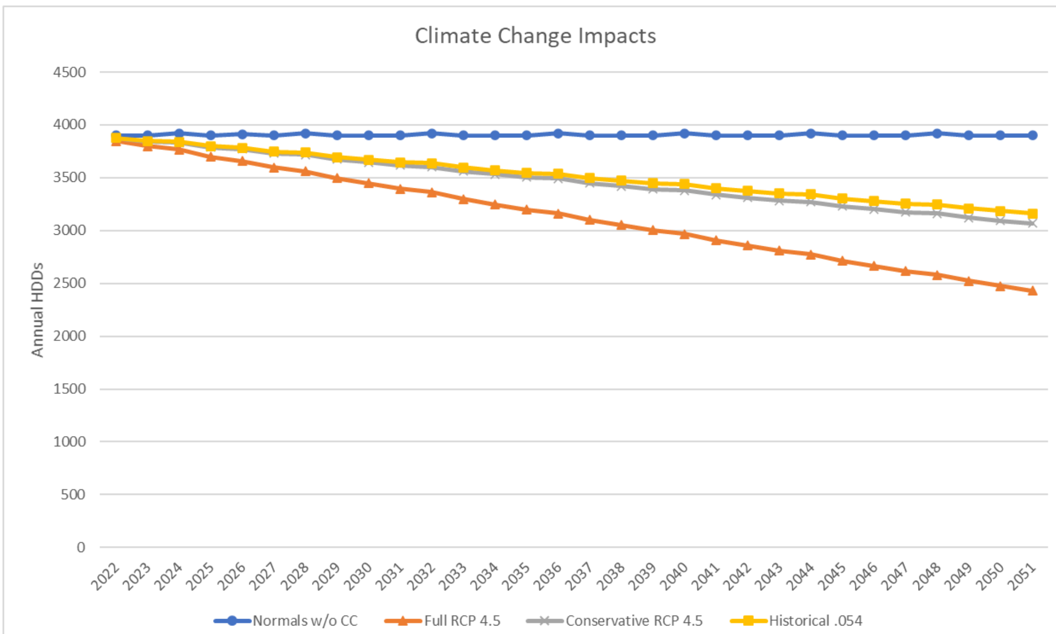
Weather

Heating Degree Day, or HDD, values are calculated with the daily average temperature, which is the simple average of the high and low temperatures for a given day. The daily average is then subtracted from an HDD degree threshold (for example 60 °F) to create the HDD for a given day. Should this calculation produce a negative number, a value of zero is assigned as the HDD. Therefore, HDDs can never be negative. The HDD threshold number is designed to reflect a temperature below which heating demand begins to significantly rise.[1]

[1] The historical threshold for calculating HDD has been 65 °F. However, as discussed in prior IRPs, Cascade has determined that lowering the threshold to 60 °F produces more accurate results for the Company's service area.

Historical weather data is provided by a contractor, Schneider Electric. Cascade has seven weather locations with four located in Washington and three in Oregon. The four locations in Washington are Bellingham, Bremerton, Walla Walla, and Yakima. Historically, Cascade has accessed data from NOAA (National Oceanic and Atmospheric Administration), but found many months/locations with missing data. The previous forecasts used 30 years of recent history as the normal or expected weather. For this IRP, Cascade has evolved its weather forecast with an analysis of climate change impacts and Monte Carlo peak day simulations. Cascade selected scenarios from the Intergovernmental Panel on Climate Change (IPCC). Figure 3-2 shows an annual HDD forecast comparison of Cascade's previous weather normals methodology in blue compared to climate change scenarios selected from the IPCC.[2]

Figure 3-2: Climate Change Impacts



- Normals w/o CC: This represents 30 years of historical data projected forward as normal weather, or expected weather.
- Full RCP 4.5: This represents the Coupled Model Intercomparison Project Phase 4 (CMIP5) with the RCP 4.5 scenario which included 36 different models. [1]
- Conservative RCP 4.5: This represents the 18 most conservative models in the Full RCP 4.5 project. [1]
- Historical 054: This represents the Environmental Protection Agency's noted historical temperature change (.54 F per decade since 1979). [3]

[2] https://ipcc-browser.ipcc-data.org/browser/search?format
[3] https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature

Cascade chose the Conservative RCP 4.5 forecast as it best represents the Western North America emission goals and was labeled as the most probable baseline scenario.[4] This is incorporated into the forecast by replacing the normal HDDs that would have been used to forecast years 2023-2150 with the HDDs in the Conservative RCP 4.5 scenario. This allows Cascade to better capture climate change's effects on HDDs, rather than simply relying on historical HDDs.

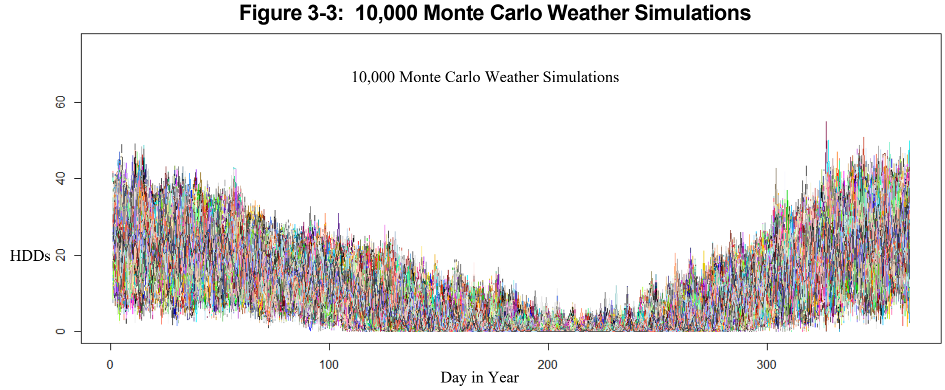
Peak Day Methodology

In order to ensure satisfaction of core customer demand on the coldest days, Cascade must use a methodology for determining what a peak day might be and then include it in the modeling. Since the prior IRP, Cascade has evolved its peak day methodology from a deterministic peak day to a stochastic peak day. Peak day forecasts enable Cascade to make prudent distribution system and peak upstream pipeline capacity planning decisions to fulfill its responsibility to provide heating under all but *force majeure* conditions, particularly as most space-heating customers will have no alternative heating source during the coldest days in the event gas does not flow.

The stochastic peak day that was analyzed in the forecast model is a weather zone specific 99th percentile peak day. This 99th percentile peak day will give Cascade the confidence that the system can handle a peak day based on the weather of each weather zone with varying amounts of demand. This peak day HDD methodology allows Gas Supply to plan for the highest peak event during a heating season.

The 99th percentile peak day is derived by running 10,000 Monte Carlo simulations on each of the seven weather zones. Once 10,000 draws are gathered and ordered for each weather zone, Cascade can pull the 9,900th draw as the 99th percentile to use in the demand forecast. Figure 3-3 displays all 10,000 draws graphed together.

Figure 3-3: 10,000 Monte Carlo Weather Simulations



[4] https://en.wikipedia.org/wiki/Representative_Concentration_Pathway

For Plexos® modeling, Cascade uses this peak day for each weather zone by applying the HDDs on December 21 of each year in the forecast. The selection of December 21st is mostly arbitrary, though one of Cascade's coldest peak days did occur on a December 21st, with the intention of mimicking a cold winter day. For example, all citygates associated with the Yakima weather station use the 99th percentile peak HDD for Yakima for each December 21st of the forecast period, and similarly for all the other weather stations and citygates. This provides a highest demand scenario for peak demand load based on Monte Carlo simulations of years of weather history for each citygate. Applying this stochastic peak day to December 21st of each forecasted year gives Cascade an accurate representation of the demand the Company could expect if this weather happened during the planning horizon.

Cascade is actively monitoring its peak day methodology to ensure an accurate and realistic peak day forecast.

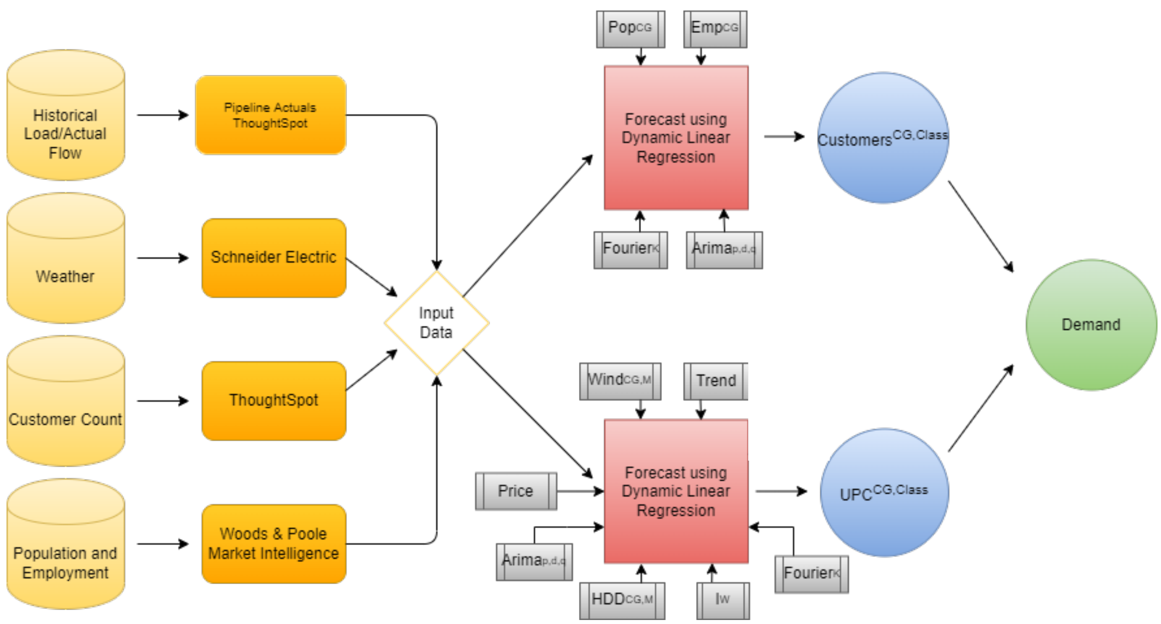
Wind

Wind values are calculated with the daily average wind speed, which is the simple average of the high and low wind speeds for a given day. Wind speeds are also weather location specific, similar to HDDs.

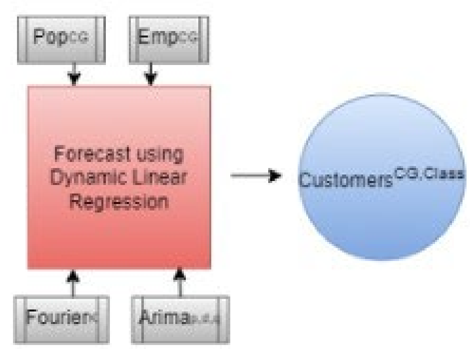
Demand Overview

Figure 3-4 provides a roadmap for Cascade's demand forecast. The inputs are displayed along with their sources in yellow and gold. The customer forecast and use-per-customer (UPC) forecast are shown in red along with their respective inputs into the model. Finally, the customer forecast is multiplied by the use-per-customer forecast to create the final demand forecast.

Figure 3-4: Demand Forecasting Process Overview



Customer Forecast Methodology



Customer count forecasts are designed to reflect both demographic trends and economic conditions both in the short- and long-term. Cascade uses population and employment growth data from Woods & Poole (W&P). Since the first quarter of 2020, Cascade has and will continue to monitor the COVID-19 impacts. Since Cascade relies on W&P for population and employment growth data, the Company is providing an update from W&P about the impacts of COVID-19 on those projections. W&P states "Despite significant 2020 impacts, COVID -19 itself does not appear to have made a quantifiable long-term economic impact that would affect forecasts: productive land area in the U.S. is still usable, productive capital (i.e. factories) are still in place, and the size of labor force has not been reduced significantly." [5] W&P growth forecasts are provided at the county level. It should be noted that W&P forecasts are adjusted when the internal intelligence about a demand

[5] Woods & Poole's 2020 State Profile: State and County Projections to 2020

area indicates a significant difference from W&P regarding observed economic trends. Cascade utilizes dynamic regression models for the customer forecast as well as regression models for the UPC forecast, which will be discussed in the next subchapter. Below is the formula the Company used to run the regressions:

$$C_{Class}^{CG} = \alpha_0 + \alpha_1 Pop^{CG} + \alpha_2 Emp^{CG} + Fourier(k) + ARIMA\epsilon(p, d, q)$$

Model Notes:

- $C_{Class}^{CG} = Customers\ by\ Citygate\ by\ Class$
- $Pop^{CG} = Population\ by\ Citygate$
- $Emp^{CG} = Employment\ by\ Citygate$
- $Fourier = Terms\ used\ to\ capture\ seasonal\ patterns$
- $k = Number\ of\ Fourier\ terms\ used\ in\ model$
- $ARIMA\epsilon(p, d, q) =$ $Indicates\ that\ the\ model\ has\ p\ autoregressive\ terms, d\ difference\ terms, and\ q\ moving\ average\ terms.$

Cascade runs this model approximately 200 times to account for each customer class by citygate. The Company begins by testing seven different combinations of the regressors in both dynamic regression models and one Autoregressive Integrated Moving Average (ARIMA) model. The dynamic regression models test Fourier, Population, Employment, Population + Fourier, Employment + Fourier, and Employment + Population + Fourier. The last model is called an ARIMA model, which uses ARIMA terms and no regressors. Unlike the dynamic regression models, the 'ARIMA Only' model's ARIMA term is not strictly modeling the errors, but is used as a model for the entire data set. The method used to compare and select a model is called the AIC, or the Akaike Information Criterion. This is a measure of the relative quality of statistical models, relative to each of the other models. In each of the models, except for the 'ARIMA Only' model, an ARIMA term is used to capture any structure in the errors (or residuals) of the model. In other words, there could be predictability in the errors, so they could be modeled as well. If the data is non-stationary, the ARIMA function will difference the data. Most times, the data does not require differencing, or only needs to be differenced once. Once the best model is selected for each customer class by citygate, a forecast is performed using the selected model.

Customer count and therm forecasts are augmented by revisions to the base data and output to create a portfolio of potential scenarios. Low and high growth scenarios are created from the confidence intervals from the forecast model. These scenarios, along with the original, best-estimate, expected scenario encapsulate a range of most-likely possibilities given known data. The most recent W&P data indicates an average annual population growth of 0.81% between 2023 and 2050 for Cascade's service territory. The projected customer growth is provided in Appendix B. Based on historical experience and given expected weather, Cascade expects system load will likely remain within a range bound by the low and high growth scenarios. Cascade locked in the forecast model in June of 2022 as it is a key input for several other aspects of this IRP.

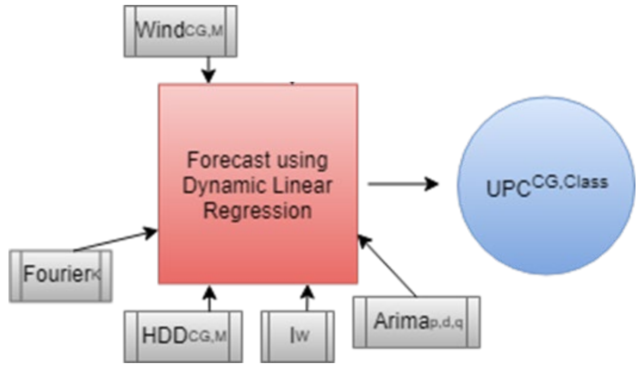
Among other reasons, the Company believes that high projected growth in the following regions is supported by the provided quantitative analysis:

- Burbank Heights Loop is expected to see a year over year average growth of 2.34%. This loop consists of the Pasco, North Pasco, and Burbank Heights citygates. These are located in southeastern Washington. Pasco sits in one of the fastest growing counties in the state, Franklin County. Future job growth is optimistic.[6]
- Kennewick Loop is expected to see a year over year average growth of 2.38%. This loop consists of the Richland Y, Kennewick, and Southridge citygates. These are located in southeastern Washington. Many new developments are a direct result of high population growth rates and optimistic job outlooks. [6]
- Bend Loop is expected to see a year over year average growth of 2.06%. This loop consists of the Bend and South Bend citygates. Bend is located in central Oregon. Bend is seeing a population boom coupled with optimistic job growth estimates. [6]
- Prineville is expected to see a year over year average growth of 2.02%. Prineville is located in central Oregon and much like Bend, Prineville has seen growth even during the pandemic. [7]

According to the Census Bureau, there has been a nationwide shift from larger cities to mid-size and smaller ones with the increase in remote work. Cities like Bend have been referred to as “Zoom towns”, referring to the new work-from-home culture allowing people to live where they want. [8]

[6] *See* According to bestplaces.net, worldpopulationreview.com, and city-data.com
[7] *See* According to bestplaces.net, worldpopulationreview.com, and city-data.com
[8] See United States Census Bureau, https://www.census.gov/newsroom/press-releases/2022/population-estimates-counties-decrease.html

Use-Per-Customer (UPC) Forecast Methodology



As previously mentioned, Cascade utilizes regression models for the UPC part of the demand forecast as well.[9] Sources for the inputs into this model are pipeline actuals, Cascade's gas management system, and Cascade's billing system data from ThoughtSpot. Cascade developed the UPC coefficient by first gathering historical pipeline demand data by day. The pipeline demand data includes core and non-core usage. The non-core data is backed out using Cascade's measurement data stored in the Company's Aligne energy transaction system which leaves only the daily core usage data. Then the daily data is allocated to a rate schedule for each citygate by using Cascade's ThoughtSpot system, which analyzes the therms billed for each rate class. Finally, this data is divided by number of customers to come up with a UPC number for each day and for each rate schedule at each citygate.

Below is the model used for the UPC forecast:

$$\frac{Therms}{C_{Class}^{CG}} = \alpha_0 + \alpha_1 HDD^{CG,M} + \alpha_2 I_w + \alpha_3 WIND^{CG,M} + Fourier(k) + ARIMA(p,d,q) + Price$$

Model Notes:

- $C_{Class}^{CG} = Customers\ by\ Citygate\ by\ Class.$
- $HDD^{CG} = Heating\ Degree\ Days\ from\ Weather\ Location$
- $m = month$
- $w = weekend$
- $I = Indicator\ variable, 1\ if\ weekend, and\ 0\ if\ weekday.$
- $WIND^{CG} = Daily\ average\ wind\ speed\ from\ Weather\ Location$
- $Fourier(k) = Captures\ seasonality\ of\ k\ number\ of\ seasons.$
- $ARIMA(p,d,q) = Indicates\ model\ has\ p\ autoregressive\ terms,\ d\ difference\ terms, and\ q\ moving\ average\ terms.$
- $Price = Front\ of\ Month\ (FOM)\ pricing$

Cascade runs this model for each of the 57 citygates and citygate loops by customer class where applicable, resulting in approximately 200 models. Cascade begins each model with a simple linear model regressing on HDDs, wind, price, and

[9] A regression model provides a function that describes the relationship between one or more independent variables and a response, dependent, or target variable. A regression analysis provides the means for many types of prediction and for determining the effects on target variables. Multiple regression indicates there are more than one input variables that may affect the outcome, or target variable.

weekend. If the residuals analyzed show structure, then the models are expanded to include ARIMA and Fourier terms.

Price as a New Regressor

Price is a new regressor for this IRP.[10] Overall, price has not seen much significance in the models. The largest coefficients were on the commercial and industrial customer classes, and even then the coefficients were quite small, seemingly insignificant. The residential coefficients were close to 0. Through the TAG process, specifically TAG 2, stakeholders suggested Cascade replace the price regressor with an income regressor in an attempt to better capture customer behavior. Cascade is excited to perform this analysis in the next demand forecast.

Building Code Impacts

As the Washington State Energy Codes (WSEC) continue to progress and impact new construction for natural gas end use appliance, Cascade must consider these impacts in the Company's customer and load forecasts.

RCW 19.27A.020(2)(a) is a broad goal that provides direction to the Washington State Building Code Council (SBCC) to adopt amendments to the WSEC that progressively moves the needle for new construction homes and buildings to be non-emitting by 2031. To achieve this goal, it is important to consider that a non-emitting (zero fossil-fuel greenhouse gas emission) home/building is typically considered based upon the net emissions; however, the legislative direction does not specify "net" in this circumstance. Consideration of net emissions is important, as it allows for a broader and more reliable energy portfolio. To achieve net-zero, emitting energy uses can be offset by renewable energy production (i.e. wind or solar) or energy that has a negative carbon intensity (i.e. Renewable Natural Gas); thus, allowing for emitting (i.e. Natural Gas) energy use during severe weather events, while still having a home/building that has net-zero emissions.

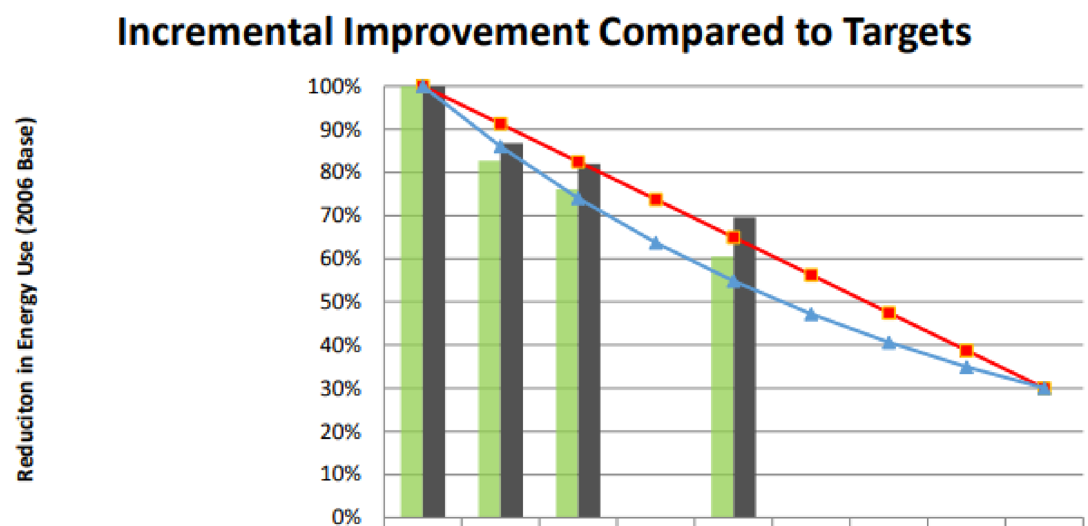
Under RCW 19.27A.020(2)(a), the SBCC is directed to "…help achieve the broader goal…" of zero emission homes/buildings. Note that this is a goal, not a mandate. Conversely, RCW 19.27A.160 is an explicit direction to the SBCC to move towards a 70% reduction in annual net energy consumption by 2031. This is a mandate, and is clear that the goal is a "net" energy.

Since RCW 19.27A.020(2)(a), the enacting legislation resulted from 2009 SB 5854. Therefore, the 2012, 2015, 2018, and 2021 code cycles were all likely impacted by

[10] A regressor is the name given to any variable in a regression model that is used to predict a response variable.

the legislation. Figure 3-5 provides an explanation of how the SBCC has addressed the more explicit legislative direction of RCW 19.27A.160.

Figure 3-5: Reduction Targets in Energy Use[11]



	2006	2009	2012	2015	2018	2021	2024	2027	2030
Residential	100%	82.7%	76.1%		60.5%				
Commercial	100%	86.8%	82.0%		69.6%				
Target: 8.75 % savings compared to the 2006 WSEC	100%	91%	83%	74%	65%	56%	48%	39%	30%
Target: 14% savings compared to each previous code	100%	86%	74%	64%	55%	47%	41%	35%	30%

The most impactful measures were found in the 2018 and 2021 WSEC. For example, NEEA's WA Residential Post Code Adoption Market Research Final Report[12] found that "…builder practices have significantly changed under the 2018 WSEC compared to the 2015 WSEC. This includes a shift towards electric space heating and water heating…" "…the incidence of electric primary space heating is 88% in this study of the 2018 WSEC; the 2015 WSEC study (CLEAResult 2020) recorded a 20% incidence of electric primary space heating for comparison. Water heating fuel is also showing significant changes. This study of the 2018 WSEC shows 87% electric water heating, while the 2015 WSEC study (CLEAResult 2020) recorded 44% electric water heating." (Note that this NEEA report was focused solely on residential; NEEA's 2018 WSEC Energy Savings Analysis for Nonresidential Buildings[13] may provide some additional insight for commercial projects).

[11] Final Cost Benefit Analysis for the 2021 WSEC-R
[12] *See* Washington Residential Post-Code Adoption Market Research (neea.org)
[13] *See* Northwest Energy Efficiency Alliance (NEEA) | 2018 Washington State…

With the forthcoming 2021 WSEC (effective July 1, 2023), the use of natural gas for space and water heating is generally prohibited for commercial buildings, and may only be used for supplementary (backup) heating or within gas heat pumps in residential buildings. Given the shift towards electric appliances already found from the 2018 WSEC, the 2021 WSEC will only further this trend.

Cascade has been monitoring the building code changes and will continue to monitor the impacts the current and future building code changes have. Due to the COVID-19 Pandemic, the 2018 WSEC did not go into effect until February 1, 2021. Cascade had one year's worth, which is a relatively small sample size, of historical data included in the customer and load forecast models for this current IRP. In future IRPs, once Cascade has gathered more data regarding the impacts of the 2018 and 2021 WSEC, the Company will investigate the impact these building code changes will have on the load and customer forecast.

Scenario Analysis

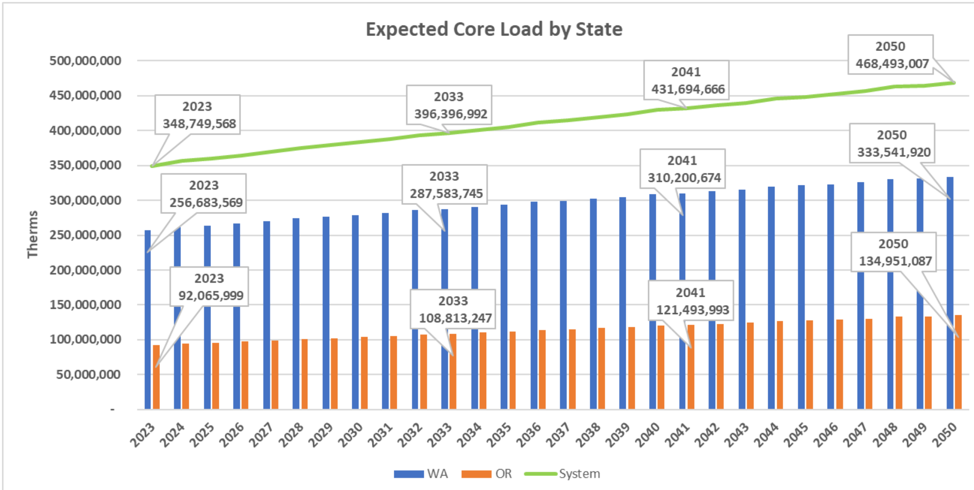
Cascade stress tests the load forecast in Plexos® by using alternative forecasting assumptions. These alternative forecasting assumptions refer to changing factors that influence demand. Alternative assumptions include high and low customer growth, and a stochastic study of weather using Monte Carlo simulations. These altered assumptions provide an effective tool for analyzing and stress testing the forecasts.

Cascade utilizes a low and high customer growth forecast to use in various Plexos scenarios. Also, as mentioned previously in the peak day section, Cascade developed a peak day weather assumption based on 10,000 Monte Carlo simulations for each weather zone. The base case contains expected weather, customer growth, and use per customer. The base case also has an annual peak day event for each weather zone. Expected weather is the Conservative RCP 4.5 forecast previously discussed in this chapter. High and low growth scenarios, discussed more on page 3-20, are developed by using modifiers to represent higher than expected growth and lower than expected growth. Cascade also performs a deep sensitivity analysis utilizing Monte Carlo runs for other variables such as price. Monte Carlo analysis is discussed further in Chapter 10, Resource Integration.

Forecast Results

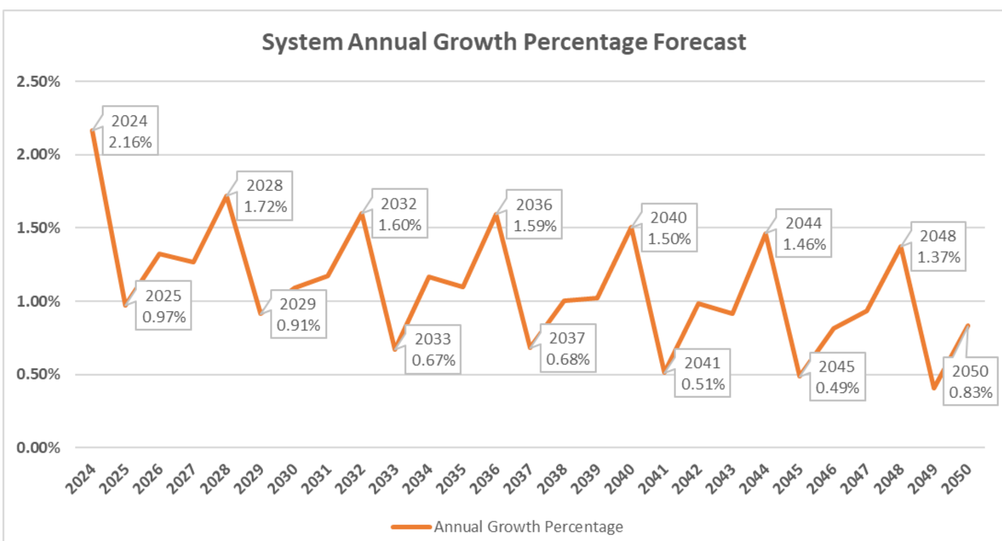
Load across Cascade's two-state service territory is expected to increase at an average annual rate of 1.10% over the planning horizon, with the Oregon portion outpacing Washington, 1.43% versus 0.98%. Figure 3-6 shows the expected core load volumes by state.

Figure 3-6: Expected Core Load by State (Volumes in Therms)



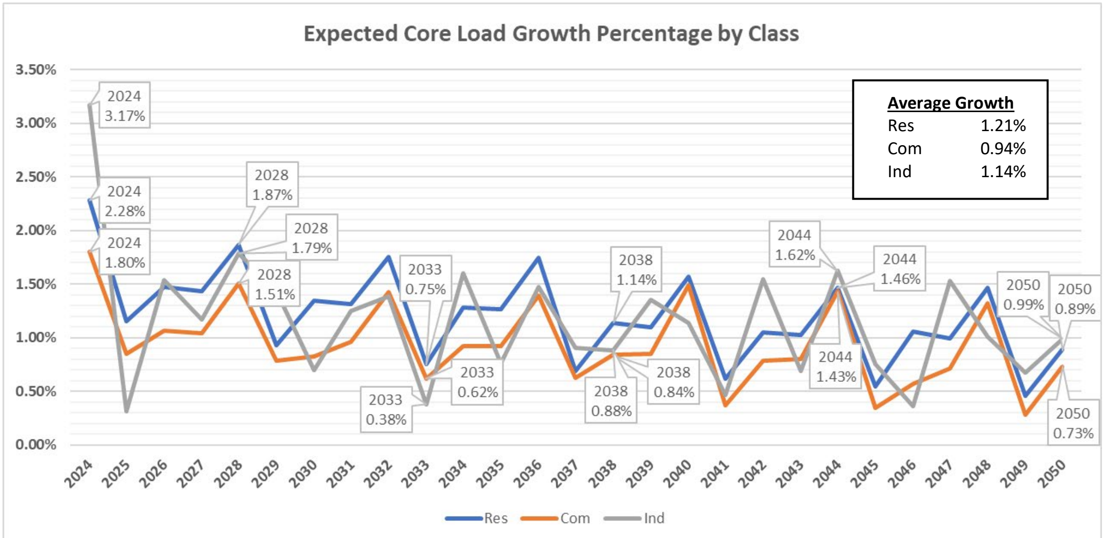
Load growth across Cascade's system through 2050 is expected to fluctuate between 0.41% and 2.16% annually, accounting for leap years. Figure 3-7 illustrates the growth forecast for Cascade's system load year over year, showing growth on Cascade's system but at a declining rate.

Figure 3-7: System Annual Growth Percentage Forecast



Load growth is split between residential, commercial, and industrial customers. Residential and commercial customer classes are expected to grow annually at an average rate of 1.21% and 0.94%, while industrial expects a growth rate of approximately 1.14%. Figure 3-8 shows the percentage of core growth by class over the planning horizon.

Figure 3-8: Expected Core Load Growth Percentage by Class



In absolute numbers, system load is expected to grow annually at an average of 4.4 million therms. A majority of core load today is residential. Cascade projects the ratio between residential, commercial, and industrial to increase in favor of residential customers. Residential customers are expected to grow from 53.3% of the total core load to 54.9% of the total core load by 2050. Figure 3-9 compares the total system annual therm usage forecast of this IRP to past IRPs dating back to 2011. The differences in forecasts can be attributed to evolutions in methodology, customers changing between core and non-core, and having more data to forecast with. Figure 3-10 displays the relative percentage relationship of expected loads by class.

Figure 3-9: System Load Comparison to Previous IRPs (Volumes in Therms)

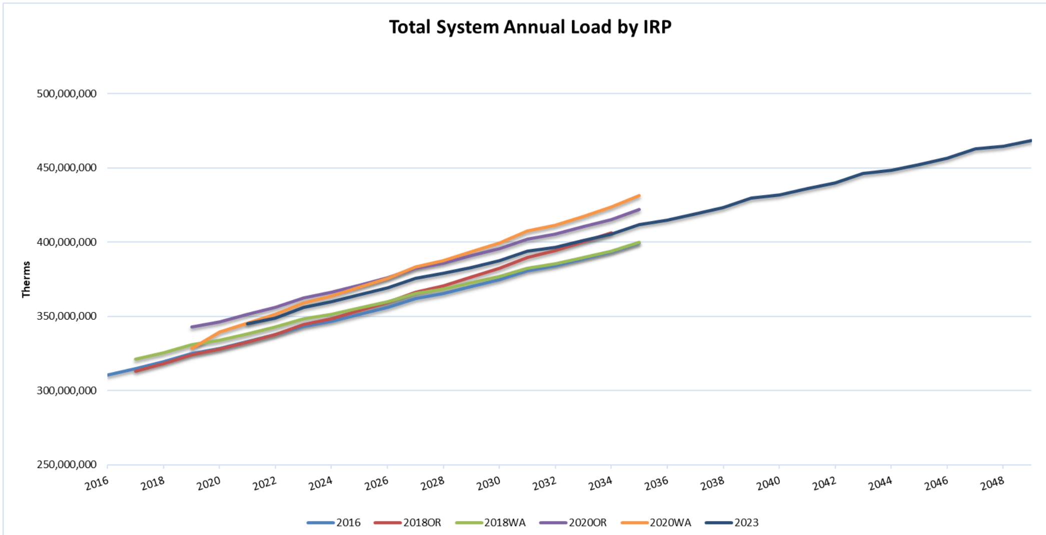
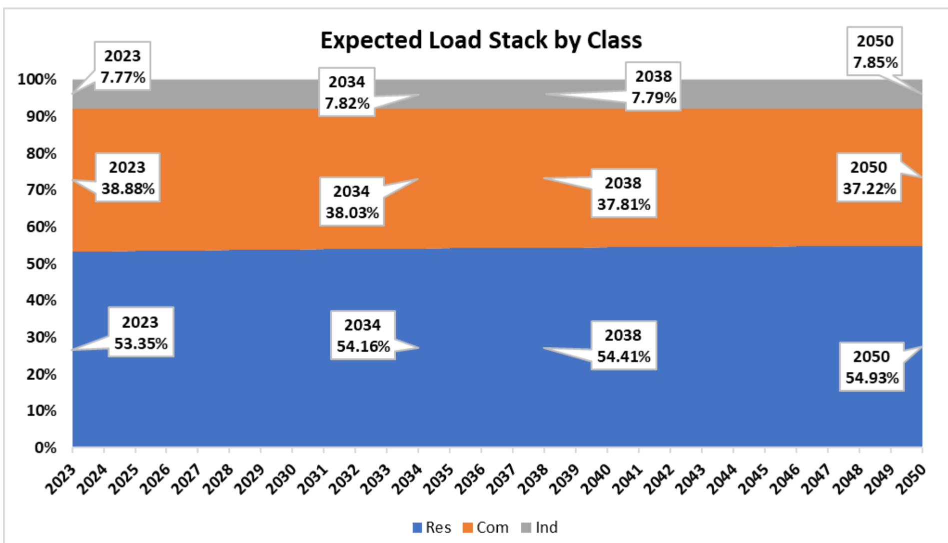
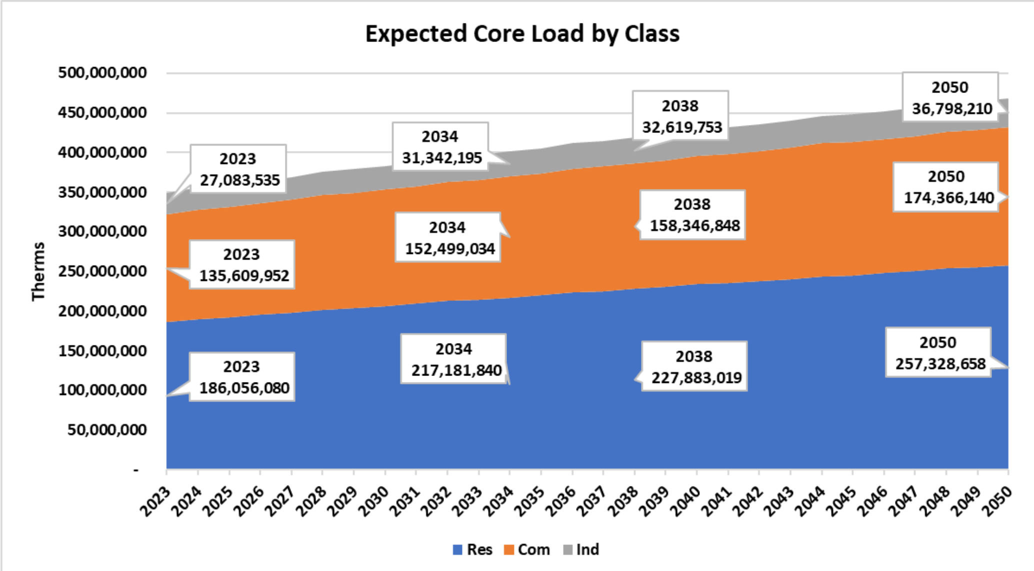


Figure 3-10: Expected Load Stack by Class



Cascade expects residential customers to increase load at an annual average growth of approximately 2.6 million therms and commercial core customers to increase load at an annual average growth of approximately 1.4 million therms over the 20-year planning horizon. Industrial customers are expected to increase load at an annual average growth of approximately 350,000 therms over the same period. Figure 3-11 displays the expected core load volumes by class.

Figure 3-11: Expected Load Growth by Class (Volumes in Therms)



Load growth is primarily a result of increased customer counts. The number of residential, commercial, and industrial customers is expected to increase at a slightly faster rate than therm usage. Figure 3-12 displays the expected customer counts by year and Figure 3-13 displays expected growth percentages by class.

Figure 3-12: Expected Customer Counts by Year

System	High	Base-Case	Low
2023	327,988	321,961	315,380
2030	393,099	364,076	334,873
2040	493,671	424,230	360,652
2050	602,450	484,386	384,533

WA	High	Base-Case	Low
2023	240,626	236,647	232,351
2030	283,937	264,754	245,475
2040	350,354	304,902	262,955
2050	421,696	345,032	279,239

OR	High	Base-Case	Low
2023	87,361	85,314	83,028
2030	109,162	99,322	89,398
2040	143,317	119,328	97,697
2050	180,754	139,354	105,293

Figure 3-13: Expected Customer Growth

System	High	Base-Case	Low
Residential	2.33%	1.56%	0.75%
Commercial	1.90%	1.28%	0.62%
Industrial	2.22%	1.47%	0.66%
Total	**2.28%**	**1.52%**	**0.74%**

WA	High	Base-Case	Low
Residential	2.12%	1.42%	0.69%
Commercial	1.95%	1.31%	0.64%
Industrial	1.87%	1.27%	0.58%
Total	**2.10%**	**1.41%**	**0.68%**

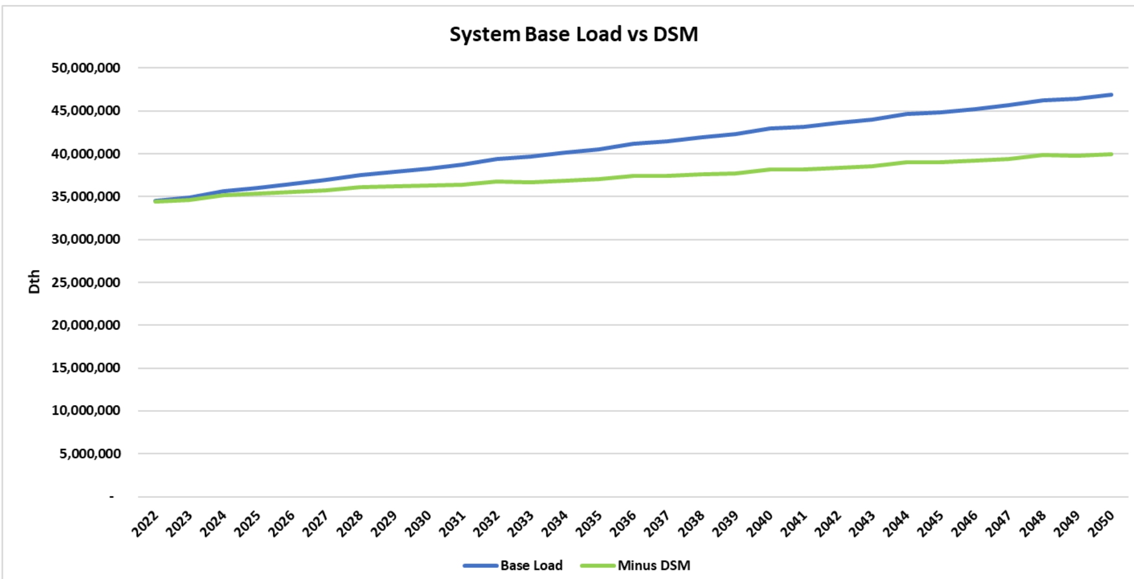
OR	High	Base-Case	Low
Residential	1.78%	1.19%	0.58%
Commercial	1.78%	1.19%	0.58%
Industrial	3.08%	2.02%	0.91%
Total	**2.73%**	**1.83%**	**0.88%**

System Load and Demand Side Management (DSM)

Demand Side Management (DSM) refers to the reduction of natural gas consumption through the installation of energy efficiency or through other load management programs such as demand response efforts that shift gas consumption to off-peak periods. For more details, please refer to Chapter 7, Demand Side Management.

Figure 3-14 displays total WA and OR DSM projected annual savings as it compares to Cascade's system load forecast.

Figure 3-14: System Base Load vs DSM



With DSM projections factored in, Cascade's anticipated system average annual growth rate drops from 1.10% to 0.54%. This represents an annual average DSM savings of 236,000 Dth, which when added cumulatively, has an important impact on overall system load.

Focusing on each individual state, Figures 3-15 and 3-16 display both OR and WA base load as it relates to projected DSM savings.

Figure 3-15 shows that with DSM projections factored in, Cascade's anticipated OR average annual growth rate drops from 1.43% to 0.86%. This represents an annual average DSM savings of 71,000 Dth, graphed as a cumulative number.

Figure 3-15: OR Base Load vs DSM

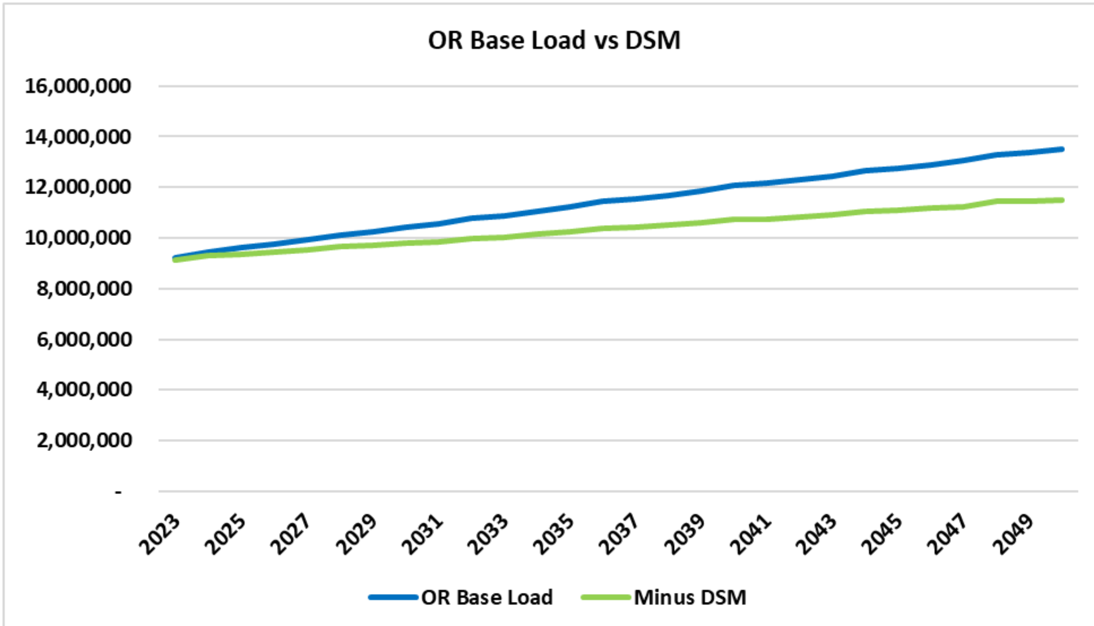
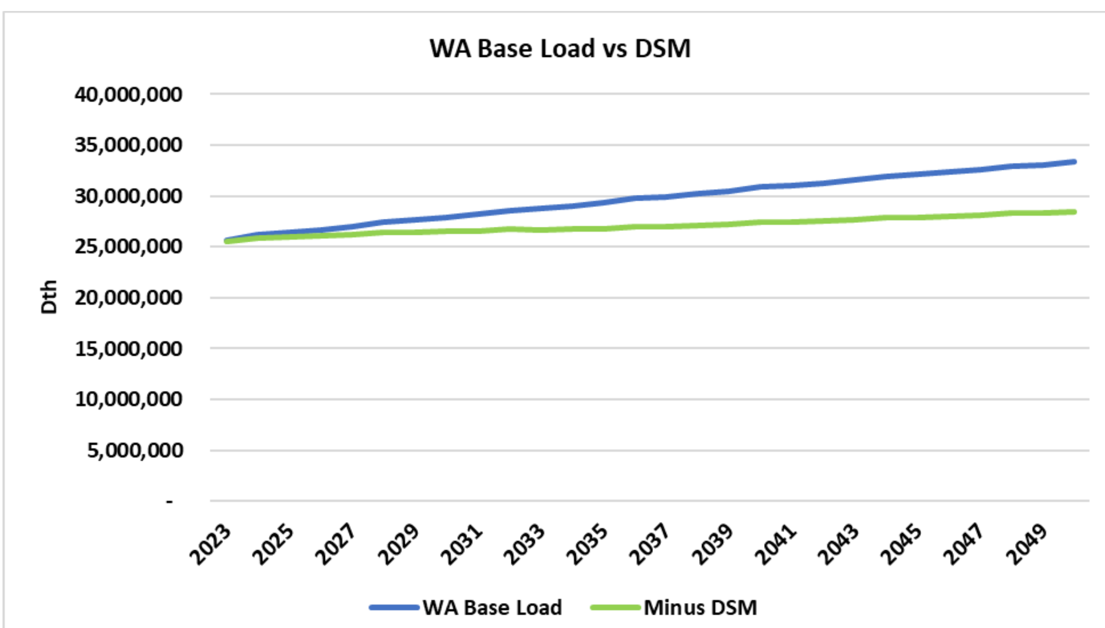


Figure 3-16 shows that with DSM projections factored in, Cascade's anticipated WA average annual growth rate drops from 0.98% to 0.41%. This represents an annual average DSM savings of approximately 168,000 Dth, graphed as a cumulative number.

Figure 3-16: WA Base Load vs DSM



Geography

Southeastern Washington and central Oregon are major drivers in Cascade's growth. These areas have multiple citygates serving counties with large increases in growth rates. Zone 20 contains the Kennewick Loop, a fast-growing area while Zone GTN contains the Bend loop, another fast growing area. Figure 13-17 shows the locations of the faster growing citygates on a map. Figure 3-18 shows the annual system load by each of Cascade's pipeline zones. Figure 3-19 shows the average annual percentage growth of load by each pipeline zone over the planning horizon. For a map of the pipeline zones, please refer to Figures 13-10 and 13-11. For a detailed list, Figure 3-1 gives information on each citygate's zone. Lastly, Figure 3-19 displays the expected system core peak day growth over the planning horizon. Peak day average annual growth is expected to be approximately 1.58%.

Figure 3-17: System 28-Year Load by Pipeline Zone (Volumes in Therms)

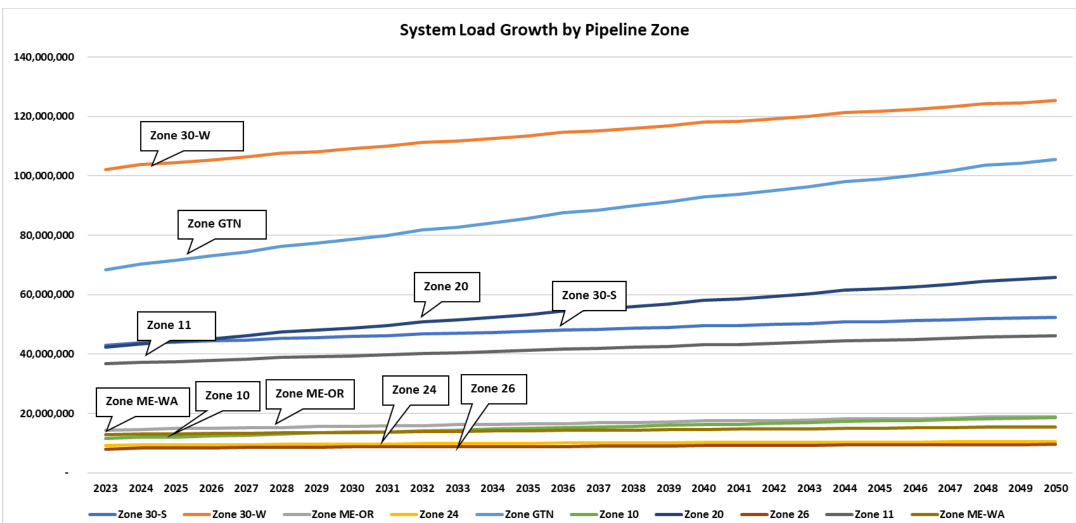
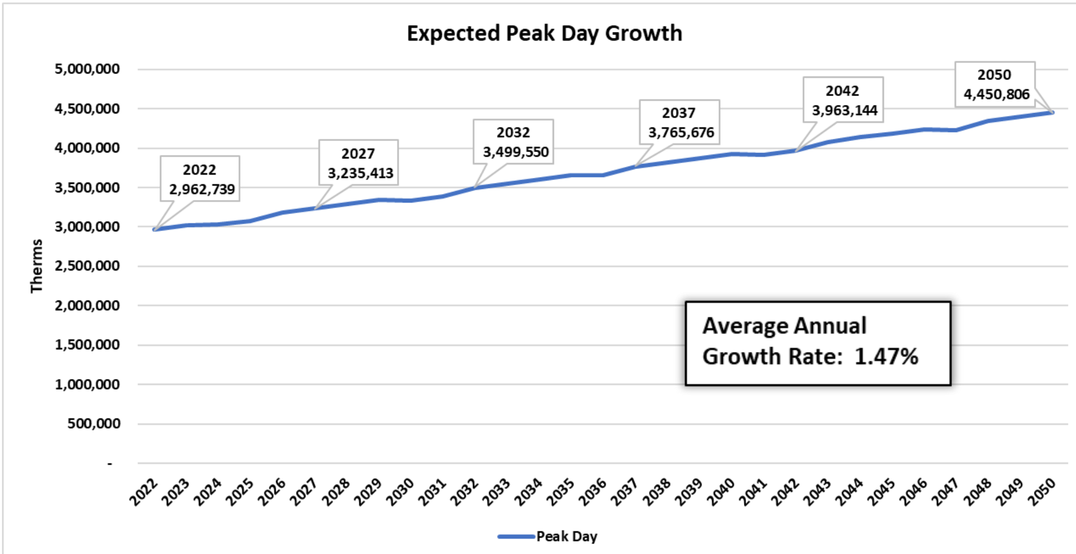


Figure 3-18: System 28-Year Average Load Growth by Pipeline Zone

Zone	Load Growth		Zone	Load Growth
Zone 10	1.79%		Zone 30-S	0.73%
Zone 11	0.86%		Zone 30-W	0.76%
Zone 20	1.65%		Zone GTN	1.62%
Zone 24	0.47%		Zone ME-OR	1.04%
Zone 26	0.71%		Zone ME-WA	0.67%

Figure 3-19: Expected System Peak Day Growth (Volumes in Therms)



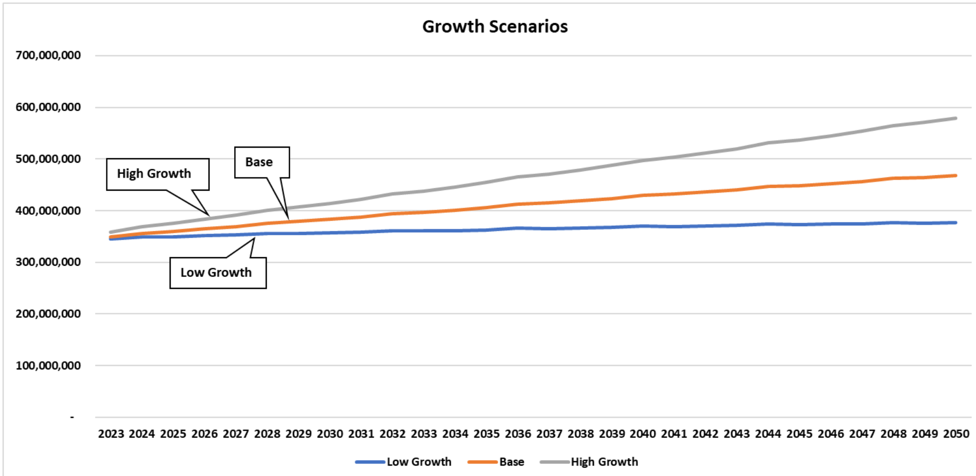
High and Low Growth Scenarios

In the previous IRP, the high and low growth scenarios were built from the confidence intervals of the customer growth forecast, which were approximately 5%. Cascade wanted a more robust scenario analysis and developed a methodology for better capturing realistic low growth and high growth scenarios. Cascade decided to analyze the slowest and fastest growth years of each citygate by comparing them to the average growth rate of each citygate. This gave a much more realistic idea of what a slow or rapid growth year might look like based on historical numbers. Cascade discovered that as a general rule, a slow growth year was about half the average growth rate whereas a fast growth year was about 1.5 times the average growth rate of a specific citygate. Figure 3-20 displays the total system load growth across the various growth scenarios.

More Scenarios

For more scenarios, including electrification, please refer to Chapter 9, Resource Integration. The section called “Portfolio Evaluation: Scenario Analyses” starts on page 9-25 and covers scenarios that vary supply, but have two scenarios (4 and 5) that vary customer growth.

Figure 3-20: Total System Load Growth Across Scenarios



Load growth under the low stochastic scenario is showing approximately 3 million less therms per year while load growth under the high stochastic scenario is showing approximately 3 million more therms per year than the stochastic All-in scenario. By analyzing historic slow growth and fast growth years, Cascade can assert with a high degree of certainty that these scenarios accurately encompass a potential range of load growth scenarios. Figure 3-21 shows the values for stochastic growth scenarios.

Figure 3-21: Stochastic Total System Load Growth Across Scenarios in Therms

Year	Low	Base	High
2023	345,673,078	348,749,568	358,789,712
2030	356,779,839	383,051,157	414,134,929
2040	369,855,291	429,497,908	497,686,804
2050	376,671,117	468,493,007	578,404,695

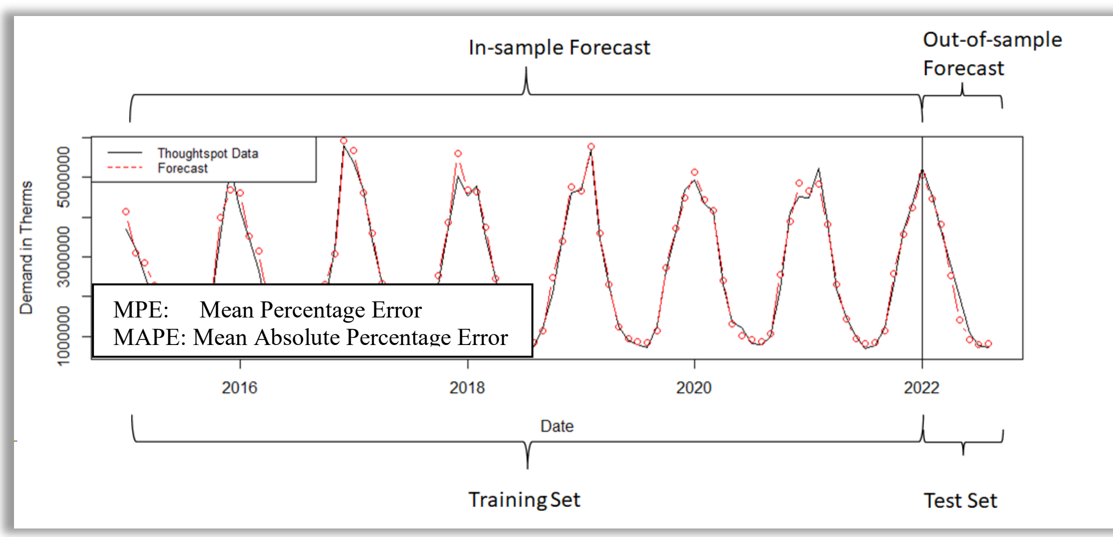
Non-Core Outlook

Unlike the core, non-core (or transportation) customers are customers who schedule and purchase their own gas, generally through a marketer, to get gas to the citygate. The customer then uses Cascade's distribution system to receive the gas. Cascade has approximately 244 transportation customers, with seven of those customers being electric generation customers. In both Washington and Oregon, the 2023 forecast for non-electric generation customers is approximately 518 million therms and that for electric generation customers is about 578 million therms for a total of 1.096 billion therms for the transportation customers. For information on the emissions for these customers, see Chapter 6 – Environmental Policy.

Cross-Validation

Cascade continues to evolve and improve its forecasting methodologies. For this IRP, Cascade performed model validation analysis, called cross-validation, in order to validate the assumptions going into the models as well as the results coming out. This process is time intensive, so Cascade selected two citygates to perform this analysis. There are many ways to cross-validate a forecasting model such as hold-out validation, k-fold validation, and bootstrap validation. Each technique has its benefits and disadvantages when it comes to strength of validation and computational time. [14] Cascade chose the hold-out method as it contains the best combination of having strong validation results with low computation time in reference to the other methodologies. The steps of the hold-out method involve selecting a specific citygate and rate class, limiting the historical data, developing a model using the same methodology as the original model, and then comparing the forecasted results to actual data. This is called out-of-sample testing. Cascade chose one of its more volatile citygates, Sumas SPE Loop, and one of its more stable citygates, Yakima Loop, in order to maximize the value of the cross-validation results by using both ends of the usage spectrum. Figure 3-22 shows the breakdown between the in-sample and out-of-sample parts. Figures 3-23 through 3-25 show the Sumas SPE Loop residential, commercial, and industrial rate classes. Figures 3-26 through 3-28 show the Yakima Loop residential, commercial, and industrial rate classes. The figures show both these citygates' ThoughtSpot data (billing data) compared to a forecast of a model made from Jan, 2015 – March, 2022. The out-of-sample range is April, 2022 to August, 2022.

Figure 3-22: Sumas SPE Loop Cross-Validation



[14] https://www.turing.com/kb/different-types-of-cross-validations-in-machine-learning-and-their-explanations

Figure 3-23: Sumas SPE Loop Residential Cross-Validation

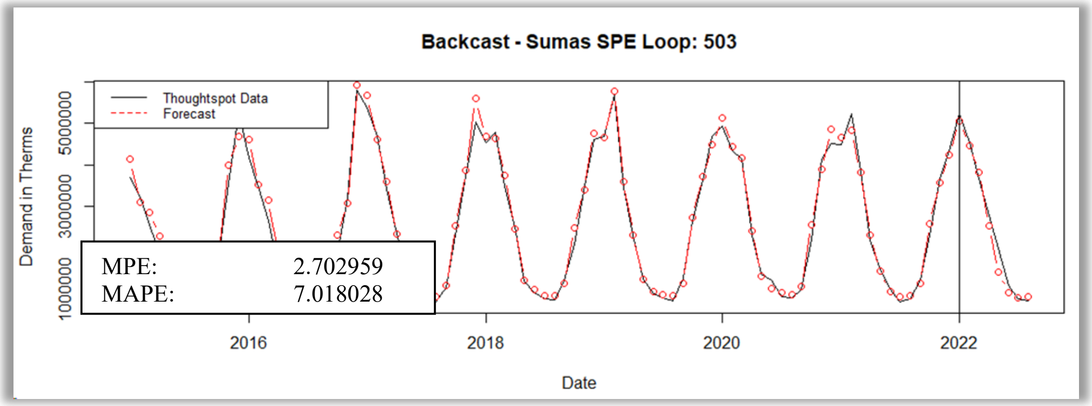


Figure 3-24: Sumas SPE Loop Commercial Cross-Validation

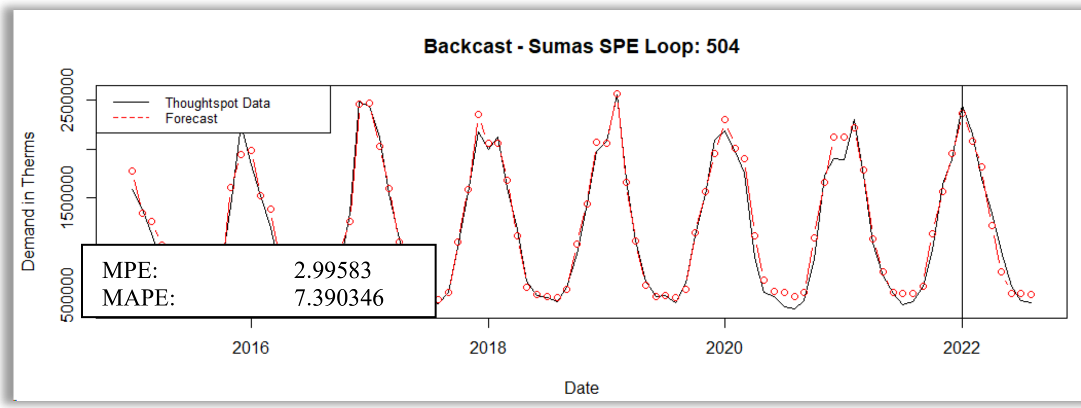


Figure 3-25: Sumas SPE Loop Industrial Cross-Validation

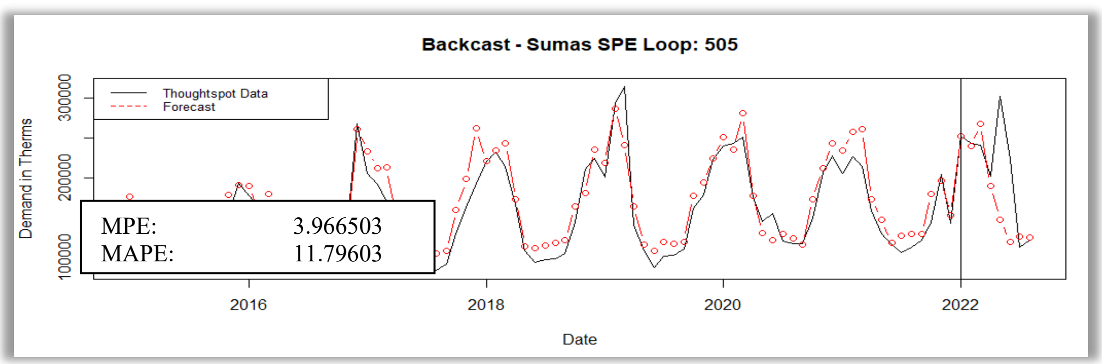


Figure 3-26: Yakima Loop Residential Cross-Validation

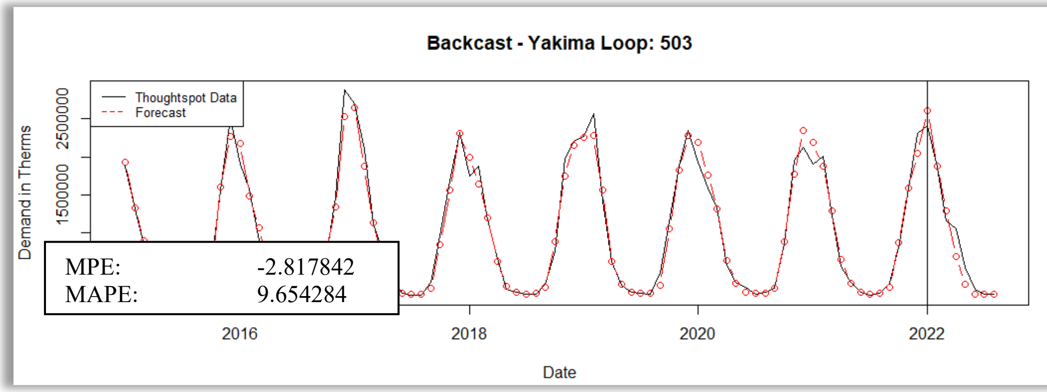


Figure 3-27: Yakima Loop Commercial Cross-Validation

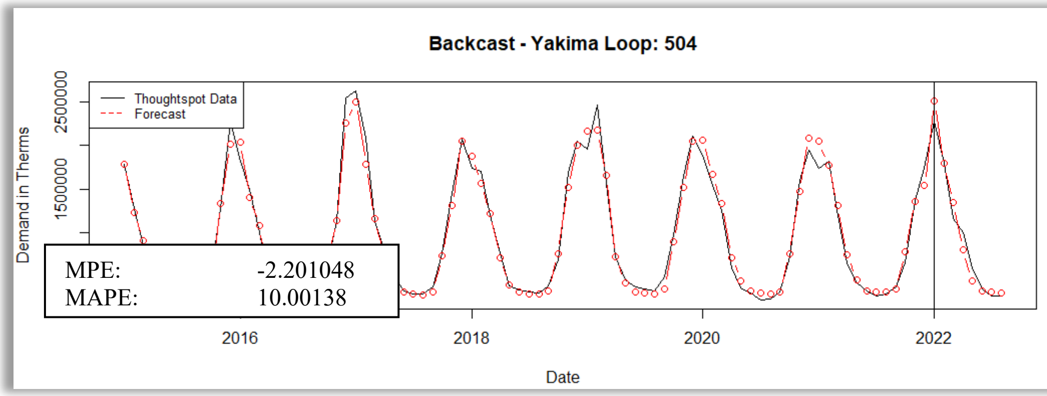
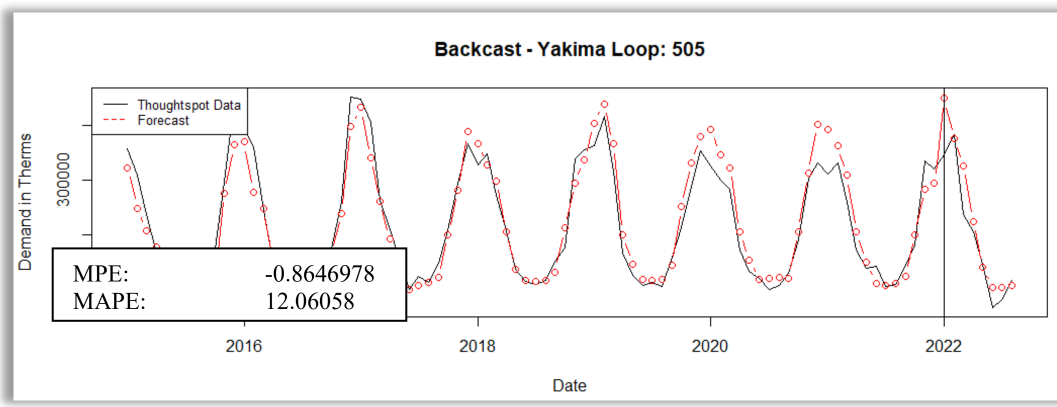


Figure 3-28: Yakima Loop Industrial Cross-Validation

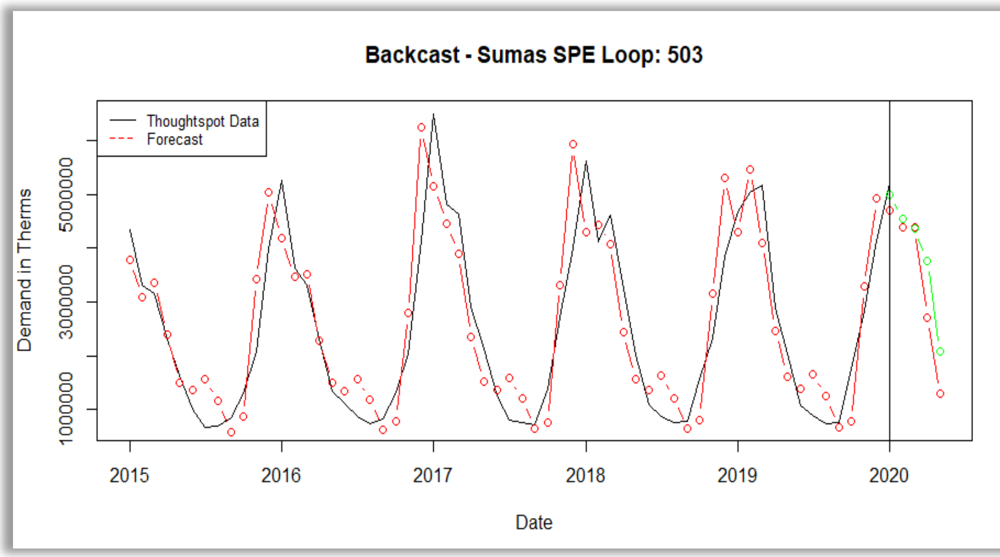


In the previous IRP, Cascade's cross-validation results showed a need to lag the Thoughtspot billing data in order to better correlate with pipeline data. The above figures show that this change in the forecast methodology increased the forecast accuracy significantly. The next section, Methodology Changes, provides more information about this change. For the next IRP, Cascade will investigate more ways to better forecast the industrial rate class and will investigate ways to make this process more efficient in order to validate more models, more often.

Methodology Changes From Previous IRPs

As mentioned in the cross-validation section, Cascade made a shift to the Thoughtspot billing data before beginning the demand forecast. Figure 3-29 shows the cross-validation results for one of Cascade's citygates from the last IRP.

Figure 3-29: Sumas SPE Loop Residential Cross-Validation



This identified that the forecast was consistently one month behind the actual pipeline flow data. After further examining the customer billing data, Cascade discovered customers on specific billing cycles should be shifted back one month to better account for the discrepancy between some billing receivables and pipeline data. After this shift, the forecasts' accuracies were vastly improved.

Another methodology change is Cascade captured price sensitivity in its use-per-customer forecast for this IRP by introducing price as a regressor (as described earlier in this chapter in the section labeled "Price as a New Regressor").

Alternative Forecasting Methodologies

Cascade's forecasting methodologies used in the customer forecast and the UPC forecast have remained consistent. Cascade continues to utilize Fourier terms and

ARIMA terms in its forecasting methods. Cascade utilizes R as its primary statistical analysis software and uses models that follow a dynamic regression methodology. The Company plans to continue improving the customer and demand forecast model through R to enhance the process' efficiency.

The Company is responsive to several regulatory principles in forecasting. These include:

- A desire for precision and a high degree of accuracy;
- A universal understanding that forecasts should mirror future realities but may have unanticipated swings in either direction;
- A disconnect between planning and operational functions, in that natural gas purchasing and dispatch will be based on immediate needs which, in actuality, are guaranteed to vary from the plan (per the previous bullet);
- An understanding that an increased cost of improved precision sometimes has decreasing customer benefits;
- A need to meet regulators' expectation that the Company show continual improvement because new tools are available. For example, the concept of "adaptive management" can be applied;
- The major differences in accounting treatment between the states regarding test years for ratemaking purposes (that is, for general rate case filings) and not necessarily for planning. At this time, Oregon uses future test year accounting while Washington employs a historic test year;
- The fuzziness of historic data that includes effects of energy efficiency, retail price (from annual PGA—purchased gas adjustment—changes and other rate changes), sometimes abnormal weather, new technology, and then-unique economic conditions (e.g., recession, interest rates, etc.). Cascade uses actual historic data. The term fuzziness is used in the context of basing forecasts on past-period data that includes many variables, any one of which may have increased or decreased in the intervening time between historical occurrence and forecasted periods. This causes difficulty for utilities trying to isolate primary factors for greater precision of long-term calculations.
- Unknown and uncertain future changes such as the assumptions around carbon policy and other environmental externalities; and
- A need to demonstrate support for assumptions such as growth in customers, use per customer and changes from previous forecasts, type of use (i.e., heating, manufacturing, etc.), to name a few.

The preceding subchapter illustrates the complexity of forecasting and highlights areas of stakeholder attention. Best efforts at appropriate reasonable cost distill these factors into a generally accepted forecast with recognition of inherent uncertainties.

Uncertainties

This forecast represents Cascade's best estimate about future events. At this time, several important factors make predicting future demand particularly difficult such as – continued economic growth, carbon legislation, building code changes, direct use of natural gas campaigns, energy efficiency, and long-term weather patterns. The range of scenarios presented here and in Chapter 10 encompass the full range of possibilities through econometric analysis. These forecasts were created after statistical analyses of a matrix of different functional forms and economic indicators. The chosen indicators were selected because of their consistency in returning statistically valid results. While they may be the best results mathematically, they are not the sole and only determinants of demand. As a result, while Cascade believes the numbers presented here are accurate and that the scenarios presented represent the full range of possibilities, there are and always will be uncertainties in forecasting future periods.

Conclusion

Cascade expects system load growth to average 1.10% per year over the 28-year planning horizon. High and low scenarios were considered and alternative forecasting assumptions were analyzed. Extensive modeling included: extending the forecast analyses of demand areas, HDDs, and wind from 20 years to 28 years to better align with emissions modeling; analyzing peak day stochastically using 10,000 Monte Carlo simulated draws for each weather zone; adding a price regressor to the Use-Per-Customer forecast.and utilizing dynamic regression modeling techniques for customer and annual demand forecasts.