Cascade Natural Gas Corporation

2020 WA Integrated Resource Plan
Technical Advisory Group Meeting #2

Wednesday, May 27th, 2020
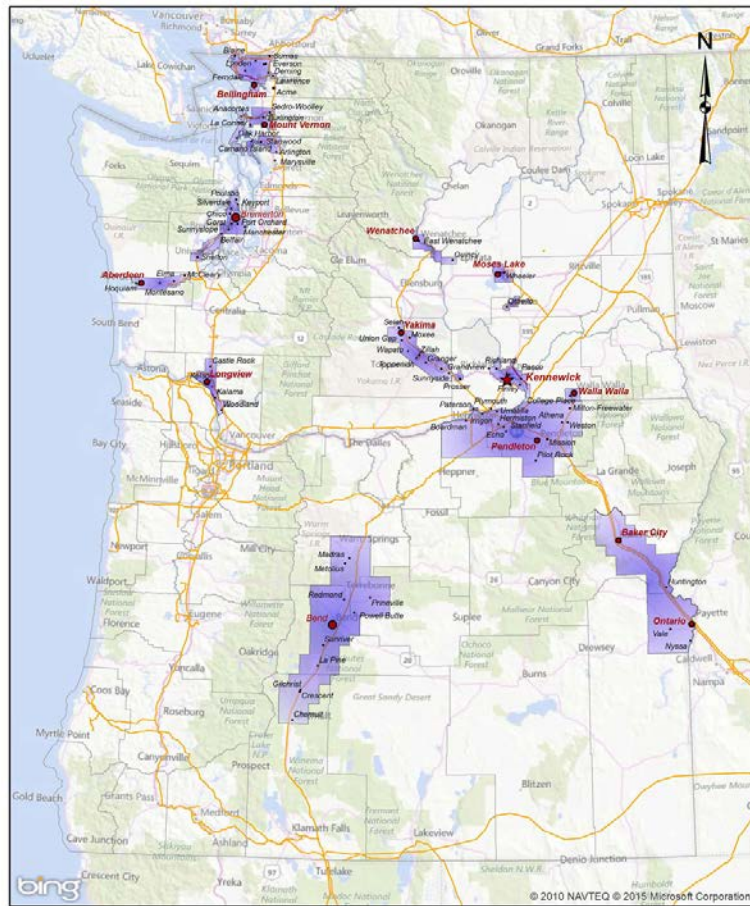
Location - Teleconference

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Agenda

- **Introductions**
- **Safety Moment**
- **Demand Forecast**
- **Customer Forecast**
- **Forecast Results**
- **Non-Core Outlook**
- **Market Outlook and Long Range Price Forecast**
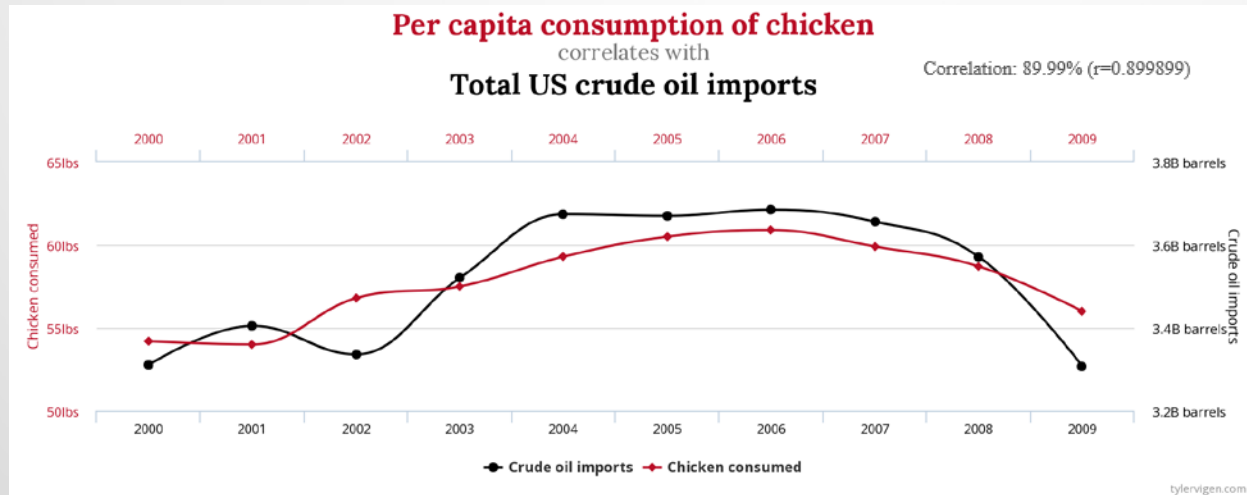- **2020 IRP Remaining Schedule**

Demand Forecast

Service Boundaries — Cascade Natural Gas Corporation

A Little Fun with Spurious Correlations…

Per capita consumption of chicken
correlates with
Total US crude oil imports
Correlation: 89.99% (r=0.899899)

Demand Forecast

- The Cascade demand forecast developed for the IRP is a forecast of customers, core natural gas demand, and core peak demand for the next 20 years.

- Demand is forecasted at:

  - the citygate and citygate loop level;

  - the rate schedule level; and

  - the daily level.
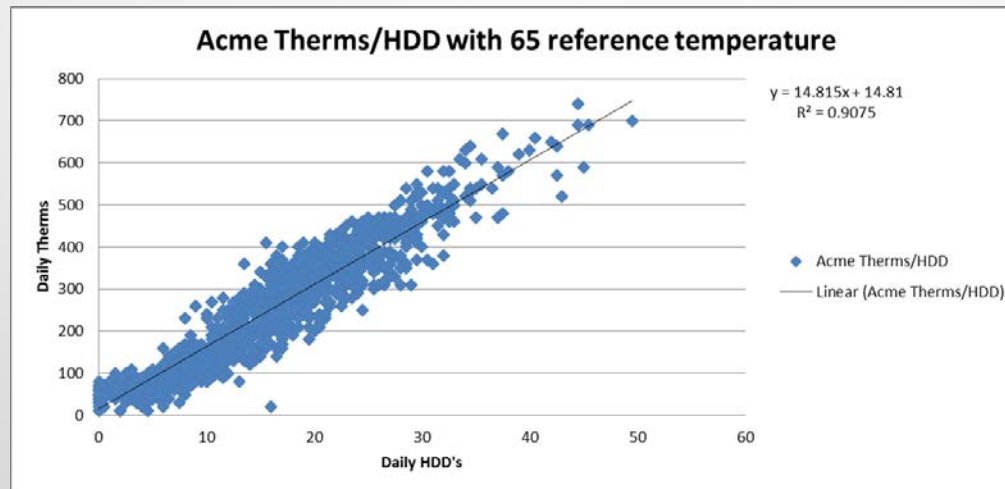
Key Definitions

- AIC: The Akaike information criterion (AIC)

  - A measure of the relative quality of statistical models for a given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of the other models. Hence, AIC provides a means for model selection.

- ARIMA: Auto-Regressive Integrated Moving Average

  - Type of model that is fitted to time series data.

  - When doing regressions using time series variables, it is common for the errors (or residuals) to have a time series structure. This could mean there is a predictable structure to the errors, meaning they can also be modeled. This is where the ARIMA term comes in.

- Define weather in terms of HDDs (Heating Degree Day).

- Citygate loops are a group of citygates that service a similar area that are forecasted together due to pipeline operations.

Key Assumptions

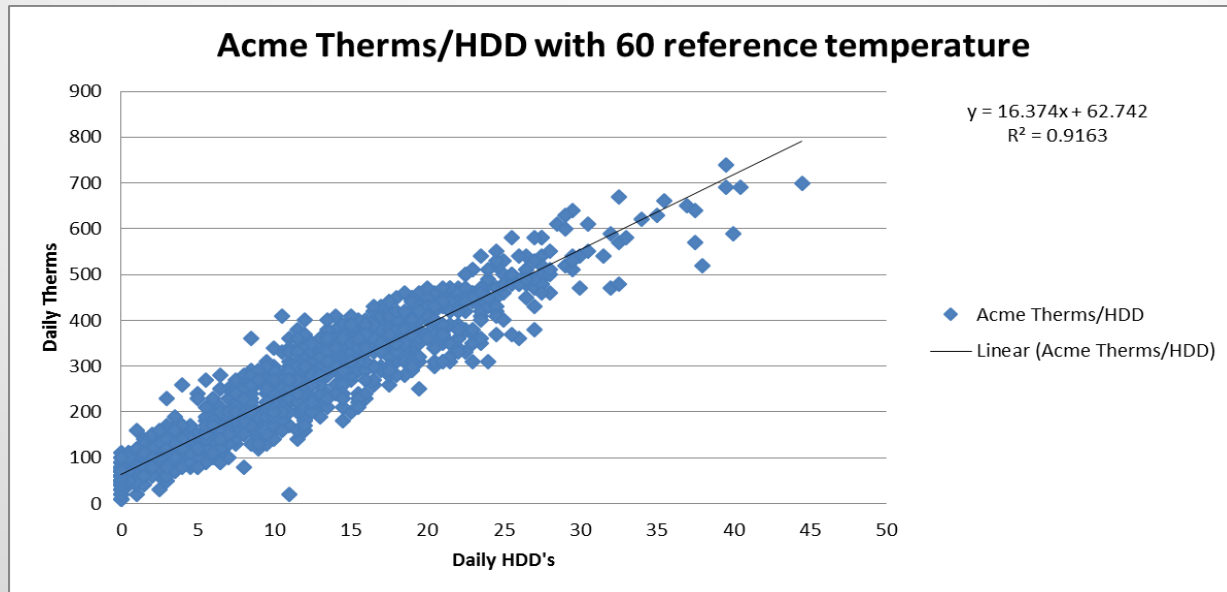- Seven weather locations effectively cover Cascade's service territory.

- This forecast uses 30 years of recent weather history as the "normal" temperatures.

- Heating demand does not appreciatively start until average temps dip below 60° F, therefore a 60° F threshold is used to calculate heating degree days.

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65 vs 60 HDD Threshold

- The historical threshold for calculating HDD has been 65°F .

- It was determined that lowering the threshold to 60°F produces better results for Cascade's service territory.

- The graph shows that heating demand does not begin to increase until an HDD of five if the traditional 65°F is utilized.

Acme Therms/HDD with 65 reference temperature

$y = 14.815x + 14.81$
$R^2 = 0.9075$

- Acme Therms/HDD
- Linear (Acme Therms/HDD)

Daily Therms (y-axis): 0, 100, 200, 300, 400, 500, 600, 700, 800
Daily HDD's (x-axis): 0, 10, 20, 30, 40, 50, 60

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Acme Therms/HDD with 6o degree reference temperature

Acme Therms/HDD with 60 reference temperature

$y = 16.374x + 62.742$
$R^2 = 0.9163$

- ◆ Acme Therms/HDD
- —— Linear (Acme Therms/HDD)

Daily Therms (y-axis): 0, 100, 200, 300, 400, 500, 600, 700, 800, 900

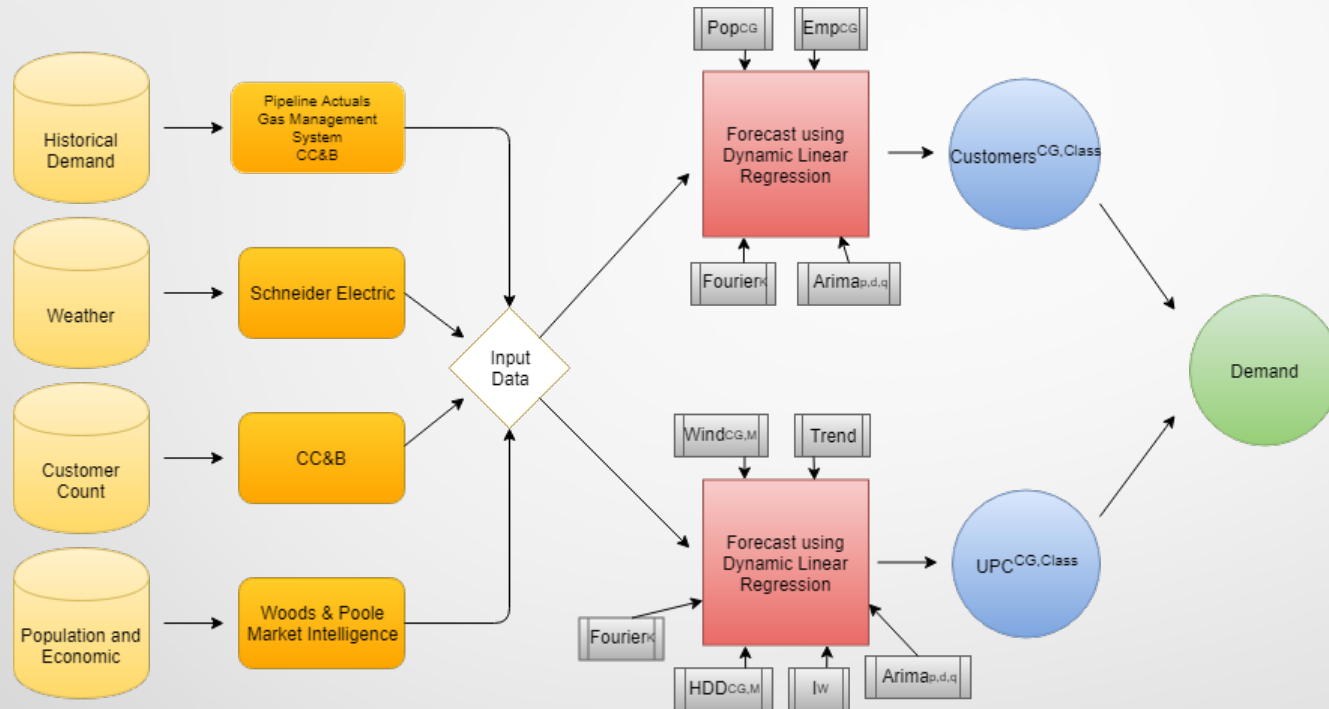Daily HDD's (x-axis): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50
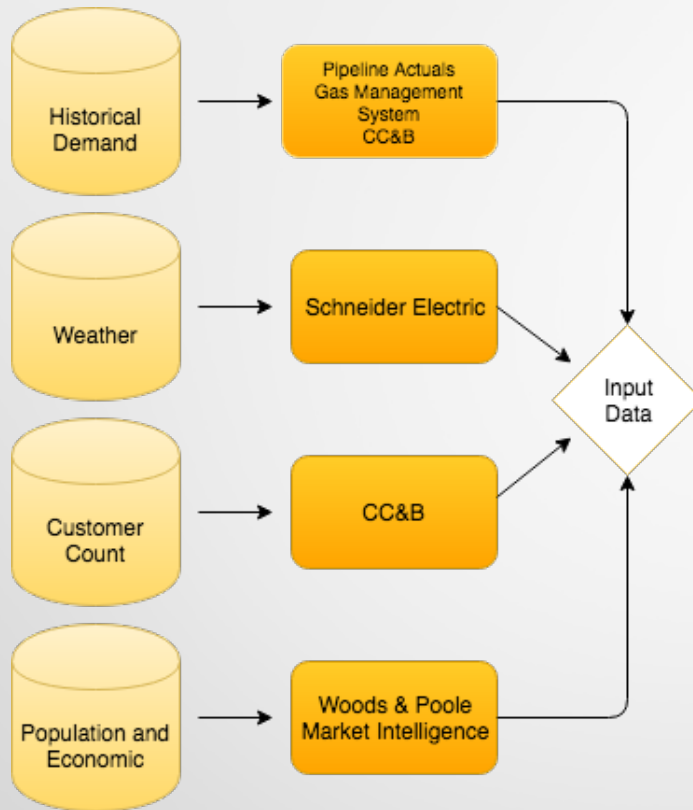
Weather Stations

- The seven weather stations are shown on the map.

- Cascade's service territory is shaded in aqua.

- Each Citygate and loop is assigned to a weather station.

Process

Inputs

- Cascade uses data from various sources:
  - Pipeline actuals at Citygate level.
  - Woods & Poole at county level.
  - CC&B citygate allocations
- Market intelligence monthly.
- Unifying inputs is an important part of the forecasting process.

Customer Forecast

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Customer Forecast

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

- Model Notes:

  - C = Customers; CG = Citygate; Class = Residential, Commercial, Industrial, or Interruptible; ARIMA$\in$(p,d,q) = Indicates that the model has p autoregressive terms, d difference terms, and q moving average terms; Pop = Population; Emp = Employment; Fourier(k) = Captures seasonality of k number of seasons.

Customer Forecast Inputs

Woods & Poole Data

County		Population	Employme
ALBANY-LEBANON	OR	70.221	29.329
ASTORIA	OR	27.905	12.293
BAKER	OR	15.219	6.517
BEND	OR	29.726	12.947
BEND-PRINEVILLE	OR	39.554	17.551
BENTON	OR	51.491	19.344
BROOKINGS	OR	13.18	4.988
CLACKAMAS	OR	156.015	47.703

CC&B
Data

Acctg Year	Acctg Mon	Gate (Loop)	Rate	Number of Prem
2019	2	Bend/South Bend	CNGOR104	144
2015	2	Pendleton/Pilot Rock	CNGOR104	64
2018	8	Ontario/NYSSA/Vale	CNGOR101	5
2015	7	Hermiston	CNGOR101	4
2018	5	Mission	CNGOR104	18
2018	8	Gilchrist Cresent	CNGOR101	78
2016	5	Ontario/NYSSA/Vale	CNGOR104	19

Model Selection

Xregs	AICc
Fourier	1505.389
Population + Fourier	1506.871
Employment + Fourier	1507.519
Employment	1562.932
Population	1566.24
Employment + Population + Fourier	1568.108
Arima Only	1597.354

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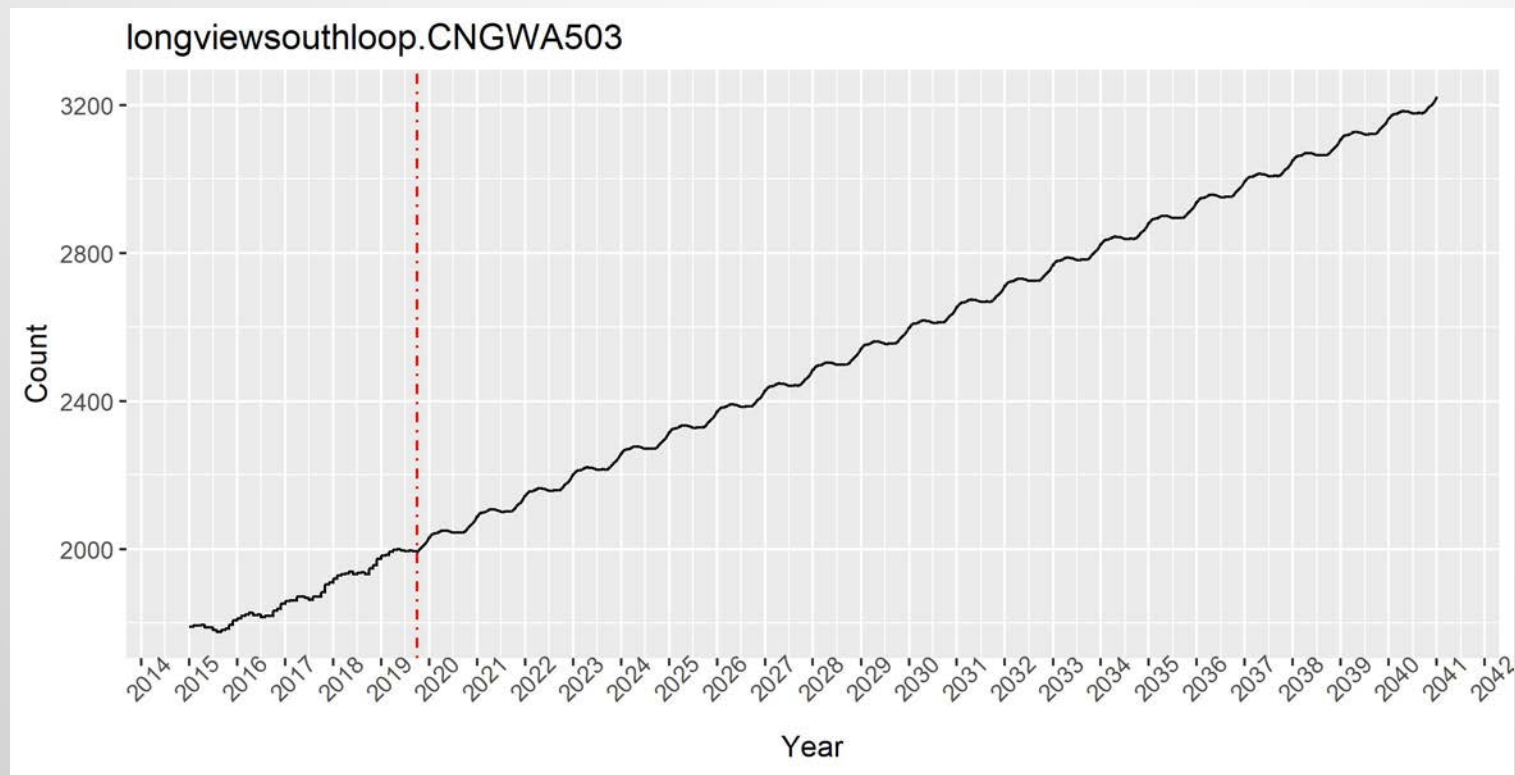
Customer Forecast

Use Per Customer Forecast
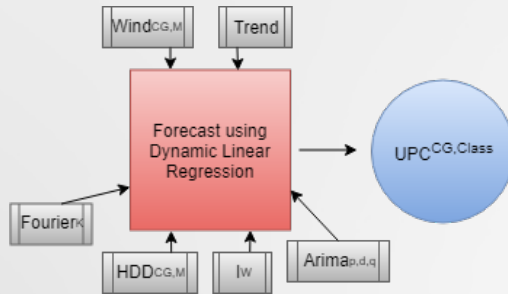
- Therms/C^{CG,Class} = α_0 + α_1HDD$^{CG, M}$ + α_2I$_w$ + α_4WIND$^{CG, M}$ +Trend+ Fourier(k)+ARIMA$\in$(p,d,q)

- Model Notes:

  - Therms/C = Therms per customer; CG = Citygate; Class = Residential, Commercial, Industrial, or Interruptible; HDD = Heating Degree Days; M= Month; I$_w$ = Indicator Variable set to 1 if it is a weekend; T = Trend Variable increasing by 1 for each day forecasted; WIND = Daily average wind speed.
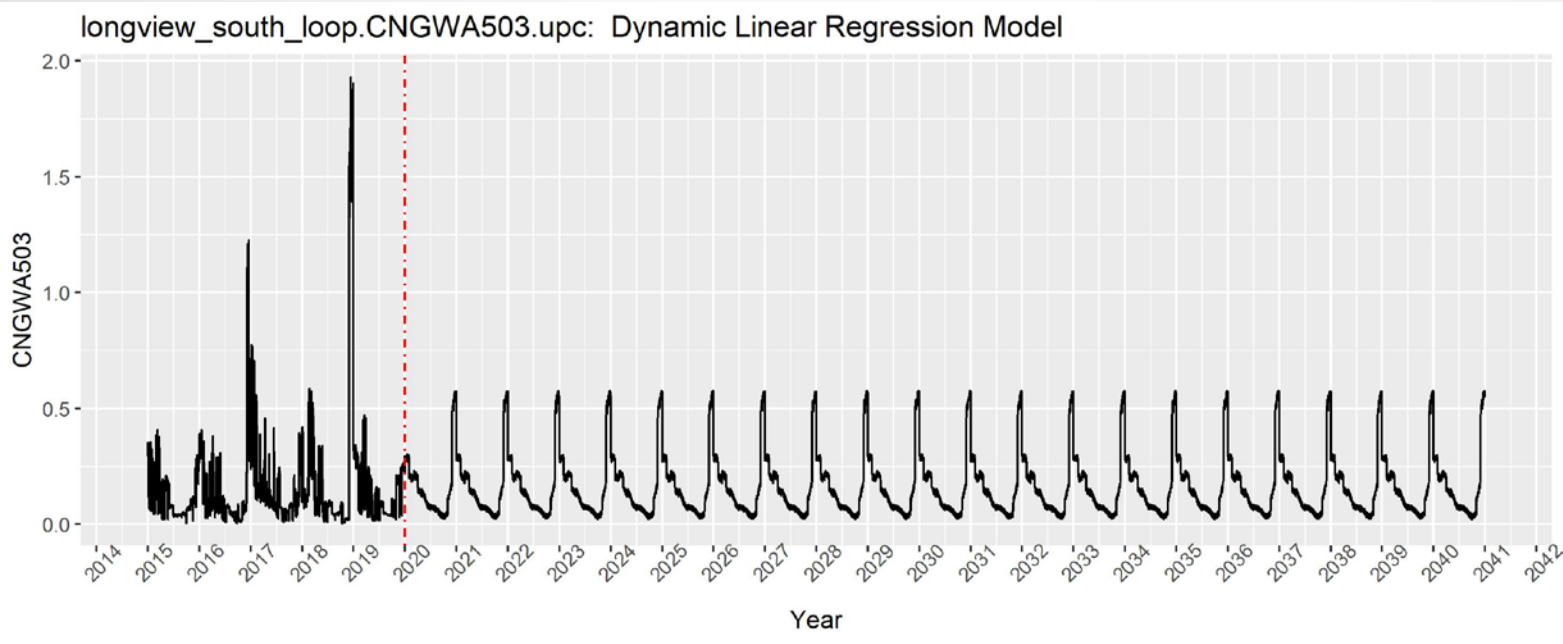
Use Per Customer Forecast Inputs

$$\text{Citygate/Rateclass} = \alpha_o + \alpha_1 HDD^M + \alpha_2 I_w + \alpha_4 WIND^M + \text{Fourier} + \text{ARIMA}$$

Year.Month.Day	CNGOR101	weekend	jan.hdd	feb.hdd	...	nov.hdd	dec.hdd	jan.wind	feb.wind	...	nov.wind	dec.wind
1/1/2015	0.31838107	0	41.5	0	...	0	0	3	0	...	0	0
1/2/2015	0.380307614	0	39	0	...	0	0	2	0	...	0	0
1/3/2015	0.266972209	1	38.5	0	...	0	0	2	0	...	0	0
1/4/2015	0.263826734	1	31	0	...	0	0	2	0	...	0	0
1/5/2015	0.27680182	0	16	0	...	0	0	4	0	...	0	0
1/6/2015	0.276113747	0	18.5	0	...	0	0	4	0	...	0	0
1/7/2015	0.326048166	0	24	0	...	0	0	2	0	...	0	0

UPC Forecast Results

ar1	ar2	ar3	ar4	ma1	ma2	ma3	intercept	weekend	jan.hdd	feb.hdd	mar.hdd	apr.hdd	may.hdd	jun.hdd	jul.hdd	aug.hdd	sep.hdd
1.550827	-0.1753	-0.91098	0.501914	-0.70202	-0.50903	0.628802	0.147384	-0.01757	0.003997	0.000935	0.001474	-0.00286	-0.00082	-0.00111	-0.00041	-0.00071	-0.00237

oct.hdd	nov.hdd	dec.hdd	jan.wind	feb.wind	mar.wind	apr.wind	may.wind	jun.wind	jul.wind	aug.wind	sep.wind	oct.wind	nov.wind	dec.wind	S1-365	C1-365	S2-365	C2-365	S3-365	C3-365
-0.00215	0.000909	0.016195	-0.00267	-0.00565	-0.00323	-0.0018	-0.00192	-0.00216	-0.00116	-0.0023	-0.00246	-0.00153	4.10E-05	-0.00109	0.06475	0.055895	0.00772	0.008905	-0.00838	0.008431

longview_south_loop.CNGWA503.upc: Dynamic Linear Regression Model

Peak Day Use-Per-Customer

- Peak HDD: Coldest in past 30 years for each weather zone

- Peak Scenarios: Plan on running other scenarios such as 5-day peak event, 3-day peak event, coldest in 20 years, and various Monte Carlo percentiles.
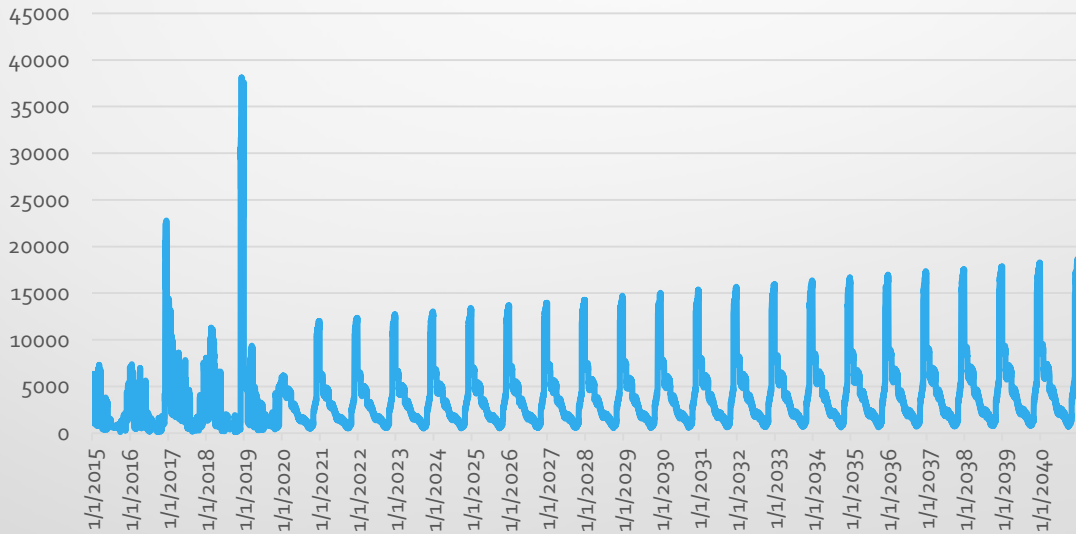

bend_loop.CNGOR101.upc: Dynamic Linear Regression Model
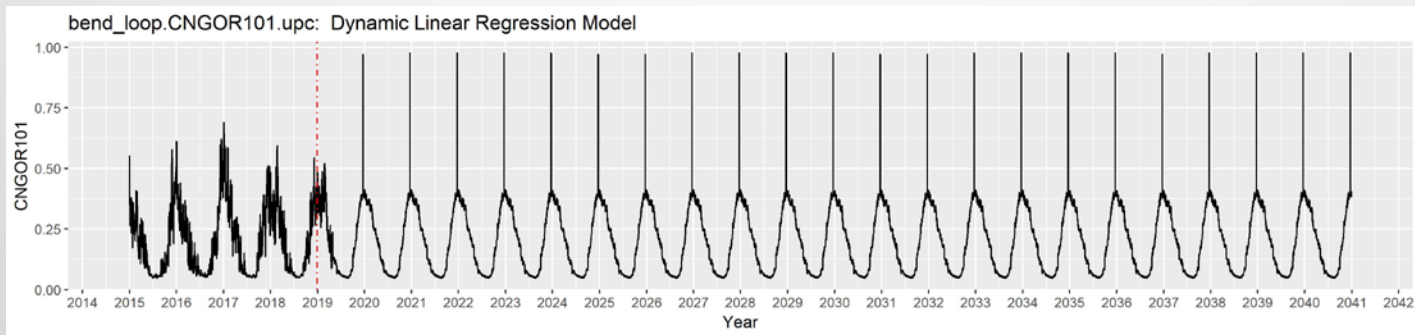
Forecast Results
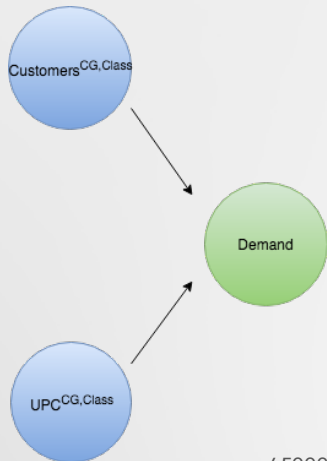
Final Demand Calculation

longviewsouthloop.CNGWA503

# Non-Weather Dependent Demand

- Demand that is not influenced by weather.

- Typically caused by a customer who ramps up production based on the time of season.

- Previously, demand was removed prior to running the use per customer vs. weather analysis.

- Now using monthly coefficients, Cascade can run the analysis while leaving the non-weather demand in.

Moxee (Beauchene)

Moxee (Beauchene)
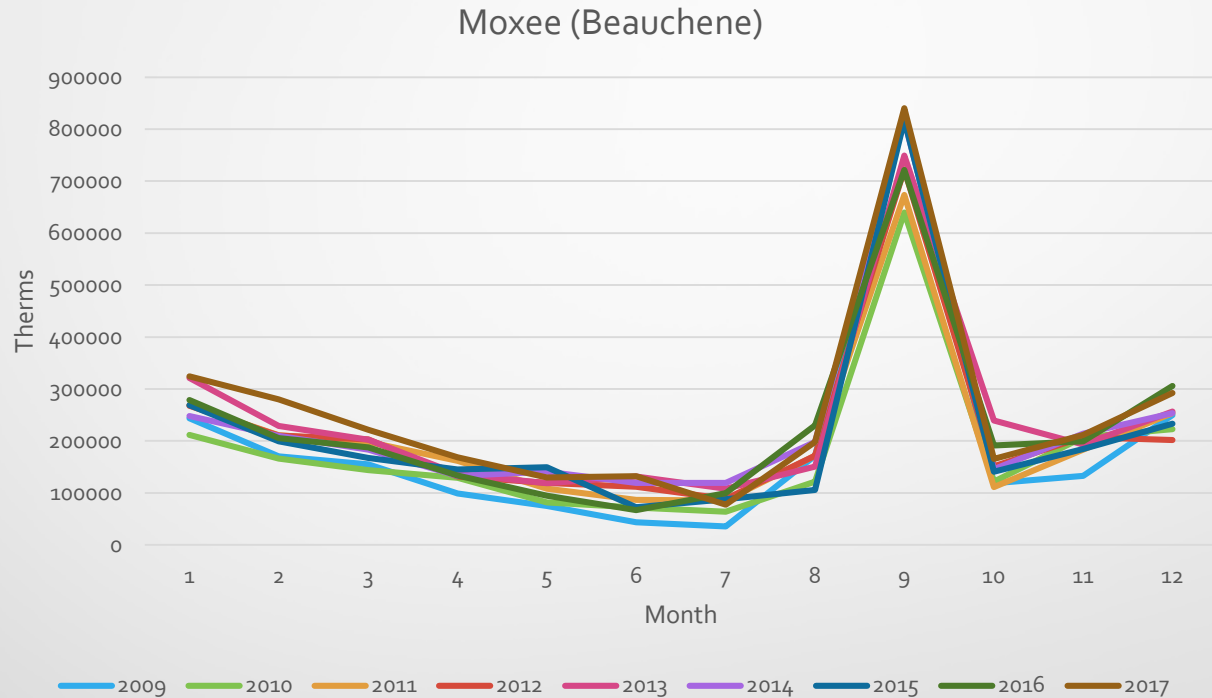
Low Customer Growth Areas

Average Year over year growth	deming	prosser	zillah/toppenish
	0.18%	0.48%	0.70%

- Deming is a small city in northwestern Washington. Higher unemployment than the national average coupled with a decline in population over the past decade has resulted in little to no customer growth. [1]

- Prosser is a small city in southern Washington. Prosser has seen high unemployment, low job growth, and slow population growth. [1]

- Zillah and Toppenish are located in southcentral Washington. Higher unemployment and slow population growth limit customer growth in these areas. [1]

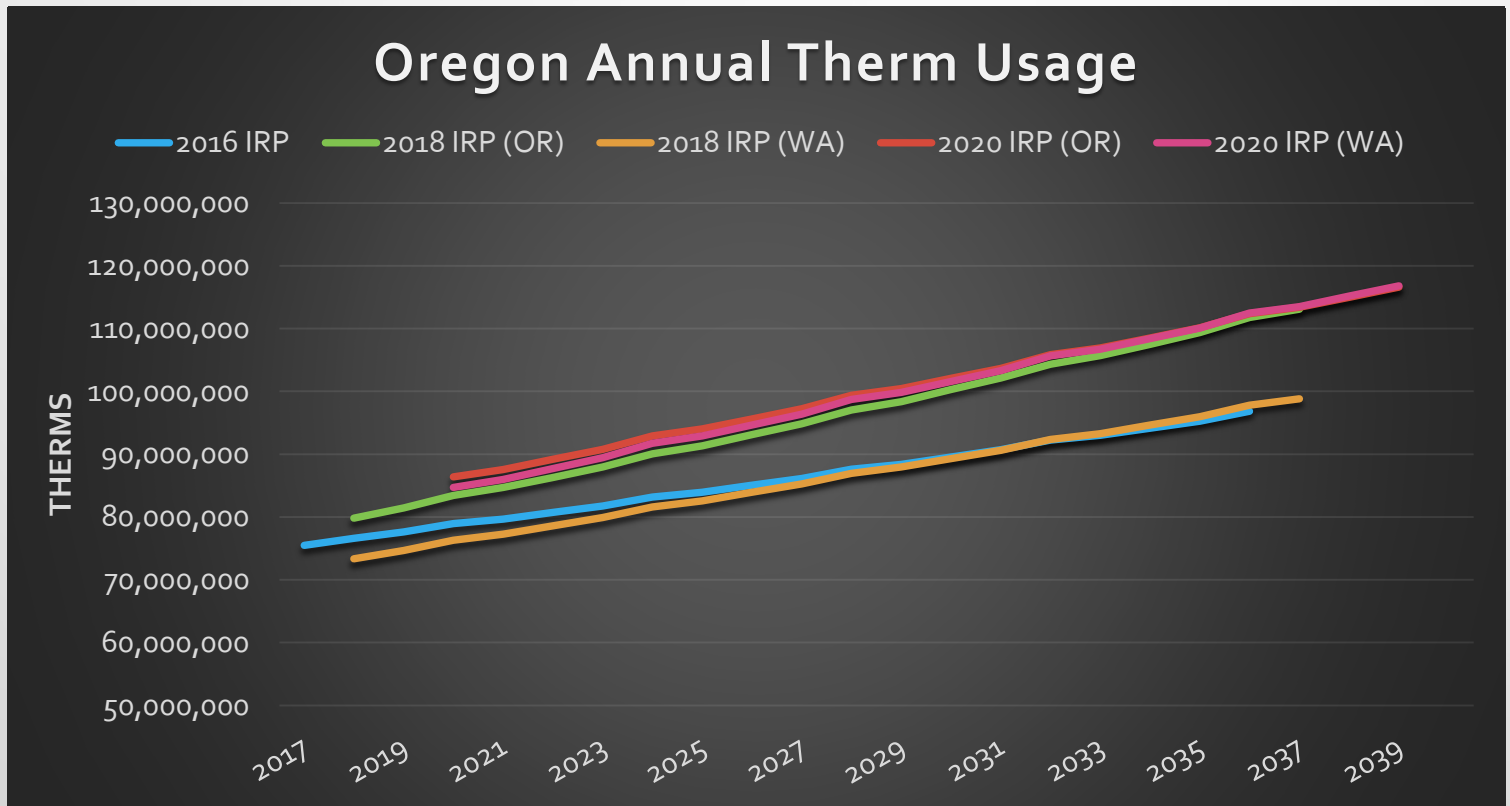[1] According to bestplaces.net, worldpopulationreview.com, and city-data.com

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High Customer Growth Areas

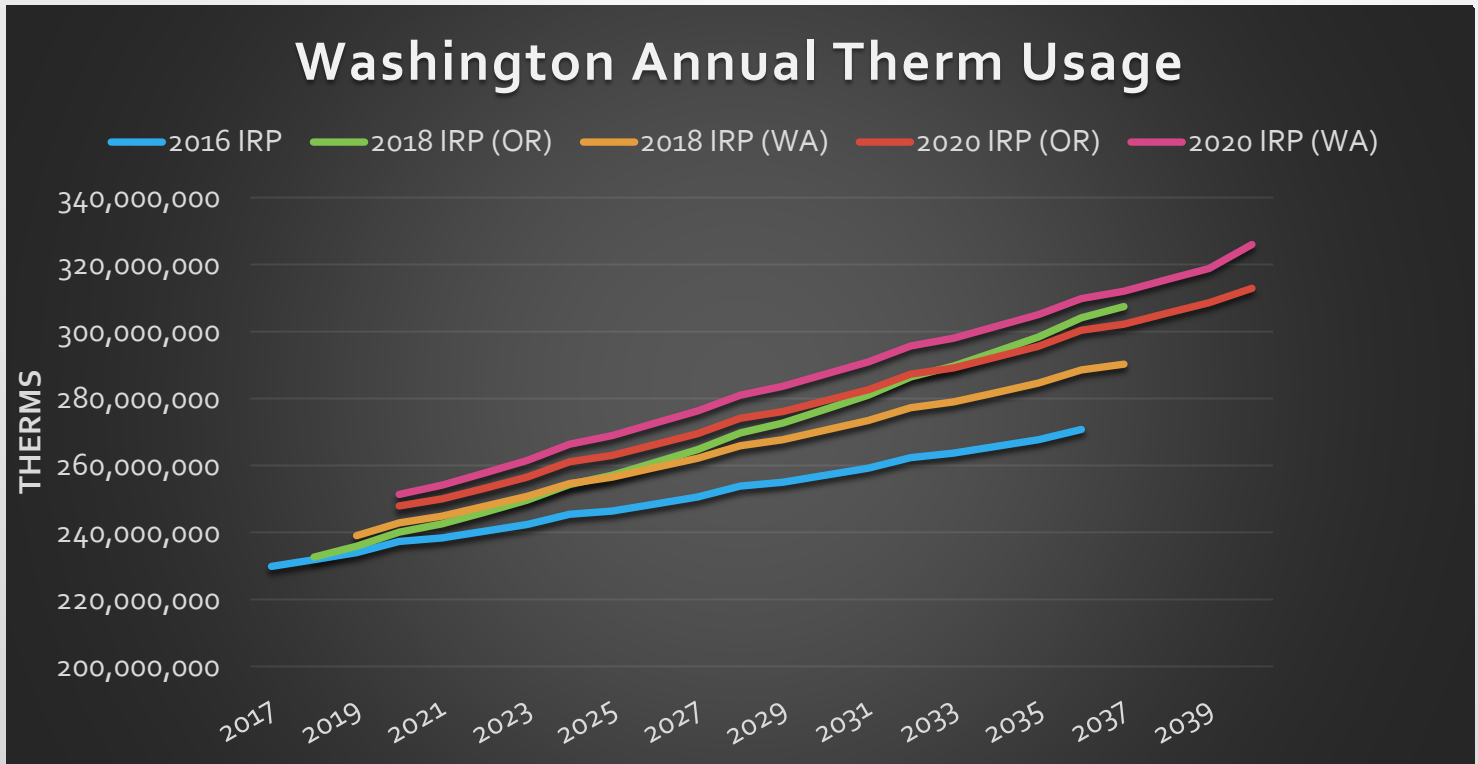|	burbankheightsloop	kennewickloop	longviewsouthloop
Average Year over year growth	1.89%	1.84%	1.94%

- Burbank Heights Loop consists of 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. [1]

- Kennewick 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. [1]

- Longview South Loop consists of South Longview and Kelso citygates. Both cities are located in western Washington. Both cities are seeing steady population growth coupled with optimistic job growth estimates. [1]

[1] According to bestplaces.net, worldpopulationreview.com, and city-data.com

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Oregon Demand

Oregon Annual Therm Usage

Legend: 2016 IRP, 2018 IRP (OR), 2018 IRP (WA), 2020 IRP (OR), 2020 IRP (WA)
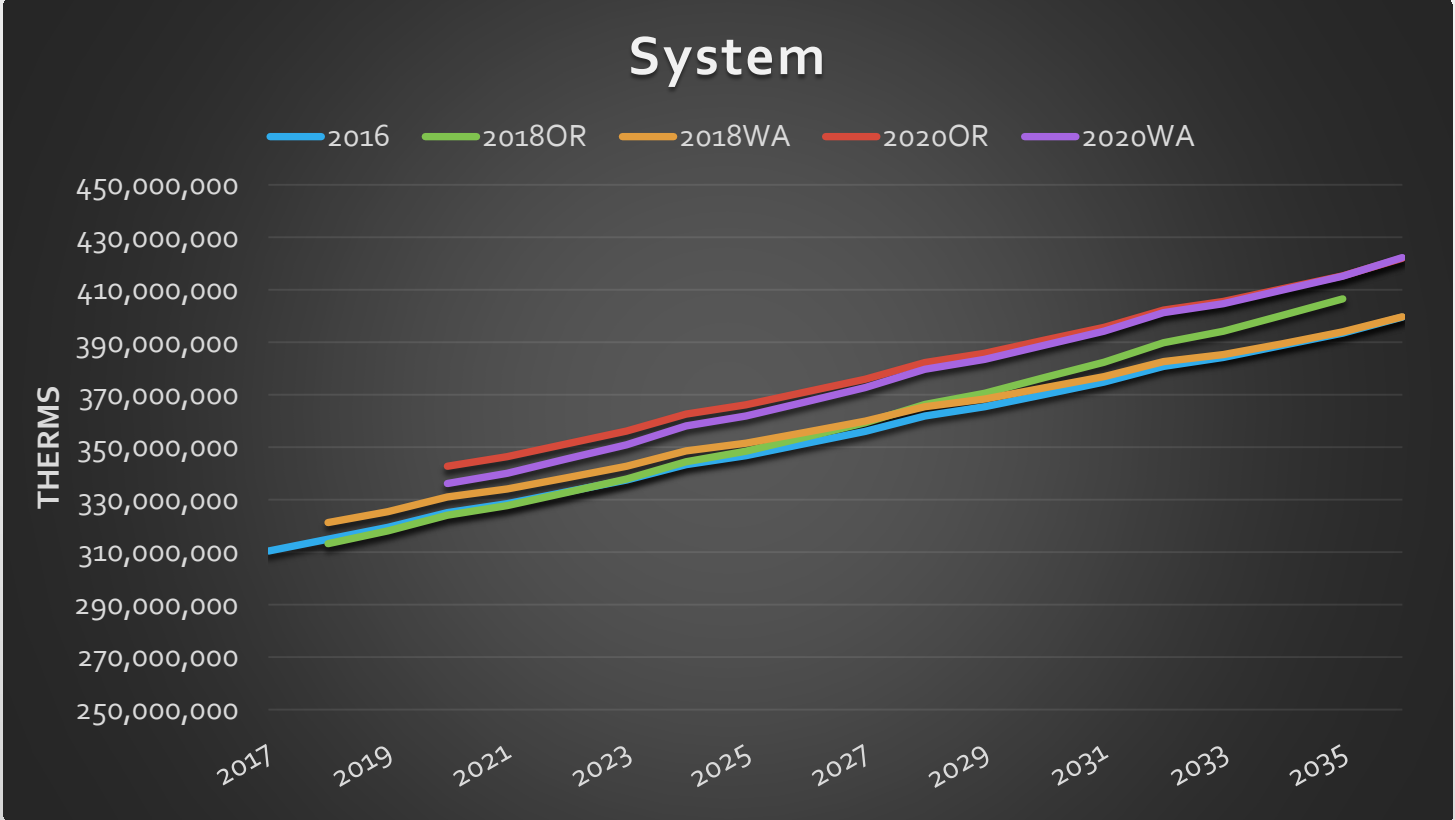
Washington Demand

Washington Annual Therm Usage

Total System Demand

Non-Core Outlook

Non-Core Outlook

- Cascade forecasts the non-core for five years.
- 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's transportation customers include all types of industrial customers. It includes farms that may not use any gas during the winter to food manufacturers that average 800,000 therms per month throughout the year.
- Cascade also serves five electric generation customers in Washington. Those five customers project to use approximately 224,000,000 therms in 2020.

Transportation Customers

- Cascade's transportation customer forecast increased from the previous forecast. The current forecast projects the customer count to be 205 in 2020 with plans to bring on several new customers over the next five years. Cascade's industrial managers are working closely with potential industrial customers.
- Cascade's projection decreased by 15 million therms from the previous forecast. The decrease is mainly a direct result from several large customers moving from a non-core rate schedule over to a core rate schedule.
- Cascade projects the transportation customers in Washington to consume approximately 498 million therms in 2020.

Electric Generation

- Cascade serves five electric generation customers in Washington. Those five customers project to use approximately 224,000,000 therms in 2020.

- Cascade doesn't anticipate bringing on additional electric generation over the next five years.

- Washington passed SB 5116 which would require that non-emitting electric generation and electricity from renewable resources supply one hundred percent of all sales of electricity to Washington retail electric customers by January 1, 2045. Essentially, this would phase out Washington electric generation customers that Cascade would serve.

Non-Core Forecast

- Transportation customers in Washington forecast to use 498 million therms in 2020.

- Transportation customers in Oregon forecast to use 63.5 million therms in 2020.

- Electric Generation customers forecast to use 390 million therms in 2020.

- Non-Core total forecast for 2020 is approximately 951 million therms.

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Long Range Market Outlook

- Natural gas prices in the AEO2020 Reference case remain lower than $4 per million British thermal units (MMBtu) through 2050 because of an abundance of lower cost resources, primarily in tight oil plays in the Permian Basin. These lower cost resources allow higher production levels at lower prices during the projection period. [1]

- Natural gas consumption in the residential and commercial sectors remains largely flat because of efficiency gains and population shifts to warmer regions that counterbalance population growth. Although natural gas consumption rises in the transportation sector--particularly for freight trucks, rail, and marine shipping--it remains a small share of both transportation fuel demand and total natural gas consumption.[1]

AEO2020 natural gas spot price at Henry Hub
2019 dollars per million British thermal units

[1] EIA's Annual Energy Outlook 2020
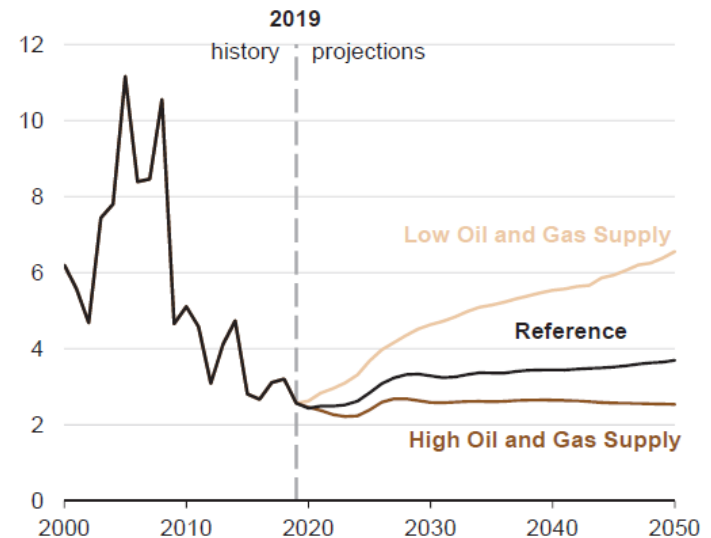
Coronavirus and Natural Gas

- Resilient Demand

  - According to a Forbes article, citing data from JTC, an energy research institute, "Despite immense downward pressure, U.S. natural gas demand has actually been higher for the first third of 2020 than year-ago levels."

  - Amidst the coronavirus pandemic, analysts at Wood Mackenzie have stated that "Globally, gas demand has been fairly resilient, down 2% versus 6% for oil. The stability reflects some of the big gas-consuming sectors, such as residential heating and power." These analysts believe prices will return to normal (flat) within 5 years and demand will stabilize gradually. [2]

- Supply Concerns

  - "exports are down a bit amid COVID-19 and could struggle through the summer, as low prices and demand globally make it harder to compete." [2]

  - Goldman-Sachs expresses concerns over rebounding demand hitting a slowing supply and possible shortages due to "production cuts implemented by all major producers. [3]

[1] https://www.forbes.com/sites/judeclemente/2020/05/17/why-us-oil-and-natural-gas-demand-will-rebound-from-covid-19/#3895bbf56a06
[2] Wood Mackenzie, The Edge: How gas bounces back from the coronavirus lows
[3] https://oilprice.com/Energy/Crude-Oil/Goldman-Sachs-Oil-Demand-Could-Exceed-Supply-By-End-May.html

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Long Range Price Forecast

- Cascade's long-term planning price forecast is based on a blend of current market pricing along with long-term fundamental price forecasts.

- The fundamental forecasts include sources such as Wood Mackenzie, EIA, the Northwest Power and Conservation Council (NWPCC), Bentek and the Financial Forecast Center's long-term price forecasts.

- While not a guarantee of where the market will ultimately finish, Henry Hub NYMEX is the most current information that provides some direction as to future market prices.

- Wood Mackenzie's long-term forecast is at a monthly level by basin. Cascade uses this to help shape the forecast's monthly basis pricing.

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Long Range Price Forecast (Cont.)

- The Company also relies on EIA's forecast; however, it has its limitations since it is not always as current as the most recent market activity. Further, the EIA forecast provides monthly breakdowns in the short-term, but longer-term forecasts are only by year.

- CNGC assigns a weight to each source to develop the monthly Henry Hub price forecast for the 20-year planning horizon.

- Although it is impossible to accurately estimate the future, for trading purposes the most recent period has been the best indicator of the direction of the market. However, Cascade also considers other factors (historical constraints) which can lead to minor adjustments to the final long-range forecast.

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Price Forecast Weights

- Considerations in weight assignments:
  - Cascade has modified its weighting system based on an analysis of the symmetric mean absolute percentage error (SMAPE) of its sources since 2010;
    - Wood Mackenzie (monthly, covers all basins)
    - EIA (industry barometer, annual long term)
    - NWPCC (regional perspective, but recognize it is also a blend)
    - NYMEX Henry Hub
  - Some sources produce forecasts daily, while others are far less frequent.
    - Cascade uses an age dampening mechanism to account for this in its price forecast, reducing the impact of forecasts that do not account for more current market information.

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SMAPE to Weights

- SMAPE = |(Actual – Forecast)/((Actual + Forecast)/2)|

- Cascade calculates the weight of the inverse of the SMAPEs of each source, which are then smoothed using Holt-Winters smoothing.

Rank (order of severity)	Weight		Interval
	Source 1	Source 2	
MSE	0.605111033	0.394888967	0.210222067
MAE	0.563119545	0.436880455	0.12623909
MAPE	0.562986465	0.437013535	0.12597293
RMSE	0.553149363	0.446850637	0.106298727
MAAPE	0.546818641	0.453181359	0.093637282
SMAPE	0.546045931	0.453954069	0.092091861

Example of SMAPE Calculations by Source

	Source 1	Source 2	Source 3	Source 4
T+1	0.11476063	0.217300759	0.100303147	0.150149419
T+2	0.155600954	0.208054622	0.210782631	0.183031285
T+3	0.180080034	0.159751563	0.211083367	0.188603149
T+4	0.180885987	0.216499212	0.116823262	0.205636302
T+5	0.204540958	0.17058102	0.13103414	0.227583943
T+6	0.205116131	0.158629542	0.123911318	0.235010724
T+7	0.193435025	0.017802511	0.087262544	0.218316379
T+8	0.153245566	0.108208036	0.125836311	0.150703308
T+9	0.19521638	0.182278012	0.083976291	0.212140322
T+10	0.173129437	0.171413928	0.100741558	0.172400617
T+11	0.209019609	0.19815898	0.159935388	0.180704729
T+12	0.206179306	0.064646764	0.09191201	0.176900657

Price Forecast Weights

- In Months T+1 to T+15, Cascade uses NYMEX Forward pricing for all locations exclusively;

    - For short term forecasting, the marketplace is ideal because forward prices should reflect all current events that impact the forecast (weather, storage, etc.)

    - Long term forecasting is more concerned about the fundamental market intelligence, which is reflected in the analysis of Cascade's sources.

- Months T+16 to T +40 are used to interpolate the weights from exclusively NYMEX to the weights calculated from each source's SMAPE.

- Months T + 41 onward use the age dampened weights of each source.

Example Weights Price Forecast For 2020 IRP (Not Interpolated)

	Source 1	Source 2	Source 3	Source 4
Nov-20	100.000%	0.000%	0.000%	0.000%
Dec-20	48.519%	10.056%	30.541%	10.884%
Jan-21	45.422%	8.696%	35.080%	10.803%
Feb-21	41.871%	6.459%	40.277%	11.393%
Mar-21	42.306%	6.147%	38.331%	13.216%
Apr-21	43.894%	6.873%	35.403%	13.830%
May-21	46.037%	7.801%	31.618%	14.543%
Jun-21	46.341%	7.786%	30.066%	15.808%
Jul-21	47.217%	7.910%	28.157%	16.716%
Aug-21	47.463%	7.852%	28.039%	16.646%
Sep-21	43.274%	5.700%	33.440%	17.585%
Oct-21	42.655%	5.209%	35.035%	17.101%

Example Weights Price Forecast For 2020 IRP (Interpolated)

	Source 1	Source 2	Source 3	Source 4
Nov-20	100.000%	0.000%	0.000%	0.000%
Dec-20	97.695%	0.450%	1.367%	0.487%
Jan-21	95.407%	0.732%	2.952%	0.909%
Feb-21	93.118%	0.765%	4.768%	1.349%
Mar-21	90.829%	0.977%	6.093%	2.101%
Apr-21	88.541%	1.404%	7.231%	2.825%
May-21	86.252%	1.988%	8.055%	3.705%
Jun-21	83.963%	2.327%	8.986%	4.724%
Jul-21	81.675%	2.746%	9.776%	5.804%
Aug-21	79.386%	3.081%	11.002%	6.532%
Sep-21	77.097%	2.301%	13.501%	7.100%
Oct-21	74.808%	2.288%	15.391%	7.512%

2020 IRP Remaining Schedule

Wednesday, June 17, 2020	TAG 3 slides distributed to stakeholders	
Wednesday, June 24, 2020	**TAG 3: Distribution System Planning, Planned Scenarios and Sensitivities, Alternative Resources, Price Forecast, Avoided Costs, Current Supply Resources, Transport Issues.**	**SeaTac Airport - 9 am to 12 pm**
Wednesday, July 29, 2020	TAG 4 slides distributed to stakeholders	
Thursday, August 6, 2020	**TAG 4 Carbon Impacts, Energy Efficiency, Bio-Natural Gas, Preliminary Resource Integration Results.**	**Community Service Room in Bellingham, WA - 9 am to 3 pm**
Wednesday, September 16, 2020	TAG 5 slides distributed to stakeholders	
Wednesday, September 23, 2020	**TAG 5: Final Integration Results, finalization of plan components, Proposed new 4-year Action Plan.**	**SeaTac Airport - 9 am to 12 pm**
Tuesday, November 17, 2020	Draft of 2020 WA IRP distributed	
Wednesday, December 23, 2020	Comments due on draft from all stakeholders	
Wednesday, January 27, 2021	TAG 6, if needed	WebEx Only
Friday, February 26, 2021	IRP filing in Washington	

ADDITIONAL QUESTIONS?

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Bruce Folsom - Consultant

Cascade Natural Gas Corporation

2020 WA Integrated Resource Plan
Technical Advisory Group Meeting #2

Wednesday, May 27th, 2020

Location TBD

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