Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #1

May 11th, 2017
Oregon Public Utility Commission
Salem, OR

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Agenda

- **Introductions**
- **About Cascade Natural Gas**
  - **Resource Decision Making Process Overview**
  - **Regional Market Intelligence Executive Summary**
  - **IRP Timeline**
  - **2014 IRP issues**
- **Cascade's Demand Study Overview**
  - **Key Points**
  - **Inputs and Data Sources**
  - **Weather Data**
  - **Demand Forecast Process**
  - **Customer Forecast Process**
- **Cascade Natural Gas Forecast Model**
  - **ARIMA Models**
  - **Statistical Analysis**
  - **Non Weather Dependent Demand**
  - **Growth Scenarios**
  - **Weather Scenarios**
  - **Peak Day**
- **Cascade Natural Gas Forecast Model Results**
- **Next Steps**

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A LITTLE HISTORY LESSON…

- Prior to 1955, natural gas was virtually unheard-of in the Pacific Northwest. Seeing an opportunity, Lester Pettit, Spencer Clark, and Stewart Matthews led a group of associates to form a company that would rise to the challenge. Cascade Natural Gas Corporation was incorporated January 2, 1953.

- In July 2007, Cascade was acquired by MDU Resources headquartered in Bismarck, ND.

    - Founded in 1924 as an electric utility in eastern Montana.

    - Core businesses are construction, utilities, and pipeline.

    - Approximately 9,600 employees, operating in 48 states.

    - Operates four utilities across eight states:

        - Montana-Dakota Utilities Co.

        - Great Plains Natural Gas Co.

        - Cascade Natural Gas Corporation

        - Intermountain Gas Co.

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AND TODAY WE ARE ...

- Cascade Natural Gas Corp. serves 282,000 customers in 96 communities – 28 of which are in Oregon and 68 in Washington. Cascade's service areas are concentrated in south central and eastern Oregon, and western and south central Washington.

- Today, Cascade serves a diverse service territory covering more than 32,000 square miles and 700 highway miles from one end of the system to the other. Interstate pipelines transmit Cascade's natural gas from production areas in the Rocky Mountains and western Canada.

4

Resource Decision Making Process Overview

- Construct a range of possible demand forecasts.
- Calculate avoidable distribution system enhancement costs.
- Provide the optimization model with the existing supply side and demand side resource options to meet demand.
- Run the optimization model to identify resource needs including the types of resources and their timing requirements. The existing portfolio is modeled under a range of demand forecast conditions.
- Identify incremental supply and demand side resources to satisfy a range of incremental growth scenarios.

Regional Market Outlook

- Cascade conducted a public meeting on April 18th, 2017 to present its 2014 IRP Update to the Oregon Public Utility Commission's Commissioners and other interested parties. The meeting was held in Salem, Oregon.

- FERC Commissioner Colette Honorable will not seek another term after June 30. FERC will be down to only one commissioner, limiting its ability to regulate projects moving forward.

- The gas futures market indicates a very bearish outlook towards natural gas pricing in the four major basins Cascade purchases gas from over the next three years.

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Regional Market Outlook (Cont.)

- There are many economic indicators that point to a stable and healthy world economic outlook. Wood Mackenzie has identified three potential pitfalls, however, that could lead to a loss of anywhere between $2.2 trillion and $3.6 trillion of potential global GDP growth by 2021.

- According to the reference case of the EIA 2017 Annual Energy Outlook, natural gas is projected to lead the power sector in gross energy consumption over the next 20+ years.

- Currently, the major Columbia Basin reservoirs range from a height of 916.44 feet to a height of 1569.35 feet, while the five major Oregon River Basins range from 88%-100% filled.

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Regional Market Outlook (Cont.)

- On April 10th, 2017 the city of Portland, OR. and surrounding Multnomah County, OR. pledged to power the region exclusively with green energy by mid-century. The plan foresees first shifting to 100% renewable electricity by 2035, then moving to electric and other renewable fuels for transportation, heating and cooling by 2050.

- National net injections into storage totaled 74 Bcf, compared with the five-year (2012–16) average net injection of 57 Bcf and last year's net injections of 64 Bcf during the same week.

- NGTL is preparing to launch an open season for capacity near the Alberta- B.C. Border. Currently they are expected to open up to 408,000 GJ/d and will be accepting bids from May 5th through May 31st, 2017.

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Draft 2018 IRP Timeline

Date	Process Element	Location (Subject to change)
Thursday, May 4, 2017	TAG 1 slides distributed to stakeholders	
Thursday, May 11, 2017	**TAG 1: Process, Key Points, IRP Team, Timeline, Regional Market Outlook, Demand Forecast, Plan for dealing with issues raised in 2014 IRP, Drilling down into segments of demand forecast.**	**OPUC Offices Salem OR 9am-12pm**
Wednesday, July 12, 2017	TAG 2 slides distributed to stakeholders	
Wednesday, July 19, 2017	**TAG 2: Distribution System Planning, Planned Scenarios and Sensitivities, Alternative Resources, Price Forecast, Avoided Costs. Current Supply Resources, Transport Issues.**	**OPUC Offices Salem OR 9am-12pm**
Thursday, August 31, 2017	TAG 3 slides distributed to stakeholders	
Thursday, September 7, 2017	**TAG 3 Carbon Impacts, Conservation (ETO), Preliminary Resource Integration Results, Proposed new 2 year Plan**	**Portland International Airport Conference Center 9am-3pm**
Wednesday, October 11, 2017	TAG 4 slides distributed to stakeholders	
Thursday, October 19, 2017	**TAG 4: Final Integration Results, finalization of plan components**	**OPUC Offices Salem OR 9am-12pm**
Monday, November 6, 2017	Draft of 2018 IRP distributed	
Tuesday, December 5, 2017	Comments due on draft from all stakeholders	
Wednesday, December 20, 2017	TAG 5, if needed	WebEx Only
Monday, January 22, 2018	Executive Summary Presentation to Senior Management	Kennewick, WebEx
Thursday, January 25, 2018	IRP filing in Oregon	

TABLE OF CONTENTS

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TABLE OF CONTENTS (Cont.)

Appendix A - IRP Process

Appendix B - Demand Forecast

Appendix C - IRP Guideline Compliance

Appendix D - Demand Side Management

Appendix E - Current and Alternative Supply Resources

Appendix F - Capacity Requirements & Peak Day Planning

Appendix G - Weather & Price Uncertainty Analyses

Appendix H - Avoided Cost Calculations

Appendix I – Response to Comments

IRP Team

Cascade is fully committed to the IRP process

A restructuring of the Resource Planning department was implemented in Spring 2016:

- **Two new IRP analyst positons were approved by Cascade senior management.**

- **One analyst hired in July 2016; the second analyst is scheduled to report to work on May 16, 2017.**

- **These incremental positions join the Manager of Resource Planning and the Sr. Resource Planning Analyst to form the principle IRP team for Cascade.**

- **Cascade has secured the services of an IRP consultant, Bruce W Folsom Consulting LLC, to assist with IRP activities by improving the process and providing support, allowing time for Cascade to properly develop new staff.**

In addition to expanding the Resource Planning team, the Company created an IRP Steering Committee to provide senior management oversight of the internal IRP process. This Steering Committee includes three VPs and two Directors.

Significant contributions are also made by internal staff in support of the IRP. These departments include Conservation, Engineering, Finance & Accounting, Gas Supply/Gas Control, Regulatory, Industrial Services, Information Technology and the Executive team.

CNGC'S 2018 IRP TAG PARTICIPANTS

- INTERNAL CASCADE IRP TEAM
- MEMBERS OF THE OPUC STAFF
- CITIZENS' UTILITY BOARD
- NORTHWEST GAS ASSOCIATION
- NORTHWEST INDUSTRIAL GAS USERS
- REGIONAL LDCS
- REGIONAL PIPELINES
- MEMBERS OF THE PUBLIC

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IRP GUIDELINES AND CONTENT

OREGON
IRP Guidelines under order No. 07-002 as set forth in the Oregon Administrative Rule (OAR) 860-027-0400.

CASCADE'S BASIC PHILOSOPHY
Primary purpose of Cascade's long-term resource planning process has been, and continues to be, to inform and guide the Company's resource acquisition process, consistent with state regulatory requirements.

Input and feedback from the Company's Technical Advisory Group (TAG) is an important resource to help ensure that CNGC's IRP is developed from a broader perspective than Cascade could have on its own.

In response to the issues identified with the 2014 IRP, Cascade has strengthened its commitment to securing and supporting the appropriate internal and external resources necessary to work with all stakeholders to produce a 2018 Integrated Resource Plan that meets the requirements of order No. 07-002.

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RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- Staff recommends that, in Cascade's IRP Update, due one year from the acknowledgement order for this IRP, Cascade present an Action Plan with Action Items meeting IRP Guideline 3n, and revise Action Items 1 and 9 to be specific and measurable, in addition, Staff recommends that, in Cascade's IRP Update, Cascade include the missing central Oregon shortfall resolution action item in the Action Plan (LC-59 Order No. 16-054 Appendix A Page 3 of 13)
  - **CASCADE HAS ADDRESSED THIS IN THE 2014 IRP UPDATE.**

- Clearly show the plan to acquire all cost effective energy efficiency (LC-59 Order No. 16-054 Appendix A Page 5 of 13)
  - **CASCADE WILL WORK WITH STAKEHOLDERS TO DISCUSS ITS COST EFFECTIVE ENERGY EFFICENCY MEASURES BY TAG 3.**

- Provide complete conservation resource potential results and inputs specific to Cascade only, not including results of other Energy Trust territories or for measures that do not apply to Cascade territory (LC-59 Order No. 16-054 Appendix A Page 5 of 13)
  - **CASCADE WILL WORK WITH STAKEHOLDERS TO DISCUSS ITS UNIQUE CONSERVATION RESULTS AND INPUTS BY TAG 3.**

RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- Provide updated data and explanations for the policies and methodologies used to inform the DSM analysis (LC-59 Order No. 16-054 Appendix A Page 5 of 13)
  - **CASCADE WILL PROVIDE UPDATED DATA AND EXPLANATIONS RELATED TO ITS DSM ANALYSIS TO STAKEHOLDERS BY TAG 3.**

- Incorporate commercial market transformation savings similar to residential methods and include an explanation for how those assumptions are derived and applied within the IRP (LC-59 Order No. 16-054 Appendix A Page 5 of 13)
  - **CASCADE WILL WORK WITH STAKEHOLDERS TO DISCUSS ITS COMMERCIAL MARKET TRANSFORMATION PROGRAMS BY TAG 3.**

- Clearly document assumptions behind capacity contribution of energy efficiency and how the capacity value is incorporated into resource planning (LC-59 Order No. 16-054 Appendix A Page 5 of 13)
  - **CASCADE WILL DISCUSS ANY ASSUMPTIONS RELATED TO CAPACITY CONTRIBUTON OF ENERGY EFFICENCY DURING TAG 3.**

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- Provide an explanation regarding how annual energy savings are translated into peak day demand and capacity resources (LC-59 Order No. 16-054 Appendix A Page 5 of 13)
  - **CASCADE WILL WORK WITH STAKEHOLDERS TO DISCUSS HOW ENERGY SAVINGS ARE TRANSLATED TO PEAK DAY DEMAND AND CAPACITY RESOURCES BY TAG 3.**

- Future Cascade IRPs include portfolio analyses and present the analysis results clearly delineating the three analysis steps, and how those steps progressively lead to identification of the preferred portfolio of resources (LC-59 Order No. 16-054 Appendix A Page 8 of 13)
  - **CASCADE WILL WORK WITH STAKEHOLDERS TO CLEARLY IDENTIFY BY TAG 4 ITS ANALYSIS STEPS, AND HOW THOSE STEPS LEAD TO THE IDENTIFICATION OF THE PREFERRED PORTFOLIO.**

- Future Cascade IRPs perform and clearly present this trade-off analysis. (LC-59 Order No. 16-054 Appendix A Page 8 of 13)
  - **BY COMPLETION OF TAG 4 CASCADE WILL WORK WITH STAKEHOLDERS TO ENSURE THAT THE ANALYSIS PERFORMED BY THE COMPANY TO DERIVE THE PREFERRED PORTFOLIO IS CLEARLY PRESENTED IN ITS IRP.**

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- In Cascade's IRP Update, Cascade resolve the apparent conflict, noted in Staffs Initial comments, between the Oregon resource deficiency depicted in Figures 7-B-2 and 7-C-2 and described in the LC 54 Second Supplemental Update, and the Appendix Section F load-resource balance figures (LC-59 Order No. 16-054 Appendix A Page 8 of 13)
  - **CASCADE HAS ADDRESSED THIS IN ITS 2014 IRP UPDATE.**

- Future Cascade IRPs provide a clear, complete, and concise presentation of the portfolio analysis results in a single section of the IRP (LC-59 Order No. 16-054 Appendix A Page 8 of 13)
  - **BY COMPLETION OF TAG 4 CASCADE WILL WORK WITH STAKEHOLDERS TO ENSURE THAT THE ANALYSIS PERFORMED BY THE COMPANY TO DERIVE THE PREFERRED PORTFOLIO IS PRESENTED IN A CLEAR AND CONCISE MANNER, IN A SECTION SOLELY DEDICATED TO INTEGRATION RESULTS.**

- In Cascade's IRP Update, Cascade present an analysis to show how much the peak day load could be reduced or delayed by accelerated DSM and recallable service agreement programs (LC-59 Order No. 16-054 Appendix A Page 8 of 13)
  - **CASCADE HAS ADDRESSED THIS IN ITS 2014 IRP UPDATE.**

RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- Staff recommends that Cascade work with Staff and other interested parties to develop a comprehensive database comprising of both economic and weather variables such as price, income, employment, different Heating Degree Days (HDD) cutoffs, seasonality, etc., and formulate alternative regression models to identify the drivers of the forecasted values and plausibility of the parameter estimates relative to the economic theory on demand for natural gas (LC-59 Order No. 16-054 Appendix A Page 9 of 13)
  - **CASCADE HAS COMPILED AND TESTED DATA ON EMPLOYMENT, POPULATION, HOUSING STARTS, SEASONALITY, AND OTHER VARIABLES, AND WOULD LIKE FEEDBACK FROM STAKEHOLDERS AT THIS MEETING REGARDING DIFFERENT HDD CUTOFFS. CASCADE HAS MADE ENHANCEMENTS TO ITS MODELING PRACTICES, WHICH WILL BE DISCUSSED IN THIS TAG MEETING.**

- Staff recommends that future Cascade IRPs include detailed descriptions of, and basis for, the gas purchasing plan and hedging strategy, as well as the gas purchasing risk management plan/policy/strategy (LC-59 Order No. 16-054 Appendix A Page 10 of 13)
  - **CASCADE WILL ADD A NEW APPENDIX TO THE 2018 IRP TO SHARE THIS INFORMATION WITH INTERESTED STAKEHOLDERS, SUBJECT TO CONFIDENTIAL TREATMENT WHERE APPLICABLE.**

- Staff also recommends that in the next IRP, Cascade comprehensively describe the rationale by which it chooses the hedging percentage levels, including upper limits of hedged gas based on the market environments (e.g,, price levels, volatility, etc.), Cascade's risk tolerance (e.g,, tolerance bands of potential losses), etc. In the meantime, Staff recommends that Cascade continue to apprise Staff and other parties during the recurring quarterly meetings of changes in the hedged gas percentage levels (LC-59 Order No. 16-054 Appendix A Page 10 of 13)
  - **CASCADE WILL ADD A NEW APPENDIX TO THE 2018 IRP TO SHARE THIS INFORMATION WITH INTERESTED STAKEHOLDERS, SUBJECT TO CONFIDENTIAL TREATMENT WHERE APPLICABLE. CASCADE WILL ALSO PROVIDE AN UPDATE REGARDING ITS PLANS TO COMPLY WITH THE WUTC HEDGING POLICY BY TAG 4 OF ITS 2018 OREGON IRP.**

- Staff recommends that future Cascade IRPs present separate listings of enhancement projects from the other projects (LC-59 Order No. 16-054 Appendix A Page 11 of 13)
  - **CASCADE WILL PROVIDE A MORE COMPREHENSIVE LISITING OF ENCHANCEMENT PROJECTS IN THE DISTRIBUTION SYSTEM PLANNING PORTION OF THE 2018 IRP NARRATIVE.**

- Staff recommends for future IRPs that Cascade inform the Commission in its IRP of the price of renewable natural gas as compared to traditional source of natural gas, and report to the Commission how much renewable natural gas it purchased between the IRP filing years (LC-59 Order No. 16-054 Appendix A Page 12 of 13)
  - **CASCADE WILL WORK WITH STAKEHOLDERS TO PRESENT AN ANALYSIS OF THE COST OF RENEWABLE NATURAL GAS VERSUS TRADITIONAL SOURCES BY TAG 3.**

- Staff also recommends that Cascade report its EPA's Greenhouse Inventory Report information to the Commission in each of its future IRPs for each year preceding each IRP (LC-59 Order No. 16-054 Appendix A Page 12 of 13)
  - **CASCADE WILL WORK WITH STAKEHOLDERS TO PRESENT ITS GREENHOUSE INVENTORY REPORT BY TAG 3.**

- Staff recommends that Cascade evaluate its staffing approach and make changes where needed, to ensure that its required regulatory IRP activities are performed on schedule and in compliance with Commission requirements (LC-59 Order No. 16-054 Appendix A Page 12 of 13)
  - **CASCADE WILL DISCUSS STAFFING DURING THIS TAG MEETING.**

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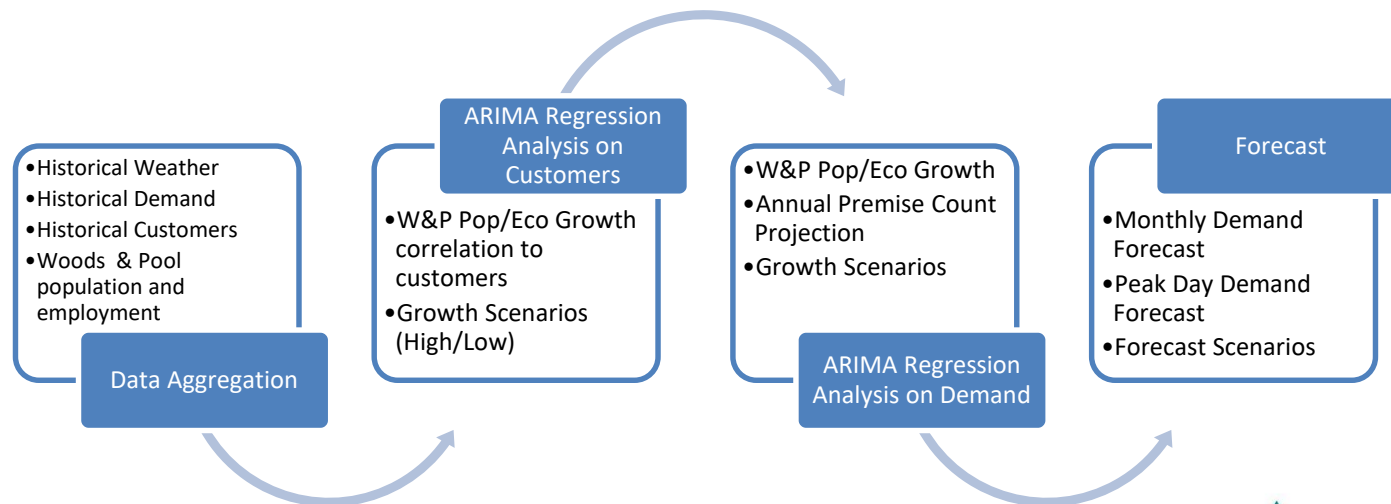*In the Community to Serve®*

- Staff recommends that future IRPs use the Executive Summary to summarize the contents of the IRP, rather than to present additional information. (LC-59 Order No. 16-054 Appendix A Page 13 of 13)
  - **CASCADE WILL UTILIZE THE EXECUTIVE SUMMARY TO PROVIDE A CLEAR, CONCISE SNAPSHOT OF ITS 2018 IRP.**

CASCADE DEMAND STUDY

High Level overview of the 20-Year demand forecast

Overview

- 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.

- Cascade's core load consists of approximately 53% residential, and 47% commercial and industrial.

Data Aggregation
- Historical Weather
- Historical Demand
- Historical Customers
- Woods & Pool population and employment

ARIMA Regression Analysis on Customers
- W&P Pop/Eco Growth correlation to customers
- Growth Scenarios (High/Low)

ARIMA Regression Analysis on Demand
- W&P Pop/Eco Growth
- Annual Premise Count Projection
- Growth Scenarios

Forecast
- Monthly Demand Forecast
- Peak Day Demand Forecast
- Forecast Scenarios

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Overview (Cont.)

- Forecast demand at the citygate and citygate loop level.

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

- Cascade allocates each citygate to either the nearest weather location or the weather location with geographic similarity.

- Forecasts are separated into four rate classes: Residential, Commercial, Industrial, and Core Interruptible.

Key Points

- Cascade's demand is principally weather and customer driven; the colder the weather or greater the customer count, the greater the demand.

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

- Forecasted under various weather and growth scenarios – average year, cold year, warm year, extreme cold day, high growth, low growth, etc.

- Analyze weather and demand for each of 55 citygates and citygate loops that serve core customers.

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

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Input Data

- Historical Demand
  - Pipeline actuals (Electronic Bulletin Board or EBB)
  - Gas Management System (Aligne, formerly GMS)
  - Customer Care and Billing (CC&B)
- Weather
  - Schneider Electric
- Population and Economic
  - Woods & Poole
  - Acquiring local market intelligence
- Customer Count
  - CC&B

Weather Data

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

- 30 years of weather data for seven weather stations was used to make weather scenarios.

- Weather data is from Schneider Electric.

- Assign a weather station to each citygate or citygate loop.
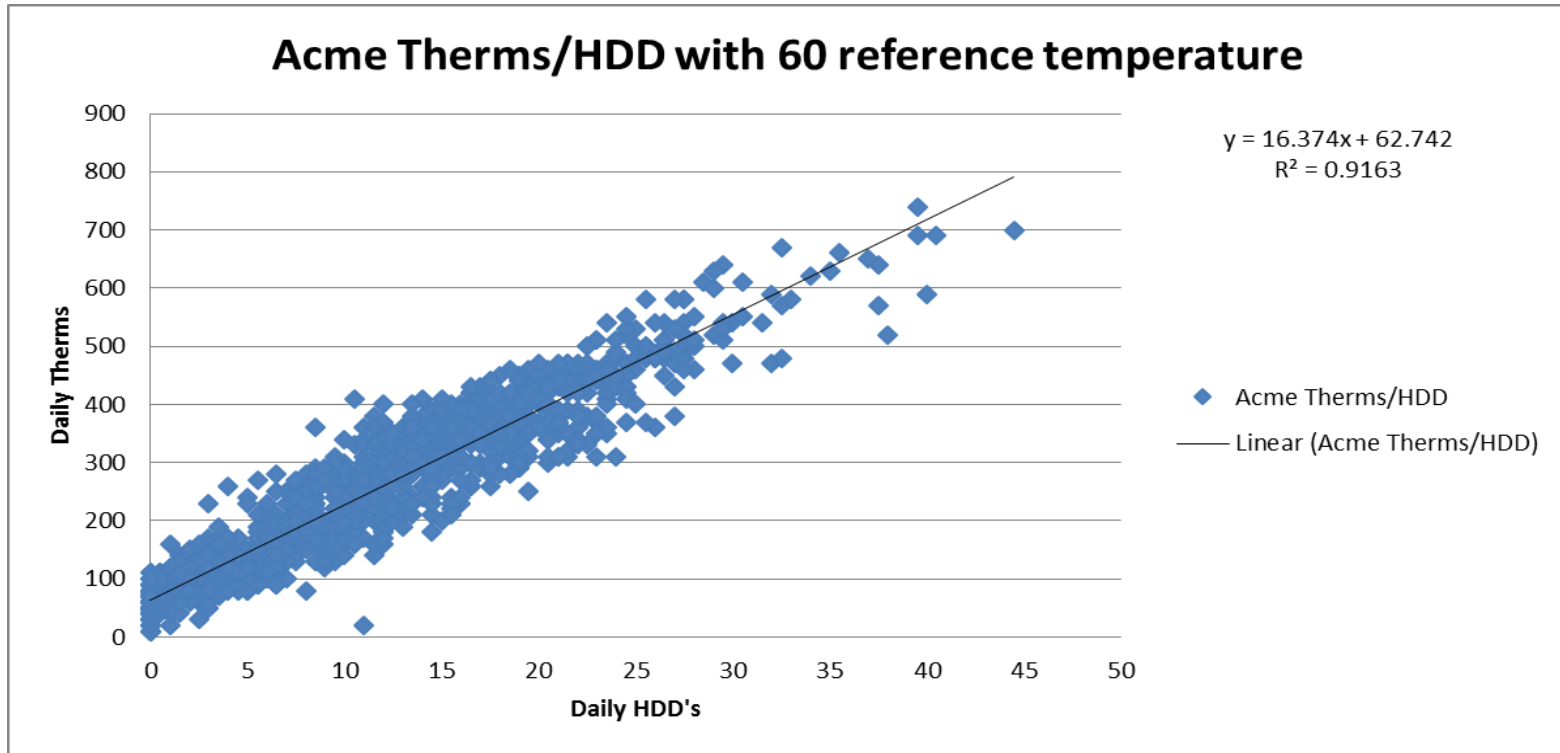
Heating Degree Day (HDD)

- HDD is used as the unit of measure for weather in the linear regression analysis.

- HDD is calculated by:
  – Determine average high and low temperature for a given day.
  – Daily average is subtracted from an HDD threshold (for example 60°F).
  – If this produces a negative number, a value of zero is assigned.

- Example:
  – Daily high temperature = 60°F; Daily low temperature = 50°F
  – Calculate average → 55°F
  – Subtract from HDD threshold (we will use 60): 60-55 = 5
  – This example day has 5 HDDs

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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

$y = 14.815x + 14.81$
$R^2 = 0.9075$
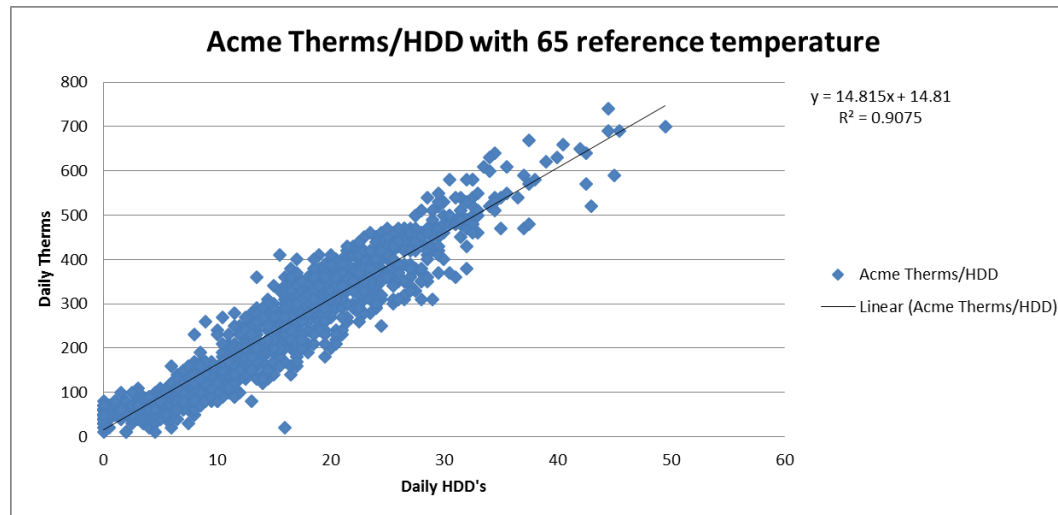
Acme Therms/HDD with 60 degree reference temperature

Acme Therms/HDD with 60 reference temperature

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

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

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Demand Forecast Process Followed

- Pipeline flow data is received as a daily number at the citygate. This daily number includes both the core and non-core with all classes combined into one number.

- Using Aligne, Cascade can remove the non-core values from the data leaving the Company with only the core data.

- Using CC&B, percentages were calculated to allocate the demand into rate classes.

Tariff Allocation

GATE	TARRIF	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bend Loop	CNGOR101	64.06%	64.09%	63.94%	62.89%	61.53%	58.60%	55.98%	56.62%	60.20%	64.86%	64.13%	64.33%
Bend Loop	CNGOR104	34.52%	34.44%	34.43%	35.24%	36.29%	38.68%	40.70%	40.32%	37.30%	33.44%	34.36%	34.26%
Bend Loop	CNGOR105	0.96%	0.95%	1.04%	1.12%	1.20%	1.32%	1.40%	1.36%	1.30%	0.97%	0.91%	0.81%
Bend Loop	CNGOR111	0.47%	0.52%	0.59%	0.74%	0.98%	1.41%	1.92%	1.71%	1.20%	0.73%	0.60%	0.59%

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Demand Forecast Process Followed

- CC&B data is provided on an accounting month basis which means a billing cycle can run from mid-month to mid-month but will be reported in the month the bill ends.

- Cascade found that shifting the data one month forward in the first 12 billing cycles matched the demand to the pipeline demand with only 5.5% error. (21.7% error unshifted.)

- Each city/town is allocated to a citygate, based on which citygate feeds the city/town.

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Demand Forecast Example

Citygate	Class	Year	Month	Day	Weekend	upc	HDD	upc	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bend Loop	Residential	2010	7	1	0	0.075677571	2	0.075677571	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	2	0	0.09530263	8	0.09530263	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	3	1	0.082065054	7	0.082065054	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	4	1	0.071402757	3	0.071402757	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	5	0	0.073864238	4.5	0.073864238	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	6	0	0.069440993	0	0.069440993	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	7	0	0.063637339	0	0.063637339	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	8	0	0.059154721	0	0.059154721	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	9	0	0.058390301	0	0.058390301	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	10	1	0.056750138	0	0.056750138	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	11	1	0.05658439	0	0.05658439	0	0	0	0	0	1	0	0	0	0	0
Bend Loop	Residential	2010	7	12	0	0.063637339	0	0.063637339	0	0	0	0	0	1	0	0	0	0	0

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Customer Forecast Process Followed

- After CC&B data is shifted, city/town is allocated to the county level as well.

- The data is combined into the four rate classes using the tariffs to allocate.

- For each month, population and employment is applied as well as a monthly indicator value.

- After the forecast is run, the county customer forecast is allocated to the citygate.

Customer Forecast Example

County	Class	Year	Month	count	Population	Employment	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Deschutes	Residential	2008	10	32791	156.82	99.343	0	0	0	0	0	0	0	0	1	0	0
Deschutes	Residential	2008	11	33004	156.82	99.343	0	0	0	0	0	0	0	0	0	1	0
Deschutes	Residential	2008	12	33126	156.82	99.343	0	0	0	0	0	0	0	0	0	0	1
Deschutes	Residential	2009	1	33262	157.345	92.688	0	0	0	0	0	0	0	0	0	0	0
Deschutes	Residential	2009	2	33215	157.345	92.688	1	0	0	0	0	0	0	0	0	0	0
Deschutes	Residential	2009	3	33160	157.345	92.688	0	1	0	0	0	0	0	0	0	0	0

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Cascade Natural Gas Forecast Model

Using SAS for ARIMA Modeling

- Therms/$C^{CG,Class}$ = α_0 + $\alpha_1 HDD^{CG}$ + $\alpha_m I_m$ + $\alpha_w I_w$ + ARIMA$\in$(p,d,q)

- $C^{CG,Class}$ = α_0 + $\alpha_1 Pop^{CG}$ + $\alpha_2 Emp^{CG}$ + $\alpha_m I_m$+ ARIMA$\in$(p,d,q)

- Model Notes:
  - C = Customers, CG = Citygate, Class = Residential, Commercial, or Industrial, HDD = Heating Degree Days, M = Month, I = Indicator Variable, where 1 if the month indicated, 0 otherwise, W = Weekend, 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.
  - Therms/C are at a daily level, C are forecasted at a monthly level

Statistical Analysis for Customer Forecast

- After running the first analysis, Cascade looked for stationarity and determined whether the data needed to be differenced.

- Cascade then looked at the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) to determine the Moving Average or Autoregressive terms for the model.

- Cascade removed non-significant variables, unless the removal made the model worse (Ex. Removing the monthly indicators usually decreased the MAPE and AIC).

- Akaike Information Criterion (AIC) and Mean Absolute Percentage Error (MAPE) were statistics used in determining which model to use.

Statistical Analysis for Demand Forecast

- Cascade analyzed each model as an Autoregressive Integrated Moving Average (ARIMA) model, but most models usually only used the Autoregressive term.

- Cascade removed non-significant variables, unless the removal made the model worse.

- Akaike Information Criterion (AIC) and Mean Absolute Percentage Error (MAPE) were statistics used in determining which model to use.

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Final Demand Forecast

- The Monthly Demand Forecast by year, month, rate class and citygate was determined by the following:

  - The demand forecast use per customer is applied to the customer forecast which makes up the monthly demand forecast.

  - Core load was forecasted by citygate by rate class.

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 indicators, Cascade can run the analysis while leaving the non-weather demand in.

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Moxee (Beauchene)
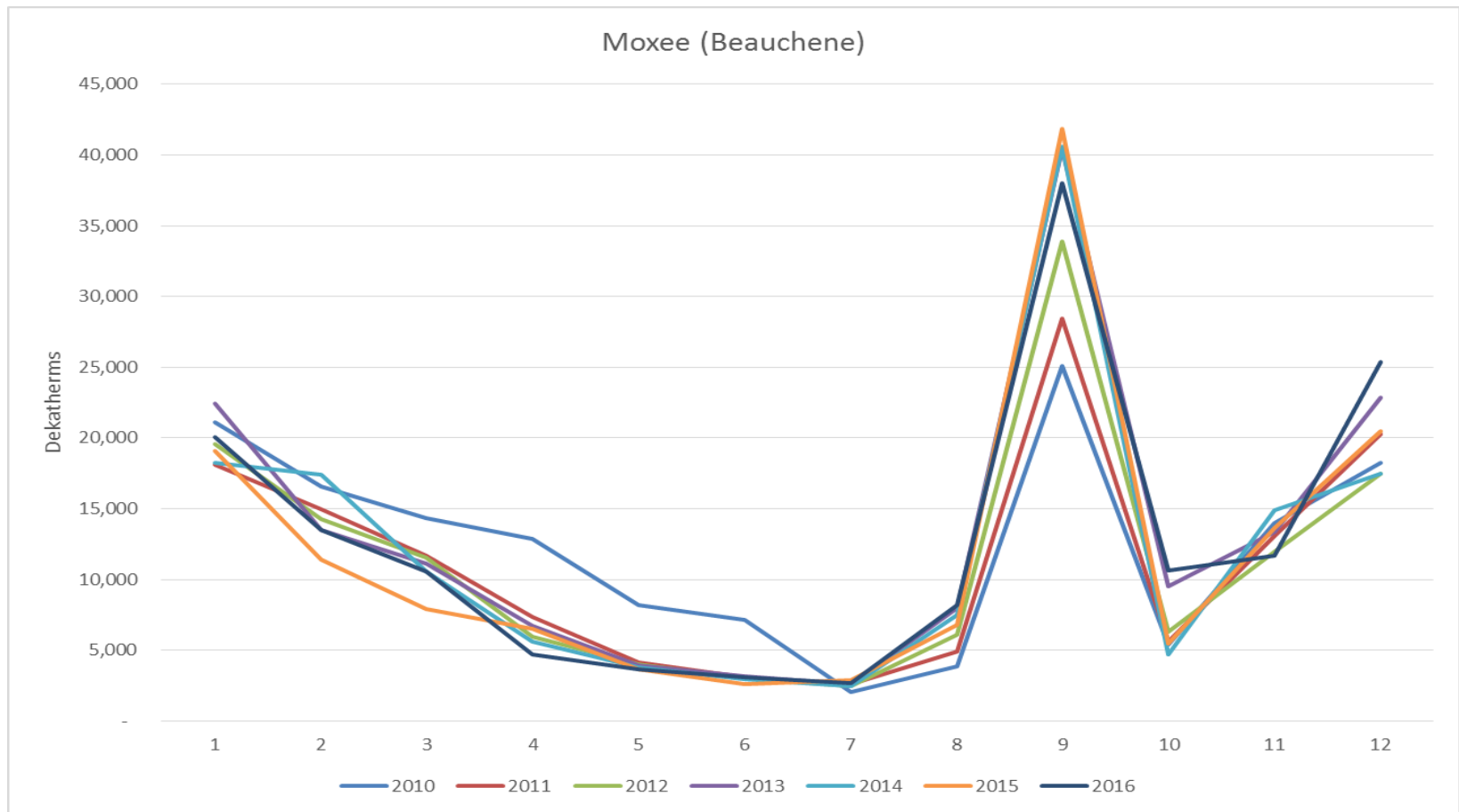
| | | | Standard | | Approx |
Variable	DF	Estimate	Error	t Value	Pr > |t|
Intercept	1	1.4304	0.083	17.23	<.0001
Weekend	1	-0.194	0.0365	-5.31	<.0001
HDD	1	0.077	0.002883	26.72	<.0001
3	1	-0.909	0.0781	-11.64	<.0001
4	1	-1.407	0.0865	-16.27	<.0001
5	1	-1.304	0.0962	-13.56	<.0001
6	1	-1.2435	0.1006	-12.36	<.0001
7	1	-1.2525	0.0987	-12.69	<.0001
8	1	-0.8777	0.0986	-8.9	<.0001
9	1	1.89	0.0972	19.44	<.0001
10	1	-1.297	0.0842	-15.4	<.0001
11	1	-0.7563	0.0708	-10.69	<.0001
12	1	0.2708	0.0705	3.84	0.0001

Parameter Estimates

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Moxee (Beauchene) Forecast

Forecast Results

Annual Forecast chart showing Dekatherms (y-axis from 0 to 45,000,000) by year (x-axis from 2018 to 2037) for Washington (blue) and Oregon (green).
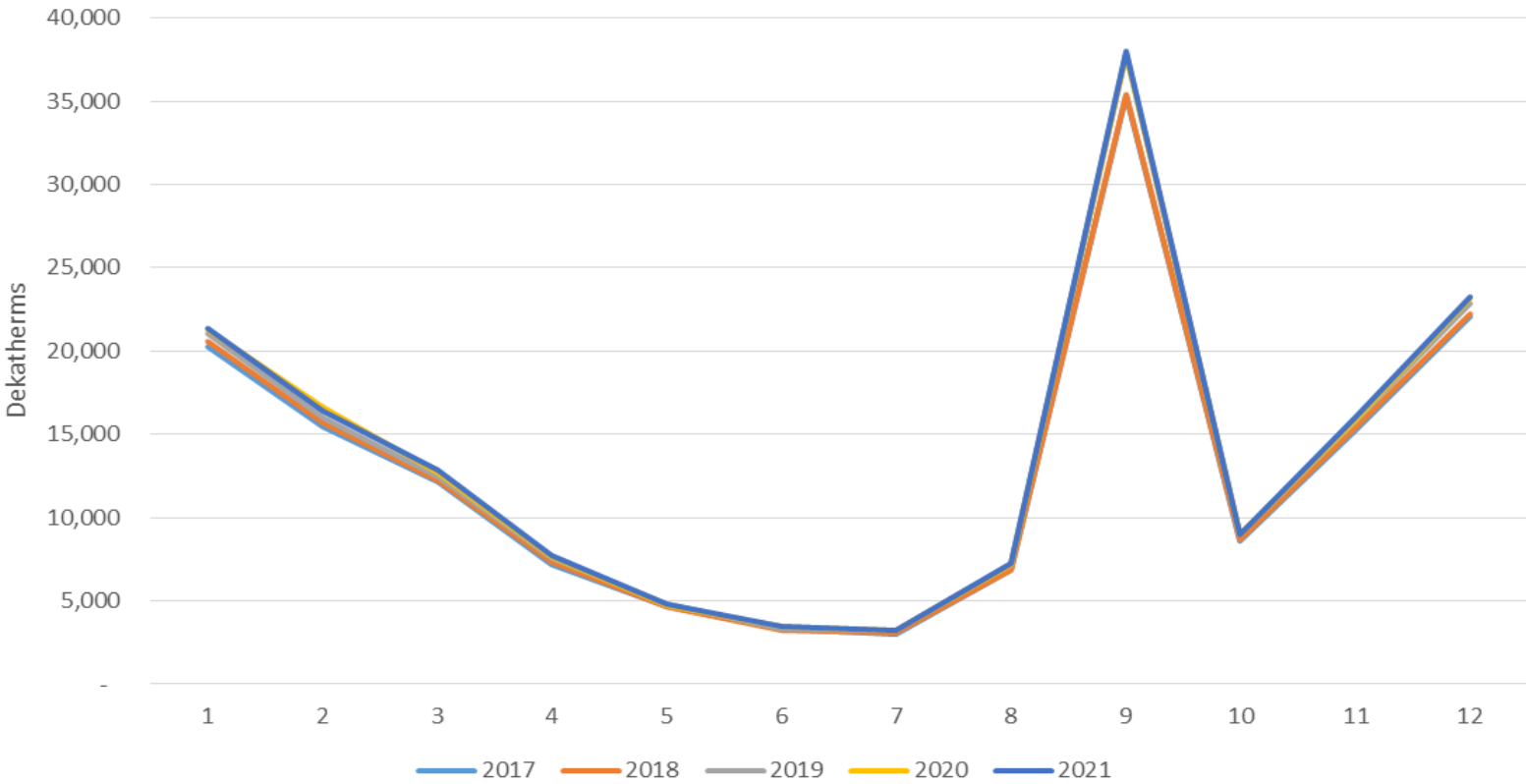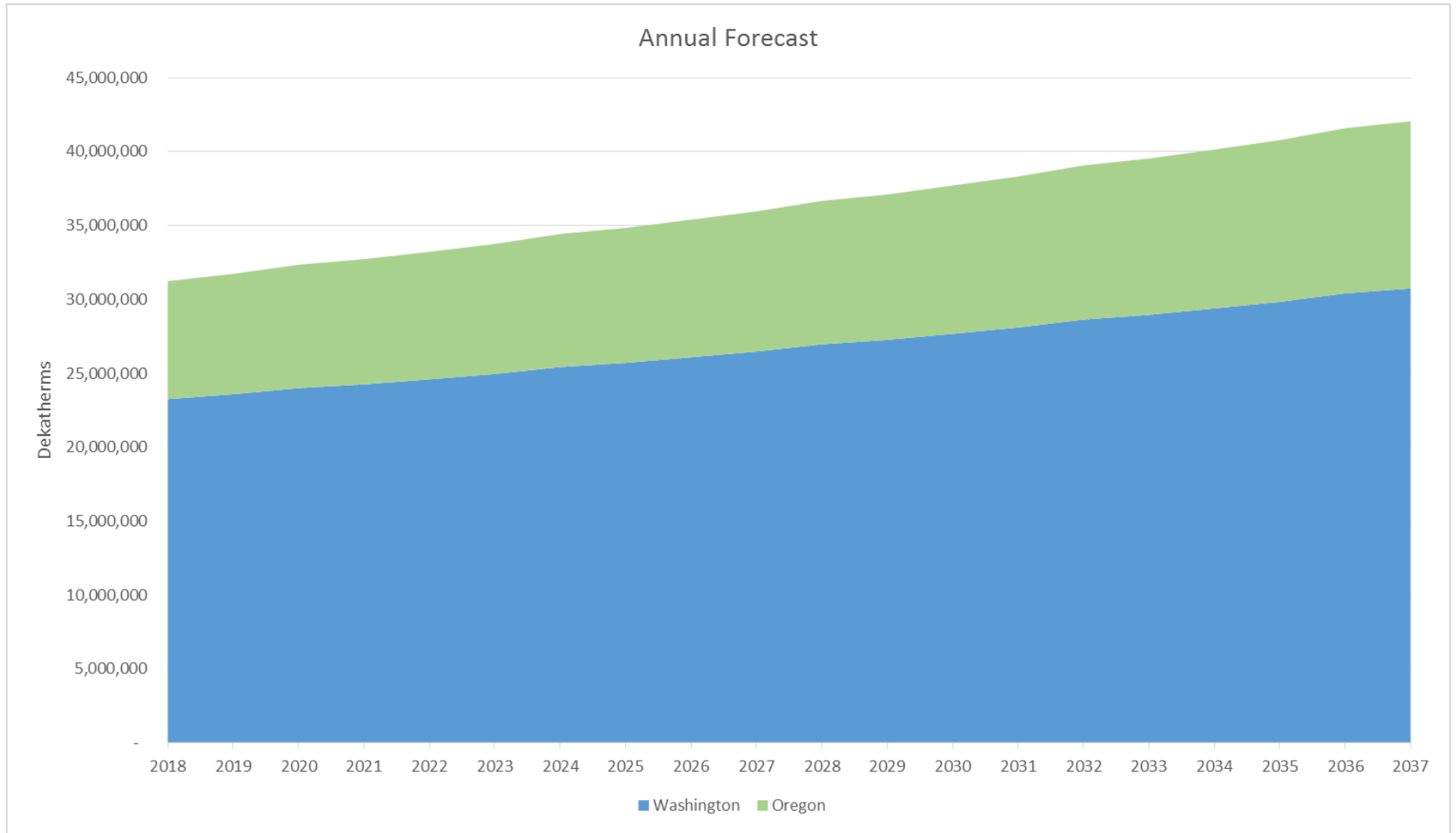
Growth Scenarios

- Forecast assumes three different growth scenarios.

- Base case assumes expected growth with figures primarily from growth factors derived from W&P population and economic employment forecast.

- High growth scenario is the upper bound of the 95% confidence interval.

- Low growth scenario is the lower bound of the 95% confidence interval.

Weather Stations
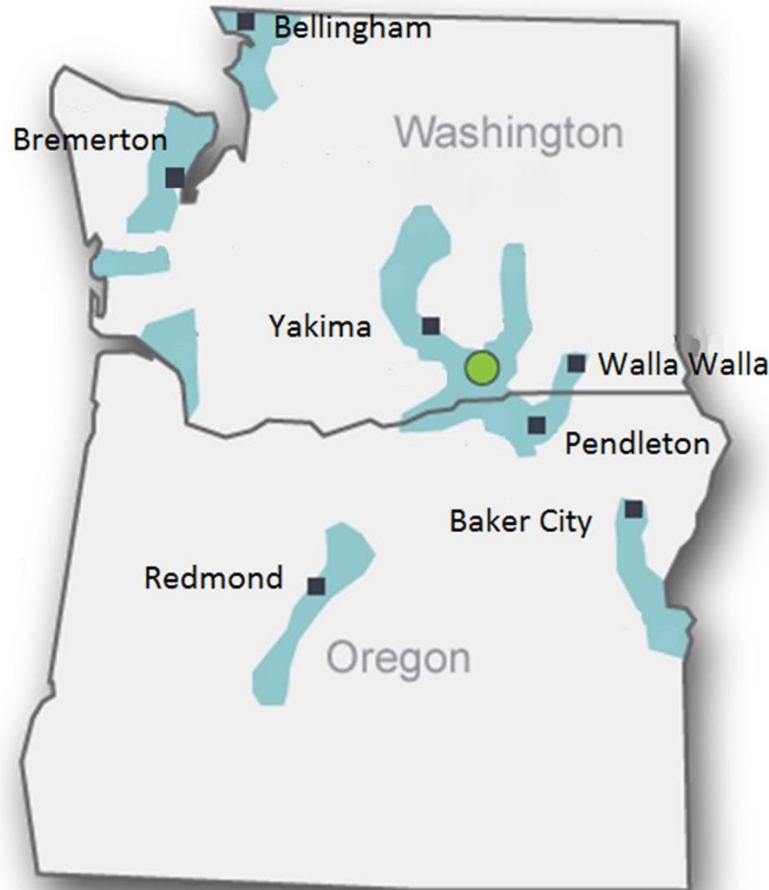
- The seven weather stations are shown on the map.

- Cascade's customer base is shaded in aqua.

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

Weather Scenarios

- The average scenario forecast assumes weather (HDD) for 12 months of the year from the 30-year average.

- Average weather scenario is the base case forecast.

- For weather scenarios, system wide HDDs are used by giving appropriate weight to the weather stations that have greater impact on system wide demand.

- To determine the high case HDD weather scenario, Cascade uses the highest draw of its 200 Monte Carlo weather simulations. This will be discussed further in TAG 4

- To determine the low case HDD weather scenario, Cascade uses the lowest draw of its 200 Monte Carlo weather simulations. This will be discussed further in TAG 4

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Demand Forecast

Year	Month	Forecast Time	System Demand (Dth)	OR Forecast (Dth)	WA Forecast (Dth)	ATHENA	BAKER	UMATILLA	CHEMULT	GILCHRIST	HERMISTON
2017	1	Jan-17	4,822,771	1,224,894	3,597,876	7,790	64,885	20,932	704	3,303	94,813
2017	2	Feb-17	3,914,503	993,911	2,920,592	6,063	49,801	17,775	560	2,859	72,972
2017	3	Mar-17	3,340,657	840,927	2,499,730	5,021	39,843	15,113	531	2,552	55,465
2017	4	Apr-17	2,233,039	583,232	1,649,807	3,171	26,305	11,961	410	1,789	33,603
2017	5	May-17	1,530,866	401,523	1,129,343	1,637	16,304	9,503	296	1,132	22,497
2017	6	Jun-17	1,085,857	270,567	815,289	810	9,081	8,079	164	677	18,378
2017	7	Jul-17	905,201	218,174	687,026	651	6,265	7,314	137	433	16,521
2017	8	Aug-17	922,294	226,905	695,388	575	6,910	7,558	144	444	16,827
2017	9	Sep-17	1,162,159	286,436	875,723	884	8,941	8,224	234	780	18,553

Peak Day Forecast

- Cascade analyzed the data that was in the 3rd quartile HDD range for peak day.

- Cascade removed the more mild months to get a better analysis on demand and weather during cold events.

- Cascade used similar models to the demand forecast to analyze the peak day data.

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Peak Day Forecast

- 3 Peak Day Scenarios:
  - Average Peak Day
  - Max Peak Day
  - Citygate Peak Day
- HDD weighting
  - To determine the peak day HDDs Cascade had to weight each HDD based on weather location.
    - Held customer count to the December 2017 forecast and used the coefficient *upc* in the linear regressions.
    - The amount of demand at each weather location based on an increase in 1 HDD determined how each weather location should be weighted.

System Weighted HDD

	Coefficient	Customers	ΔHDD	Demand			
DEM AbrdnHoq | RES	0.007014	3496	1	24.5			
	Baker City	**Bellingham**	**Bremerton**	**Pendleton**	**Redmond**	**Walla Walla**	**Yakima**
Sum of Demand	81.2	1135.6	497.3	166.1	528.4	579.9	478.4
Weather Weight	2.3%	32.8%	14.3%	4.8%	15.2%	16.7%	13.8%
12/17/2016	HDD	Weights	Weighted HDD				
Baker City	64.5	0.0234	2				
Bellingham	39	0.3275	13				
Bremerton	36	0.1434	5				
Pendleton	51.5	0.0479	2				
Redmond	52.5	0.1524	8				
Walla Walla	49	0.1673	8				
Yakima	50	0.1380	7				
			45				

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Average Peak Day Forecast

- The Average Peak Day Forecast ensures that Cascade can plan for the expected peak day during a year.
  - Using the weighted HDDs, Cascade found the coldest day in each of the most recent 30 years (1987-2016).
  - Using those HDDs, Cascade averaged each day for each weather location to come up with 7 HDDs.
  - Those HDDs were then applied to the regressions to come up with an average peak day forecast.

Max Peak Day Forecast

- The Max Peak Day Forecast allows Cascade to plan for the coldest day in the past 30 years with today's usage rates and customer counts.
  - Using the weighted HDDs, Cascade found the coldest day from the past 30 years (This is December 21st, 1990).
  - The HDDs for each weather location from this day were used in the regressions to come up with the Max Peak Day Forecast.

Citygate Peak Day Forecast

- The citygate Peak Day Forecast allows Cascade to plan for the coldest day in the past 30 years at each individual weather location.

  - Using weather location HDDs, Cascade found the coldest HDD in the past 30 years for each individual weather location.

  - The HDDs for each weather location were used in the regressions to come up with the Citygate Peak Day Forecast.

Max and Citygate Peak HDDs

Peak Rank	System Peak Day	System Peak HDD	City Gate Peak HDD						
			Baker City	Bellingham	Bremerton	Pendleton	Redmond	Walla Walla	Yakima
		3	4	5	6	7	8	9	10
1	12/21/90	56.1	70.5	46	46	67	70.5	65	58
2	02/03/89	53.9	68	46	46	63.5	64.5	60.5	55.5
3	12/29/90	52.6	60	47	44	65.5	53.5	59	60
4	12/20/90	51.9	59	46	42	63	62	57.5	53
5	12/22/90	51.6	72.5	41	41.5	61.5	62.5	60.5	57.5
6	02/02/89	51.3	52	51.5	45	60.5	50	53	53.5
7	01/05/04	50.3	70	39	37	63	55.5	64	61
8	01/30/96	50.3	61.5	40.5	37	64	55.5	63.5	59
			City Gate Peak HDD						
			Baker City	Bellingham	Bremerton	Pendleton	Redmond	Walla Walla	Yakima
			72.5	51.5	46	67	70.5	65.5	64.5

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Cascade Natural Gas Forecast Model Results

Gilchrist
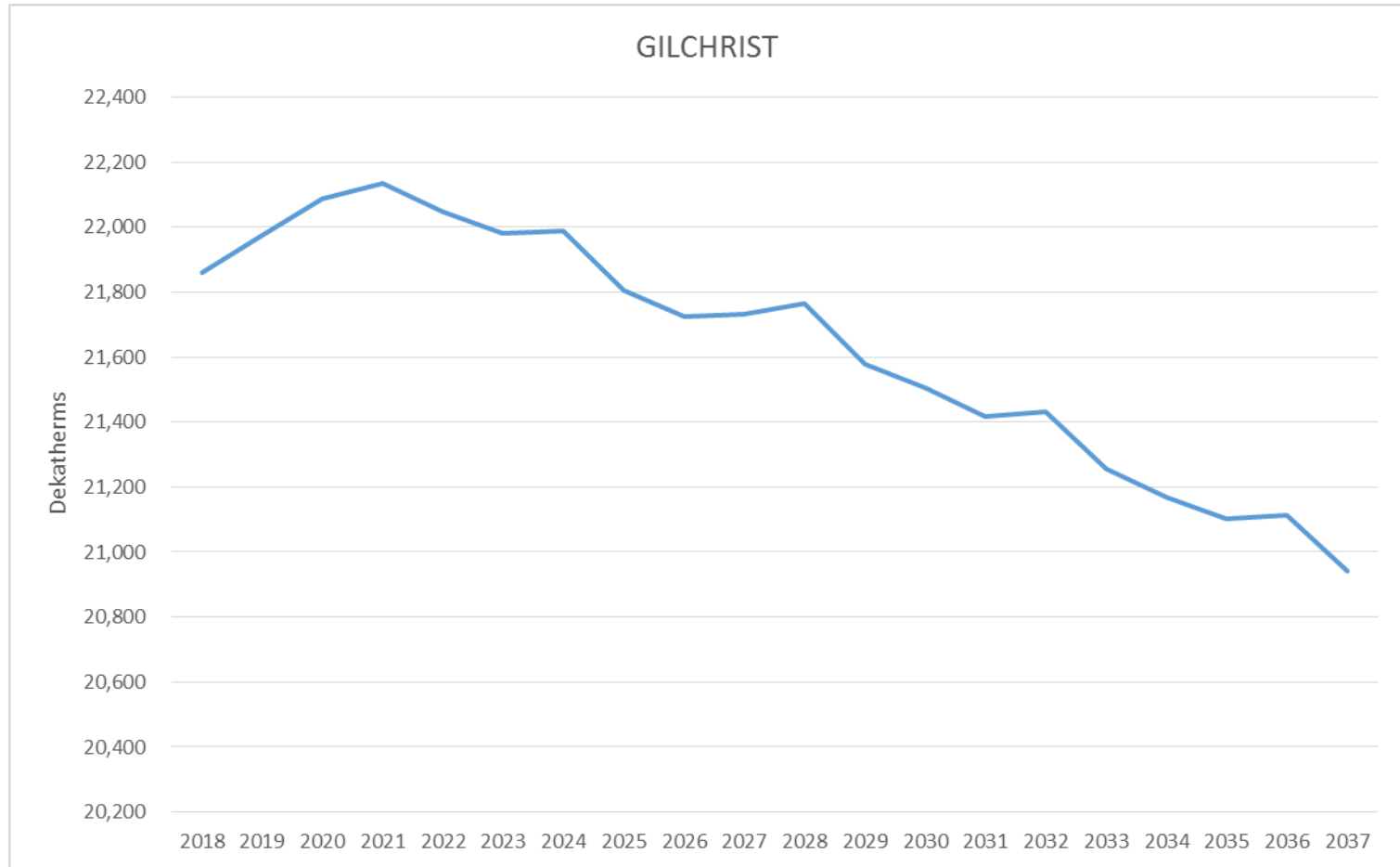
Gilchrist Peak Day
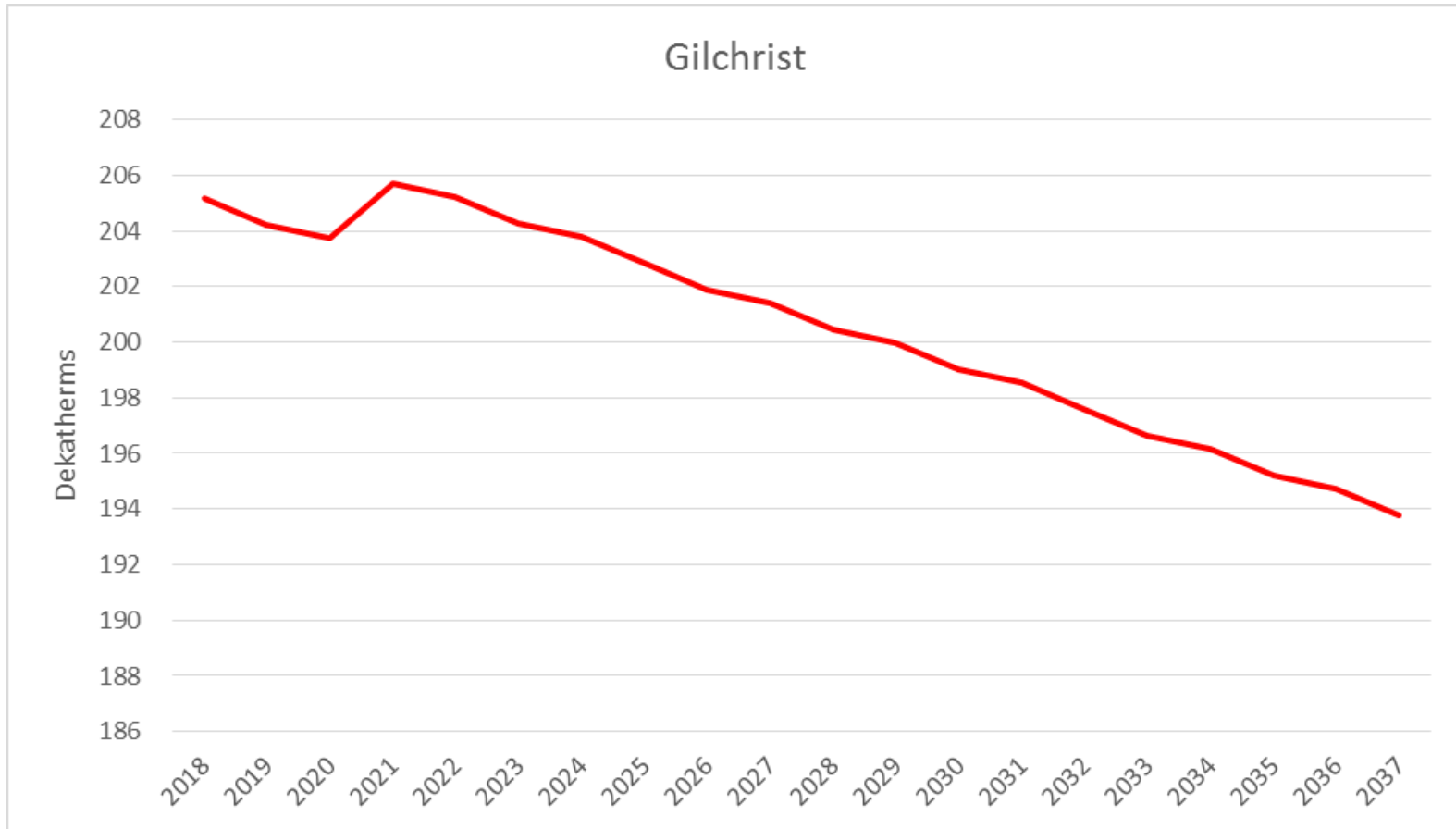
Nyssa-Ontario
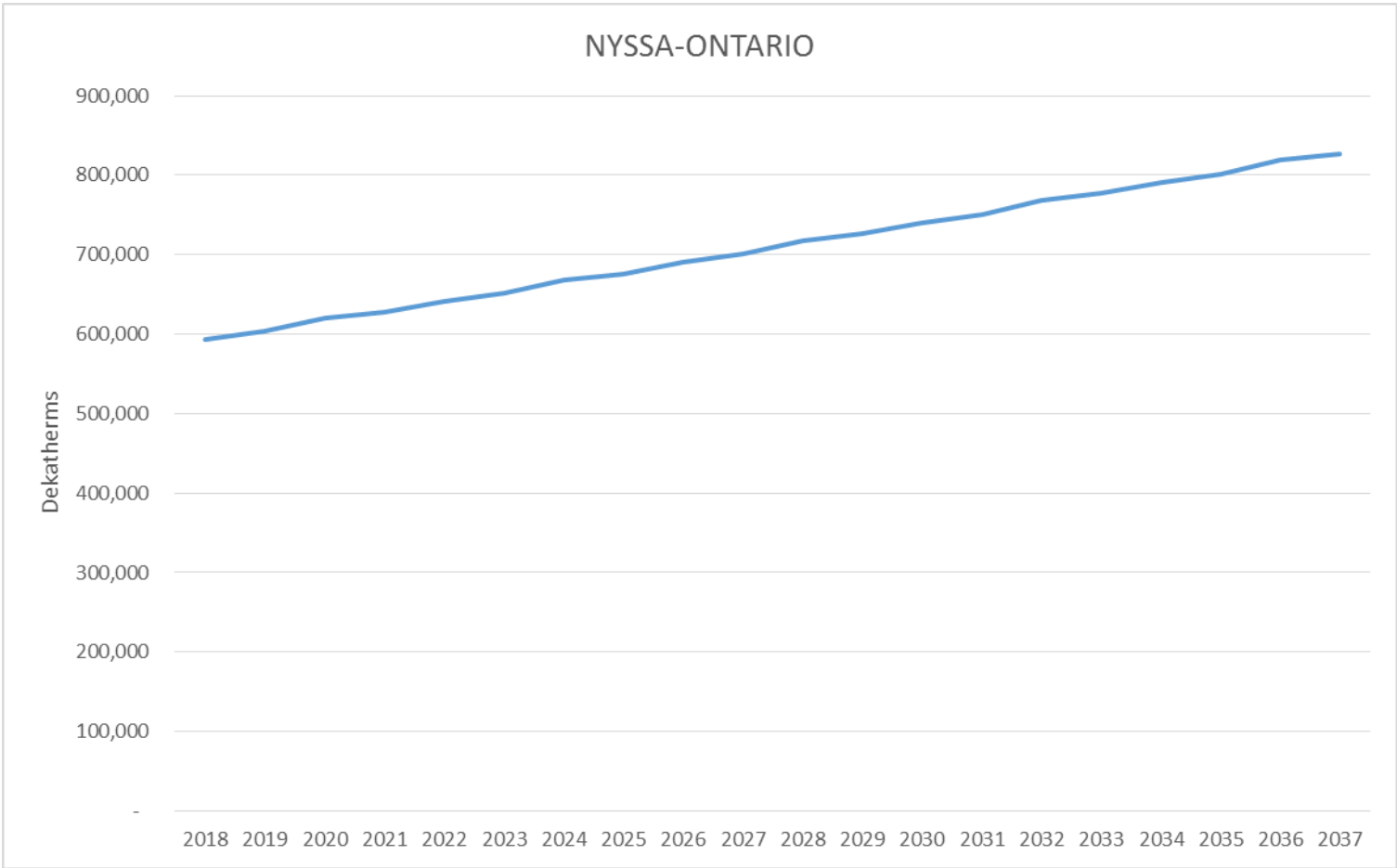
NYSSA-ONTARIO

Nyssa-Ontario Peak Day
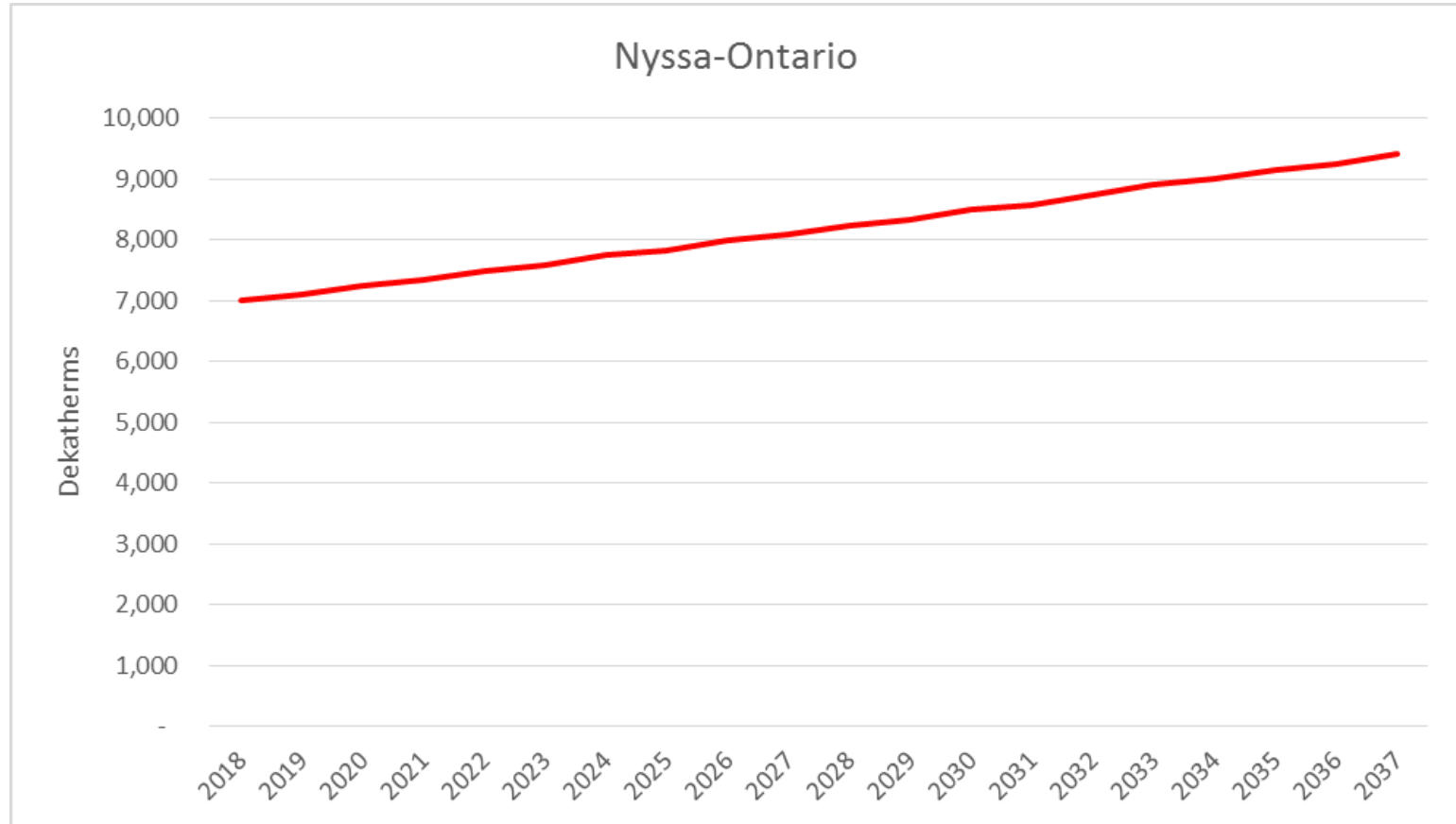
Redmond
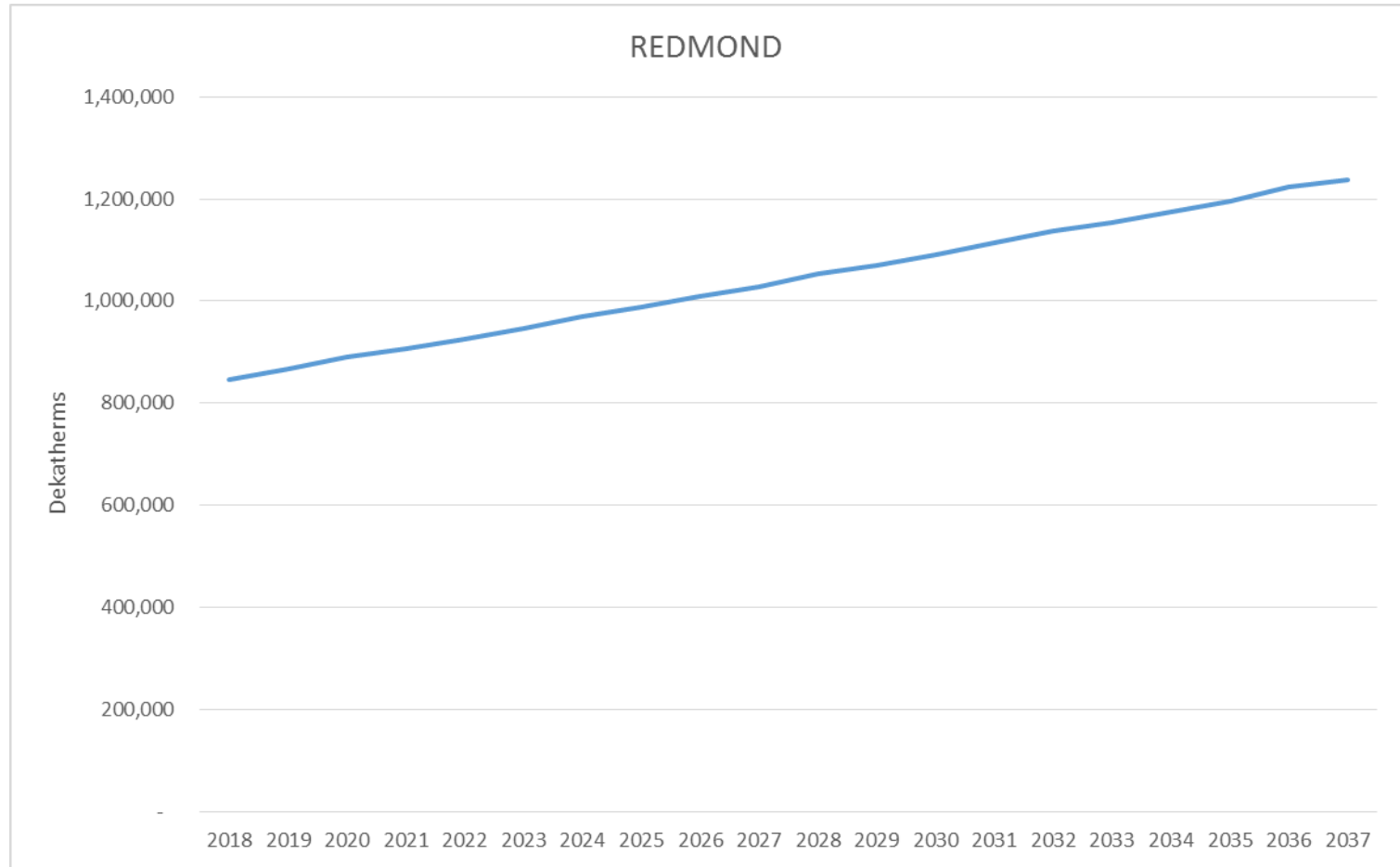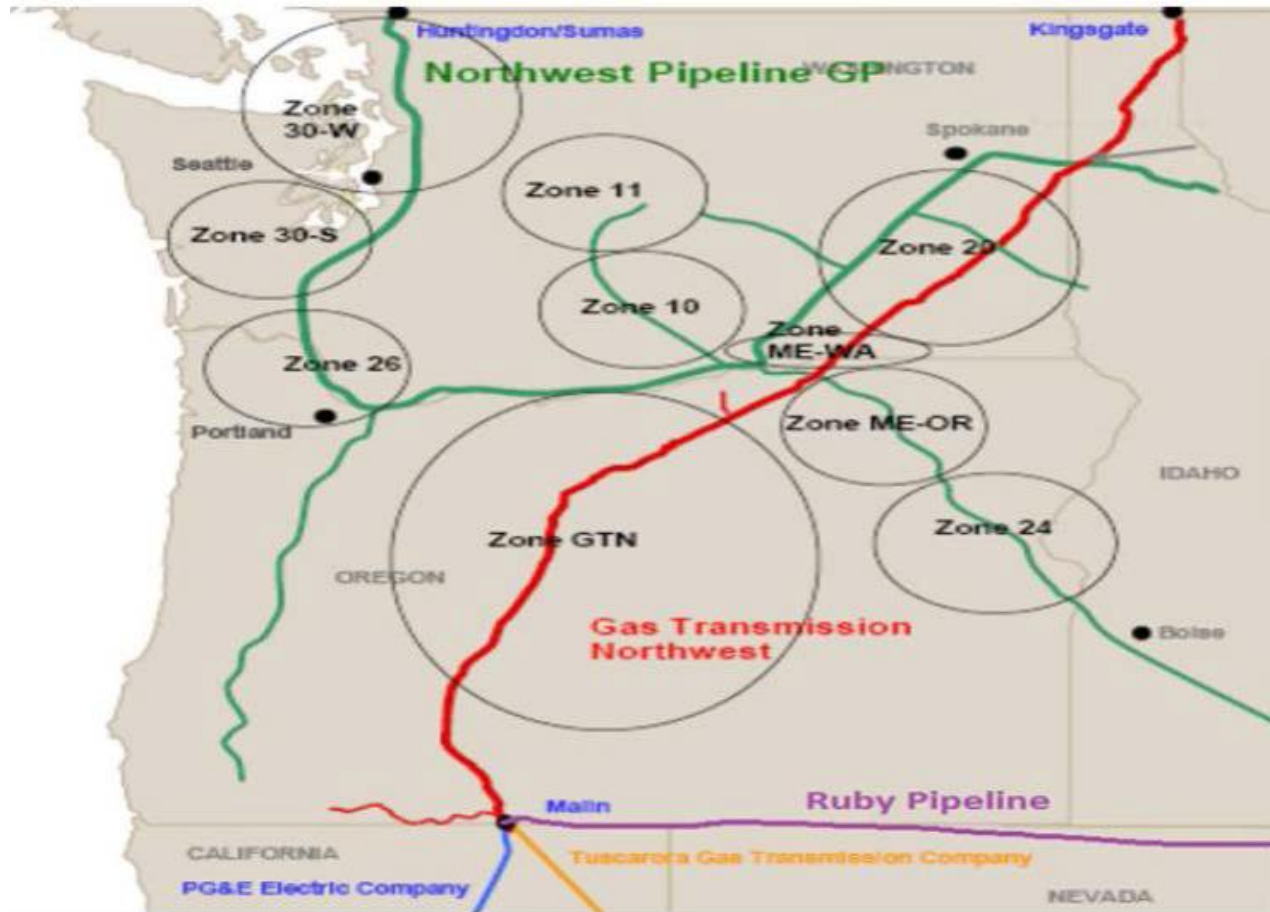
Redmond Peak Day
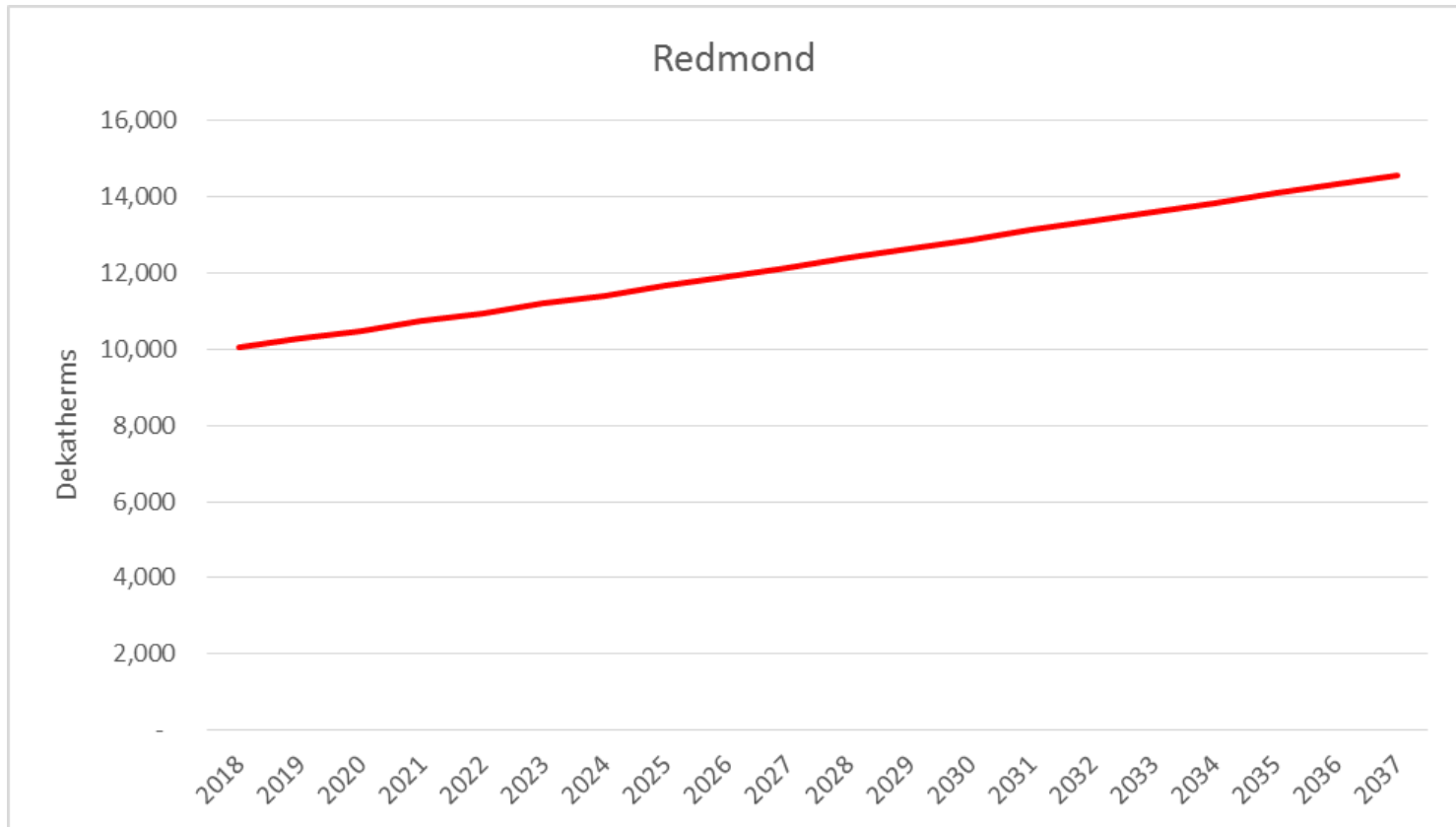
Bend Loop
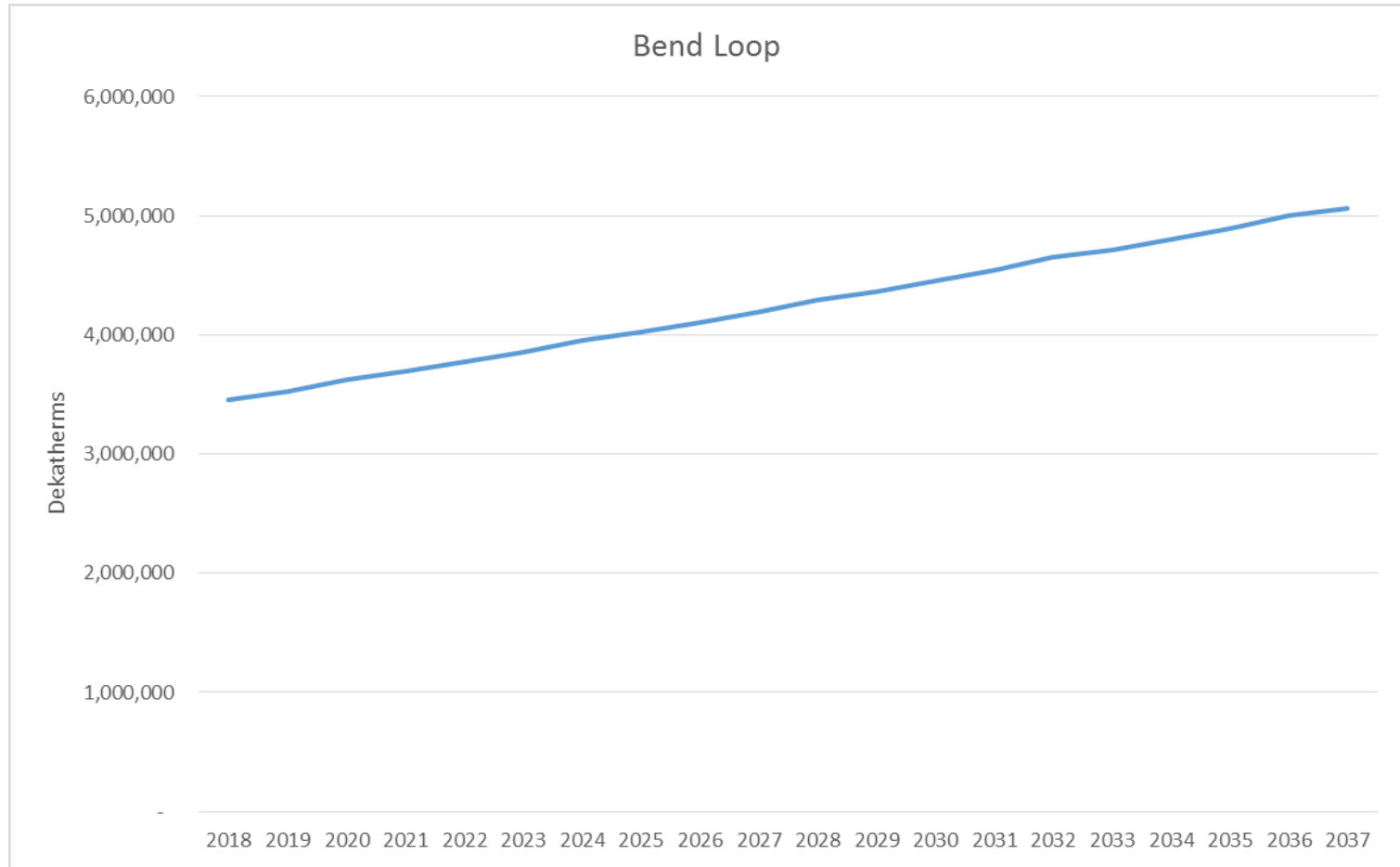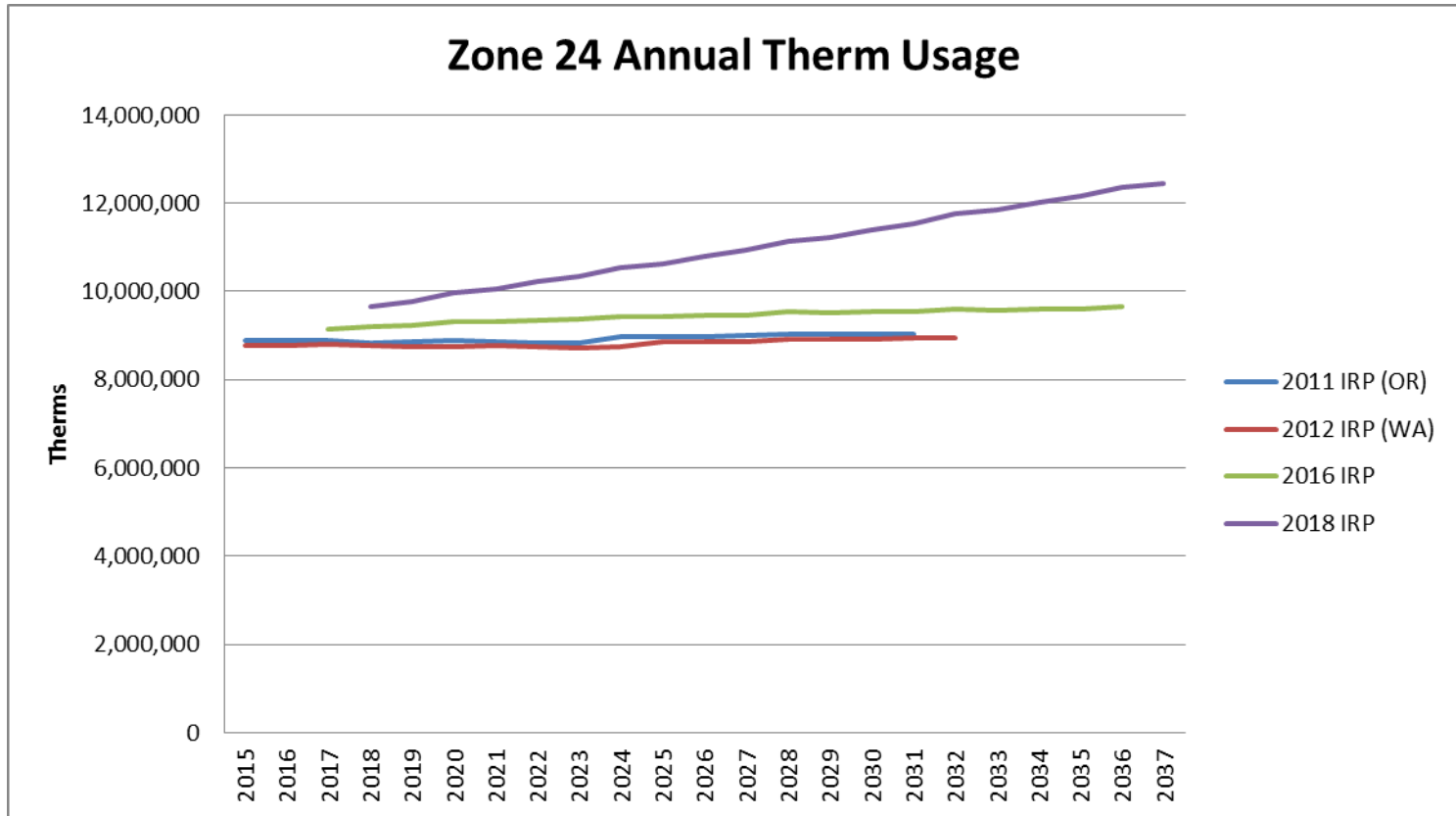
Bend Loop Peak Day
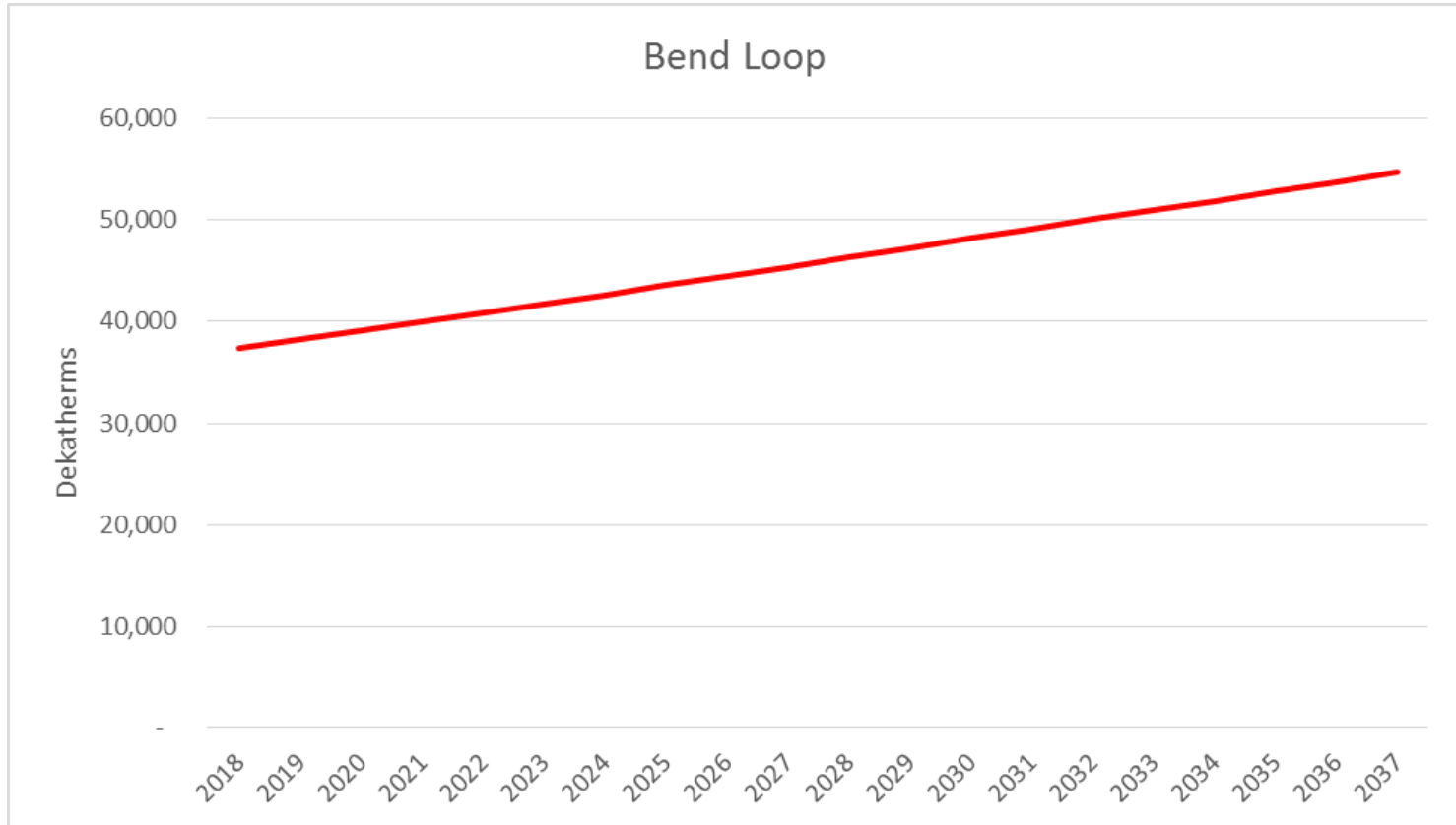
Bend, Oregon

- Bend, Oregon – The city of Bend recently approved an urban growth plan that is projected to allow for the development of 2,380 acres of land. City planners project this will add more than 17,000 homes and 21,000 jobs. No specific timeline for the completion of this expansion is provided in their May 2016 project update.

- http://www.bendbulletin.com/localstate/4818463-151/state-approves-bend-urban-growth-plan
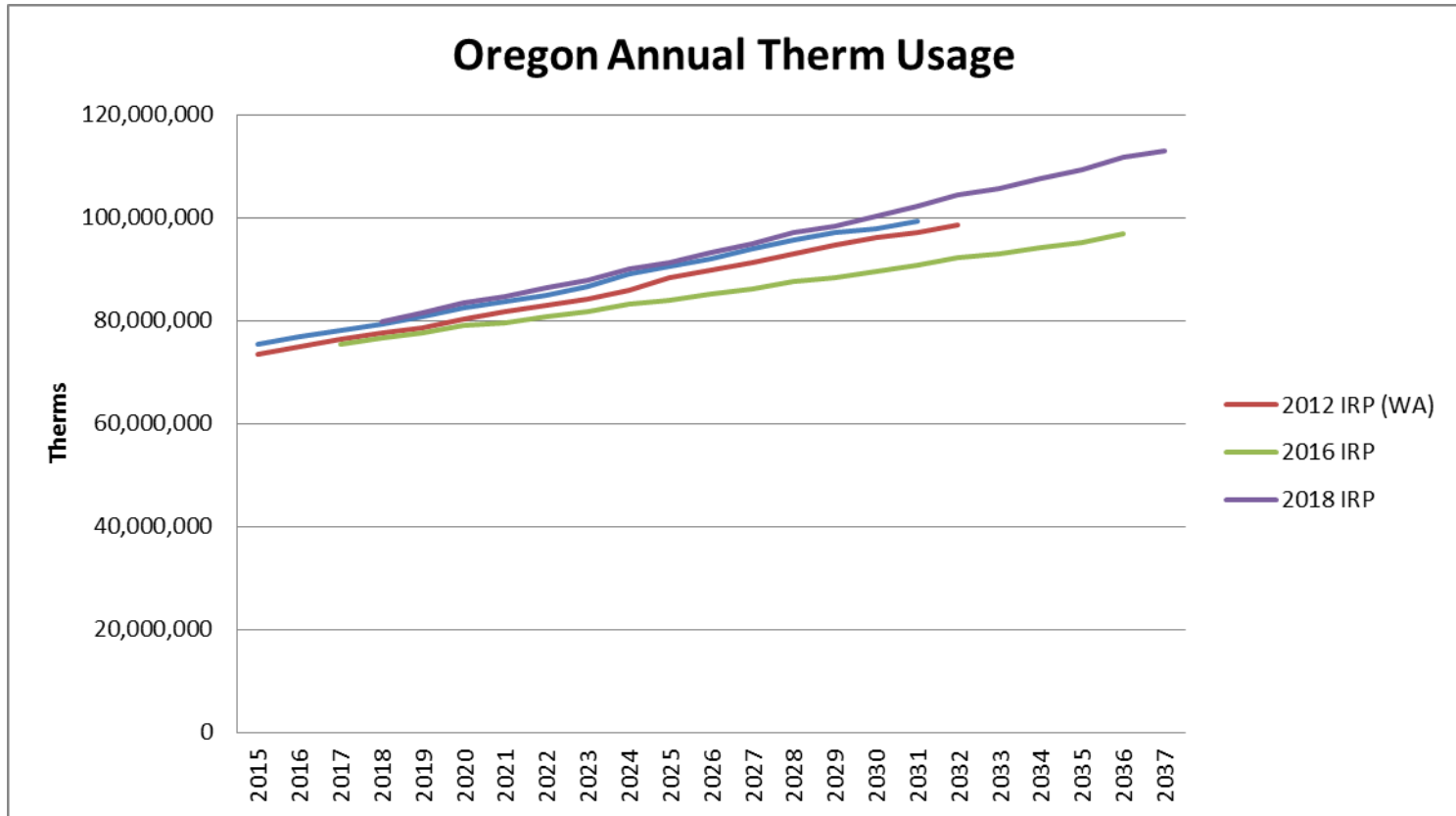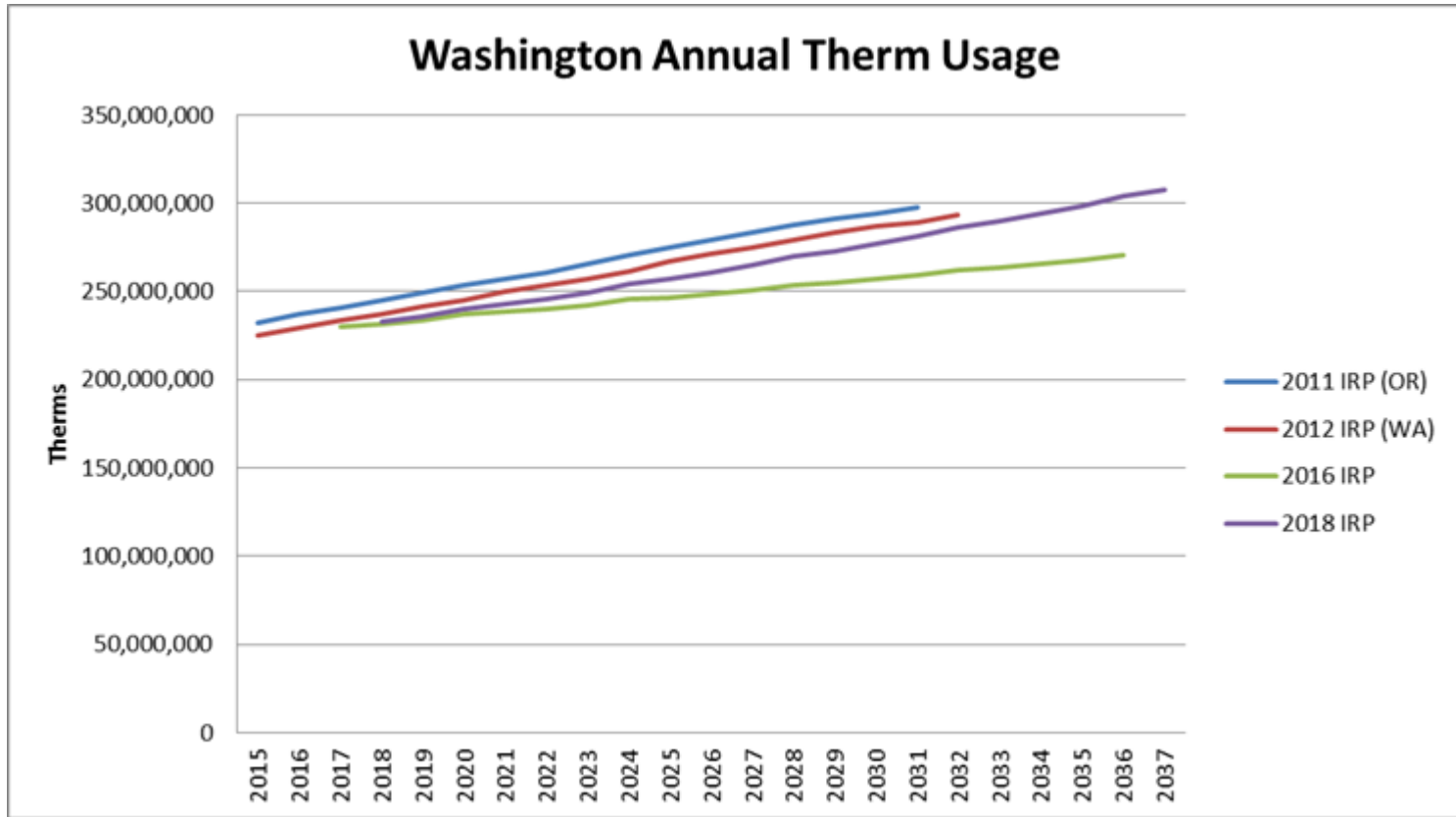
Cascade Zonal Map

Zone 24

Zone 24 Annual Therm Usage

Zone GTN

Zone ME-OR

Zone ME-OR Annual Therm Usage
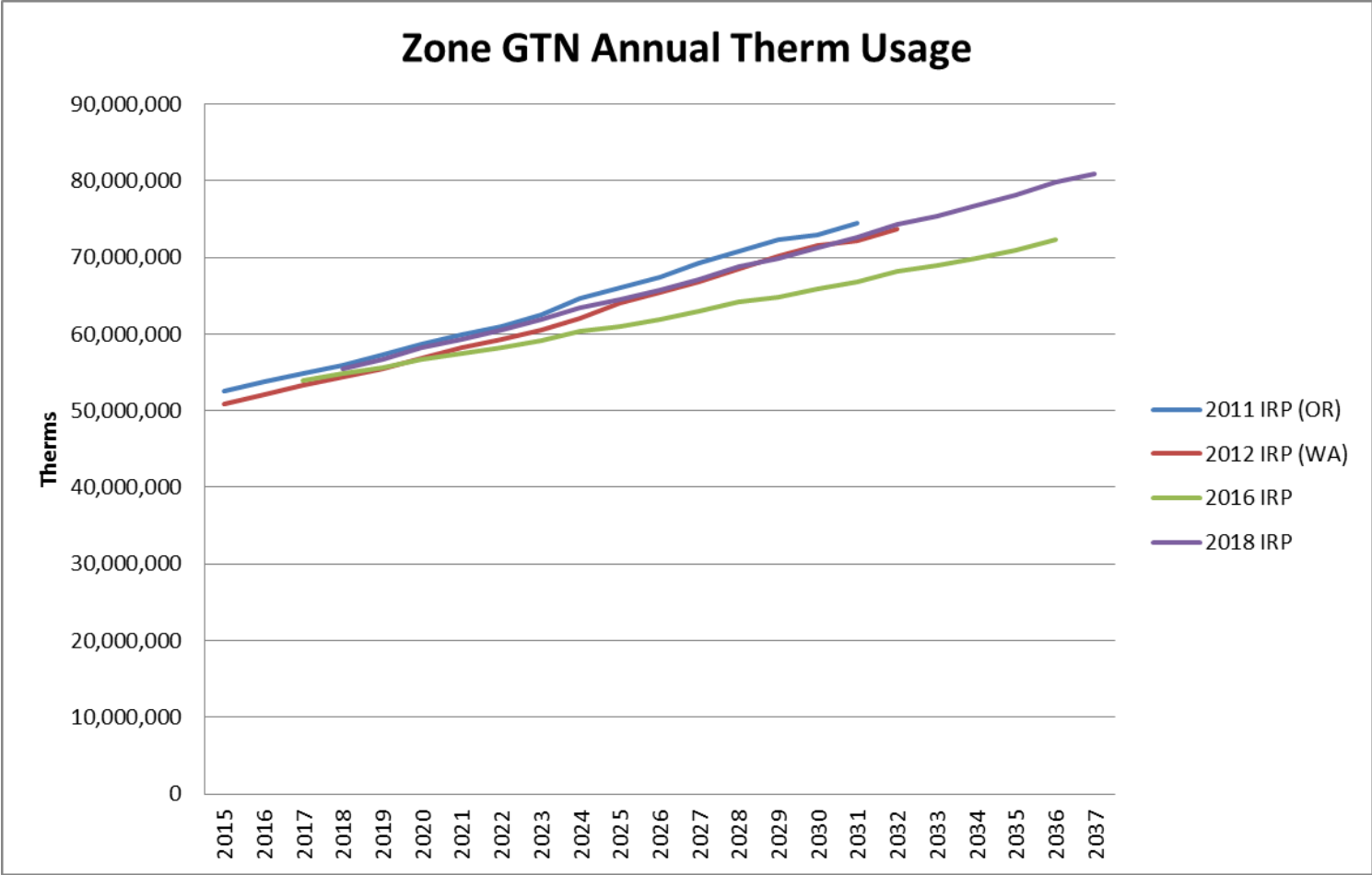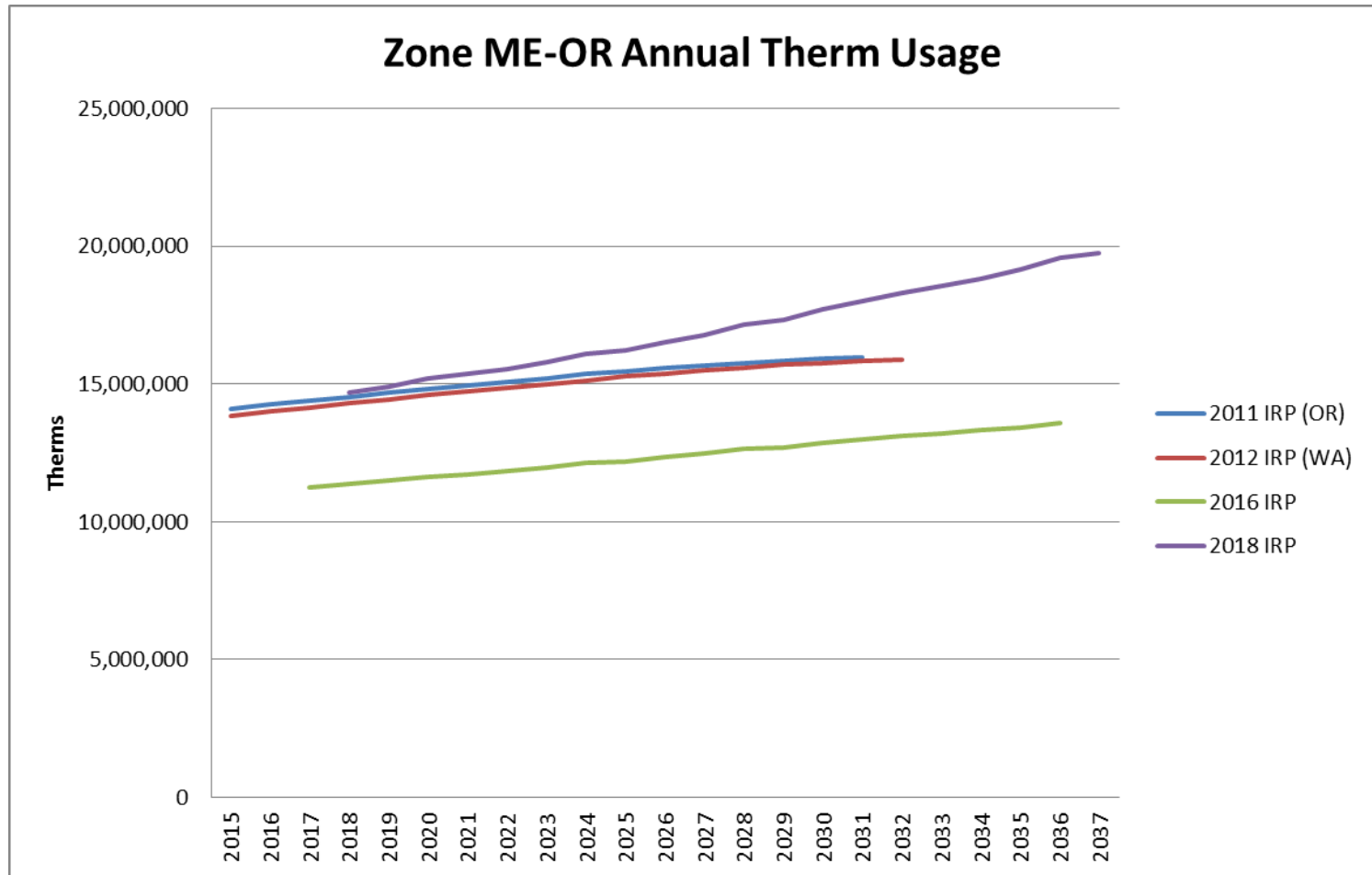
Oregon

Washington

Total System

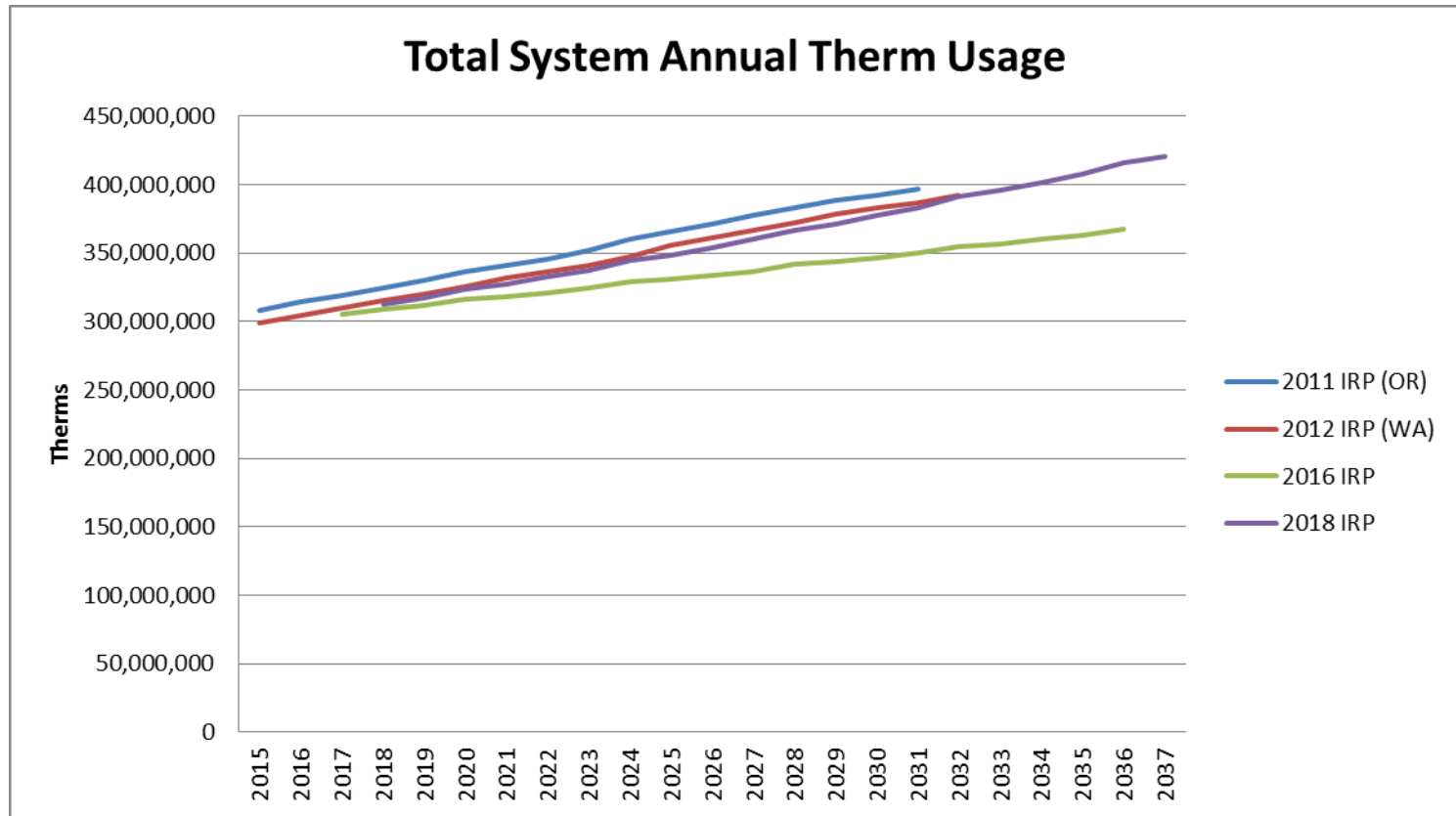**Total System Annual Therm Usage**

Questions/Next Steps

- Review Plans for TAG 2 Discussion
  - Update on any Action Items.
  - Current and Potential Supply Resources.
  - Distribution System Planning.
  - Next TAG is Wednesday, July 19th at OPUC Offices in Salem, OR.

Mark Sellers-Vaughn – Manager, Resource Planning: (509)-734-4589
mark.sellers-vaughn@cngc.com

Brian Robertson – Senior Resource Planning Analyst: (509)-734-4546
brian.robertson@cngc.com

Devin McGreal – Resource Planning Analyst I: (509)-734-4681
devin.mcgreal@cngc.com

Bruce Folsom - Consultant