Appendix A

IRP PROCESS

2018 OR IRP Final

Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #1

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

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.

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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.

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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	

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TABLE OF CONTENTS

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TABLE OF CONTENTS (Cont.)

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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.

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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.**

RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- 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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RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- 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.**

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RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- 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.**

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RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- 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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RESOLVING THE 2014 ISSUES WITH THE 2018 IRP

- 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

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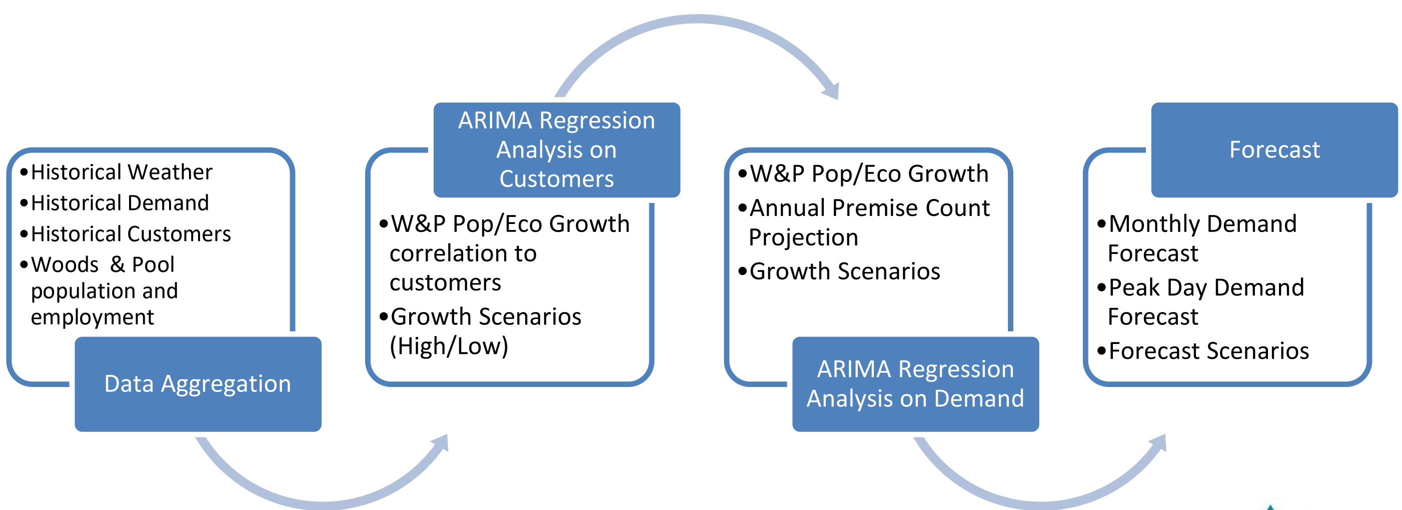
Overview

- 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.



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.

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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

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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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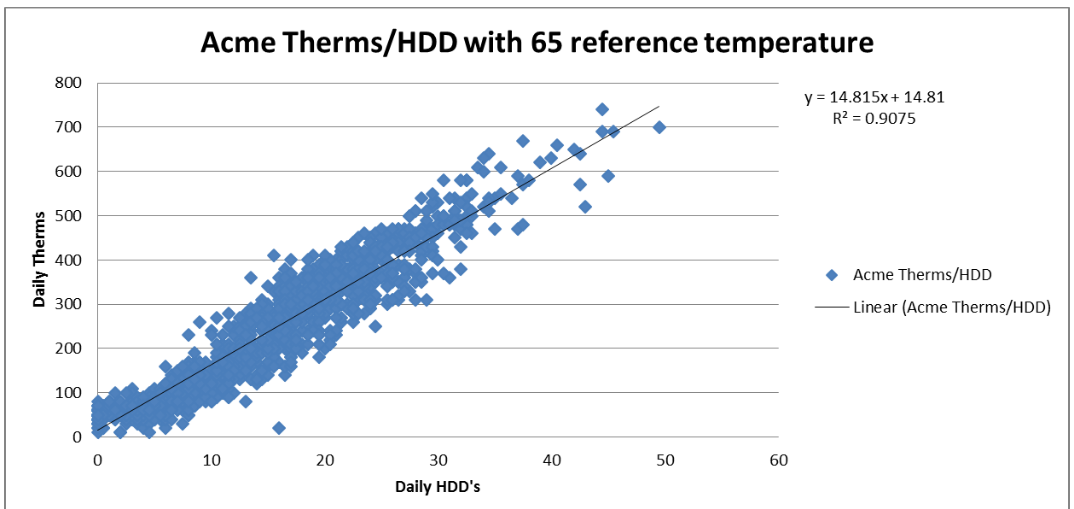
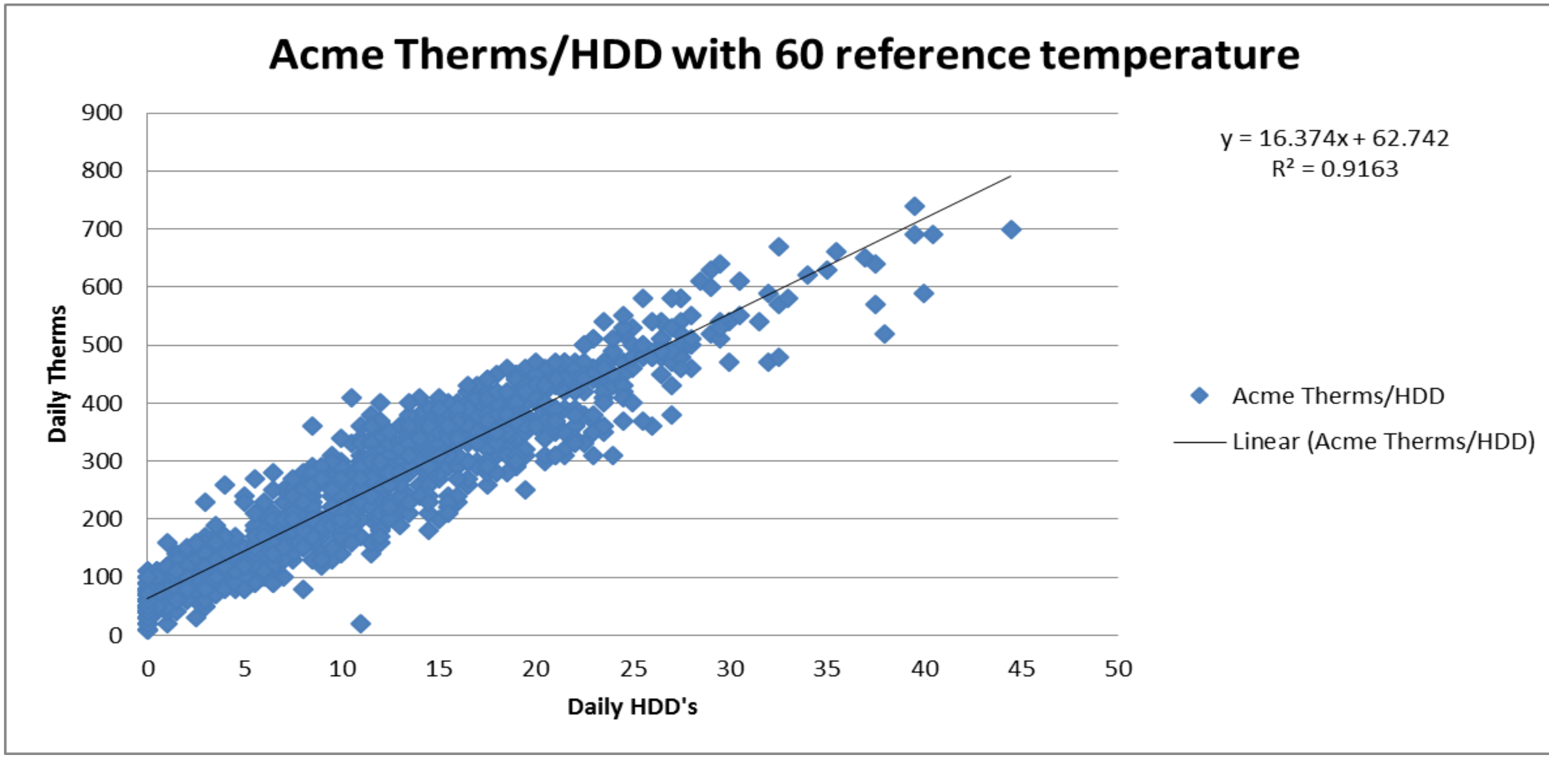
65 vs 60 HDD Threshold

- 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 60 degree reference temperature



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.

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

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

Cascade Natural Gas Forecast Model

Using SAS for ARIMA Modeling

- $\text{Therms}/C^{CG,Class} = \alpha_0 + \alpha_1 HDD^{CG} + \alpha_m I_m + \alpha_w I_w + ARIMA \in (p,d,q)$
- $C^{CG,Class} = \alpha_0 + \alpha_1 Pop^{CG} + \alpha_2 Emp^{CG} + \alpha_m I_m + ARIMA \in (p,d,q)$

- 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∈(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.

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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.

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.

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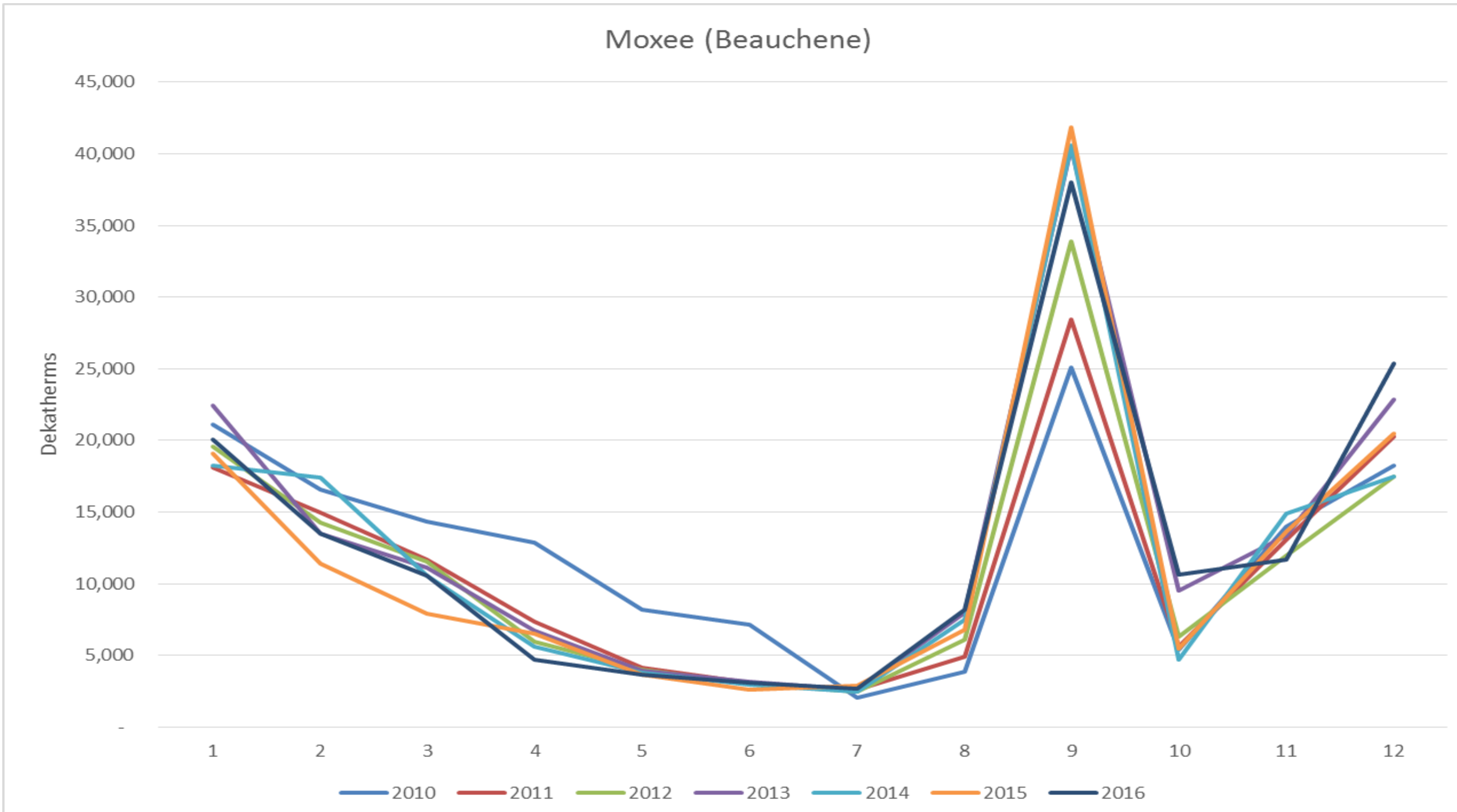
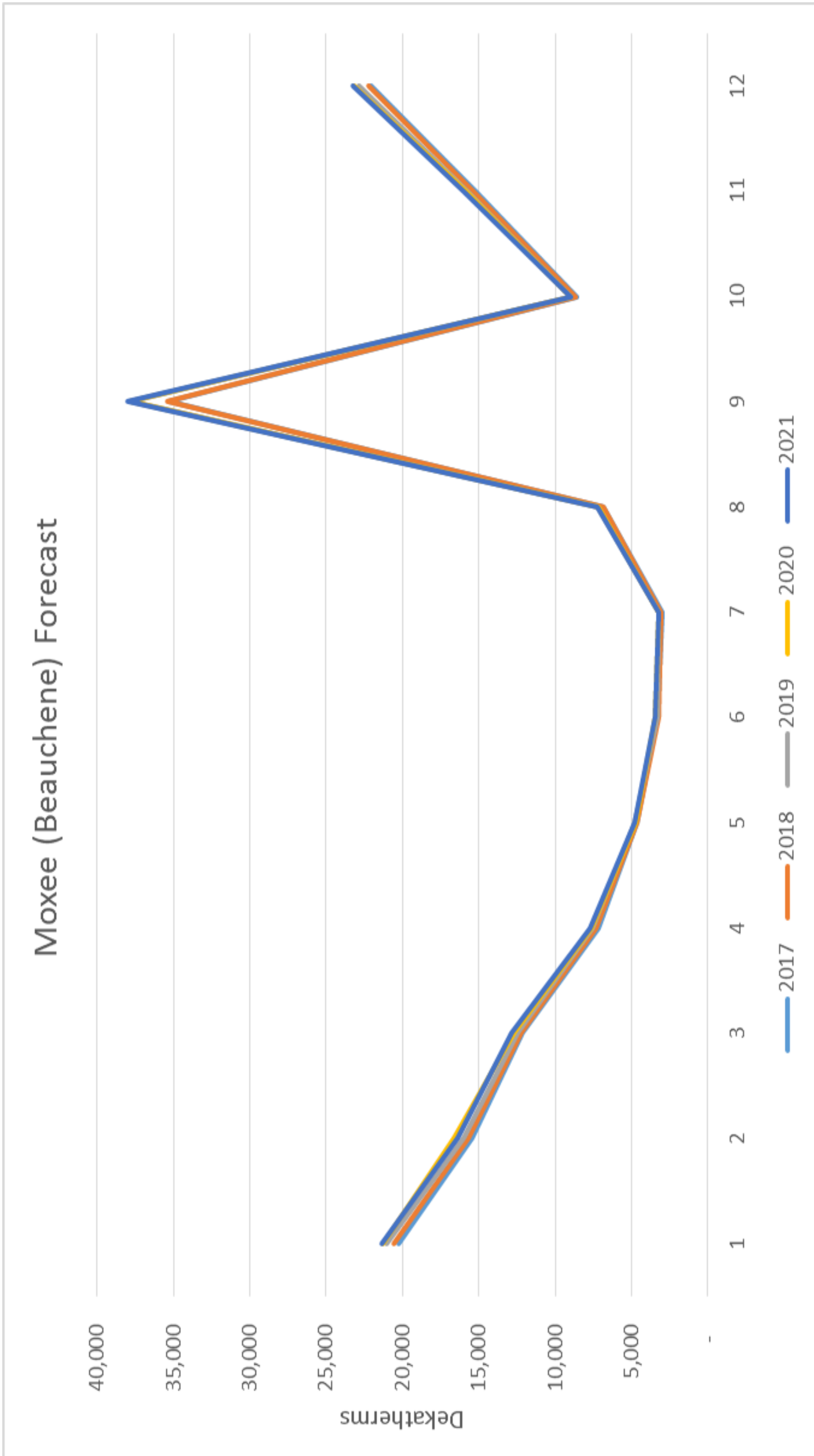
Non-Weather dependent demand

- 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.

Moxee (Beauchene)



Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx 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



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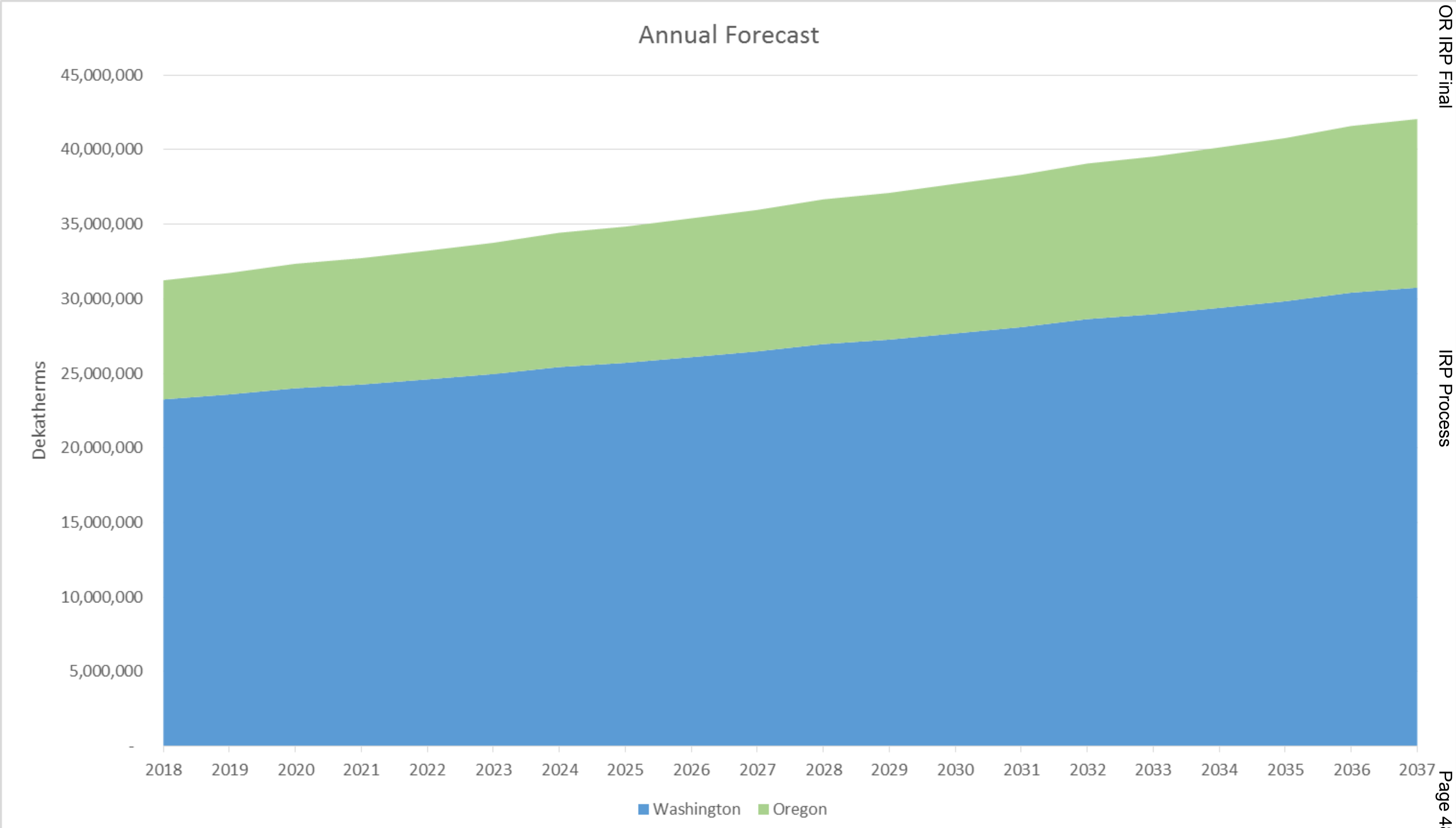
46

Forecast Results



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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.

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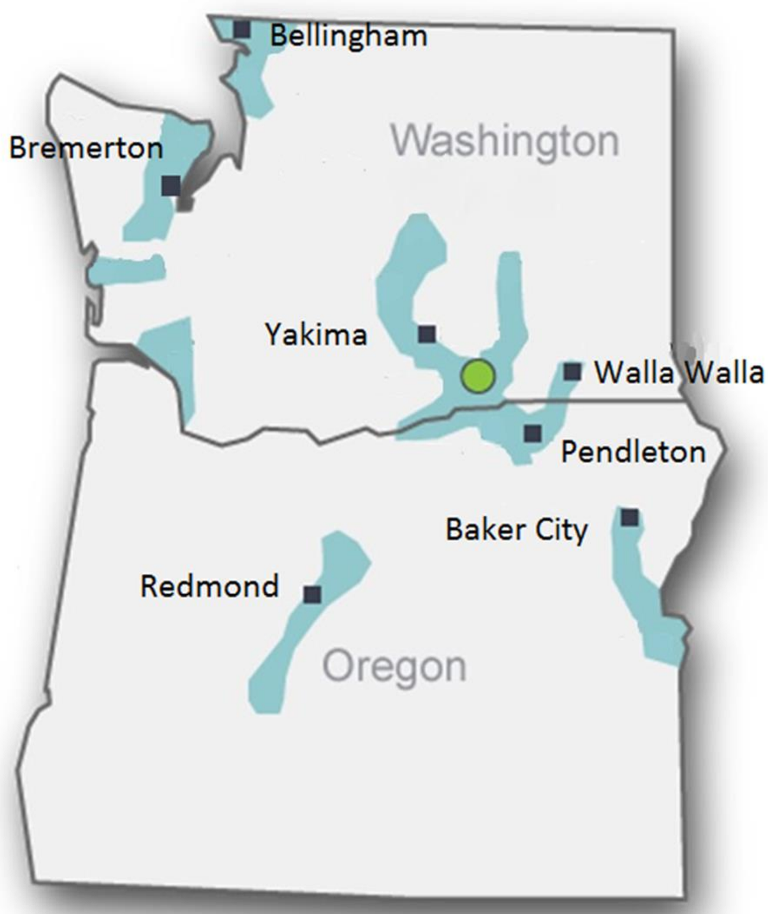
Weather Stations



- 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.

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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

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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.

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.

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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.

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Max and Citygate Peak HDDs

			City Gate Peak HDD						
Peak Rank	System Peak Day	System 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

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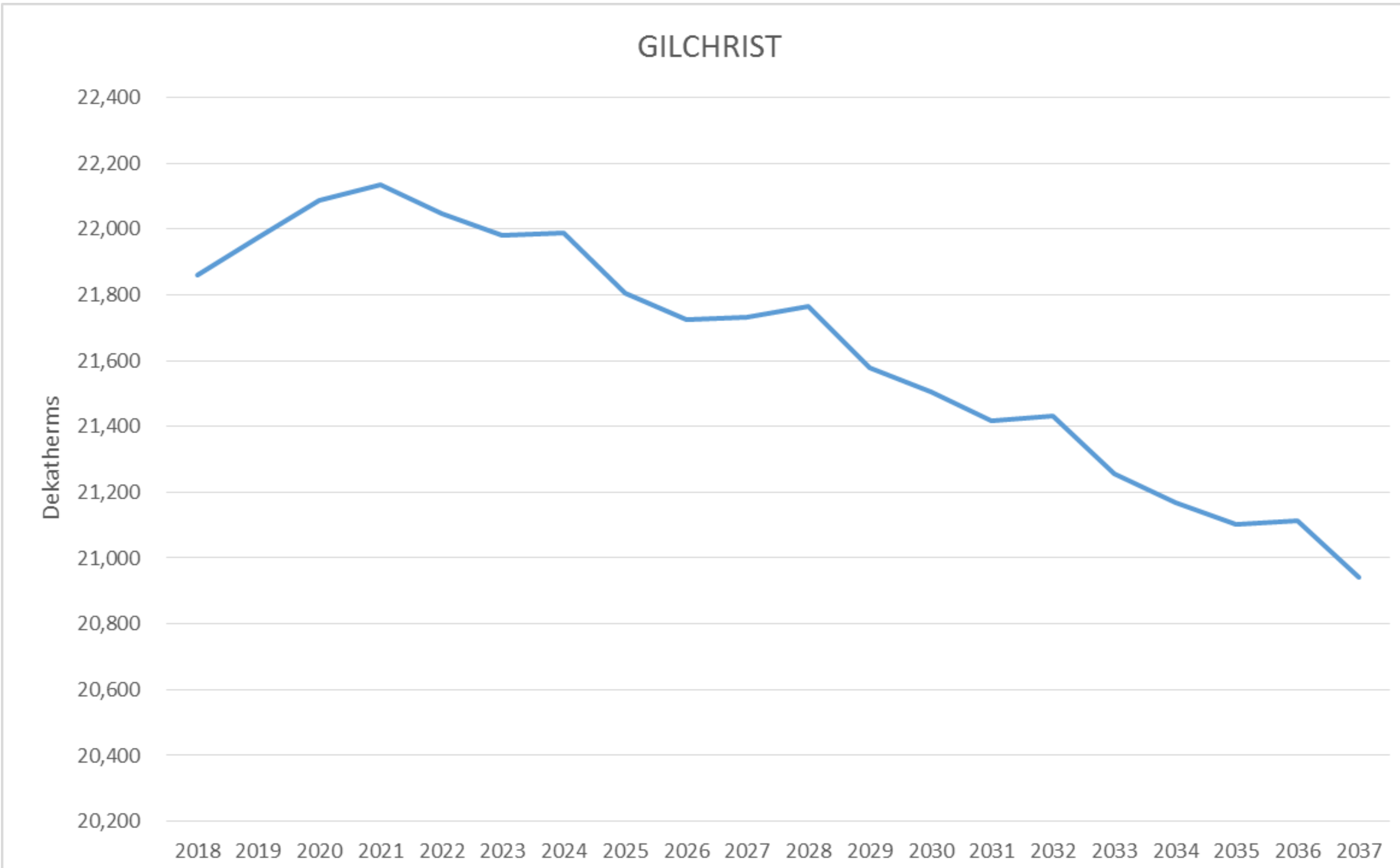
Gilchrist


GILCHRIST
Dekatherms
22,400
22,200
22,000
21,800
21,600
21,400
21,200
21,000
20,800
20,600
20,400
20,200
2018
2019
2020
2021
2022
2023
2024
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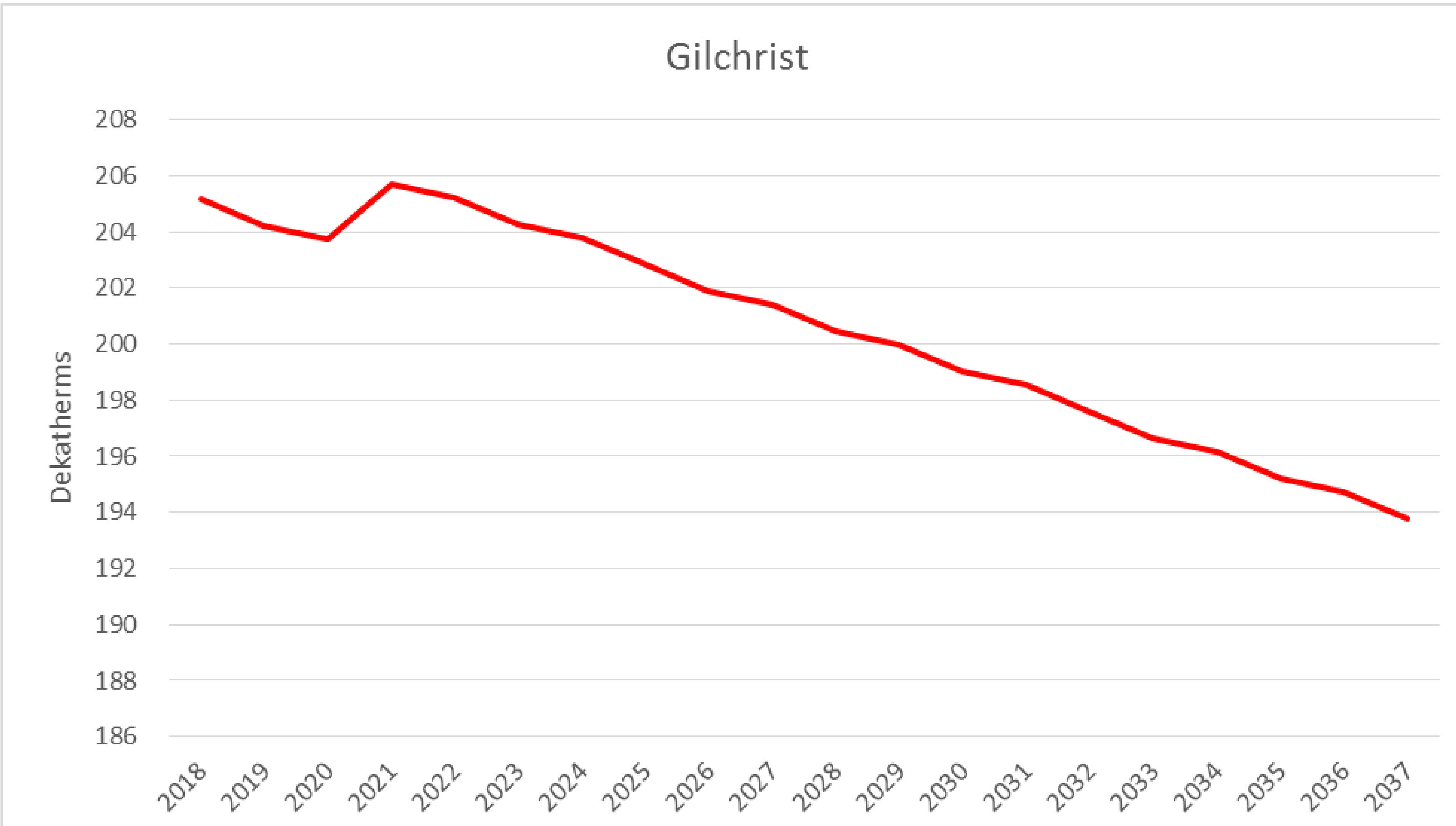
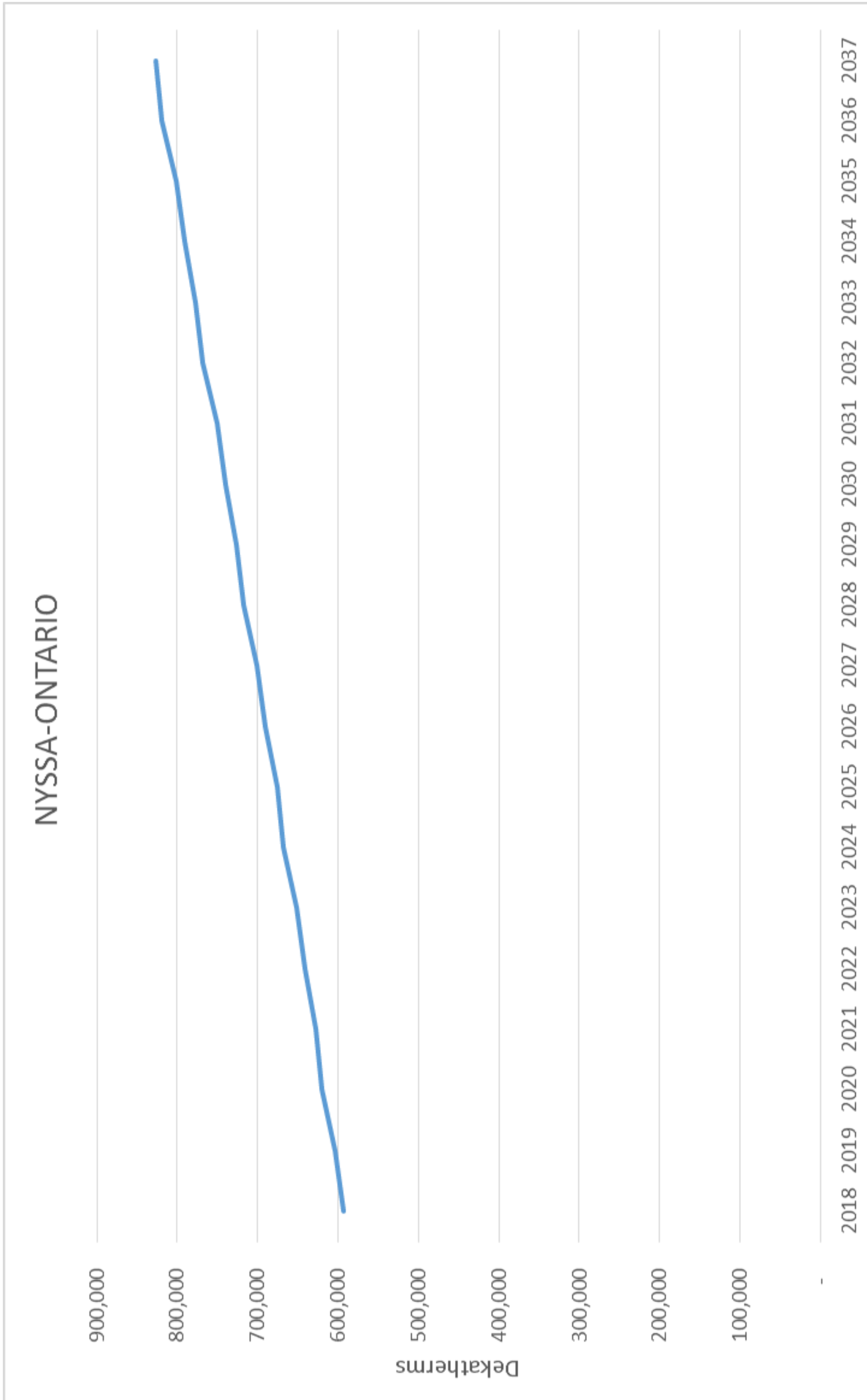
Gilchrist Peak Day



Nyssa-Ontario



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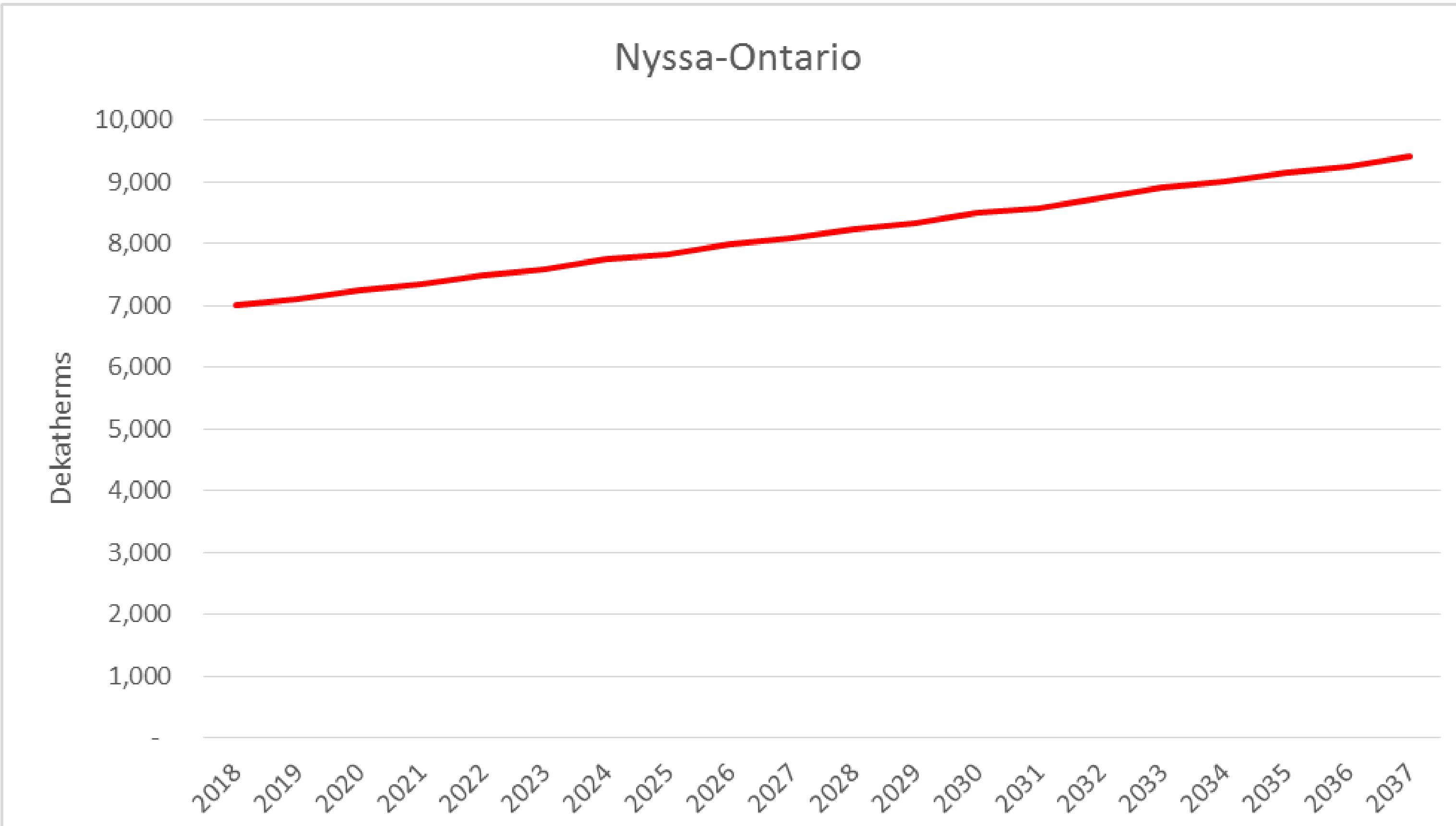
Nyssa-Ontario Peak Day



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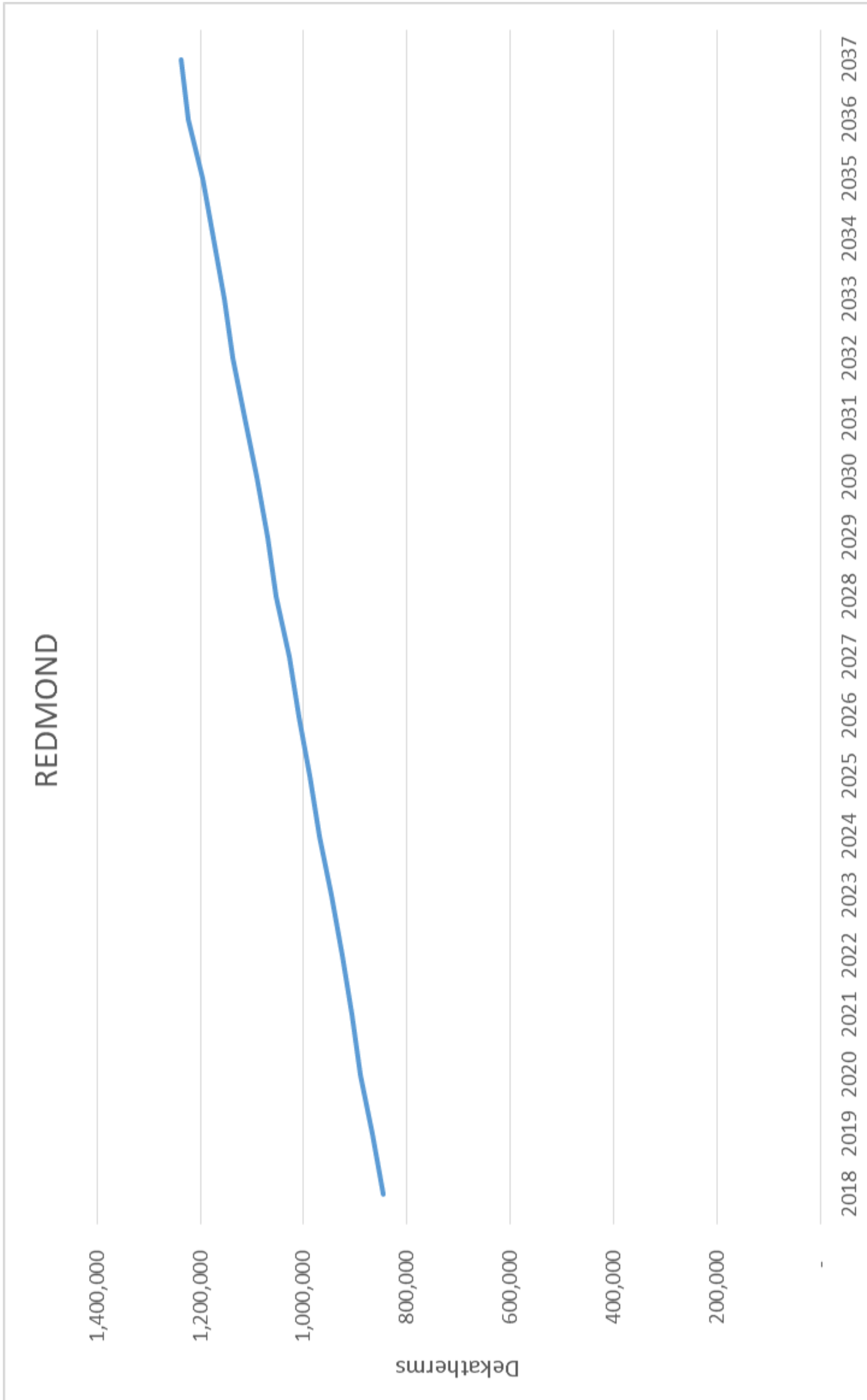
Redmond



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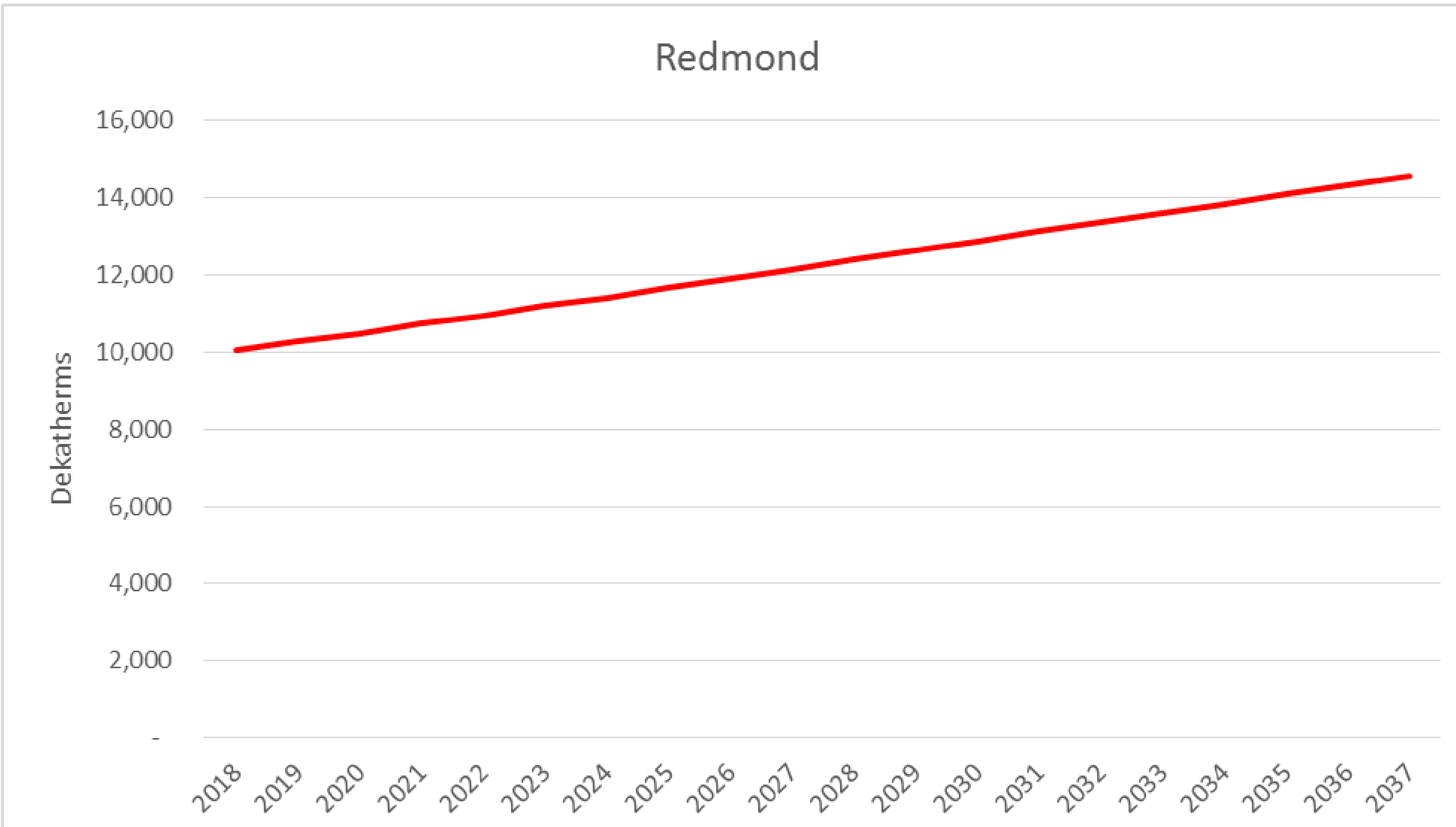
Redmond Peak Day



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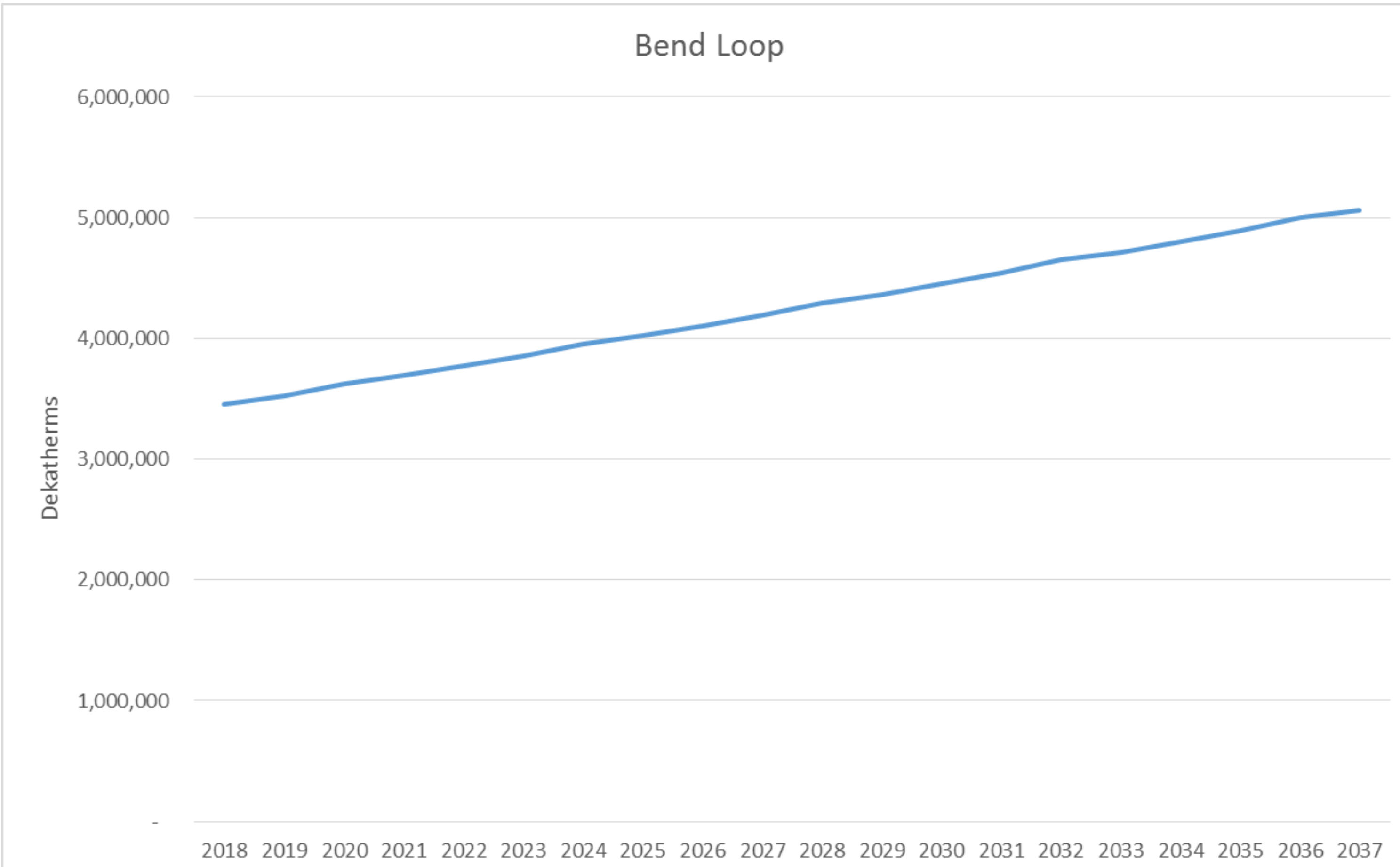
Bend Loop



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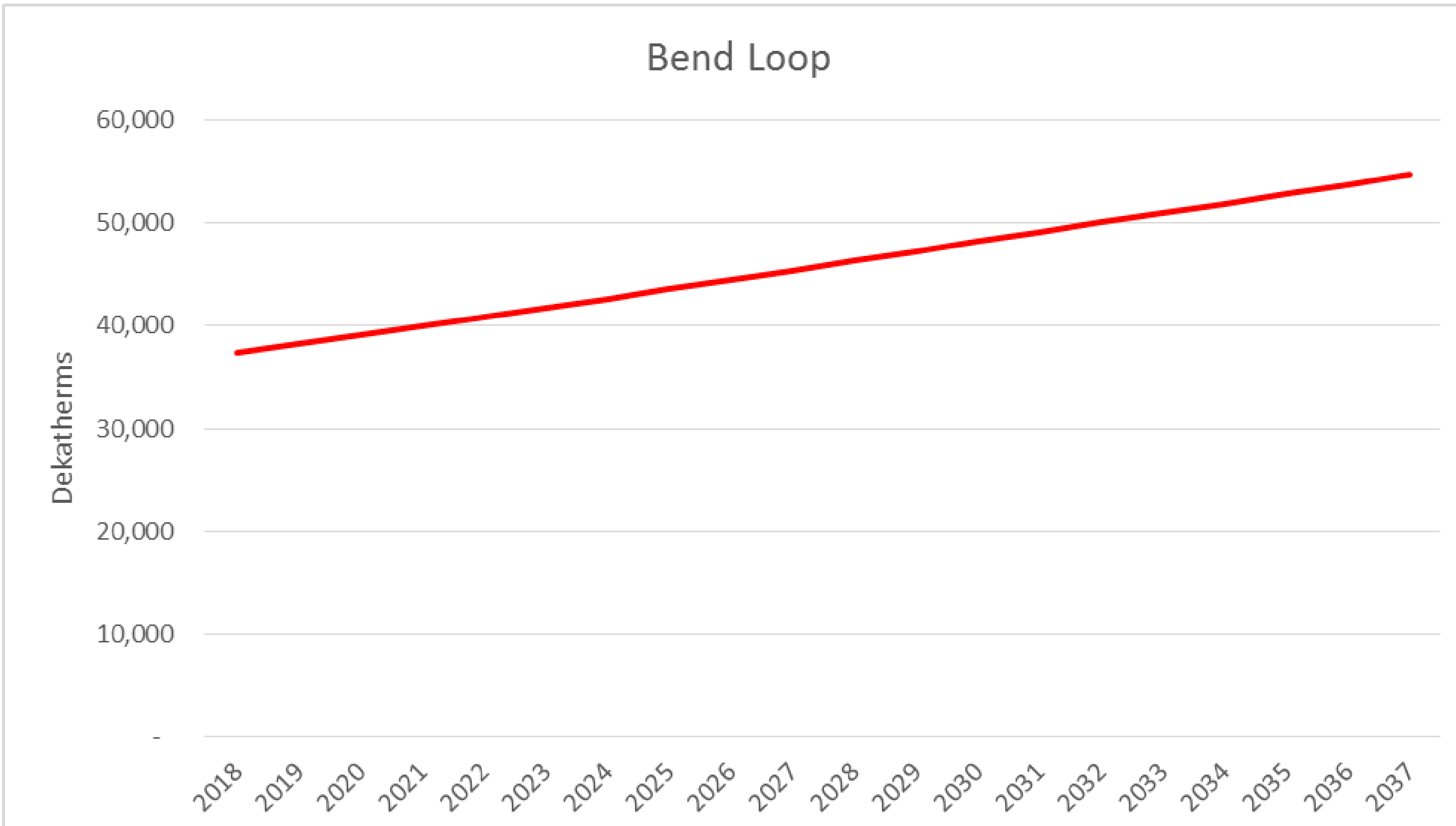
Bend Loop Peak Day



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

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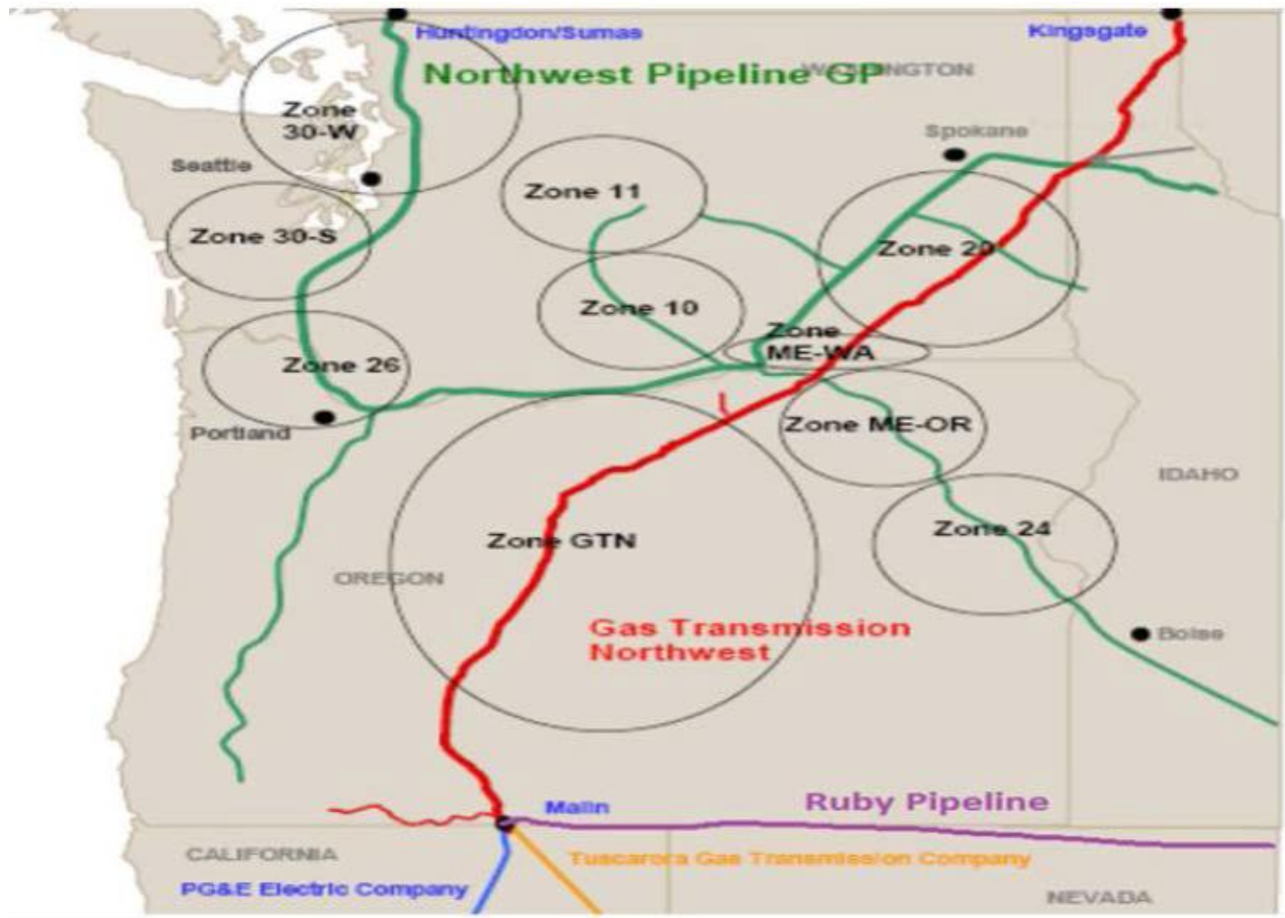
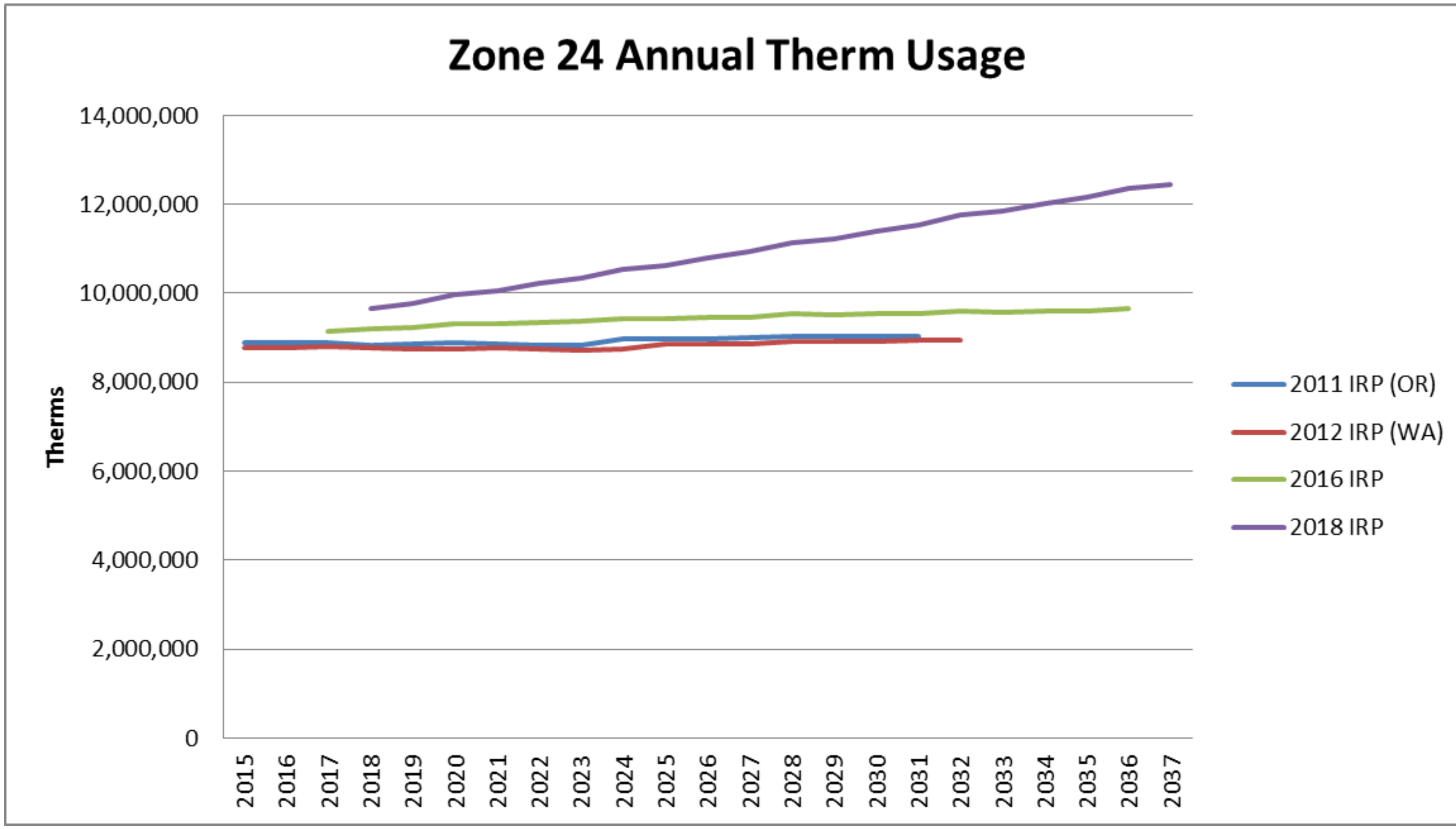
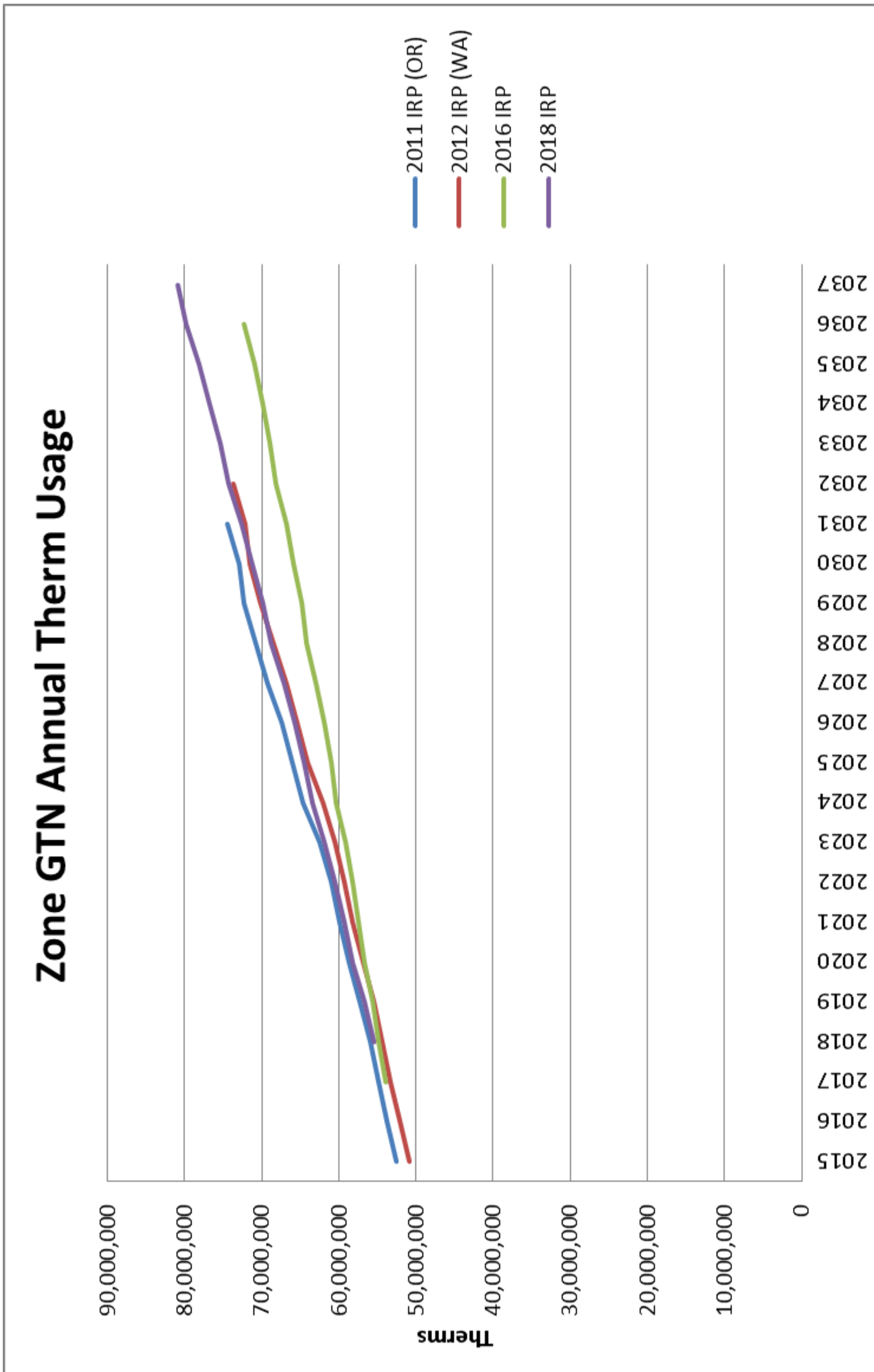
Cascade Zonal Map



Zone 24


Zone 24 Annual Therm Usage
Therms
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2011 IRP (OR)
2012 IRP (WA)
2016 IRP
2018 IRP

Zone GTN


Zone GTN Annual Therm Usage
Therms
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
2015
2016
2017
2018
2019
2020
2021
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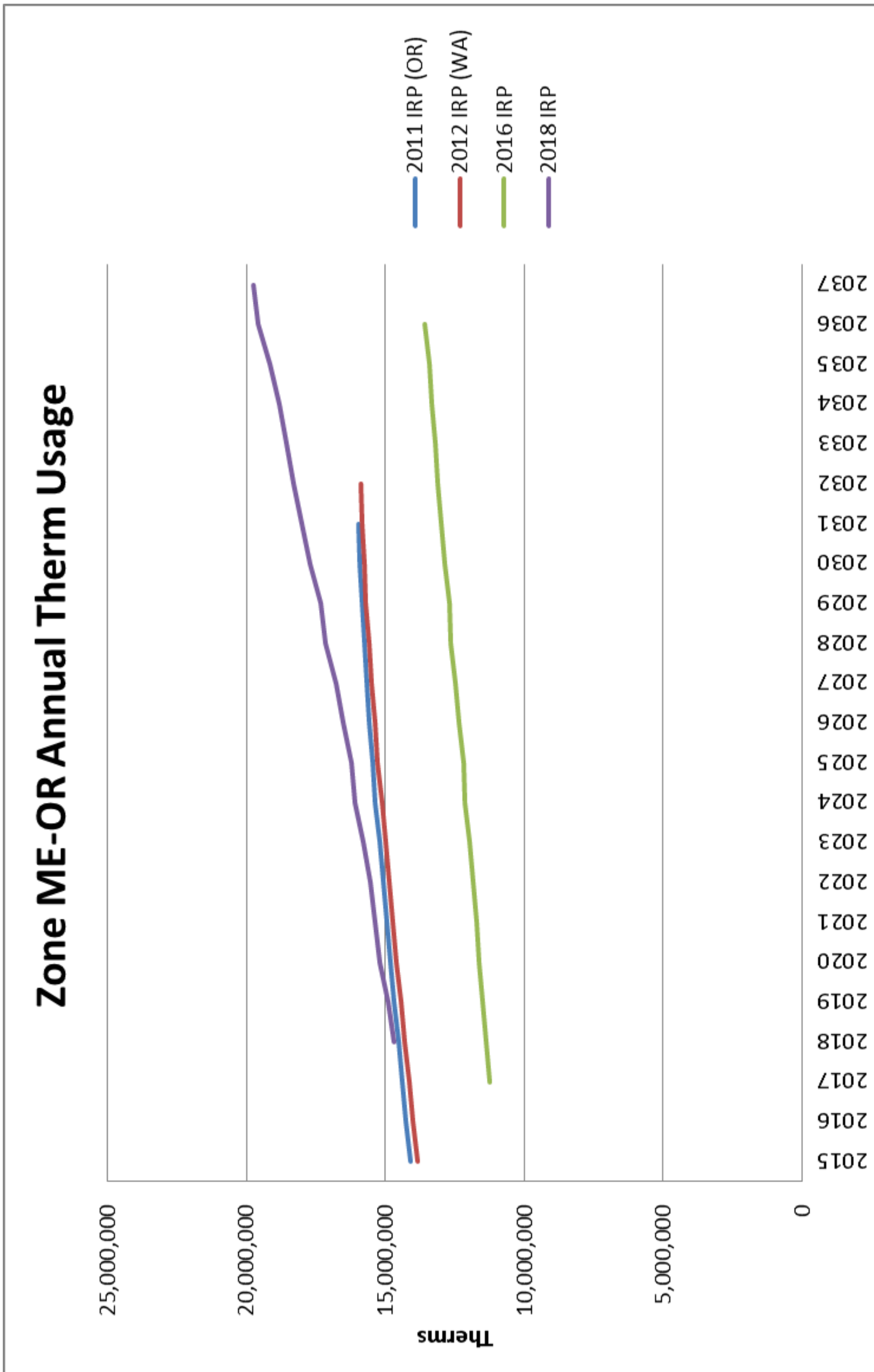
2011 IRP (OR)
2012 IRP (WA)
2016 IRP
2018 IRP

71

Zone ME-OR



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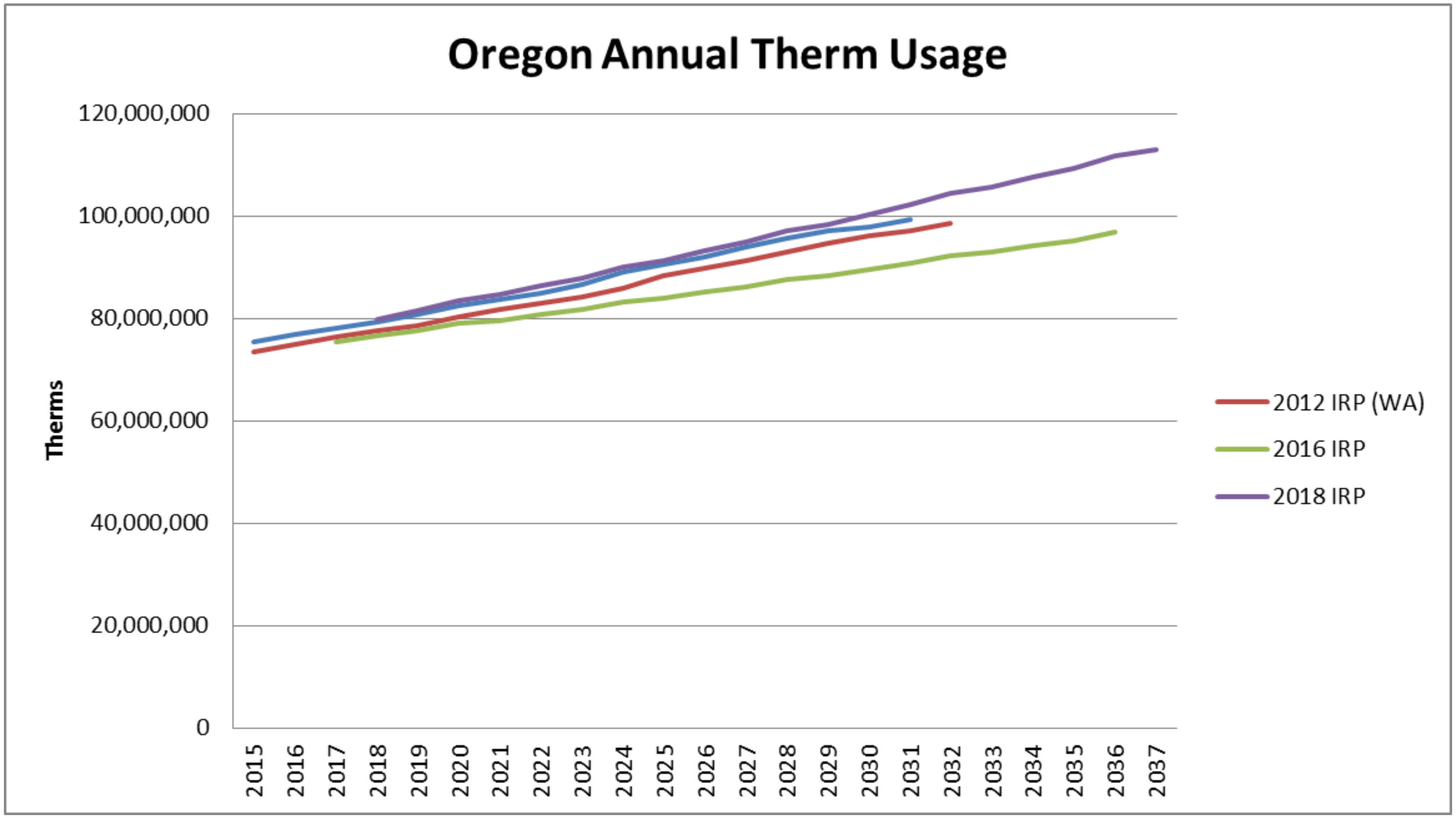
Oregon


Oregon Annual Therm Usage
Therms
120,000,000
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
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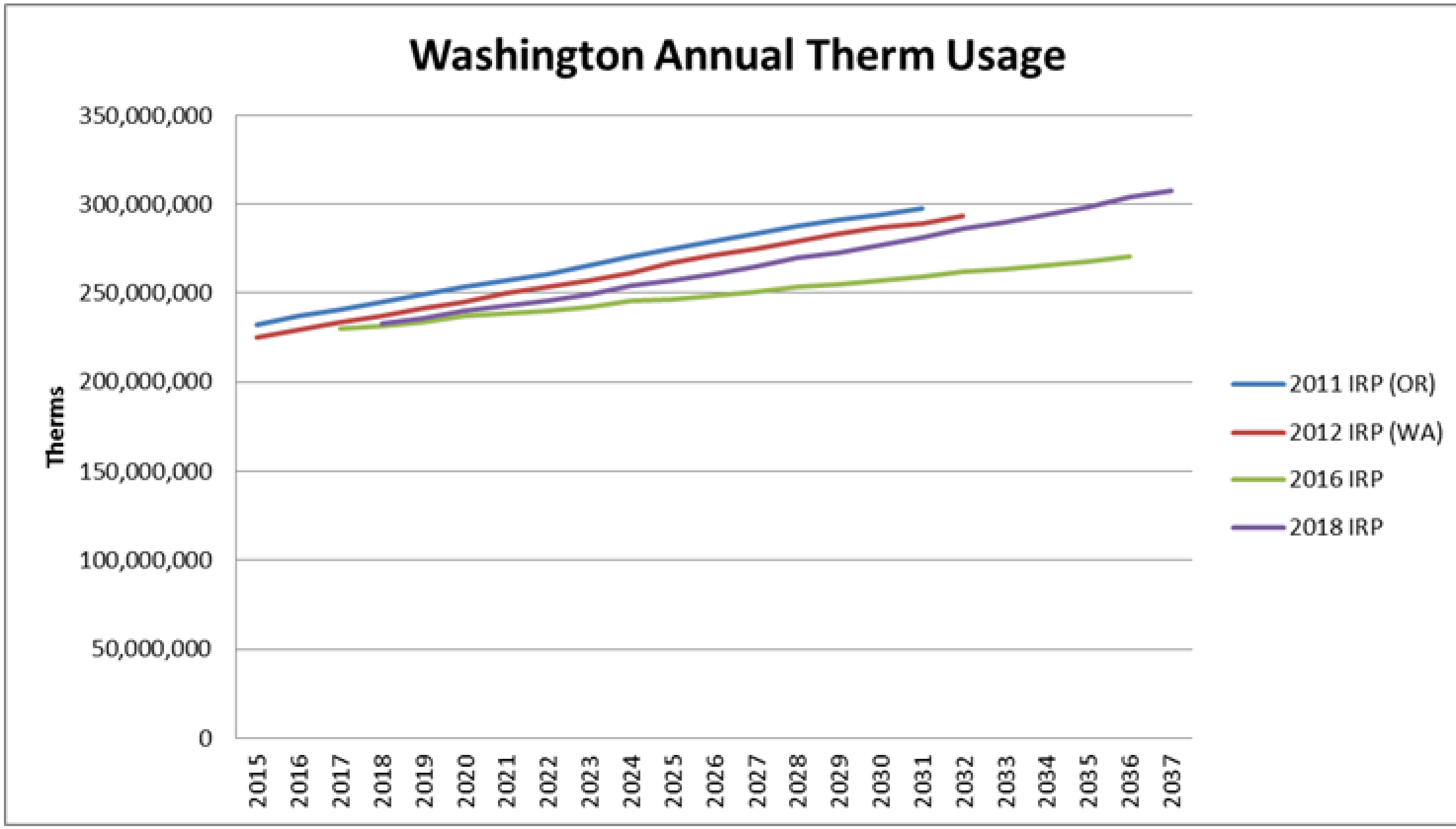
2037
2012 IRP (WA)
2016 IRP
2018 IRP

Washington



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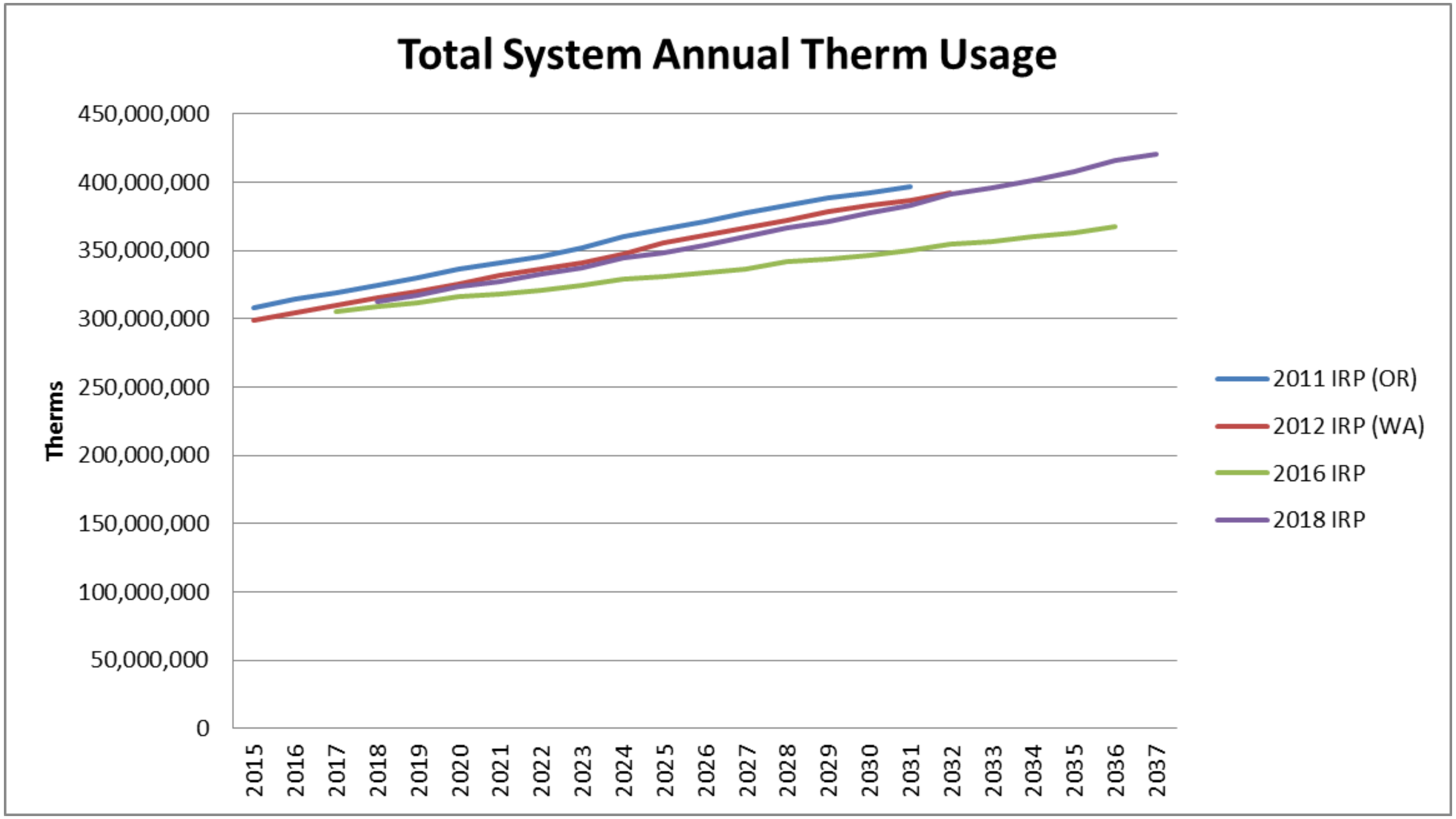
Total System



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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.

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Bruce Folsom - Consultant

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1st External TAG Meeting

05/11/2017, 9:00 - 10:35 AM

Presenters: Mark Sellers-Vaughn & Brian Robertson

In attendance: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal

Called in: Garret Senger, Bob Morman, Miki Bode Jones – NWP, Monica Cowlishaw, Bruce Folsom, Paul Russell OPUC Staff Representative, Ed Finklea, Mike Paruszkiewicz – Northwest Natural Gas, Deborah Glosser OPUC Staff, Carolyn P Stone

Minutes by: Carolyn P Stone

Mark welcomed everyone to the meeting, noting that Deborah & Lisa are out ill and Paul Russell is in attendance today as OPUC Staff representative.

Mark went over today's Agenda and explained that Brian Robertson would be giving the Cascade Demand Study overview and model results, then back with Mark for the next steps.

Slide #'s 3 & 4 - Mark started out on Slide 3 & 4 with the history of Cascade Natural Gas.

Slide #5, 6 & 7 - Devin McGreal discussed the "Resource Decision Making Process" including regional market outlook factors, noting 3 pitfalls (slide #7) that could lead to large economic losses such as:

1. An "isolationist" attitude in the US
2. The European Union (recent election in France)
3. Possible Chinese debt crises

Other than this the natural gas industry looks healthy. They are watching water & storage levels, as well as keeping an eye on the NGTL capacity per Slide #8, the "open season" opening bids up to 408 GJ/d. Slide #8 also refers to the Portland and surrounding county "pledge" to power the region with green energy only and national "net" storage injections.

Slide #9 - Mark then went over the Draft 2018 IRP Timeline. The TAG meetings, except for TAG 3, will all be held in Salem. TAG 3 will be held at the Portland airport. He urges the group to look at this timeline and to confirm there are no conflicts.

Slide #10& 11 - Table of Contents & Appendix Table of Contents. Mark briefly discussed the 2014 IRP issues here…i.e. staffing, the narrative content, etc.

Slide #12- Mark described the addition of new staff to the Resource Planning Department in 2016. The IRP team also has a consultant, Bruce Folsom assisting.

Bruce introduced himself as being retired from Avista Utilities and before that was part of the WUTC staff, thus he brings 30 years of IRP experience! He went on to say he is pleased with Cascade's commitment and progress on the IRP's. The filing in Washington was strong and had an aggressive schedule. He is very impressed with the 2 new analysts, their progress & Mark's leadership.

Mark also went on to mention that, in addition, there is an IRP Steering Committee including 2 directors and 3 vice-presidents. There are also many other departments that have provided help to the IRP such as Conservation, Engineering, Accounting, Regulatory, IT, the executive team, Gas Supply and others….

Mark stated about the Table of Contents for the group to let them know if there is anything else needed here, improvements or additions??

Mark stated Cascade has a webpage solely for the OR IRP Process.

Ed Finklea made some comments about the fact that the plan is becoming challenging with pipeline capacity issues, etc. and political pressure. He went on to discuss the "electrifying" of the economy. Since electricity is carbon free, there are some movements to convert the economy to electricity from gas!

Slide #13- Shows the 2018 IRP TAG participants

Slide #14- The IRP Guidelines, order #07-002, Admin Rule #860-027-0400. This is a long-term resource planning process per regulatory requirement.

Slide #15 – 2014 IRP Issue updates.

Mark discussed the recent publishing by the Washington Utility Commission of a "Hedging Policy". Cascade is required to develop a policy regarding financial hedging. We intend to present this as part of the 2018 IRP.

Also, there will be a more comprehensive list of engineering projects to be implemented over the next several years included.

Presentation #1 – Brian Robertson
Cascade Demand Study

Slide #24- Brian Robertson went over the 20-year forecast of core natural gas demand and core peak demand. Core load is 53% is residential and 47% is commercial.

Population, employment growth, and historical weather are used in study. Creates a monthly demand forecast for 20 years at the citygate & citygate "Loop" level. Allocates citygate to each weather location, classes used are residential commercial, industrial and core interruptible.

Slide #26- **Key Points**

Demand weather/customer driven. Forecast uses 30 years of weather history to forecast 2018 – 2037.
Uses various scenarios with average year and extreme cold year, high growth and low growth. Analyzes 55 citygates & citygate "loops". 60-degree HDD threshold is used.

Slide #27- **Input Data**
Brian Robertson explained that inputs include data from EBB (Pipeline electronic bulletin boards), the gas management system called "Aligne" and CC&B (customer care & billing). Weather data is obtained from "Schneider Electric" and population/employment information from "Woods & Poole" and local market intelligence.

Slide #28 – **Weather Data**

Weather data is defined in terms of "Heating Degree Day" (HDD) using 30 years of data. Brian explained why the 60° threshold is used rather than 65° and gave an example of how the 60° figure is used to determine HDD. 65° was the figure used for many years, but in testing it, it has been determined that 60° provides more accurate results.

Slide #31 – **HDD with 60° reference temperature**

In Slide #31 Brian shows the group a graph using HDD with 60° reference. Brian asked if staff was expecting anything else here.

Slide #32 – **Demand Forecast Process Followed**

Pipeline data is received daily at the citygate = both CORE/Non-Core. Brian said his group uses Aligne to "back out" the Non-Core values to get the Core values at the citygate. They then use CC&B to allocate the demand into "rate classes" as mentioned earlier. Ex scenario: What % of "Bend Loop" comes from residential demand?" CC&B data doesn't run on a "month to month" basis, so had to be "shifted forward" 1 month to match values to day of month. The IRP team then worked with the GIS group to get even more accurate allocations.

Slide #35 – **Demand Forecast Example**

This sample shows the results to the query above regarding Bend Loop.

Question: Mark asked what units this represented.
Answer: Brian answered "Dth's"

Brian stated that in the columns titled with month names, there are "seasonality indicators". Also, after shifting from city level allocations to County are made. Then after that the county customer forecast is allocated to citygate.

Slide #37 – Brian shows here how customer count, population, and employment factors are used.

Slide #39 – Brian explained here that this is the formula using SAS software for Autoregressive Integrated Moving Average (ARIMA) modeling and goes through the next few slides explaining the technical aspects of this methodology.

Slide #40 – Brian explained the way statistical analysis is used in the customer forecast.

Slide #42 – The final demand forecast includes year, month, rate class & citygate. Each model was done as using ARIMA, removing non-significant variables, using Akaike info. & MAPE. The demand forecast per customer is then applied to the customer forecast and that makes up the monthly demand forecast.

Slide #43 – Brian explained that there is demand which is not influenced by weather, for example, a customer may ramp up usage based on the season. Cascade now leaves this non-weather demand in the model, rather than removing it.

Slide #44 – This is an example of the city "Moxee" using seasonal monthly indicators, where you see the "ramp up" captured in September!

Slide #47 – Brian explained this slide shows the forecast results, with WA in blue and OR in green.

Slide #48 – This slide discusses the "growth scenarios" used in the model and Slide #49 shows the 7 weather stations associated with each citygate and loop.

Slide #50 – This slide discusses the "weather scenarios" used in the Monte Carlo weather simulations associated with the forecast.

Slide #51 – Brian shows a page of the resulting Demand Forecast including 6 areas through 9 months of 2017. Oregon citygates are shown in green. The Washington forecast is broken down by district & zone.

Slide #52 – Brian explained how the peak day forecast was created, showing the system weighted HDD on Slide #54.

Brian stated the max peak day was on 12/21/1990 - 56° weighted HDD. Our peak day was 11 degrees colder than this most recent winter.

Slide #55 – Brian discussed the value of the average peak day forecast.

Slide #57 – Citygate peak day forecast – Brian stated that this assumes every single weather location has their coldest day on the same date!

Slide #58 – Citygate peak day forecast – allows planning for coldest day at each weather location. On Slide #58, the max & citygate peak HDD's are shown.

Slide #60 – Is an example of one location's forecast from 2018 – 2037. Not all forecasts show a decrease as does this Gilchrist graph, most of the bigger cities showed growth, Brian said!

Slide #66 – This shows Bend Loop growth to 2037. The biggest growth is 1.5m Dth over 20 years. As shown on Slide #68, there is planned growth for the Bend, OR area.

Question: Mark asked Deborah if she would like the model results in the Narrative or Appendix of the IRP.
Answer: Deborah stated in the Appendix.

Slide #69 – Shows Cascade's "zonal" map = citygates by zone.

Slide #70 – Shows growth in the Baker City and Nyssa-Ontario areas – zone 24. On Slide #71 Zone GTN goes from 55m to 80m Dth!

Slide #73 – Shows Oregon's annual Therm usage – 80m to 120 m therms.

Slide #75 –This slide shows total system annual Therm usage over the forecast period. Devin McGreal stated that the group started to indicate a trend variable, numerical that goes up by 1 and comes with a coefficient. When added in, it is a negative. This trend effectively captures the heating of 1 new house into the modeling.

Mark then went over questions and the next steps in the IRP process:

Mark asked the group if they wanted to see the same information for peak day, the group answered yes, they felt it was relevant.

At the next meeting, there will be:

1. An update to any action items (such as an answer to the earlier question about assumptions in the model.
2. The next meeting is July 19th and includes "distribution planning".

Mark asked for any final comments:

Bob stated that the regarding staffing needs, in light of the hedging review/policy, will continue to be monitored and thanked the team for their hard work on this presentation!

Question: Garrett Senger asked if the next tag meeting on July 19th is a "firm" date.
Answer: Mark said yes!

Mark thanked everyone for their participation today!

Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #2

Wednesday, July 19, 2017

Public Utility Commission of Oregon

Salem, OR

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Agenda

- Introductions
- IRP Action Plan Update
- Distribution System Planning
- Current Supply Resources & Transportation Issues
- Alternative Resources
- Price Forecast
- Avoided Cost Calculation
- Planned Scenarios and Sensitivities
- Upcoming Schedule
- Questions

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IRP Action Plan Update

2014 IRP Action Item	Update
1. Cascade will improve its demand forecast by developing a report to track the issuance of corrected bills and reclassifying therms from corrected bills to the month those therms were used. In its next IRP, Cascade will use its new Statistical Analysis Software (SAS) to test non-linear weather effects on natural gas, to perform analysis on potential serial correlation problems, and to create a time series autoregressive integrated moving average (ARIMA) model for customer forecasting.	As stated in TAG 1 Cascade now forecasts usage per customer by customer class. MDUR is in the process of developing the report to track the issuance of corrected bills and reclassifying therms for all of their LDCs. Cascade is currently using SAS for its statistical analysis to create an ARIMA model for customer forecasting. Cascade is exploring the possibility of expanding its software library to include R for auto ARIMA functionality and other uses.
2. Cascade will continue to monitor outside determinants of natural gas usage, such as legislative building code changes and electrical "Direct Use" campaigns as they are determined to significantly affect the Company's forecast.	Since the 2014 Action Plan, Cascade has monitored the following legislation, campaigns, and other external actions with the potential to influence natural gas use in the States of Washington and Oregon: - National standard practice manual, Portland renewable energy goals, gas to electric fuel switching, HB-2711 moratorium on hydraulic fracturing for oil and gas exploration and production, several Washington state bills on Carbon taxes, deep decarbonization, and the clean air rule.
3. Cascade will continue to monitor the effectiveness of the Oregon Public Purpose Fund to ensure the funds are adequate to capture significant portions of achievable therm savings in Oregon.	Since the 2014 IRP, Cascade has made two filings to increase its public purpose charge to ensure funding would be sufficient to acquire the therm savings target established in the IRP as a least cost resource: Advice No. O15-12-01 on December 11th, 2015 to increase its public purpose charge from 1.85% to 3.7% (reduced to 3.4% before Commission approval) and Advice No. O16-10-01 on October 31st, 2016, in which the Company asked to increase the Public Purpose Charge from 3.4% to 4.87%.
4. The company will continue to follow and analyze the impacts of the Western Climate Initiative and proposed carbon legislation at both the state and federal level as they pertain to natural gas conservation, as well as other such acts that may arise from these efforts. The company will continue to monitor the timing and the costs associated with carbon legislation and analyze the impacts on the company's overall portfolio costs. As specific carbon legislation is passed, the company will update its avoided cost calculations, conservation potential and make modifications to its DSM incentive programs as necessary.	The Company has continued to monitor the Western Climate Initiative and proposed carbon legislation since the 2014 Action Plan. While no significant action has been taken on the WCI with impacts to the Company, the Company is actively following the current legislation and is monitoring the potential impacts to portfolio costs.

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IRP Action Plan Update Cont'd

2014 IRP Action Item	Update
5. The company will continue to monitor the cost effectiveness of existing conservation measures and emerging technologies to ensure that the current mix of measures included in the Washington Conservation program is appropriate. Areas for further analysis include the impacts associated with modifications to building codes along with the cost effectiveness of newer technologies such as the next generation of high efficiency water heaters (.70 EF) and high-efficiency hybrid heat pumps. The applicability of these measures within Cascade's service territory will be analyzed and the company's Conservation Incentive Program will be modified as necessary.	Cascade continually monitors the region and natural gas industry on currently available technology advancements as part of our Washington incentive programs. We reevaluate the portfolio cost-effectiveness paired with current technology and update install costs to maintain viability and as robust of a program as feasible. The Company is also engaged with the Northwest Energy Efficiency Alliance market transformation collaborative in coordination with other local utilities and the Energy Trust of Oregon as well as the Gas Technology Institute's emerging technology program to stay abreast of new technologies and opportunities for additions and changes to the Company's offerings. The Company also maintains a Trade Ally network for our Washington programs and routinely connects with local contractors to gauge availability of product and costs associated with installs of rebate eligible equipment and measures. The landscape is constantly evolving and Cascade works with its partners and local agencies and builders (including home builder associations) to track building code updates as well as changes to industry standards.
6. The Company will continue to monitor the potential reporting, administrative and potential financial impacts of long term resources as a result of concerns surrounding fracking. In particular we are awaiting the EPA to reveal the results of their current study in alleged water contamination found in Wyoming as a result of fracking activities.	In December 2016 the EPA published its final report on fracking. The comment period ended January 2017. Cascade is reviewing the final report and will provide a slide update at TAG 3.

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IRP Action Plan Update Cont'd

2014 IRP Action Item	Update
7. Cascade will continue to evaluate gas supply resources on an ongoing basis, including supplies of varying lengths (base, swing, peaking) and pricing alternatives. We will continue to analyze the uncertainties associated with supply and demand relationships.	On June 26th Cascade's Gas Supply Oversight Committee (GSOC) met and was provided an update on the 2017 portfolio procurement plan, which included recent market intelligence and updated pricing. In TAG 3 the company will discuss its supplies of varying lengths and pricing alternatives.
8. The Company will continue to monitor the proposed pipeline expansion projects to access more supplies out of the Rockies. As cost estimates change, the company will analyze those resources under consideration to determine if modifications to the preferred portfolio are necessary.	Cascade will be discussing all potential pipeline expansions during today's TAG meeting.
9. As part of the Cascade's risk management policy and implementation, the Company will report on the status of the UM 1720 as well as related risk management policy enhancements to Cascade's risk management policy, at the first Purchased Gas Adjustment (PGA) quarterly meeting with OPUC Staff in early 2017. This docket is the Commission's Investigation into Long Term Hedging Policy.	The first planned PGA quarterly meeting was postponed due to scheduling conflicts. Cascade provide an update during today's TAG meeting.
10. The Company will continue to explore options to incorporate biogas into its portfolio, as specific projects are identified in our service territory. Price, location and gas quality considerations of the biogas supply will be evaluated.	Cascade has filed a Biomethane Reciept Services (Schedule 800) in Oregon to estabilsh biogas injection terms, conditions and gas quality requirements. Cascade continues to work with possible biomthane producers and evaluate those projects for possible future core supplies.
11. The Company will continue to monitor proposed LNG import facilities as information becomes available and will evaluate the various options that, if built, could result. Issues to monitor include specific cost, the availability of pipeline capacity and project timing.	After consultation with upstream pipelines, Cascade has determined that a pipeline expansion is a more prudent long-term solution.
12. The Company will continue to monitor the futures market for price trends and will evaluate the effectiveness of its risk management policy. Implementation of Dodd- Frank in the coming year raises potential administrative challenges from a reporting standpoint; additionally it is unknown how the costs associated with the use of clearinghouses might impact prices of natural gas in the future.	Cascade has updated its price forecast to modify its weights based on a backcast of the accuracy of its sources. At this time the price impacts of Dodd-Frank and hedging related dockets such as UM 1720 and UG-132019 continues to be unknown. The Company will continue to provide updates in coming TAG meetings.

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Distribution System Planning

CHRIS BOLTON, ENGINEER II

TECHNICAL ADVISORY GROUP
JULY 19TH, 2017

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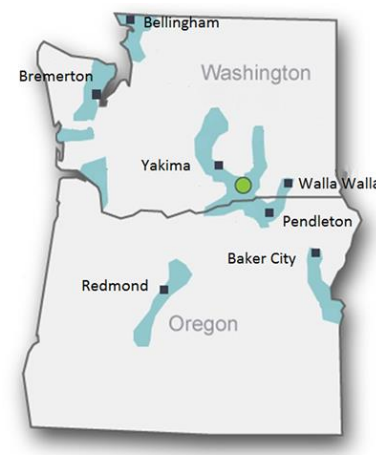
Outline

- Company overview
- Network Design Fundamentals
- Interstate Pipeline Companies
- Software Technology
- Data Gathering
- Data Analysis
- System Enhancement Techniques
- Future Planning Process Flow
- Future Projects



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CNGC System Overview

Pipeline:

- Diameter – ½” to 20”
- Material – Polyethylene and Steel
- Operating Pressure - 20 psi to 900 psi
- Washington – approx. 4,744 miles of distribution main
- Oregon – approx. 1,604 miles of distribution main

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CNGC System Overview Cont'd

Facilities:

- Regulator stations – Over 700
- Valves – Over 1600
- Also other equipment such as heaters, odorizers, and compressors

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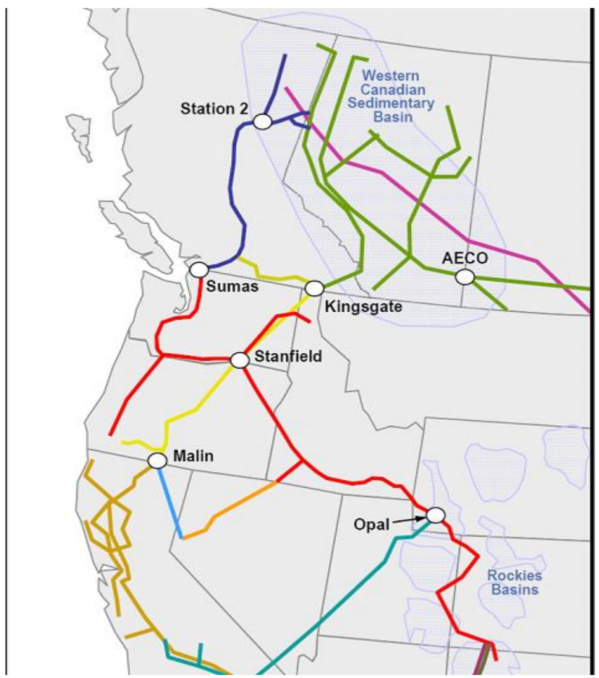
Where do we get our gas?



- Many interstate pipeline companies
- Williams Northwest Pipeline (Red)
- Transcanada Pipelines (Yellow)
- Enbridge Pipelines (Dark Blue)

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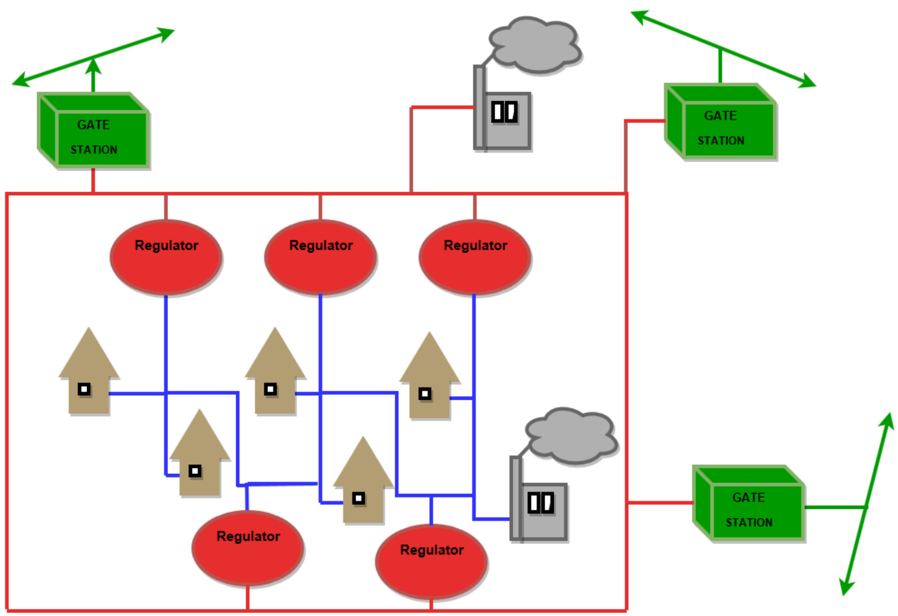
Network Design Fundamentals

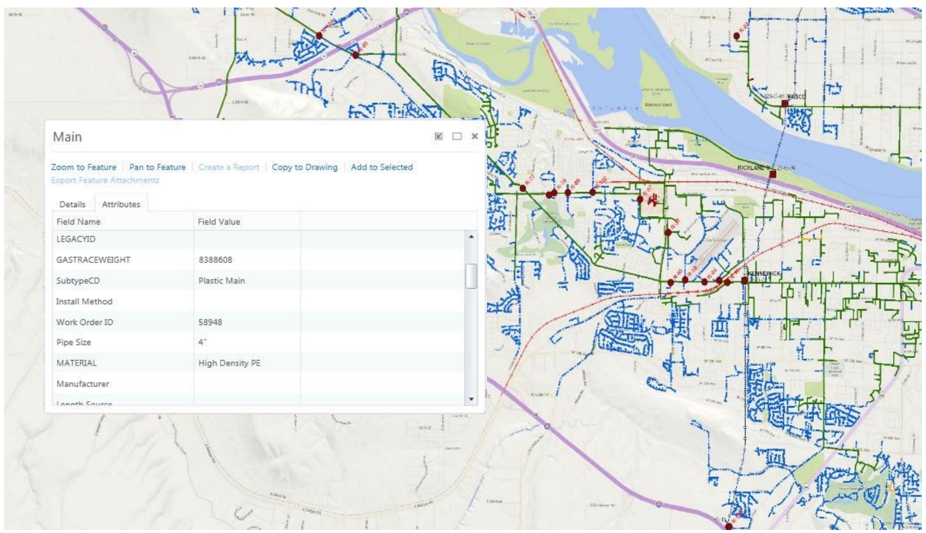


Keys:

- Gate station capacity
- Reg station placement
- Pipe size and grid

GIS – Geographic Information System

- GIS system keeps an up-to-date record of pipe and facilities complete with all system attributes



- Pipe Size (Dia.)
- Material
- Date of install
- Operating Pressure
- Work Order
- Etc…

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System Modeling

…Using internal GIS environment and other input data CNGC is able to create system models through the software – Synergi.

What is Synergi?

- Software to theoretically model piping and facilities to represent current pressure and flow conditions while also predicting future events and growth.

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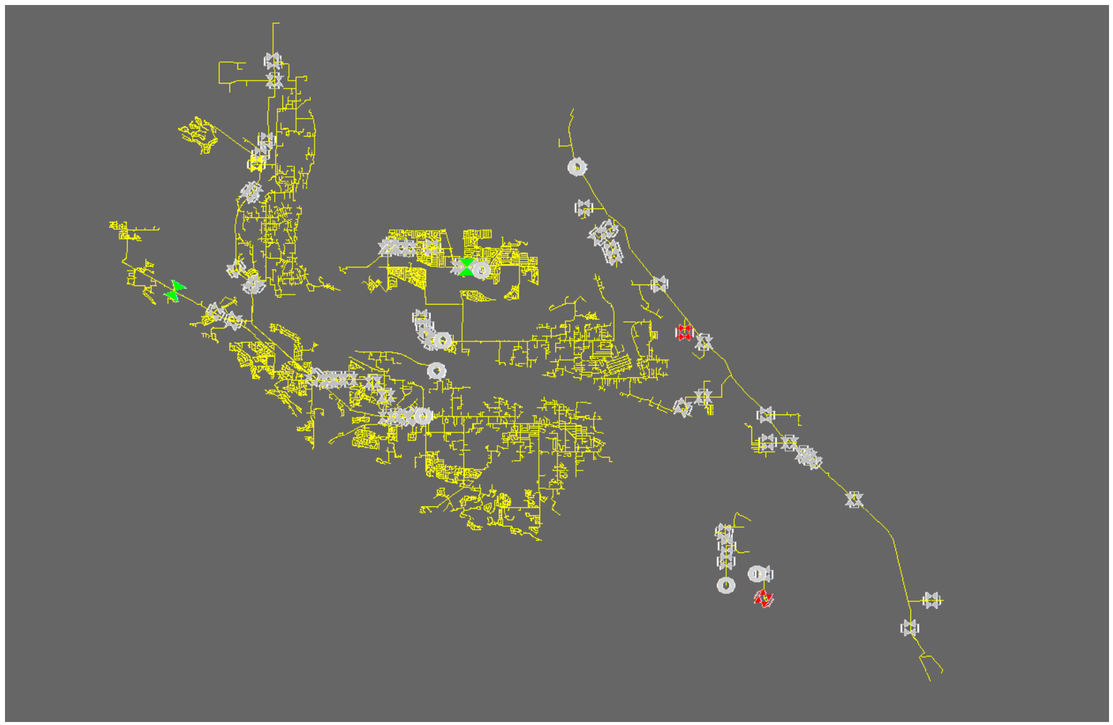
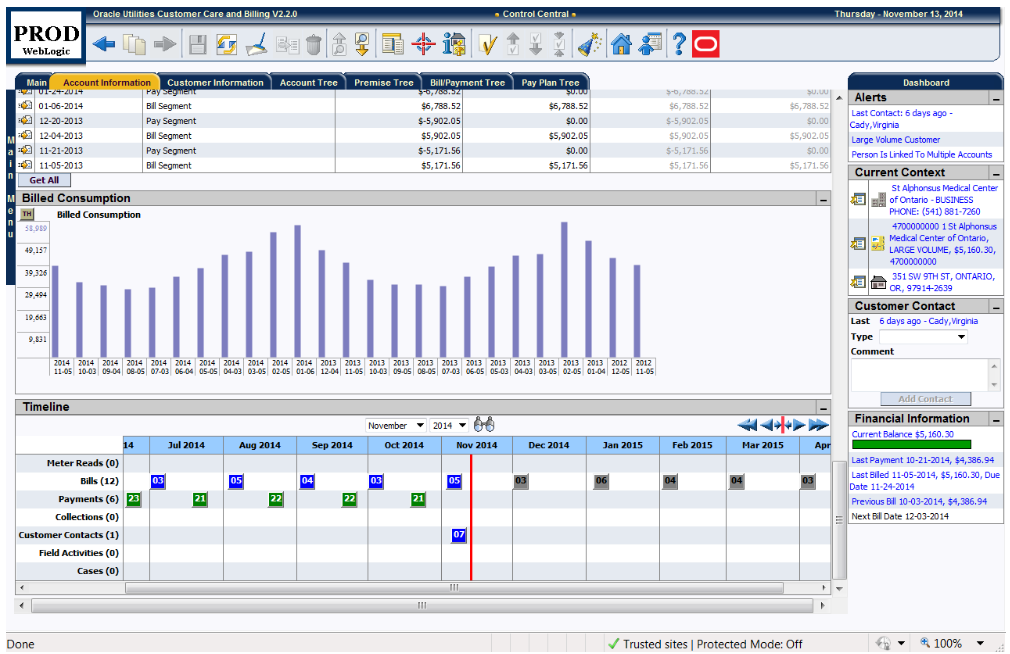
Model Example



How do we make this model accurate?

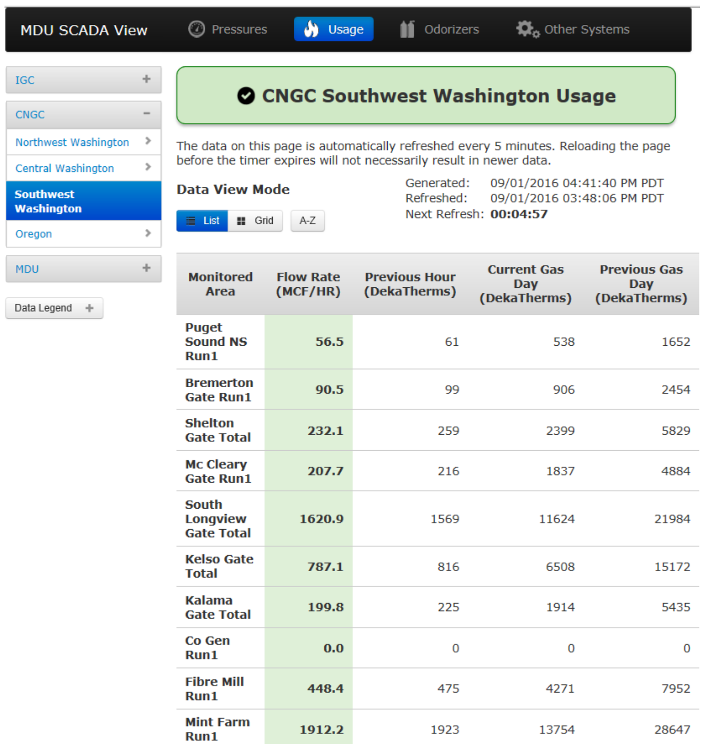
Data Gathering

- CC&B (customer billing data)



15

Data Gathering Cont’d


MDU SCADA View | Pressures | Usage | Odorizers | Other Systems

IGC | CNGC | Northwest Washington | Central Washington | Southwest Washington | Oregon | MDU | Data Legend

CNGC Southwest Washington Usage

The data on this page is automatically refreshed every 5 minutes. Reloading the page before the timer expires will not necessarily result in newer data.

Data View Mode List | Grid | A-Z

Generated: 09/01/2016 04:41:40 PM PDT
Refreshed: 09/01/2016 03:48:06 PM PDT
Next Refresh: **00:04:57**

Monitored Area	Flow Rate (MCF/HR)	Previous Hour (DekaTherms)	Current Gas Day (DekaTherms)	Previous Gas Day (DekaTherms)
Puget Sound NS Run1	56.5	61	538	1652
Bremerton Gate Run1	90.5	99	906	2454
Shelton Gate Total	232.1	259	2399	5829
Mc Cleary Gate Run1	207.7	216	1837	4884
South Longview Gate Total	1620.9	1569	11624	21984
Kelso Gate Total	787.1	816	6508	15172
Kalama Gate Total	199.8	225	1914	5435
Co Gen Run1	0.0	0	0	0
Fibre Mill Run1	448.4	475	4271	7952
Mint Farm Run1	1912.2	1923	13754	28647

- SCADA Data : Real time and historical flow characteristics at specific locations in the system.

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Data Gathering Cont'd

- IRP Customer Growth

Year	Baker	Umatilla	Hermiston	Huntington	Milton-Freewater	Mission Tap	Pendleton	Prineville	Redmond	Pronghorn	Bend Loop
2018	0.77%	1.41%	1.28%	0.75%	1.15%	1.22%	1.31%	1.92%	2.45%	2.24%	2.46%
2019	0.78%	1.55%	1.38%	0.75%	1.21%	1.48%	1.40%	1.89%	2.42%	2.02%	2.44%
2020	0.78%	1.55%	1.45%	0.86%	1.27%	1.46%	1.48%	1.83%	2.39%	1.81%	2.42%
2021	0.78%	1.62%	1.52%	0.85%	1.42%	1.38%	1.54%	1.82%	2.40%	2.57%	2.40%
2022	0.79%	1.61%	1.57%	0.67%	1.38%	1.54%	1.61%	1.78%	2.36%	1.93%	2.38%
2023	0.80%	1.70%	1.64%	0.89%	1.43%	1.82%	1.66%	1.75%	2.35%	1.83%	2.36%
2024	0.80%	1.73%	1.68%	0.72%	1.55%	1.55%	1.71%	1.72%	2.32%	2.17%	2.34%
2025	0.80%	1.70%	1.73%	0.77%	1.59%	1.84%	1.76%	1.69%	2.31%	1.76%	2.32%
2026	0.80%	1.82%	1.78%	0.93%	1.59%	1.73%	1.81%	1.67%	2.28%	1.76%	2.30%
2027	0.81%	1.81%	1.81%	0.65%	1.54%	1.70%	1.85%	1.63%	2.25%	2.08%	2.28%
2028	0.81%	1.84%	1.86%	0.86%	1.70%	1.97%	1.89%	1.61%	2.24%	1.69%	2.25%
2029	0.81%	1.77%	1.90%	0.80%	1.75%	1.85%	1.92%	1.58%	2.20%	1.80%	2.23%
2030	0.82%	1.89%	1.92%	0.95%	1.70%	1.92%	1.95%	1.53%	2.18%	1.99%	2.21%
2031	0.82%	1.89%	1.95%	0.68%	1.78%	1.89%	1.98%	1.54%	2.16%	1.90%	2.17%
2032	0.81%	1.86%	1.97%	0.99%	1.77%	1.93%	2.00%	1.50%	2.11%	1.60%	2.13%
2033	0.81%	1.89%	1.98%	1.13%	1.79%	2.04%	2.02%	1.49%	2.08%	1.70%	2.10%
2034	0.82%	1.87%	2.01%	0.92%	1.80%	1.98%	2.03%	1.46%	2.06%	1.91%	2.07%
2035	0.81%	1.94%	2.01%	0.81%	1.96%	2.08%	2.05%	1.45%	2.02%	1.49%	2.04%
2036	0.81%	1.95%	2.03%	0.85%	1.91%	1.94%	2.06%	1.43%	1.99%	1.62%	2.01%
2037	0.80%	1.87%	2.05%	0.74%	1.91%	2.11%	2.06%	1.40%	1.97%	1.59%	1.98%
Average Annual Growth	0.80%	1.76%	1.77%	0.83%	1.61%	1.77%	1.80%	1.63%	2.23%	1.87%	2.25%

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Data Gathering Cont’d

- Peak Heating Degree Day (HDD) in the different CNGC weather zones.
- Uses historical weather data to determine which degree day matches which zone.

Peak HDD = 60 - average daily temp

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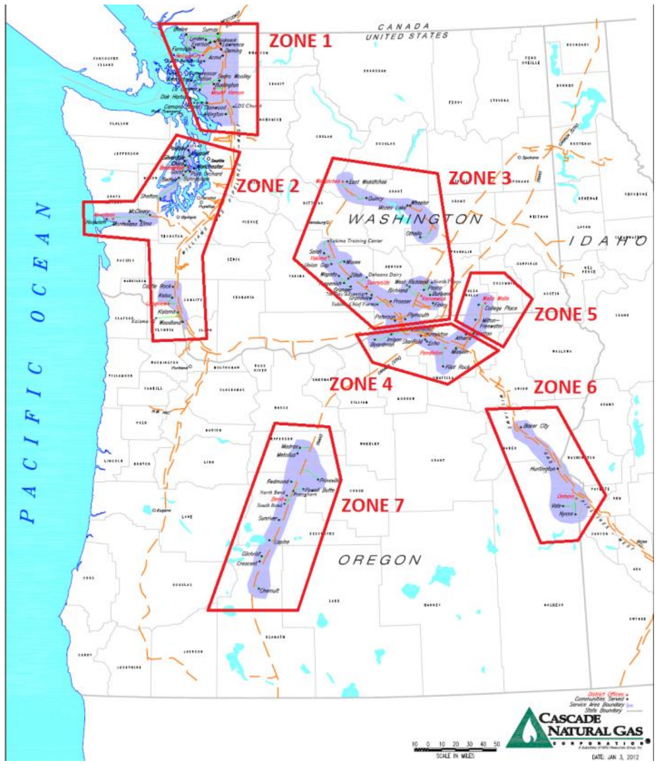
CNGC Weather Zones



System Peak Day	12/21/90
System Peak HDD	56
Zone 1	46
Zone 2	46
Zone 3	58
Zone 4	67
Zone 5	65
Zone 6	70.5
Zone 7	70.5

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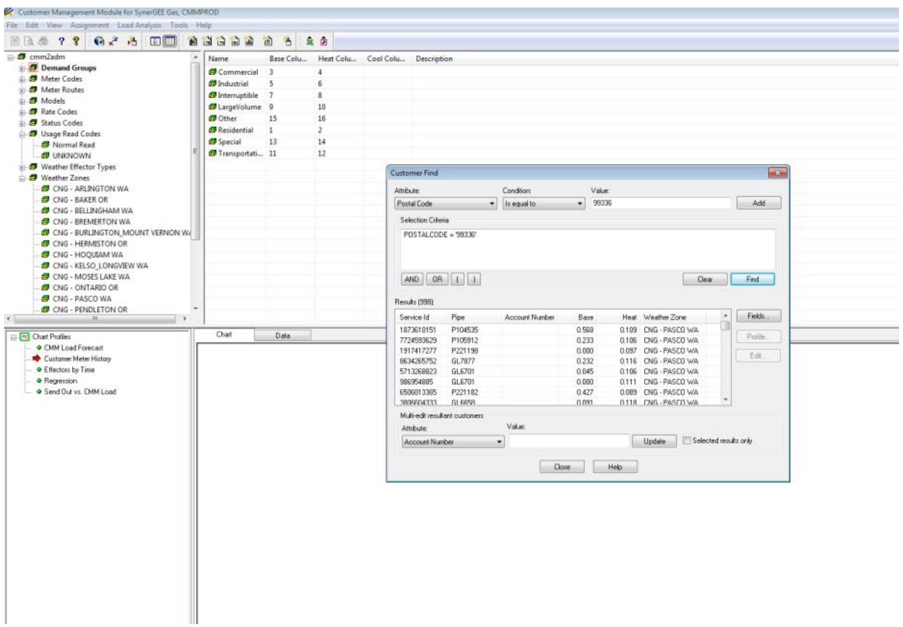
Customer Management Module (CMM)



- Software that compiles data from CC&B, HDD, and/or growth studies to manage customer loads.
- Works directly with Synergi to input customer data and represent pressures and flows in the model.

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CMM → Synergi

- Conversion can result in 3 model types:
  - Calibrated model – model to represent a specific date and time.
  - Design Day Model – Uses the peak HDD for selected areas to simulate a cold weather (worst case scenario).
  - Growth model - Uses design day model along with growth data to predict future projects.

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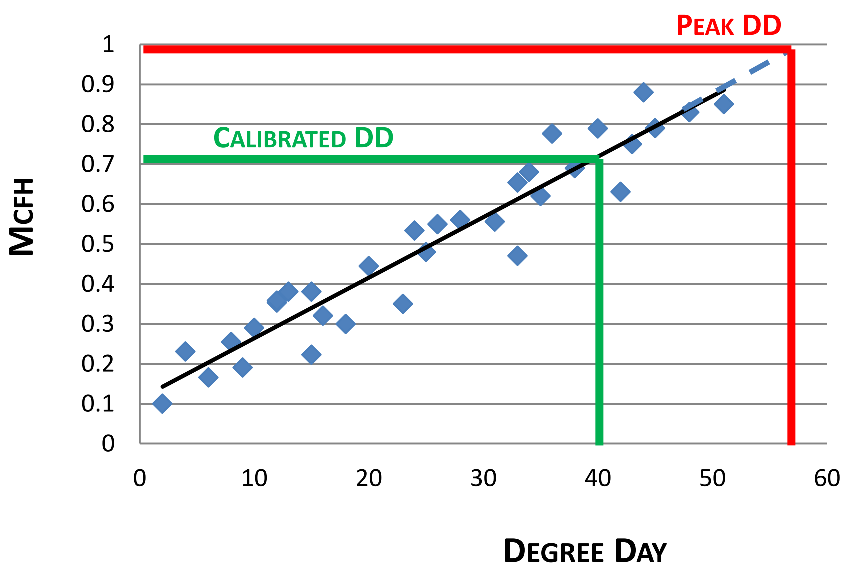
Calibrated vs Degree Day

- Different loads will be applied to each customer

LOAD VS TEMPERATURE



$y = 0.0152x + 0.1118$

HEAT BASE

40 DD = 0.72 MCFH

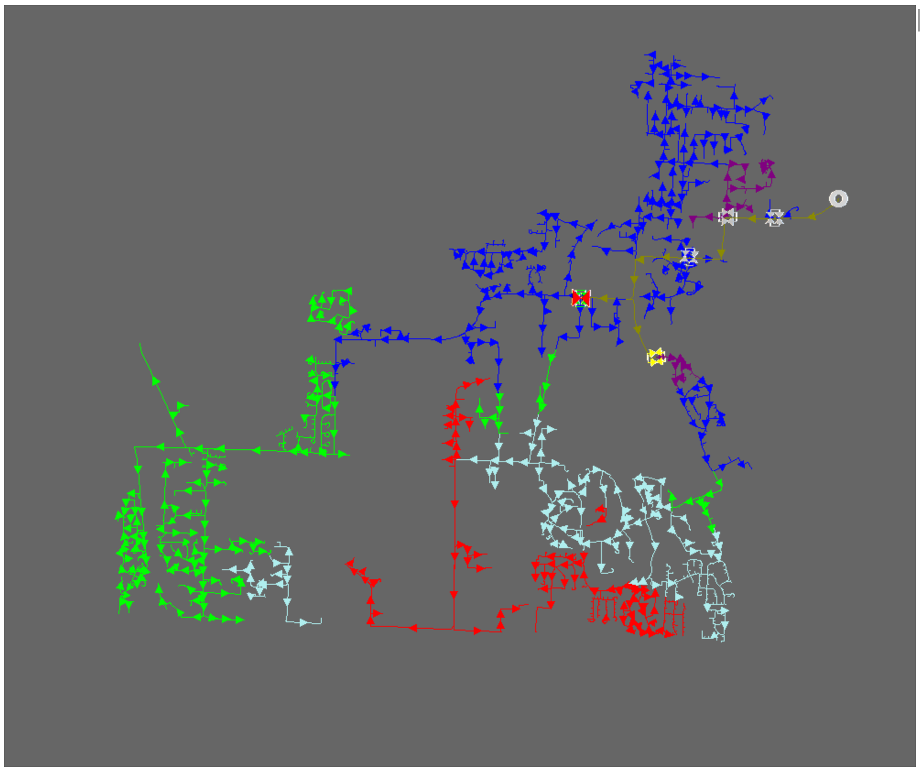
58 DD = 0.99 MCFH

System Modeling Cont'd

- All customers are loaded based upon base and heat trend.
- Growth model – works with design day model and customer growth numbers to simulate pressures and flows in the future.
- Benefits of the models:
  - Customer requests
  - Future planning
  - System reliability
  - Optimizing potential reinforcement

Synergi

- Theoretical low pressure scenario



Facilities Color By
Pressure (Primary Only) (psig)
Not Applicable (7)
< 10.00 (301)
10.00 - 15.00 (518)
15.00 - 25.00 (548)
25.00 - 40.00 (627)
40.00 - 60.00 (67)
> 60.00 (16)

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Capacity Enhancement Options

- Pipes:
  - Replacements
  - Reinforcements
  - Loops
- Regulator Stations
- Compressors

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Pipe Enhancements

PROS

- Reliable capacity
- Low maintenance
- Permanent

CONS

- Can be expensive
- Potential land acquisition/permitting issues

Reg Station Upgrades/Installs

PROS

- Adds source pressure to alternate system location
- Increases flow control
- Increases pressure control

CONS

- Long term regulator and valve maintenance
- High installation/fabrication costs
- Potential land acquisition issues

Compressor Stations

PROS

- Adding capacity at lower initial cost
- Less land required
- Situational operation

CONS

- Continuous maintenance/training
- Cost of fuel consumption
- Emissions/permitting
- Beneficial only on transmission type lines

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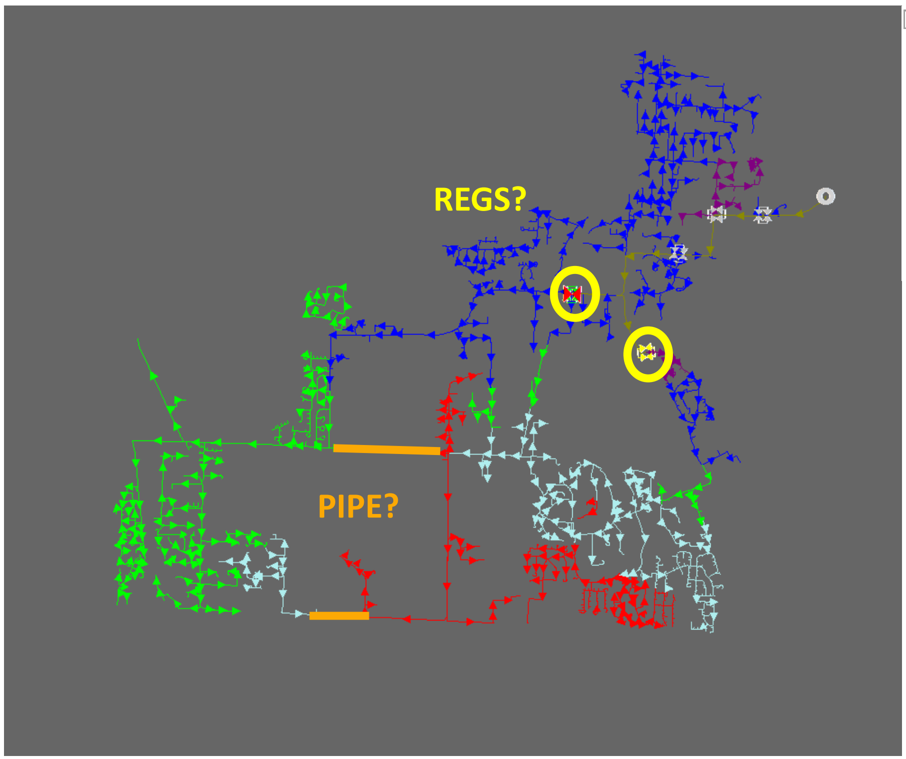
Synergi

- Low pressure scenario



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- 10.00 - 15.00 (518)
- 15.00 - 25.00 (548)
- 25.00 - 40.00 (627)
- 40.00 - 60.00 (67)
- > 60.00 (16)

- Compressor station infeasible
- Other Solutions?

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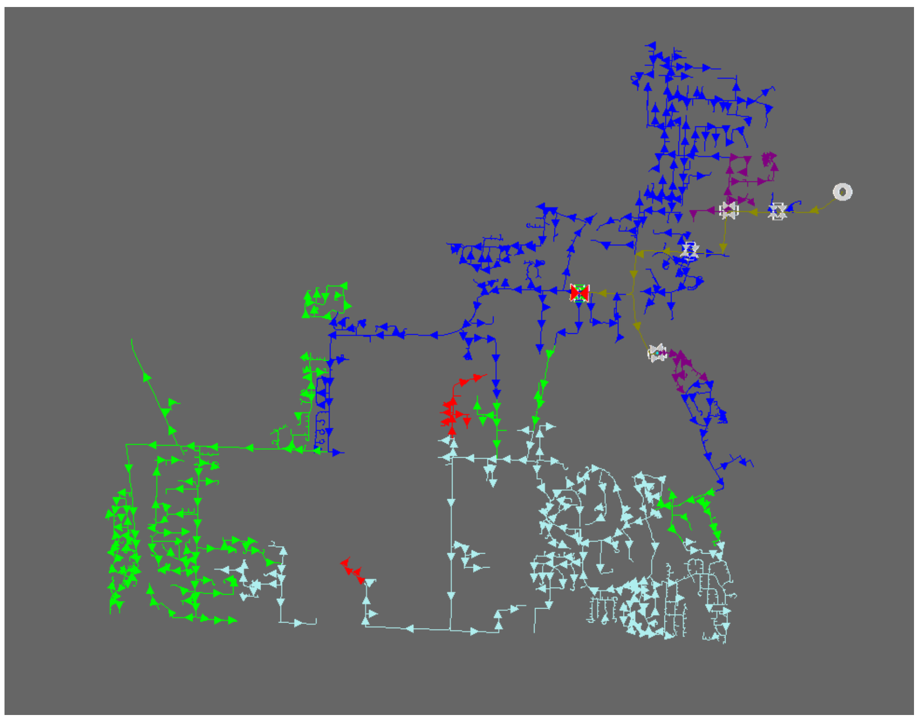
29

Synergi

- Possible solutions – raising reg station set points



Facilities Color By

Pressure (Primary Only) (psig)

- Not Applicable (7)
- < 10.00 (27)
- 10.00 - 15.00 (773)
- 15.00 - 25.00 (483)
- 25.00 - 40.00 (708)
- 40.00 - 60.00 (70)
- > 60.00 (16)

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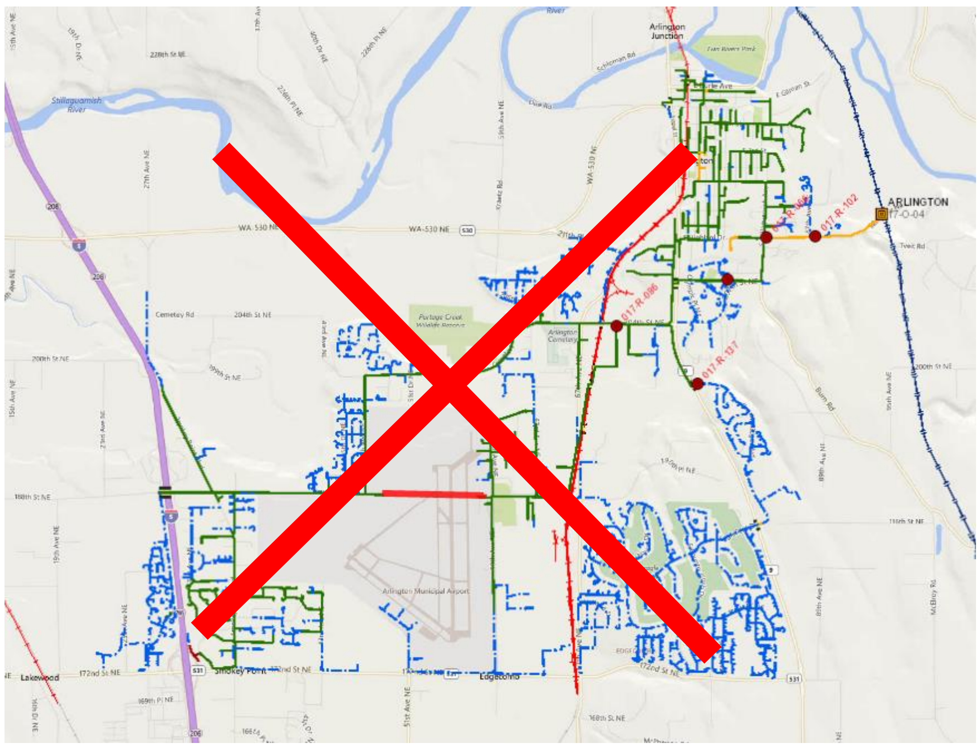
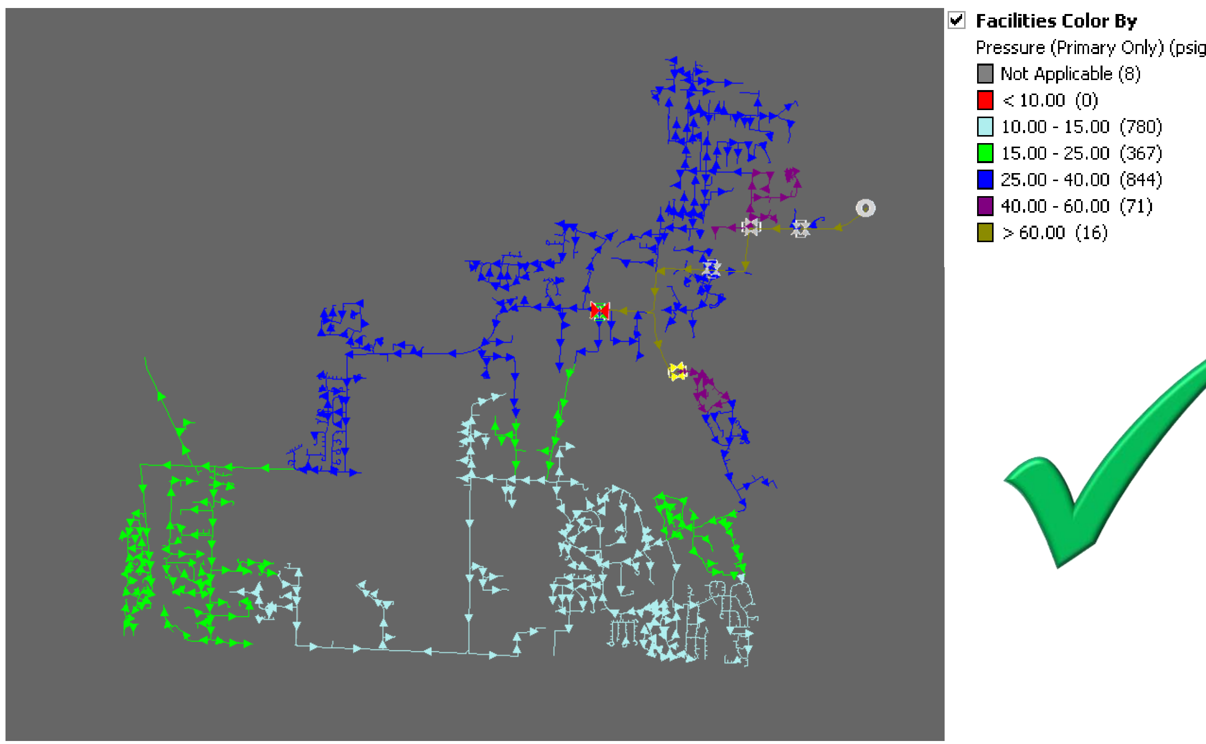
Synergi

- Reinforcement option #1

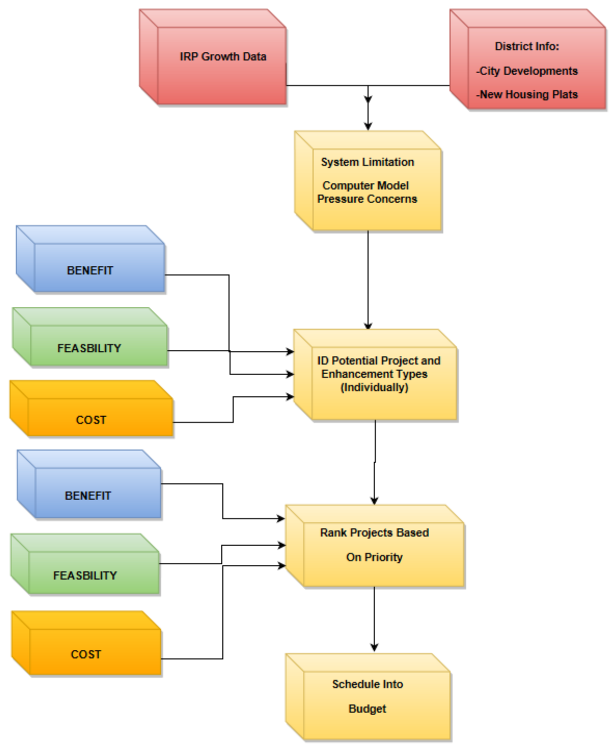


Synergi

- Reinforcement option #2



Project Process Flow



Info & Data

Project & Schedules

33

CNGC Future Projects

- Example upcoming growth projects

Location	2017	2018	2019
Pilot Rock 4” IP PE Reinforcement	$ 219,566		
Bend 8” HP Steel Reinforcement		$ 1,930,648	
Bend 4” IP PE Reinforcement			$ 185,210

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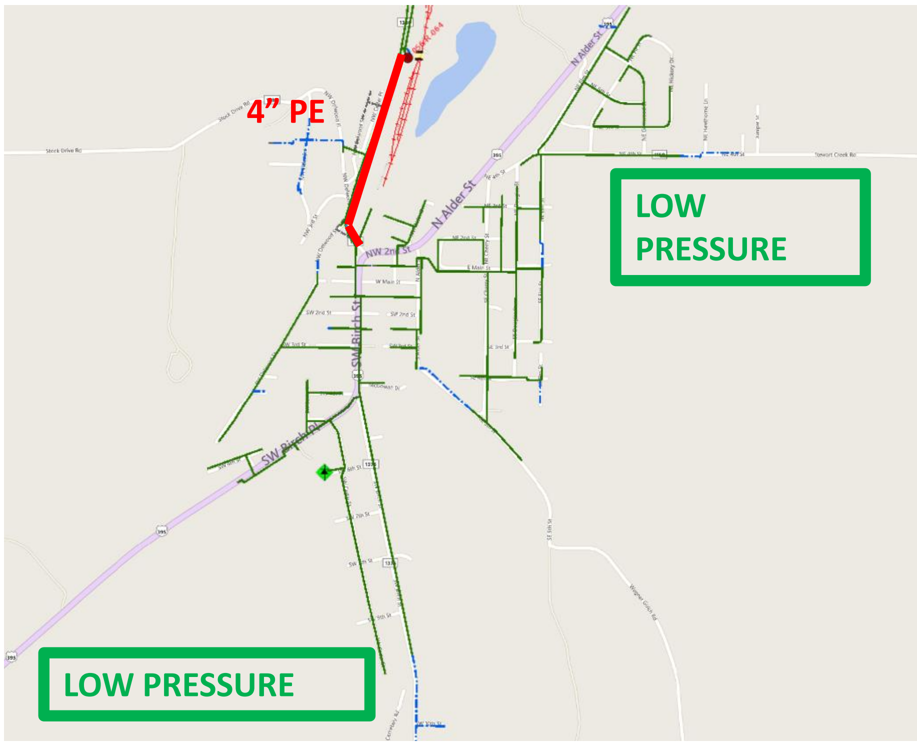
Pilot Rock 4” IP PE Reinforcement



- 2017 project
- 1,950’ of 4” PE
- Have experienced low pressure during peak heating
- Allow for growth in system

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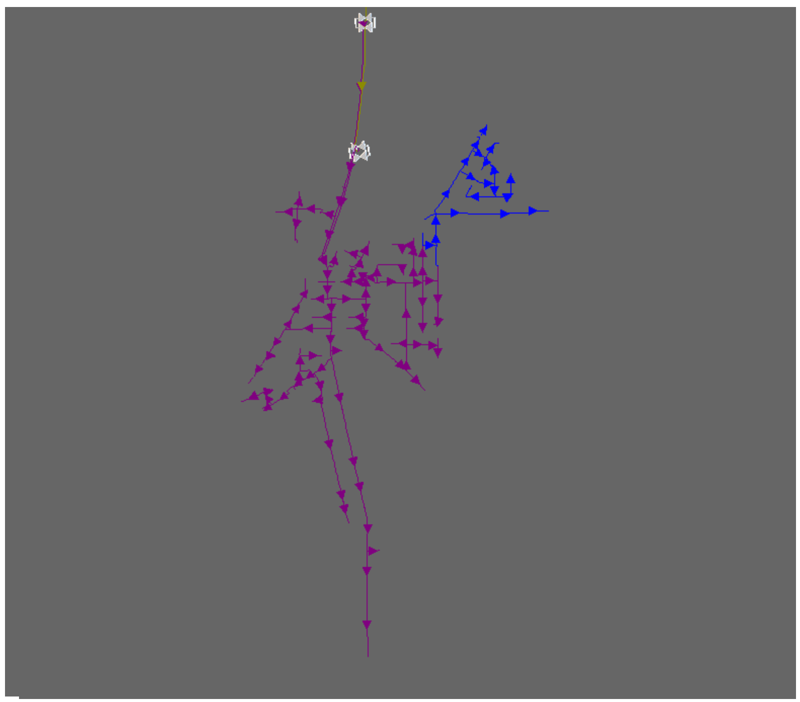
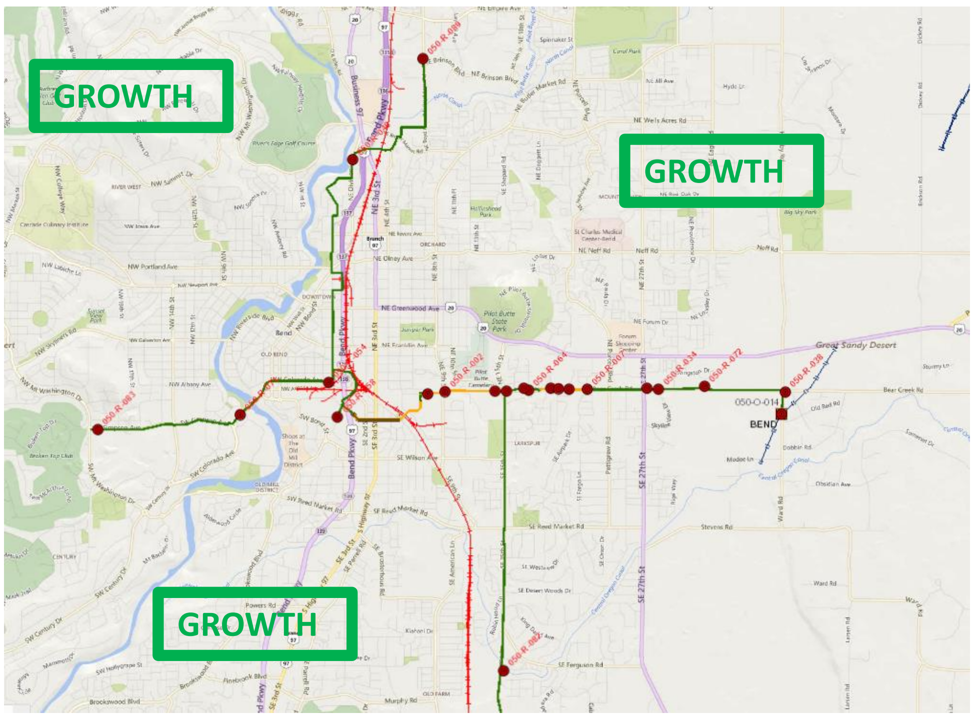
Pilot Rock 4” IP PE Reinforcement

- Design day pressure before/after



☑ **Facilities Color By**
Pressure (Primary Only) (psig)
- Not Applicable (72)
- < 0.00 (17)
- 0.00 - 10.00 (158)
- 10.00 - 20.00 (283)
- 20.00 - 30.00 (2044)
- 30.00 - 60.00 (3956)
- 60.00 - 250.00 (285)
- > 250.00 (93)

Bend 8” HP Steel Reinforcement



- 2018 project
- 6,400’ of 8” HP Steel
- Pressure loss in high pressure lines
- Allow for growth in the entire district

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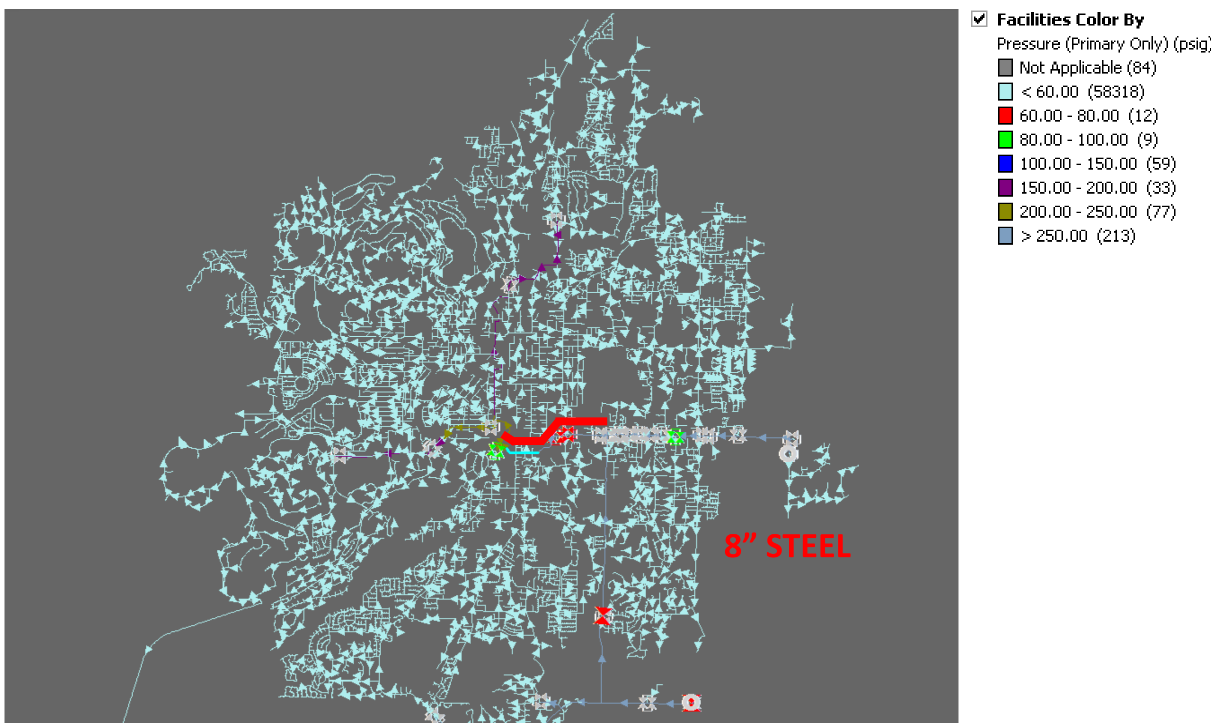
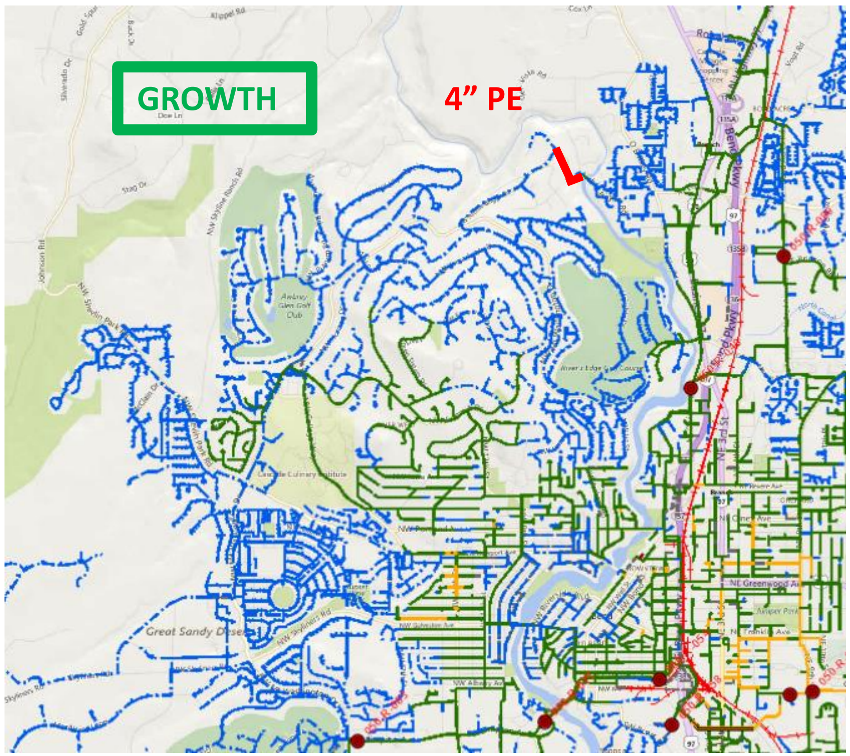
Bend 8” HP Steel Reinforcement

- Design day pressure before/after



38

Bend 4” IP PE Reinforcement



- 2019 Project
- Growth all over the Bend Area
- Short reinforcement will enhance capacity to NW area

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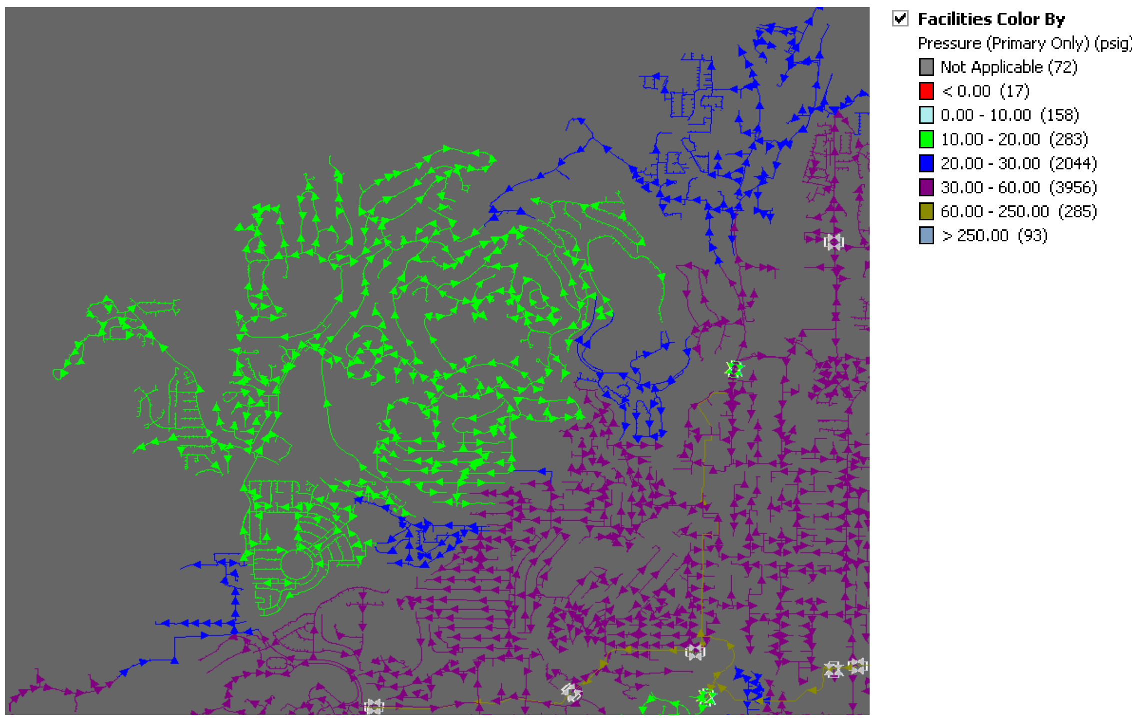
39

Bend 4” IP PE Reinforcement

- Model pressure before/after project



Conclusion

- CNGC uses technology to gather data, analyze, plan, and design a reliable, safe and economical distribution system.

QUESTIONS?

Current Supply Resources & Transportation Issues

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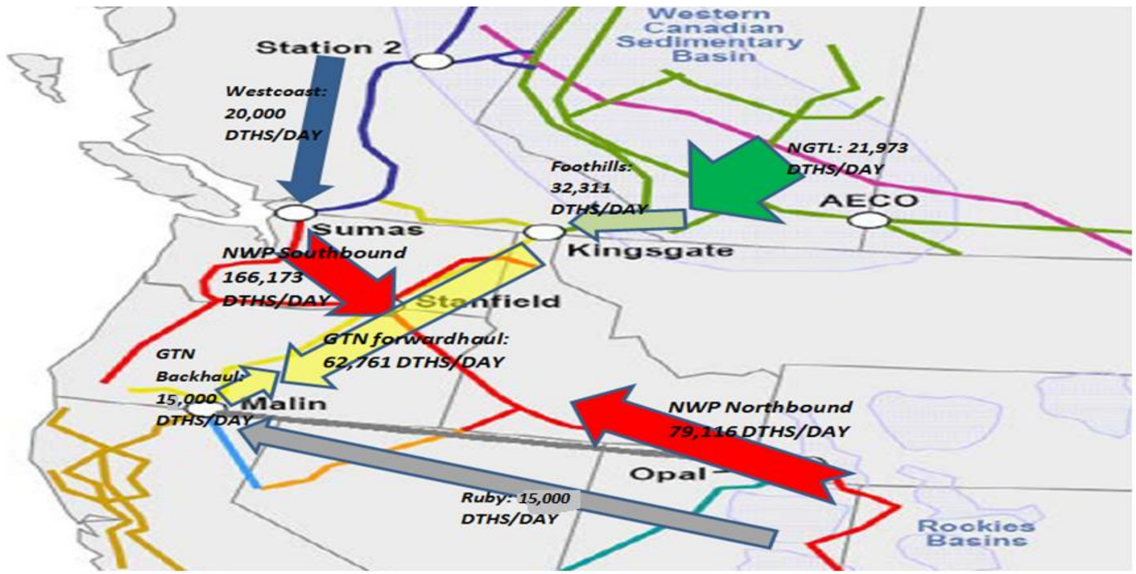
Pipeline transport flow



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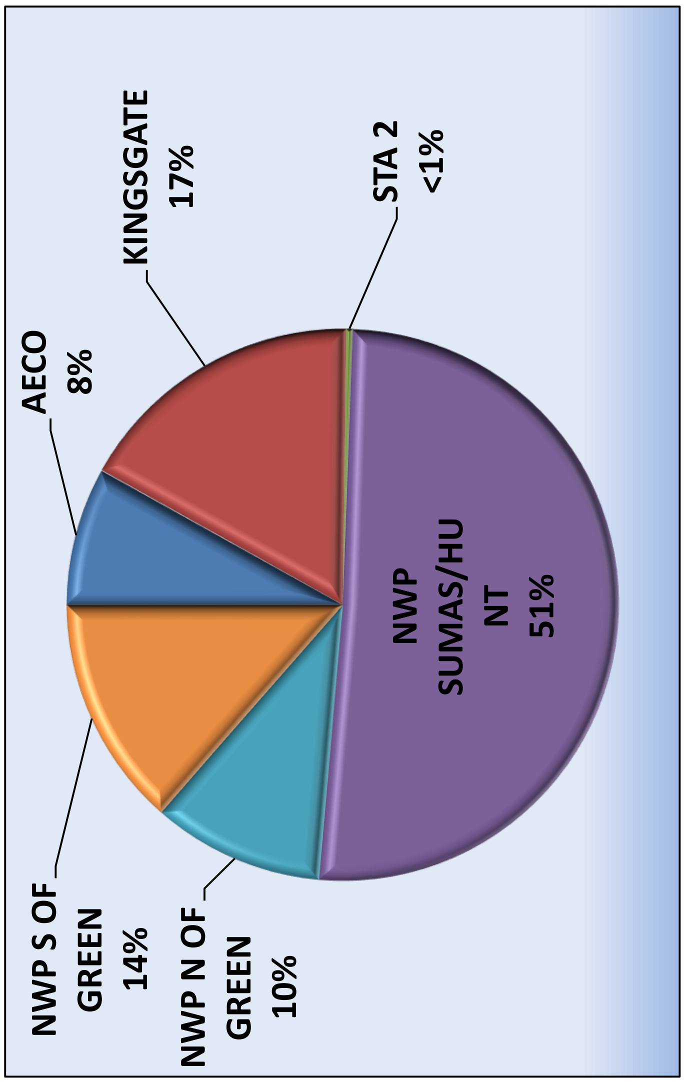
43

Transport Summary



44

Storage Resources

- Jackson Prairie
  - 4 accounts with 1,235,593 dths capacity
  - CNGC cycled approximately 90% of Jackson Prairie storage over the past winter season
  - CNGC targets cycling Jackson Prairie
- Plymouth
  - 2 accounts with 662,200 dths capacity
  - New account of 100,000 dths added for the 2016/2017 season
  - In addition to above we acquired TF-2 (Firm Redelivery Transportation) of 10,675 dths
  - CNGC remains committed to using Plymouth as a peaking resource.

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HIGHLIGHTS FOR THE 2017 PORTFOLIO DESIGN

- PORTFOLIO PROCUREMENT DESIGN BASED ON A DECLINING PERCENTAGE EACH YEAR, ACCORDINGLY: Year 1: Approximately 80% of annual requirements; Year 2: 40%, Year 3: 20%.
  - 80% allows more flexibility operationally
  - Allows us to be in the market monthly through FOM purchase or Day Gas purchases
- Hedged Percentages (fixed-price physical) Currently max 40% of annual requirements. Second year should be set at 25%, and 20% hedged volumes for year three.
  - Due to new WUTC hedging policy, may need to consider puts, calls, or financial derivatives to address fixed-priced physicals that may become "out of the money"
  - Hedging may need to be more flexible as policy develops
- CNGC's Gas Supply Oversight Committee (GSOC) would consider a modification of this plan if the outer year 3 year forward price is 20% higher/lower than the front month over a reasonably sustained period.
- Annual load expectation (Nov-Oct) is approximately 30,000,000 dths, consistent with recent load history.

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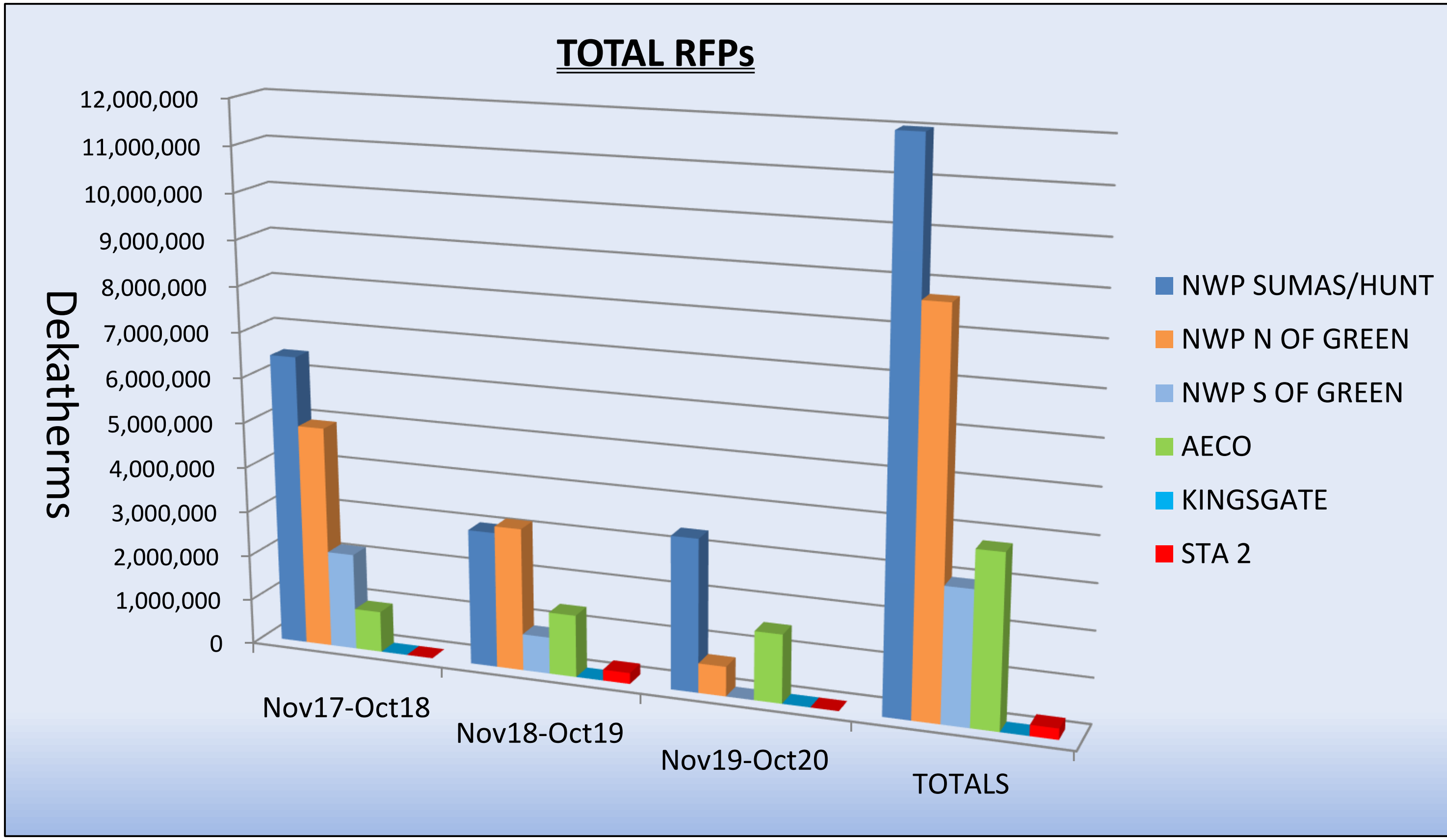
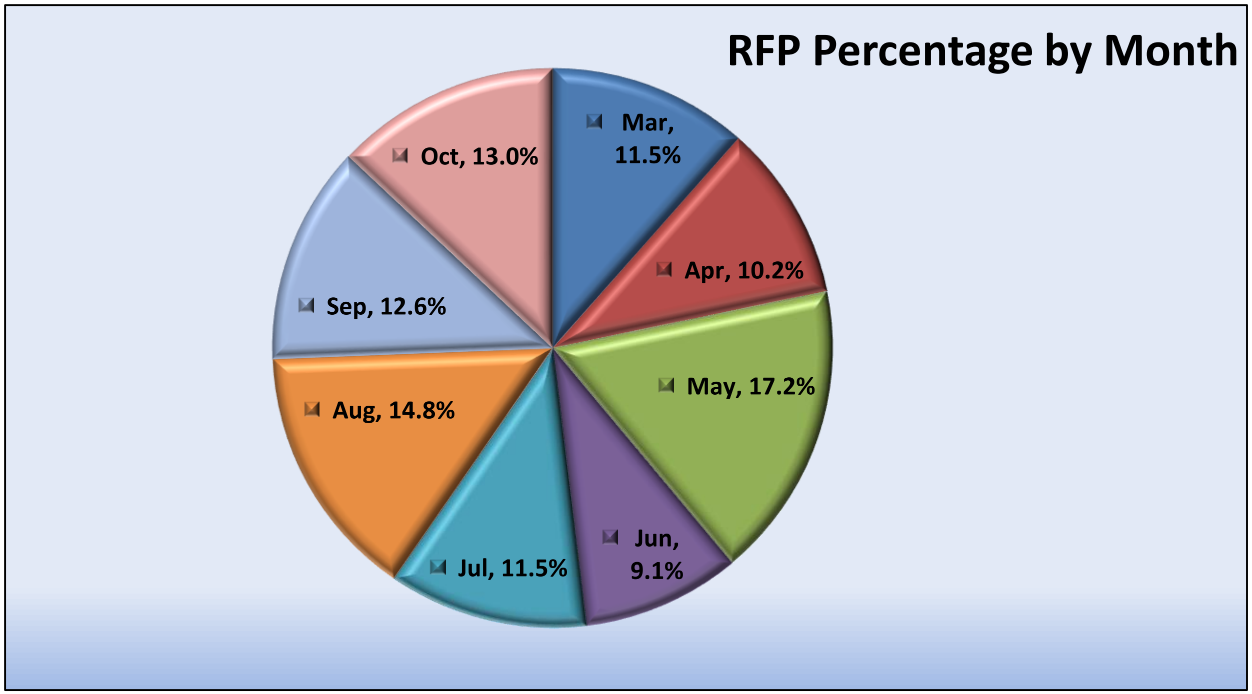
Total RFPs


TOTAL RFPs
Dekatherms
12,000,000
11,000,000
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
Nov17-Oct18
Nov18-Oct19
Nov19-Oct20
TOTALS
NWP SUMAS/HUNT
NWP N OF GREEN
NWP S OF GREEN
AECO
KINGSGATE
STA 2

RFP Percentage by Month



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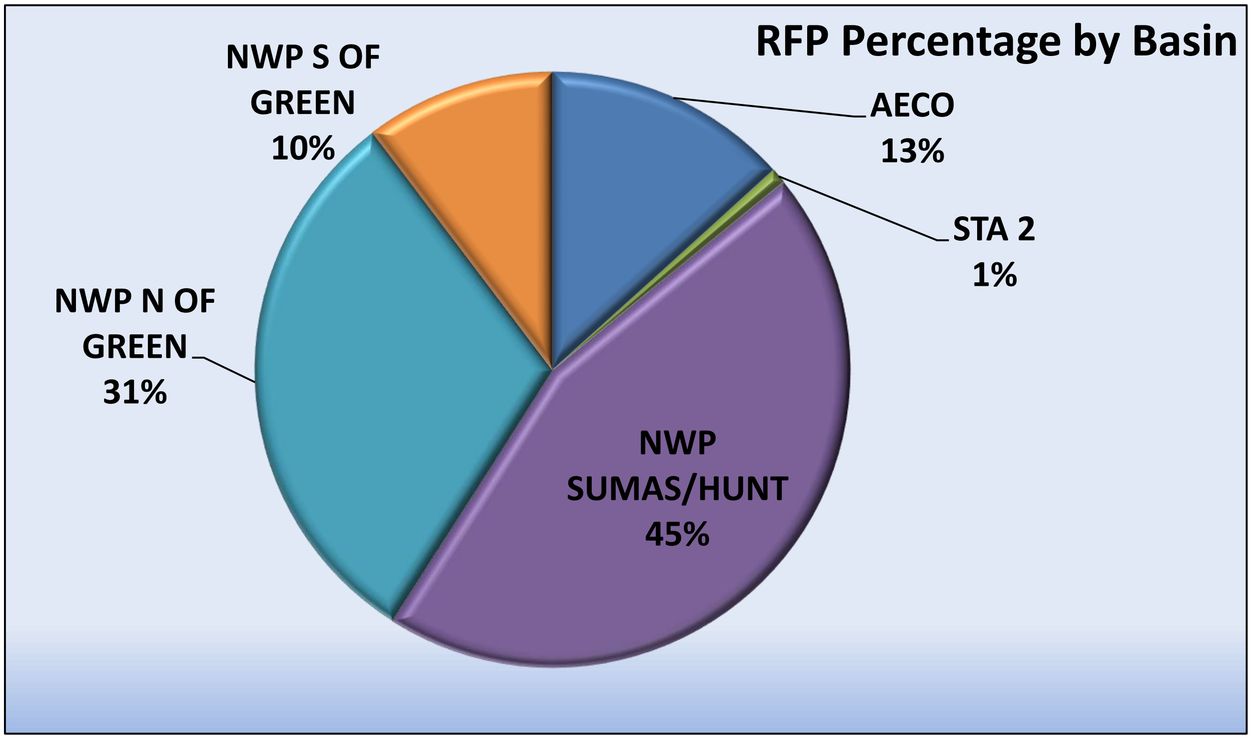
RFP Percentage By Basin



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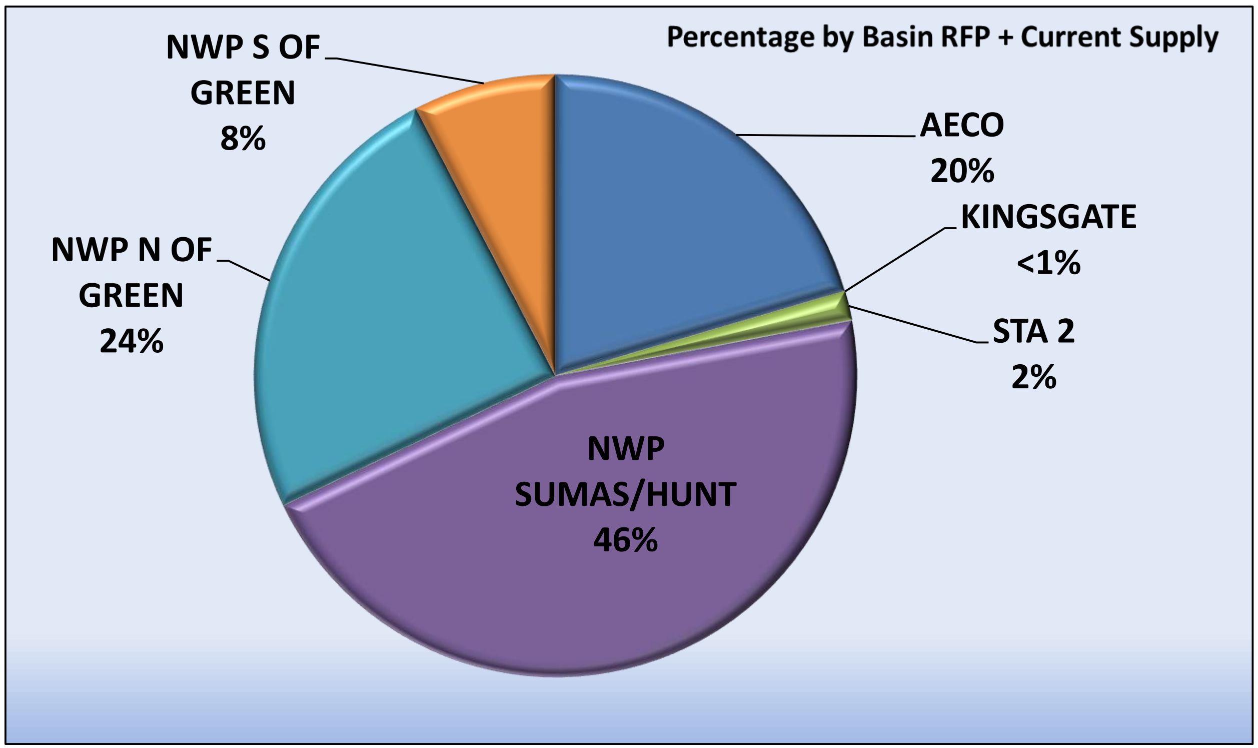
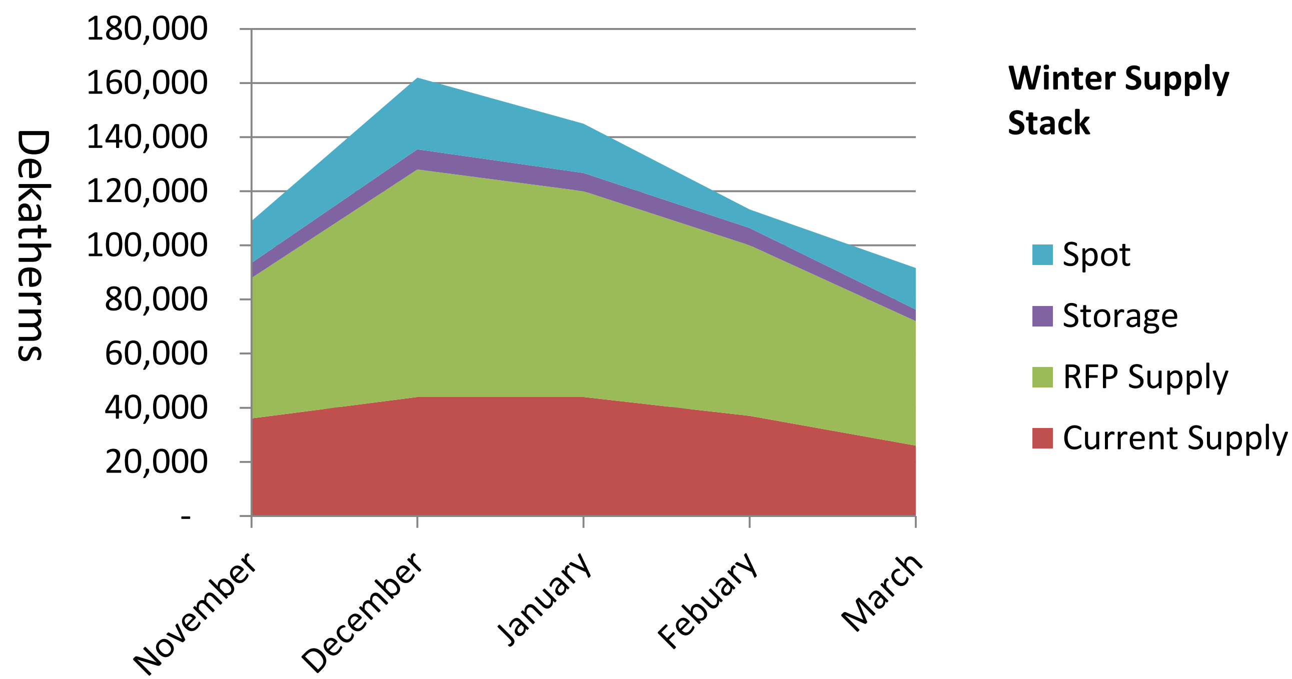
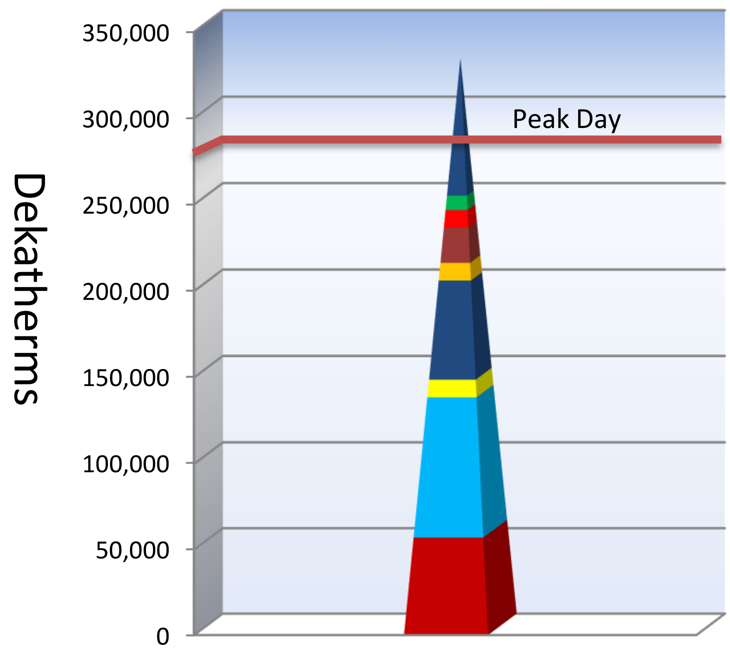
Percentage by Basin RFP + Current Supply



Winter Supply Stack



Peak Day Stack Example



Peak Day Stack Example

78,125	LS Storage
8,156	Pipeline Pack
10,000	3rd Party Citygate
20,000	Peaking Deal
10,000	Daily Spot Gas
56,366	SGS Storage
10,000	FOM Spot Gas
80,000	RFP Supply
56,000	Current Supply

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Alternative Resources

Major Resource Issues on the Horizon

- Once a deficiency is identified, Cascade must analyze potential solutions to ensure service over the planning horizon.
- Conversations with partners at various pipelines, storage facilities, new supply sources.
- SENDOUT® is used to ultimately derive the optimal mix of resources, referred to as the "preferred portfolio."

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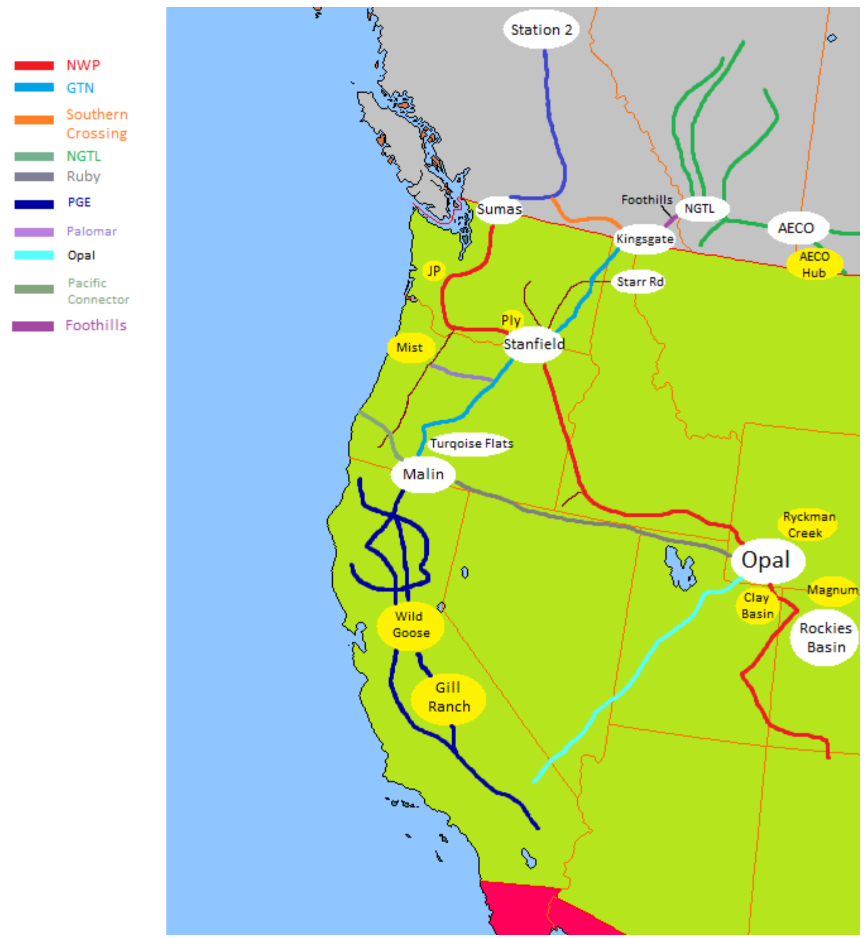
Location of Current & Alternative Resources



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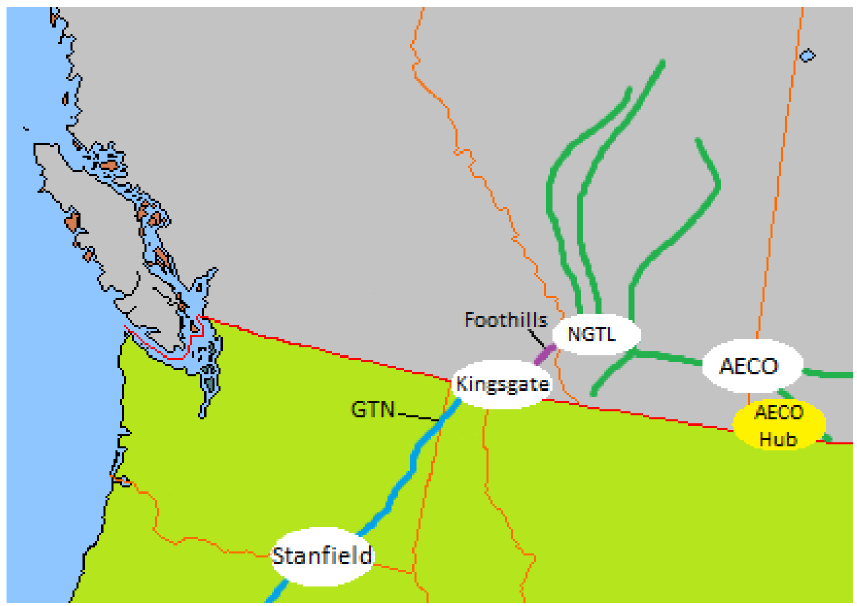
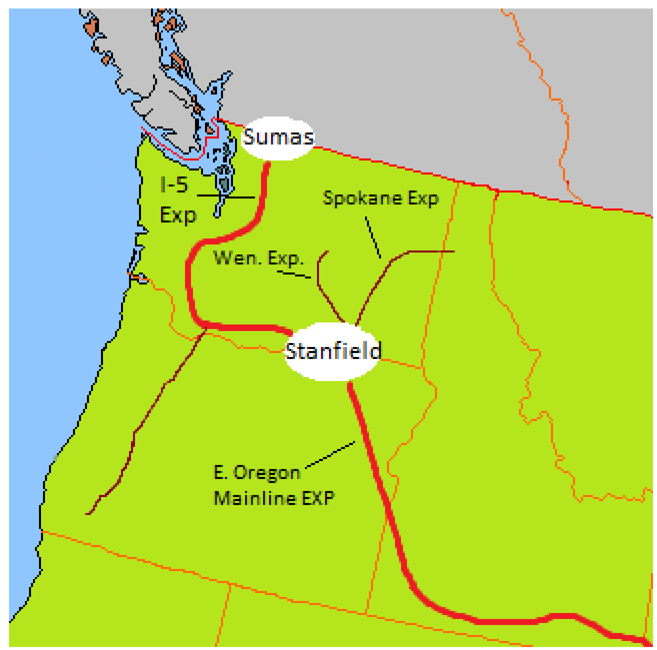
Incremental Transport – North to South

- Incremental NGTL – Additional capacity to move gas from AECO basin to Alberta/BC border
- Incremental Foothills – Additional capacity to move gas from Alberta/BC border to Kingsgate
- Incremental GTN N/S – Additional capacity to move gas from Kingsgate to various citygates along GTN



Incremental Transport – Northwest Pipeline

- I-5 Mainline Expansion – Additional capacity to move gas along I-5 corridor in western Washington
- Wenatchee Lateral Expansion – Additional capacity to move gas along Wenatchee Lateral to central Washington
- Spokane Lateral Expansion – Additional capacity to move gas along Spokane Lateral to eastern Washington
- Eastern Oregon Mainline Expansion – Additional capacity to move gas along Eastern Oregon Lateral to Oregon citygates

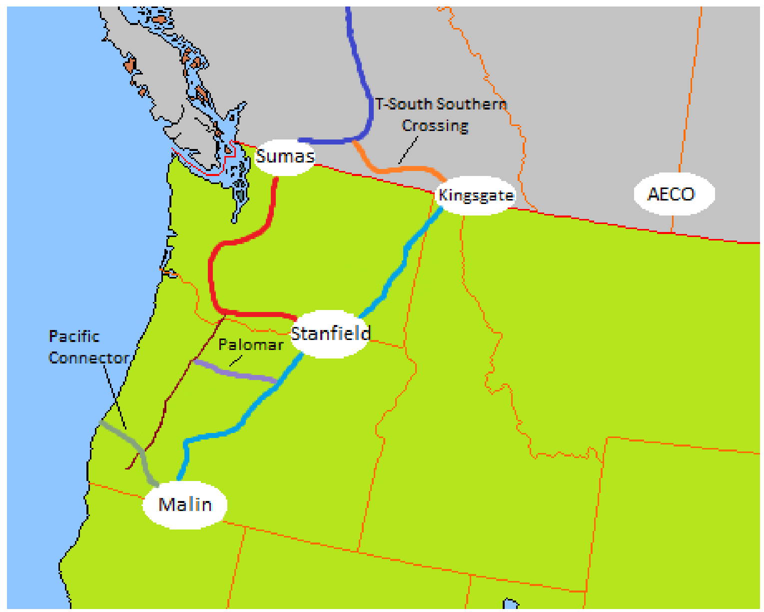


Incremental Transport – South to North

Incremental Opal– Additional capacity to move gas from Utah to Opal
Incremental Ruby – Additional capacity to move gas from Rockies Basin to Turquoise Flats
Incremental GTN S/N – Additional capacity to move gas from Turquois Flats to various citygates along GTN

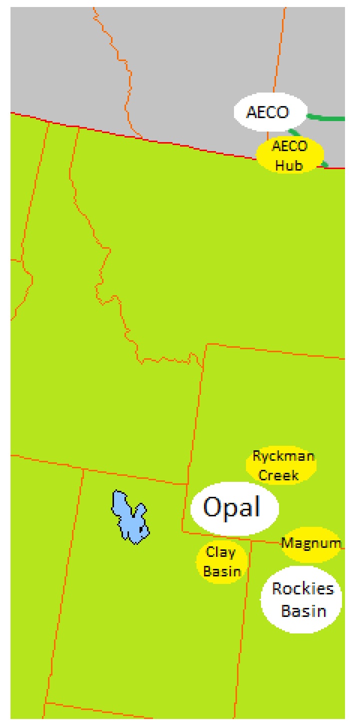
Incremental Transport – Bilateral

- T-South Southern Crossing – Price arbitrage opportunity to move gas between Sumas and AECO basins bilaterally
- Trails West (Palomar) – Additional capacity to move Rockies gas to the I-5 corridor
- Pacific Connector – Pipeline that will feed LNG facility on Oregon coast, increasing liquidity at Malin



Incremental Storage - North and East

- Ryckman Creek Storage – Additional storage in southwest Wyoming serving the system, primarily Oregon
- Magnum Storage – Additional storage near Rocky Mountains, serving the system, primarily Oregon
- AECO Hub Storage – Additional storage near AECO Hub, serving the system
- Clay Basin Storage – Additional storage near Opal, serving the system



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Incremental Storage - South and West

- Gill Ranch Storage – Additional storage in central California, serving the system, primarily Oregon
- Mist Storage – Additional storage in northern Oregon, serving the system, primarily Washington
- Wild Goose Storage – Additional storage in northern California, serving the system, primarily Oregon

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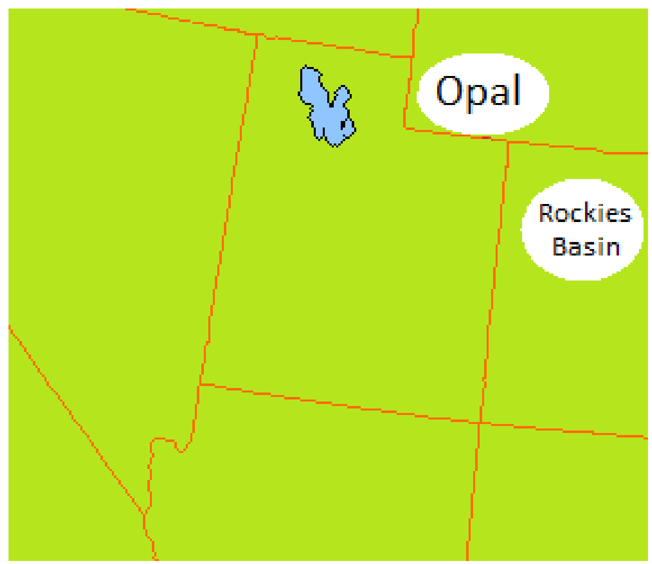
Incremental Supplies

- Incremental Opal Supply – Additional supply around the Rockies Basin
- Renewable Natural Gas – Incremental biogas supply directly to distribution system



Market Outlook and Long Range Price Forecast

Long Range Market Outlook

- According to the Energy Information Administration (EIA) 2017 Annual Energy Outlook (AEO), Natural Gas is projected to lead the power sector in gross energy consumption over the next 20+ years.
- On a percentage basis, renewable energy is forecasted to grow the fastest.
- As expected, high natural gas consumption leads to a robust production forecast for natural gas.

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Long Range Market Outlook Cont'd

- Like consumption, nonhydroelectric renewable energy shows a significant production growth projection.
- Global GDP growth looks strong, but Wood Mackenzie has identified three potential pitfalls that could lead to a loss of anywhere between $2.2 trillion and $3.6 trillion of potential global GDP growth by 2021.
- Wood Mackenzie projects in its 2017 first half North American highlight report that gas prices will remain above $3/mmbtu.

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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 Wood Mackenzie, EIA, the Northwest Power Planning Council (NPPC), 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.
- 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.

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Long Range Price Forecast Cont’d

- 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.

Price Forecast Weights

- Considerations in weight assignments
  - Cascade has modified its weighting system based on a backcast 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)
    - NPPC (regional perspective, but recognize it is also a blend)
    - NYMEX Henry Hub
  - EIA is the only source who produces a forecast after 2036
    - EIA typically forecasts higher than most other sources, so their forecast needs to be normalized based on their average error

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Example of SMAPE Calculations by Source

	Source 1	Source 2	Source 3	Source 4
T+1	0.126033375	0.217301	0.1446299	0.152795
T+2	0.167033935	0.208055	0.1973402	0.193328
T+3	0.201221558	0.159752	0.1774237	0.180943
T+4	0.207867469	0.216499	0.0567454	0.206089
T+5	0.240209263	0.170581	0.0149917	0.203743
T+6	0.223763051	0.15863	0.0308552	0.178014
T+7	0.224086048	0.017803	0.160998	0.126166
T+8	0.173107419	0.108208	0.1654999	0.101882
T+9	0.22366183	0.182278	0.1409933	0.190653
T+10	0.197011026	0.171414	0.1373605	0.182815
T+11	0.232436816	0.198159	0.0881173	0.177821
T+12	0.235293955	0.064647	0.046813	0.169711

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Example Weights Price Forecast For 2018

Date	Source 1	Source 2	Source 3	Source 4
18-Jan	7.443%	27.601%	51.155%	13.802%
18-Feb	4.103%	40.758%	43.028%	12.111%
18-Mar	4.142%	42.124%	38.518%	15.216%
18-Apr	4.619%	41.958%	37.283%	16.140%
18-May	5.469%	41.641%	36.015%	16.876%
18-Jun	5.248%	40.041%	37.548%	17.163%
18-Jul	3.654%	41.433%	39.335%	15.578%
18-Aug	3.970%	41.695%	38.973%	15.362%
18-Sep	3.324%	48.277%	34.266%	14.132%
18-Oct	4.354%	49.429%	31.572%	14.646%
18-Nov	4.459%	51.308%	29.570%	14.663%
18-Dec	5.599%	49.377%	29.287%	15.737%

Avoided Cost Methodology and Calculation

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Avoided Cost Overview

- As part of the IRP process, Cascade calculates a 20-year forecast and 45 years of avoided costs.
- The avoided cost is an estimated cost to serve the next unit of demand with a supply side resource option at a point in time. This incremental cost to serve represents the cost that could be avoided through energy conservation.
- The avoided cost forecast can be used as a guideline for comparing energy conservation with the cost of acquiring and transporting natural gas to meet demand.
- Cascade evaluates the impact that a range of environmental externalities, including CO_2 emission prices, would have on the avoided costs in terms of cost adders and supply costs.
- We produce an expected avoided cost case based on peak day.

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Avoided Cost Formula

The components that go into Cascade's avoided cost calculation are as follows:

$$AC_{nominal} = TC_f + TC_v + SC_f + SC_v + (CC * C_{tax} * C_{adder}) + DSC + RP$$

Where

- $AC_{nominal}$ = The nominal avoided cost for a given year. To put this into real dollars you must apply the following: Avoided Cost/(1+discount rate)^Years from the reference year.
- TC_f = Fixed Transportation Costs
- TC_v = Variable Transportation Costs
- SC_f = Fixed Storage Costs
- SC_v = Variable Storage Costs
- CC = Commodity Costs
- C_{tax} = Carbon Tax
- C_{adder} = Carbon Adder, as recommended by the Northwest Power and Conservation Council
- DSC = Distribution System Costs
- RP = Risk Premium

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METHODOLOGY

- Transportation costs are pulled directly from the major pipelines that Cascade utilizes (NWP, GTN, Enbridge, Ruby, Nova Gas Transmission (NGTL) and Foothills).
- Storage costs come from the two major storage facilities that Cascade utilizes (Jackson Prairie and Plymouth).
- Commodity Costs are take from Cascade's 20-year price forecast.
- Risk Premium is the cost associated with hedging.
- Cascade does not include distribution system costs in its current avoided cost calculation, but is considering it for future iterations.

SENDOUT® Scenarios and Inputs

SENDOUT® Model

- Cascade utilizes SENDOUT® for resource optimization.
- This model permits the Company to develop and analyze a variety of resource portfolios to help determine the type, size, and timing of resources best matched to forecast requirements.
- SENDOUT® is very powerful and complex. It operates by combining a series of existing and potential demand side and supply side resources, and optimizes their utilization at the lowest net present cost over the entire planning period for a given demand forecast.

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SENDOUT® Model Cont'd

- SENDOUT® utilizes a linear programming approach.
- The model knows the exact load and price for every day of the planning period based on the analyst's input and can therefore minimize costs in a way that would not be possible in the real world.
- Therefore, it is important to acknowledge that linear programming analysis provides helpful but not perfect information to guide decisions.

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Modeling Transportation In SENDOUT® is a Balancing Act

- Start with a point in time look at each jurisdiction's resources
- Use the Nov17-Oct18 PGA portfolio
- Contracts –Receipt and Delivery Points
- We start with current transport contracts, using centralized receipts and approx. 66 delivery locations
- Rates - Current contractual, with CPI increase every 3 years
- Contractual vs. Operational
- Contractual can be overly restrictive
- Operational can be overly flexible
- Incorporating operational realities into our modeling can defer the need to acquire new resources.
- Gas Supply's job is to get gas from the supply basin to the pipeline citygate.
- IRP focus is on the core
- Operations job is to take gas from the pipeline gate to our customers.
- Operations focus is on the system, not just the core
- Limiting factor is receipt quantity –how much can you bring into the system?

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Modeling Challenges

- Supply needs to get gas to the citygate.
- Many of Cascade's transport agreements were entered into decades ago, based on demand projections at that point in time.
- Sum of receipt quantity and aggregated delivery quantity can help identify resource deficiency depending on how rights are allocated.
- The aggregated look can mask individual citygate issues for looped sections, and the disaggregated look can create deficiencies where they don't exist.
- In many cases operational capacity is greater than contracted.
- SENDOUT® has perfect knowledge.

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Supply Resource Optimization Process

- **Step 1: As-Is Analysis**
  - Run a deterministic optimization of existing resources with a three-day peak event to uncover timing and quantity of resource deficiencies
- **Step 2: Introduce Additional Resources**
  - Include incremental supply, storage, and transportation to derive a deterministic optimal portfolio
- **Step 3: Stochastic Analysis of All Resources Under Existing Conditions**
  - Run all current and incremental resources through a Monte Carlo weather simulation, using expected growth, supply and storage accessibility. Record the probability of each resource being selected
    - Derive a stochastic optimal portfolio for this scenario by inserting most selected resource one at a time until resource deficiencies are eliminated
    - Consider probability curves for amount, timing of resources when deriving optimal portfolio

Supply Resource Optimization Process Cont’d.

- **Step 4: Stochastic Analysis of All Scenarios**
    - Run Monte Carlo simulations on all scenarios, record optimal portfolio of each scenario.
- **Step 5: Selection of Preferred Portfolio**
    - Analyze the optimal portfolios of each scenario and rank portfolios. The preferred portfolio will be the best combination of cost and risk for Cascade and its customers.
- **Step 6: Sensitivity of Preferred Portfolio**
    - Run the preferred portfolio through Monte Carlo simulations on price. Review results to determine if total system cost is within a tolerable range across all sensitivities.
- **Step 7: Re-evaluation of Preferred Portfolio**
    - If the total system costs fall outside of a tolerable range in sensitivity analysis, select the next most optimal portfolio to run sensitivity analysis on. Repeat as needed.

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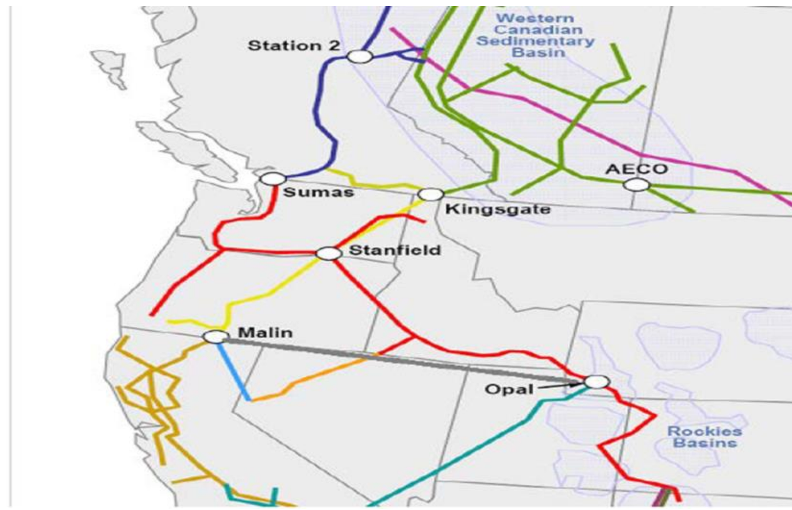
Additional Preferred Portfolio Considerations

- Does it get supply to the citygate?
- Is it reliable?
- Does it have a long lead time?
- How much does it cost?
- New build vs. depreciated cost
- The rate pancake
- Is it a base load or peaking resource?
- How many dekatherms are needed?
- What is the “shape” of resource?
- Is it tried and true technology, new technology, or yet to be discovered?
- Who else will be competing for the resource?

All In Case

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
All In	**Current Station2**	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
	Incremental GTN N-S	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		



The All In Case run allows the Company to see what the model would select if all current and potential resources are available.

As-Is and Incremental Storage

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
As Is	Current Station2 Current NGTL Current GTN Current NWP Current Foothills Current Ruby *Incremental NGTL* *Incremental GTN N-S* *NWP I-5 Mainline EXP* *Incremental Ruby* *NWP Wen lateral EXP* *Incremental Foothills* *NWP Z20 lateral EXP* *T-South-So Crossing* *Trails West (Palomar)* *NWP East OR Mainline EXP* *Incremental GTN S-N* *Incremental Enbridge* *Pacific Connector*	JP1 JP2 JP3 JP4 PLY-1 PLY-2 *Ryckman Crk Storage* *Gill Ranch Storage* *Mist Storage* *Wild Goose Storage* *Aeco Hub Storage* *Magnum Storage* *Clay Basin Storage*	AECO Base/Fixed, Winter, Day W/S, Peak SUMAS Base/Fixed, Winter, Day W/S, Peak ROCKIES Base/Fixed, Winter, Day W/S, Peak HUNT Base/Fixed, Winter, Day W/S KINGSGATE Base OPAL Base STAT2 Base *Opal Incrm Supply* *BioNaturalGas* *Resource Mix - 3 Basins*

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Incr Storage	Current Station2 Current NGTL Current GTN Current NWP Current Foothills Current Ruby *Incremental NGTL* *Incremental GTN N-S* *NWP I-5 Mainline EXP* *Incremental Ruby* *NWP Wen lateral EXP* *Incremental Foothills* *NWP Z20 lateral EXP* *T-South-So Crossing* *Trails West (Palomar)* *NWP East OR Mainline EXP* *Incremental GTN S-N* *Incremental Enbridge* *Pacific Connector*	JP1 JP2 JP3 JP4 PLY-1 PLY-2 *Ryckman Crk Storage* *Gill Ranch Storage* *Mist Storage* *Wild Goose Storage* *Aeco Hub Storage* *Magnum Storage* *Clay Basin Storage*	AECO Base/Fixed, Winter, Day W/S, Peak SUMAS Base/Fixed, Winter, Day W/S, Peak ROCKIES Base/Fixed, Winter, Day W/S, Peak HUNT Base/Fixed, Winter, Day W/S KINGSGATE Base OPAL Base STAT2 Base *Opal Incrm Supply* *BioNaturalGas* *Resource Mix - 3 Basins*

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Incremental Transport and All in

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Incr Transport	**Current Station2** **Current NGTL** **Current GTN** **Current NWP** **Current Foothills** **Current Ruby**	**JP1** **JP2** **JP3** **JP4** **PLY-1** **PLY-2**	**AECO Base/Fixed, Winter, Day W/S, Peak** **SUMAS Base/Fixed, Winter, Day W/S, Peak** **ROCKIES Base/Fixed, Winter, Day W/S, Peak** **HUNT Base/Fixed, Winter, Day W/S** **KINGSGATE Base** **OPAL Base** **STAT2 Base**
	Incremental NGTL ***Incremental GTN N-S*** ***NWP I-5 Mainline EXP*** ***Incremental Ruby*** ***NWP Wen lateral EXP*** ***Incremental Foothills*** ***NWP Z20 lateral EXP*** ***T-South-So Crossing*** ***Trails West (Palomar)*** ***NWP East OR Mainline EXP*** ***Incremental GTN S-N*** ***Incremental Enbridge*** ***Pacific Connector***	***Ryckman Crk Storage*** ***Gill Ranch Storage*** ***Mist Storage*** ***Wild Goose Storage*** ***Aeco Hub Storage*** ***Magnum Storage*** ***Clay Basin Storage***	***Opal Incrm Supply*** ***BioNaturalGas*** ***Resource Mix - 3 Basins***

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
All In	**Current Station2** **Current NGTL** **Current GTN** **Current NWP** **Current Foothills** **Current Ruby**	**JP1** **JP2** **JP3** **JP4** **PLY-1** **PLY-2**	**AECO Base/Fixed, Winter, Day W/S, Peak** **SUMAS Base/Fixed, Winter, Day W/S, Peak** **ROCKIES Base/Fixed, Winter, Day W/S, Peak** **HUNT Base/Fixed, Winter, Day W/S** **KINGSGATE Base** **OPAL Base** **STAT2 Base**
	Incremental NGTL ***Incremental GTN N-S*** ***NWP I-5 Mainline EXP*** ***Incremental Ruby*** ***NWP Wen lateral EXP*** ***Incremental Foothills*** ***NWP Z20 lateral EXP*** ***T-South-So Crossing*** ***Trails West (Palomar)*** ***NWP East OR Mainline EXP*** ***Incremental GTN S-N*** ***Incremental Enbridge*** ***Pacific Connector***	***Ryckman Crk Storage*** ***Gill Ranch Storage*** ***Mist Storage*** ***Wild Goose Storage*** ***Aeco Hub Storage*** ***Magnum Storage*** ***Clay Basin Storage***	***Opal Incrm Supply*** ***BioNaturalGas*** ***Resource Mix - 3 Basins***

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Low Growth and High Growth

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Low Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
	Current Station2	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
Low Growth	***Incremental GTN N-S***	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO		
	High Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
	Current Station2	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
High Growth	***Incremental GTN N-S***	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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Limit BC and Limit Alberta

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit BC	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Alberta	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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Limit Canada and Limit Rockies

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Canada	**Current Station2** **Current NGTL** **Current GTN** **Current NWP** **Current Foothills** **Current Ruby**	**JP1** **JP2** **JP3** **JP4** **PLY-1** **PLY-2**	**AECO Base/Fixed, Winter, Day W/S, Peak** **SUMAS Base/Fixed, Winter, Day W/S, Peak** **ROCKIES Base/Fixed, Winter, Day W/S, Peak** **HUNT Base/Fixed, Winter, Day W/S** **KINGSGATE Base** **OPAL Base** **STAT2 Base**
	Incremental NGTL ***Incremental GTN N-S*** ***NWP I-5 Mainline EXP*** ***Incremental Ruby*** ***NWP Wen lateral EXP*** ***Incremental Foothills*** ***NWP Z20 lateral EXP*** ***T-South-So Crossing*** ***Trails West (Palomar)*** ***NWP East OR Mainline EXP*** ***Incremental GTN S-N*** ***Incremental Enbridge*** ***Pacific Connector***	***Ryckman Crk Storage*** ***Gill Ranch Storage*** ***Mist Storage*** ***Wild Goose Storage*** ***Aeco Hub Storage*** ***Magnum Storage*** ***Clay Basin Storage***	***Opal Incrm Supply*** ***BioNaturalGas*** ***Resource Mix - 3 Basins***

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Rockies	**Current Station2** **Current NGTL** **Current GTN** **Current NWP** **Current Foothills** **Current Ruby**	**JP1** **JP2** **JP3** **JP4** **PLY-1** **PLY-2**	**AECO Base/Fixed, Winter, Day W/S, Peak** **SUMAS Base/Fixed, Winter, Day W/S, Peak** **ROCKIES Base/Fixed, Winter, Day W/S, Peak** **HUNT Base/Fixed, Winter, Day W/S** **KINGSGATE Base** **OPAL Base** **STAT2 Base**
	Incremental NGTL ***Incremental GTN N-S*** ***NWP I-5 Mainline EXP*** ***Incremental Ruby*** ***NWP Wen lateral EXP*** ***Incremental Foothills*** ***NWP Z20 lateral EXP*** ***T-South-So Crossing*** ***Trails West (Palomar)*** ***NWP East OR Mainline EXP*** ***Incremental GTN S-N*** ***Incremental Enbridge*** ***Pacific Connector***	***Ryckman Crk Storage*** ***Gill Ranch Storage*** ***Mist Storage*** ***Wild Goose Storage*** ***Aeco Hub Storage*** ***Magnum Storage*** ***Clay Basin Storage***	***Opal Incrm Supply*** ***BioNaturalGas*** ***Resource Mix - 3 Basins***

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Limit JP and Limit Ply Storage

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - JP	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - Ply	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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Limit Both Storage and No JP

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - Both	**Current Station2**	JP1	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	JP2	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	JP3	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	JP4	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	PLY-1	**KINGSGATE Base**
	Current Ruby	PLY-2	**OPAL Base**
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - JP	**Current Station2**	JP1	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	JP2	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	JP3	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	JP4	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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No Ply Storage and No Storage

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - Ply	**Current Station2** **Current NGTL** **Current GTN** **Current NWP** **Current Foothills** **Current Ruby** ***Incremental NGTL*** ***Incremental GTN N-S*** ***NWP I-5 Mainline EXP*** ***Incremental Ruby*** ***NWP Wen lateral EXP*** ***Incremental Foothills*** ***NWP Z20 lateral EXP*** ***T-South-So Crossing*** ***Trails West (Palomar)*** ***NWP East OR Mainline EXP*** ***Incremental GTN S-N*** ***Incremental Enbridge*** ***Pacific Connector***	**JP1** **JP2** **JP3** **JP4** **PLY-1** **PLY-2** ***Ryckman Crk Storage*** ***Gill Ranch Storage*** ***Mist Storage*** ***Wild Goose Storage*** ***Aeco Hub Storage*** ***Magnum Storage*** ***Clay Basin Storage***	**AECO Base/Fixed, Winter, Day W/S, Peak** **SUMAS Base/Fixed, Winter, Day W/S, Peak** **ROCKIES Base/Fixed, Winter, Day W/S, Peak** **HUNT Base/Fixed, Winter, Day W/S** **KINGSGATE Base** **OPAL Base** **STAT2 Base** ***Opal Incrm Supply*** ***BioNaturalGas*** ***Resource Mix - 3 Basins***

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - Both	**Current Station2** **Current NGTL** **Current GTN** **Current NWP** **Current Foothills** **Current Ruby** ***Incremental NGTL*** ***Incremental GTN N-S*** ***NWP I-5 Mainline EXP*** ***Incremental Ruby*** ***NWP Wen lateral EXP*** ***Incremental Foothills*** ***NWP Z20 lateral EXP*** ***T-South-So Crossing*** ***Trails West (Palomar)*** ***NWP East OR Mainline EXP*** ***Incremental GTN S-N*** ***Incremental Enbridge*** ***Pacific Connector***	**JP1** **JP2** **JP3** **JP4** **PLY-1** **PLY-2** ***Ryckman Crk Storage*** ***Gill Ranch Storage*** ***Mist Storage*** ***Wild Goose Storage*** ***Aeco Hub Storage*** ***Magnum Storage*** ***Clay Basin Storage***	**AECO Base/Fixed, Winter, Day W/S, Peak** **SUMAS Base/Fixed, Winter, Day W/S, Peak** **ROCKIES Base/Fixed, Winter, Day W/S, Peak** **HUNT Base/Fixed, Winter, Day W/S** **KINGSGATE Base** **OPAL Base** **STAT2 Base** ***Opal Incrm Supply*** ***BioNaturalGas*** ***Resource Mix - 3 Basins***

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Sensitivities Analyses

Sensitivities		Assumptions
Price	High	Medium Load Growth, Average Weather with Peak Event, High Gas Price Environment.
	Low	Medium Load Growth, Average Weather with Peak Event, Low Gas Price Environment.
Carbon Adder	10%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 10% Adder for Unknown Regulatory Impacts
	20%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 20% Adder for Unknown Regulatory Impacts
	30%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 30% Adder for Unknown Regulatory Impacts
Per Ton	$10	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $10 per ton Carbon Tax
	$20	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $20 per ton Carbon Tax
	$30	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $30 per ton Carbon Tax

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Additional Input From Stakeholders

Feedback on…

- Avoided cost methodology and calculations
- New price forecast weighting system
- New optimization process
- Clarification for scenarios versus sensitivities
- Risk analysis proposed, any additional analysis to be considered

2018 IRP Timeline

Date	Process Element	Location (Subject to change)
Friday, July 21, 2017	Citygate Update to CNGC Gas Supply Oversight Committee	
Wednesday, July 26, 2017	CAG Q3 Meeting	
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 4, 2017	CAG Q4 Meeting	
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	

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NEXT STEPS?

Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #2

Wednesday, July 19, 2017
Public Utility Commission of Oregon
Salem, OR

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2nd External TAG Meeting - OPUC

07/18/2017, 9:00 – 11:19 AM

Presenters: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Eric Wood, Ashton Davis & Chris Bolton

In attendance: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Ashton Davis, Eric Wood, Bruce Folsom, Debb Glosser, Geoffrey Ihle, Dan Kirschner, & Jon Kreider

Called in: Garret Senger, Miki Bode Jones & Laura Flanders – NWP, Monica Cowlishaw, Jim Abrahamson, Chris Robbins, Carolyn Stone, Kary Burin, Jeremy Ogden, Jennifer Gross, Isaac Myhrum, & Tom Pardee

Minutes by: Carolyn P Stone

Mark Sellers Vaughn started the meeting by welcoming everyone and stating that there is a lot of material to cover today.

Presentation #1 – Mark Sellers-Vaughn
IRP Action Plan Update

Mark stated there would be an "open comment period" and an "IRP Action Plan Update", Chris Bolton will present "Distribution System Planning", Eric Wood will discuss "Current Supply Resources & Transportation Issues", Ashton Davis will present "Major Issues on the Horizon", Devin McGreal will present "Market Outlook & Long-Range Price Forecast", and Brian Robertson will discuss the "SENDOUT Model".

Mark asked Garret Senger if he had any opening comments. Garret welcomed everyone and said he was looking forward to the discussion & interaction and the presentation.

Slide #3 thru 5 - Mark stated that the IRP group committed to providing an IRP Action Plan Update at each and every TAG meeting. If Staff has questions or comments on the update, please state them.

Presentation #2 – Chris Bolton
Distribution System Planning

Slide #8 – "CNG System Overview" - Chris presented the CNG system. In Washington, we have 4,744 miles of distribution line and Oregon, 1,605 miles. We have over 700 regulator stations and over 1600 valves.

Slide #10 – "Where do we get our gas?" Chris explains primarily pipelines Williams, TransCanada & Enbridge.

Slide #12 – "GIS" (Geographic Information System)" - Chris explains that the GIS system helps keep up to date records of pipe, facilities and is completed with all system attributes. CNG uses GIS to model its system.

Slide #14 – "Synergi" Chris explains that this is engineering software that models piping and facilities to represent pressure & flow to help predict future events & growth.

Slide #15 thru 18 "Data Gathering" – The data gathering used to feed Synergi comes from:

1. CC&B
2. SCADA
3. Resource Planning

Slide #19 – "CNG Weather Zones" - Chris said Resource Planning provides them with CNG Weather zones.

*Mark pointed out that historical weather data availability is limited!

Slide #20 – "Customer Management Module. "

- Chris explained this works with the Synergi to input customer data helping them to see pressures and flows.
- The module takes in CC&B Data, HDD and growth information.

Question: Does this model include past or future data?
Answer: Conversion of CC&B to Synergi. Involves the following:

1. Grabs data and matches what we see.
2. Then ramps up customer usage and shows trends.
3. Growth model uses severe temperature data and other growth data to predict future projects.

Question: Do you have a "Summer Plan"?
Answer: Chris said "Not really, we don't really look at summertime load, maybe for large customer load only.

Slide #24 – Shows a "Synergi" low pressure scenario…

Slide #25 – "Capacity Enhancement Options"

Question: Is there a minimum pressure that you would assume there were problems?
Answer: Anything under 15/20 we will evaluate thru prioritization.

Question: Do you evaluate economic solutions vs engineering solutions?
Answer: We will be talking about that topic a little later.

Slide #26 - Shows the pros and cons of various "Pipe enhancements"

Slide #33 – "Project Process Flow"

- The process starts with input of information and data and finishes with the projects and schedules.
- Chris said they determine the feasibility and costs associated, then identify the best project, and rank it. Then it is put into the budget.

Slide #34 – “Future Projects”

- This is a sample of upcoming projects needed for growth.
- Project #2 requires 6,400 feet of 8-inch steel in Bend.
- Chris said Bend is a district with high growth!

Slide #41 – Conclusion

Question: How is the final decision for projects made?
Answer: Chris said upper management decides based on budget. Chris’s group comes up with 2 solutions, then go through them in a step by step decision making process with the different options. They talk with the district and city personnel on the importance of each project.

Mark asked if Jeremy Ogden had anything to add to this answer. Jeremy said Chris covered it well, but, in general, when pressures dip to 20 PSI it gets on their radar! Decisions are also based on growth and where the project is located.

Question: Mark asked a question of Staff. For future projects, what is the criteria for how many projects you would want to see in the narrative or appendix of the IRP, all projects or a small “picture”?
Answer: Staff doesn’t need to see all the projects but would like to see ones with a “typical analysis”.

Presentation #3 – Eric wood
Current Supply Resources & Transport Issues

Slide #43 – “Pipeline Transport Flow”

- Eric highlighted flow from South to North on Ruby (for Oregon transport) and stated Oregon gas comes from AECO.
- Eric also said gas can also be put on at Stanfield for Oregon.

Slide #44 – “Transport Summary” – Eric said this slide shows the % of our transport at each location.

Question: Are these long-term firm contracts?
Answer: Yes, out until 2023.

Slide #45 – “Storage Resources”

- Plymouth is used as a “peaking resource”.
- Eric said 50% of Plymouth was used last year!

Question: Do you cycle storage in summer for winter?
Answer: Yes

Question: Are we able to negotiate smaller lease rates?
Answer: No, the rates are tied to long-term transport contracts.

Mark stated that CNG relies on storage to balance the system because of Cascade’s diverse structure, it provides price “arbitrage” and we would be remiss not to use it.

Slide #46 – “Highlights for the 2017 Portfolio Design”

Question: How is the "20% in the third year" decided? Is the risk tolerance higher than other LDC's?
Answer: The GSOC sets the lower % based on a tolerance level.

Mark stated that there are currently 2 open dockets on financial hedging. CNG will comply with the Washington Hedging Policy and provide something back to them, but there will be no dramatic changes until both policies for both states are issued. CNG may need a split portfolio between the 2 states. In August CNG will be filing its policy for the Washington Hedging Strategy with GSOC and then update that at TAG #3.

Question: Potential options seem "thorny". Options are like an insurance product. You pay the extrinsic option premium, but is this useful? Did you read the "Gettings" paper?
Answer: 5% of our portfolio at this time is structured projects. We have not entered into any financial options at this time. We are familiar with the Gettings paper.

Devin advised that you can't look at where a financial option price goes or whether they are "profitable" or not because the job of the derivative transaction is to create a risk "barrier" of how much you are willing to lose due to the market conditions and how much hedging losses you are willing to take.

Slide #47 – Shows "Total RFPs" per basin coinciding with transport available in those regions.

Slide #51 – "Winter Supply Stack" shows the supply type/volume by month using RFP's, storage and spot purchases.

Slide #52 – "Peak Day Stack Example"

- Eric stated that CNG has a "peaking deal" for 20,000 per day we can call on and we could use 10,000 of 3rd party citygate deliveries.
- Our tolerance level is at 3%.
- The red line is 275K for expected peak day.

There was a bit of discussion on tolerance levels. Eric said CNG tries to always stay within our tolerance levels but at times we go outside of them, but at the end of the month we are usually within levels.

Mark announced that this is Ashton Davis' first tag meeting. He will present the next section of the presentation.

Presentation #4 – Ashton Davis
Major Resource Issues on the Horizon

Slide #57 – "Incremental Transport – North to South" – This is incremental or additional capacity to move gas at NGTL (NOVA) from AECO to Alberta/BC border, Foothills to move gas from AB/BC Border to Kingsgate and GTN North to South moves gas from Kingsgate to various citygates along GTN.

Slide #58 – "Incremental Transport – NWP" this slide shows expansions such as I-5, Wenatchee Lateral, Spokane Lateral and Eastern OR Mainline

Slide #59 – "Incremental Transport – Bilateral", T-South, Trails West & Pacific Connector.

Question: Do these locations provide price arbitrage?

Answer: Primarily but could be risk mitigation too, if supply gets held up at one location.

Slide #60 – "Incremental Storage – North and East" – These are additional storage locations that are available:

Rickman Creek =	Wyoming, serving Oregon
Magnum =	Serving Oregon
AECO Hub =	Serving system
Clay Basin =	Serving system

Slide #61 – "Incremental Storage – South and West"

Gill Ranch =	Serving Oregon
Mist =	Serving Washington
Wild Goose =	Serving Oregon

Presentation #5 – Devin McGreal
Market Outlook and Long Range Price Forecast

Slide #65 – "Long Range Market Outlook Cont'd" –
- Devin explained that nonhydroelectric renewables are significant and GDP looks good by 2021.
- Devin stated Wood Mackenzie projects gas prices above $3.00 in the 1st half of 2017.

Slide #66 – "Long Range Price Forecast" –
- Devin explained that price forecasting is more of an "art" than a science.
- Ashton has been researching papers on price forecasting so the group can see what methodologies are being used.
- Is futures pricing the best? Devin said we try to prove them wrong!
    - o Theoretically, Futures pricing should be good.
    - o Factors – optional reporting would be needed.
    - o Futures pricing goes through a clearing house.
    - o Forward pricing can be diluted.

Slide #67 – "Long Range Price Forecast Cont'd -

- Cascade assigns weight to sources using Henry Hub pricing (HH) for a 20-year planning horizon
- This makes it a bit more scientific

Slide #68 – "Price Forecast Weights" –
- Bruce Folsom gave a "spoiler alert" for Slide #93. The IRP team will be speaking about this an input from stakeholders would be helpful
- Sources used for giving weights are Wood MacKenzie, EIA, NPPC and HH
- Devin mentioned that the EIA's price is generally $2 higher in their forecasts

Slide #69 & 70 – "Example of SMAPE Calculations by Source" & "Example Weights Price Forecast for 2018"

- Devin explained that this shows the "Error %"

- He explained that you take the inverse of that and add up each total and it gives them a "weight" at T + 4, which is not so accurate.
- "Whole Winter Smoothing" data shows the exponent, trending & seasonality.

Mark asked Staff: Would they like to see a sample of the "Holt-Winter Smoothing"?
Answer: Yes!

Slide #72 – "Avoided Cost Overview"
Avoided cost is the estimated cost to serve the next unit of demand – we want to avoid this cost with supply side resources.

Slide #73 & 74 – "Avoided Cost Formula" & "Methodology"

Question: Is this methodology standard?
Answer: Devin explained that, there isn't really a standard beyond commodity. Each LDC does this differently! We all use SENDOUT, but distribution cost is not in our model.

Question: How do you quantify the "Risk Premium"?
Answer: Figure financial derivatives for X volume, then figure the costs of the physical product. You can't hedge smaller physical volumes; those costs are minute and not material.

Presentation #5 – Brian Robertson
SENDOUT Model

Slide #76 – "SENDOUT Model"
- Brian stated that SENDOUT is used for resource optimization….
- it is powerful & complex

Slide #77 - "SENDOUT Model Cont'd"
- This model uses a linear programming approach
- It has perfect information
- It provides good input but not perfect input, it is a "balancing" act
- Cascade has more DELIVERY (DEL) rights than RECEIPT (REC) rights

Question: Why the DEL & REC rights difference, due to a supply spot?
Answer: Mark explained that the pipelines divested themselves (1980) as a way to handle Oregon points. It was decided by NWP to create a flexibility for LDC's by giving more RECEIPT than DELIVERY rights. CNG has 1/3 more DELIVERY rights than RECEIPT rights due to our geographic diversity. Mark explained that there is a section in the IRP that goes through this and he can send it out.

Slide #79 – "Model Challenges"

Question: Why is this a "modeling challenge"?
Answer: Brian explained that some contracts are flexible. If the model had its way it would choose the best choice economically. We must give the model as much "reality" as possible and this is a challenging process! Brian stated that some contracts must be broken into smaller contracts, but you come out with one decision.

Slide #80 – “Supply Resource Optimization Process”

Step 1 – Uncover resource deficiencies…
Step 2 – Give model additional resources…
Step 3 – Run stochastic analysis by running resources through a Monte Carlo (MC) simulation and develop probability distributions.

- Brian said once we have the probability distributions, we go back to the Stochastic model run deterministically to see if that solved the resource deficiencies.

Question: Does this process reveal less “risky” resources?
Answer: We rank alternate resources each run and then cost them.

Slide #81 – “Supply Resource Optimization Process Cont’d”

Step 4 – Stochastic analysis of all scenarios…
Step 5 – Selection of preferred portfolio…
Step 6 – Sensitivity analysis of preferred portfolio then….
Step 7 – Re-evaluate best portfolio by running sensitivity analysis on it

Question: Do you run Monte Carlo simulations on standard deviations?
Answer: Brian said we put in the forecast and that produces standard deviations for weather. We use the past 30 years data average to get the standard deviations.

- Devin said we try to get granular, but are limited by operational capacity (200 draws).
- We must use 5 machines to run a SENDOUT, which takes a day.
- The price is correlated to weather, hopefully reducing runs.
- Mark said all LDC’s do 200 draws!

Slide #82 – “Additional Preferred Portfolio Considerations”

Question: Is there a point where the “rubber hits the road” on distribution?
Answer: We look at reliability, for example, was there a storage facility explosion? We use a qualitative perspective, but how reliable is it??

Slide #83 – “All in Case”

- Brian stated that this shows what the model would select if all current & potential resources available including transportation, storage & supply.

Slide #84 - 91 show additional results from the model

- Mark said they include transport when deciding on incremental storage resources!

Slide #92 – “Sensitivities Analyses”

Includes:
- Price (run Monte Carlos)
- Use a “Carbon adder”
- Per Ton adder (related to carbon tax)

- High gas price environment
- Low gas price environment

Slide #93 – “Additional Input from Stakeholders”

- Mark stated that his group wants feedback. We can do a Skype meeting or come to you!
- We can also send you workbooks.
- Various participants commented that this was great work!
- Mark thanked Eric & Chris for their help with presenting!
- Bruce Folsom commented that Ashton is new to CNG, Devin has been here under a year and Brian 3-4 years and they have done excellent work! Mark added that they have brought so much to the process!

Slide #94 - Mark went over the 2018 IRP Timeline.

- Mark wondered if we can provide food for the next meeting because TAG #3 goes from 9 AM to 3 PM in the “Umatilla Room”.
- Mark mentioned the IRP filing is January 25th in Oregon

Bruce said that it was a good meeting and appreciated the background material provided & presentation!

Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #3

Thursday, Sept. 7th, 2017

Portland International Airport

Portland, OR

Agenda

- Introductions
- IRP Action Plan Update
- Walkthrough of Resource Assessment and Modeling
- Policies and Methodologies Informing DSM Outcome
- Acquisition of all Cost Effective DSM
- Oregon Low Income Energy Conservation (OLIEC) & Conservation Achievement Tariff (CAT) Programs
- Action Plan/Other Items
- SENDOUT® Modeling Update
- Preliminary Modeling Results
- Incremental GTN Capacity
- Upcoming Schedule
- Questions

IRP Action Plan Update

2014 IRP Action Item	Update
1. Cascade will improve its demand forecast by developing a report to track the issuance of corrected bills and reclassifying therms from corrected bills to the month those therms were used. In its next IRP, Cascade will use its new Statistical Analysis Software (SAS) to test non-linear weather effects on natural gas, to perform analysis on potential serial correlation problems, and to create a time series autoregressive integrated moving average (ARIMA) model for customer forecasting.	On June 26th Cascade's Gas Supply Oversight Committee (GSOC) met and was provided an update on the 2017 portfolio procurement plan, which included recent market intelligence and updated pricing. In TAG 3 the company will discuss its supplies of varying lengths and pricing alternatives.
2. Cascade will continue to monitor outside determinants of natural gas usage, such as legislative building code changes and electrical “Direct Use” campaigns as they are determined to significantly affect the Company’s forecast.	Since the 2014 Action Plan, Cascade has monitored the following legislation, campaigns, and other external actions with the potential to influence natural gas use in the States of Washington and Oregon: - National standard practice manual, Portland renewable energy goals, gas to electric fuel switching, HB-2711 moratorium on hydraulic fracturing for oil and gas exploration and production, several Washington state bills on Carbon taxes, deep decarbonization, and the clean air rule.
3. Cascade will continue to monitor the effectiveness of the Oregon Public Purpose Fund to ensure the funds are adequate to capture significant portions of achievable therm savings in Oregon.	Since the 2014 IRP, Cascade has made two filings to increase its public purpose charge to ensure funding would be sufficient to acquire the therm savings target established in the IRP as a least cost resource: Advice No. O15-12-01 on December 11th, 2015 to increase its public purpose charge from 1.85% to 3.7% (reduced to 3.4% before Commission approval) and Advice No. O16-10-01 on October 31st, 2016, in which the Company asked to increase the Public Purpose Charge from 3.4% to 4.87%.
4. The company will continue to follow and analyze the impacts of the Western Climate Initiative and proposed carbon legislation at both the state and federal level as they pertain to natural gas conservation, as well as other such acts that may arise from these efforts. The company will continue to monitor the timing and the costs associated with carbon legislation and analyze the impacts on the company’s overall portfolio costs. As specific carbon legislation is passed, the company will update its avoided cost calculations, conservation potential and make modifications to its DSM incentive programs as necessary.	The Company has continued to monitor the Western Climate Initiative and proposed carbon legislation since the 2014 Action Plan. While no significant action has been taken on the WCI with impacts to the Company, the Company is actively following the current legislation and is monitoring the potential impacts to portfolio costs.

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IRP Action Plan Update Cont'd

5. The company will continue to monitor the cost effectiveness of existing conservation measures and emerging technologies to ensure that the current mix of measures included in the Washington Conservation program is appropriate. Areas for further analysis include the impacts associated with modifications to building codes along with the cost effectiveness of newer technologies such as the next generation of high efficiency water heaters (.70 EF) and high-efficiency hybrid heat pumps. The applicability of these measures within Cascade's service territory will be analyzed and the company's Conservation Incentive Program will be modified as necessary.	Cascade continually monitors the region and natural gas industry on currently available technology advancements as part of our Washington incentive programs. We reevaluate the portfolio cost-effectiveness paired with current technology and update install costs to maintain viability and as robust of a program as feasible. The Company is also engaged with the Northwest Energy Efficiency Alliance market transformation collaborative in coordination with other local utilities and the Energy Trust of Oregon as well as the Gas Technology Institute's emerging technology program to stay abreast of new technologies and opportunities for additions and changes to the Company's offerings. The Company also maintains a Trade Ally network for our Washington programs and routinely connects with local contractors to gauge availability of product and costs associated with installs of rebate eligible equipment and measures. The landscape is constantly evolving and Cascade works with its partners and local agencies and builders (including home builder associations) to track building code updates as well as changes to industry standards.
6. The Company will continue to monitor the potential reporting, administrative and potential financial impacts of long term resources as a result of concerns surrounding fracking. In particular we are awaiting the EPA to reveal the results of their current study in alleged water contamination found in Wyoming as a result of fracking activities.	Cascade has included a slide in TAG 3 to address this action item. Additionally, Cascade has extended an invitation to NWIGU to discuss this item.

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IRP Action Plan Update Cont'd

7. Cascade will continue to evaluate gas supply resources on an ongoing basis, including supplies of varying lengths (base, swing, peaking) and pricing alternatives. We will continue to analyze the uncertainties associated with supply and demand relationships.	Due to the robust nature of TAG 3, this will now be discussed in TAG 4.
8. The Company will continue to monitor the proposed pipeline expansion projects to access more supplies out of the Rockies. As cost estimates change, the company will analyze those resources under consideration to determine if modifications to the preferred portfolio are necessary.	NWP has provided an updated Wenatchee lateral expansion which is currently being considered for modeling.
9. As part of the Cascade's risk management policy and implementation, the Company will report on the status of the UM 1720 as well as related risk management policy enhancements to Cascade's risk management policy, at the first Purchased Gas Adjustment (PGA) quarterly meeting with OPUC Staff in early 2017. This docket is the Commission's Investigation into Long Term Hedging Policy.	Interested parties met on August 23rd, with the conclusion that an agreement could not be reached. The parties at this meeting (Staff, regional LDCs, NWIGU and CUB) will be requesting that this docket be closed. Cascade continues to work on enhancing its risk management policies in compliance with Washington's new hedging rules
10. The Company will continue to explore options to incorporate biogas into its portfolio, as specific projects are identified in our service territory. Price, location and gas quality considerations of the biogas supply will be evaluated.	Cascade has filed a Biomethane Reciept Services (Schedule 800) in Oregon to estabilsh biogas injection terms, conditions and gas quality requirements. Cascade continues to work with possible biomethane producers and evaluate those projects for possible future core supplies.
11. The Company will continue to monitor proposed LNG import facilities as information becomes available and will evaluate the various options that, if built, could result. Issues to monitor include specific cost, the availability of pipeline capacity and project timing.	Cascade is continuing to monitor the progress of import/export facilities such as the proposed Jordan Cove LNG terminal. The status of these projects are documented each month in Cascade's monthly internal market intelligence report
12. The Company will continue to monitor the futures market for price trends and will evaluate the effectiveness of its risk management policy. Implementation of Dodd- Frank in the coming year raises potential administrative challenges from a reporting standpoint; additionally it is unknown how the costs associated with the use of clearinghouses might impact prices of natural gas in the future.	Cascade has updated its price forecast to modify its weights based on a backcast of the accuracy of its sources. At this time the price impacts of Dodd-Frank and hedging related dockets such as UM 1720 and UG-132019 continues to be unknown. The Company will continue to provide updates in coming TAG meetings.

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Update on Fracking

- Cascade has reviewed the EPA document released in 2016 regarding Hydraulic Fracturing for Oil and Gas.
- Environmental impacts were documented but the results were overall inconclusive, included many data gaps, and any estimates contained high degrees of uncertainty.
- Cascade has determined that there are no immediate reporting, administrative and financial impacts of fracking that need to be addressed.

ETO/CNGC Joint DSM Presentation to Cascade Natural Gas Technical Advisory Group

TAG III Presentation

Thursday, September 7
Portland International Airport

Purpose

- To discuss the Company's Demand Side Management (DSM) strategy for the acquisition of all cost-effective conservation- in partnership with the Energy Trust of Oregon;

- Review of progress on adaptations based on OPUC order since last planning cycle; and

- Consideration of future DSM-focused action items to further strengthen & refine future analysis

OPUC Order Guidance

- Clearly show the plan to acquire all cost effective energy efficiency
- 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
- Provide updated data and explanations for the policies and methodologies used to inform the DSM analysis
- Incorporate commercial market transformation savings similar to residential methods and include an explanation for how those assumptions are derived and applied within the IRP
- Clearly document assumptions behind capacity contribution of energy efficiency and how the capacity value is incorporated into resource planning
- Provide an explanation regarding how annual energy savings are translated into peak day demand and capacity resources

Today's Agenda

1. Walkthrough of Resource Assessment and Modeling
2. Policies and Methodologies Informing DSM Outcome
3. Acquisition of all Cost Effective DSM
4. Oregon Low Income Energy Conservation (OLIEC) & Conservation Achievement Tariff (CAT) Programs
5. Action Plan/Other Items

Energy Trust of Oregon

Energy Efficiency Resource Potential Study

September 7, 2017

EnergyTrust of Oregon

About

- Independent nonprofit
- Serving 1.5 million customers of Portland General Electric, Pacific Power,
  NW Natural and
  Cascade Natural Gas
- Providing access to affordable energy
- Generating homegrown, renewable power
- Building a stronger Oregon and SW Washington

Resource Assessment Overview

What is a resource assessment?

- Estimate of available, cost-effective efficiency available to be acquired in Cascade's service territory over 20 years

Resource Assessment Inputs:

Utility Service Territory Data

- Customer counts, 20-year load forecasts
- Avoided costs, discount rate

Demographic statistics

- Heating & hot water fuel splits, measure saturations
- Energy use intensity for Commercial

Measure assumptions

- Savings, costs, O&M, measure life, load profile, end use, baseline, technical applicability, achievability rates

Background – How is RA used?

- Energy Trust uses the resource assessment model for utility IRP work, strategic planning, and program planning

- Does not dictate what annual savings are acquired by programs

- Does not set incentive levels

Model Assumptions

- Factor in known codes & standards
- Utilize 3rd party research and survey work to inform saturation rates
- A more direct approach to quantifying RES & COM building stock as an input
- Incremental measure savings approach for potential instead of market shares
- New approach to emerging technologies

Measure Updates

Refreshed measure assumptions

- Updated measures across all Sectors (RES, COM, IND)
  - Residential New Home Construction packages
  - Residential Showerheads, aerators
  - New Homes Tankless Water Heaters

Added New Measures

- Commercial Strategic Energy Management (SEM) – Behavioral
- Commercial Cooking measures
- Residential Smart Thermostats

Cost-Effectiveness Screen

Total Resource Cost (TRC) test

- TRC benefit cost ratio (BCR) = NPV of Benefits / Total Resource Cost

Benefits

- Savings x Avoided Costs per therm
- Quantifiable non-energy benefits

Total Resource Measure Costs

- Full cost of EE measure or incremental cost of installing efficient measure over baseline measure

Cost-Effectiveness Override in Model

Energy Trust applied this feature to measures found to be NOT Cost-Effective in the model but are offered through programs, sometimes with OPUC exception. Examples:

- Commercial Insulation and Windows
- Residential Furnaces
- New Homes Construction Pathways
- Residential Smart Thermostats
- Residential Windows
- Residential Insulation (ceiling, floor, wall)
- Residential Tank Water Heater

Emerging Technology

- New model includes savings potential from emerging technologies
- Factor in changing performance, cost over time
- Use risk factors to hedge against uncertainty

ET Risk Factor Scorecard

Risk Category	10%	30%	50%	70%	90%
Market Risk (25% weighting)	High Risk: • Requires new/changed business model • Start-up, or small manufacturer • Significant changes to infrastructure • Requires training of contractors. Consumer acceptance barriers exist.			Low Risk: • Trained contractors • Established business models • Already in U.S. Market • Manufacturer committed to commercialization	
Technical Risk (25% weighting)	High Risk: Prototype in first field tests. A single or unknown approach	Low volume manufacturer. Limited experience	New product with broad commercial appeal	Proven technology in different application or different region	Low Risk: Proven technology in target application. Multiple potentially viable approaches.
Data Source Risk (50% weighting)	High Risk: Based only on manufacturer claims	Manufacturer case studies	Engineering assessment or lab test	Third party case study (real world installation)	Low Risk: Evaluation results or multiple third party case studies

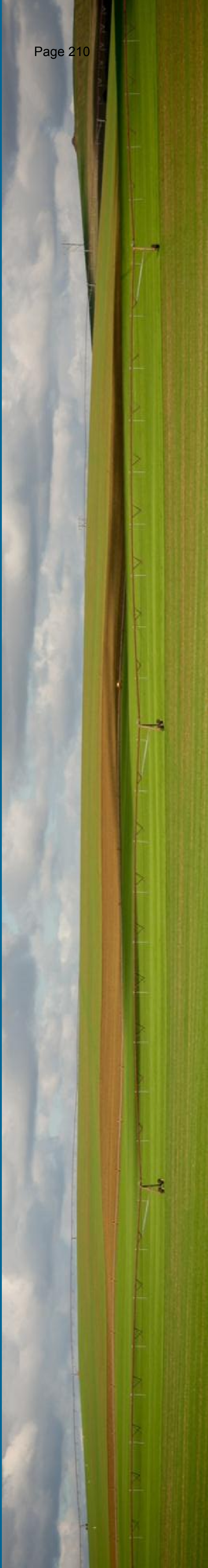
Emerging Technologies

Residential	Commercial	Industrial
• Window Replacement (U<.20) • Advanced Insulation Technologies • Smart Devices Home Automation / Controls • Absorption Gas Heat Pump Water Heaters • AFUE 98/96 Furnace	• AC Heat Recovery, Hot Water • Advanced Ventilation Controls • Smart/Dynamic windows • Highly Insulated Windows • Energy Recovery Ventilator	• Gas-Fired Heat Pump Water Heaters • Wall Insulation

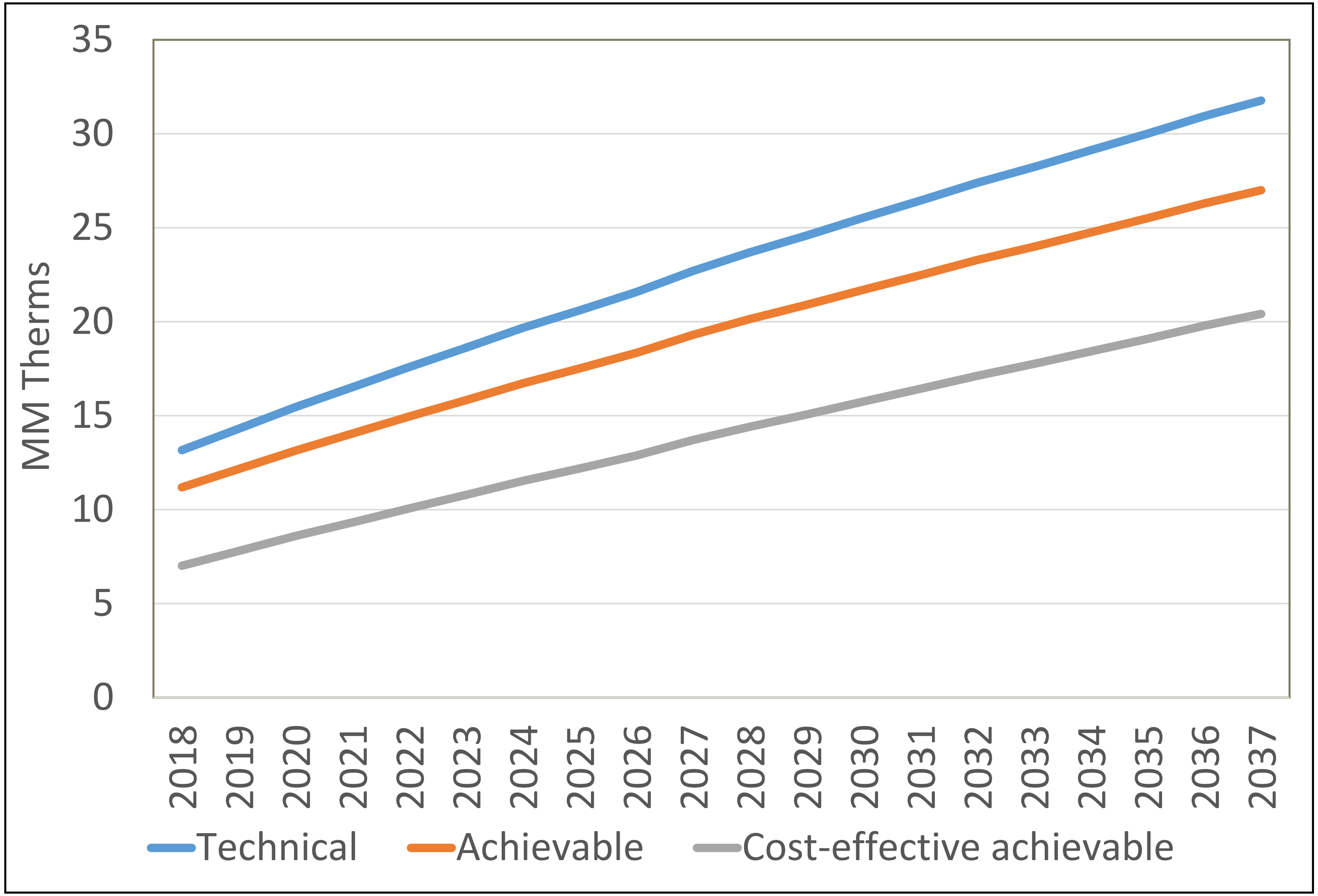
Outputs:

Not technically feasible	Technical Potential		
Not technically feasible	Market barriers	Achievable Potential 85% of Technical	
Not technically feasible	Market barriers	Not cost effective	Cost-Effective Potential

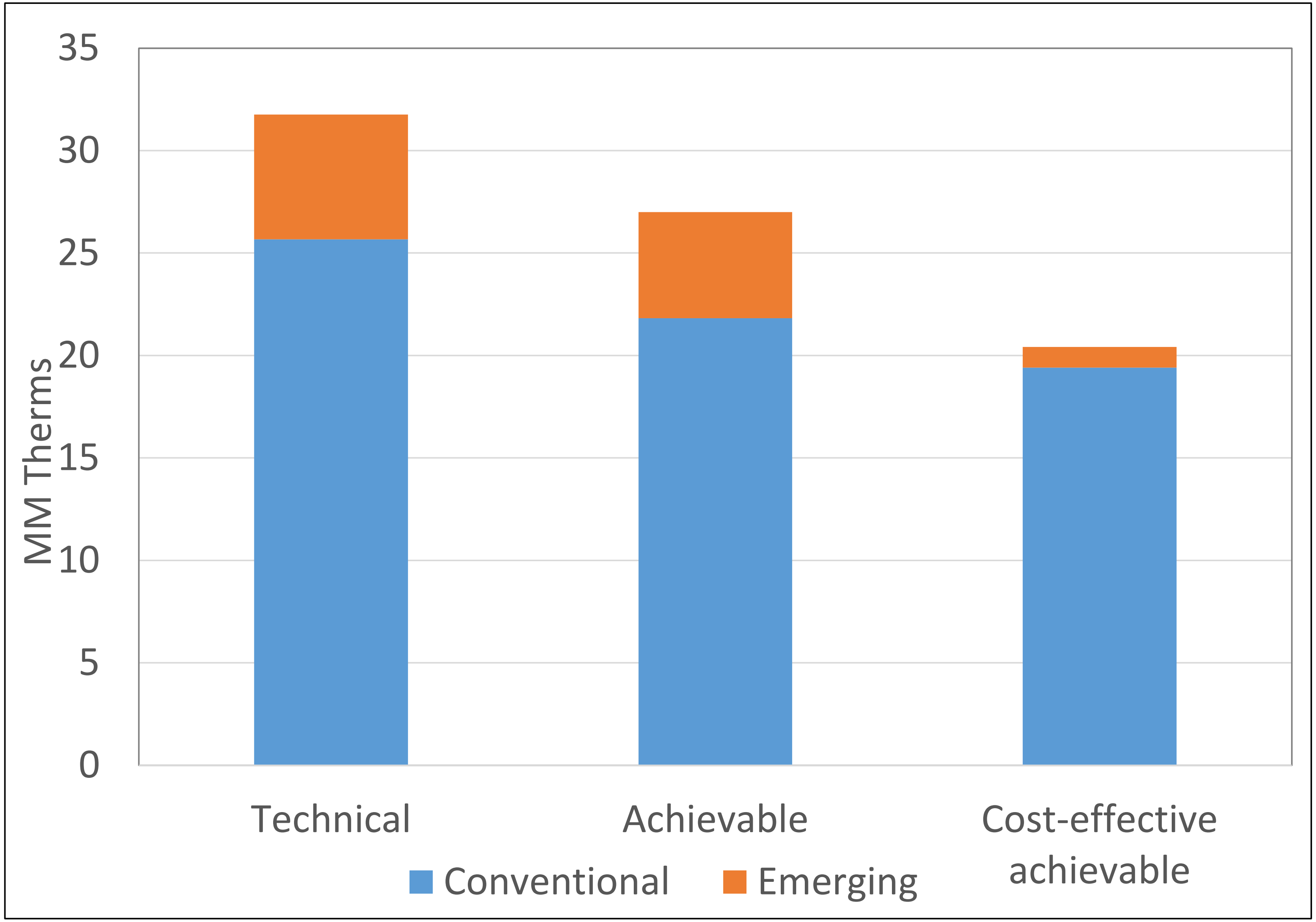
Results



Cumulative Potential by Type and Year



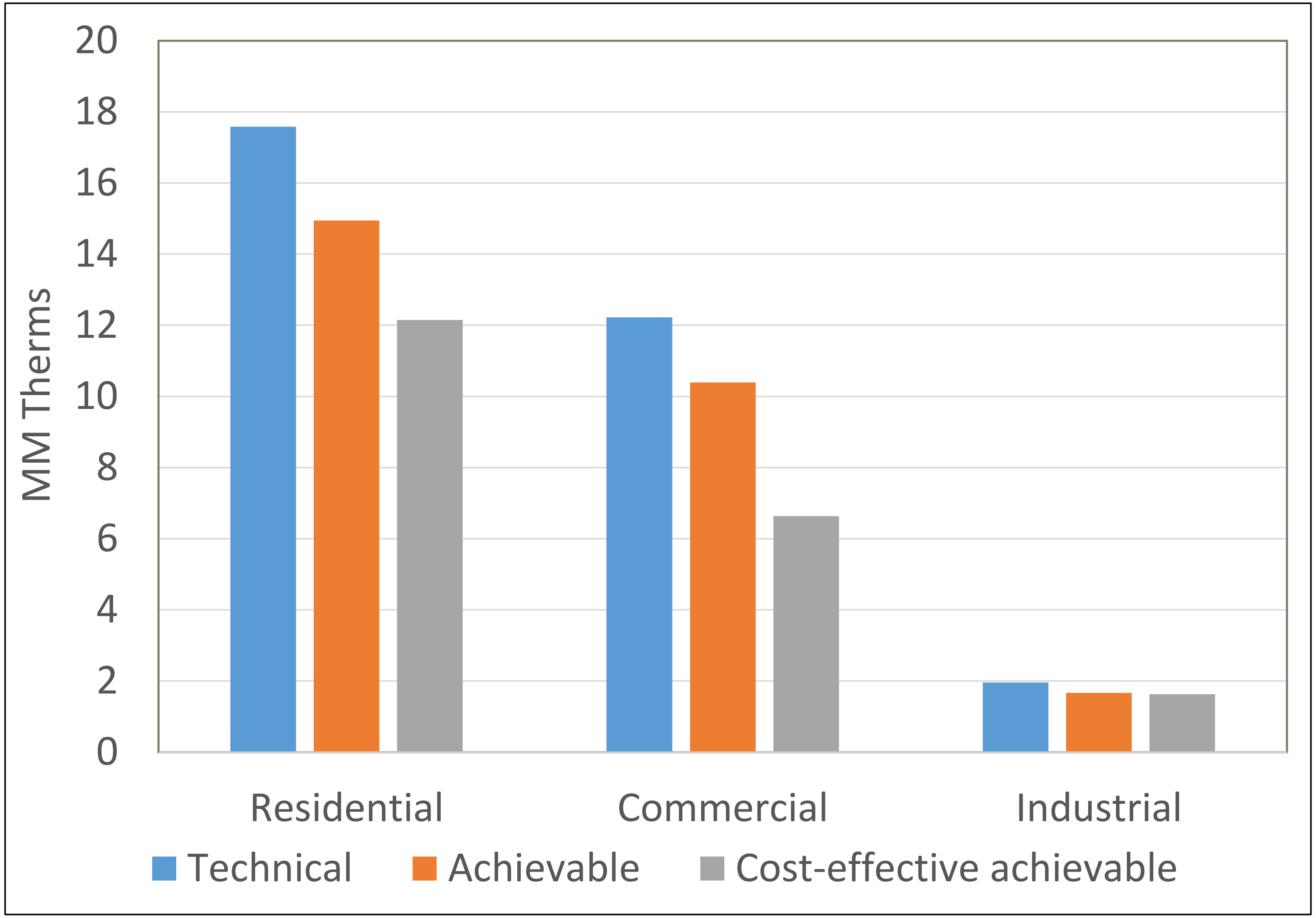
Cumulative Emerging Technology Contribution



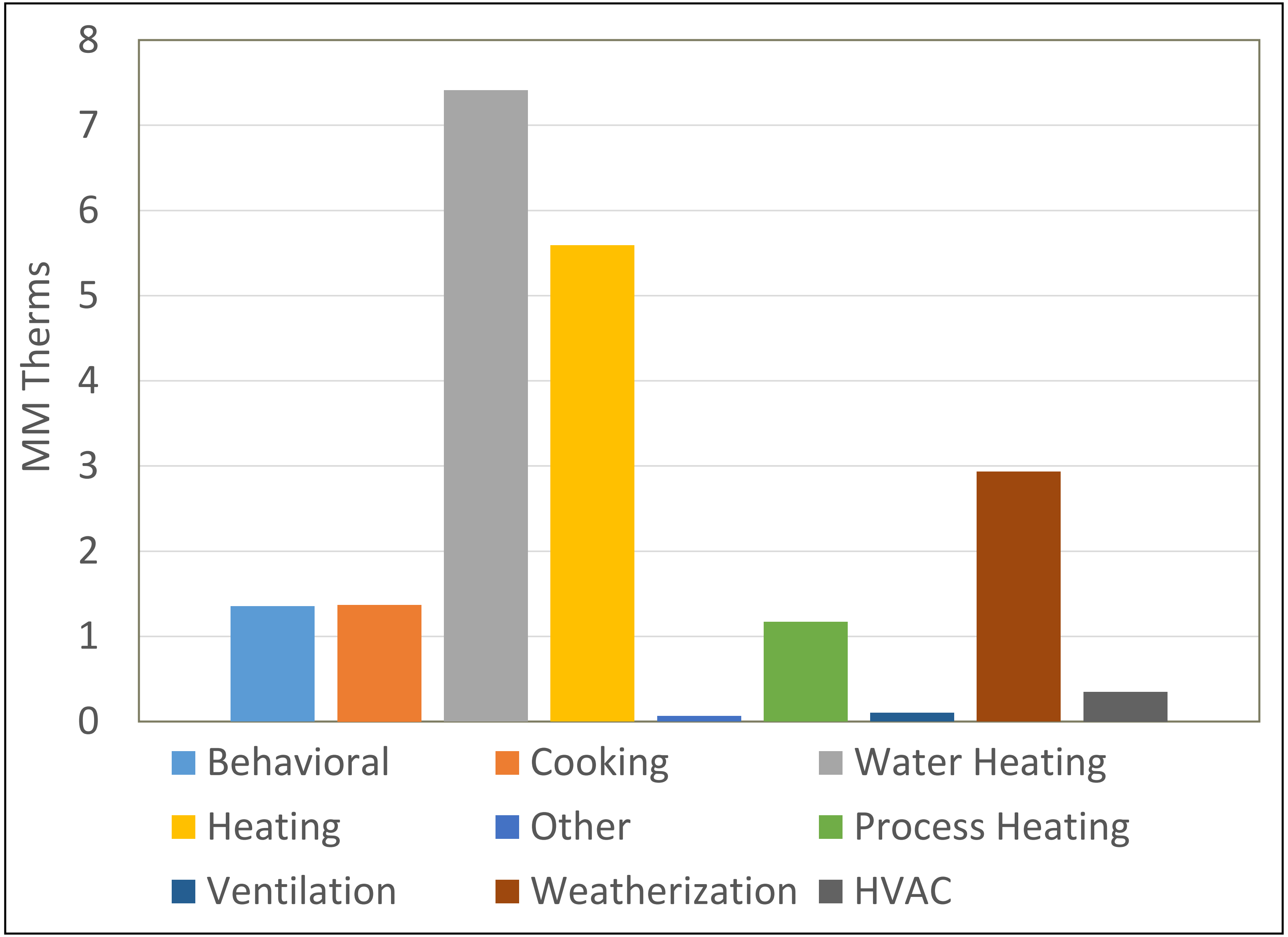
Cost-Effective Override – MM Therms

Sector	Yes CE Override	No CE Override	Difference
Residential	12.15	5.78	6.37
Commercial	6.64	6.47	0.17
Industrial	1.63	1.63	-
Total DSM:	**20.42**	**13.88**	**6.54**

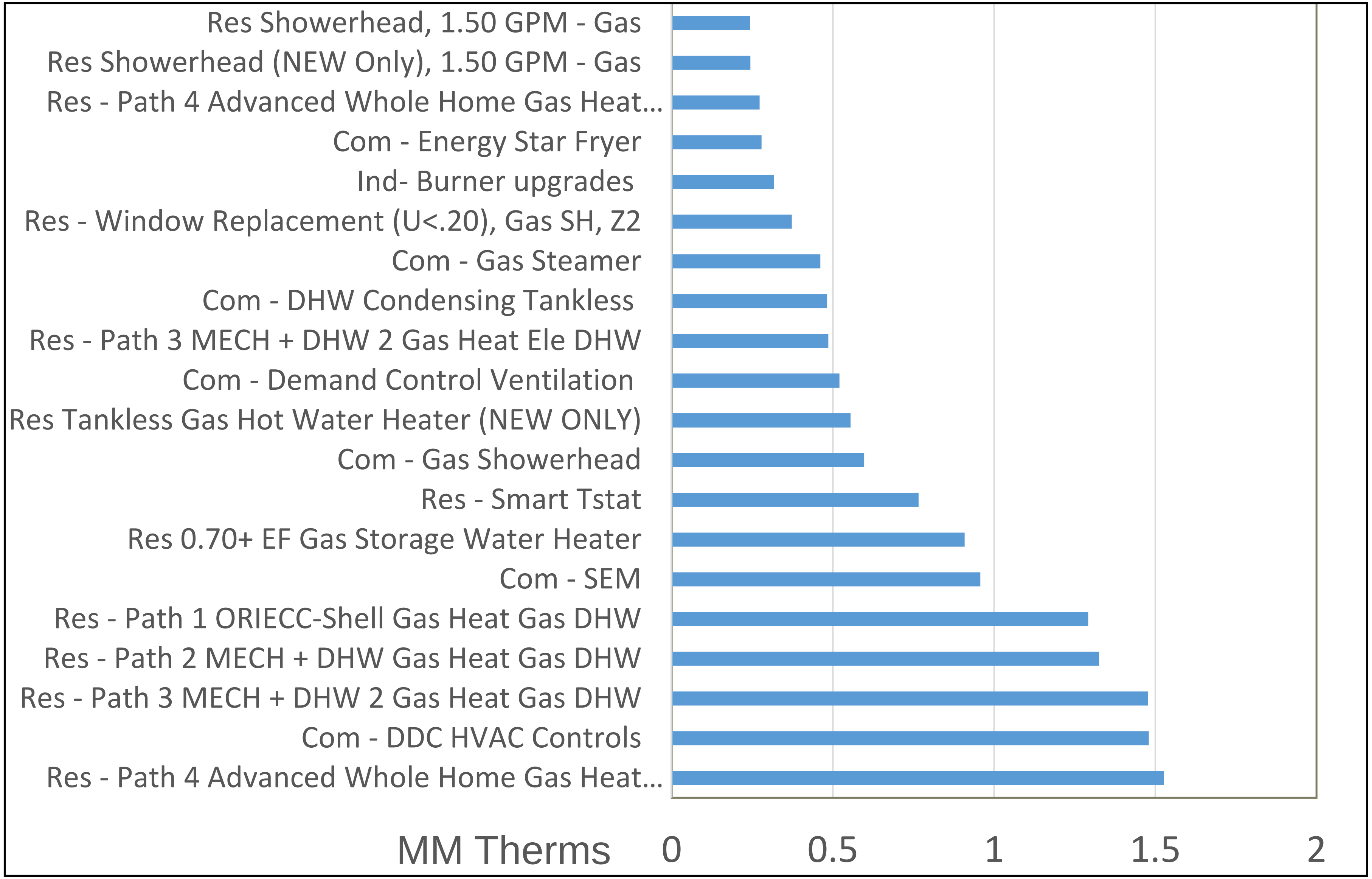
Cumulative Potential by Sector and Type



Cumulative Cost-effective Potential by End Use



Top-20 Measures – Cost-Effective Cumulative Potential

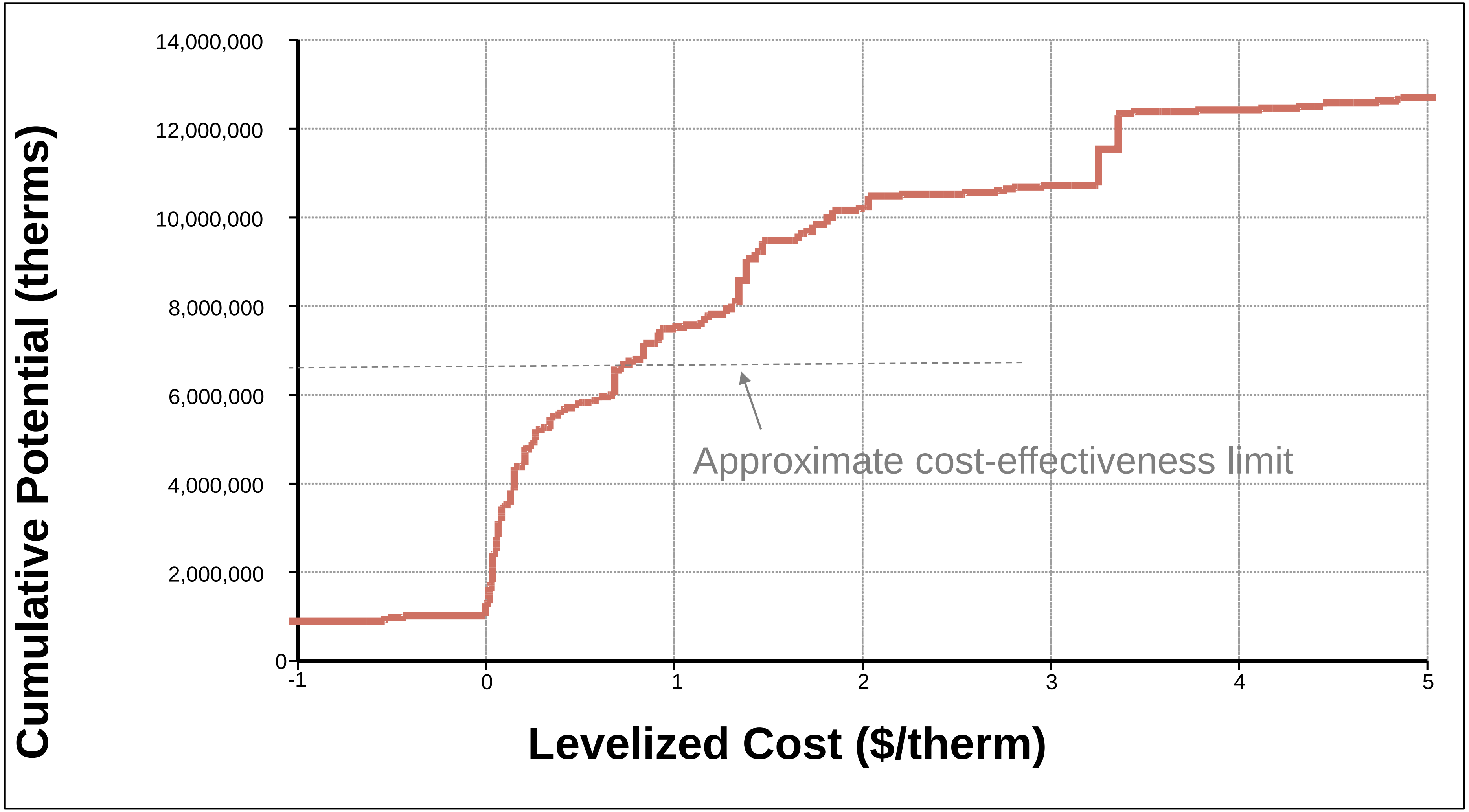


Market Transformation Savings Forecasts from Program Building Code Efforts

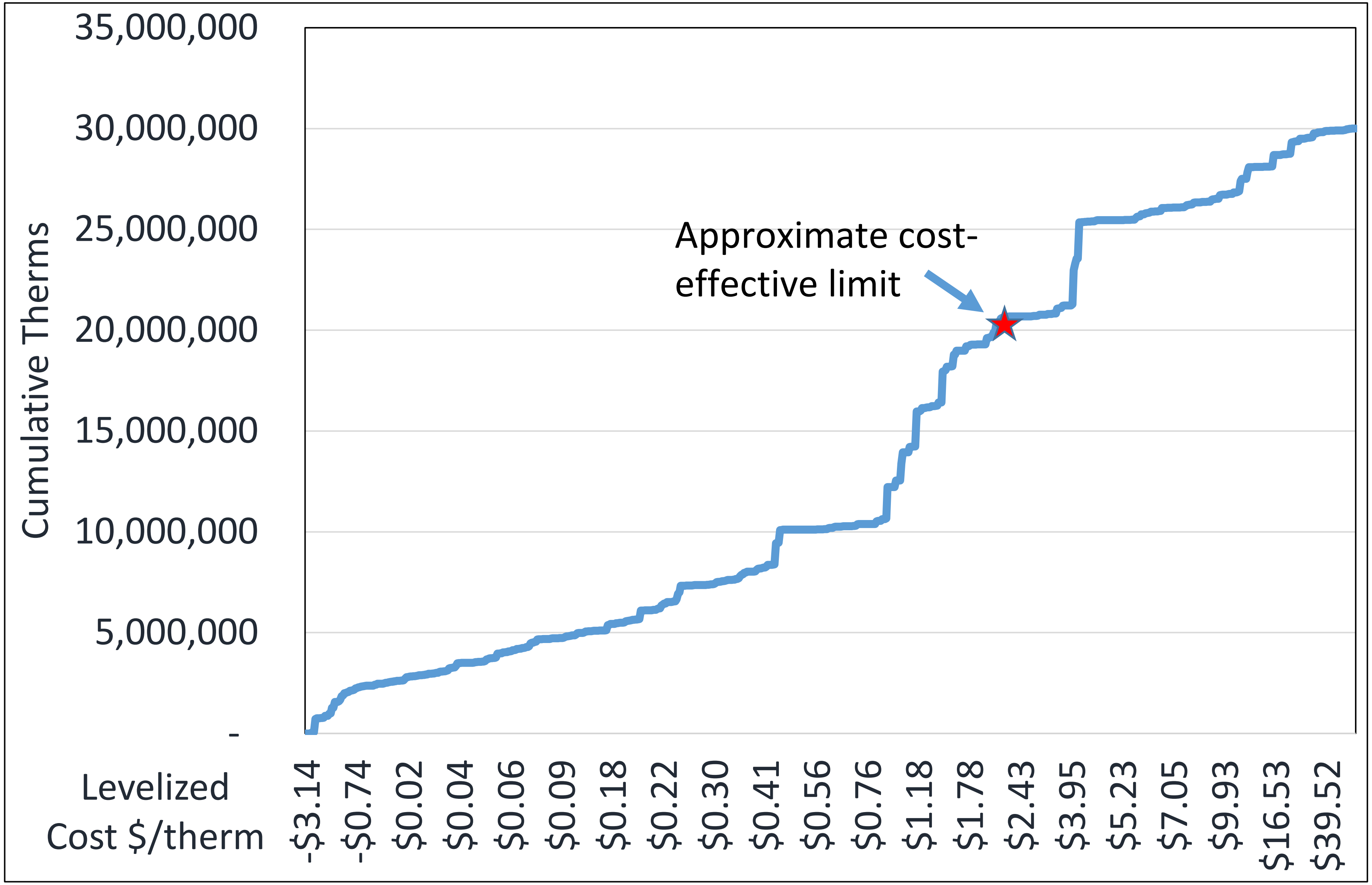
- New Home Construction Market Transformation:
  - 2018 Forecast of 54,335 therms
  - 2019 Forecast of 55,983 therms

- New Buildings Construction Market Transformation:
  - 2018 Forecast of 5,510 therms
  - 2019 Forecast of 5,510 therms

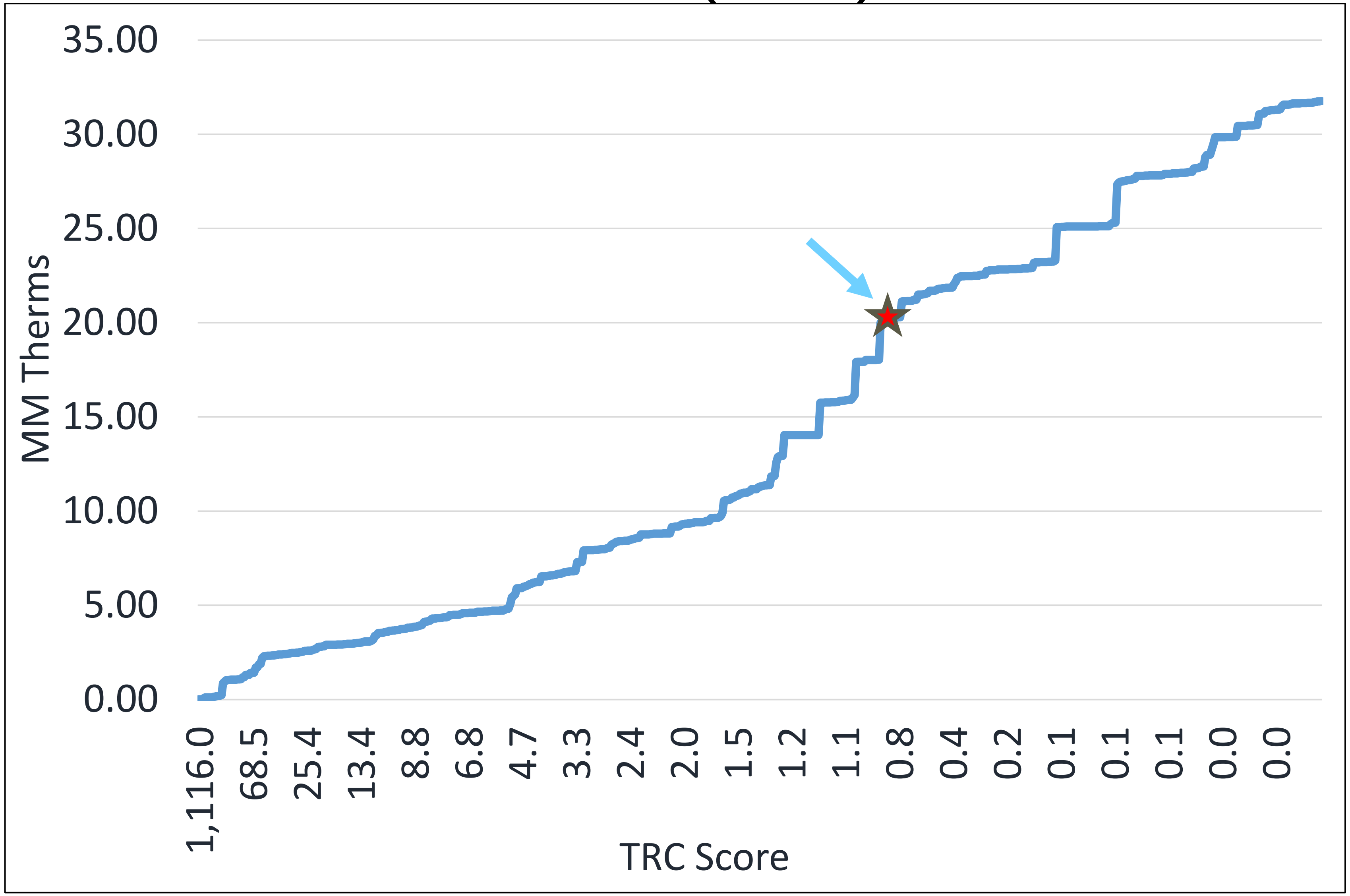
2015 Supply Curve – 20 Year Technical Potential



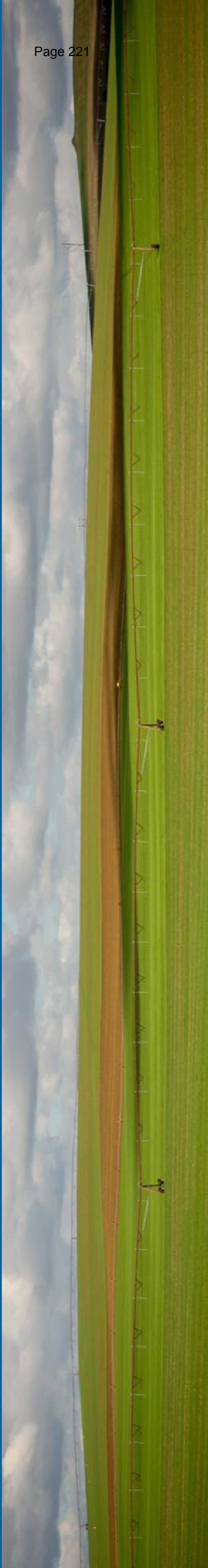
2018 Supply Curve – 20 Year Technical Potential by Levelized Cost of Energy



Supply Curve – 20 Year Cumulative Technical Potential by Total Resource Cost (TRC) Score



2018 IRP Projected Savings

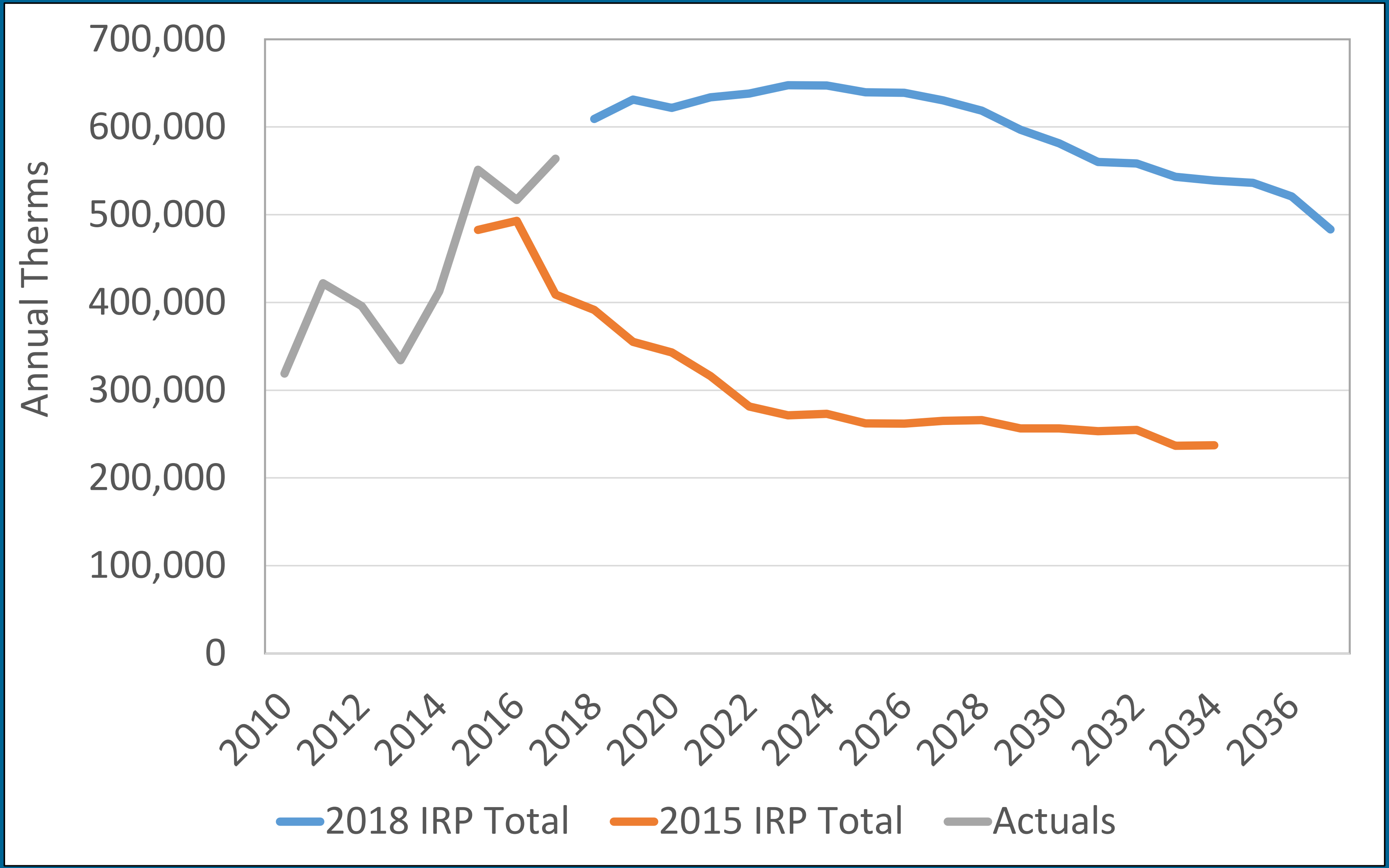


Not technically feasible	Technical Potential			
Not technically feasible	Market barriers	Achievable Potential		
Not technically feasible	Market barriers	Not cost effective	Cost Effective Potential	
Not technically feasible	Market barriers	Not cost effective	Program design, market penetration	Program Savings Projection

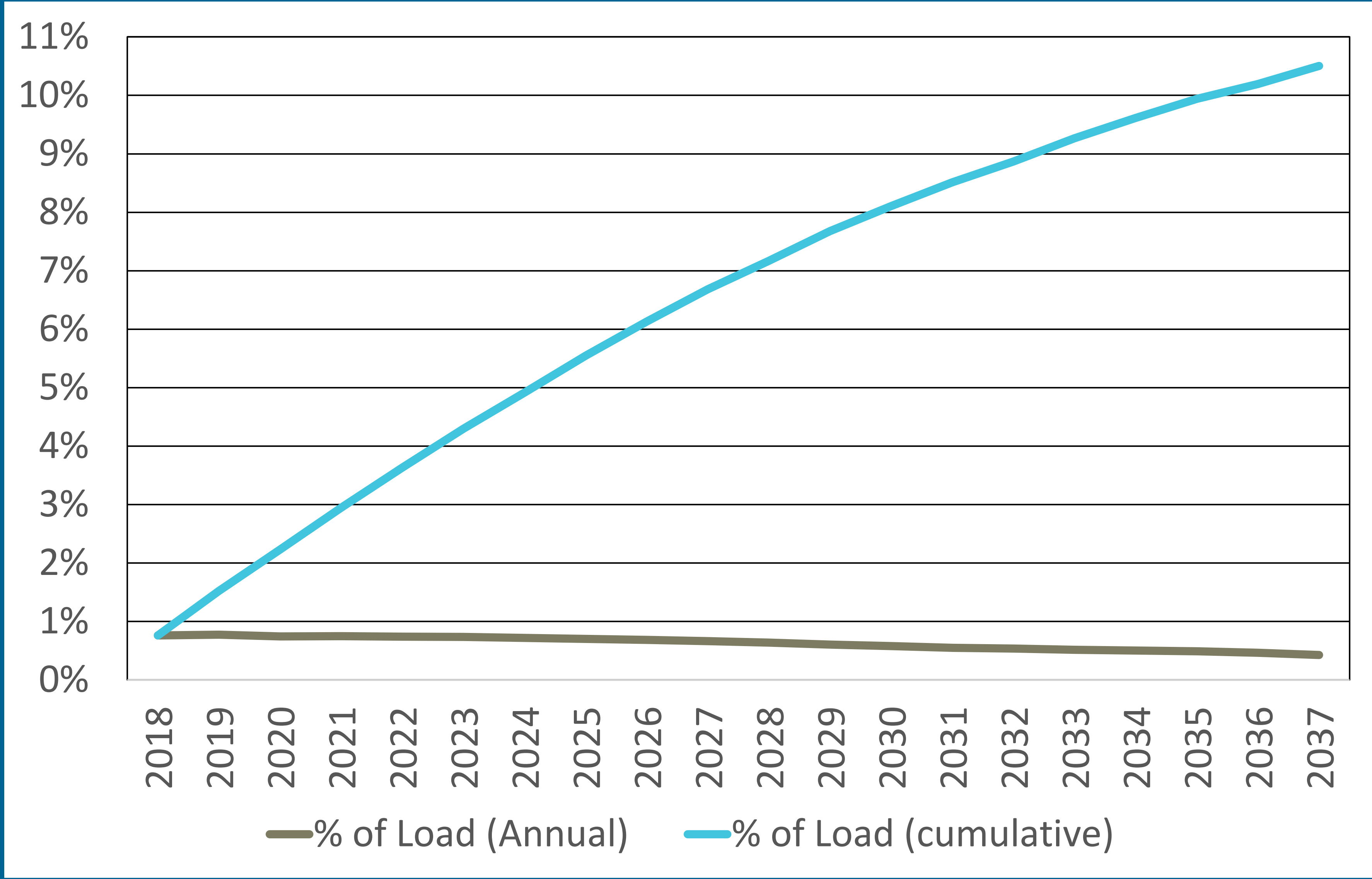
20-Year Potential by Type

	Technical	Achievable	Cost-effective	Energy Trust Savings Projection
Residential	17,580,928	14,943,789	12,148,348	4,344,727
Commercial	12,225,805	10,391,934	6,638,878	6,285,500
Industrial	1,957,048	1,663,491	1,627,931	1,245,219
All DSM	**31,763,780**	**26,999,213**	**20,415,156**	**11,875,446**

2015 vs. 2018 IRP Cost-Effective EE Savings Projections and Actuals



Annual Projected Savings as Percent of CNG's Annual and Cumulative Load Forecasts



Policies and Methodologies Informing DSM Outcome

Externalities

- Cascade evaluates the impacts of a range of environmental externalities
  - Price of carbon
  - Supply costs
  - Other associated adders
- Potential impacts on the cost of natural gas (carbon adders, etc.)
- Include code changes and cost-effectiveness methodologies
- To the best extent possible, these potential impacts have been incorporated into the Oregon DSM projections

- Carbon policy adder = price forecast x 10% to factor for environmental externalities
  - Per Northwest Power and Conservation Council

- After 10% added, Cascade converts $10/ton carbon tax into dollar value per MMBtu
  - Then added to commodity cost

Capacity Contribution and Value in Energy Efficiency

- Analysis at citygate level
- Demand reduced by the inputted level of EE before any optimization calculated
- Examining NWN approach
- Analysis will benefit from evolving conversation on capacity/avoided cost in Oregon

National

- National Standard Practice Manual
  - National Efficiency Screening Project, and E4TheFuture
  - Expands upon California Standard Practice Manual
  - Regulators select core costs/benefits for valuation of utility-run conservation
- Clean Power Plan
  - Requires existing fossil fuel-fired electric generating facilities to reduce carbon dioxide emissions
  - Currently being reevaluated by the EPA for consistency with the Executive Order on Promoting Energy Independence and Economic Growth

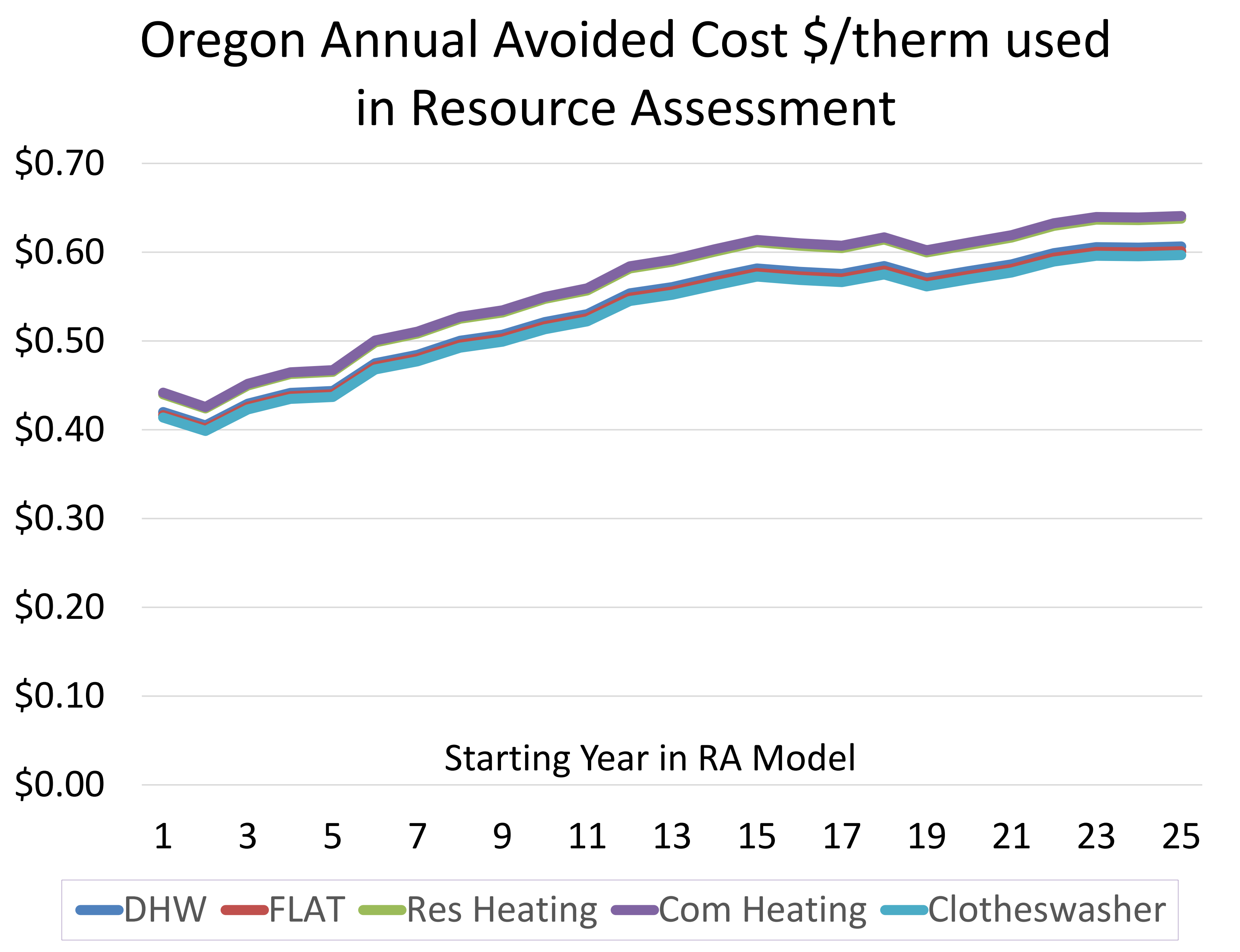
Oregon

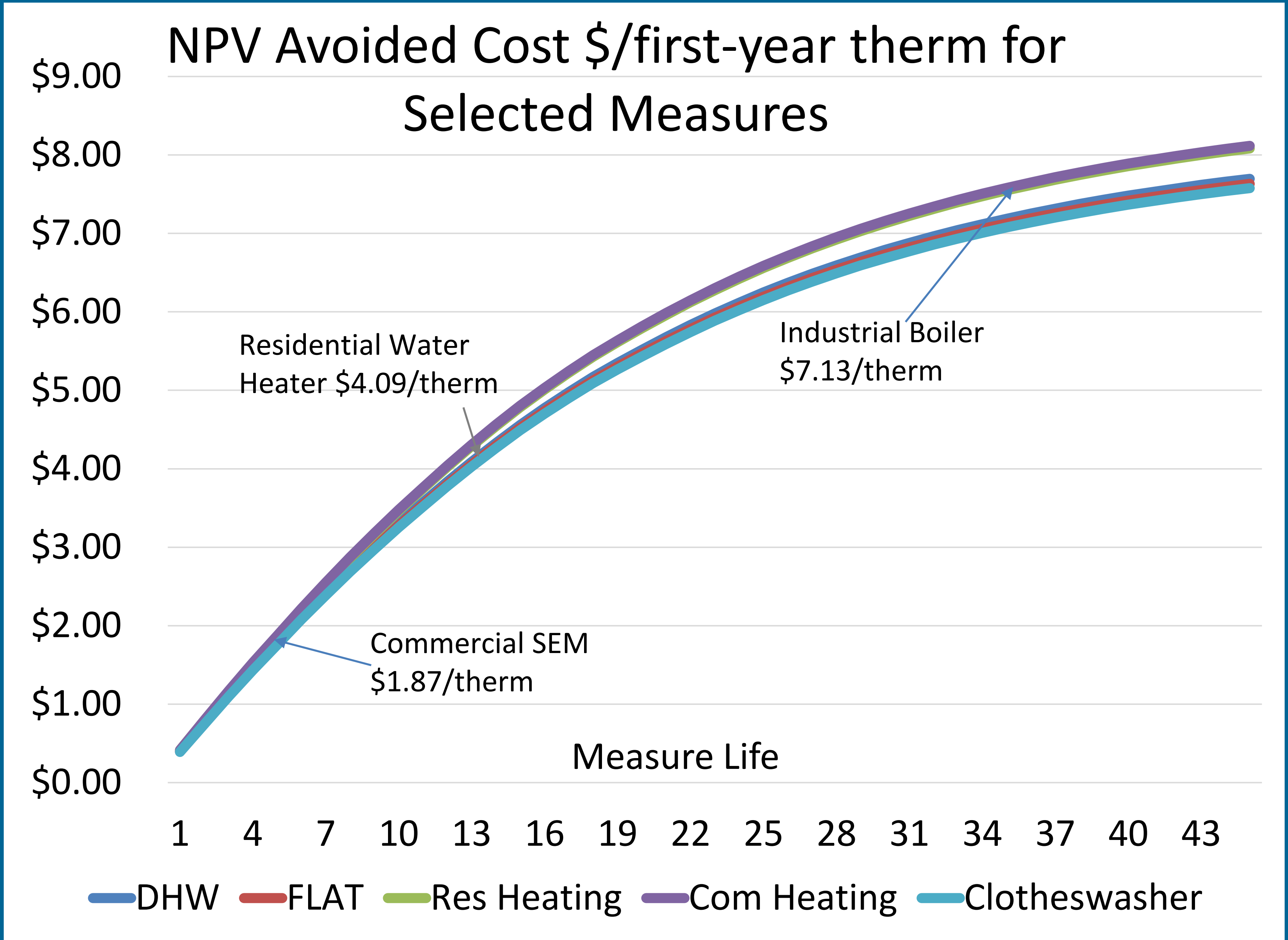
- Renewable Energy Goals
  - Portland proposes to go 100% renewable energy by 2035, and 100% economy wide by 2050
  - Similar goals are under consideration in Hillsboro, Milwaukie, & Beaverton
- Gas to Electric Fuel-Switching
  - Ashland and Eugene have adopted energy action plans to reduce carbon emissions
  - Migration from direct use to gas-to-electric fuel switching
  - Cities plan use of renewables for electric generation as 1st phase
- HB3711 Moratorium on Hydraulic Fracturing for Oil and Gas Exploration and Production
  - Would prohibit hydraulic fracking in Oregon with moratorium until December 31, 2026
  - Exceptions for natural gas storage wells, geothermal wells/energy, & coal bed methane extraction wells
  - Passed through House, but not through Senate

Washington

- <u>Carbon Tax</u>
  - Many bills circulated in the state of Washington
  - Ranges from $15/ton to $25/ton & increasing upwards over time
  - None passed, but watching closely
  - Movement by Alliance for Jobs and Clean Energy and The Natural Conservancy
    - Price on carbon- petroleum, natural gas electricity, stationary sources
- <u>Deep Decarbonization</u>
  - Governor Inslee's office released "deep decarbonization" study
  - Emissions reductions
  - Goal to curb global temperature increase below two degrees Celsius
  - Envisions replacing natural-gas with biomethane, synthetic natural gas & hydrogen
- <u>Clean Air Rule</u>
  - Cascade continues to evaluate options for compliance with the Clean Air Rule

Avoided Costs

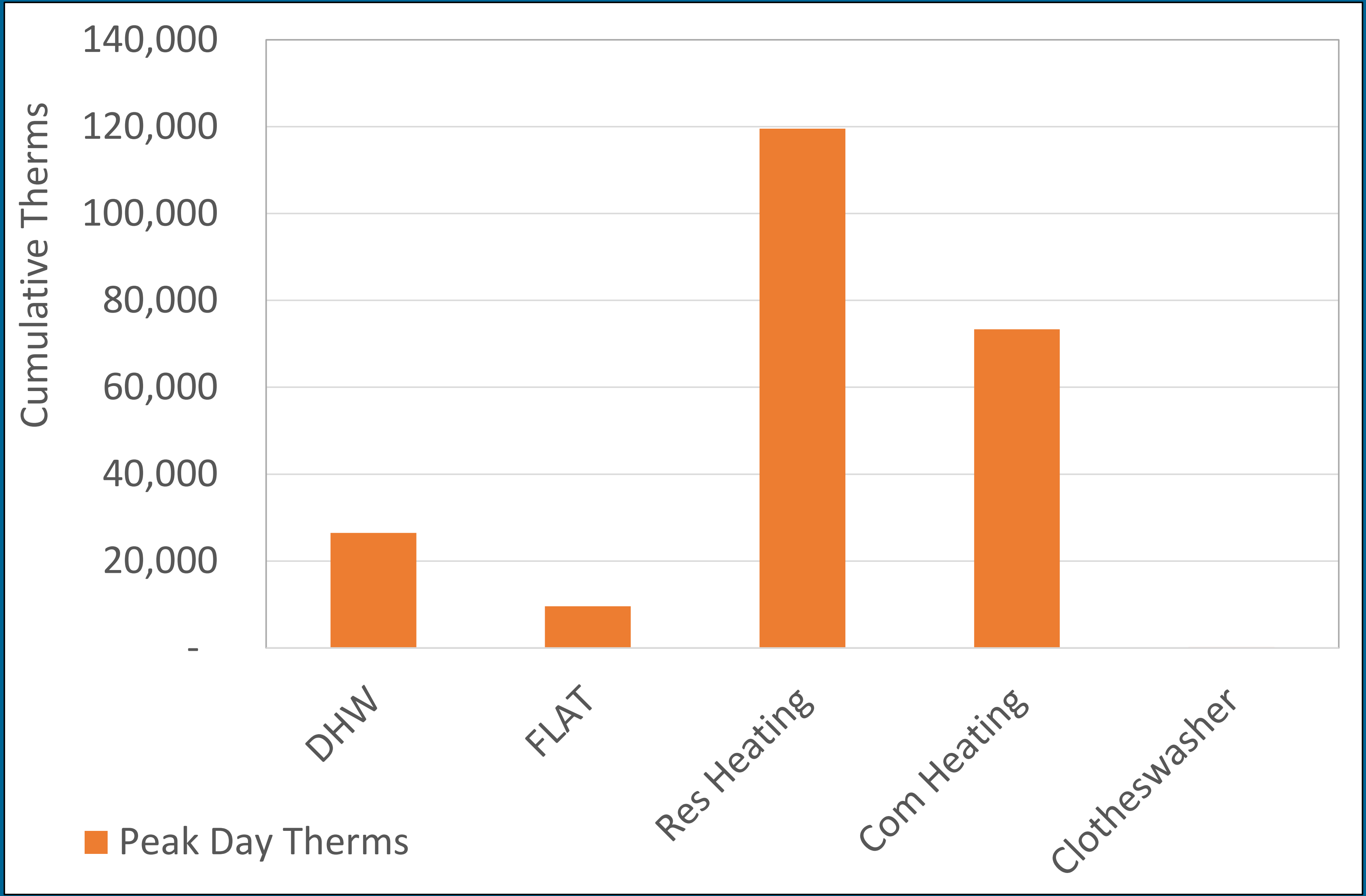

Oregon Annual Avoided Cost $/therm used in Resource Assessment
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Starting Year in RA Model
1
3
5
7
9
11
13
15
17
19
21
23
25
DHW
FLAT
Res Heating
Com Heating
Clotheswasher


NPV Avoided Cost $/first-year therm for Selected Measures
$9.00
$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
$0.00
Residential Water Heater $4.09/therm
Industrial Boiler $7.13/therm
Commercial SEM $1.87/therm
Measure Life
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
DHW
FLAT
Res Heating
Com Heating
Clotheswasher

Peak-Day Savings

Peak Day/Annual Usage Savings Factors	
Load Profile	Peak Day Factor
DHW	0.4%
FLAT	0.3%
Res Heating	2.1%
Com Heating	1.8%
Clotheswasher	0.2%

Peak-Day Savings by Load Profile – 20 Year Potential



Acquisition of all Cost Effective DSM

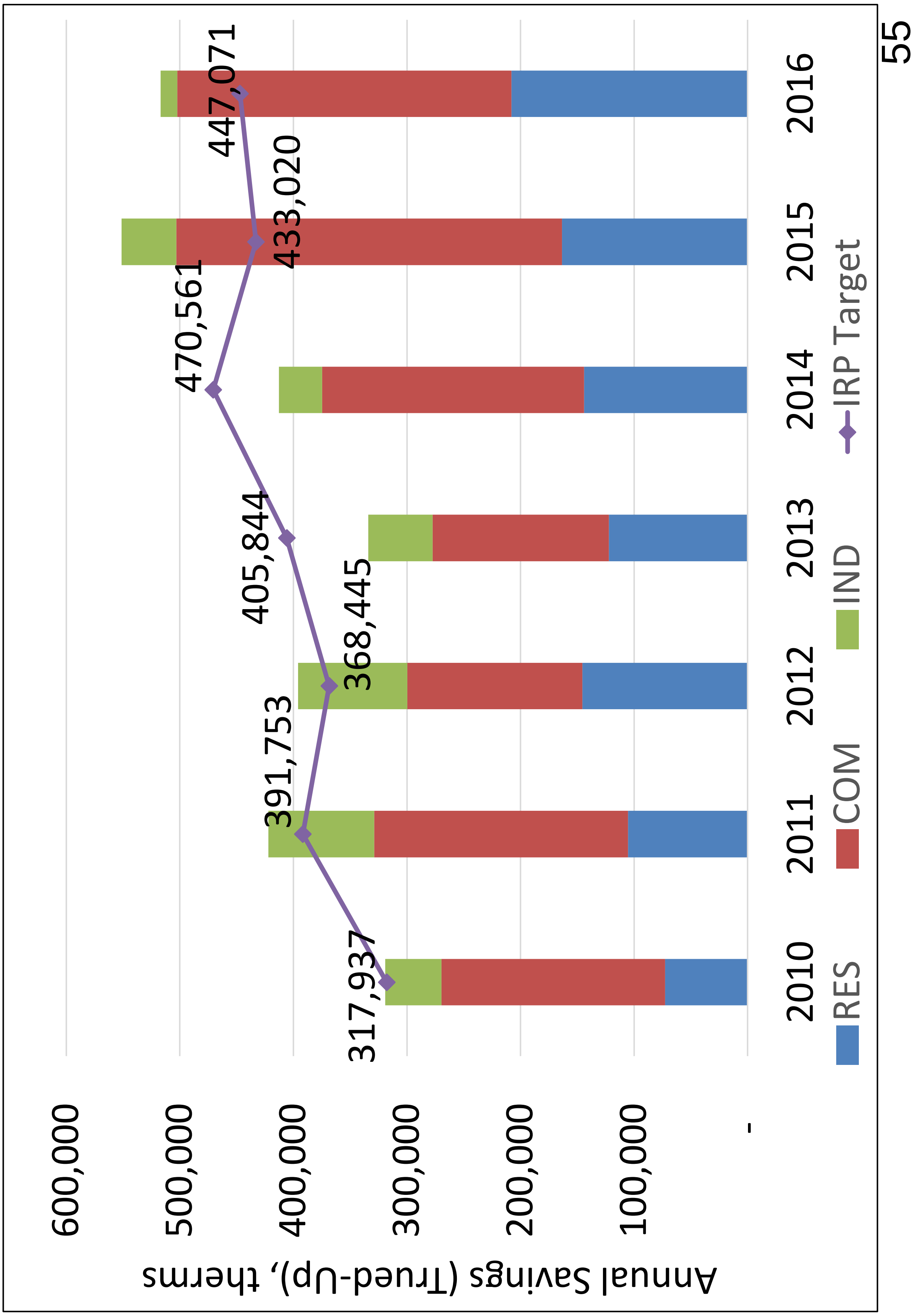
2018 Programs – Pursuing all C/E Efficiency

- Residential – Existing and New Home Construction
  - Single family, moderate income (SWR), manufactured homes
  - Weatherization (insulation, windows)
  - Gas fireplaces, furnaces for rentals and SWR
  - Water heaters, showerheads, aerators

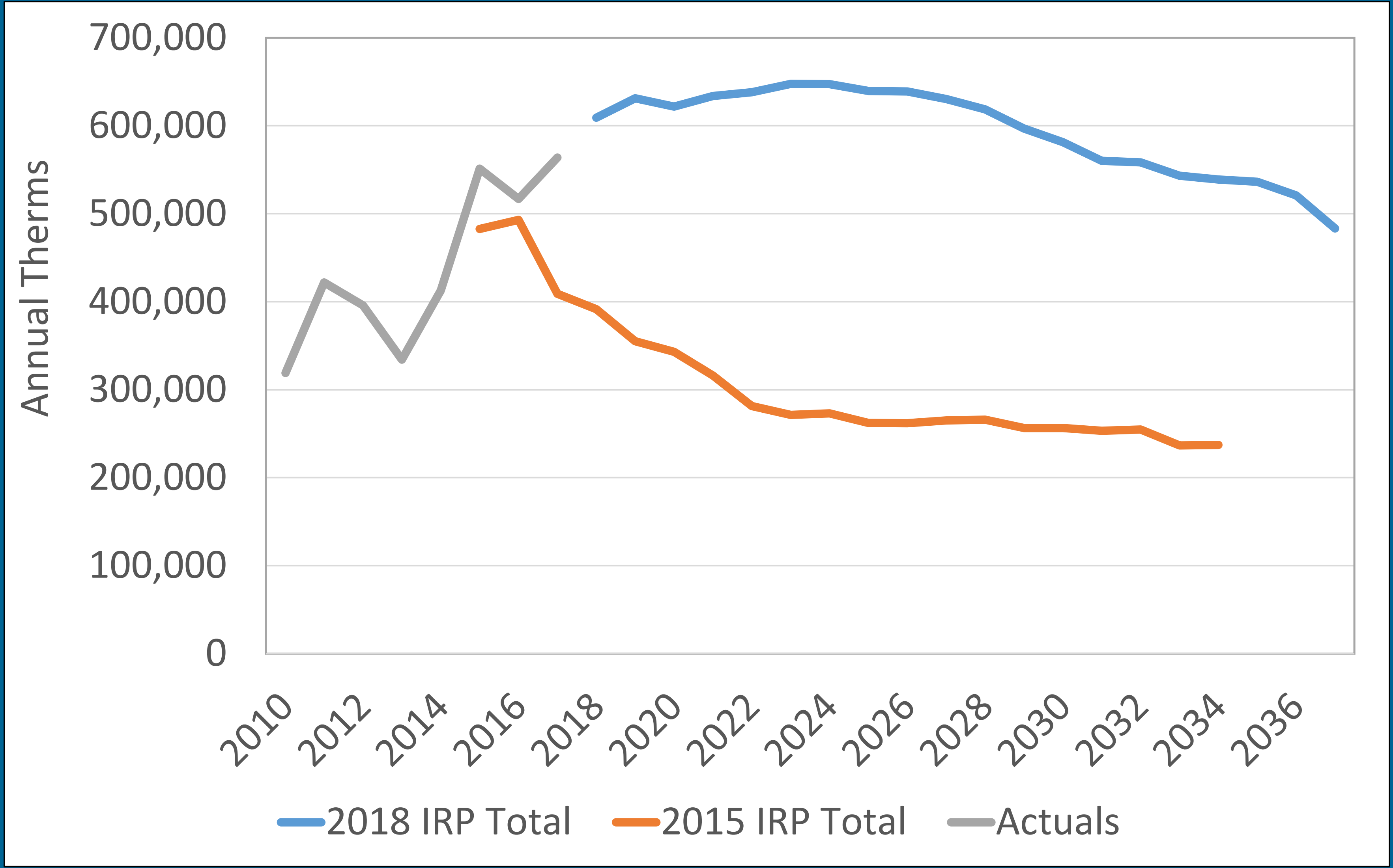
- Commercial – Existing, New and multifamily in Oregon
  - Retail, offices, schools, groceries….all market segments
  - HVAC, controls, cooking equipment, water heating, windows, insulation

- Industrial & Agriculture in Oregon– Non transport sites
  - Manufacturing facilities, greenhouses
  - HVAC, O&M, process improvements

- Cascade Natural Gas & Energy Trust
    - Serving Oregon since 2006:
        - Served over 18,000 households, over 1,100 commercial sites and over 44 industrial sites


Annual Savings (Trued-Up), therms
600,000
500,000
400,000
300,000
200,000
100,000
-
317,937
391,753
368,445
405,844
470,561
433,020
447,071
2010
2011
2012
2013
2014
2015
2016
RES
COM
IND
IRP Target
55

2015 vs. 2018 IRP Cost-Effective EE Savings Projections and Actuals



Program Funding

- Public Purpose Charge is established at a rate adequate to fund all cost-effective energy efficiency efforts identified with ETO
- OPUC Schedule No. 31, Public Purpose Funding
- Total PPC amount varies depending upon gas usage (weather-sensitive) and price
- Schedule 31 adjusted over time to align customer charges with program funding requirements

Adjustment History

Effective Date June 15, 2007
- Charge set at 1.5% of Revenues
  - 80% to ETO
  - 20% LI Programs

November 1, 2011
- Charge increased to 2.44%
- 88% to ETO
- 12% to LI Programs

November 1, 2012
- Charge increased to 3.91%
  - 93% to ETO
  - 7% to LI Programs

July 1, 2013
- Charge increased to 5.46%
  - 95% to ETO
  - 5% to LI Programs

April 1, 2014
- Charge decreased to 1.85%
  - 87% to ETO
  - 13% to LI Programs

February 1, 2016
- Charge increased to 3.4%
  - 93% to ETO
  - 7% LI Programs

- Revision to Schedule 31
  - Effective date of 12/1/2016

- Increase to 4.87% with the intent of collecting $3,353,88

  - 88% was designated to the Energy Trust
    - $2,927,795 for the acquisition of 569,405 therm savings

  - 12% of funds directed towards Cascade’s low income programs:
    - $50,000 to fund low income bill pay assistance
    - $361,627 for OLIEC and CAT

Oregon Low Income Energy Conservation (OLIEC) & Conservation Achievement Tariff (CAT) Programs

Cascade Community Action Partners
Serving Central & Eastern Oregon

- NeighborImpact
- Community Action Program East Central Oregon (CAPECO)
- Community Connection of NE Oregon (CCNO)
- Community In Action (CINA)
- Oregon Human Development Corporation

OLIEC

- Covers cost-effective portion of tariff approved measures
  - Ceiling, floor, wall and duct insulation
  - Duct sealing & infiltration system upgrades
  - High efficiency furnace installations, tune-up and filter replacement; and
  - High-efficiency water heaters

- New LI residential construction & individual custom efforts also eligible

- Additional $225 for admin & directly incurred program costs

Conservation Achievement Tariff

- Bridges gap between avoided cost & installed cost of qualified work
- Established as permanent program Dec 1, 2016 via Advice No. O16-10-02
- Funding equals .0625% of gross revenues
- Resulting 2017 OLIEC and CAT budget of $361,627
- $550 audit and $300 inspection fee to agency per job completed
- Total installed costs under OLIEC/CAT may not exceed $10,000

Achievements and Projections

- Since 2006:
  - **570** homes weatherized
  - **86,700** therms saved
  - **150** (approx.) therms per home on average
  - **$6,800** average per home cost

- Approximately **50** homes will be served each year (estimated **7,500** therms a year) if funds maintained near **$361,627** level

- Based on pilot activities, likely Agencies would be able to serve around **100** homes annually if funded at full capacity

Other Items

Future Action Plan Items (DSM)

- Coordination with ETO to achieve Geographically Targeted DSM
- Maintain holistic approach to planning & acquisition of demand side resources
- Integration of results deriving from OPUC Investigation into EE Avoided Costs
- Ongoing refinement of energy savings analysis to further align with capacity contribution and demand

Questions

Allison Spector, Manager of Conservation Policy
Cascade Natural Gas Corporation
206-310-1120
allison.spector@cngc.com

- Thank You

Andy Hudson
Planning Project Manager

andrew.hudson@energytrust.org
503.546.3622

EnergyTrust of Oregon

SENDOUT Modeling Update

SENDOUT® Model

- Cascade utilizes SENDOUT® for resource optimization.
- This model permits the Company to develop and analyze a variety of resource portfolios to help determine the type, size, and timing of resources best matched to forecast requirements.
- SENDOUT® is very powerful and complex. It operates by combining a series of existing and potential demand side and supply side resources and optimizes their utilization at the lowest net present cost over the entire planning period for a given demand forecast.

SENDOUT® Model Cont’d

- SENDOUT® utilizes a linear programming approach.
- The model knows the exact load and price for every day of the planning period based on the analyst’s input and can therefore minimize costs in a way that would not be possible in the real world.
- Therefore, it is important to acknowledge that linear programming analysis provides helpful but not perfect information to guide decisions.

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Portfolios

- Deterministic Optimal
- NWP Only
- NWP with Incremental Storage
- GTN Only
- GTN with Incremental Storage
- Incremental Storage Only

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Supply Resource Optimization Process

- **Step 1: As-Is Analysis**
  - Run a deterministic optimization of existing resources with a three-day peak event to uncover timing and quantity of resource deficiencies.
- **Step 2: Introduce Additional Resources**
  - Include incremental supply, storage, and transportation to derive a deterministic optimal portfolio, additional portfolios.
- **Step 3: Stochastic Analysis of All Portfolios Under Existing Conditions**
  - Run all portfolios through a Monte Carlo weather simulation, using expected growth, supply and storage accessibility. Record the probability distributions of total system costs for each portfolio.
- **Step 4: Ranking of Portfolios**
  - Determine the preferred portfolio based on mean total system cost and Value at Risk (VaR) of each portfolio. This resource mix will be the best combination of cost and risk for Cascade and its customers.

Supply Resource Optimization Process Cont’d.

- **Step 5: Stochastic Analysis of Preferred Portfolio**
    - Run Monte Carlo simulations of various scenarios on preferred portfolio; comparing Mean and VaR to a managerial limit.
- **Step 6: Analysis of Preferred Portfolio**
    - Review data to confirm total system costs did not exceed Mean and VaR limits in any scenario. If limit is exceeded, repeat step 5 with next highest ranked portfolio.
- **Step 7: Sensitivity of Preferred Portfolio**
    - Run the preferred portfolio through Monte Carlo simulations on price. Review results to determine if total system cost is within the Mean and VaR limits across all sensitivities.
- **Step 8: Re-evaluation of Preferred Portfolio**
    - If the total system costs fall outside of the Mean and VaR limits in sensitivity analysis, select the next most optimal portfolio to run scenario and sensitivity analysis on. Repeat as needed.

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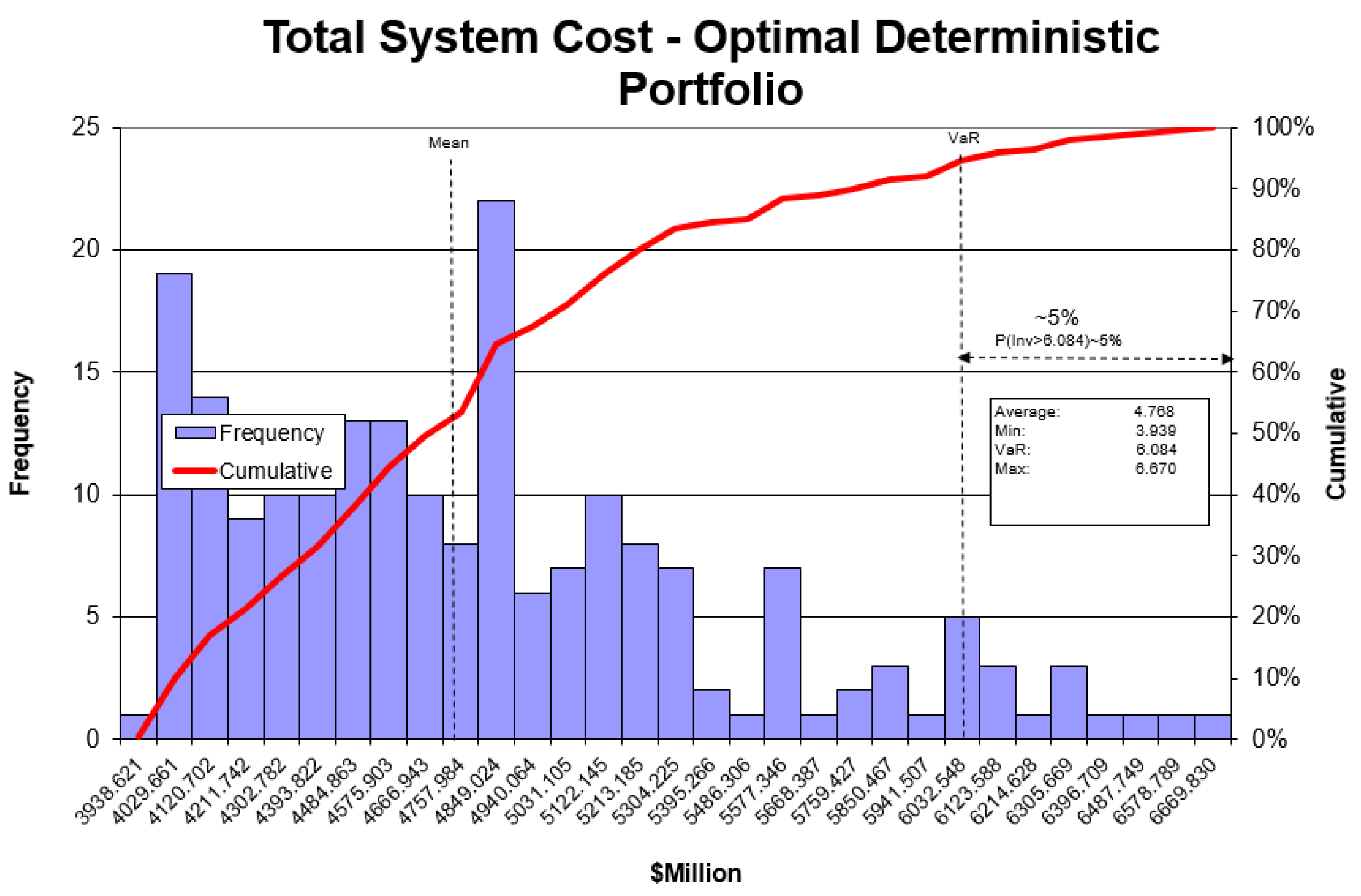
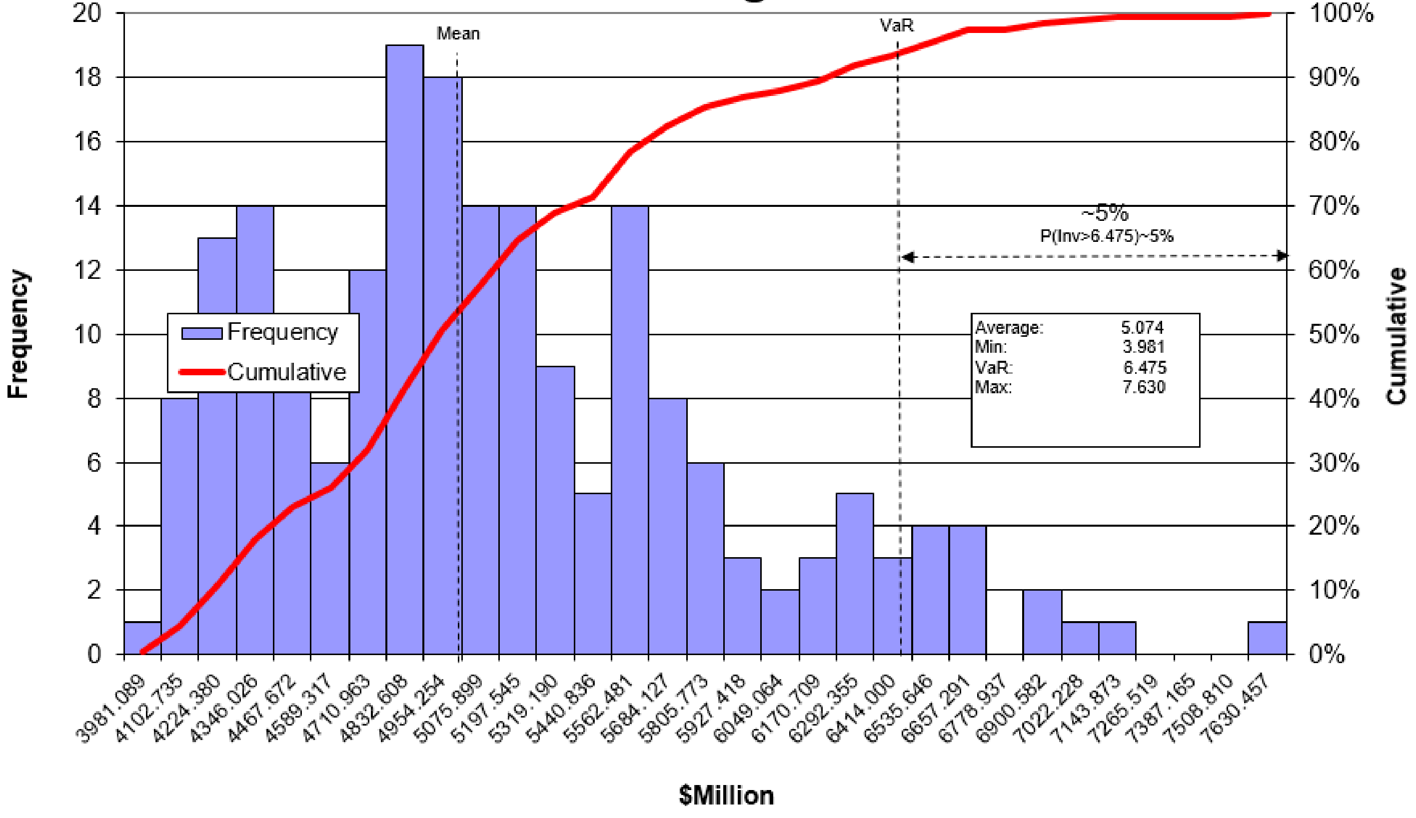
Preliminary Results

Preliminary Results



Preliminary Results

Total System Cost - Only NWP with Incremental Storage



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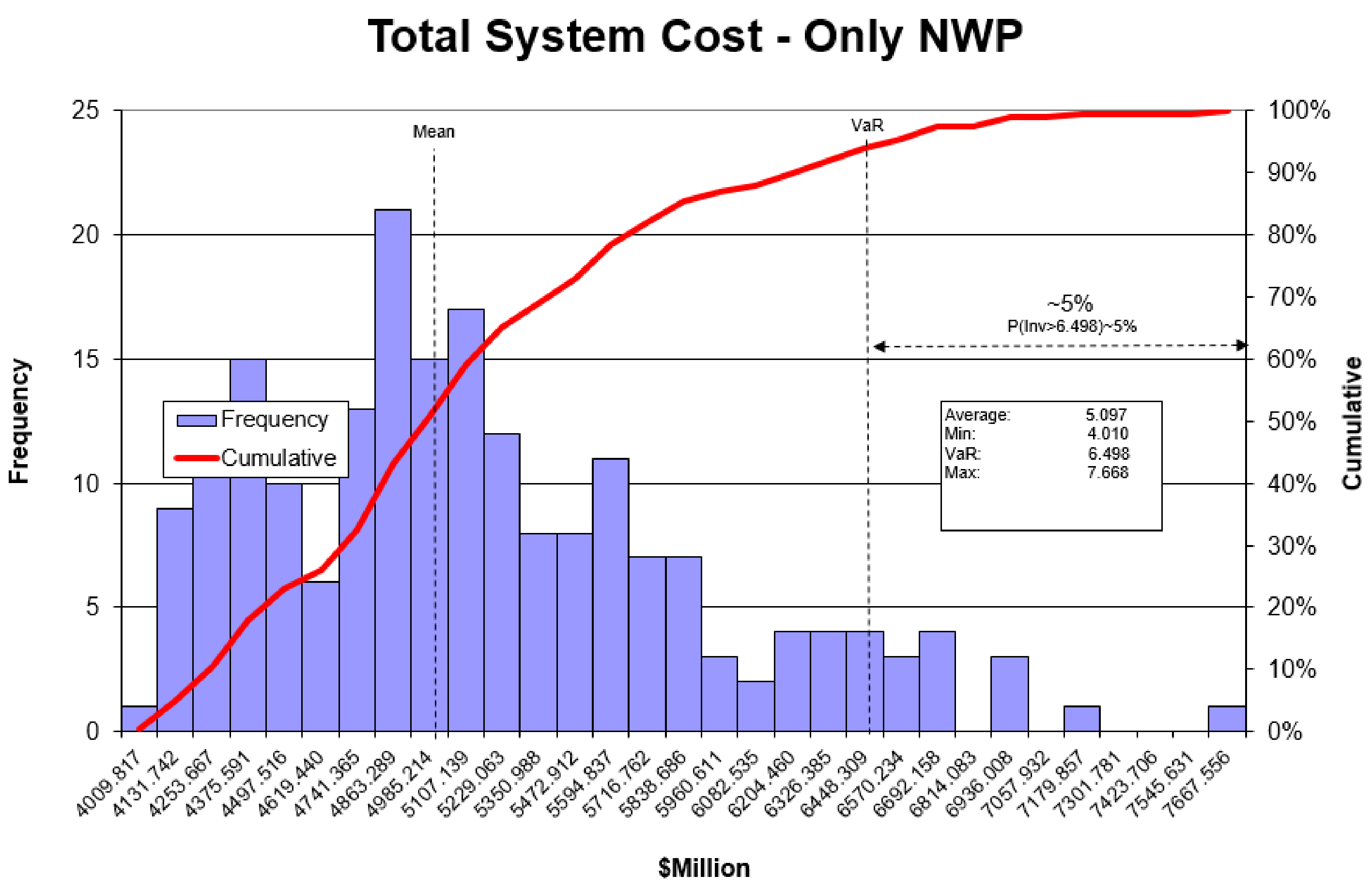
Preliminary Results



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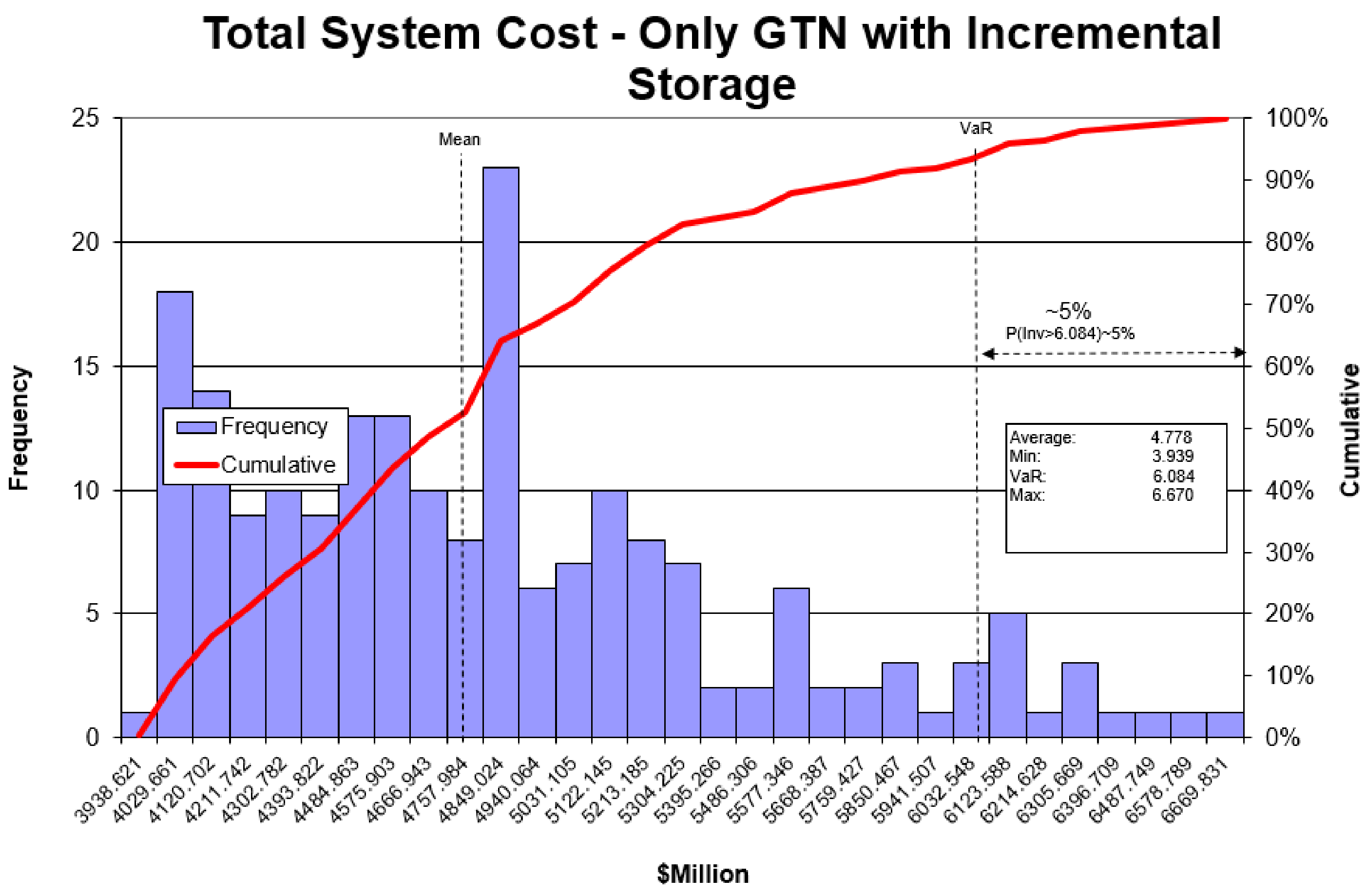
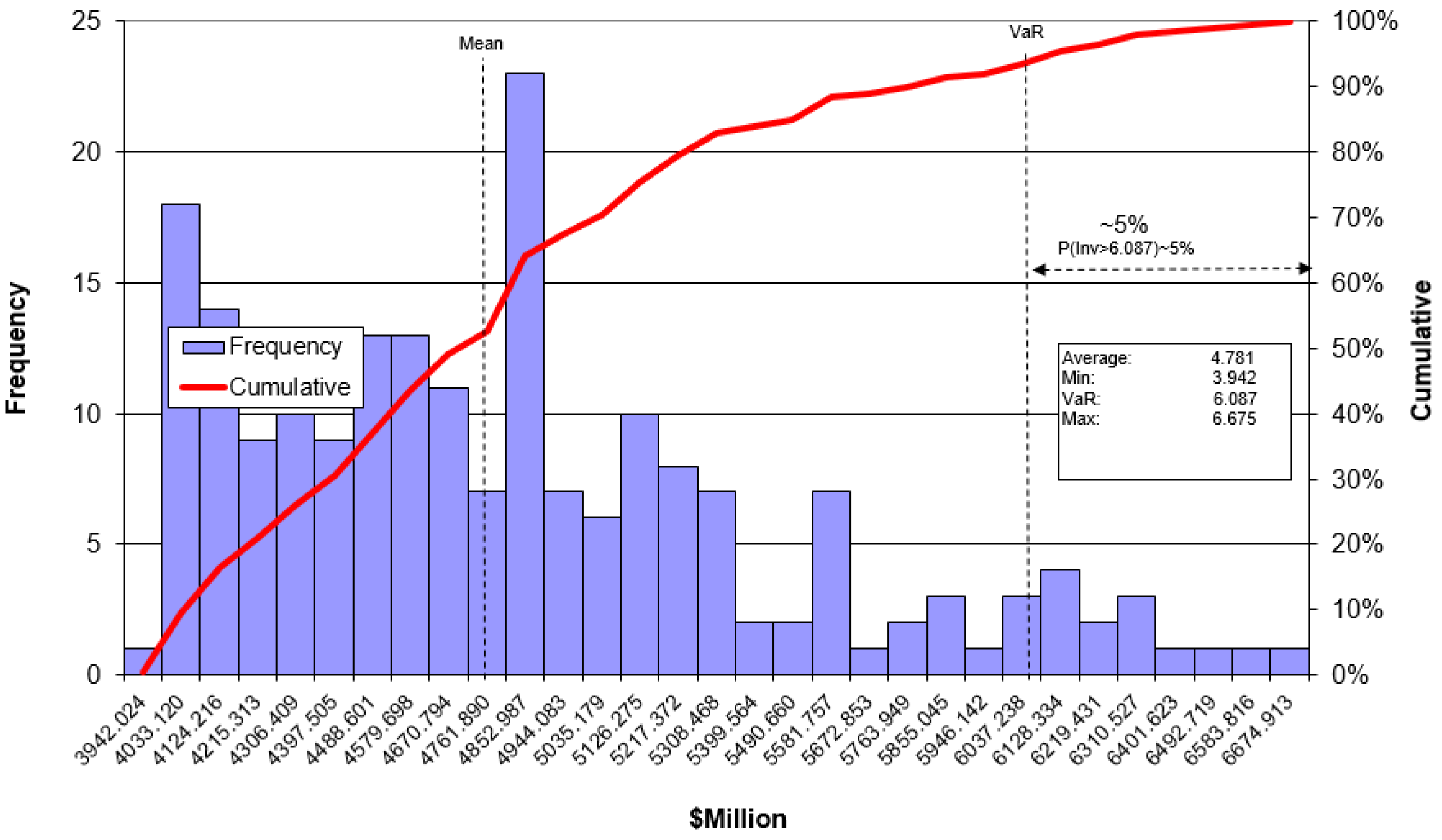
78

Preliminary Results



Preliminary Results

Total System Cost - Only GTN



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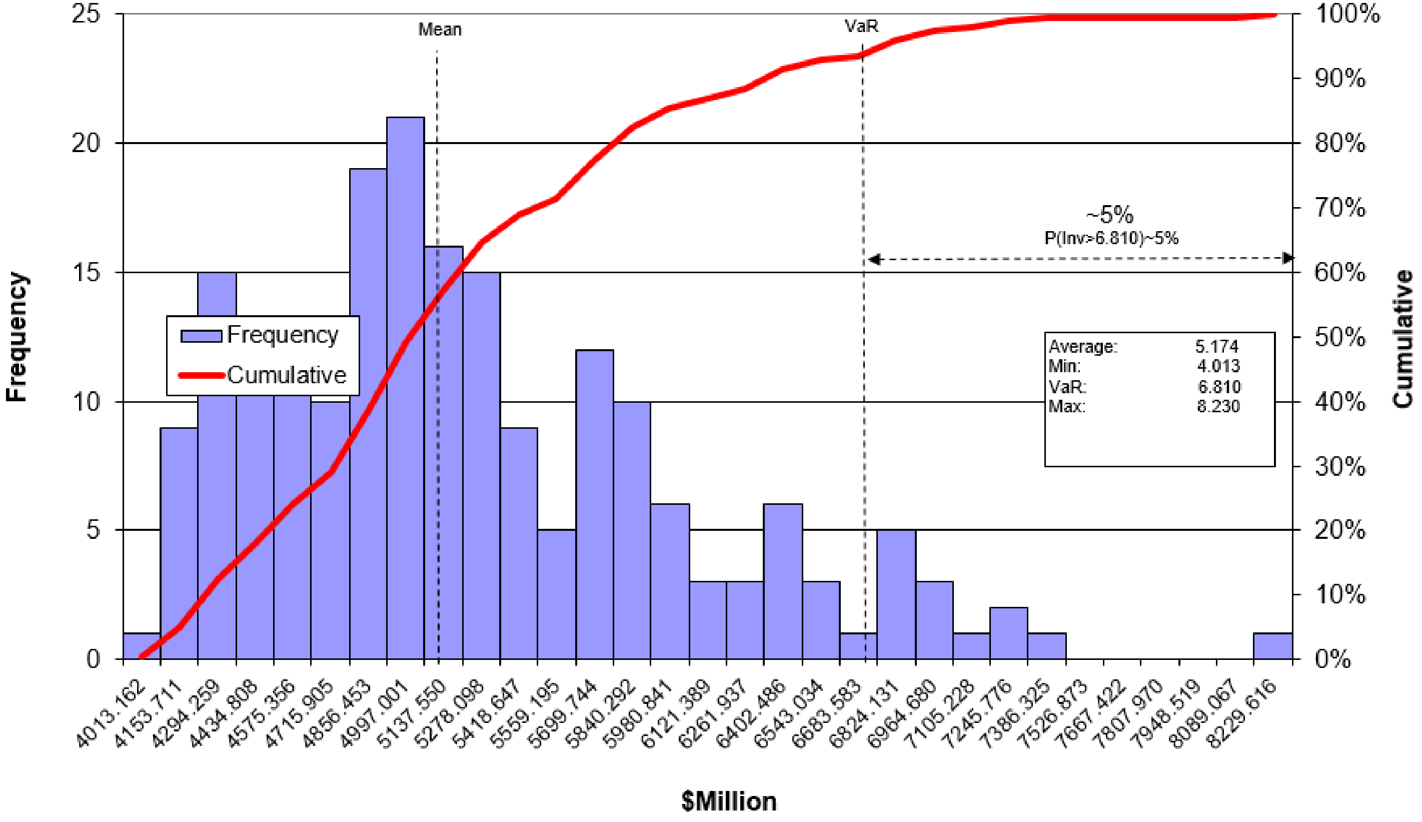
Preliminary Results

Total System Cost - Only Storage



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Preliminary Results – Mean and VaR ($000)

Portfolio	Mean	VaR
2018 IRP OPTIMUM DETERMINISTIC PORTFOLIO	4,767,939	6,083,974
2018 IRP ONLY GTN WITH STORAGE PORTFOLIO	4,778,447	6,083,974
2018 IRP ONLY GTN PORTFOLIO	4,781,488	6,086,634
2018 IRP ONLY NWP WITH STORAGE PORTFOLIO	5,073,169	6,474,956
2018 IRP ONLY NWP PORTFOLIO	5,097,485	6,498,092
2018 IRP ONLY STORAGE PORTFOLIO	5,173,884	6,810,359

Next Steps

- Continued discussions of VaR limits with senior management
- Stress test candidate portfolio in Monte Carlo scenarios
- Stress test candidate portfolio in Monte Carlo sensitivities
- Selection of Preferred Portfolio

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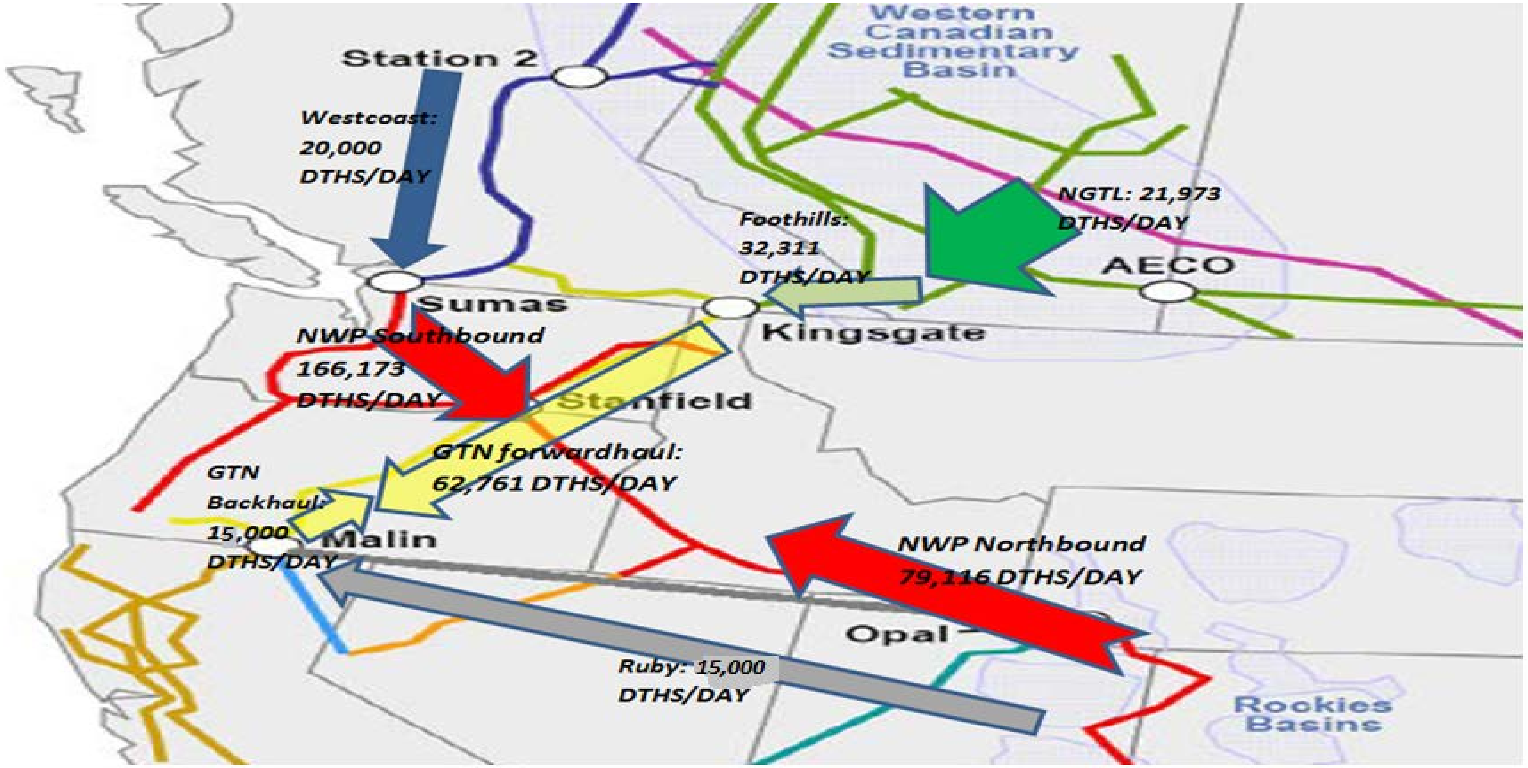
Incremental GTN Capacity

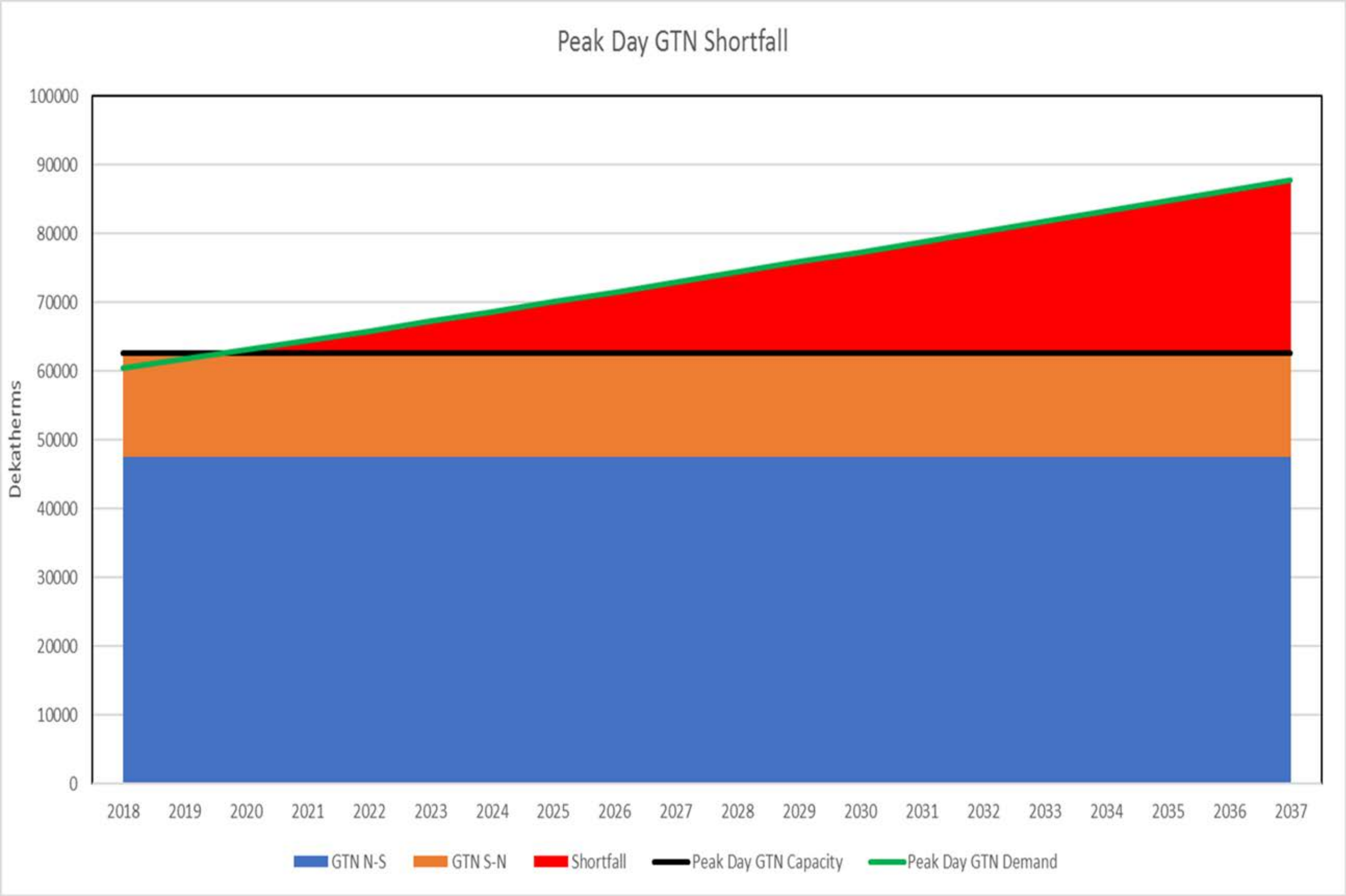
Pipeline transport flow



85

Upstream Pipeline Capacity Update - GTN

- As of July 28 IRP modeling:
  - Beginning in 2020 Cascade is short approximately 400 dths day of GTN capacity.
  - By the end of the 20 year horizon the shortfall is approximately 31,000.



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Upstream Pipeline Capacity Update - GTN

- Cascade IRPs over at least the last 15 years have identified significant capacity shortfalls for Central Oregon in the 2020s.
- GTN has been significantly undersubscribed for years.
- Instead of picking up long-term, incremental GTN capacity, Cascade has relied on picking up capacity release on the day market if needed for peak day.
- Looks like will be changing around 2019 due to new projects.
- Many signs point to a probability that GTN will be fully contracted by 2020
  - NGTL and Foothills recently held an open season to eliminate the mismatch of capacity in the NGTL-Foothills-GTN pathway.
  - Most of the open season was acquired by Canadian producers at AECO.
  - This summer, Seven Generations Energy (7G) contracted delivery capacity to the Pacific Northwest and northern California on TransCanada's Foothills and GTN pipelines starting with modest volumes in November 2019, ramping up to about 90000 dths/day in 2020.
  - If a methanol plant or Coos Bay happens they will likely acquire GTN capacity, making GTN fully-subscribed.
  - Of the 400,000 dths/day of incremental Kingsgate capacity, only 80000 remains or that other utilities' IRPs also indicate a desire for the remaining capacity.

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Upstream Pipeline Capacity Update – Incremental GTN capacity

Upstream Pipeline Capacity Update – Options

- PGA demand costs will increase by approx. 2% (changing from $0.164 per therm to $0.167 per therm)

- Bear in mind under GTN's tariff they are only obligated to accept this offer only six months prior to a effective date
- Anyone requesting firm capacity for one year or more at recourse rates with an effective date six months from today would be awarded the capacity

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Upstream Pipeline Capacity Update – Decision

- Conservation impacts will affect load
- Amount of shortfall may notably change
- GTN might not become fully subscribed
- Market conditions may change dramatically over 22 years

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2018 IRP Timeline

Date	Process Element	Location (Subject to change)
Friday, September 22, 2017	Tentative - Price Forecast Workshop	Skype
Wednesday, October 4, 2017	CAG Q4 Meeting	
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	

NEXT STEPS?

Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #3

Thursday, Sept. 7th, 2017

Portland International Airport

Portland, OR

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3rd External TAG Meeting - OPUC

09/07/2017, 9:00 AM to 12:00 PM

Presenters: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Ashton Davis, Allison Spector, Spencer Moersfelder, & Andrew Hudson

In attendance: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Ashton Davis, Bruce Folsom, Spencer Moersfelder, Andrew Hudson, Allison Spector, Bob Morman, Lisa Gorsuch & Mike Parvinen.

Called in: Garret Senger, Chris Robbins, Eric Wood, Carolyn Stone, Jennifer Gross, Jeremy Ogden, & Kary Burin.

Minutes by: Carolyn P Stone

Slide #'s 3,4 & 5 - Brian stated anything shown on the IRP Action plan update in white is not updated, but yellow highlighted items have been updated.

Slide #6 – Ashton went over the EPA document released on 2016 environmental impact results. The EPA concluded the results to be inconclusive. There are many data gaps causing uncertainty. Mark said there would be a presentation on fracking during TAG 4.

Presentation #3 – Andrew Hudson
DSM Presentation

Allison that Spencer and Andy have done a great job developing this analysis. The level of coordination is appreciated. They have been reviewing progress based on the last planning cycle.

Allison stated that since their OPUC order guidance they have addressed all points and integrated them.

Andy went through today's Agenda. Lisa interjected that the Commission is in a "transitional period" and they are trying to make this transition "seamless". The new commissioner wanted to participate today but will be reaching out later. Anyone having a hard time getting a hold of commissioner should contact Lisa.

Slide #12 – About - Energy Trust of Oregon

- Andy explained that the "Energy Trust of Oregon" is an independent, non-profit organization delivering affordable energy & renewable power to 1.5 million customers of PGE, Pacific Power, NWN & CNG.

Slide #13 – Resource Assessment Overview

- A Resource Assessment (RA) is an estimate of the available of cost-effective efficiency able to be acquired in CNG service territory.
- Andy explained that, they are using a modeling tool that is "bottom up". It uses residential, industrial, commercial & agricultural inputs. It assesses buildings in the cascade service territory to determine equipment savings and measure opportunities.

Question: Is a “stand alone” Natural Gas (NG) company harder to get conservation information for than an electric company? Can you touch on the idiosyncrasies?

Answer: Andy states they have “outreach managers” in the CNG territory that connect with customers and organizations and contractors dedicated to those regions. There are locals “on the ground” that help, so it isn’t as big of a challenge.

Question: Is it harder to reach “outside” customers?

Answer: Andy said he has not heard that it is more difficult to acquire gas savings for these customers. There is instrumental equipment in buildings. Alison added that, in earlier years, there were some challenges in terms of being outside of Portland. The ETO has adapted to approaches to outside customers and ramped up outreach! These issues are being addressed. Andy added, that they have built relationships over time and adapted!

Slide #14 – Background – How is the RA used?

- Andy stated that they take the results of the model and give it to Program Planning, then they help set the deployment of a supply curve. The model does not say what annual savings are acquired by programs nor does it set incentive levels.

Slide #15 – Resource Assessment Inputs

- Andy went over the Resource Assessment inputs:
    1. Service territory data (from CNG)
    2. Demographics - what % of customers have gas and gas hot water, # of homes with insulation & energy use for residential & commercial.
    3. Measurement assumptions

- Andy said that this was the 2nd time the model has been used. It is a more direct approach. They use “building stock assessments” received from the Northwest Energy Efficiency Alliance (NEEA) as a primary resource. Their tool is a “bottom up” measure based model. It looks at savings, cost and measure life. Load profiles used and associated savings value related to those…. tells what the savings will be. The model takes incremental savings and tests for cost effectiveness. It doesn’t force us to “guess what the customer will do”! We look at technology that is in “research stage” also.
- Andy also said every 3 years the model is “rescreened” to make sure cost-effectiveness and savings are still the same.

Slide #16 – Outputs

- Andy said this shows the technical potential and all potential savings
- The cost-effective potential – remaining potential after screen applied!
- Hood River offered free services came out 85 - 95% used as #’s for being achievable

Results

Slide #18 – Cumulative Potential by Type and Year

- This shows the potential by type technical, achievable & cost-effective achievable

Slide#19- Cumulative Emerging Technology Contribution

- 5% of total 20M therms

Slide #20 – Cumulative potential by sector & type (in CNG territory)

- Driven by residential & commercial
- Cost effective override affected residential by 2/3rds when using the override.

Slide #21 – Cumulative Cost Effective Potential End Use

- Coming from water heating and heating savings

- Water heating includes water heating equipment from all 3 sectors, shower heads, aerators, etc.
- Heating load both commercial and residential controls, HVAC is industrial HVAC.
- Behavioral = Commercial strategic energy management, Smart Home Energy devices!

Slide #22 – Top-20 Measures – Cost Effective Cumulative Potential

- This shows the types of measures and their potential savings in therms
- Quite a few from residential paths = new homes!

Discussion of OPUC Exception:

- Allows builders to exceed code – efficient water heaters
- Forces pathways NOT cost effective in also.
- In the end, the savings projection for new home construction is a lost opportunity. Lots of potential shown here but we only get 30%, this is because the homes are built before we can intervene.

Question: What % of the market does your program get to?
Answer: The % varies, Bend area is growing rapidly!

Slide #23 & 24 – Peak-Day Savings/Peak-Day Savings by Load Profile

- What does energy efficiency do to eliminate the need for Peak Day reserves?

Question: Is this involving the 2014-2016 timeframe?
Answer: Yes!

- Peak Factor = the Amount of load expense on Peak Day/Annual Load
- 1 ÷ 365 = .3% savings, happens only on Peak Day
- Some of this data derived from electric profiles – DHW (Electric Resistance Hot Water Heater)
- Residential/Commercial info represents an accurate than electric load profiles from the Power Council.
- Factors X savings correspond with different Load Factors
- For residential/commercial, space heaters drive the heat on cold days!

Slide #25– Market Transformation Savings Forecasts

- Collaborative work with NEEA to drive advancement of codes and help builders comply with new code.
- Savings come from adoption of code!
- 2 years of savings imbedded
- New buildings have not claimed those savings in the past but will incorporate in the future about 5,500 therms, reflected in savings projections ahead….

Slide #26 – Cost-Effectiveness Override in Model – MM Therms

- Andy said they use CNG avoided costs in programs. They use a "blended" avoided cost to reduce cost & standard incentive rates. This "blended avoided cost" might be different than the utilities' avoided cost calculation.
- When there is an exception, Andy said, to cost-effectiveness from OPUC we expect to make for purposes of the 20-year forecast, they keep measures in, expecting them to be cost-effective in the future.
- This override is applied when measures are found not cost-effective offered through programs.
- Andy stated that they've put together a method to forecast savings by:
  1. Changing performance
  2. Using a risk factor score card to hedge uncertainty

Question: Is the model "off the shelf" or something you developed?

Answer: This model was built by a “Navigant” associate. There are a number of sources used in the model, federal DOE, NEEA…etc.

Question: Are new “pilot programs” factored in?
Answer: Andy explained that it isn’t considered it if it goes through a pilot program, as the cost is too high.

Slide #27 – Cost-Effective (CE) Override – MM Therms
- Shows difference when CE override is applied by sector!
- In residential section, this is about 30% of total $20m of Cost-Effectiveness savings.

Slide #28 – 2015 Supply Curve – 20-year Technical Potential
- Levelized cost of therms
- Cost effective limit just under 7m therms
- Cost effective override not used in 2015!

Slide #29 – New 2018 Supply Curve
- 20m cost-effective limit, $1.88 levelized cost
- Common metric used but not how the model identifies what is cost-effective!

Question: How are programs providing “negative” level of cost-effectiveness?
Answer: This is because of measures with non-energy benefits. This winds up giving a negative cost!

Slide #30 – TRC Score
- At what score can you get cost effectiveness?

2018 IRP Projected Savings

Slide #32 – Types of Potential
- Identifies potential, technical, achievable, cost-effective & program savings
- How effective are programs? Retrofit measures… can happen any time
- Replacement – new homes lost opportunities as stated previously. We have a short window of time to intervene, then gone! We get 30 -35% of those savings.
-

Question: Any known or guesses on why 30-35% of new construction savings obtained?
Answer: It’s generally due to “budget builders”. It is hard to get them to spend $ on efficiency! Builders meet code and that’s it. We make lots of effort to connect with these builders and have had some success….30-35% improvement over the last few years. If we intervene, this drives savings!

Slide #33 – 20-Year Potential by Type
- In terms of trends of programs, the importance is the success and ability to get programs. You can have programs but customers still must make the investment on their own!

Slide #34 – 2015 vs 2018 IRP Savings/Projected & Actuals
- Compares 2018 IRP to 2015 IRP totals
- We have doubled the savings from 2015!
- Using the Navigant model is more efficient and projects closer to reality!

Question: Is this an “aggressive” scenario?
Answer: Yes, in some ways. This is how energy trust operates. We go after more and more each year. It is aggressive but realistic!

Slide #35 – Annual Projected Savings as % of CNG's Annual and Cumulative Load Forecast
- 8% of annual load in first 1 to 10 years!
- Cumulative will be over 10% in a 20-year period!

Question: Are you double counting Smart Automation savings?
Answer: Those are primarily residential. Smart thermostats save heating, smart home automation – we're not familiar with these measures. It is a challenge annually reviewing measures and the assumptions going into them! The average savings and baselines are at times a concern. Concerns are addressed through continued evaluation and building analysis!

Question: How are the evaluations carried out?
Answer: We contract out studies, but we do also have an internal team!

Question: What is not technically "feasible" mean?
Answer: Like a boiler measure – the building might be able to have a boiler but not able to install the boiler due to lack of infrastructure (ductwork, etc.).

Question: What are non-energy benefits?
Answer: Like shower heads and aerators for example; they restrict water and the customer saves energy and $ value.

Presentation #4 – Allison Spector
Policies & Methodologies Informing DSM Outcome

Slide #37 & 38 – Externalities
- Anything outside the control of the company raising or lowering DSM potential!
- Includes code changes to DSM
- Incorporated into Oregon DSM projections
- Carbon Policy Adder – price forecast x 10%

Slide #39 – Capacity Contribution & Value in Energy Efficiency
- We are working on this externality.
- Analysis at the citygate level.
- We are starting to look at NWN's approach and we think it will benefit us!

Slide #40 – Policies in our Service Territory
- Can impact cost effectiveness of program!

1. National Standard Practice Manual
    - Could be impacts from this.
    - They may use "custom" variables in this manual…?
    - It takes base components based on regulatory goals.
    - We are aware of it and are keeping an eye on it in WA and OR.
    - If adapted, could impact how cost effectiveness is looked at in Oregon.

2. Clean Power Plan
    - Executive order evaluated!

Slide #41 – Oregon
1. Renewable goals – greater focus on renewable energy!

2. Increased focus in Oregon on migrating gas to electric, using 1st, renewable energy and 2nd phase gas to electric.
3. Moratorium on fracturing.

- This was passed thru the House but not the Senate, so not a law yet, but we are tracking this!

Slide #42 – Washington

1. Carbon Cap bills – None have passed yet, but we are watching closely and it does have traction!
2. Decarbonization – Involves emissions reductions
3. Clean Air Rule – We are evaluating options to comply with this rule

Question: Bruce asked if avoided costs are included?
Answer: Allison said a presentation of avoided costs will be shown in a few slides. We generally follow the lead of the OPUC. We are primarily a taker of inputs from utilities.

- Mark stated that the CNG forecast contains some avoided costs.

Question: What information do you have on Avoided Costs from the Commission?
Answer: Next week we will have some information. Could be a recommendation made to parties to have a collaborative effort. Andy stated that Avoided Costs were put in after Alison's talk on policy because there are implications.

Slide #58 - OR annual Avoided Costs used in Resource Assessment

1. We do include Carbon Policy adders…and
2. Risk reduction value
3. Using a capacity value method driven by peak savings. Winter is 0 now, in workshops this fall it will be decided.

*Starting year going out, each year savings run through Avoided Costs.

Slide #59- NPV Avoided Cost/first-year Therm for selected measures

1. Lifetime of measure (has significant impact on value of savings!
2. Load profile (time of year of savings occurs)

Resource Assessment Modeling Tool and Updates

Slide #44 – Model Assumptions

Slide #45- Cost-Effectiveness Screen

- TRC Cost test = TRC ratio = NPV of benefits/TRC

Slide #46 – Updates to Cost-Effectiveness

- OPUC Exceptions (Docket 1622)
- Non- Cost-Effective Gas measures
    - o Weatherization
    - o Gas Tank Water heaters
    - o Gas Washing machine
    - o New homes

Slide #47 – Measure Updates

- Updated measures across all sectors!
- Adding new measures

Slide #48 – Define Measures Incrementally

- Don't count total savings of each technology!

Slide #51 – ET Risk Factor Scorecard

1. 25% market risk
2. 25% technical risk (what stage is the program in, is it a "prototype", has it been tested?
3. 50% weight to source of data, how good is it on this program?
4. If low risk technology then 80% factor.

Slide #54 – 2018 Programs, all Cost-Effective efficiency

- Residential, Commercial & Industrial/Agricultural programs

Slide #55 – Cascade Natural Gas & Energy Trust

- Serving Oregon since 2006!
- All customers except the largest NW transport customers

Slide #56, – Historical Performance Against IRP Target

- Net savings here, NOT gross!
- Risk of treating DSM as a resource.
- This shows our net or exceeded goals.
- It is challenging to forecast large project savings results. Large projects swing the results!
- Our planning team has been working on this.

Slide #34 – 2015 vs 2018 IRP Savings

- This gives confidence in looking at past projects vs current!

Avoided Costs

Slide #60 – Program Funding (Alison Spector)

- Alison mentioned schedule 31, Public Purpose Funding adjusts over time!

Slide #62 – Revision to Schedule 31

- A revision will be effective 12/1/2016
- Charge increase to 4.87%

Oregon Low Income Energy Conservation (OLIEC) & Conservation Achievement Tariff (CAT) Programs

Slide #64 – Action Partners Serving Central & Eastern Oregon

- Action partners provide weatherization, etc. for low income!

Slide #65 – OLIEC

- Covers portion of tariff approved measures, ceiling, floor, wall, ducts, etc.

Slide #66 – Conservation Achievement Tariff

- Established 12/1/2016
- .0625% of gross revenues from electric side & natural gas.
- CAP is the same as for NWN - $10K

Slide #67 – Achievements & Projections

- 50 homes served per year!
- 100 homes annually if funded at full capacity!

Other Items

Slide #69 – Future Action Plan Items (DSM)

- Geographically targeted DSM, coordinate with ETO

Question: Can you expand on execution of pilot programs?
Answer: Yes, we have done the following:

1. Meetings with ETO Staff
2. Discussed interest in geographically targeted DSM
3. Coordinated in order to have a plan!
4. In planning stages…. find it to be intriguing…. need to look at the constraints on the system!

Question: Mark asked Lisa if the action plan items are "quantifiable" and if they are going on the right path?
Answer: Lisa said it looks good to her, but she said she cannot speak for others. She said - yes definitely in the right direction. The planning process is an evolution. This changes what we are looking for in the IRP and we need to keep track of changes. She said she knows this is challenging but really appreciates CNG's efforts! Lisa continued that the planning process is a collaborative effort including all stakeholders. She said to remember, this is worked on together and is not an adversarial process! She appreciates all the hard work. She said if she cannot definitively answer questions, she will work hard toward that. She knows we've been working hard!

Presentation #5 – Ashton Davis & Brian Robertson
SENDOUT Modeling Update

Slide #73 – SENDOUT Model (Ashton Davis)

- The SENDOUT model is used for resource optimization
- Portfolios are developed and analyzed
- SENDOUT is very powerful & complex!

Slide #74 – SENDOUT (cont'd)

- SENDOUT uses linear programming
- SENDOUT is helpful information but not a "perfect" solution – used as a guide
- SENDOUT has perfect knowledge

Slide #76 & 77 – Supply Resource Optimization Process (Brian Robertson)

- At Tag #2, we presented a resource optimization using a Monte Carlo run creating 200 decisions – this was too many and not informative!
- There are 8 steps we use:
  1. See where we are short
  2. Introduce resources to solve
  3. Develop portfolio, run stochastic and weather via Monte Carlo simulation
  4. Rank Portfolios
  5. Change Variables – run Monte Carlo and see how model reacts
  6. Analyze preferred portfolio
  7. Sensitivity analysis
  8. Test other portfolios (EX: NWP only, etc.), select optimal and re-evaluate
- After this, is there any unserved demand?

Preliminary Results

Slide #79 – 84 - Results

1. Storage – How SENDOUT informs but does NOT decide!
    - o What is the optimal storage? SENDOUT could choose optimal solution (with a mean cost) but unquantifiable factors, humans MUST intervene, not practical!
    - o Certain solves may lead to more unserved demand.
    - o We assign “penalties” to SENDOUT to prevent certain solves.

Slide #79 – Optimal Deterministic Portfolio

- All Variables in the “Optimal Portfolio”
- Resource Mix – Sendout chooses what resources it wants, we lock that in and run it stochastically.
- VaR – Devin explained that the resource analysts went to a seminar in San Francisco on and learned about the extrinsic value of what your portfolio can do!
- This is if everything works as planned – but have all events been included?
- The model does not do a “standard deviation”
- Peak day analysis is good to use but Monte Carlo doesn’t show “peak day”. In 95% of the cases you can use this value (95^{th} percentile).
- Shows the “mean” of costs.

Slide #81 – Total System Cost – only NWP

- Value is higher here
- Doesn’t have storage options!

Slide #82 – Total System Cost – only GTN w/ Incremental Storage

- Almost optimal portfolio!
- Mean/VAR lower with NWP options

Slide #84 – Total System Cost – Only Storage

- This is NOT a solve!

Slide #85 – Mean & VaR

- Ranking Portfolios here
- All Portfolios under same weather curves
- Mark said that Tag #2 meetings’ portfolios will be recapped. This shows the diversity of our system!
- Lisa mentioned that she needs to “catch up”!
- Devin McGreal said they are excited about this process. The capture of extrinsic elements is important!

Presentation #6 – Devin McGreal
Next Steps

Slide #86 – Next Steps

1. Get together with senior management to determine VaR limit
2. Test portfolios in Monte Carlo
3. Stress test sensitivities – price (high or low), carbon taxes, etc.
4. Select the preferred portfolio (tested against the VaR limit)

Presentation # – Devin McGreal & Mark Sellers-Vaughn
Incremental GTN Capacity

Slide #88 – Pipeline Transport Flow

- Devin went over the system transport flow, noting our diverse system
- Devin explained that SENDOUT showed a very popular solution – need for GTN capacity!
- Mark mentioned the “direct connect” we have

Slide #89 – Upstream Pipeline Capacity Update – GTN

- Mark went over this slide that shows IRP modeling as of July 28 that CNG is short by 400 Dth's per day of GTN capacity
- By the end of year 20 the shortfall is 31,000

Slide #90 – Upstream Pipeline Capacity Update – GTN

- The IRP goes over 15 years into 2020
- GTN has been undersubscribed for years, CNG has been picking up daily gas to make up for peak day
- GTN could be highly subscribed around year 2019
- GTN planning on filing with FERC for firm hourly service. CNG should lock in capacity now or it may not be available later!
- Mark explained that CNG has been negotiating with GTN for:
    - Path - Kingsgate to Malin
    - 20K per day
    - 22 years (to 10/31/2039)
    - Starting 11/1/2017

Slide #92 – Options

1. Take offer for 2017
2. Take 20K in 2018 (GTN tariff says they are only obligated to take offers 6 months prior to effective date)
3. Take lower amount of 10K for 15 years and lose discount offered
4. Do nothing and continue to buy daily for Peak

Slide #93 – Decision

- Mark explained that the GSOC agreed to 10K for 15 years effective 12/1/2017.
- This satisfies peak day needs to 2028/2029
- Mark went on to state that previously this shortfall has been identified and he notes we are now taking steps. It was time to do something!
- He also stated that NWP as offered capacity in the past but been very patient with us.
- Lisa stated that this is like "insurance" on an unknown hedge risk.

2018 IRP Timeline

Slide #94 – Timeline

- Brian went over the timeline, stating filing will happen January 25, 2018.

Next Steps

Mark stated he really appreciated everyone coming today!

Cascade Natural Gas Corporation

2018 Integrated Resource Plan
Technical Advisory Group Meeting #4

Thursday, Oct. 19th, 2017
Oregon Public Utility Commission Offices
Salem, OR

Agenda

- **Introductions**
- **IRP Action Plan Update**
- **Fracking Presentation (NWIGU)**
- **SENDOUT® Optimization Modeling**
- **Alternative Resources**
- **Candidate Portfolios**
- **Monte Carlo Simulations**
- **Results**
- **Upcoming Schedule**
- **Questions**

IRP Action Plan Update

2014 IRP Action Item	Update
1. Cascade will improve its demand forecast by developing a report to track the issuance of corrected bills and reclassifying therms from corrected bills to the month those therms were used. In its next IRP, Cascade will use its new Statistical Analysis Software (SAS) to test non-linear weather effects on natural gas, to perform analysis on potential serial correlation problems, and to create a time series autoregressive integrated moving average (ARIMA) model for customer forecasting.	On June 26th Cascade's Gas Supply Oversight Committee (GSOC) met and was provided an update on the 2017 portfolio procurement plan, which included recent market intelligence and updated pricing. In TAG 3 the company will discuss its supplies of varying lengths and pricing alternatives.
2. Cascade will continue to monitor outside determinants of natural gas usage, such as legislative building code changes and electrical “Direct Use” campaigns as they are determined to significantly affect the Company’s forecast.	Since the 2014 Action Plan, Cascade has monitored the following legislation, campaigns, and other external actions with the potential to influence natural gas use in the States of Washington and Oregon: - National standard practice manual, Portland renewable energy goals, gas to electric fuel switching, HB-2711 moratorium on hydraulic fracturing for oil and gas exploration and production, several Washington state bills on Carbon taxes, deep decarbonization, and the clean air rule.
3. Cascade will continue to monitor the effectiveness of the Oregon Public Purpose Fund to ensure the funds are adequate to capture significant portions of achievable therm savings in Oregon.	Since the 2014 IRP, Cascade has made two filings to increase its public purpose charge to ensure funding would be sufficient to acquire the therm savings target established in the IRP as a least cost resource: Advice No. O15-12-01 on December 11th, 2015 to increase its public purpose charge from 1.85% to 3.7% (reduced to 3.4% before Commission approval) and Advice No. O16-10-01 on October 31st, 2016, in which the Company asked to increase the Public Purpose Charge from 3.4% to 4.87%.
4. The company will continue to follow and analyze the impacts of the Western Climate Initiative and proposed carbon legislation at both the state and federal level as they pertain to natural gas conservation, as well as other such acts that may arise from these efforts. The company will continue to monitor the timing and the costs associated with carbon legislation and analyze the impacts on the company’s overall portfolio costs. As specific carbon legislation is passed, the company will update its avoided cost calculations, conservation potential and make modifications to its DSM incentive programs as necessary.	The Company has continued to monitor the Western Climate Initiative and proposed carbon legislation since the 2014 Action Plan. While no significant action has been taken on the WCI with impacts to the Company, the Company is actively following the current legislation and is monitoring the potential impacts to portfolio costs.

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IRP Action Plan Update Cont'd

2014 IRP Action Item	Update
5. The company will continue to monitor the cost effectiveness of existing conservation measures and emerging technologies to ensure that the current mix of measures included in the Washington Conservation program is appropriate. Areas for further analysis include the impacts associated with modifications to building codes along with the cost effectiveness of newer technologies such as the next generation of high efficiency water heaters (.70 EF) and high-efficiency hybrid heat pumps. The applicability of these measures within Cascade's service territory will be analyzed and the company's Conservation Incentive Program will be modified as necessary.	Cascade continually monitors the region and natural gas industry on currently available technology advancements as part of our Washington incentive programs. We reevaluate the portfolio cost-effectiveness paired with current technology and update install costs to maintain viability and as robust of a program as feasible. The Company is also engaged with the Northwest Energy Efficiency Alliance market transformation collaborative in coordination with other local utilities and the Energy Trust of Oregon as well as the Gas Technology Institute's emerging technology program to stay abreast of new technologies and opportunities for additions and changes to the Company's offerings. The Company also maintains a Trade Ally network for our Washington programs and routinely connects with local contractors to gauge availability of product and costs associated with installs of rebate eligible equipment and measures. The landscape is constantly evolving and Cascade works with its partners and local agencies and builders (including home builder associations) to track building code updates as well as changes to industry standards.
6. The Company will continue to monitor the potential reporting, administrative and potential financial impacts of long term resources as a result of concerns surrounding fracking. In particular we are awaiting the EPA to reveal the results of their current study in alleged water contamination found in Wyoming as a result of fracking activities.	Cascade has included a slide in TAG 3 to address this action item. Additionally, Cascade has extended an invitation to NWIGU to discuss this item.

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IRP Action Plan Update Cont’d

2014 IRP Action Item	Update
7. Cascade will continue to evaluate gas supply resources on an ongoing basis, including supplies of varying lengths (base, swing, peaking) and pricing alternatives. We will continue to analyze the uncertainties associated with supply and demand relationships.	Due to the robust nature of TAG 3, this will now be discussed in TAG 4.
8. The Company will continue to monitor the proposed pipeline expansion projects to access more supplies out of the Rockies. As cost estimates change, the company will analyze those resources under consideration to determine if modifications to the preferred portfolio are necessary.	NWP has provided an updated Wenatchee lateral expansion which is currently being considered for modeling.
9. As part of the Cascade’s risk management policy and implementation, the Company will report on the status of the UM 1720 as well as related risk management policy enhancements to Cascade’s risk management policy, at the first Purchased Gas Adjustment (PGA) quarterly meeting with OPUC Staff in early 2017. This docket is the Commission’s Investigation into Long Term Hedging Policy.	Interested parties met on August 23rd, with the conclusion that an agreement could not be reached. The parties at this meeting (Staff, regional LDCs, NWIGU and CUB) will be requesting that this docket be closed. Cascade continues to work on enhancing its risk management policies in compliance with Washington's new hedging rules
10. The Company will continue to explore options to incorporate biogas into its portfolio, as specific projects are identified in our service territory. Price, location and gas quality considerations of the biogas supply will be evaluated.	Cascade has filed a Biomethane Reciept Services (Schedule 800) in Oregon to estabilsh biogas injection terms, conditions and gas quality requirements. Cascade continues to work with possible biomethane producers and evaluate those projects for possible future core supplies.
11. The Company will continue to monitor proposed LNG import facilities as information becomes available and will evaluate the various options that, if built, could result. Issues to monitor include specific cost, the availability of pipeline capacity and project timing.	Cascade is continuing to monitor the progress of import/export facilities such as the proposed Jordan Cove LNG terminal. The status of these projects are documented each month in Cascade's monthly internal market intelligence report
12. The Company will continue to monitor the futures market for price trends and will evaluate the effectiveness of its risk management policy. Implementation of Dodd- Frank in the coming year raises potential administrative challenges from a reporting standpoint; additionally it is unknown how the costs associated with the use of clearinghouses might impact prices of natural gas in the future.	Cascade has updated its price forecast to modify its weights based on a backcast of the accuracy of its sources. At this time the price impacts of Dodd-Frank and hedging related dockets such as UM 1720 and UG-132019 continues to be unknown. The Company will continue to provide updates in coming TAG meetings.

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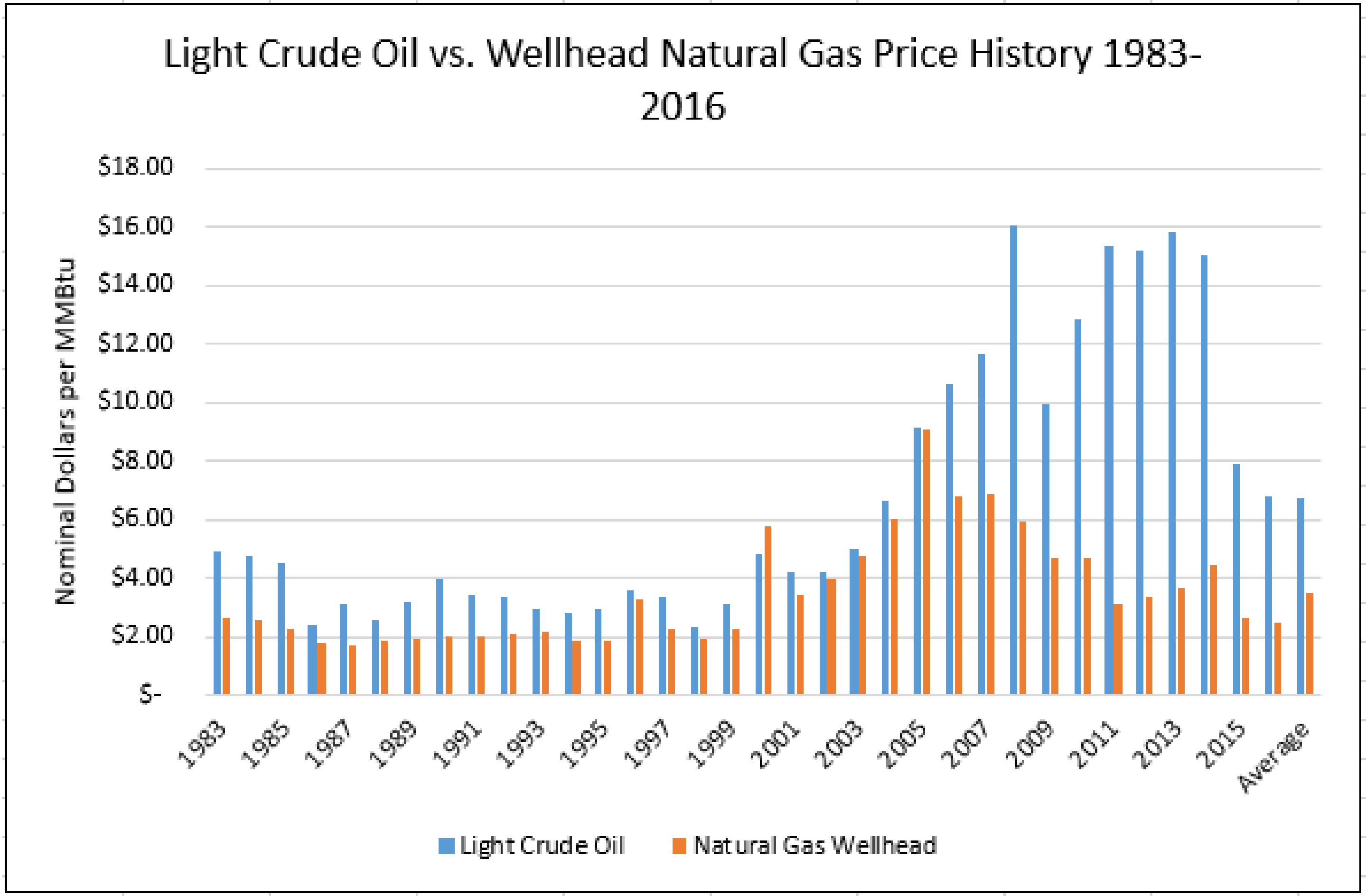
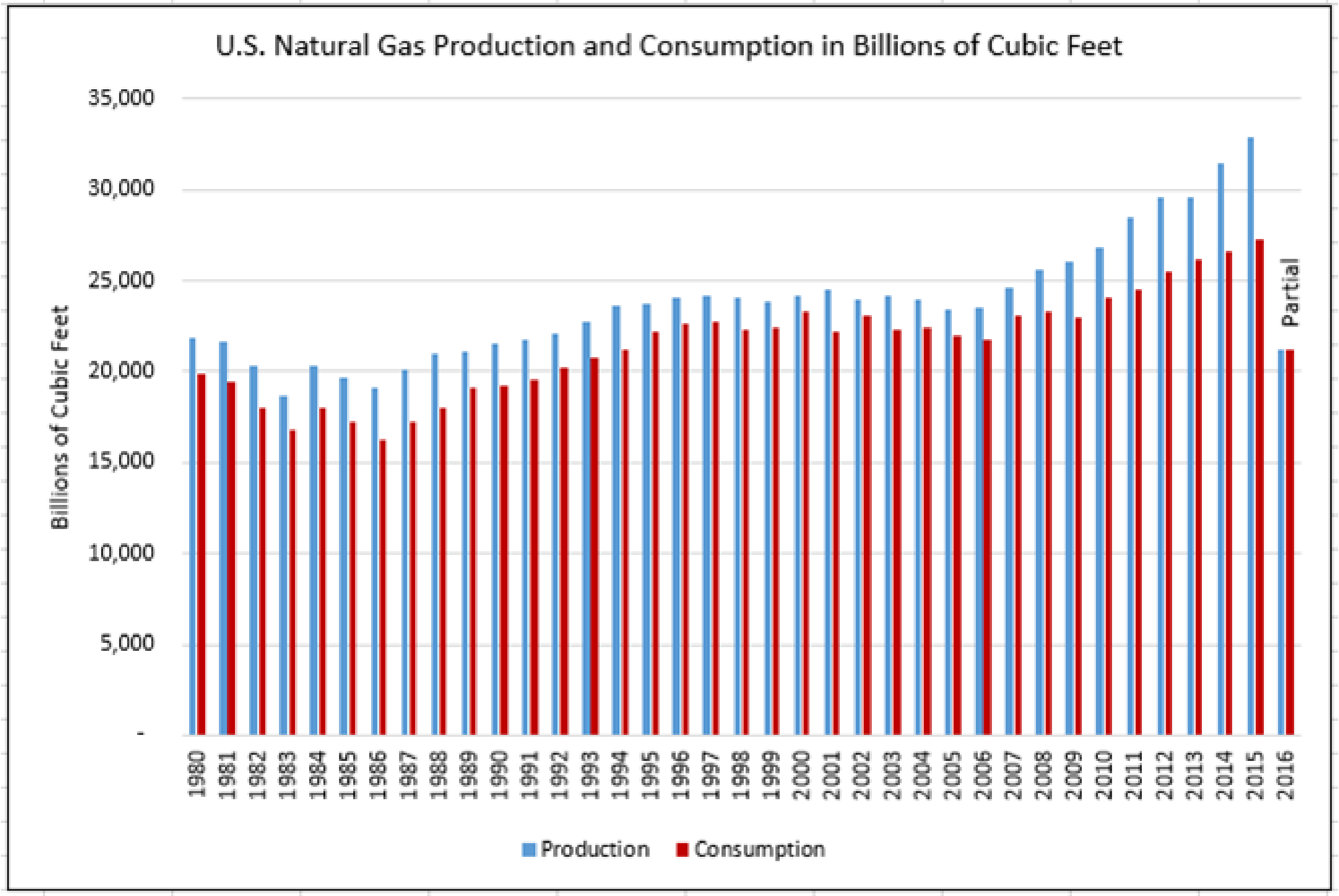
Consumer and Environmental Benefits of Shale Revolution

Ed Finklea
Northwest Industrial Gas Users
Presentation to Cascade TAG
October 19, 2017

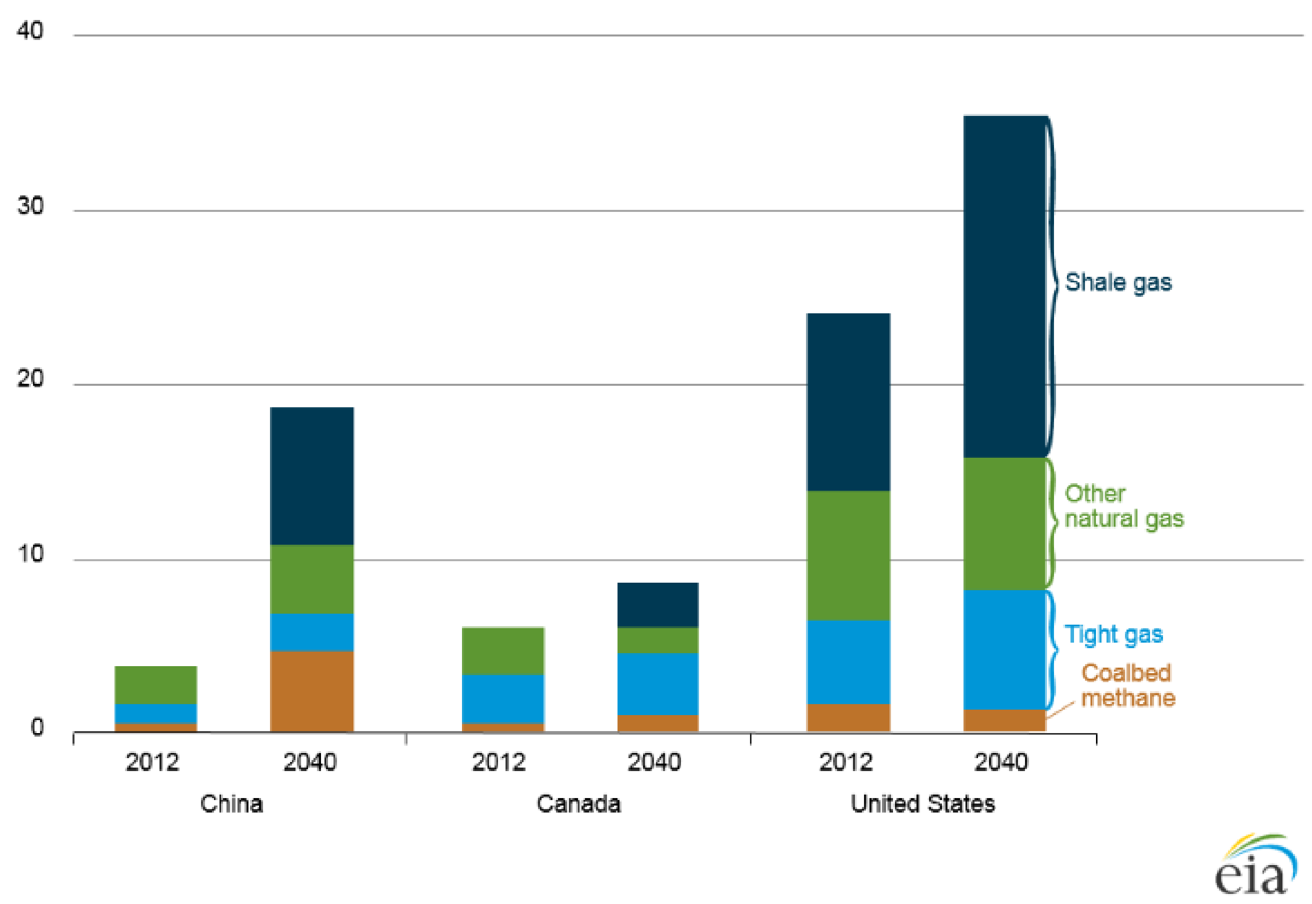
Oil and Natural Gas Price History 1983-2016



U.S. Natural Gas Production and Consumption in Billions of Cubic Feet 1980-2016



Natural Gas Production Outlook in North America, 2012-2040 in Trillion Cubic Feet

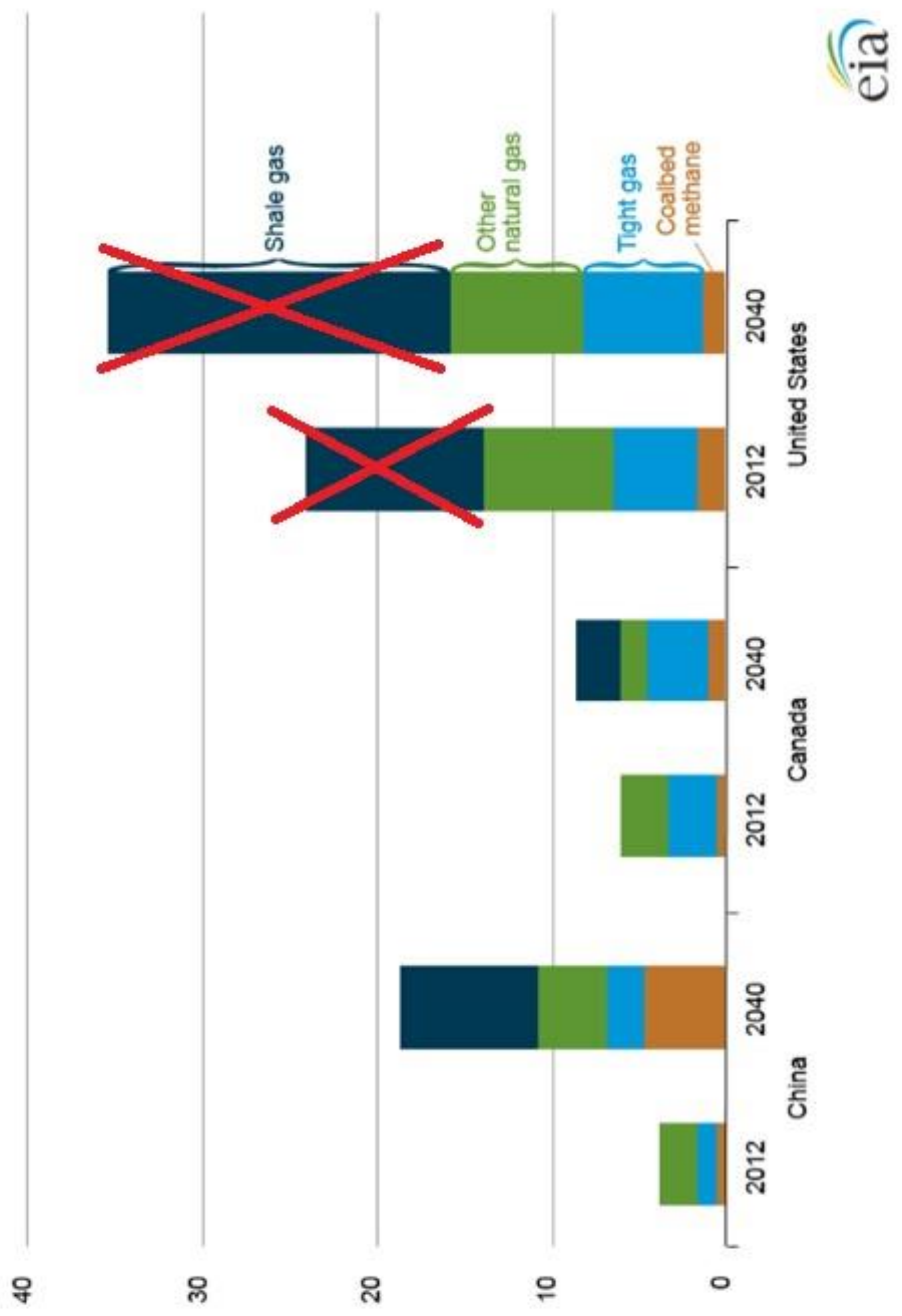


10

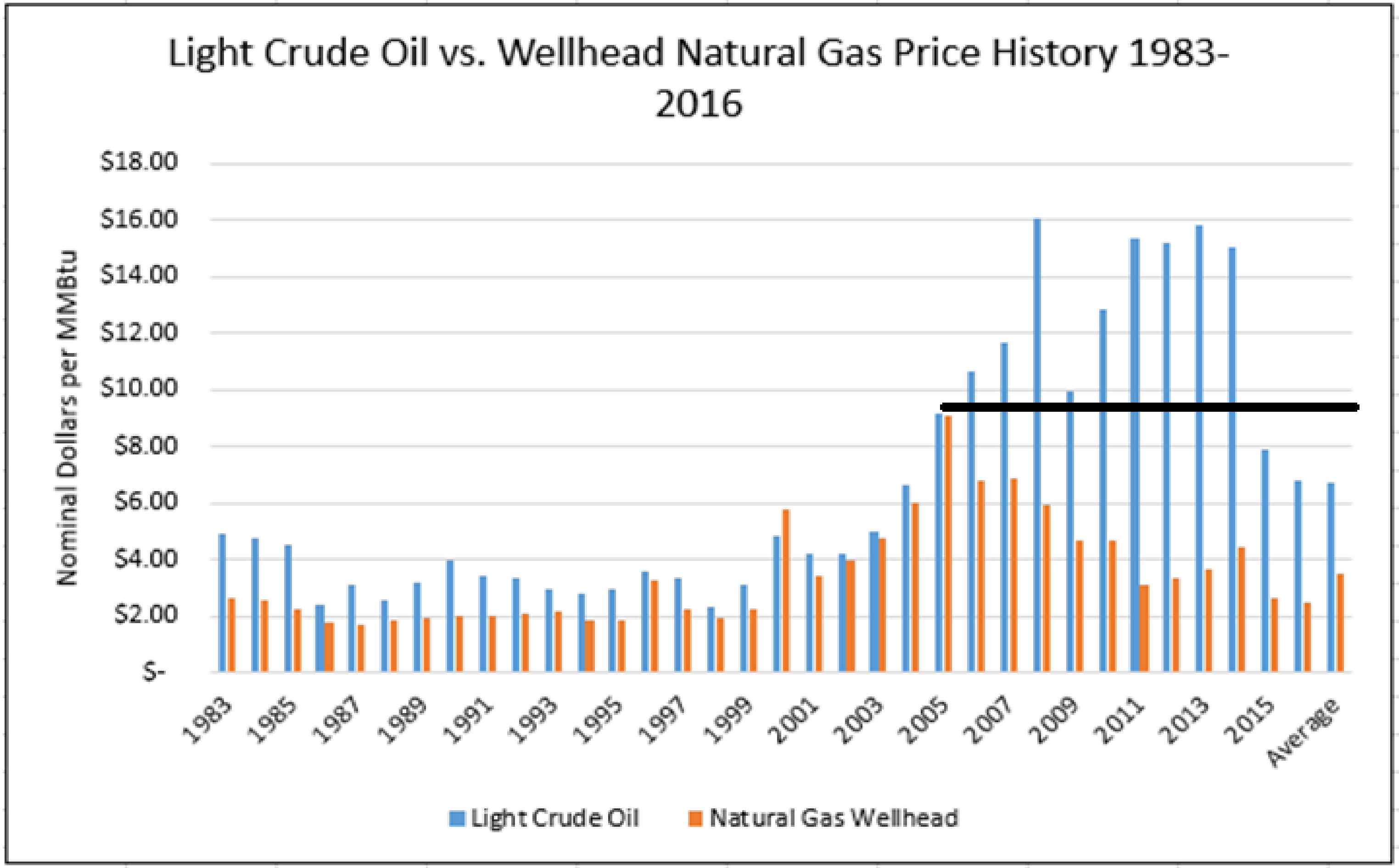

GOVERNOR CUOMO
IMAGINE THERE'S NO FRACKING...
YOKO & SEAN
WWW.ARTISTSAGAINSTFRACKING.COM

11

Eliminate Shale

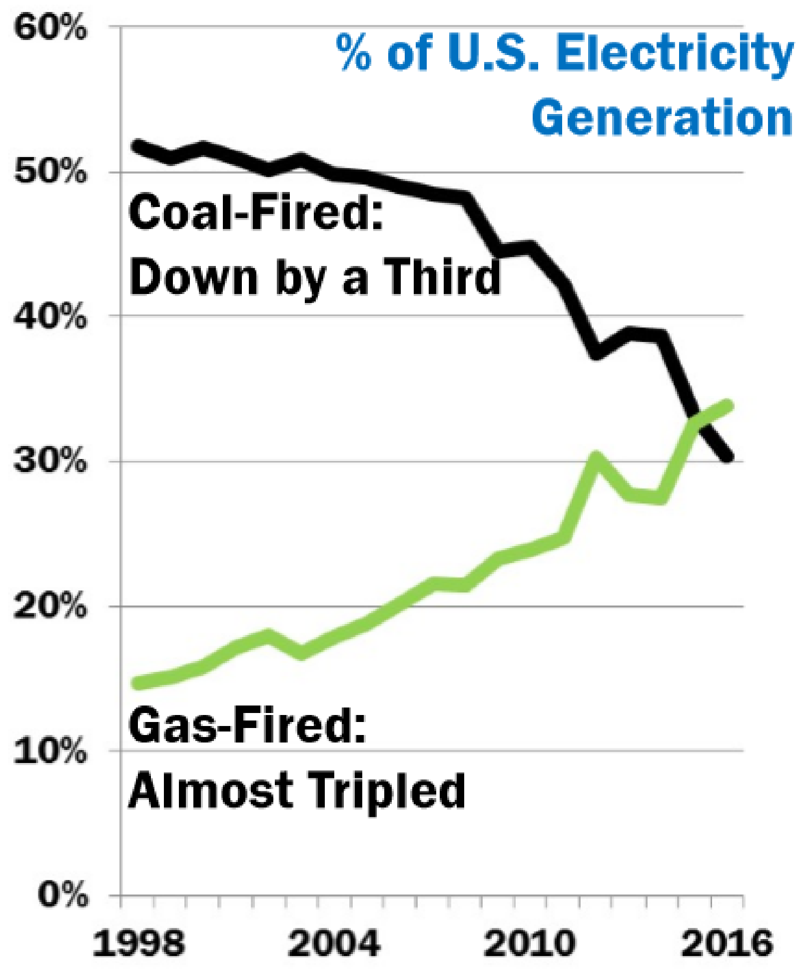


Prices Stay Above $8.00



No Fracking’s Impact on Oregon Consumers

- Oregon Natural Gas Consumers Burned 239 million Dekatherm's in 2016.
- If no fracking raised natural gas prices by $5.00 per Dekatherm, staying at the pre fracking price of just above $8.00, Oregon consumers would have paid at least $1.1 billion more for natural gas in 2016.
- Every $1.00 per Dekaterm price reduction annually saves Oregon consumers $239 million on natural gas.
- US would have approximately a 10TCF shortfall to meet 2016 consumption levels without shale gas. How much LNG would US be importing? From where? Through what terminals? In Oregon, where would our natural gas be coming from? Would Canada be saving us at higher prices?



Source: Energy Information Administration

Total Carbon Emissions Reduction, 2007—2014 (Million Metric Tons per Year)

U.S.A	(590.8)
Spain	(118.1)
Italy	(109.6)
United Kingdom	(66.4)
Canada	(57.3)
Australia	(35.9)
France	(31.6)
Ukraine	(25.6)
Romania	(25.4)
Germany	(24.8)

Source: Global Carbon Atlas

SENDOUT® Optimization Modeling

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SENDOUT® Model

- Cascade utilizes SENDOUT® for resource optimization.
- This model permits the Company to develop and analyze a variety of resource portfolios to help determine the type, size, and timing of resources best matched to forecast requirements.
- SENDOUT® is very powerful and complex. It operates by combining a series of existing and potential demand side and supply side resources, and optimizes their utilization at the lowest net present cost over the entire planning period for a given demand forecast.

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SENDOUT® Model (Cont’d)

- SENDOUT® utilizes a linear programming approach.
- The model knows the exact load and price for every day of the planning period based on the analyst’s input and can therefore minimize costs in a way that would not be possible in the real world.
- Therefore, it is important to recognize that linear programming analysis provides helpful but not perfect information to guide decisions.

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Modeling Transportation In SENDOUT® is a Balancing Act

- Start with a point in time look at each jurisdiction's resources
- Use the Nov17-Oct18 PGA portfolio
- Contracts –Receipt and Delivery Points
- We start with current transport contracts, using centralized receipts and approximately 66 delivery locations
- Rates - Current contractual, with CPI increase every 3 years
- Contractual vs. Operational
- Contractual can be overly restrictive
- Operational can be overly flexible
- Incorporating operational realities into our modeling can defer the need to acquire new resources.
- Gas Supply's job is to get gas from the supply basin to the pipeline citygate
- IRP focus is on the core
- Operations job is to take gas from the pipeline gate to our customers
- Operations focus is on the system, not just the core
- Limiting factor is receipt quantity –how much can you bring into the system?

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Modeling Challenges

- Supply needs to get gas to the citygate.
- Many of Cascade's transport agreements were entered into decades ago, based on demand projections at that point in time.
- Sum of receipt quantity and aggregated delivery quantity can help identify resource deficiency depending on how rights are allocated.
- The aggregated look can mask individual citygate issues for looped sections, and the disaggregated look can create deficiencies where they don't exist.
- In many cases operational capacity is greater than contracted.
- SENDOUT® has perfect knowledge.

Supply Resource Optimization Process

- **Step 1: As-Is Analysis**
  - Run a deterministic optimization of existing resources with a three-day peak event to uncover timing and quantity of resource deficiencies.
- **Step 2: Introduce Additional Resources**
  - Include incremental supply, storage, and transportation to derive a deterministic optimal portfolio, additional portfolios.
- **Step 3: Stochastic Analysis of All Portfolios Under Existing Conditions**
  - Run all portfolios through a Monte Carlo weather simulation, using expected growth, supply and storage accessibility. Record the probability distributions of total system costs for each portfolio.
- **Step 4: Ranking of Portfolios**
  - Determine the preferred portfolio based on the mean and Value at Risk (VaR) of the total system cost and unserved demand of each portfolio. This resource mix will be the best combination of cost and risk for Cascade and its customers.

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Supply Resource Optimization Process (Cont'd)

- **Step 5: Stochastic Analysis of Preferred Portfolio**
  - Run Monte Carlo simulations of various scenarios on preferred portfolio; comparing Mean and VaR to a managerial limit.
- **Step 6: Analysis of Preferred Portfolio**
  - Review data to confirm total system costs did not exceed Mean and VaR limits in any scenario. If limit is exceeded, repeat step 5 with next highest ranked portfolio.
- **Step 7: Sensitivity of Preferred Portfolio**
  - Run the preferred portfolio through Monte Carlo simulations on price. Review results to determine if total system cost is within the Mean and VaR limits across all sensitivities.
- **Step 8: Re-evaluation of Preferred Portfolio**
  - If the total system costs fall outside of the Mean and VaR limits in sensitivity analysis, select the next most optimal portfolio to run scenario and sensitivity analysis on. Repeat as needed.

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Base Case Sendout Inputs

- Supply
- Storage
- Transportation
- Constraints
- Demand
- Weather
- Price Forecast

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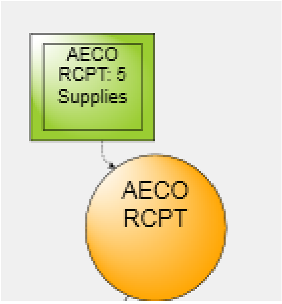
Supply

- Cascade can purchase gas at four markets; AECO, SUMAS, KINGSGATE and OPAL.
- At each market Cascade can purchase gas at different locations along the pipeline.
- For the first year, Cascade uses all current contracts for Supply inputs.
- For years 2-20, Cascade uses Base, Fixed, Winter base, Summer and Winter day gas, and Peak day incremental supplies as inputs.
- Over the planning horizon, the contracts are renewed in November and April.



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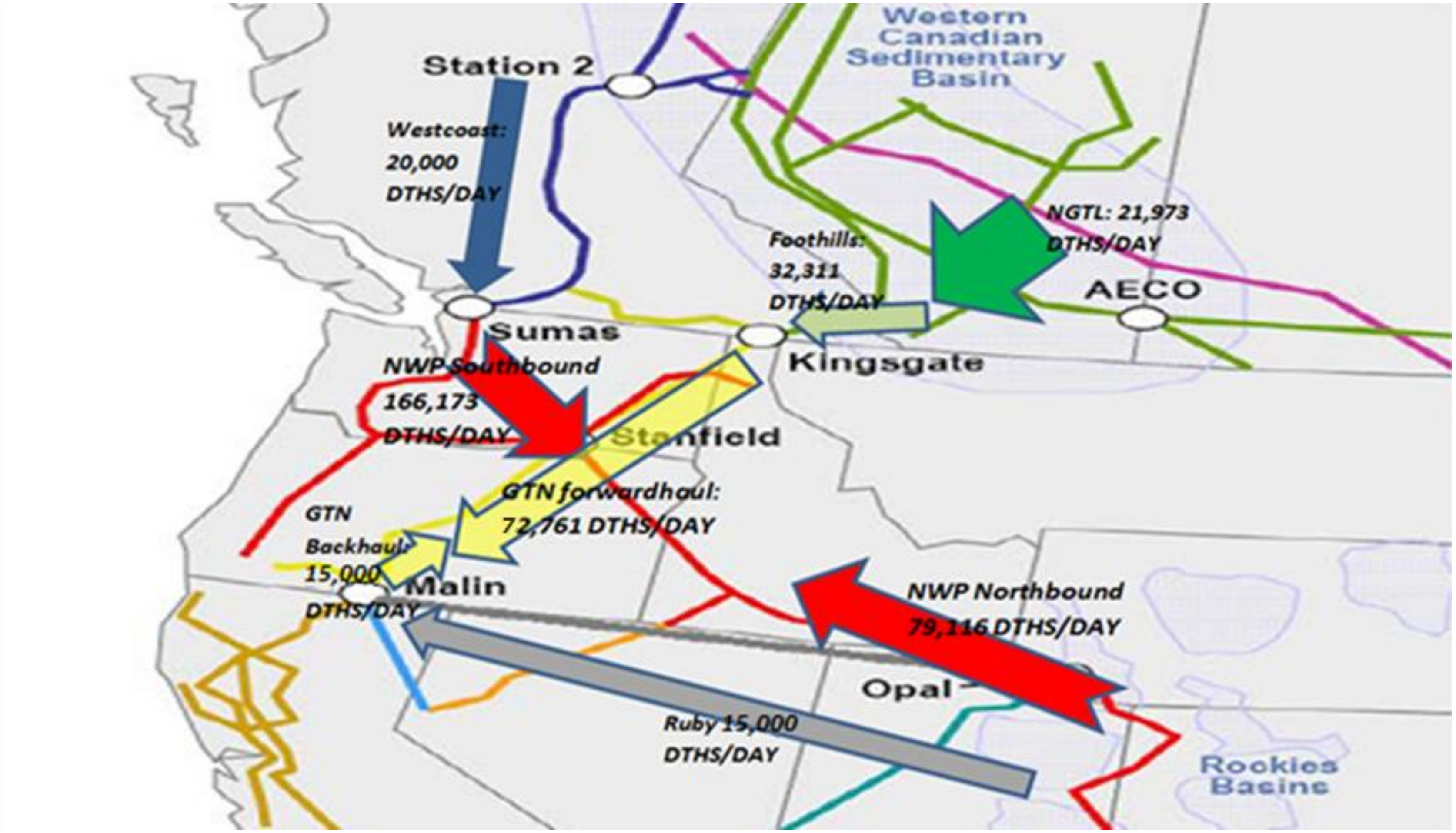
Supply



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Supply Base and Fixed

- Supply Base and Fixed are the baseline supply contracts that are entered into every 12 months.
- A base contract has a basis rate. This is defined as the price of gas at a given market (i.e., AECO base is the expected cost of gas at NYMEX plus the basis for AECO, for a given month).
- A fixed contract has a fixed rate.
- A penalty is applied to each contract when the gas is not taken for a day. This type of penalty forces these types of contracts to only take the optimal amount of gas to serve the base demand.

Supply Example

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier	Index	Adder	Multiplie
*Daily MDQ	25000									Same					
*Daily Minimum Percent	100									Same					
Annual Maximum										Same					
Annual Minimum Percent										Same					
Monthly Maximum										Same					
Monthly Minimum Percent										Same					
Seasonal Maximum										Same					
Seasonal Minimum Percent										Same					
Known Take										Same					
*Rate - Commodity	2.5									Same	CPI				
Rate - Dispatch										Same					
Rate - Known Commodity Cost										Same					
Rate - Other Variable 1										Same					
Rate - Other Variable 2										Same					
Rate - Penalty Annual										Same					
Rate - Penalty Seasonal										Same					
Rate - Penalty Monthly										Same					
Rate - Penalty Daily	2.5									Same				-0.01	
Rate - D1										Same					
Rate - D2										Same					
Volume - D1 Volume										Same					
Volume - D2 Volume										Same					
Temp Cutoff Max Temperature										Same					
Available % Below Min/Above Max										Same					
Temp Cutoff Min Temperature										Same					
Apply Temperature Cutoff										Same					
Energy Conversion Factor										Same					
Process Indicator										Same					
Resource Mix Start\Stop Indicators	Start									Last Year					
Rmix MDQ Range Max	25000									Same					

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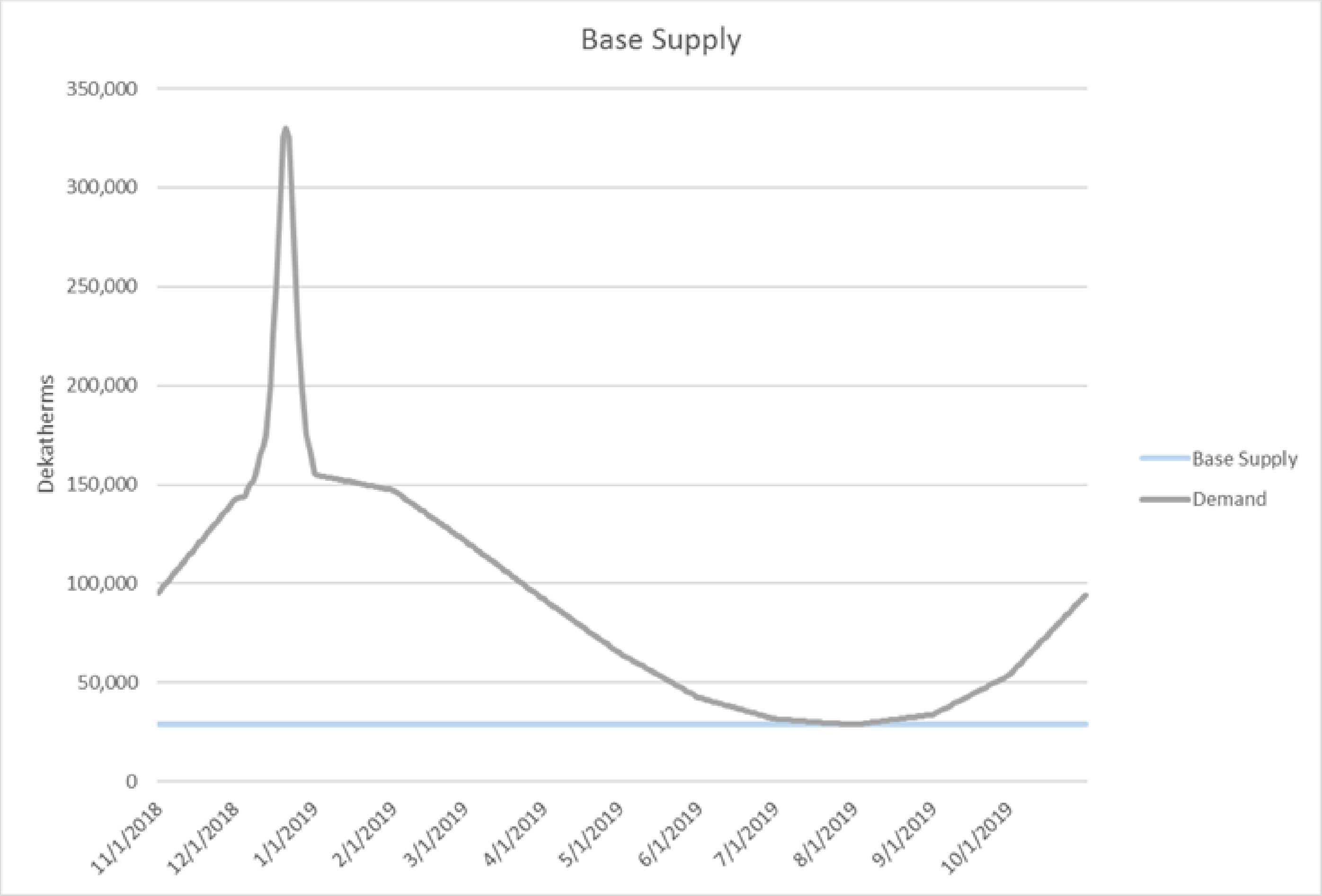
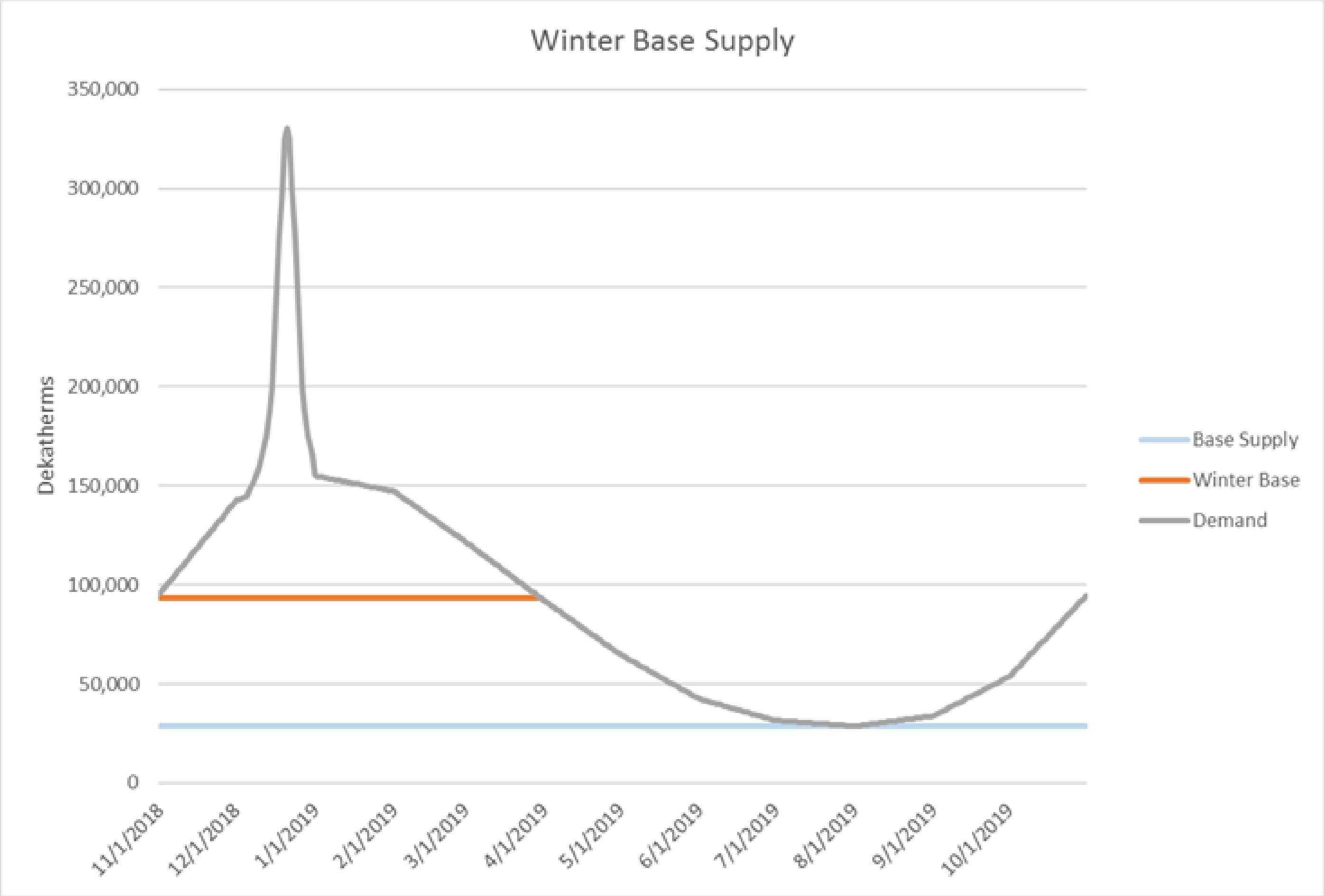
Base Supply (Cont'd)



Winter base Supply

- Winter base supply is contracted supply with a premium charge that is slightly higher than base gas.
- The Maximum Daily Quantity (MDQ) is optimally set by SENDOUT.
- Winter supply is renewed every November and completes at the end of March.
- Winter Supply is additional baseline supply on top of the base or fixed supplies for the winter months.
- There is a penalty associated to this contract to force SENDOUT to take the optimal amount of additional winter base gas.

Winter Base Supply (Cont'd)



Day Supply (Winter)

- Winter Day supply is gas that is R-mixed at the beginning of November each year.
- The R-mix function takes into account the fixed and variable costs of a resource to determine the proper amount to take in a given period.
- Winter day gas has an MDQ cap but is not a must take supply.
- If a winter day supply has an MDQ of 10,000 dth then it can take anywhere from 0 to 10,000 dth of gas on any given day in the winter.
- Winter day supply has a slightly higher premium than winter base supply and it can be contracted from November to April.

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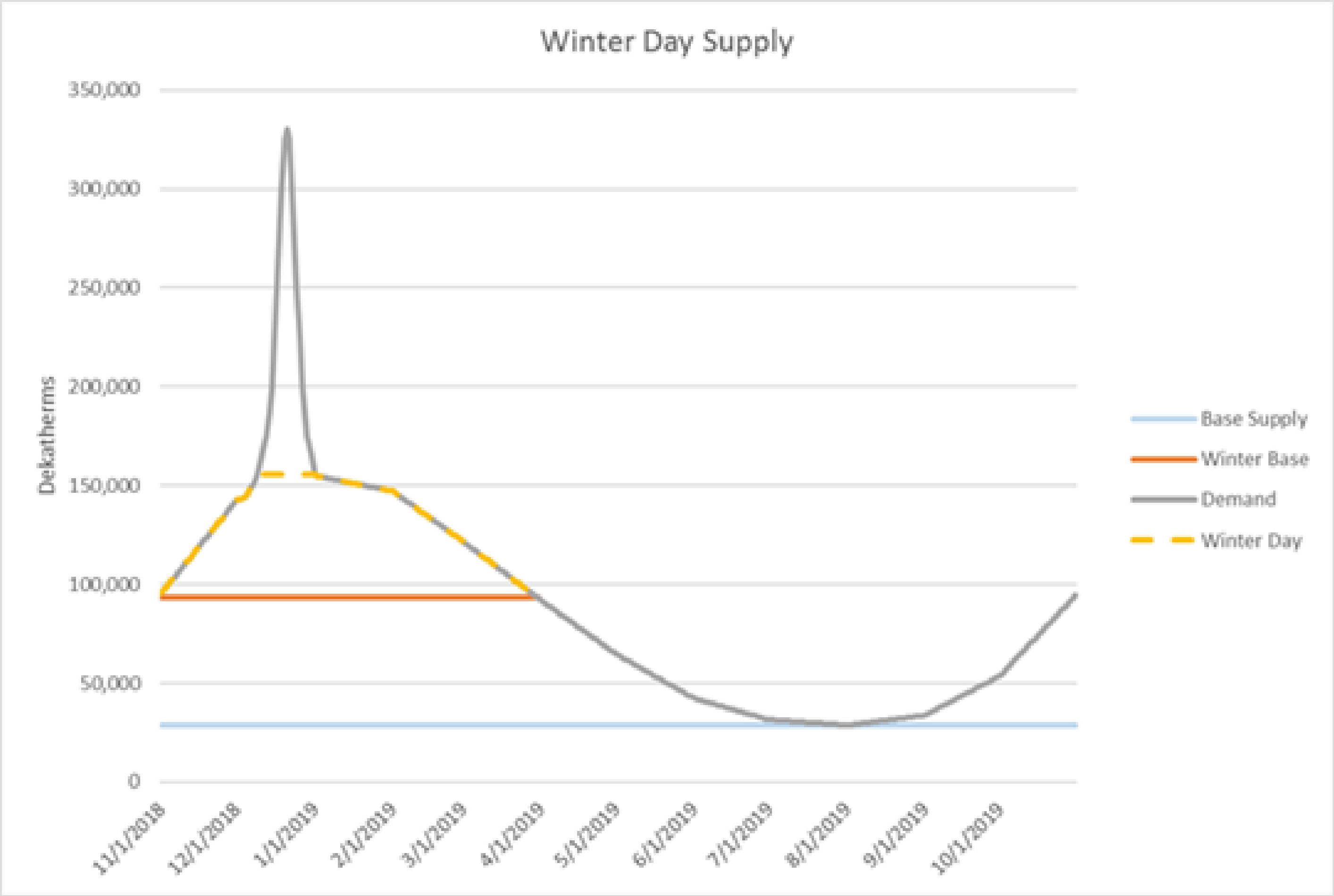
Winter Day Supply (Cont’d)



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Day Supply (Summer)

- Summer day supply is gas that is R-mixed at the beginning of April each year.
- Summer day gas has an MDQ cap but is not a must take supply.
- If a summer day supply has an MDQ of 10,000 dth then it can take anywhere from 0 to 10,000 dth of gas on any given day in the summer.
- Summer day supply has a slightly higher cost than base supply and it can be contracted from April to November.

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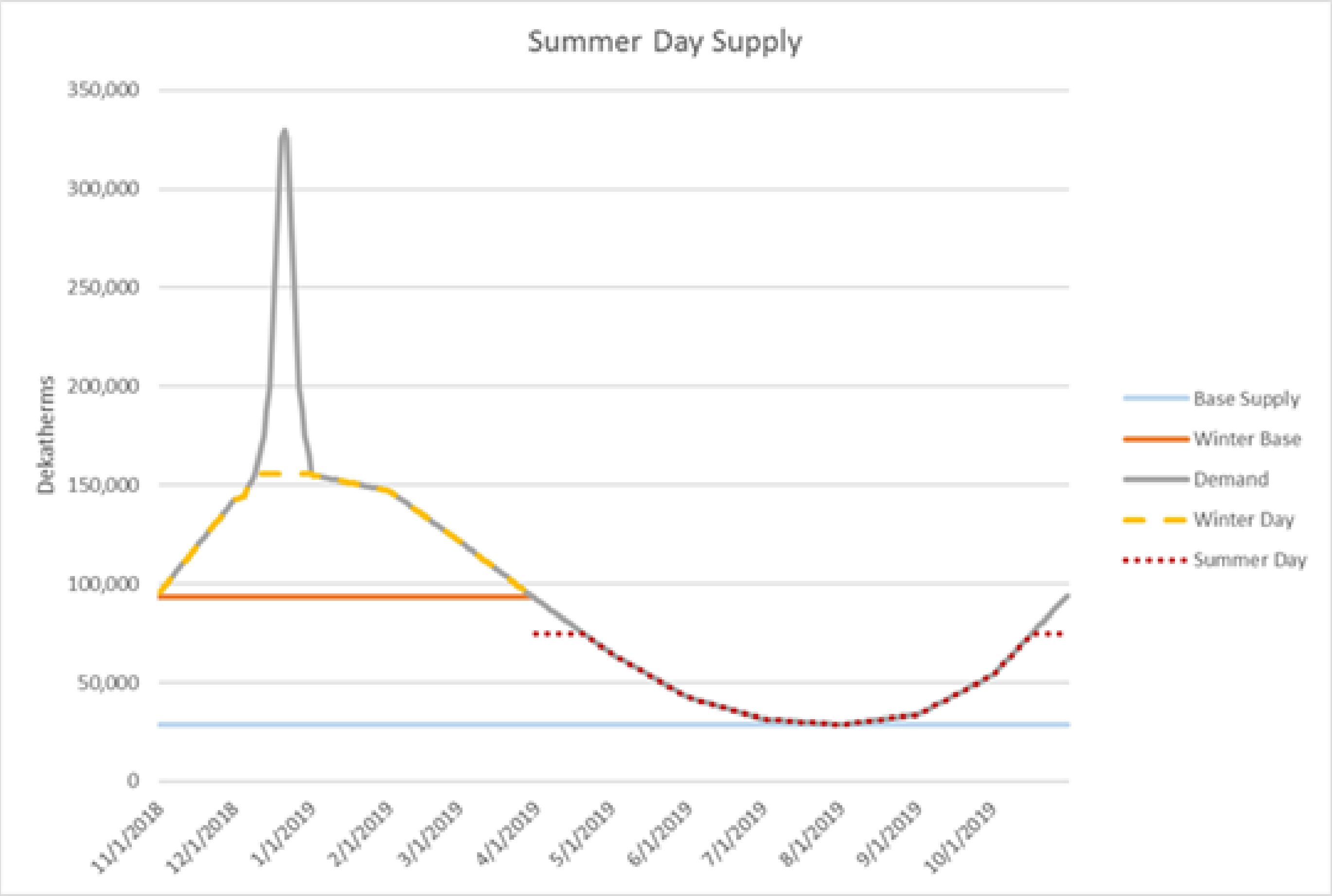
Day Supply (Summer)



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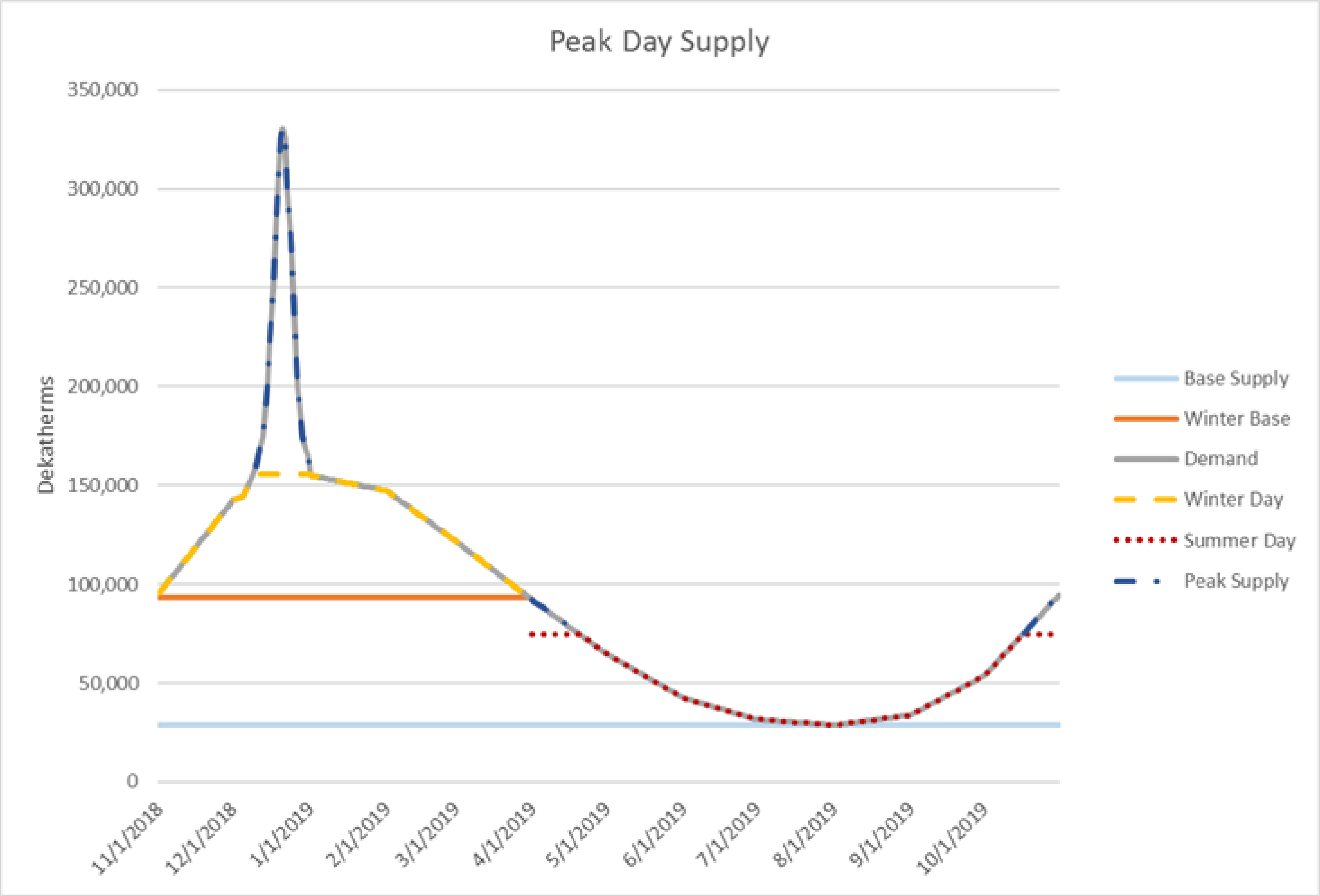
Peak Supply

- Peak supply is gas purchased on high demand days where base, index, winter base, or day supply cannot accommodate.
- Peak supply has a slightly higher premium to buy than day supply.
- As long as Cascade has the transport capacity or can utilize a third party's transport capacity, we can purchase as much peak supply as needed to meet peak demand.

Total Supply



Storage

- Cascade leases storage at 2 locations: Jackson Prairie (JP) and Plymouth (Ply).
- Cascade has 4 storage contracts with JP and 2 contracts with Plymouth.
- Storage injections targets are set at 35% by the end of June, 80% by the end of August, and 100% by the end of September.
- These targets are set by our Gas Supply Oversight Committee.
- Cascade can withdrawal approximately 56,000 dth per day from JP and 78,000 dth per day from Plymouth for a total of approximately 134,000 dth per day.

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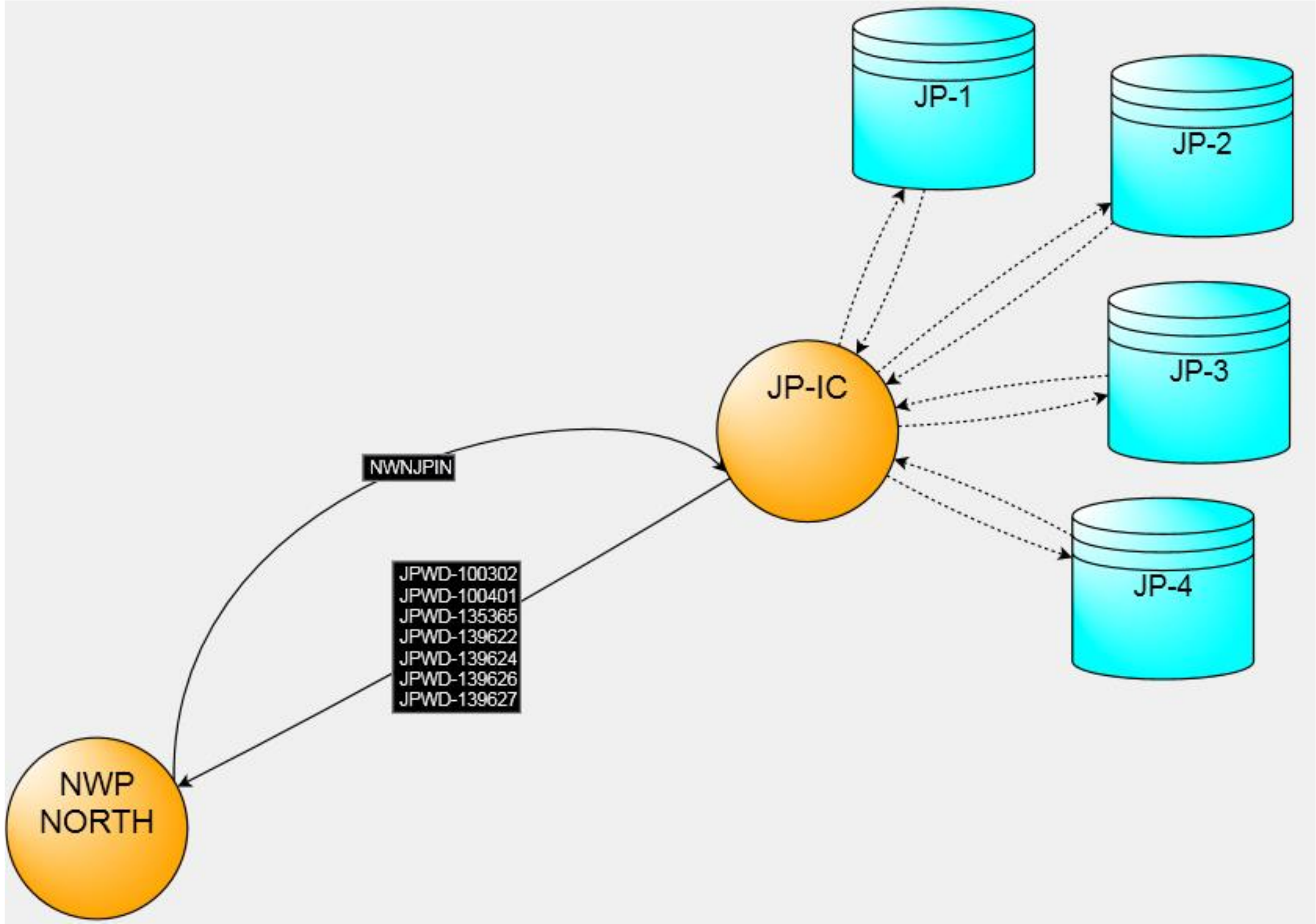
Storage Example



Storage Example 2

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier
Process Indicator										Same		
Inventory Maximum Physical Capacity	604351									Same		
Inventory Minimum Physical Percent										Same		
*Target Inv - End of Period Max Pct										Same		
*Target Inv - End of Period Min Pct						35		80	100	First Year		
*Inventory Adjustment - Value per Unit										Same		
*Inventory Adjustment - Volume										Same		
*Injection Daily MDQ				16789						First Year		
*Injection Daily Min Percent										Same		
*Withdrawal Daily MDQ				0						Last Year		
*Withdrawal Daily Min Percent										Same		
Fuel - Injection	0.15									Same		
Fuel - Withdrawal	0.15									Same		
Rate - Carry										Same		
Rate - Injection										Same		
Rate - Withdrawal										Same		
Rate - Other Injection										Same		
Rate - Other Withdrawal										Same		
Rate - Volume Charge										Same		
Rate - D1	.01558									Same		DaysInMonth
Rate - D2	.00057									Same		DaysInMonth
Volume - D1 Volume	16789									Same		
Volume - D2 Volume										Same		
Storage Ratchets Table	JP									Same		
Starting Inv Layer 1 Value per Unit	3									Same		
Starting Inv Layer 1 Volume	604351									Same		
Energy Conversion Factor										Same		
Injection Costing List - Transport										Same		
Injection Costing List - Source										Same		

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Transportation

- Transportation contracts are the means of how Cascade gets the gas from the supplier to the end user.
- Cascade has multiple types of transportation:
  - A single delivery point.
  - Multiple delivery points.
- The multiple delivery point contracts gives Cascade the flexibility to move the gas where it’s most needed.
- On NWP, transportation goes to the zonal level because MDDO’s can be reallocated within a zone to the citygate. Additionally, NWP typically issues constraint concerns at the zonal level.
- On GTN, transportation goes to the citygate level as MDDO’s cannot be reallocated within the GTN zone.

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Transportation (Cont’d)

- Transportation has an MDQ, a D1 rate, a transportation rate, and a fuel loss percentage.
- A maximum delivery quantity (MDQ) which is the maximum amount of gas Cascade can move on the pipeline on a single day.
- A D1 rate which is the reservation rate to have the ability to move the MDQ amount on the pipeline.
- A transportation rate which is the rate per dekatherm that is actually moved on the pipeline.
- The fuel loss percentage is the statutory percent of gas based on the tariff from the pipeline that is lost and unaccounted for from the point of where the gas was purchased to the citygate.

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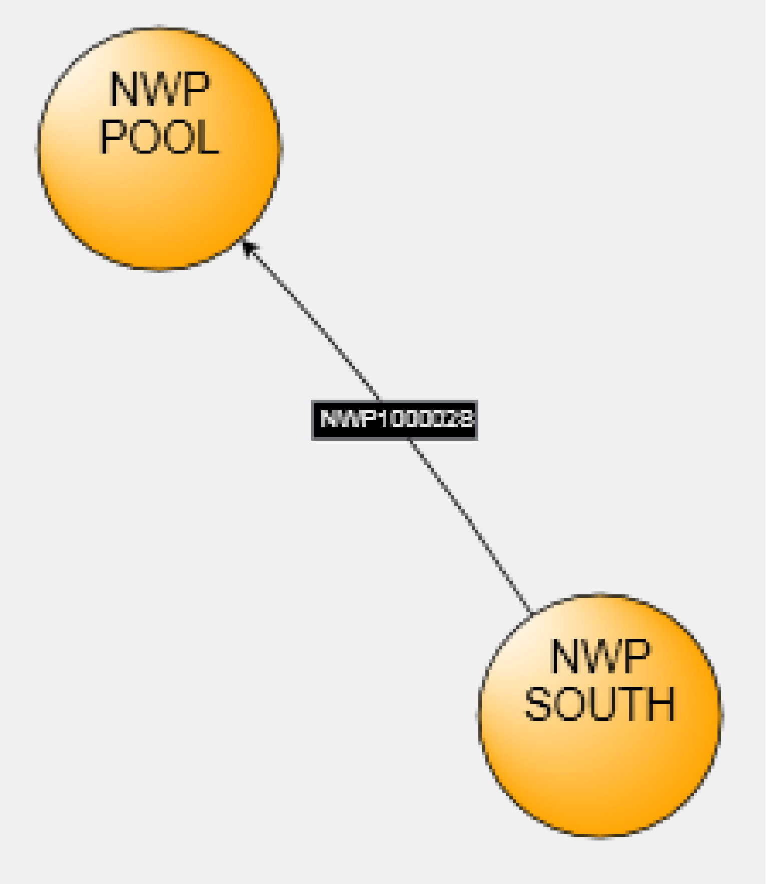
Transport Example



Transport Example

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier
*Daily MDQ	116866									Same		
*Daily Minimum Percent										Same		
Fuel	1.28									Same		
Rate - Transportation	0.03									Same		
Rate - Other Variable										Same		
Rate - D1 Rate	0.39249									Same		DaysInMonth

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Delivery Rights vs Receipt Rights

- Cascade has more Delivery Rights than Receipt Rights.
- Approximately 457,000 Dth of Delivery Rights.
- Approximately 360,000 Dth of Receipt Rights.
- The excess Delivery Rights allow Cascade to be flexible with the 360,000 Dth of Receipt Rights.

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Example of delivery right flexibility

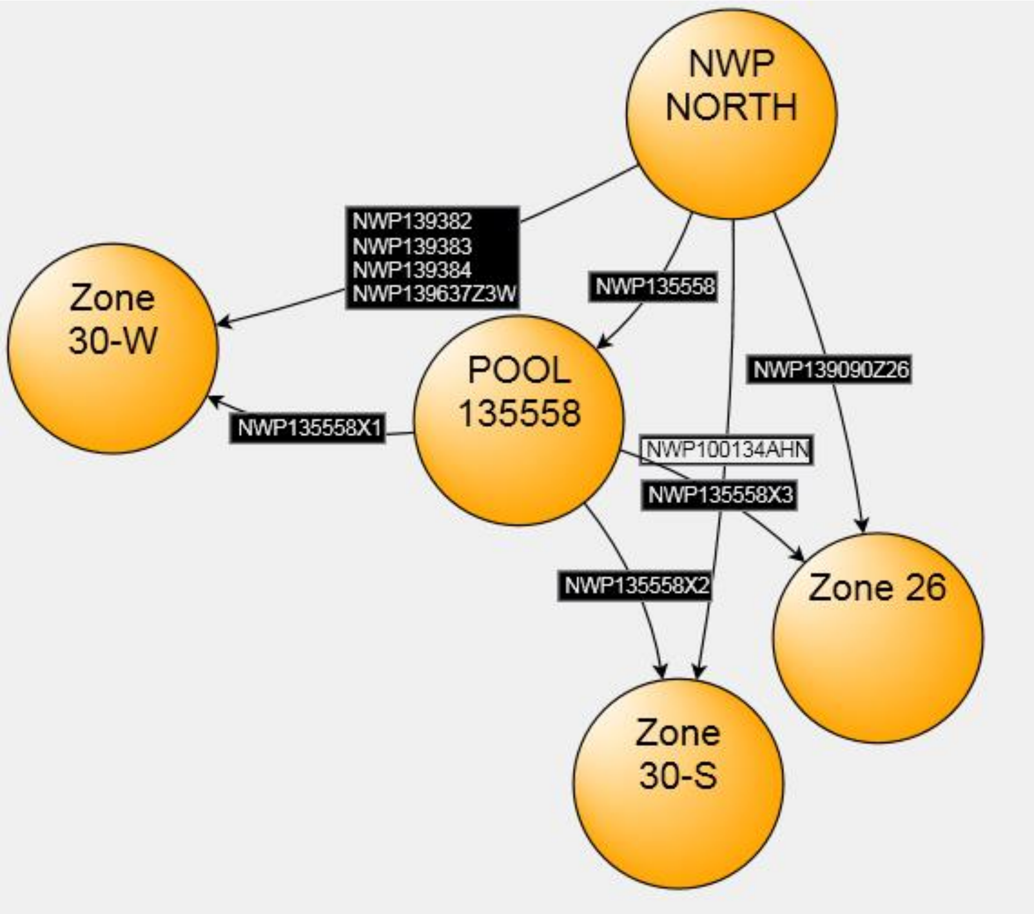
All of the following must be true

$X1 \leq 4\text{MDTs}$

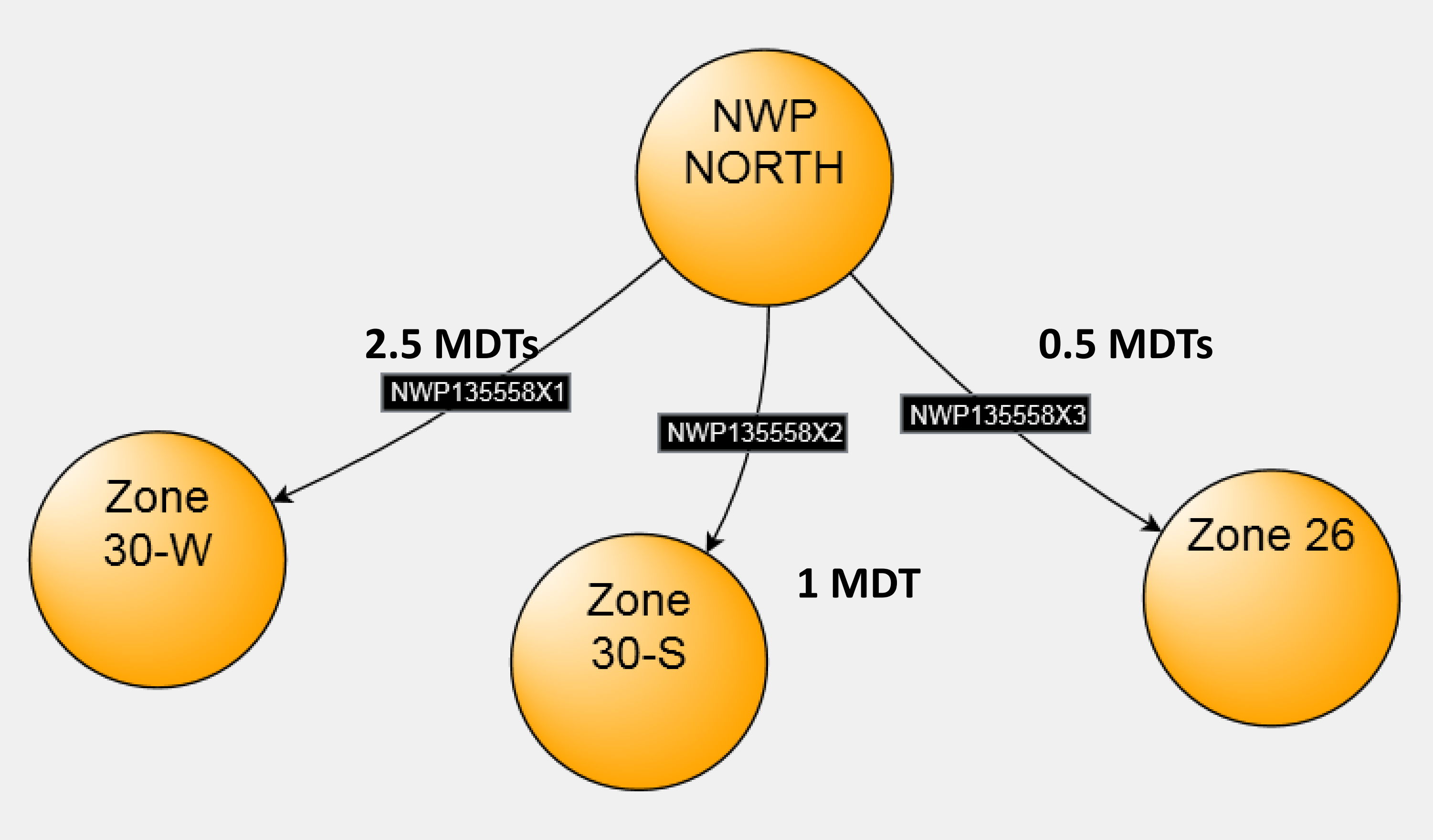
$X2 \leq 4\text{MDTs}$

$X3 \leq 4MDTs$

$X1 + X2 + X3 \leq 4MDTs$



Example of delivery right inflexibility



Transport Constraints

- To simplify modeling in SENDOUT®, the software allows the user to group multiple paths of one contract into a constraint group.
- This tells SENDOUT® to allow each path to take up to X Dekatherms, but not to exceed X Dekatherms for all paths of the contract.
- The analyst identifies which contracts should be in the group and assigns an MDQ for the constraint group.

Transport Constraints Example

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option
Annual Max										Same
Annual Min Percent										Same
Seasonal Max										Same
Seasonal Min Percent										Same
Monthly Max										Same
Monthly Min Percent										Same
*Daily Max	47603									Same
*Daily Min Percent										Same
Resource Mix Start\Stop Indicators										Same
RMIX MDQ Max										Same
RMIX MDQ Min										Same
Fixed Rate										Same
Demand Annual Max Percent										Same
Demand Annual Min Percent										Same
Demand Seasonal Max Percent										Same
Demand Seasonal Min Percent										Same
Demand Monthly Max Percent										Same
Demand Monthly Min Percent										Same
*Demand Daily Max Percent										Same
*Demand Daily Min Percent										Same

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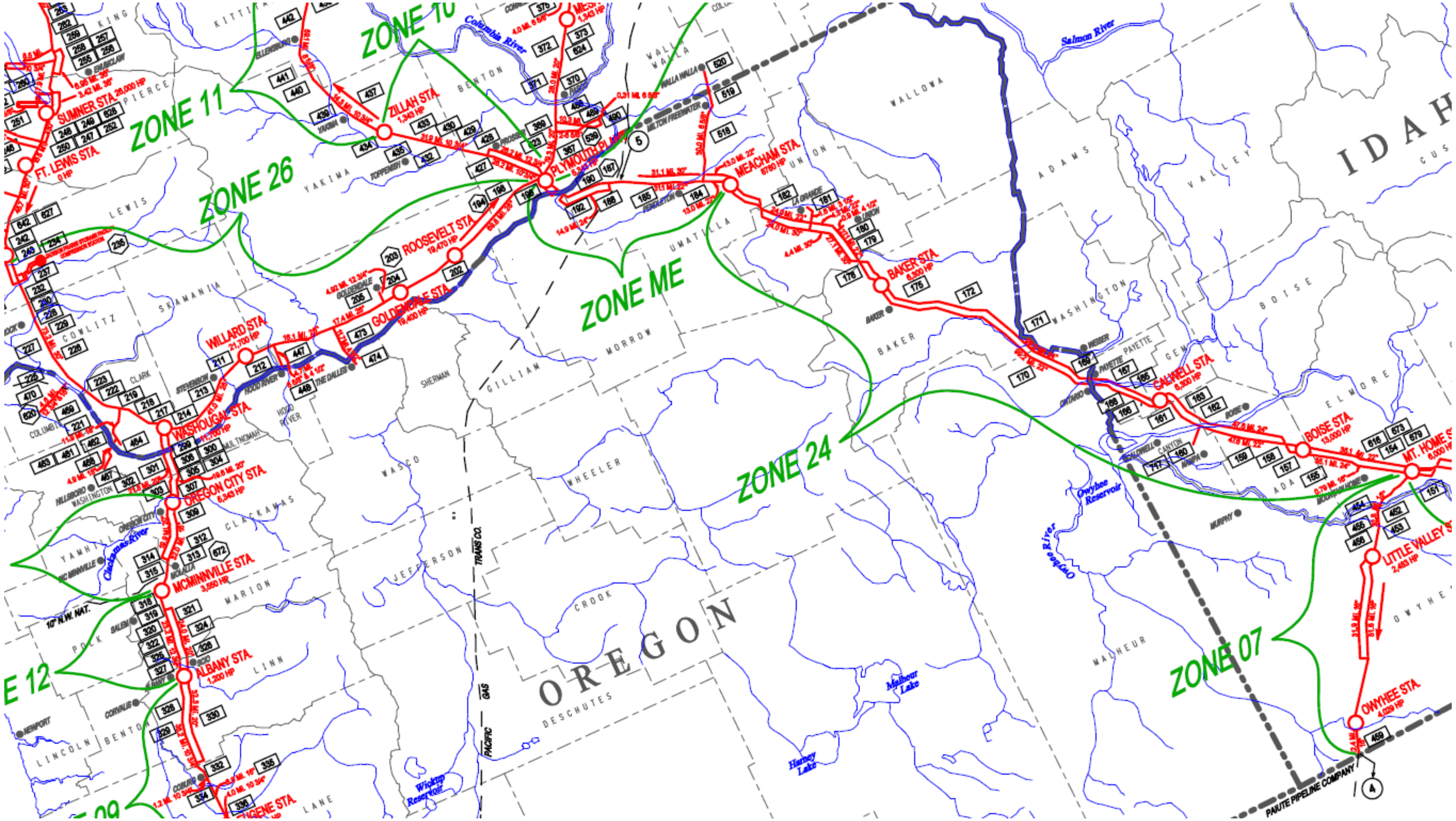
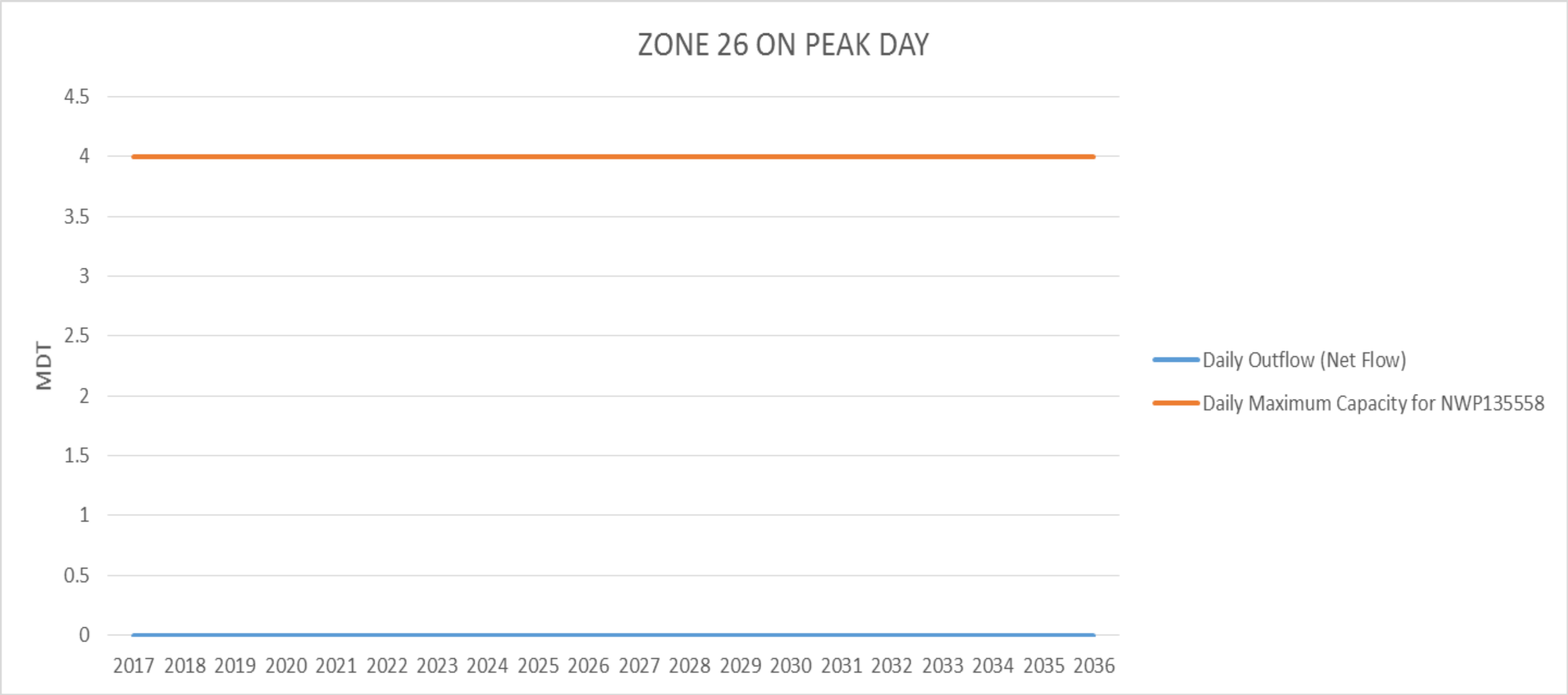
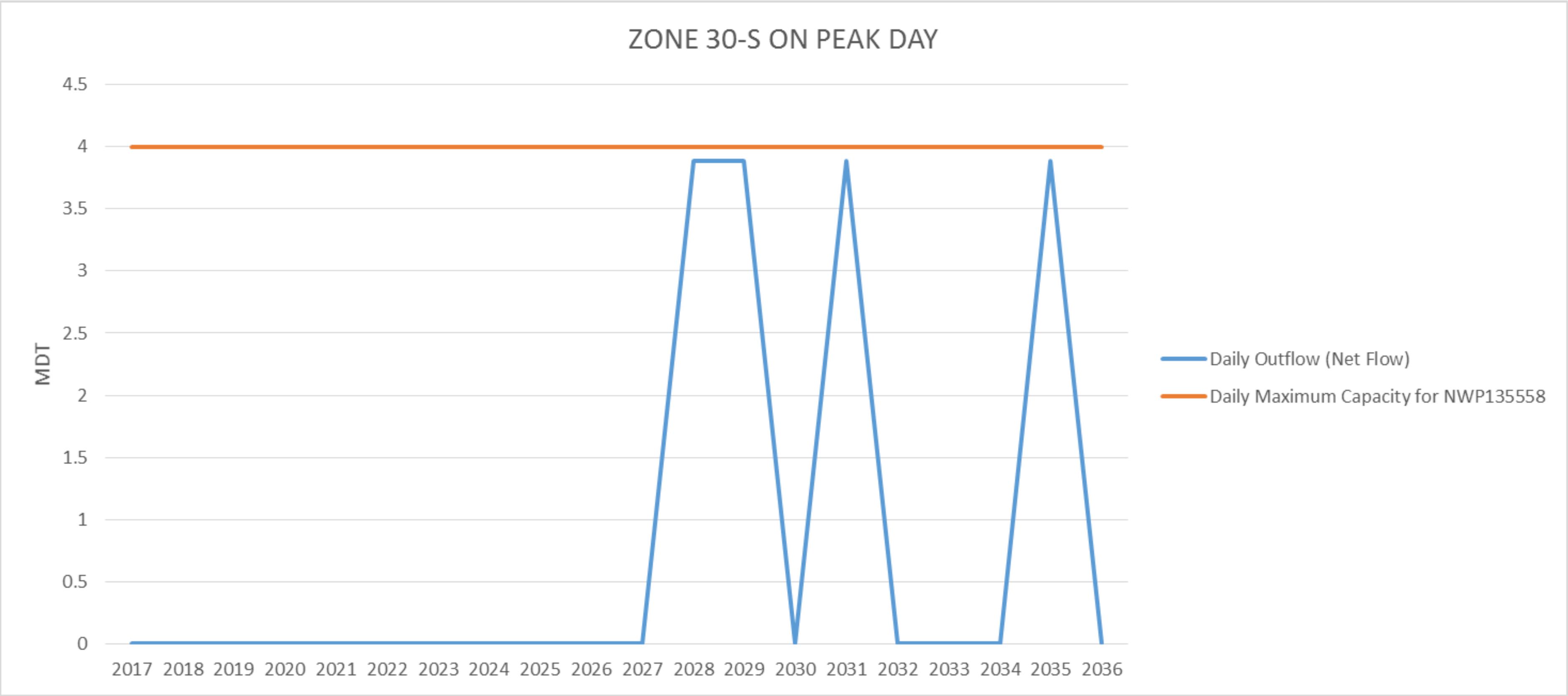
Location of Zones (Source: NWP)



Zone 26 on Peak Day for Transport 135558



Zone 30-S on Peak Day for Transport 135558



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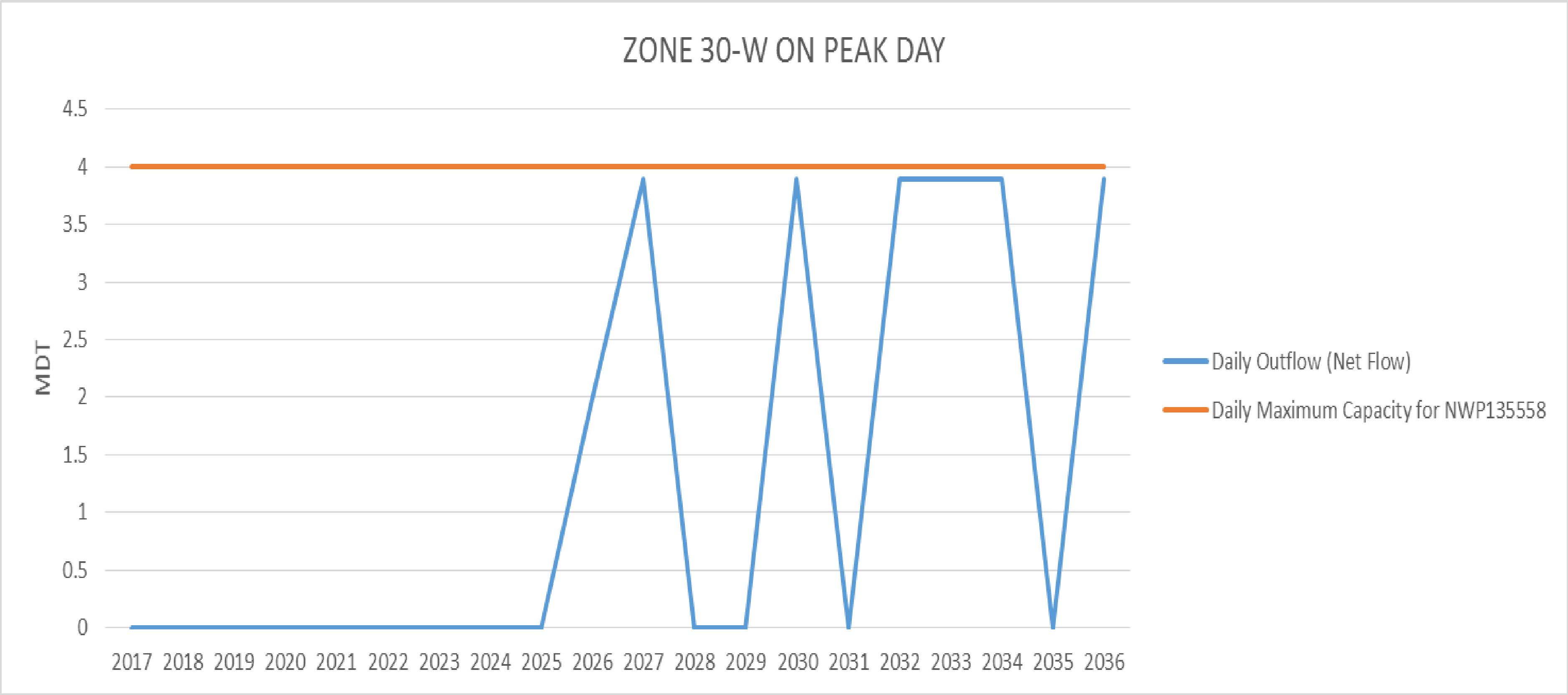
Zone 30-W on Peak Day for Transport 135558



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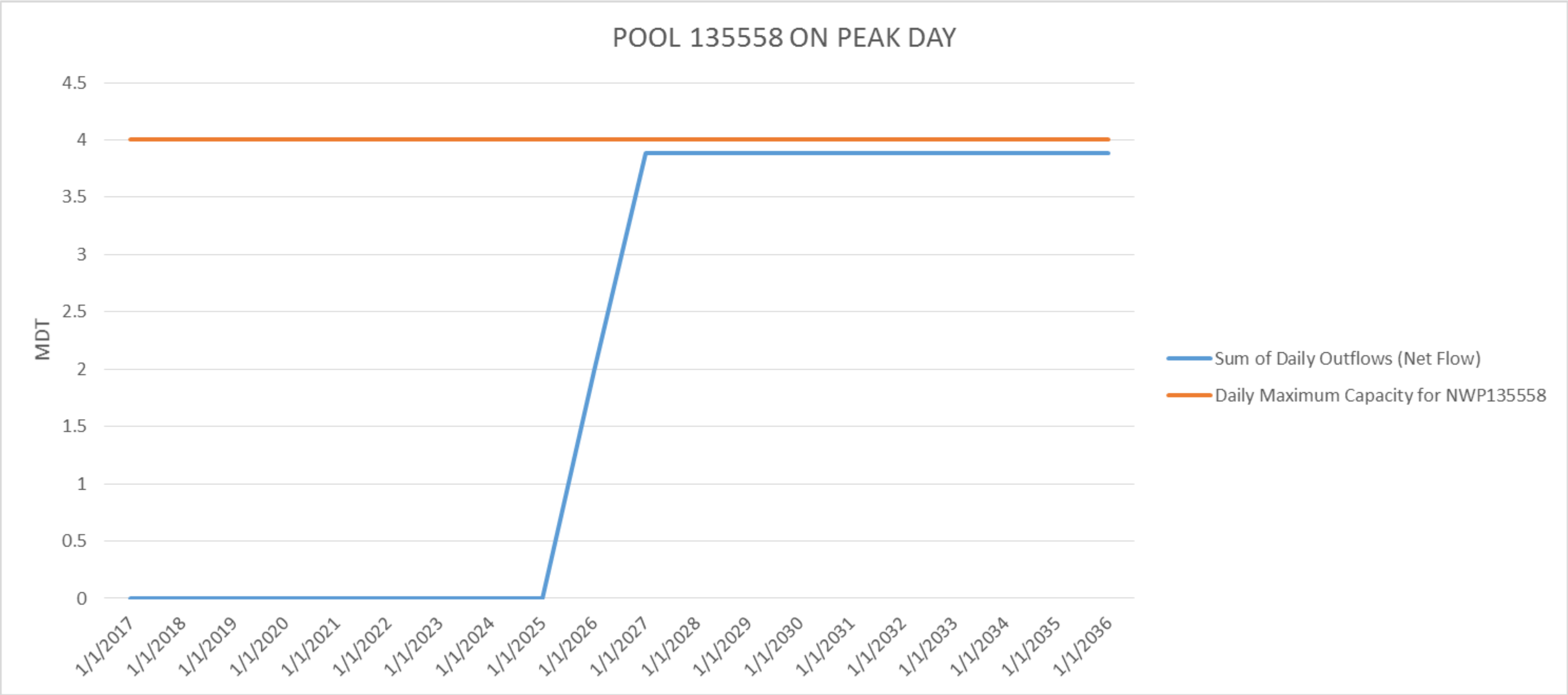
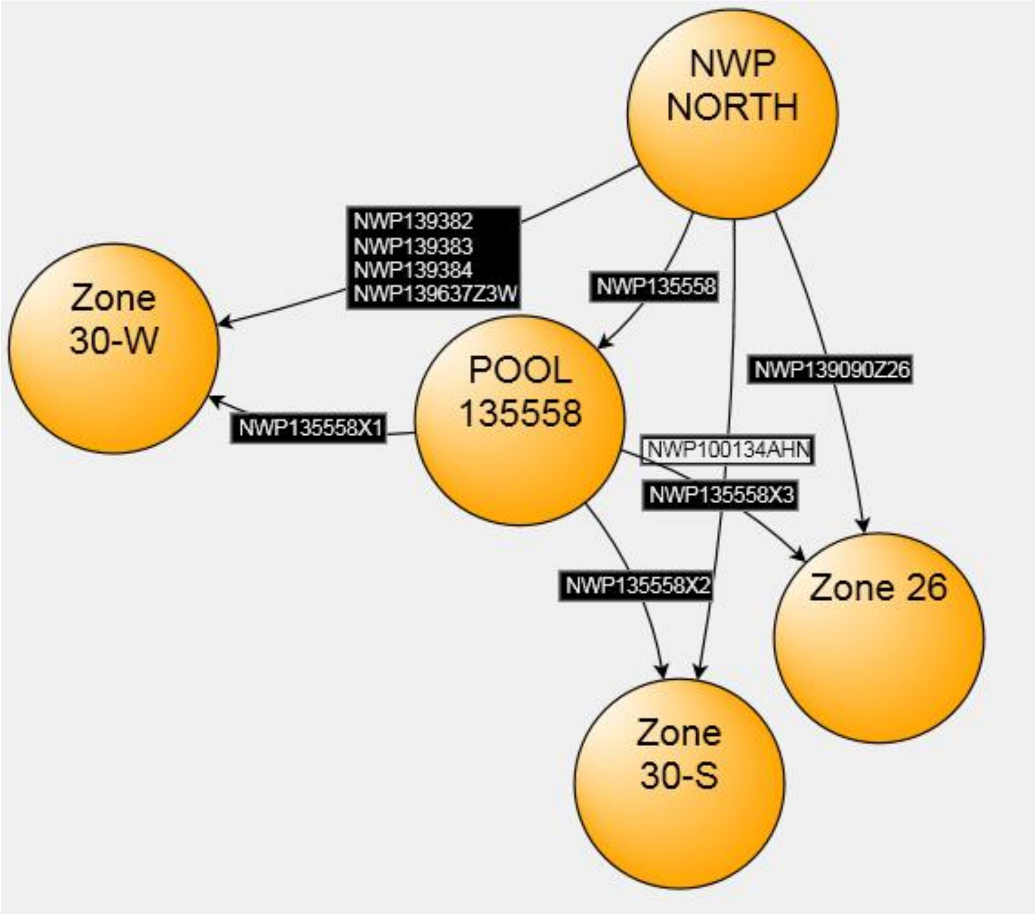
Transport Contract 135558 on Peak Day



Example of delivery right flexibility



Demand Behind the Gate

- Cascade has strived over the last several years to enhance the IRP forecast and resource analysis to get to as granular a level as possible using the available data.
- Attempts to forecast demand behind the gate using existing forecasting methodology has been challenging.
- Customer billing data does not have daily meter reads for core customers making regression analysis on use per HDD per customer difficult.
- Given Cascade is not a contiguous system, DSM by citygate is currently is an ongoing complication:
  - This year we have added the Climate Zone.
  - Future IRPs will address the citygate level.
- Some towns can be served by multiple pipelines and the mix can change over time.

Demand

- Demand is forecasted at the citygate level by rate schedule.
- For NWP, each citygate's demand is associated with the zone.
- For GTN, each citygate's demand is associated with it's respective citygate interconnect.
- Demand Inputs
  - Forecast type (Monthly amount or Regressions).
  - Monthly projected customers for 20 years.
  - Regression coefficients if using the Regression forecast type.
  - If using a monthly number, it is the 2016 demand for that month with a growth factor.

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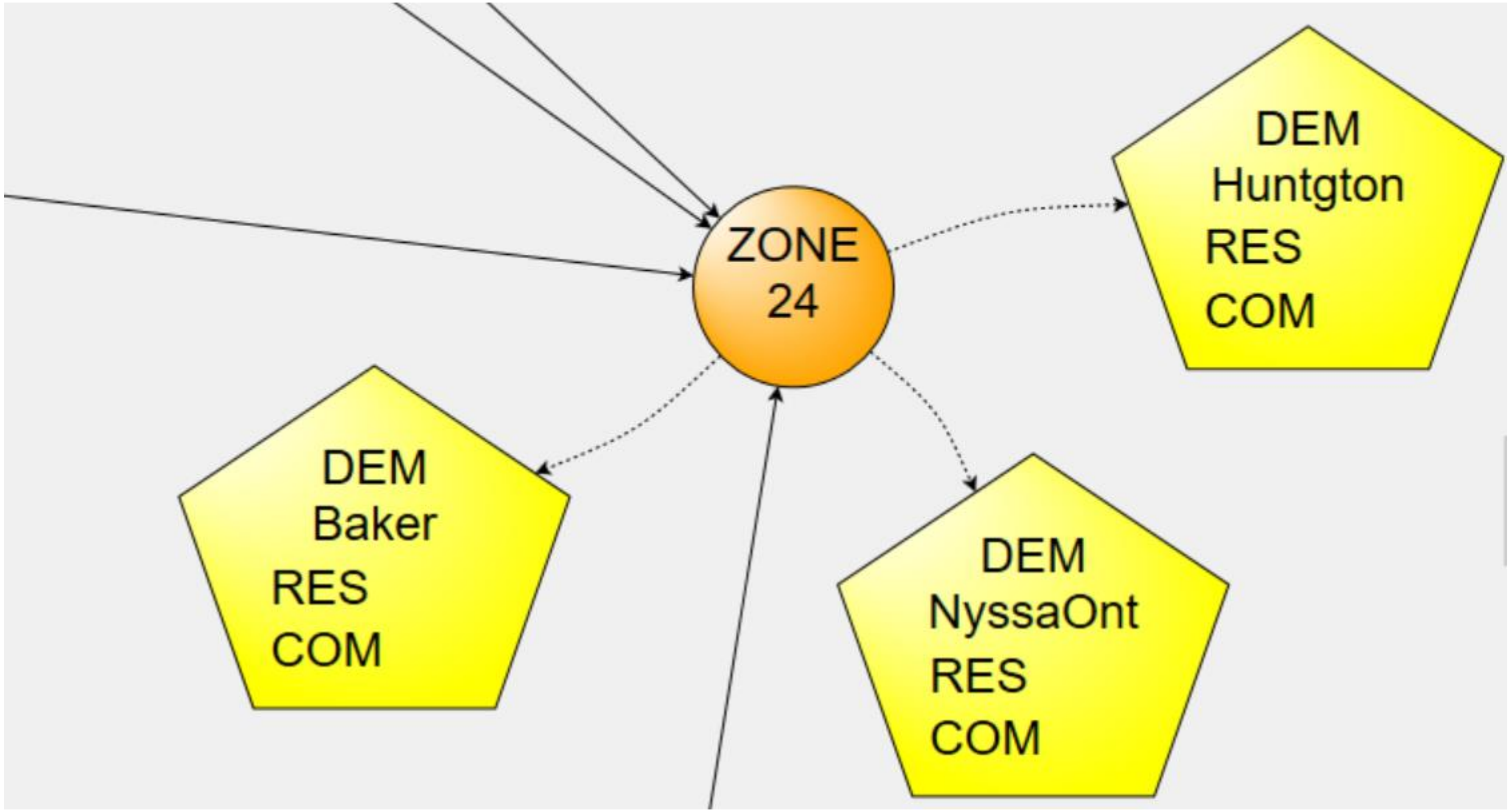
Demand Example



Demand Example 2

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier	Index	Adder	Multiplier
Forecast Method	Usage Fac									Same					
Customers	28347	28386	28429	28435	28456	28442	28450	28469	28489	Same					
*Demand - Daily										Same					
Demand - Monthly Base										Same					
Demand - Monthly Heat										Same					
Demand - Monthly Total										Same					
Demand - Percent Factor - non P non Q										Same					
Demand - Percent Factor - non Q										Same					
Usage Factors - Weekday Base	0.1919	0.1659	0.1396	0.0979	0.0741	0.0625	0.0589	0.0581	0.06	First Year					
Usage Factors - Weekday Heat	0.007448									Same					
Usage Factors - Weekend Base	0.186298	0.160298	0.133998	0.092298	0.068498	0.056898	0.053298	0.052498	0.054398	First Year					
Usage Factors - Weekend Heat	0.007448									Same					
*Rate - Unserved Dispatch (Pri 1)										Same					
*Rate - Unserved (Pri 2)	960									Same					

Weather

- Weather inputs for SENDOUT include:
  - Monte Carlo
  - Historical
  - Normal
- Monte Carlo inputs include mean, standard deviation, max, minimum, and distribution.
- Historical data is used to build weather profiles for Monte Carlo.
- Normal weather is the daily average of the 30-year most recent history (1987-2016).

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Weather Example – Monte Carlo

	JAN 2014	FEB 2014	MAR 2014	APR 2014	MAY 2014	JUN 2014	JUL 2014
HDD Mean	1031.8	804.1	639.6	453.9	254.2	92.6	10.3
HDD Std Dev	145.4	133.1	84.4	93.0	72.2	40.4	15.2
HDD Distribution	Normal						
HDD Max	1291	1242	841	641	426	170	75
HDD Min	772	568	448	254	92	19	0
CDD Mean							
CDD Std Dev							
CDD Distribution							
CDD Max							
CDD Min							
Scaling Year	Best Match						

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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 Wood Mackenzie, EIA, the Northwest Power Planning Council (NPPC), 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.
- 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.

Long Range Price Forecast (Cont’d)

- 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.

Price Forecast Weights

- Considerations in weight assignments
  - Cascade has modified its weighting system based on a backcast 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)
    - NPPC (regional perspective, but recognize it is also a blend)
    - NYMEX Henry Hub
  - EIA is the only source who produces a forecast after 2036
    - EIA typically forecasts higher than most other sources, so their forecast needs to be normalized based on their average error

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Example of SMAPE Calculations by Source

	Source 1	Source 2	Source 3	Source 4
T+1	0.126033375	0.217301	0.1446299	0.152795
T+2	0.167033935	0.208055	0.1973402	0.193328
T+3	0.201221558	0.159752	0.1774237	0.180943
T+4	0.207867469	0.216499	0.0567454	0.206089
T+5	0.240209263	0.170581	0.0149917	0.203743
T+6	0.223763051	0.15863	0.0308552	0.178014
T+7	0.224086048	0.017803	0.160998	0.126166
T+8	0.173107419	0.108208	0.1654999	0.101882
T+9	0.22366183	0.182278	0.1409933	0.190653
T+10	0.197011026	0.171414	0.1373605	0.182815
T+11	0.232436816	0.198159	0.0881173	0.177821
T+12	0.235293955	0.064647	0.046813	0.169711

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Example Weights Price Forecast For 2018

Date	Source 1	Source 2	Source 3	Source 4
18-Jan	7.443%	27.601%	51.155%	13.802%
18-Feb	4.103%	40.758%	43.028%	12.111%
18-Mar	4.142%	42.124%	38.518%	15.216%
18-Apr	4.619%	41.958%	37.283%	16.140%
18-May	5.469%	41.641%	36.015%	16.876%
18-Jun	5.248%	40.041%	37.548%	17.163%
18-Jul	3.654%	41.433%	39.335%	15.578%
18-Aug	3.970%	41.695%	38.973%	15.362%
18-Sep	3.324%	48.277%	34.266%	14.132%
18-Oct	4.354%	49.429%	31.572%	14.646%
18-Nov	4.459%	51.308%	29.570%	14.663%
18-Dec	5.599%	49.377%	29.287%	15.737%

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65

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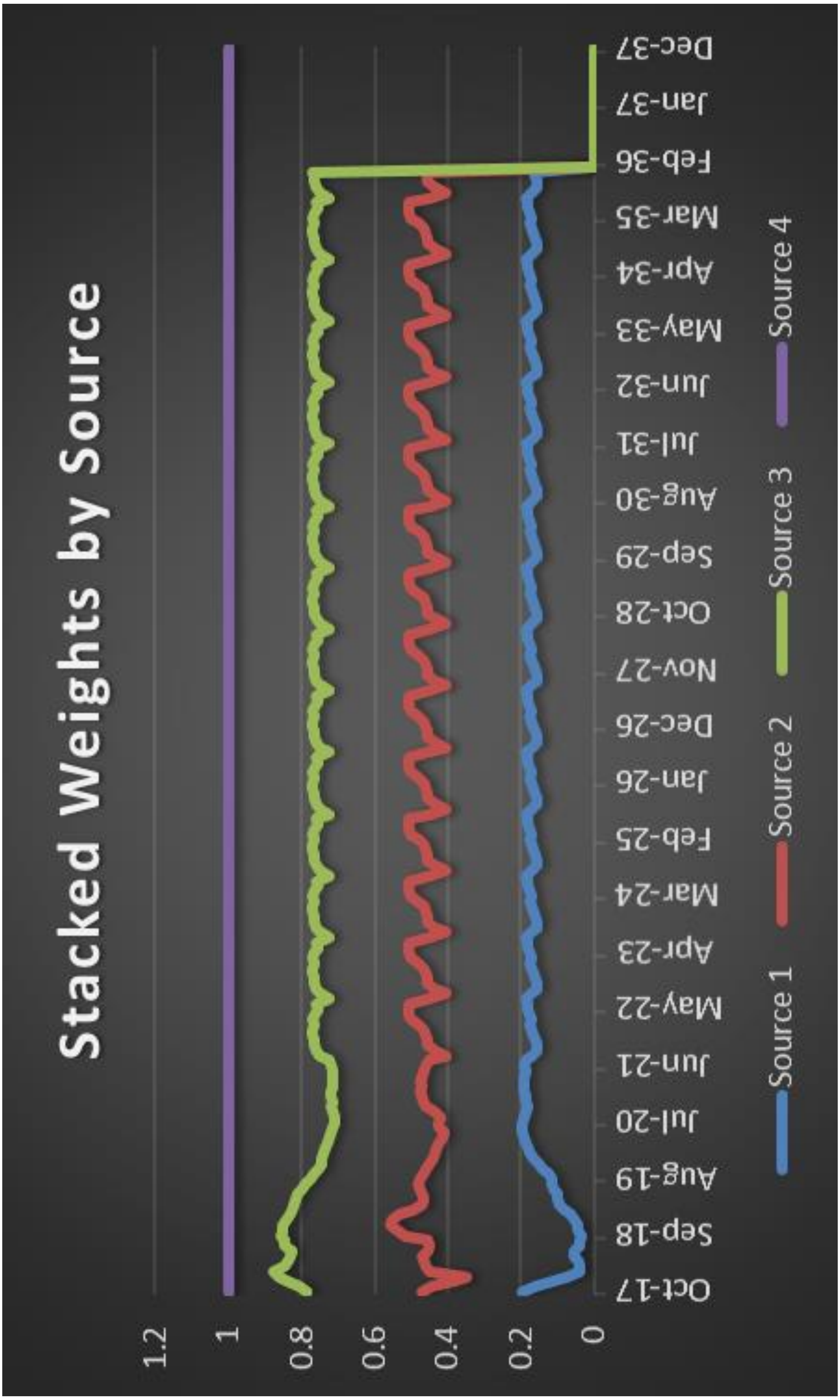

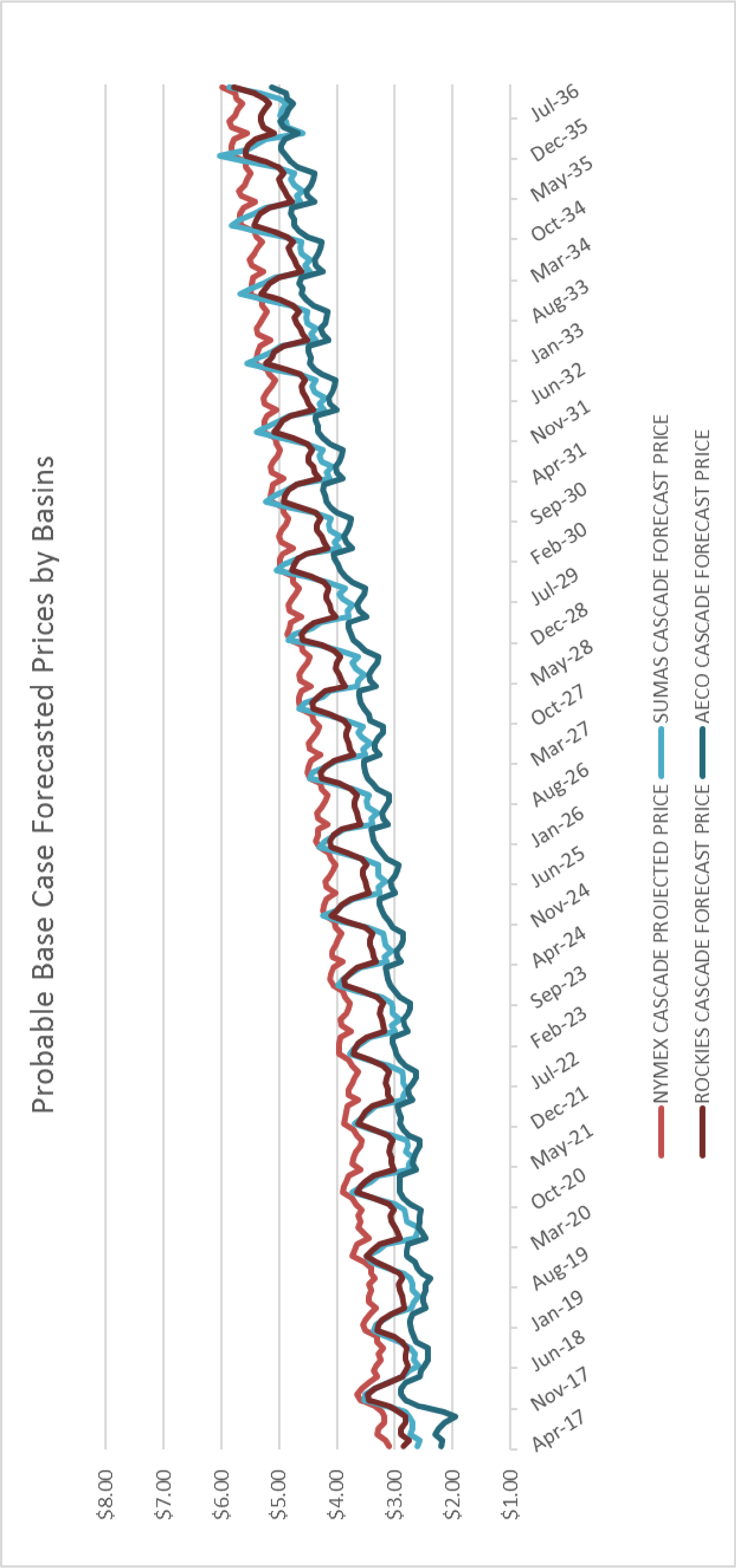

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66

Alternative Resources

Major Resource Issues on the Horizon

- Once a deficiency is identified, Cascade must analyze potential solutions to ensure service over the planning horizon.

- Conversations with partners at various pipelines, storage facilities, new supply sources.

- SENDOUT® is used to ultimately derive the optimal mix of resources, referred to as the “preferred portfolio”.

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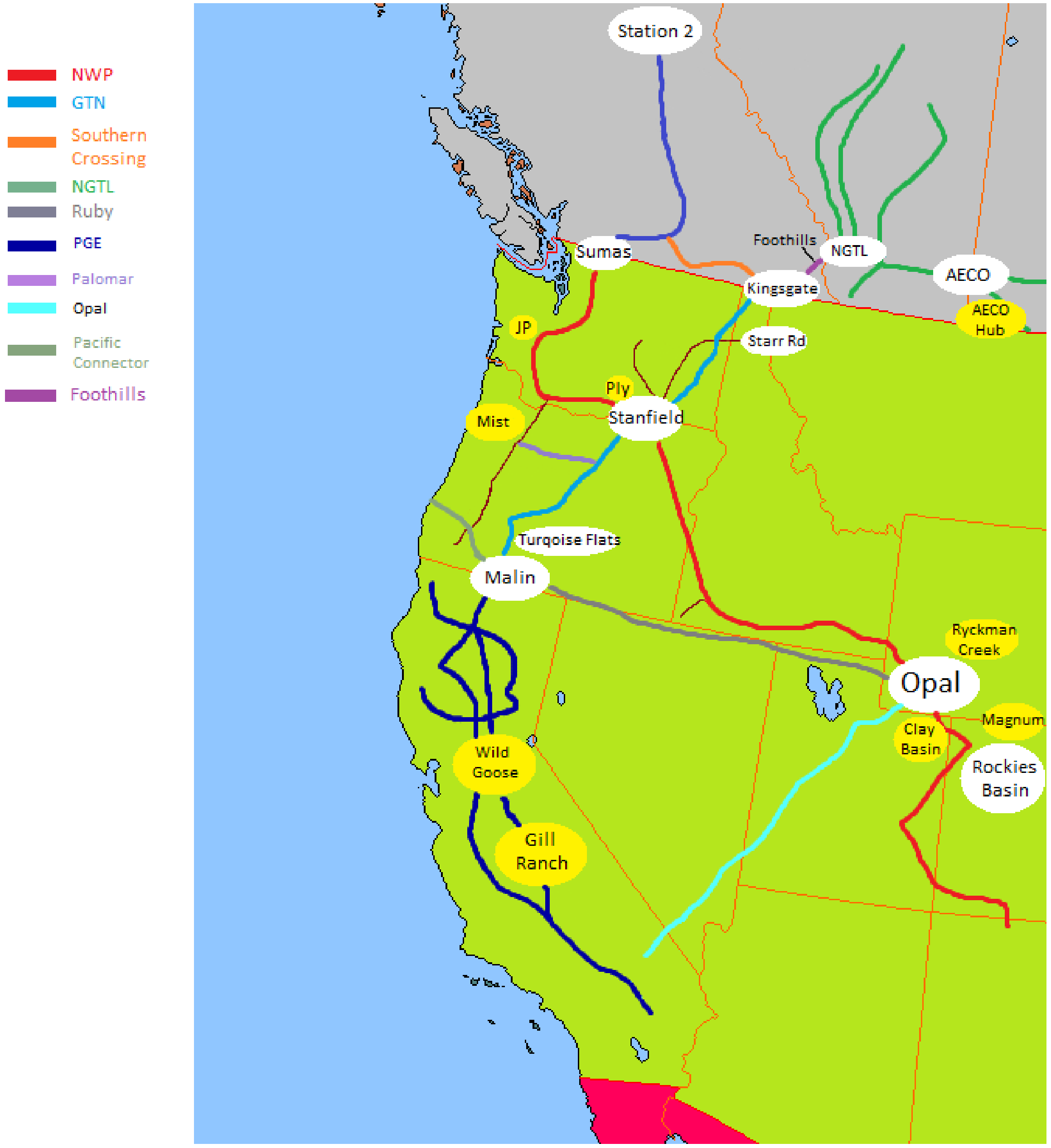
Location of Current & Alternative Resources



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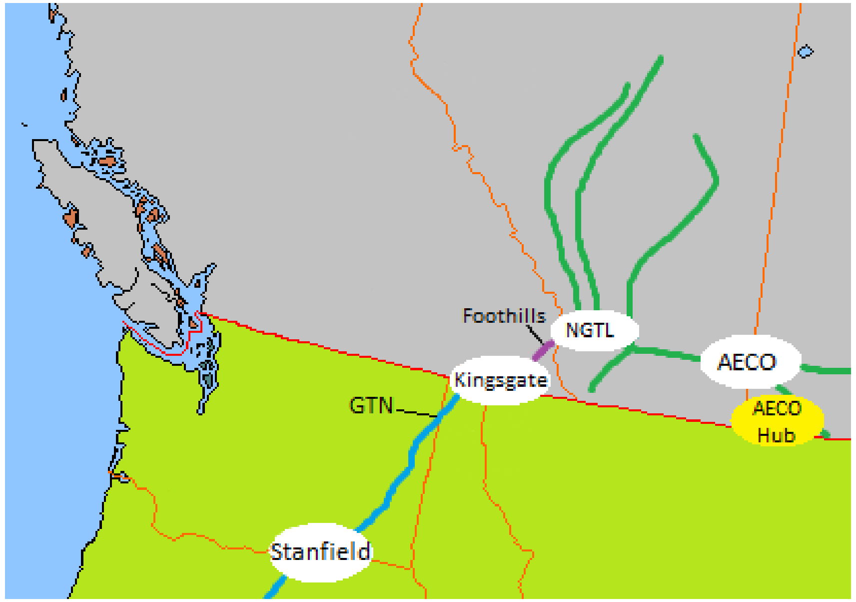
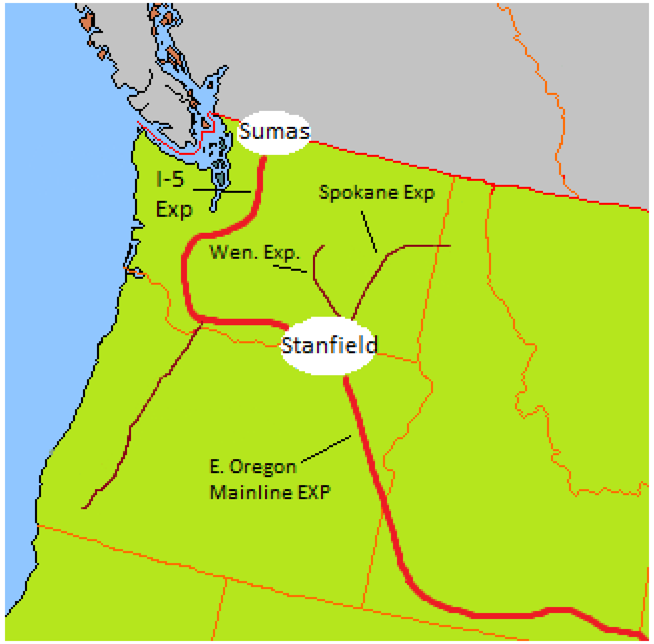
Incremental Transport – North to South

- Incremental NGTL – Additional capacity to move gas from AECO basin to Alberta/BC border
- Incremental Foothills – Additional capacity to move gas from Alberta/BC border to Kingsgate
- Incremental GTN N/S – Additional capacity to move gas from Kingsgate to various citygates along GTN



Incremental Transport – Northwest Pipeline

- I-5 Mainline Expansion – Additional capacity to move gas along I-5 corridor in western Washington
- Wenatchee Lateral Expansion – Additional capacity to move gas along Wenatchee Lateral to central Washington
- Spokane Lateral Expansion – Additional capacity to move gas along Spokane Lateral to eastern Washington
- Eastern Oregon Mainline Expansion – Additional capacity to move gas along Eastern Oregon Lateral to Oregon citygates



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Incremental Transport – South to North

Incremental Opal– Additional capacity to move gas from Utah to Opal
Incremental Ruby – Additional capacity to move gas from Rockies Basin to Turquoise Flats
Incremental GTN S/N – Additional capacity to move gas from Turquois Flats to various citygates along GTN

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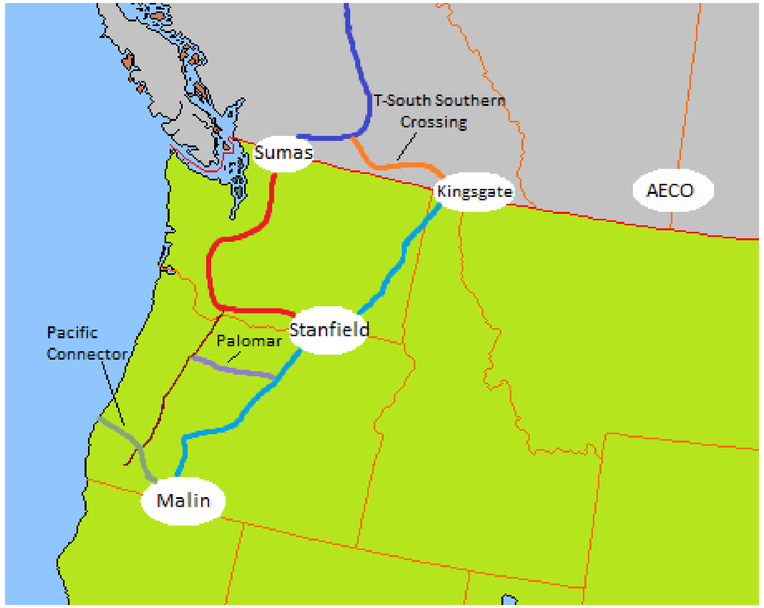
Incremental Transport – Bilateral

- T-South Southern Crossing – Price arbitrage opportunity to move gas between Sumas and AECO basins bilaterally
- Trails West (Palomar) – Additional capacity to move Rockies gas to the I-5 corridor
- Pacific Connector – Pipeline that will feed LNG facility on Oregon coast, increasing liquidity at Malin



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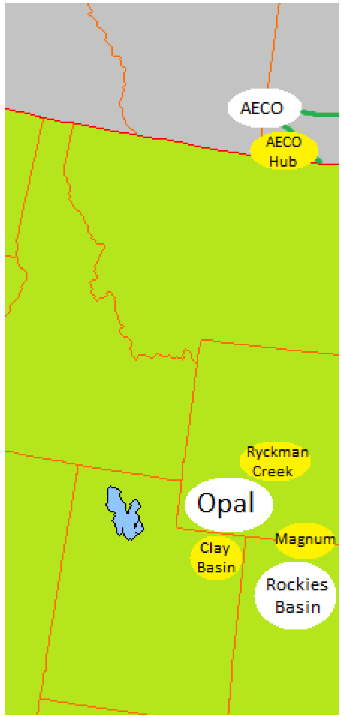
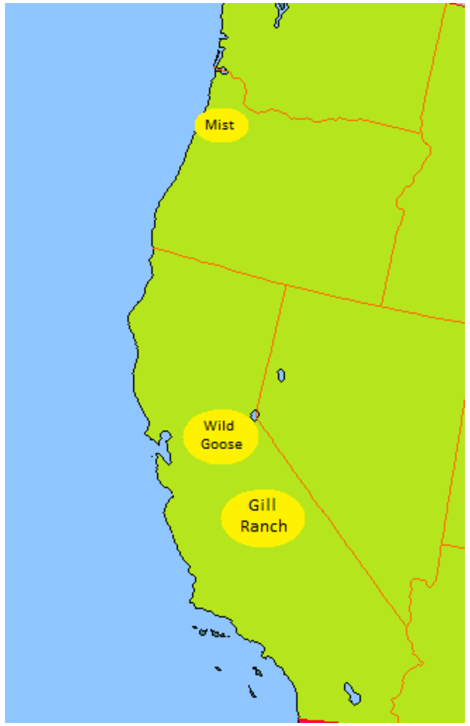
Incremental Storage - North and East

- Ryckman Creek Storage – Additional storage in southwest Wyoming serving the system, primarily Oregon
- Magnum Storage – Additional storage near Rocky Mountains, serving the system, primarily Oregon
- AECO Hub Storage – Additional storage near AECO Hub, serving the system
- Clay Basin Storage – Additional storage near Opal, serving the system



Incremental Storage - South and West

- Gill Ranch Storage – Additional storage in central California, serving the system, primarily Oregon
- Mist Storage – Additional storage in northern Oregon, serving the system, primarily Washington
- Wild Goose Storage – Additional storage in northern California, serving the system, primarily Oregon



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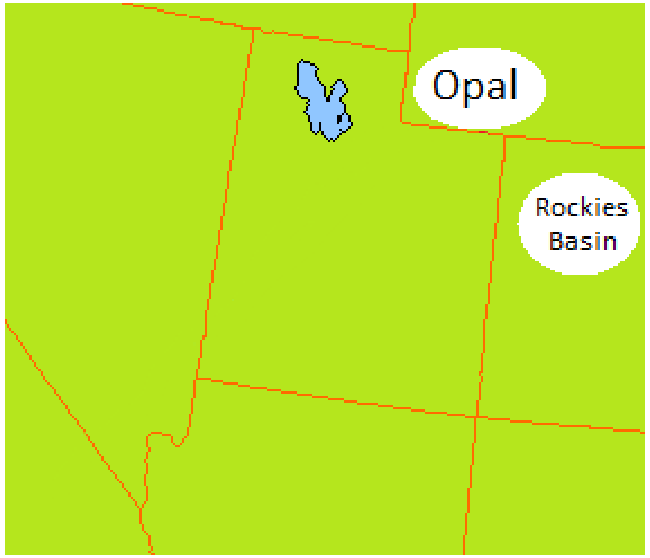
Incremental Supplies

- Incremental Opal Supply – Additional supply around the Rockies Basin
- Renewable Natural Gas – Incremental biogas supply directly to distribution system



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Candidate Portfolios

Portfolio Summary

	GTN	No GTN
NWP	• ALL-IN	• NWP Only • NWP Only w/ Storage
No NWP	• GTN Only • GTN Only w/ Storage	• Only Storage

Portfolio Components

	All In	Incremental GTN	Incremental GTN & Storage	Incremental NWP	Incremental NWP & Storage	Storage Only
Incremental NGTL	X	X	X			
Incremental Foothills	X	X	X			
Incremental GTN N/S	X	X	X			
I-5 Expansion	X			X	X	
Wenatchee Lateral						
Spokane Expansion				X	X	
Eastern OR Expansion						
Incremental Opal						
Incremental Ruby						
Incremental GTN S/N						
T-South Southern Crossing						
Trails West (Palomar)						
Pacific Connector						
Ryckman Creek Storage			X		X	X
Magnum Storage						
AECO Hub Storage						
Clay Basin Storage						
Gill Ranch Storage						
Mist Storage						
Wild Goose Storage						
Incremental Opal Supply						
Renewable Natural Gas						

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All In Portfolio

- Deterministic optimum mix of all evaluated resources, including incremental transportation on NWP & GTN, and all regional storage facilities.
- Components:
  - Incrm GTN: 10,200 Dths by Nov. 2027, escalating to 25,021 Dths by Nov. 2037
  - Incrm Fthls: 25,908 Dths by Nov. 2037
  - Incrm I-5 Exp: 17,469 Dths by Nov. 2027, escalating to 41,035 Dths by Nov. 2037
  - Incrm Nova: 36,246 Dths by Nov. 2037

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Incremental GTN & Storage Portfolio

- Deterministic optimum mix of incremental transportation on GTN and all regional storage facilities.
- Components:
  - – Incrm GTN: 21,218 Dths by Nov. 2027, escalating to 43,490 Dths by Nov. 2037
  - – Incrm Fthls: 48,783 Dths by Nov. 2027
  - – Incrm Nova: 6,364 Dths by Nov. 2027, escalating to 59,121 Dths by Nov. 2037
  - – Incrm Ryckman Creek: 1,000 Dths by Nov. 2027

Incremental GTN Only

- Deterministic optimum mix of incremental transportation on GTN .
- Components:
  - Incrm GTN: 21,218 Dths by Nov. 2027, escalating to 43,490 Dths by Nov. 2037
  - Incrm Fthls: 48,783 Dths by Nov. 2027
  - Incrm Nova: 6,364 Dths by Nov. 2027, escalating to 59,121 Dths by Nov. 2037

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Incremental NWP & Storage Portfolio

- Deterministic optimum mix of incremental transportation on NWP and all regional storage facilities.
- Components:
  - – Incrm I-5 Exp: 7,531 Dths by Nov. 2027, escalating to 37,321 Dths by Nov. 2037
  - – Incrm Spokane Exp: 14,794 Dths by Nov. 2037
  - – Incrm Ryckman Creek: 1,000 Dths by Nov. 2027

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Incremental NWP Only

- Deterministic optimum mix of incremental transportation on NWP.
- Components:
  - – Incrm I-5 Exp: 7,531 Dths by Nov. 2027, escalating to 37,321 Dths by Nov. 2037
  - – Incrm Spokane Exp: 14,794 Dths by Nov. 2037

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Incremental Storage Only

- Deterministic optimum mix of incremental regional storage facilities.
- Components:
  - Incrm Ryckman Creek: 1,000 Dths by Nov. 2027

Final Ranking – Mean and VaR

	Total System Cost		Unserved Demand	
Portfolios	**Mean ($000)**	**VaR ($000)**	**Mean (Mdts)**	**VaR (Mdts)**
All-In	3,730,375	3,761,824	0	0
Incrm GTN	3,605,874	3,636,062	36.04	92.46
Incrm GTN with Storage	3,607,897	3,638,312	36.04	92.46
Storage Only	3,741,640	3,772,235	46.35	86.65
Incrm NWP with Storage	3,763,508	3,794,217	46.06	86.64
Incrm NWP	3,763,540	3,795,170	46.06	86.55

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Candidate Portfolio - All In Portfolio

- Deterministic optimum mix of all evaluated resources, including incremental transportation on NWP & GTN, and all regional storage facilities.
- Components:
  - – Incrm GTN – 10,200 Dths by Nov. 2027, escalating to 25,021 Dths by Nov. 2037
  - – Incrm Fthls – 25,908 Dths by Nov. 2037
  - – Incrm I-5 Exp – 17,469 Dths by Nov. 2027, escalating to 41,035 Dths by Nov. 2037
  - – Incrm Nova – 36,246 Dths by Nov. 2037

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Scenarios and Sensitivities

Monte Carlo Simulations

- Monte Carlo Scenarios – Weather
- Monte Carlo Sensitivities – NYMEX price
- Why not Monte Carlo on both together?

Monte Carlo – Weather

- Using historical weather, we had SENDOUT run 200 simulations to stress test our candidate portfolio over a variety of different scenarios.
- In each scenario, we are testing to confirm that the mean and VaR are within acceptable limits as set by Cascade’s Gas Supply Oversight Committee.
- This ensures that our expected resource portfolio is still the optimal choice even in extreme weather situations.

Low Growth and High Growth

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Low Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in **RED** mean those elements were excluded from the scenario. All items in **BLUE** mean those elements were dampened in the scenario.		
	Current Station2	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
Low Growth	***Incremental GTN N-S***	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO		
	High Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in **RED** mean those elements were excluded from the scenario. All items in **BLUE** mean those elements were dampened in the scenario.		
	Current Station2	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
High Growth	***Incremental GTN N-S***	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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Limit JP and Limit Ply Storage

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - JP	Current Station2 Current NGTL Current GTN Current NWP Current Foothills Current Ruby	JP1 JP2 JP3 JP4 PLY-1 PLY-2	AECO Base/Fixed, Winter, Day W/S, Peak SUMAS Base/Fixed, Winter, Day W/S, Peak ROCKIES Base/Fixed, Winter, Day W/S, Peak HUNT Base/Fixed, Winter, Day W/S KINGSGATE Base OPAL Base STAT2 Base
	Incremental NGTL *Incremental GTN N-S* *NWP I-5 Mainline EXP* *Incremental Ruby* *NWP Wen lateral EXP* *Incremental Foothills* *NWP Z20 lateral EXP* *T-South-So Crossing* *Trails West (Palomar)* *NWP East OR Mainline EXP* *Incremental GTN S-N* *Incremental Enbridge* *Pacific Connector*	*Ryckman Crk Storage* *Gill Ranch Storage* *Mist Storage* *Wild Goose Storage* *Aeco Hub Storage* *Magnum Storage* *Clay Basin Storage*	*Opal Incrm Supply* *BioNaturalGas* *Resource Mix - 3 Basins*

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - Ply	Current Station2 Current NGTL Current GTN Current NWP Current Foothills Current Ruby	JP1 JP2 JP3 JP4 PLY-1 PLY-2	AECO Base/Fixed, Winter, Day W/S, Peak SUMAS Base/Fixed, Winter, Day W/S, Peak ROCKIES Base/Fixed, Winter, Day W/S, Peak HUNT Base/Fixed, Winter, Day W/S KINGSGATE Base OPAL Base STAT2 Base
	Incremental NGTL *Incremental GTN N-S* *NWP I-5 Mainline EXP* *Incremental Ruby* *NWP Wen lateral EXP* *Incremental Foothills* *NWP Z20 lateral EXP* *T-South-So Crossing* *Trails West (Palomar)* *NWP East OR Mainline EXP* *Incremental GTN S-N* *Incremental Enbridge* *Pacific Connector*	*Ryckman Crk Storage* *Gill Ranch Storage* *Mist Storage* *Wild Goose Storage* *Aeco Hub Storage* *Magnum Storage* *Clay Basin Storage*	*Opal Incrm Supply* *BioNaturalGas* *Resource Mix - 3 Basins*

Limit Both Storage and No JP

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - Both	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - JP	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

No Ply Storage and No Storage

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - Ply	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO		
	Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - Both	Current Station2	JP1	AECO Base/Fixed, Winter, Day W/S, Peak
	Current NGTL	JP2	SUMAS Base/Fixed, Winter, Day W/S, Peak
	Current GTN	JP3	ROCKIES Base/Fixed, Winter, Day W/S, Peak
	Current NWP	JP4	HUNT Base/Fixed, Winter, Day W/S
	Current Foothills	PLY-1	KINGSGATE Base
	Current Ruby	PLY-2	OPAL Base
			STAT2 Base
	Incremental NGTL	*Ryckman Crk Storage*	*Opal Incrm Supply*
	Incremental GTN N-S	*Gill Ranch Storage*	*BioNaturalGas*
	NWP I-5 Mainline EXP	*Mist Storage*	*Resource Mix - 3 Basins*
	Incremental Ruby	*Wild Goose Storage*	
	NWP Wen lateral EXP	*Aeco Hub Storage*	
	Incremental Foothills	*Magnum Storage*	
	NWP Z20 lateral EXP	*Clay Basin Storage*	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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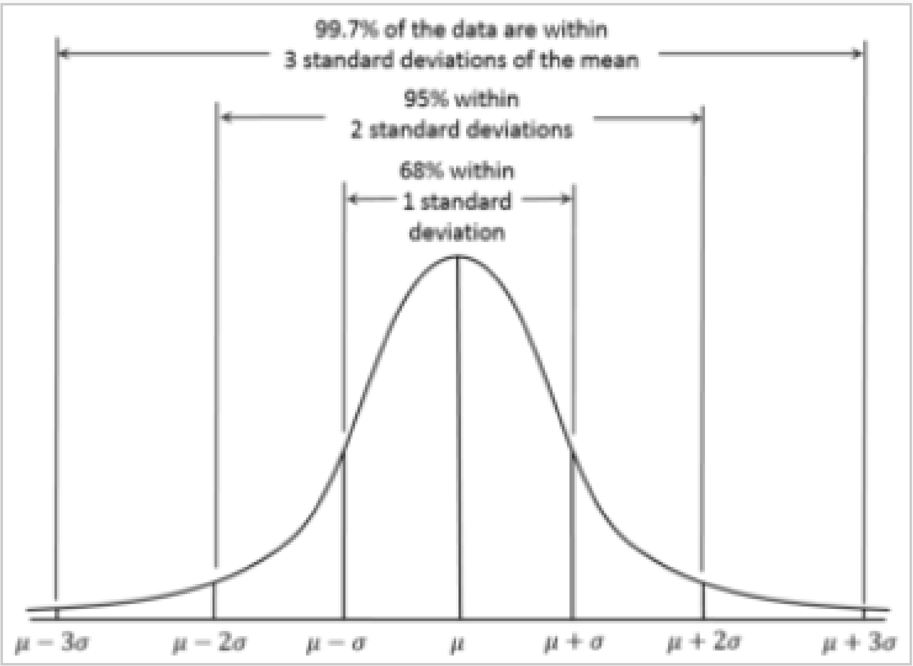
Monte Carlo Weather – Normal Distribution

	JAN 2014	FEB 2014	MAR 2014	APR 2014	MAY 2014	JUN 2014	JUL 2014
HDD Mean	1031.8	804.1	639.6	453.9	254.2	92.6	10.3
HDD Std Dev	145.4	133.1	84.4	93.0	72.2	40.4	15.2
HDD Distribution	Normal						
HDD Max	1291	1242	841	641	426	170	75
HDD Min	772	568	448	254	92	19	0
CDD Mean							
CDD Std Dev							
CDD Distribution							
CDD Max							
CDD Min							
Scaling Year	Best Match						

Monte Carlo Weather – Normal Distribution

- When following a normal distribution your data will follow the 68%, 95%, 99.7% rule like in the below diagram.



For the normal distribution, the values less than one standard deviation away from the mean account for 68.27% of the set; while two standard deviations from the mean account for 95.45%; and three standard deviations account for 99.73%.

Monte Carlo Weather – Normal Distribution

- To build our monthly inputs for SENDOUT we analyze our 30 data samples for each weather location which are the monthly HDD totals for the years 1987-2016. After getting the mean and standard deviation we can compute how many data samples fall within each range of standard deviations.

	All Months Combined
Within 1 Std Dev	69%
Within 2 Std Dev	96%
Within 3 Std Dev	99.4%

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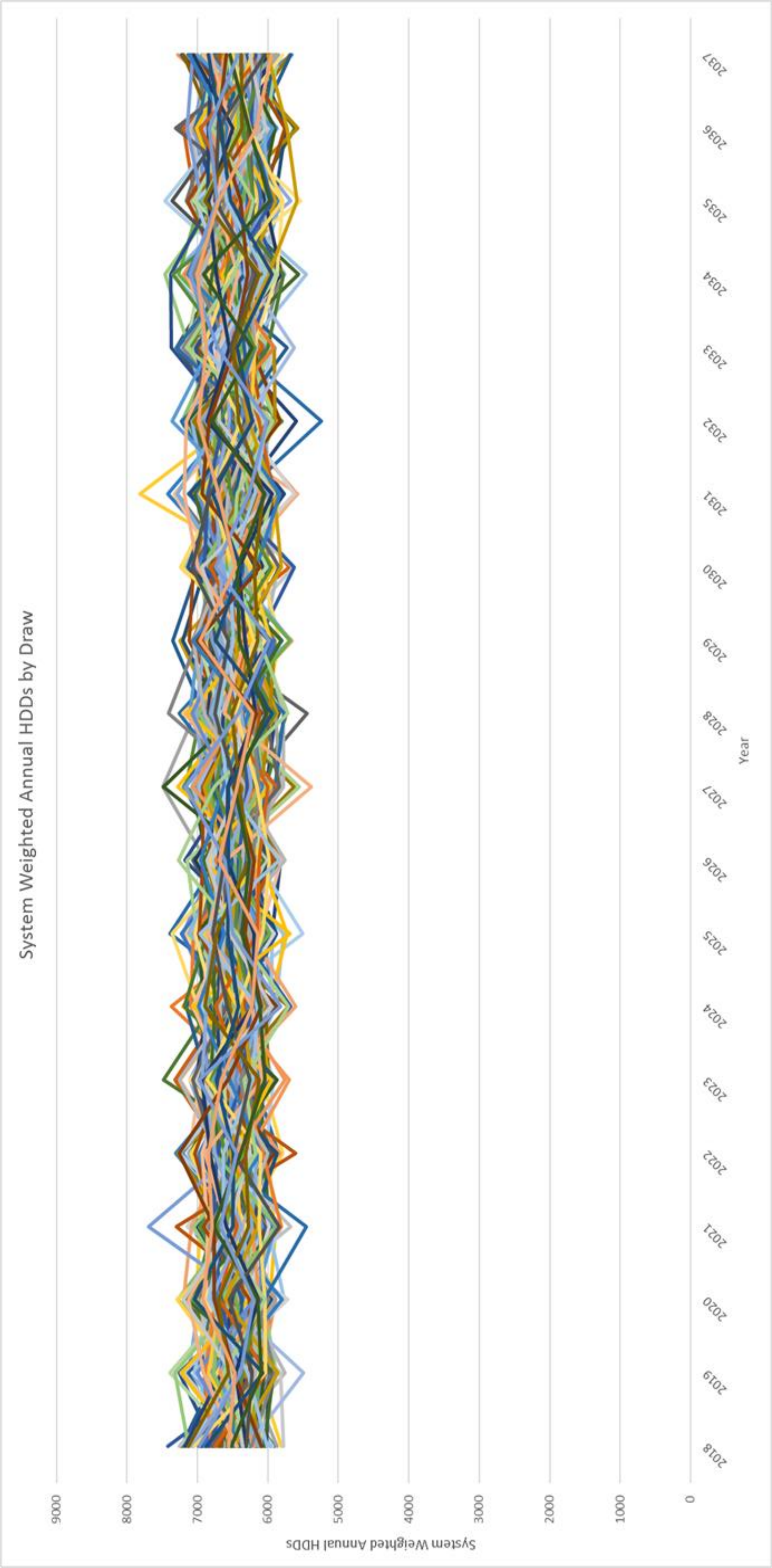
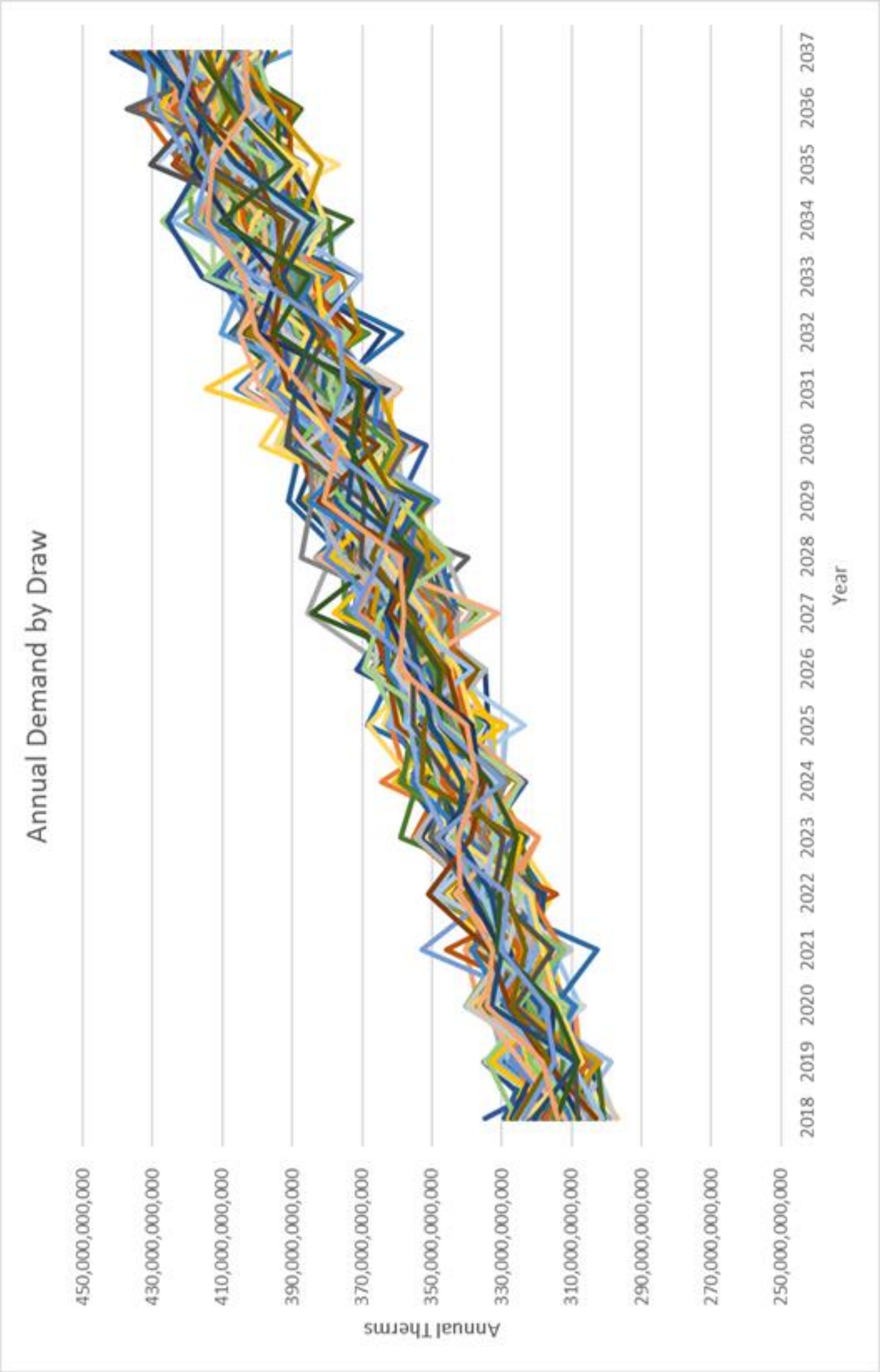
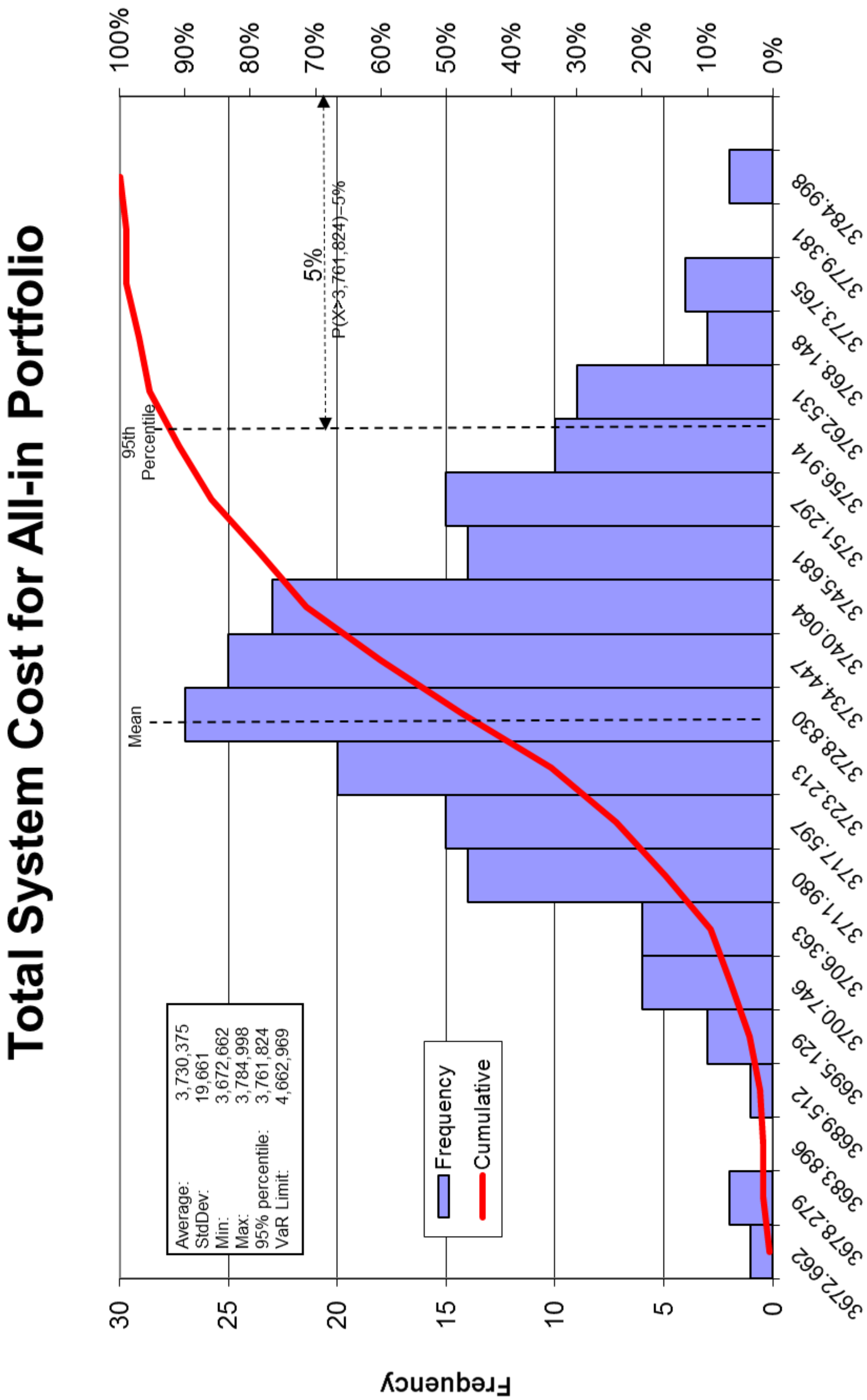

System Weighted Annual HDDs by Draw
System Weighted Annual HDDs
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
Year

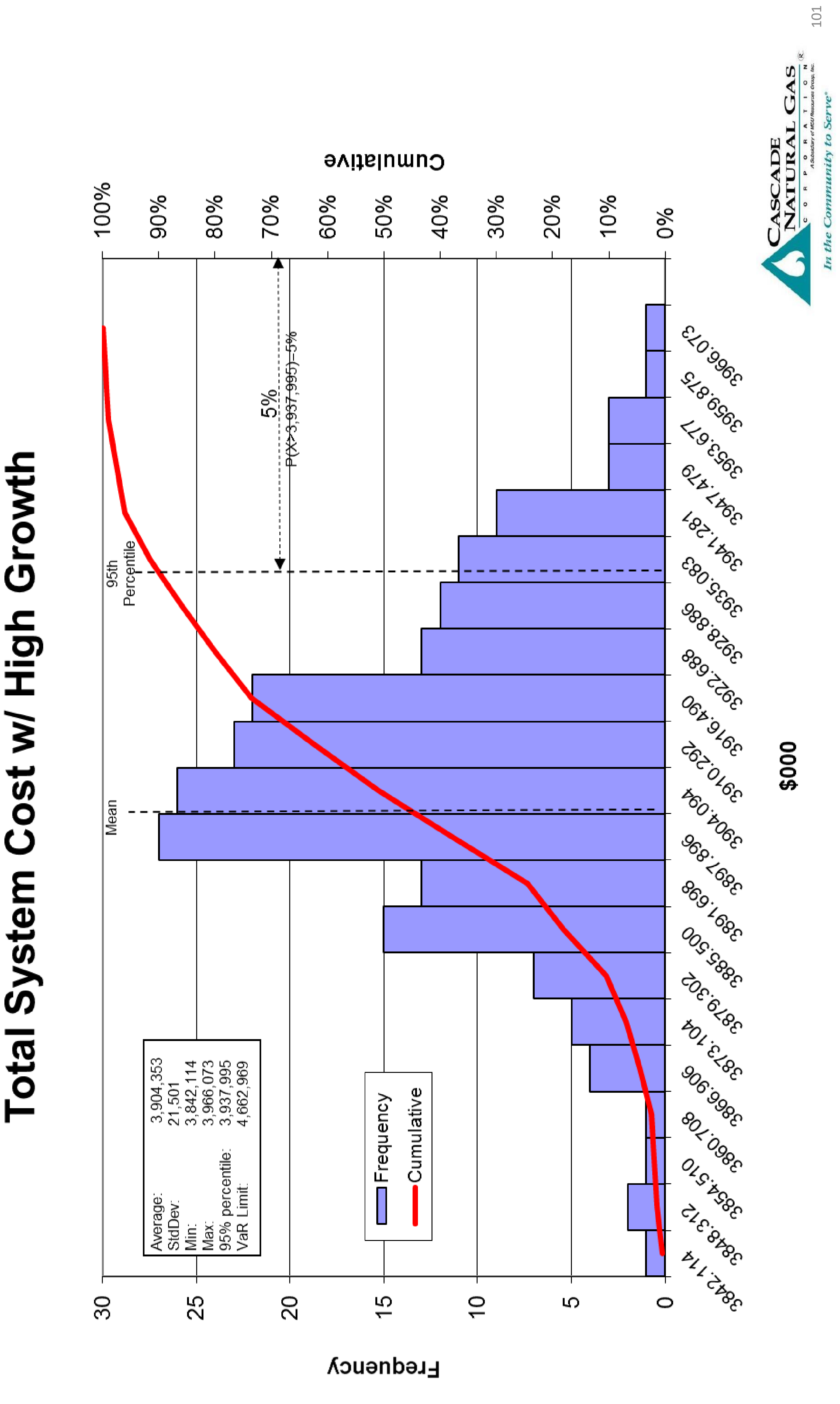
98


Annual Demand by Draw
Annual Therms
450,000,000,000
430,000,000,000
410,000,000,000
390,000,000,000
370,000,000,000
350,000,000,000
330,000,000,000
310,000,000,000
290,000,000,000
270,000,000,000
250,000,000,000
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
Year

99

100


Total System Cost for All-in Portfolio
Frequency
Cumulative
$000
Average: 3,730,375
StdDev: 19,661
Min: 3,672,662
Max: 3,784,998
95% percentile: 3,761,824
VaR Limit: 4,662,969
Frequency
Cumulative
Mean
95th Percentile
5%
P(X>3,761,824)=5%
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
3672.662
3678.279
3683.896
3689.512
3695.129
3700.746
3706.363
3711.980
3717.597
3723.213
3728.830
3734.447
3740.064
3745.681
3751.297
3756.914
3762.531
3768.148
3773.765
3779.381
3784.998


Total System Cost w/ High Growth
Average: 3,904,353
StdDev: 21,501
Min: 3,842,114
Max: 3,966,073
95% percentile: 3,937,995
VaR Limit: 4,662,969
Frequency
Cumulative
Mean
95th Percentile
5%
P(X>3,937,995)=5%
Frequency
Cumulative
$000
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
3842.114
3848.312
3854.510
3860.708
3866.906
3873.104
3879.302
3885.500
3891.698
3897.896
3904.094
3910.292
3916.490
3922.688
3928.886
3935.083
3941.281
3947.479
3953.677
3959.875
3966.073
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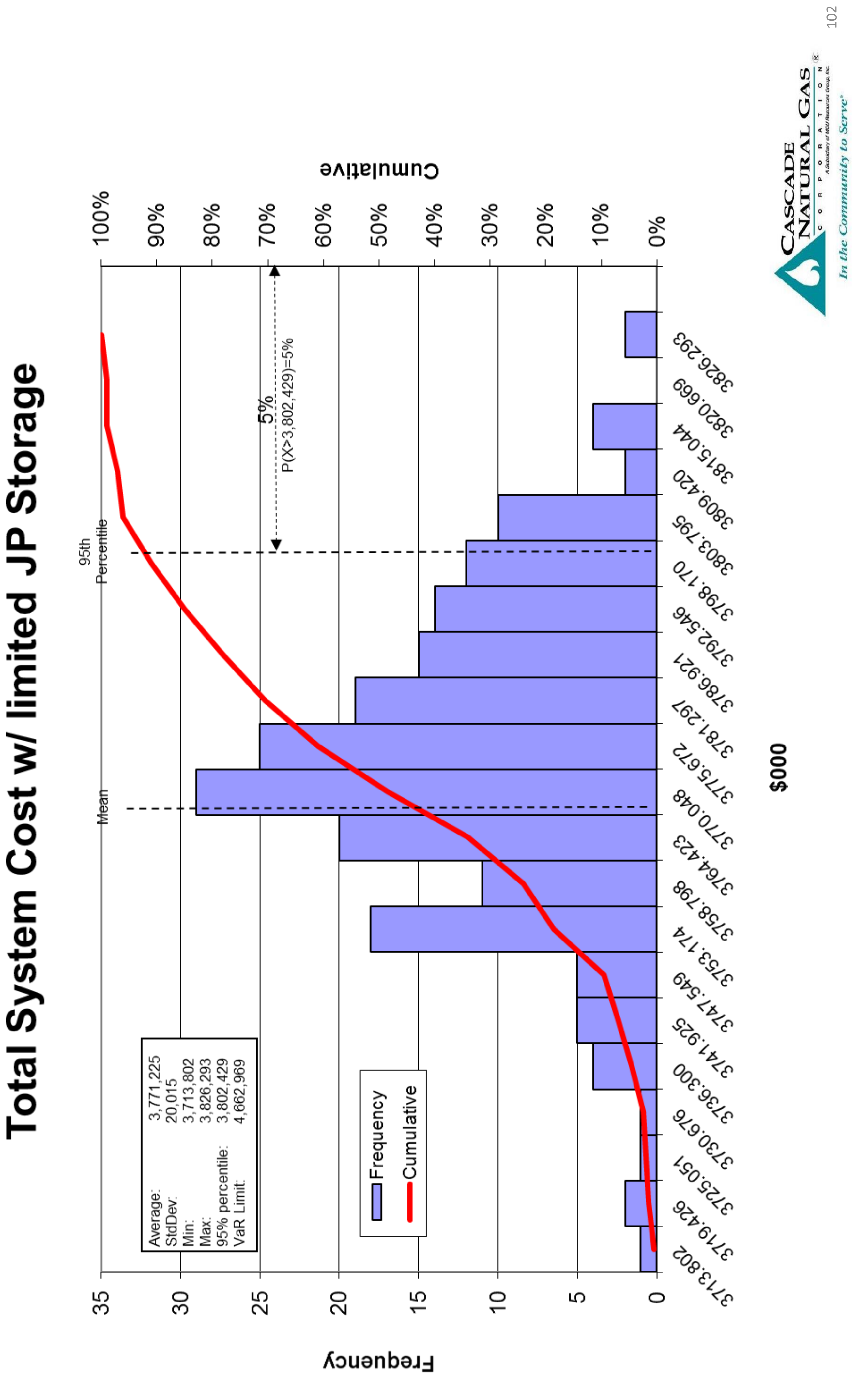
101


Total System Cost w/ limited JP Storage
Frequency
Cumulative
$000
Average: 3,771,225
StdDev: 20,015
Min: 3,713,802
Max: 3,826,293
95% percentile: 3,802,429
VaR Limit: 4,662,969
Frequency
Cumulative
Mean
95th Percentile
5%
P(X>3,802,429)=5%
3713.802
3719.426
3725.051
3730.676
3736.300
3741.925
3747.549
3753.174
3758.798
3764.423
3770.048
3775.672
3781.297
3786.921
3792.546
3798.170
3803.795
3809.420
3815.044
3820.669
3826.293
0
5
10
15
20
25
30
35
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
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Monte Carlo – NYMEX Price

- Using our 20 year price forecast as the mean value for the NYMEX market, we had SENDOUT run 200 simulations to stress test our expected case over a variety of different pricing environments.
- In each sensitivity test, we are testing to confirm that the mean and VaR are within acceptable limits as set by Cascade’s Gas Supply Oversight Committee.
- This ensures that our expected resource portfolio is still the optimal choice even in extreme pricing situations.

Sensitivities Analysis

Sensitivities		Assumptions
Price	High	Medium Load Growth, Average Weather with Peak Event, High Gas Price Environment
	Base	Medium Load Growth, Average Weather with Peak Event, Expected Gas Price Environment
	Low	Medium Load Growth, Average Weather with Peak Event, Low Gas Price Environment
Carbon Adder	10%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 10% Adder for Unknown Regulatory Impacts
	20%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 20% Adder for Unknown Regulatory Impacts
	30%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 30% Adder for Unknown Regulatory Impacts
Per Ton	$10	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $10 per ton Carbon Tax
	$20	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $20 per ton Carbon Tax
	$30	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $30 per ton Carbon Tax

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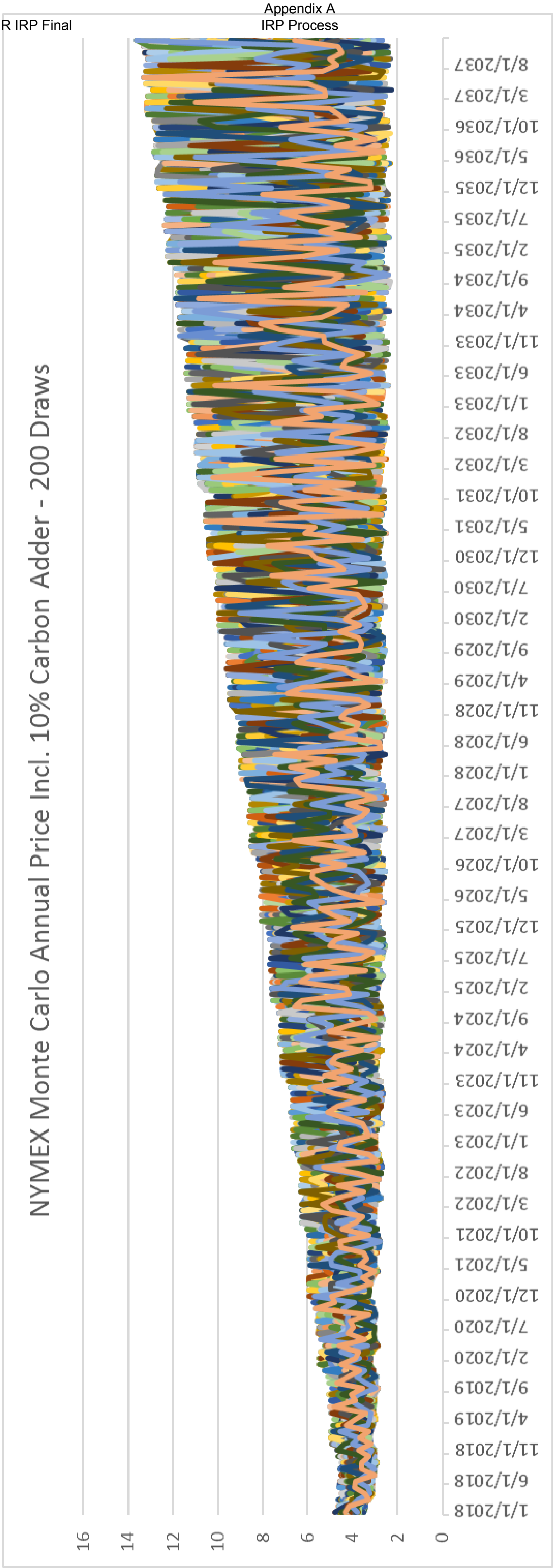
NYMEX Monte Carlo Annual Price Incl. 10% Carbon Adder - 200 Draws
0
2
4
6
8
10
12
14
16
1/1/2018
6/1/2018
11/1/2018
4/1/2019
9/1/2019
2/1/2020
7/1/2020
12/1/2020
5/1/2021
10/1/2021
3/1/2022
8/1/2022
1/1/2023
6/1/2023
11/1/2023
4/1/2024
9/1/2024
2/1/2025
7/1/2025
12/1/2025
5/1/2026
10/1/2026
3/1/2027
8/1/2027
1/1/2028
6/1/2028
11/1/2028
4/1/2029
9/1/2029
2/1/2030
7/1/2030
12/1/2030
5/1/2031
10/1/2031
3/1/2032
8/1/2032
1/1/2033
6/1/2033
11/1/2033
4/1/2034
9/1/2034
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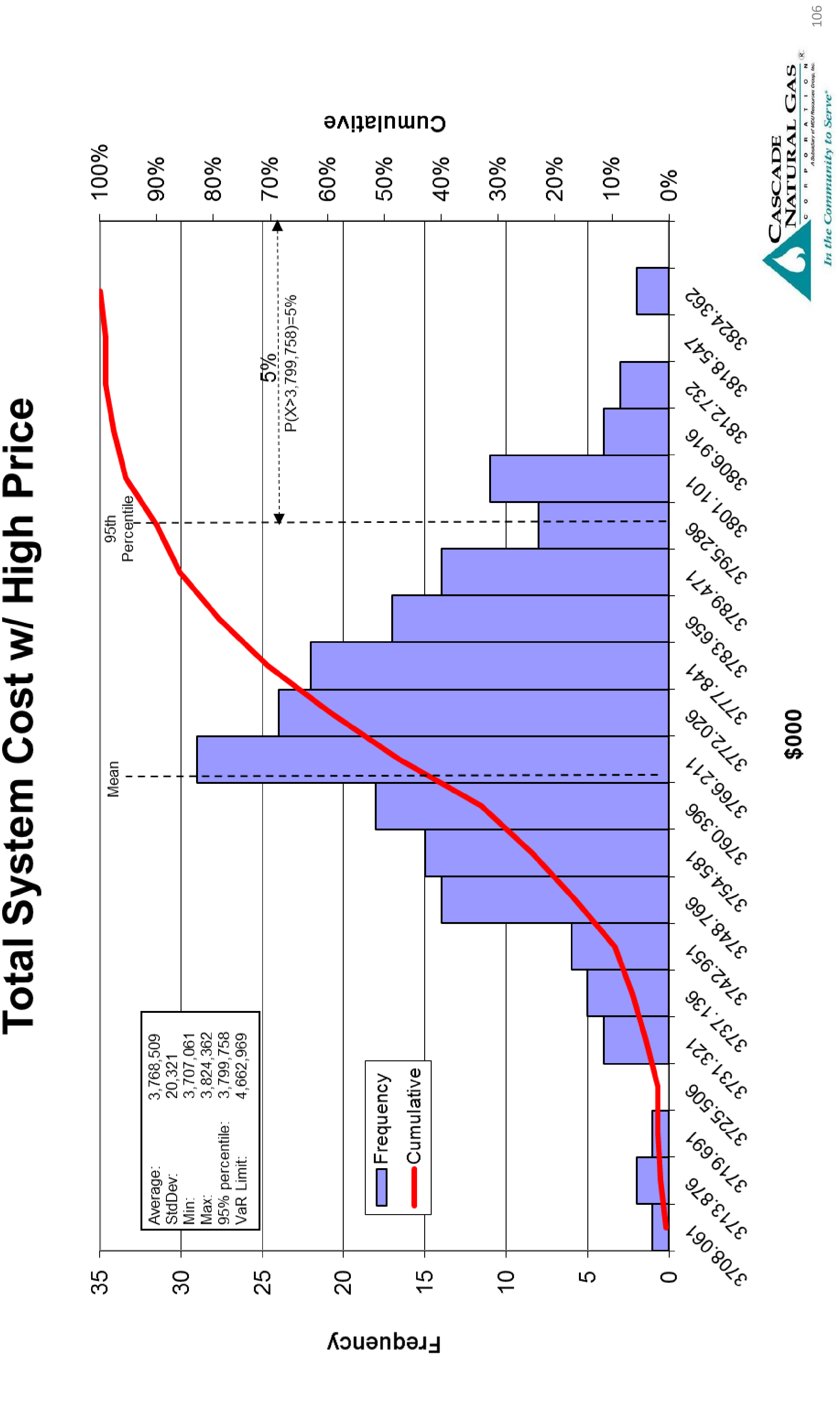
3/1/2037
8/1/2037


Total System Cost w/ High Price
Average: 3,768,509
StdDev: 20,321
Min: 3,707,061
Max: 3,824,362
95% percentile: 3,799,758
VaR Limit: 4,662,969
Frequency
Cumulative
Mean
95th Percentile
5%
P(X>3,799,758)=5%
Frequency
Cumulative
$000
0
5
10
15
20
25
30
35
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
3708.061
3713.876
3719.691
3725.506
3731.321
3737.136
3742.951
3748.766
3754.581
3760.396
3766.211
3772.026
3777.841
3783.656
3789.471
3795.286
3801.101
3806.916
3812.732
3818.547
3824.362
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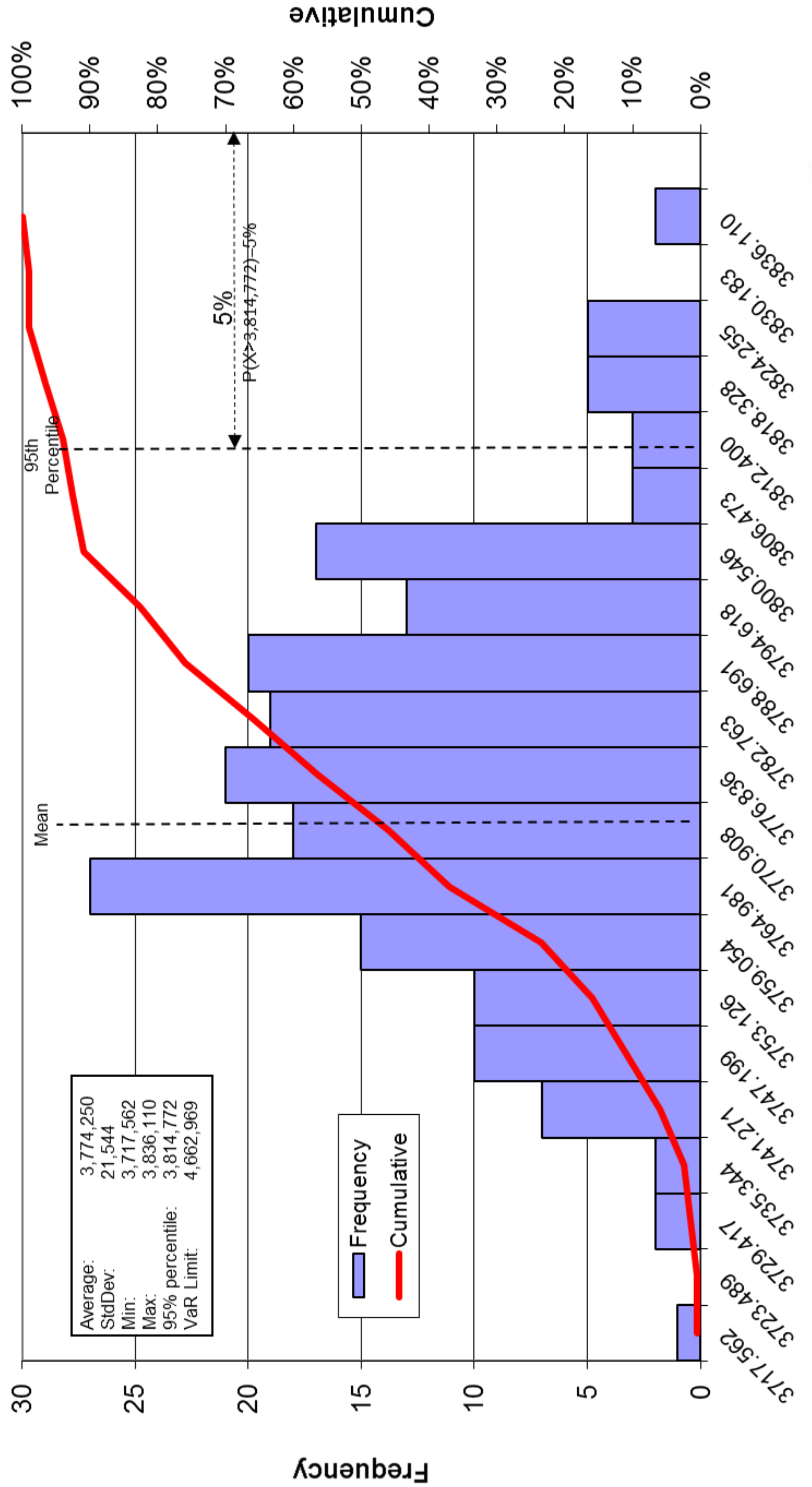
Total System Cost w/ 10% Carbon Adder



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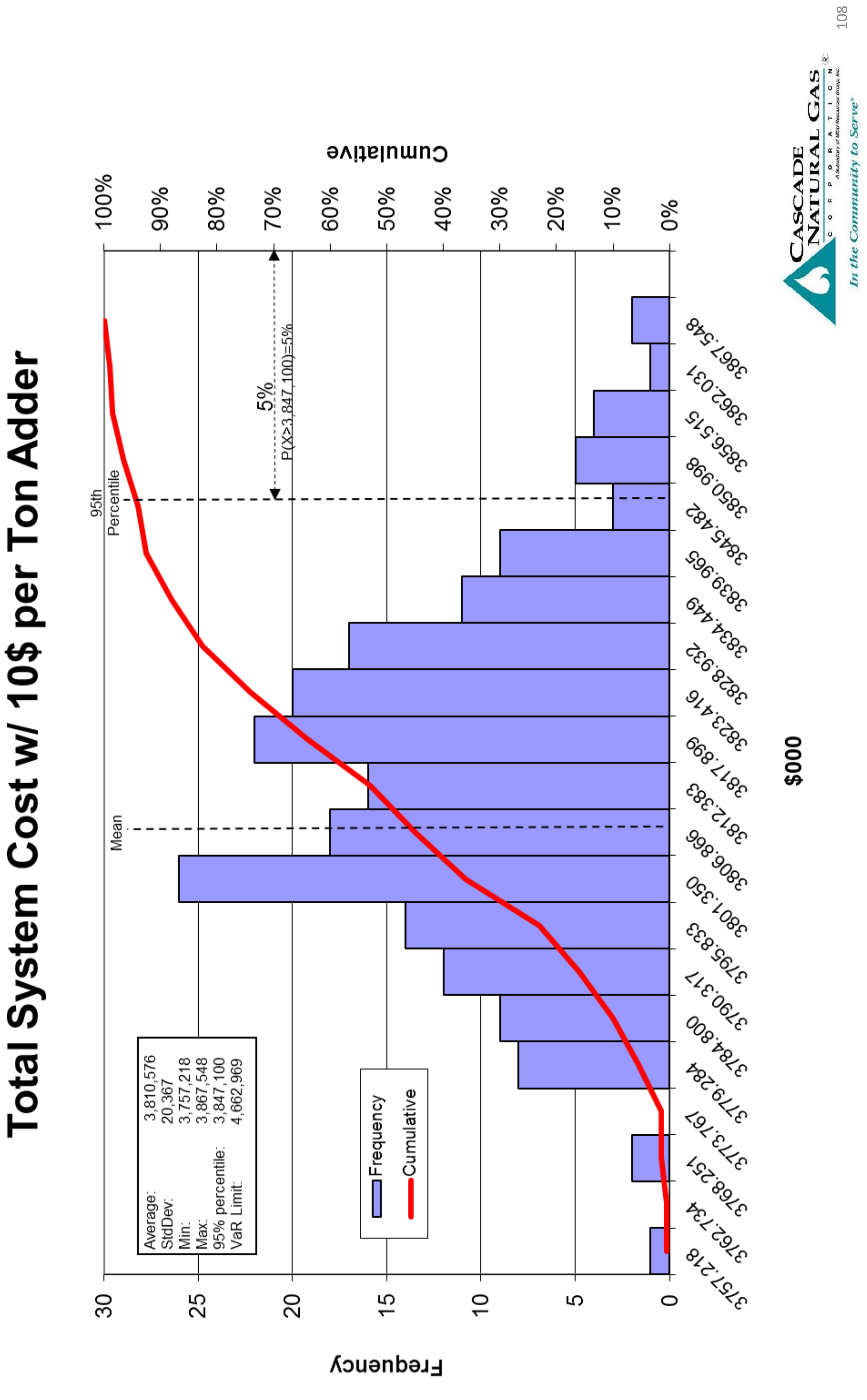
Total System Cost w/ 10$ per Ton Adder
Average: 3,810,576
StdDev: 20,367
Min: 3,757,218
Max: 3,867,548
95% percentile: 3,847,100
VaR Limit: 4,662,969
Frequency
Cumulative
Mean
95th Percentile
5%
P(X>3,847,100)=5%
$000
3757.218
3762.734
3768.251
3773.767
3779.284
3784.800
3790.317
3795.833
3801.350
3806.866
3812.383
3817.899
3823.416
3828.932
3834.449
3839.965
3845.482
3850.998
3856.515
3862.031
3867.548
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
5
10
15
20
25
30
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Scenario/Sensitivity Analysis ($000)

Scenarios and Sensitivities	Mean Total System Cost	VaR Total System Cost	Distance From VaR Limit
Low Growth	3,558,879	3,586,974	1,075,995
All-in Low Price	3,677,101	3,706,370	956,598
All-in Base Price	3,730,375	3,761,824	901,145
Limit Ply	3,735,878	3,767,042	895,927
No Storage - Ply	3,735,878	3,767,042	895,927
All-in High Price	3,768,059	3,799,758	863,210
Limit JP	3,771,225	3,802,429	860,540
10% Carbon Adder	3,774,250	3,814,772	848,196
Limit Both JP and Ply	3,781,513	3,813,037	849,932
No Storage - JP	3,786,551	3,817,561	845,408
No Storage - Both JP and Ply	3,806,273	3,843,720	819,249
10$ Per Ton Adder	3,810,576	3,847,100	815,868
20% Carbon Adder	3,845,766	3,880,357	782,612
20$ Per Ton Adder	3,901,711	3,933,235	729,733
High Growth	3,904,353	3,937,995	724,974
30% Carbon Adder	3,907,371	3,938,963	724,006
30$ Per Ton Adder	3,978,920	4,006,628	656,341

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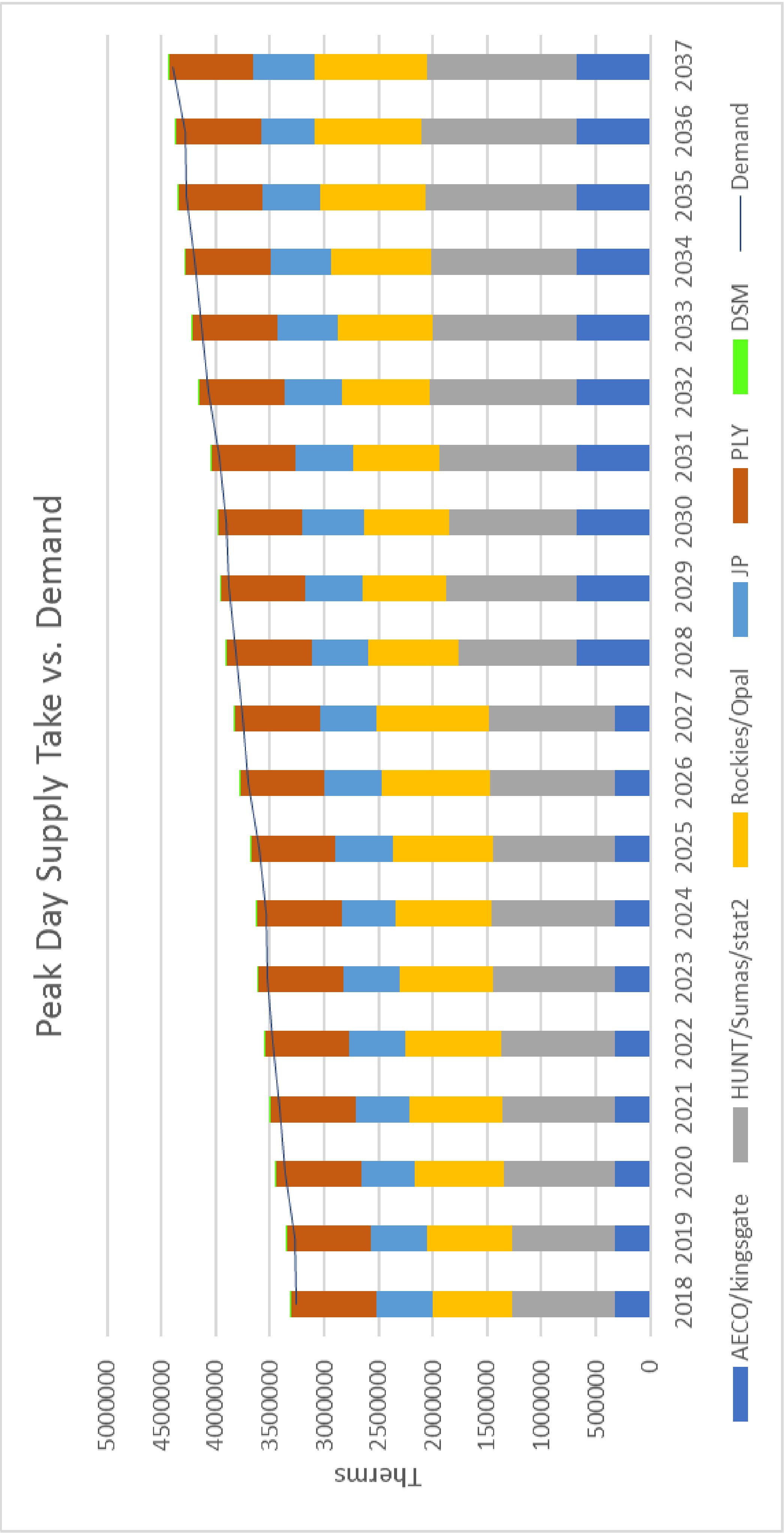
110



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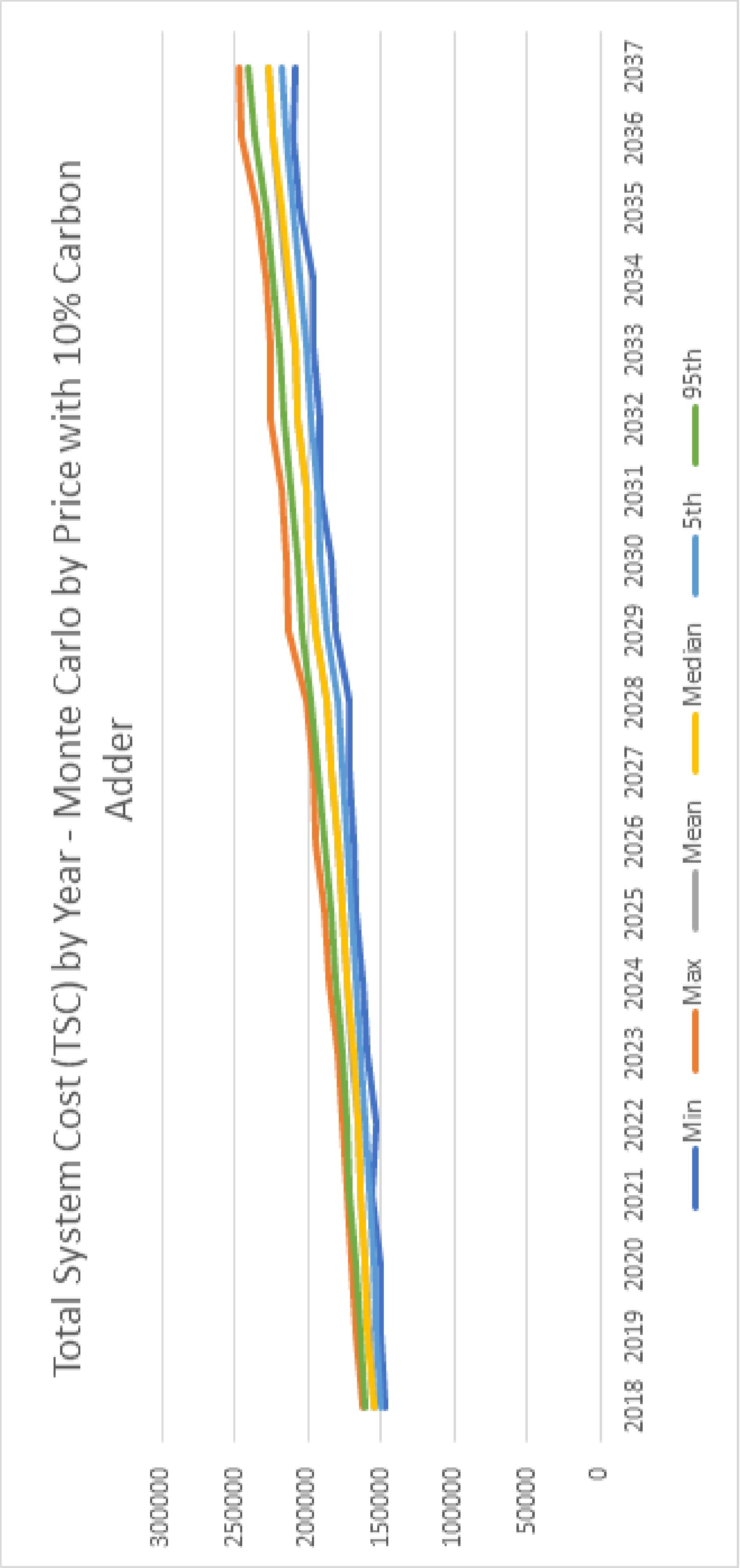

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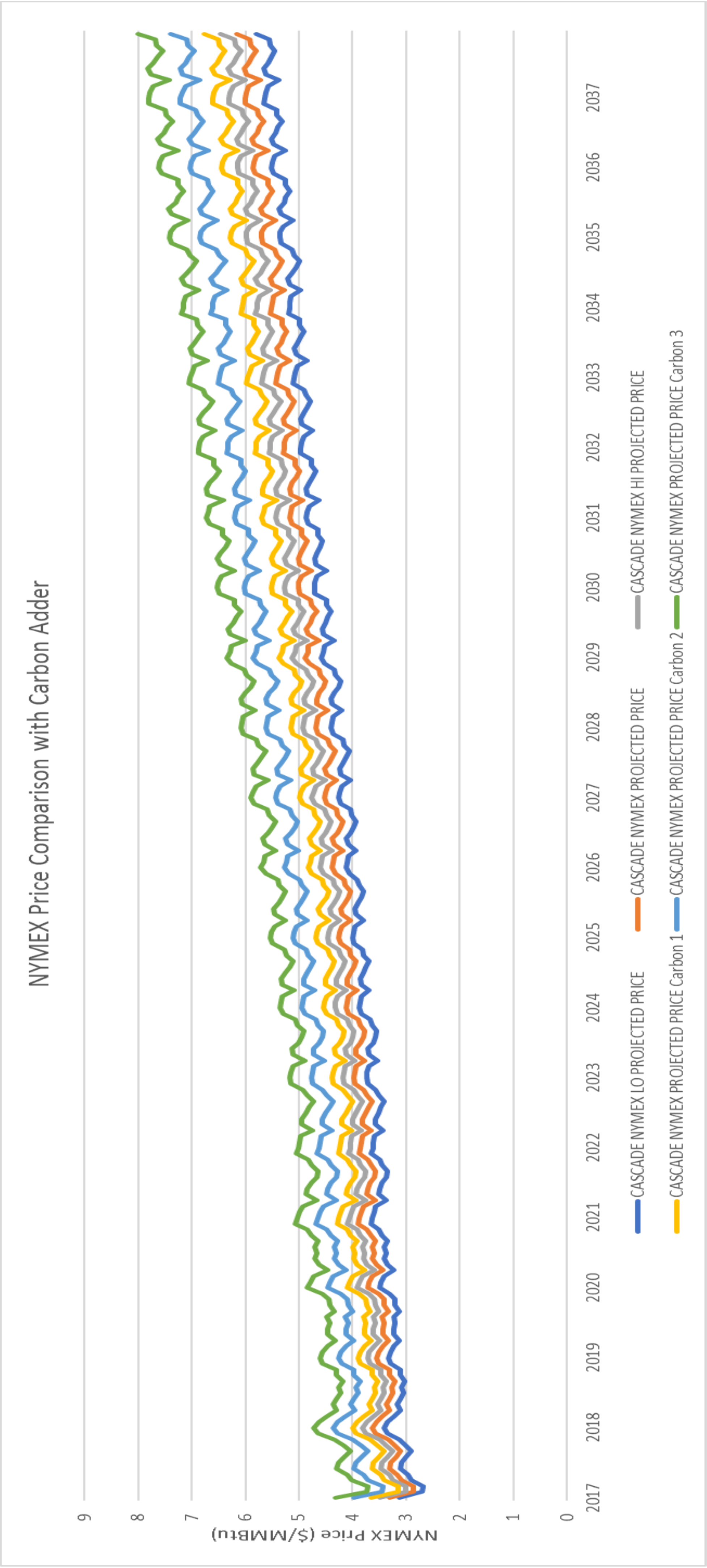
111


NYMEX Price Comparison with Carbon Adder
NYMEX Price ($/MMBtu)
0
1
2
3
4
5
6
7
8
9
2017
2018
2019
2020
2021
2022
2023
2024
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2034
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2036
2037
CASCADE NYMEX LO PROJECTED PRICE
CASCADE NYMEX PROJECTED PRICE
CASCADE NYMEX HI PROJECTED PRICE
CASCADE NYMEX PROJECTED PRICE Carbon 1
CASCADE NYMEX PROJECTED PRICE Carbon 2
CASCADE NYMEX PROJECTED PRICE Carbon 3

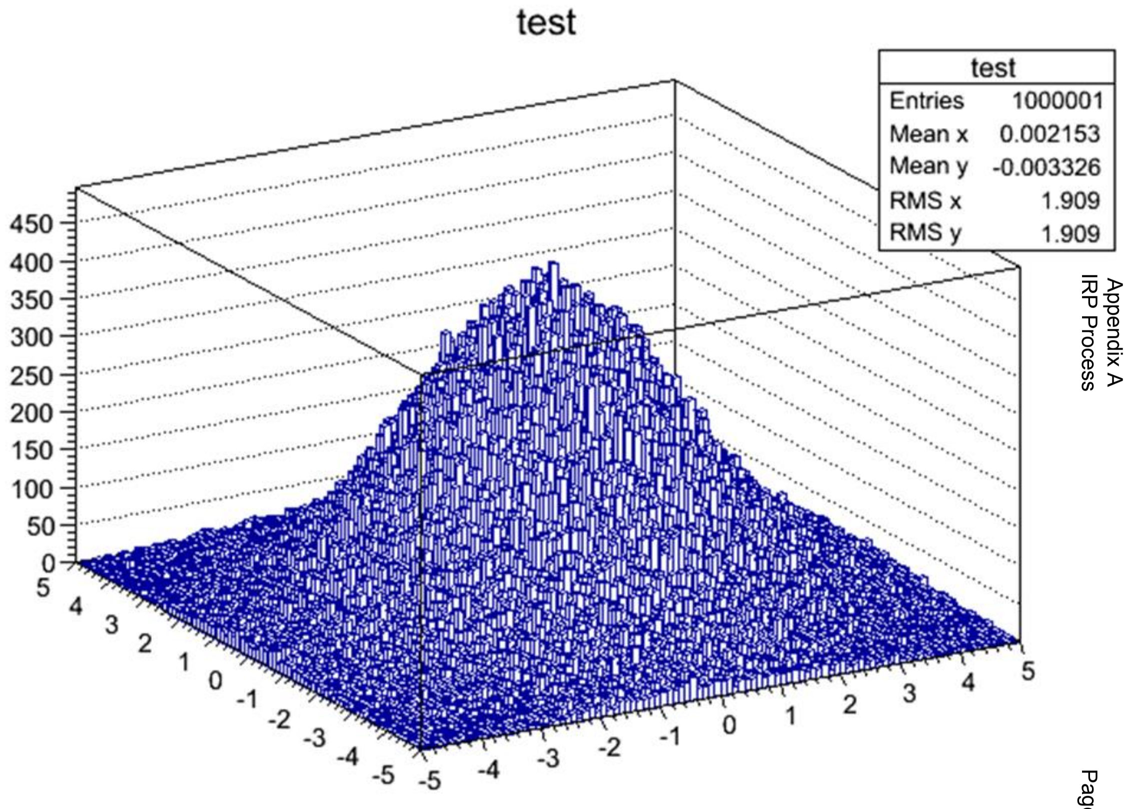
112

Why not Monte Carlo Price AND Weather?

- What happens when we look at drawing on both price and weather at the same time?

- We can imagine a 3 dimensional histogram, instead of the 2 dimensional histograms on the previous pages. Filling this in takes many more draws.

- 200 draws of weather on the X axis and 200 draws of price on the Y axis might need 200 x 200 = 40,000 draws to fill in a histogram like this…



2018 IRP Timeline

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	

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Questions?

Cascade Natural Gas Corporation

2018 Integrated Resource Plan
Technical Advisory Group Meeting #4

Thursday, Oct. 19th, 2017
Oregon Public Utility Commission Offices
Salem, OR

4th External TAG Meeting

Date & time: 10/19/2017, 09:00 AM – 11:30 AM

Location: OPUC Offices in Salem, OR

Presenters: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Ashton Davis & Ed Finklea

In attendance: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Ashton Davis, Bruce Folsom, Deborah Glosser – OPUC, Lisa Gorsuch – OPUC, Paul Rosson – OPUC, JP Batmale – OPUC, Ed Finklea – NWIGU, Matthew Doyle - NWN, Teresa Hagins - NWP

Called in: Garret Senger, Jennifer Gross, Jeremy Ogden, Tom Pardee - AVA, Carolyn Stone

Minutes by: Carolyn P Stone

Garret welcomed everyone and stated he thought it would be a great session and he appreciated the dedication of the IRP Team and looking forward to input.

Presentation #1 – Brian Robertson
IRP Action Plan Update

- Brian stated that there are no areas highlighted in yellow meaning there are NO updates from Tag #3 to Tag #4, however, there will be some changes to the narrative.

Presentation #2 – Ed Finklea
Consumer and Environmental Benefits of Shale Revolution

- Ed started by stating that the purpose of his presentation is to show what Shale means to consumers
- He said that his career has been primarily working with consumers!
- The membership of Northwest Industrial Gas Users includes 35 companies, and is diverse. Some companies have seasonal loads while others use 365 day loads and the group includes everyone else in between. The organization was formed around the region served by NWP and GTN to the side. They are active at the PUC level.
- Ed answers the question - how much consumers benefit from the Shale Revolution, in other words, what's really happened? He said that Shale is a big deal for every consumer!

Slide #7 – Oil and Natural Gas Price History 1983 – 2016
- Oil and Natural gas, Ed said, used to be tied at the burner tip. Industrial customers used to switch between oil and gas so they followed each other.

- From graph, you see that back in 2005 oil and gas prices were linked!
- Ed stated that per the slide you can see a gas price “run-up” from 1997-1999 and there were sustained “shorts”. 2005 was also an active hurricane season!
- $ at that time was being invested to import NG
- Lisa Gorsuch mentioned that back in 2005, they were modeling getting cut-off from Canadian gas!
- By 2009 Ed says, gas and oil prices were “delinked”. Gas was about $8 per mmbtu – now it is down to $3.00.

Slide #8 – US Natural Gas Production and Consumption in Billions of Cubic feet 1980 – 2016

- Ed stated that the majority of NG by 2040 will come from Shale. Some people think we are there already!
- Ed reminded us that there is opposition to hydraulic fracking, but the benefits to consumers are significant!

Slide #10 & #11 – YOKO & Sean sign

- Ed posits if the price stayed at $8.00 from the early 2000’s…. Lisa said it was predicted to jump to $14 in 2008. Ed said it could have been much higher!

Slide #13 – No Fracking’s Impact on Oregon Consumers

- In 2016 consumers burned 239m Dth in Oregon (not via electric generation)
- Consumers would pay 1.1 billion more for NG in 2016 with no fracking!
- But there is more to it than saving $, said Ed.

Slide #14 – Electric Generation & Carbon Emissions

- Emissions are part of the story – and it is a big deal!
- Why this country has “bragging rights” about reducing carbon emissions more than ANY other country….
  - Shale
  - Efficiency
  - Rapidly expanding renewables

- USA using less when prices are down, we are the region leader in efficiency!

Question: Mark asked why this is not advertised?
Answer: Ed stated that we tend to play “defense”! We need to be activists, he stated, and not be afraid to tell people what are doing and be vocal about it!

Question: Someone else asked if the Permian Basin is at “peak fracking” in some places?
Answer: Ed stated that that has not happened so far. He said it’s like the old-style drilling and then oil prices increase!

- Someone else said that the challenge with horizontal fracking is that it causes secondary damages, and rare effects.

Question: I used to work at Energy Trust. What is the appetite for transportation customers to be on Energy Trust?
Answer: Ed stated that he will be talking about this topic later this afternoon. There is a Volunteering Program. Most of his members never participate in demand side programs. He wonders if there could be a program as a transporter. Can I sign up for

some type of Demand Side management without becoming a “sales customer” …i.e. without forcing it down our throats? Some companies would be willing. But if **Cap & Trade** is enacted, then all bets are off!

- Ed went on to say that one of his members’ pulp shortage on the West Coast put them out of business! Also, an aluminum smelter is down because aluminum is now being imported from China. Those companies used a lot of energy! There is a thin margin in many of these businesses, 92% of their cash goes out the door!

Presentation #3 – Ashton Davis, Devin McGreal & Brian Robertson
Sendout Optimization Modeling

Slide #16 – Sendout Model
- Ashton started by stating that the Sendout Model is used for resource optimization. He said it is complex and powerful!
- It minimizes costs in a way not possible in the real world, so this tool is a guide, not a decision maker!

Slide #19 – Modeling Challenges
- Supply needs to get gas to the Citygate.
- Sendout has perfect knowledge!

Slide #20 – Supply Resource Optimization Process

Question: Mark stated to Tom Pardee from Avista that CNGC discusses their candidate portfolio to get the total system costs and compare 25% with other industry practices, what does AVA do?
Answer: Tom said that they use scenarios to see what happens to an expected case. They have a new method as to how they look at Portfolios, based on normal distributions. Tom said yours is in line with other industrial methodologies.

Slide #21 – Supply Resource Optimization Process (Cont’d), steps 5 thru 8
- Later there will be a slide including all sensitivities!

Slide #22 & #23– Base Case Sendout Inputs/Supply
- Devin clarified **scenarios** vs **sensitivities**.
- Devin stated we get our supply from AECO, Sumas, Kingsgate & OPAL

Slide #24 – CNG Supply Chart
- Shows North to South using NWP
- South to North with all pipelines
- North to South using GTN

Slide #25 – Supply Base and Fixed
- Sendout will choose the supply needed to cover the load!

Slide #28 – Winter Base Supply
- The “winter” covers November thru March
- This is the “heating season”, additional baseline supply for winter months
- We can let Sendout choose the optimum MDQ (Max Daily Quantity).

- A penalty forces Sendout to take optimal additional winter gas.

Slide #29 – Winter Base Supply (Cont'd)
- Graph shows base during winter months only!

Slide #30 – Day Supply (Winter)
- November through April period.
- Winter day gas has MDQ cap but that is not an unlimited amount of gas at a cheaper price!
- Winter has a slightly higher premium.

Slide #31 – Winter Day Supply (Cont'd)

Question: Are you assuming you will always purchase on the daily market?
Answer: Day gas covers any demand along the yellow dotted curve of slide #31 at a reasonable rate for a period.

Slide #32 – Day Supply (Summer)
- This timeframe is April – November.
- Summer day supply has a slightly higher cost.

Slide #34 – Peak Supply
- Peak has a higher cost

Slide #36 – Storage
- Jackson Prairie (JP)
  - 4 storage contracts
  - Can withdraw 56K Dth per day
- Plymouth (Ply)
  - 2 storage contracts
  - Can withdraw 78K Dth per day

- Total withdrawal 134K Dth per day!

Question: During the summer peak days are you injecting?
Answer: More so in the heating season. Day supply is needed for high demand, non-heating season!

Slide #37 – Storage Example
- Our storage is not specifically tied to our system!

Slide #38 – Storage, Sendout example 2
- The target % is shown here
- Rates for storing/withdrawing storage and withdrawing/ injecting and withdrawing shown.

Slide #39 – Transportation
- NWP goes to a "zonal level" and can be constrained.
- GTN goes to the Citygate level only, no zones here.

Slide #40 – Transportation (Cont'd)

- Transport has an MDQ (maximum demand quantity), a D1 rate, a transportation rate and a fuel loss %.

Slide #41 – Transport Example
- NWP Pool South to NWP Pool (Dispersed to different zones & eventually Citygate)

Slide #43 – Delivery Rights vs Receipt Rights
- CNGC has more delivery rights than receipt rights
- This gives CNG flexibility!

Slide #44 – Example of delivery right flexibility
- Total of contracted cannot exceed 4K but we can drop 4K at any location!

Slide #47 = Transport Constraints Example
- Shows when constrained to daily max of 47,603

Slide #48 – Locations of Zones (NWP)
- For example, see zone “ME-OR” is the Pendleton area

Slide #51 – Zone 30 on Peak Day for Transport #135558
- It is the same price, so we could send it to 30-W, rather than 30-S!

Slide #52 – Transport Contract #135558 on Peak Day
- Example of this contract fully utilized!

Slide #54 – Demand Behind the Gate,
- Customer billing system doesn’t have daily meter reads for CORE customers. Brian said this makes analysis difficult!
- This year we added citygate & zonal levels!

Slide #55 – Demand
- Demand is forecasted at citygate level by rate schedule Brian stated.
- He said for NWP demand is associated with zone and for GTN Citygate demand is associated with its interconnect.
- The inputs are forecast type, projected customers, regression coefficients & 2016 demand for the month with a growth factor.

Slide #57 – Demand Example 2
- Sendout inputs - usage factors
- Customer demand 20 years out – weekend base!

Slide #58 – Weather
- Weather inputs – Monte Carlo (MC), Historical & Normal (average 30 year)

Slide #59 – Weather Ex. MC
- HDD mean & Std. Dev = based on actual 30 years historical
- Once run, Sendout finds the best match year & uses that profile!

Slide #60 - Long term price forecast
- Market pricing & Long-term price forecasts

- Henry Hub (HH) Nymex future prices.

Slide #61 – Long Range Price Forecast (Cont'd)
- Weighted to each source
- Using most recent trading period!

Slide #62 – Price Forecast Weights
- Symmetric mean absolute percentage error (SMAPE) – looks at all sources – how accurate have they been?

Slide #63 – Example of SMAPE Calculations by Source
- Sources are EIA past 2036
- Calculates error and how much of an error, 1 month, 2 months – 3 months out

Slide #64 – Example Weights Price Forecast for 2018
- Added up and divided by total to get % weights, then value these inputs!

Slide #66 – Probable Base Case Forecasted Prices by Basins
- Nymex, Sumas, Rockies & AECO used

Question: Do Sumas & AECO stay below Nymex?
Answer: YES

Presentation #4 – Ashton Davis
Alternative Resources

Slide #68 – Major Issues on the Horizon
- Cascade identifies deficiencies & provides solutions
- CNG talks with pipelines, storage facilities and new resource sources

Slide #71 – Incremental Transport – NWP
- West Central Washington, Oregon lateral & entering Southeast Oregon.

Slide #72 – Incremental Transport – S to N
- OPAL
- RUBY
- GTN South to North

Slide #73 – Incremental Transport – Bilateral
1. T-South Southern Crossing
2. Trails West
3. Pacific Connector – Oregon Coast

Slide #74 – Incremental Storage – N and E
- Ryckman Creek, Gill Ranch, Magnum, Mist, Clay Basin & Wild Goose

Slide #76 – Incremental Supplies
- OPAL & Renewable NG (biogas)

Presentation #5 – Brian Robertson
Candidate Portfolios

Slide #78 – Portfolio Summary
- This shows scenarios based on whether we use NWP, GTN or storage.

Slide #80 – All in Portfolio (PF)
- All evaluated resources!
- Pick up GTN 10,200 by Nov 2027
- Gas Supply already picked up additional GTN, starts Dec 1, 2017 –
  - o Originally, Gas Supply tried to get start date of Nov 1, 2017 but due to maintenance, it was moved to December with the same termination date.
- Lookout 10 years!
- Incremental Foothills – 25K by Nov 2037
- Incremental I-5 expansion 17,469 Dth by 2027 increase to 41,035 Dth by Nov 2037
- Incremental NOVA – 36K Dth by Nov 2037

Slide #81 – Incremental GTN & Storage Portfolio
- Includes Incremental GTN and all regional storage facilities!

Slide #83 – Incremental NWP & Storage
- Incremental I-5 Expansion – 7.5K Dth by Nov 2027
- Spokane 14,794 Dth by 2037
- Ryckman Creek, 1000 Dth by Nov 2037

Slide #86 – Final Ranking – Mean & VaR
- Shows Mean and VaR & unserved demand

Question: I asked Brian what does “mdt” stand for?
Answer: Brian answered that it stands for “thousands of Dth’s”.

Slide #87 – All in Portfolio
- Optimum mix of all evaluated resources including NWP/GTN & Storage

Presentation #6 – Devin McGreal
Scenarios & Sensitivities

Slide #89 – Monte Carlo
- M/C scenarios – weather

Slide #90 – Monte Carlo – Weather
- We ran 200 simulations to stress test our expected portfolio.

Slide #91& #92 – Low & High Growth scenarios
- Will we be able to serve our customers at a reasonable cost??

Slide #95 & 96 – Monte Carlo Weather – Normal Distribution
- Weather is normal, distribution follows rule!

Slide #98 – System Weighted Annual HDD’s by Draw

- Graphical representation, NOT data inclusive!

Slide #99 – Annual Demand by Draw
- What happens over the course of 200 demand draws!

Slide #101 – Total System Cost with High Growth
- All-in Portfolio!
- 3.7 million average cost, total system
- Min/Max increase
- $3.904 average
- Doesn't exceed VaR limit!

Slide #103 – Monte Carlo - Nymex Price
- 20-year price forecast
- 200 price simulations
- Over variety of pricing environments
- Expected PF is still optimal!

Slide #104 – Sensitivities Analysis
- 9 scenarios, at High, Base & Low-price environment
- Carbon adder impacts
- Using base price, then adding $10, $20 or $30…

Question: Was this compared with the base case price?
Answer: Yes!

Slide #105 – Nymex Monte Carlo Annual Price, including 10% carbon adder – 200 draws
- Price range here is from $2 - $14

Slide #109 – Scenario/Sensitivity Analysis ($000)
- Overall conclusion?
- Most risky is $30 per ton carbon adder

Slide #110 – Peak Day Supply Take vs Demand
- Shows how demand is served on Peak Day.
- Shows what amount from all sources is needed.
- Shows the impact of DSM.

Slide #113 - Why not use Monte Carlo AND Weather?
- We spoke with the vendor of Sendout and we can only do 1 at a time.
- If you want to get the true results using 2 variables, it works out to be 200 X 200 variables.
- 200 draws scenario takes 5 hours, so doing both MC and Weather is not time effective!

Presentation #8 – Brian Robertson
2018 IRP Timeline

Slide #114 – Timeline
- Comments are due on 12/5
- Presenting to management on 1/22

- Filing on 1/25 official filing in OR
- Deadline for IRP is 2/9/2017!

Question: It was asked if each Commission member wants a hard copy?
Answer: Lisa said there should be no less than 10 hard copies created.

Mark said feedback from stakeholders is appreciated!

QUESTIONS??:

Question: Even with a $30 carbon adder in 2037 would there still be the same demand?
Answer: We would expect that demand for gas will still be there!

Question: Are you assuming we will want a Tag 5 or, is it too early to say?
Answer: Too early to say at this time.

Question: Do we want a public meeting or a phone conference?
Answer: Lisa answered that other stakeholders who want to become involved may want a public meeting. If we have multiple questions from other stakeholders, we may need a Tag 5. We love verbal communication but written documentation is super helpful to us!

Brian Robertson thanked everyone for attending

To better facilitate our upcoming discussions, please see the recap below of Staff's comments and Cascade's initial response.

Section 3 Demand Forecast

Staff's Comments: Staff believes that Cascade's demand forecast is an improvement from past filings: In the new approach, the Company developed a normal, or expected, future weather year by shaping 30 years of weather data. Heating degree day (HDD values) were assigned to each day in the model weather year. To ensure the Company will be able to serve its firm customers during extreme weather, the Company tested the model weather year three times, each time with a unique extreme weather event. An average peak HDD (the average coldest day for each year in the last 30 years), a system-wide max peak HDD (the systemwide, single coldest day recorded in the last 30 years), and a max citygate peak HDD (the coldest HDD for each weather station in the last 30 years). Peak day demand was then derived for each weather scenario by applying the HDD to the peak day forecast for each citygate. Staff appreciates the citygate level analysis, and detailed description of the SENDOUT models and results. While the demand forecasting appears to be reasonably comprehensive, Staff's questions will be regarding whether corporate versus residential customer were treated differently, and how the decision to select particular stochastic parameters for load uncertainty were made.

Cascade's response:

1. Please clarify what is meant by "corporate" customers.
2. Does the verbiage "questions will be" mean there will be data requests? Is there anything we can address now?
3. We would like to better understand Staffs' comment about the "stochastic parameters for load uncertainty." Is this related to the Monte Carlo weather inputs?
4. Would Staff like us the expand on any of the language in Section 3?

Section 4 Supply Side Resources

Staff's comments: Cascade's gas supply portfolio is sourced from three areas of North America: British Columbia, Alberta, and the Rockies. The Company secures its gas through firm gas supply contracts and open market purchases. Cascade has contracted for storage service directly from Northwest Pipeline since 1994. Storage is held in their Jackson Prairie and Plymouth facilities. Jackson Prairie is located in Lewis County, Washington, approximately ten miles south of Chehalis. Plymouth is located in Benton County, Washington approximately 30 miles south of Kennewick. Both Jackson Prairie facilities and the Plymouth facility are located directly on NWP's transmission system. Therefore, storage withdrawal rates can be changed several times during an individual gas day to accommodate weather driven changes in core customer requirements. Staff appreciates the details provided in Section 4, as well as the efforts taken by the Company to secure supply and lease storage to reduce the risk of shortfalls in Oregon. Staff is interested in understanding if and how the Company will incorporate "peak cooling" days into the supply analysis. Staff is also interested in learning what progress the Company has made in negotiating additional storage options noted in the IRP draft, and what factors the company will consider in whether to obtain these contracts.

Cascade's initial response:

1. Please help Cascade understand why Staff is asking about “peak cooling” days as Cascade core demand has no relevant cooling related demand.
2. In the IRP, Cascade uses the word “consider” to indicate that the Company modeled various storage options as potential resources. The model results did not indicate acquiring any incremental storage at this point in time. Does Staff believe Cascade is actively negotiating additional storage? Cascade is not currently negotiating any incremental storage contracts. Is there language in the IRP that leads staff to believe Cascade is acquiring additional storage? If so, please provide Cascade with the specific language in the IRP where Staff believes the Company is currently negotiating new storage contracts.

Section 5 Avoided Costs

Staff’s comments: Cascade’s avoided cost includes fixed transportation costs, variable transportation costs, fixed storage costs, variable storage costs, commodity costs, a carbon tax, a 10% adder, and a hedge premium. Essentially, the avoided cost is the cost of the Company’s resource stack on a per therm basis plus three values for benefits specifically acquired with energy efficiency. Staff believes CNG is on the correct track with its avoided cost analysis. However, given that Cascade does not forecast a need to acquire additional storage, please clarify if Cascade can avoid its current fixed storage costs? Also, in section 4 Cascade affirmatively stated that it is considering other storage options, so Staff would appreciate clarification on the apparent contradiction. but will have questions in the initial IRP relating to why Cascade believes price elasticity must be considered. Elaborating on the sentence “if usage materially decreases with higher prices, then fewer purchases and less capital investment by an LDC would be necessary” might be helpful. Specifically, elasticity is not a variable in the $AC_{nominal}$ equation on page 5-2, so the impact of elasticity on avoided cost is not obvious. Staff would also request that CNG please provide some examples of the results. For instance, some of the carbon tax scenarios in Appendix H increase the 2018 avoided cost. It might be useful to add a discussion of how the carbon tax scenarios affect which energy conservation measures should be undertaken.

Cascade’s response:

1. Cascade appreciates Staff’s feedback on fixed storage. After checking the calculations, it was not numerically significant to include it one way or another, but Staff’s comments have certainly prompted the Company to be sure to explore this subject further during the upcoming Oregon avoided cost workshops.
2. Cascade will remove the second to last key point of section 5 and move the price elasticity discussion into a qualitative analysis in section 3. This will include a discussion with stakeholders on how to incorporate price elasticity in future IRPs.
3. Cascade will add an action item to discuss how carbon tax scenarios impact which energy conservation measures are undertaken with ETO.

Section 6 Demand Side Management and Environmental Policy

Cascade acquires therm savings through its energy efficiency programs. In Oregon, the Energy Trust of Oregon (Energy Trust) administers the Company’s programs and in Washington, Cascade administers

its own programs. In both states, the programs offer Cascade customers financial incentives to install specific cost-effective energy efficiency measures. The program savings projections included in this IRP are higher than those presented in the Company's 2014 IRP for the following reasons: 1) New measures were considered in the analysis; 2) Measure assumption were updated based on more current data; 3) Emerging technologies were included in the analysis; and 4) Updated measure saturation rates from third-party research and survey work were used. Section 6 also considers environmental policies being both enacted and considered in Oregon, Washington, and nationally. A number of initiatives intended to reduce, eliminate, or mitigate the effects of greenhouse gases on the atmosphere are in play. Carbon legislation will be a reality in a matter of time. Staff's question's and comments regarding Section 6 are related to what percentage of its energy efficiency measures does Cascade expect to be brought into cost-effective compliance in the near future, and whether and how Cascade considered seasonality of savings in its avoided costs. Staff also requests that CNG please describe the nature of the ETO's DSM projections for Cascade's Oregon service area for the period 2018-2037, including: when the projection will be updated, the review process the projection went through, and how the accuracy of the projection will be evaluated (if applicable). Please describe how the accuracy of the DSM projection affects Cascade's long-term planning. Finally, Staff requests that CNG please elaborate on the gas to electric fuel switching topic, specifically, does Cascade believe that, that topic affects its long-term planning.

Cascade's response:

1. ETO includes load profiles of selected measures that recognizes seasonality of savings. The Company will discuss this with stakeholders for possible inclusion in future IRPs.
2. Cascade performed an analysis on the impact of accelerated DSM on its resource decisions on pages 8-12 of its 2014 IRP update. Ultimately, the Company concluded that even with accelerated DSM programs there would be no change to any resource decisions made.
3. Cascade will monitor what other regional LDCs will do with regards to electrification. The Company will consider additional scenarios related to decrements to demand from electrification in future IRPs.
4. Cascade will be discussing the remainder of these questions with ETO during a supplemental teleconference.

Section 7 Resource Integration

Staff's Comments: The Company considered a host of resource alternatives that can be added to its resource portfolio, including additional conservation programs, incremental off-system storage alternatives at AECO Hub, Mist, Ryckman Creek, Wild Goose, and Gill Ranch. Additionally, incremental transportation capacity on NWP, Ruby, NGTL, Foothills and GTN pipeline systems was considered, along with on-system satellite LNG facilities, bio-natural gas, and imported LNG. Even after the savings from energy efficiency programs are realized, Cascade will need to acquire additional capacity resources or enter into other supply arrangements to meet anticipated peak day requirements, primarily due to continued growth in the Company's residential and commercial customer base. Utilizing the SENDOUT resource optimization model, several scenarios were run. Staff again has questions regarding the apparent contradiction between the stated need to acquire additional resources, and the apparent lack of consideration of such resources noted in the avoided costs section of the IRP draft. Staff's other questions are regarding the identified shortfall, and the deterministic approach the company used to foreclose on the shortfall. Particularly, why were the six selected portfolios tested? Did the Company consider alternative approaches given potential changes in

storage and supply contracts? Staff is also curious about the sensitivity limit applied by CNG. Why was 1.25 time the mean total system cost chosen, as opposed to say, 2 times? Staff also notes that table 7-2 is not very clear to read (i.e. blurry) and suggests higher resolution.

Cascade's response:

1. Cascade performed its analysis on the six portfolios presented in the IRP because the Company determined that the portfolios were a comprehensive sample of the alternative resources available on the various pipelines Cascade contracts with. Cascade presented these portfolios in its final two TAG meetings, requesting feedback from stakeholders regarding its methodology for selection of these portfolio. No stakeholders expressed concern with these portfolios.
2. Cascade's contracts are firm related to storage and supply contracts. Cascade did, however, consider extreme circumstances related to its contracts in its scenario analysis.
3. Cascade will provide additional discussion related to its upper VaR limit in the final IRP.
4. Cascade has increased the resolution of table 7-2

Section 8 Distribution System Planning

Staff's comments: Cascade's geographical information system (GIS) keeps an as-to-date record of pipe and facilities, complete with all system attributes such as date of install and operation pressure. Using the Company's geographical information system (GIS) environment and other input data, Cascade is able to create system models through the use of Synergi software. The software provides the means to theoretically model piping and facilities to represent current pressure and flow conditions while predicting future events and growth. Combining these models with historical weather data can provide a Design Day model that will predict a worst-case scenario. Design Day models that experience less than ideal conditions can then be identified and remedied before a real problem is encountered. Staff is very pleased with the DSP section and the detailed GIS analysis, and integration with Synergi modeling. Staff appreciates the Company's walkthrough of design day conditions, and the identification of enhancement projects in upcoming years. Staff would like to see more detail on how the enhancement projects align with the company's internal risk modeling. If there are any inconsistencies between the Company's risk assessment system for distribution systems, and the results of the analysis, Staff would like to know how the Company plans to reconcile these differences.

Cascade's response:

1. Please confirm what is meant by "internal risk modeling"

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.

5th External TAG Meeting

Date & time: 12/21/2017, 09:00 AM – 10:00 AM

Location: CNGC Kennewick GO

Presenters: Mark Sellers-Vaughn, Brian Robertson, & Devin McGreal

In attendance: Mark Sellers-Vaughn, Deborah Glosser – OPUC, JP Batmale – OPUC

Called in: Devin McGreal, Brian Robertson, Carolyn Stone Jeremy Ogden, Eric Wood Mike Parvinen, Bruce Folsom, Mike Clapp, Isaac Myhrum, Jay Story - GTN

Minutes by: Carolyn P Stone

Mark Sellers-Vaughn started out the meeting by stating that the goal for the day was to go over Staff comments and provide clarifications and answers to questions. He said there is no “set agenda” just review of comments. He also thanked Staff for providing good comments!

Section 3 - Demand Forecast:

- Brian asked if there will be Data Requests (DR’s) to respond to now or after the final filing?
  - Deborah stated that there will be some general questions now and likely DR’s after the official filing related to load predictions and how the factors differ.

- Mark asked, “DR’s after the final filing?”
  - Deborah answered “yes”. It is an attempt to get clarifying information only.

- Brian asked Deborah if, on Question 1, she meant commercial vs industrial (rather than corporate, as it states in the question)?
  - Deborah answered “Yes!”
  - JP said that in the past DR’s go back and forth to clarify questions, it’s not a “knock or ding” for CNGC. It takes 10 business days to negotiate once the IRP is filed. We are trying to get DR’s out to you in time!

- Brian asked about the stochastic parameters, related to the Monte Carlo runs.
  - Deborah said regarding the number of Monte Carlo runs selected, paths of distribution determines the input. She said that using a deterministic rather than a log normal distribution can distort data.

- Brian stated that there will be more language about this subject put into Section 3.

- Deborah asked why 200 runs, is this industry standard or are there other reasons?
  - Devin answered that their consultant, Jeff Baker, recommended 200, as in his experience this is a representative sample, considering the time needed for the runs, etc. Above the standard 200 “hazards” using price and weather stochastics, we would need to do 40K runs. This would be outside the time horizons and representative data.

- Deborah asked is 200 draws enough to get the information you want, and will the IRP explain the rationale behind this? More than 200 runs are not necessary but the reason why 200 we will want to talk about.
  - Mark said that Avista also uses 200 runs.
  - Deborah said she will ask Lisa about this. The Principle Component Analysis has more runs. Is this an appropriate number of runs and how to determine this? We need a little more than "someone advised us 200 runs is a good number."

Section 4 - Supply Side Resources:

- Brian went over question 1 and asked what Staff meant about "peak cooling days". He stated that there is no relevant cooling demand...no peaking demand for cooling for CORE customers
  - Mark added that there is not a spike in demand during the summer only.

- Regarding question 2, Brian answered as to how the word "consider" is used. He stated that they are getting information and modeling it to see if the Sendout model would choose the option or not. There is no additional storage being negotiated.
  - Deborah mentioned specifically Page 1.5 of the IRP. Does Cascade consider alternate resources like Mist, etc and other alternatives for Natural Gas storage. There is some confusion between resource deficiency and load resource balance figures and resource alternative additional conservation and incremental storage alternatives.
  - Devin said there was a resource deficiency in 2014. We addressed the problem by letting the Sendout model consider all alternative resources. Additional storage options were ordered to evaluate the shortfall in Oregon due to deficiencies in the prior IRP.
  - Deborah said we want to make sure we're all on the same page...i.e. if resources are needed or is it just because the Commission told you to look at them?
  - Mark stated that due to shortfalls in the IRP they modeled 5 to 6 difference storage options. None were cost effective or reliable. Ryckman Creek, for example has filed bankruptcies and has other liabilities – it is not a reliable resource. We can expand on this discussion...?
  - Deborah said that, in the next draft, they will send out a DR on this topic to get it on the record.
  - Mark said it seems like you want more detail on the analysis of alternative resources.
  - Deborah said information on the resources recognized and evaluated mainly.
  - Devin stated that Sendout allows you to test all alternative resources at the same time to gain the optimal solution. He said we could add language to make sure it is clear that storage alternatives were looked at.

Section 5 - Avoided Costs:

- Brian stated that all action items are being worked on.

- Deborah said that the resources are excellent here and well addressed.

Section 6 (skipped) - Demand Side Management and Environmental Policy:

- Brian said we will have a 2nd meeting on this topic when Allison Spector and the "ETO" representative can be here.

Section 7 – Resource Integration:

- Devin said that this discussion is similar to the item 1 issue of 200 draws – why 6 portfolios tested? He went on to say that this was used to get a good representation of what's available of different options.
  - Deborah said that she might contact Devin for further discussion via phone.

- Brian stated that they had many discussions on how to do this, however are open to other ideas.

Section 8 – Distribution System Planning:

- Brian asked what is meant by "Internal Risk Modeling"?
  - Deborah stated that CNG filed a Safety Plan through "Triage Risk". She asked was this level of analysis done on the IRP and if not, why?

- Jeremy asked is "Integrity Management" what you want?
  - Deborah answered "Yes".

End of meeting discussion:

- Brian said that was it for today for the OPUC comments, but we welcome any other questions or concerns regarding the Draft IRP!
- Deborah and JP indicated that there was lots of good work in this!
- Mark Thanked Deborah for her patience!
- Deborah said she thinks Mark's group is doing great!
- Mark said there may be a hill to climb after 2024, so……and then asked how many hard copies Deborah's group needs?
- JP teased "106 on a pallet", but then said no more than 5!
- Mark asked to please make sure we know before publishing!
- Mark also asked Deborah if they want a redlined and integrated final?
- Deborah said to send electronically and send a redline copy as well.
- JP thanked everyone!
- Deborah said she is looking forward to the final draft and addressing any questions.

Extension of 5th External TAG Meeting

Date & time: 01/10/2018, 10:00 AM – 11:00 AM

Location: CNGC Kennewick GO

Presenters: JP Batmale & Deborah Glosser – OPUC, Brian Robertson & team - CNGC

In attendance: Brian Robertson, Devin McGreal, Ashton Davis, Carolyn Stone, Isaac Myhrum, Mike Clapp

Called in: Garret Senger, Allison Spector, Teresa Hagins, Bruce Folsom, Deborah Glosser, JP Batmale, Andy Hudson-ETO, Spencer Moersfelder-ETO, Amanda Sargent, Jay Story-GTN, Brian Cunnington

Minutes by: Carolyn P Stone

Brian Robertson began the meeting with introductions. He explained that the meeting was an extension of the 5th External TAG meeting to review and discuss comments from Staff on the IRP, specifically addressing **Section 6**. Brian stated that if the ETO (Energy Trust Oregon) had any questions or there were questions from Staff we could go over those at this meeting.

Section 6 - Demand Side Management and Environmental Policy

- Andy from ETO said that they sent over comments from Staff and that Staff wanted a discussion between Cascade and the ETO.
- Andy mentioned that the ETO would like to have a better understanding and coordination with CNG.

Question 1 discussion – Savings Projection

- JP started out the discussion regarding why the savings projection was higher in this IRP than in the 2014 IRP? There are 4 reasons shown in the new IRP and Staff wanted confirmation of those reasons and to know why more savings in 2014.
    - Spencer stated that the "Cost Effective Override" (CEO) was used in the current IRP.
- JP asked what % of cost savings comes from using the CEO?
    - Spencer stated that 50 – 52% of the cost savings are due to the use of the CEO. 25% came from measures that have exceptions from Staff, tank water heaters & insulation, ex. 4 pathways for EP's and 4 iterations within those pathways.

Question: Andy asked if the CEO for savings was over 20 years?
Answer: Spender said "yes" for a full 20 years!

- Andy asked if there were other questions and Alison asked if we were approached by other utilities. Spencer said "yes".
- Brian Robertson said there were no questions from the Kennewick GO on that.

Question 2 discussion - Environmental Policies

- It was stated that environmental policies are “off the table” at this time**.**

Question 3 discussion – Emerging Technologies

- JP said that they are 1% of energy cost compliance.
- Over time, they will be cost effective.
- Avoided costs will be changing over time – additions & assumptions will be cost effective.
- JP asked if there were any more thoughts?
- Allison said she has discussed the ETO already, but if there are more questions, she encouraged us to ask!

Question 4 discussion – How the forecast has seasonality integrated into savings

- Andy stated that CNG provided them with the avoided cost value reference price of gas, transport and storage. They then take the load shapes and look at the end use (ex: residential furnace operations during winter causes price of gas to increase) and multiply the fraction of load therms per month by the price differential per month. Hot water heating has a slightly different value than furnaces.

Question: JP asked if both parties could speak to the coordination and timing of the forecast…when the project is updated and the progress of it?

Answer: Allison stated that the coordination effort is strong, “phenomenal” with ETO in developing of this section. She said there was lots of lead time, sharing our stats and outcomes back and forth. They took information to the IRP Planning Team then pulled all of it into a narrative working closely together! The finite numbers went to ETO and back with lots of coordination and lead time. There was time to review and coordinate on all sides. Mark also said that since they started the OPUC IRP process the cooperation has been good and we have a very good process!

Andy stated he agreed with this and said that first there was a kick-off meeting, then CNG provided the avoided cost calculation at a more generalized level. He said there was extra work needed on the load and stack forecast before ETO did their work. CNG did a nice job putting the forecast together based on SIC codes! We had workshops on our process and additional meetings with the CNG team. We all shared more and went deeper with the processes which gave a really good outcome!

Question: JP asked when the project was finalized?

Answer: Andy answered “July”. Mark asked Brian Robertson if that was correct. Brian said that July does sound correct. Devin added that it was exactly July 21st.

Question: JP asked if the group has talked about the next DSM updates – will they be in 2 years, i.e. July 2019?

Answer: Spencer stated that is about the right timeframe to do a 20-year forecast. It is a 2-year cycle.

Question: JP asked what the review process is for the final numbers?

Answer: Allison stated that there is a Preliminary Review that is shared with CNG. Then they give numbers to CNG and talk through it as well as hold meetings, so they understand it. There was a lot of dialogue so everyone would be on the same page!

Question: JP asked Mark if that was a good explanation?

Answer: Mark said it was a good explanation of what our internal process is. Brian explained that they take the DSM numbers and put them into the daily numbers, then put that into Sendout and treat it as "free supply" which decrements demand. We look at the DSM #'s anomalies after the Sendout runs.

Question: Deb asked what anomalies?
Answer: Brian and Devin stated errors, glitches, and correct units.

Question: Deb asked what errors were noted?
Answer: Devin said nothing jumped out whatsoever, it was "spot on"!

Question 5 discussion – Fuel Switching

- JP stated that OPUC would like to retract the comment on Fuel Switching.
- Brian said "OK".

JP said, "That's it for us"!
Brian asked if there were any further questions from ETO or Allison?
Spencer said all OK and Allison said she appreciated the time and discussion!
Mark said he appreciated Staff's flexibility in breaking up the comments sessions and Allison said she appreciated the coordination of the meeting.
Bruce said it was good discussion!
Garret thanked everyone and agreed it was good discussion.
Mark asked his team if there were any other questions at this time. Brian replied, "nothing right now".
JP thanked everyone who called in and thanked the CNG team. He is waiting for a copy of the document, but said "no rush".
Devin asked for clarification on the location and the time of the Avoided Cost Allocation Meeting.
JP replied that the location will be Portland but will get back to the group on the time.