Appendix A

IRP PROCESS

2020 OR IRP

Appendix A contains Cascade's Stakeholder Engagement document as well as Technical Advisory Group (TAG) presentations and the minutes. The purpose of the Stakeholder Engagement document is to lay out expectations that stakeholders can expect from the Company during the IRP process and vice versa. Cascade's TAG presentations and minutes can be found in this document as well as on the Company's website at: https://www.cngc.com/rates-services/rates-tariffs/oregon-integrated-resource-plan/

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

In the Community to Serve®

CASCADE NATURAL GAS STAKEHOLDER ENGAGEMENT DESIGN DOCUMENT

Abstract

This document contains the rational, assumptions, and explanation behind the Stakeholder Engagement process of Cascade's IRP Process

Table of Contents

Introduction

Cascade welcomes input from technical experts and the interested public in developing its Integrated Resource Plan (IRP). Cascade seeks to employ best industry practices and recognizes external participation can add incremental improvements.

Cascade recognizes stakeholders have a multitude of projects before them. This Design Document is intended to assist in optimizing participation by interested parties to yield a solid IRP to the benefit of customers and the Company.

Purpose

The goal of the IRP process is to produce a plan that addresses meeting long-term load giving consideration to the best combination of expected costs and associated risks and uncertainties for the utility and its customers. Cascade strongly believes this process is best accomplished with input from all stakeholders.

The purpose of this document is to align perspectives for maximizing the effectiveness, influence, and amount of contributions from stakeholders in an environment of robust workloads by all parties. The stakeholder engagement process is summarized in Box #1.

Box #1: From OPUC 5/15/18 Workshop

Principles

Cascade applies the following four principles throughout this Design Document and the overall IRP process.

- A quality stakeholder engagement process is an iterative activity that requires collaboration and commitment

- Input from diverse perspectives improves the resulting IRP
- Removing barriers to participation and communicating in clear language with solid data is critical
- Transparency, and availability of Cascade staff for associated discussions, is central to the IRP process

Context

This Design Document is provided with the understanding that some organizations (e.g., Commission Staffs) may rotate its members through its various utility's IRP processes as well as onboard new Staff. Thus, beyond memorializing Cascade's commitments, this Document can be a primer for analyst-to-analyst mutual expectations.

Cascade's perspective is to capture the benefits of interested parties' knowledge by seeking to implement best-practices of stakeholder engagement, beyond this simply being a regulatory requirement.

Mutual Expectations

The Company will commit to the following series of actions for an efficient process to enhance stakeholders' participation. In turn, Cascade hopes that participating stakeholders will agree to general expectations on their part.

<u>Cascade Commitments</u>

- The Company will provide reasonable accommodations for people with disabilities. Additionally, the Company will reasonably accommodate items such as requests for meeting locations, audio and visual capabilities, and other items requested by external stakeholders
- Publishing an annual schedule of meetings, for calendaring and coordination purposes, to be included in the workplan
- Publish a brief section that lists the recommendations from the previous Commission IRP acknowledgement
- Providing meeting materials (agenda and PowerPoint) approximately 7 days in advance of meetings
- Responding to pre- or post-meeting communication going over information of interest to stakeholders
- Offering separate workshops (e.g., forecasting, Sendout®, DSM) as requested
- Recognize that some (e.g., Commission Staffs) organizational representatives cannot bind their organizations (i.e., Commissioners) but are making best efforts to provide relevant information
- Keeping a running list of items that need to be further addressed if not directly related to the then-meeting topic or if more time is required to respond
- Allowing for open, inclusive, and balanced participation and information sharing
- Recognizing that some parties may not have the industry knowledge or the resources to devote to analyzing all aspects of the IRP and that their interest may be one of breadth

- Understanding TAG members can and should speak up if they need more information or if the time for discussion is too short and merits further discussion
- Responding to questions in a reasonable time period
- Noting when confidential information has been requested (or provided) and associated treatment
- Seeking perspectives on inputs and results of the components of the IRP
- Present information in a clear and transparent manner

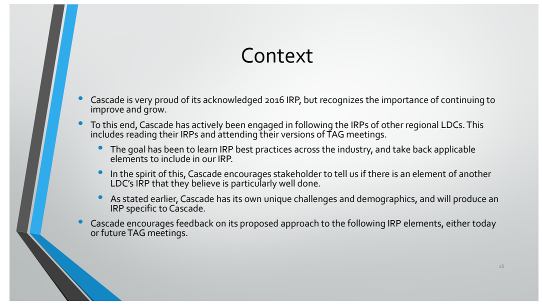
Cascade Requests of Stakeholders

- Ask questions of the Company on technical and methodological aspects
- Be a point of contact within their organization so as to distribute information to peers unless specifically requested of Cascade to provide distribution to their peers. However, if the latter occurs, Cascade respectfully requests that the designated lead analyst or organization representative respond to all Cascade requests unless directed otherwise
- By sharing information among internal colleagues, provide organizational positions, opinions, or perspectives to all stakeholders. (This is particularly relevant for organizations that have different lead analysts assigned to different companies or who have relatively new Staff members participating in any given IRP process.)
- Recognize relative informality of the meetings and ability to interject for clarification and understanding
- These requests of stakeholders are not to say, “speak now or forever hold your peace” or to put undue pressure on others’ timelines and workload; rather these are ways to maximize the effectiveness of the stakeholders’ comments, which optimizes the process. Again, comments received earlier in the process can better influence the final draft document.
- When possible, provide feedback to meeting materials in advance of the meeting, to give Company representatives time to prepare information for an informed discussion.

Desired End-Result

A well-planned and executed stakeholder engagement process would have all technical and methodological issues examined in meetings prior to parties later providing comments on the final draft document. This is the proverbial win-win-win situation. Commission Staffs and interested parties would have full understanding of the Company's data and analytical approaches. These studies can be refined through analyst-to-analyst discussions. Consideration of new approaches can be put to the forefront for current or future IRPs, based on budgets and benefit to customers. The Company benefits by gaining access to perspectives perhaps not otherwise known. Commission Staff and others may be aware of emerging policies and approaches given the breadth of their interactions with Commissioners and new issues. As Cascade strives to implement best planning practices, as depicted in Box #2, stakeholders can provide advice based on what they've seen in the industry.

Box #2: From WUTC 6/18/18 Workshop



The Company has and will continue to encourage stakeholder feedback, questions and suggestions to assist Cascade in producing an IRP that meets the regulatory requirements and Cascade's customers' needs. Cascade prefers to receive feedback as early as possible in the process (e.g., in the course of its technical advisory group meetings or soon thereafter) so that the Company has a better opportunity to address questions or analyze/apply more stakeholder suggestions. Cascade recognizes that all parties are extremely busy, but strongly believes that stakeholder participation is crucial from the outset.

The above recognizes that key analytical components of the IRP—such as the demand forecast—need to be "locked down" at least midway through the process so that resource integration can be addressed. Interested parties can best influence these components earlier, rather than later, in the process.

Conclusion

While Cascade "owns" and is responsible for the IRP, the Company desires to have involvement from stakeholders to provide a diversity of perspectives. A best practices IRP is informed by perspectives, analyses and access to concerns and approaches that the Company may not have considered. Some stakeholders participate in multiple IRP processes and have a line-of-sight that may not be available to Cascade, despite the Company monitoring other utilities' IRPs and associated processes.

Cascade recognizes parties will submit sometimes-detailed comments at the conclusion of the stakeholder involvement process in advance of Commission acknowledgement. The Company's hope is that the guidelines contained in this Document will allow stakeholders to demonstrate to the Commission their work in the final IRP while concurring with its conclusions given the parties' influence.

Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #1

August 15th, 2019

Deschutes Room at Springhill Suites

Bend, OR

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Agenda

- Introductions
- Safety Moment
- About Cascade Natural Gas
- Purpose of the IRP
- IRP Process
- Best Practices Discussion
- IRP Team
- Regional Market Outlook
- Key IRP Discussions for Future IRP Meetings
    - Load Forecast
    - Hedging
    - Avoided Cost
    - Carbon
    - Energy Efficiency
    - Renewables
    - Distribution System Planning
    - Stochastic Analysis Techniques
- Additional Items
- 2020 OR IRP Timeline
- Next Steps

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

AND TODAY WE ARE …

- Cascade Natural Gas Corp. serves approximately 293,000 customers in 96 communities – 68 of which are in Washington and 28 in Oregon. Cascade's service areas are concentrated in western and south central Washington, and south central and eastern Oregon.
- 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.

Purpose of the IRP

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Purpose of the IRP

- The purpose of an IRP is to depict the <u>overall</u> company plan more <u>transparently</u> …
  - For immediately-contemplated actions (i.e., in the next two to four years);
  - To characterize emerging issues and related approaches for mitigation, if necessary; and
  - To outline the long-term direction a company is headed *vis-a-vis* the industry, including economic trends, industry structure (partners such as the pipeline(s) and their impact/actions), technology, customer usage, etc.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

IRP Objectives

- Present a transparent roadmap of the overall corporate plan per the previous slide.
- Promote internal coordination.
- Describe to key stakeholders and the public the complex utility system unique to the local distribution company (LDC) and management decision-making processes.
- Provide previews of future projects and issues which can lead to improved regulatory filings.
- Meet regulatory requirements.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Benefits

- A company can describe its unique circumstances, opportunities and challenges over the planning horizon.
- More specifically, while commissions do not approve the IRP—and, hence future actions—the description of potential actions generally provides for an improved process of future filings, because stakeholders have a basis, in advance, for what is driving those decisions.

In Conclusion

- An IRP provides an understanding of industry and utility-specific practices.
- That the Commission acknowledges the plans, rather than approve them, does not lessen the process's regulatory importance.
- The commitment from Cascade's senior leadership has been outstanding and recognized by stakeholders.

IRP Process

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Overview of IRP Process

- Scoping
  - Work Plan, Outline, and Timeline
- Address Topical Areas
  - Studies, Analyses, and Narratives
- Gain input through iterative external engagement
- Integrate
- Draft Plan
- Final Plan

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

TAG Meetings in the IRP Process

- Cascade believes the TAG meetings are of significant value to the IRP process, and encourages as much active stakeholder participation as possible.
- Feedback from stakeholders is critical to the production of a document that clearly and effectively communicates the Company's plan to acquire the reasonable lowest cost mix of natural gas supply and conservation resources to serve forecasted demand.
- Five TAG meetings will be held, with a potential sixth scheduled if needed.
- Multiple opportunities for public participation will be made available.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Meeting Principles

- TAG meetings will be effective if…
  - Start and end on time, with participants fully present.
  - Allow for open, inclusive and balanced participation and discussions.
  - Ask questions.
  - Slides are disseminated to stakeholders in advance, and reviewed by stakeholders prior to the meeting.
  - Be clear about next steps and action items.
  - Deadlines to hit milestones are described and respected by all parties.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Importance of Milestones

- The IRP team plays an internal coordination role, assisting many departments working as one.
- This can be challenging, as each department has its own core function beyond the IRP.
- Milestones allow the Company to achieve this task while being respectful of each other's individual challenges and workload.
- The Company has critical milestones related to the completion of its load forecast, price forecast, avoided cost, and other critical processes. These often inform other parts of the IRP process, and must be met on time.

Cascade Natural Gas Corporation®
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Best Practices Discussion

Context

- Cascade is proud of its acknowledged 2018 IRP, but recognizes the importance of continuing to improve and grow.
- To this end, Cascade has actively been engaged in following the IRPs of other regional LDCs. This includes reading their IRPs and attending their versions of TAG meetings.
  - The goal has been to learn IRP best practices across the industry, and take back applicable elements to include in our IRP.
  - In the spirit of this, Cascade encourages stakeholder to tell us if there is an element of another LDC's IRP that they believe is particularly well done.
  - As stated earlier, Cascade has its own unique challenges and demographics, and will produce an IRP specific to Cascade.
- Cascade encourages feedback on its proposed approach to the following IRP elements, either today or future TAG meetings.

Key Items for Best Practices

- Welcomes input from stakeholders.
- Recognize stakeholders are busy so, therefore, seek to optimize participation (See Stakeholder Engagement Document).
- Provide for iterative and collaborative process.
- Promote gaining all perspectives.
- Reduce barriers with clear communication and data.

Cascade Natural Gas Corporation®
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Key Items (Continued)

- Create transparency with availability of Cascade staff for analyst-to-analyst discussions throughout process.
- Memorialize Cascade's commitments (per Stakeholder Engagement Document).
- Requests of stakeholders.
- Recognize important aspects, such as:
  - Cascade's need to lock down certain components early in process.
  - Stakeholders as point of contact within organization and coordinate organizational positions (as best as possible).

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

IRP Team

INTERNAL TEAM MEMBERS OF CNGC'S INTEGRATED RESOURCE PLAN:

LAST NAME	FIRST NAME	TITLE	COMPANY
Archer	Pam	Supervisor, Regulatory Affairs	Cascade
Burin	Kary	Supervisor, Conservation	Cascade
Chiles	Mark	Vice President, Customer Service and Regulatory Affairs	Intermountain
Connell	Kevin	Director, Gas Supply Utility Group	MDU
Cooley	John	Manager, Industrial Services	Cascade
Cowlishaw	Monica	Manager, Energy Efficiency & Community Outreach	Cascade
Cunnington	Brian	Manager, Industrial Services	Cascade
Davis	Ashton	Resource Planning Analyst, Gas Supply	Cascade
Folsom	Bruce	Consultant	Bruce W Folsom Consulting LLC
Goodman	Chad	System Administrator	Cascade
Hensyel	Phillip	Lead Economic Energy Efficiency Analyst II	Cascade
Krebsbach	Abbie	Director, Environmental	MDU
Martuscelli	Eric	Vice President, Operations	Cascade

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

INTERNAL TEAM MEMBERS OF CNGC'S INTEGRATED RESOURCE PLAN:

LAST NAME	FIRST NAME	TITLE	COMPANY
McGreal	Devin	Resource Planning Analyst, Gas Supply	Cascade
Mellinger	Becky	Financial Analyst	Cascade
Myhrum	Isaac	Regulatory Analyst II, Regulatory Affairs	Cascade
Offerdahl	Linda	Engineering II, Engineering	Cascade
Parvinen	Mike	Director, Regulatory Affairs	Cascade
Robbins	Chris	Manager, Gas Supply and Control- CNGC/IGC	Cascade/ Intermountain
Robertson	Brian	Supervisor, Resource Planning, Gas Supply	Cascade
Sellers-Vaughn	Mark	Manager, Supply Resource Planning	Cascade
Senger	Garret	Executive Vice President, Regulatory, Customer Service, Gas Supply	MDU
Sorensen	Renie	Manager, Engineering	Cascade
Spector	Alyn	Manager, Conservation Policy	Cascade
Stone	Carolyn	Gas Supply Analyst III	Cascade
Tyssen	Nathan	Network Administrator	Cascade
Wood	Eric	Supervisor, Gas Supply	Cascade/ Intermountain

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Regional Market Outlook

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Regional Market Outlook

- Although the market expects the Enbridge pipeline to be fully repaired by November of 2019, uncertainty regarding the timing for completion of repairs is causing instability and uncertainty in the market out to 2022 and winter Sumas prices to trade at a premium.
- Cascade's 2019 Hedge Execution Plan was presented to Cascade's GSOC (Gas Supply Oversight Committee) on July 9th. GSOC decided on a hedge level of 60% with a 5% cap on financial transactions. According to a July 16th workshop with the OPUC, Avista plans to hedge 40% and NW Natural plans to hedge 55%.
- The gas futures market indicates a bullish outlook towards natural gas pricing with August Henry Hub gas prices remaining <$2.40/MMBtu.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Regional Market Outlook (Cont.)

- Due to the US economy's continued growth and resulting confidence in the market, a number of new industrial projects have been jumpstarted in the medium term. Analysts at Wood Mackenzie claim "Stronger structural demand in North America will protect Henry Hub from further downside risk.
- According to the reference case of the EIA 2018 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 918'-1570', while the five major Oregon River Basins range from 52%-87% (2018: 52%-81%) filled.

Regional Market Outlook (Cont.)

- Jordan Cove LNG's final FERC review is due by October 11th. This final environmental impact statement will be followed by a final order set for January 9th, 2020.
- The 2019 U.S natural gas inventory injection season started at the lowest storage level since 2014 yet despite this, injections have outpaced the five-year average during the second quarter of 2019.
- GTN will potentially be having a Kingsgate south open season in the near future. Cascade has entered into a non-binding agreement to participate.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Key IRP Discussions for Future IRP Meetings

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Load Forecast

- The Company currently utilizes an Autoregressive Integrated Moving Average (ARIMA) methodology with Fourier terms to predict customer count and usage.
- Cascade uses a 60 degree reference temperature to calculate HDDs.
- Multiple scenarios are analyzed such as high/low growth, warm/cold weather, peak day events, etc.
- Cascade has continued to evaluate other potential predictors such as housing starts, but have encountered the same problem as other regional LDCs related to the availability of data to accurately reflect its service area.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Customer Forecast

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

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

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Use Per Customer Forecast

- $\text{Therms/C}^{CG,Class} = \alpha_0 + \alpha_1 \text{HDD}^{CG,D} + \alpha_2 \text{Wind}^{CG,D} + \alpha_3 I^{w} + \text{ARIMA} \in (p,d,q)$
- Model Notes:
  - Therms/C = Therms per customer; CG = Citygate; Class = Residential, Commercial, Industrial, or Interruptible; HDD = Heating Degree Days; Wind=Average Windspeed; D= Day; I_w = Indicator Variable set to 1 if it is a weekend; ARIMA$\in$(p,d,q) = Indicates that the model has p autoregressive terms, d difference terms, and q moving average terms.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Hedging

- In the 2018 OR IRP, Cascade noted that the Company was actively participating in UM 1720, Investigation into Long-Term Hedging Policy.
  - On January 18, 2018 the docket was closed.
- Cascade is actively involved with Washington Utilities and Transportation Commission (WUTC) Docket UG 132019, Inquiry into Local Distribution Companies' Natural Gas Hedging Practices and Transaction Reporting.
  - Cascade filed the 2018 Annual Hedge Plan on September 28, 2018 and received an acknowledgement letter on April 29, 2019.
  - The 2019 Annual Hedging Plan will be filed on or before August 31, 2019.

Avoided Cost

- Cascade has continued its active participation in UM 1893, Staff Investigation of Methodology and Process of EE Cost-Effectiveness.
  - Elements of Cascade's 2019 avoided cost calculation, for use in the 2020 IRP, will be informed by the workbook provided by OPUC Staff during this docket.
- In the 2020 OR IRP, Cascade will be including values for distribution system costs and risk premium as part of the total avoided cost calculation, as well as a value for the impact of peak hour, to be used in conjunction with distribution system values.
- Based on stakeholder feedback from the 2018 OR IRP and UM 1893 proceedings, Cascade will ensure that all inputs to the avoided calculation are presented as transparently as possible.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Avoided Cost Formula

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

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 = Incremental Fixed Transportation Costs
- TC_v = Variable Transportation Costs
- SC_f = Incremental Fixed Storage Costs
- SC_v = Variable Storage Costs
- CC = Commodity Costs
- C_{tax} = Carbon Tax
- E_{adder} = Environmental Adder, as recommended by the Northwest Power and Conservation Council
- DSC = Distribution System Costs
- HM = Hourly Modifier
- RP = Risk Premium

Energy Efficiency

- The IRP team is an active participant in Cascade's Conservation Advisory Group (CAG).
- The Company will continue to integrate relevant aspects of the CAG meetings in its IRP process.
- Recently passed state law HB 1257, setting new conservation program targets and mandates, will impact many aspects of the Company's energy efficiency and renewable energy efforts.
- Cascade is carefully following Docket U-190485, Investigation into Initiating Implementation Process for Energy Legislation Passed in the 2019 Legislative Session.

Carbon

- The Company will continue to operate robust energy conservation programs under the new parameters determined by HB 1257, and will also implement offset programs in compliance with the new law.
- Cascade will continue to analyze various carbon reduction scenarios in its 2020 IRP.
- The Company will determine the impacts of regional carbon policy and will model the impacts of restrictions on the use of natural gas within local communities.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Renewables

- Cascade is continuing to look at renewables as an option for long-term supplies.
- The Company has met with several biodigester developers who are trying to capture value in the current Renewable Identification Number (RIN) market. However, none of these have moved passed the discussion phase to date.
- In addition, Cascade has met with the City of Richland (WA) to discuss the possibility of capturing biogas from their landfill. They have hired a consultant to assess the feasibility of that project.
- Cascade does have a renewable tariff in Oregon. This tariff is designed for the producer, and not the end users or core customers.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Distribution System Planning

- 2020 IRP includes a discussion of the elements utilized in distribution system planning to determine needed system enhancements.
- Cascade will provide all planned OR projects and costs under confidential treatment.
- Cascade encourages stakeholder feedback related to distribution system planning.
- Cascade will be monitoring/participating in UM 2005.

Stochastic Analysis

- Cascade appreciated Staff feedback requesting further stochastic analysis in the Company's 2018 IRP.
- In the 2018 IRP, Cascade only ran stochastic analysis on the preferred deterministic portfolio.
- For the 2020 IRP, Cascade will perform Monte Carlo simulations on all potential portfolios before scenario and sensitivity testing.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Resource Integration

- Cascade will stochastically test multiple portfolios in its 2020 IRP to capture the extrinsic value of all portfolios before selecting a candidate portfolio.
- This candidate portfolio will then be tested through stochastic scenario and sensitivity modeling.
- Cascade will compare the Value at Risk (VaR) of the candidate portfolio in each scenario/sensitivity to a VaR limit to ensure that the extrinsic risk of the portfolio is within tolerable levels.
- Cascade will detail its determination of future long-term resource needs, its analysis of the expected costs and associated risks of the alternatives to meet those needs, and its action plan to select the best portfolio of resources to meet those needs.

2020 IRP Schedule

Date (Subject to change)	State	Process Element	Responsible Party	Location	Notes
Thursday, August 8, 2019	OR	TAG 1 slides distributed to stakeholders	RPT		
Thursday, August 15, 2019	**OR**	**TAG 1: Process, Key Points, IRP Team, Timeline, Regional Market Outlook, Plan for dealing with issues raised in 2018 IRP**	**RPT**	**Bend, OR - 9 am to 12 pm**	**Deschutes Room Sprinhill Suites Bend, OR**
Wednesday, August 28, 2019	OR	TAG 2 slides distributed to stakeholders	RPT		
Thursday, September 5, 2019	**OR**	**TAG 2: Demand and Customer Forecast and Non-Core Outlook, Drilling down into segments of demand forecast. NWP/GTN Present Demand Taps.**	**RPT, GTN/NWP**	**Salem, OR - 9 am to 12 pm**	**Meadow room at OPUC Offices**
Wednesday, October 30, 2019	OR	TAG 3 slides distributed to stakeholders	RPT		
Wednesday, November 6, 2019	**OR**	**TAG 3: Distribution System Planning, Planned Scenarios and Sensitivities, Alternative Resources, Price Forecast, Avoided Costs, Current Supply Resources, Transport Issues.**	**RPT/Linda/Eric W**	**Kennewick, WA - 9 am to 12 pm**	**Deschutes Room at Cascade's Kennewick General Office**
Wednesday, January 8, 2020	OR	TAG 4 slides distributed to stakeholders	RPT		
Wednesday, January 15, 2020	**OR**	**TAG 4 Carbon Impacts, Conservation (Energy Trust of Oregon), Bio-Natural Gas, Preliminary Resource Integration Results.**	**RPT/ETO/Al/Chris R/Abbie**	**Portland, OR - 9 am to 3 pm**	**Multnomah Room at Portland International Airport**
Wednesday, March 4, 2020	OR	TAG 5 slides distributed to stakeholders	RPT		
Wednesday, March 11, 2020	**OR**	**TAG 5: Final Integration Results, finalization of plan components, Proposed new 4-year Action Plan.**	**RPT**	**Salem, OR - 9 am to 12 pm**	**Meadow room at OPUC Offices**
Tuesday, May 12, 2020	OR	Draft of 2020 OR IRP distributed	RPT		
Friday, June 12, 2020	OR	Comments due on draft from all stakeholders	RPT		
Tuesday, June 30, 2020	OR	TAG 6, if needed	RPT/Other Parties	WebEx Only	
Friday, July 31, 2020	OR	IRP filing in Oregon	RPT		

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Questions/Next Steps

- Review Plans for TAG 2 Discussion
  - Demand and Customer Forecast.
  - Non-Core Forecast.
  - Pipeline Capacity Overview.
  - Next TAG is Thursday, September 5th in the Meadow room at OPUC Offices.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Natural Gas Corporation

Integrated Resource Plan
Technical Advisory Group Meeting #1

August 15th, 2019

Deschutes Room at Springhill Suites

Bend, OR

CASCADE NATURAL GAS CORPORATION

A Subsidiary of MDU Resources Group, Inc.

In the Community to Serve®

OPUC Tag Meeting 1

Date & Time: 8/15/2020, 09:00 AM – 11:15 AM

Location: Springhill Suites in Bend, OR – Deschutes Room

In attendance: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Linda Offerdahl, Bruce Folsom, Chris Robbins, Eric Wood, William Gherke

Called in: Alyn Spector, Ashton Davis, Monica Cowlishaw, Mike Parvinen, Kevin Connell, Tammy Nygard, Chad Stokes (Cable Huston), Laura Johnson (NWP), Jim Cordaro (Ruby), Mark Iverson (Ruby), Mike Paruszkiewicz (NWN), Anna Kim (OPUC)

Minutes by: Brian Robertson

Mark Sellers-Vaughn kicked off the meeting by thanking everyone that showed up. Brian went over fire safety of the building, introductions and the agenda.

- Mark gave a quick background of the history of Cascade Natural Gas.
- Brian Robertson hit on the main points of the purpose of the IRP:
  - It is a regulatory rule.
  - Transparent road map of the company's 20-year plan.
  - Promotes internal coordination.
  - Serves as a tool for other filings such as a rate case.
- Bruce Folsom discussed the IRP Process:
  - TAG meetings are very important to receive feedback.
  - Receiving feedback in a timely manner will help the current IRP.
  - Milestones are important. Beginning parts of the IRP feed the end of the IRP, if milestones are missed then it pushes back other milestones.
- Brian went over the Best Practice Discussion:
  - Pointed out that Cascade created a Stakeholder Engagement Document to be used for the IRP process.
  - Noted again that receiving feedback on a timely manner will help serve the current IRP process.
- Brian introduced and showed all the members who are a part of the internal IRP team.
- Ashton Davis discussed the Regional Market Outlook:
  - Noted the Enbridge event and the future timeline of repairing Enbridge.
  - Noted the update on the hedge level moved to 60%. William Gherke asked what the previous hedge percentage was. Ashton responded with 40%.

- Ashton also noted other information regarding other items such as the US economy, natural gas projections, Jordan Cove, and upstream GTN open season.
- Cascade then discussed Key Items that will be heavily discussed and involved in the IRP:
  - Ashton discussed the forecast model. He also expressed the difficulty of getting housing start information in our rural cities/towns.
  - William questioned the usage of wind in the use per customer model and stated that he hasn't seen it elsewhere. Ashton responded that Cascade has found it to be significant in our models. He also noted that Northwest Natural Gas uses it.
  - Devin explained the hedging process that is currently going on in Washington.
  - Devin discussed the upcoming plans for the avoided cost. Specifically, adding distribution system cost, hourly modifier, and risk premium. Anna asked if that was too much in one IRP. Devin responded that most of this work has been done within UM 1893 so it shouldn't be that much additional work. William asked about the Environmental Adder. Devin responded that the 10% environmental adder is from NWPCC power plan.
  - Alyn Spector touched on the energy efficiency slides and that Cascade is working closely with ETO. He also noted that Cascade will be analyzing various carbon reduction scenarios.
  - Chris Robbins discussed renewable natural gas and the current plans Cascade is looking into.
  - Linda Offerdahl talked about distribution system planning. She noted that Cascade will provide analysis on the Company's future projects. She also mentioned Cascade will be following UM 2005.
  - Devin pontificated on stochastic analysis and how Cascade has expanded the analysis from past IRPs. He also mentioned that Cascade will be using the stochastic analysis on multiple portfolios to ultimately come up with a preferred portfolio.
- Brian wrapped up the meeting discussing the remaining schedule.

TAG 2 will take place on September 5th, 2019 in Salem, OR at the OPUC offices – Meadow room.

The meeting was adjourned at 11:15 AM.

Cascade Natural Gas Corporation

2020 OR Integrated Resource Plan
Technical Advisory Group Meeting #2

Thursday, September 5th, 2020

Public Utility Commission of Oregon

Salem, OR

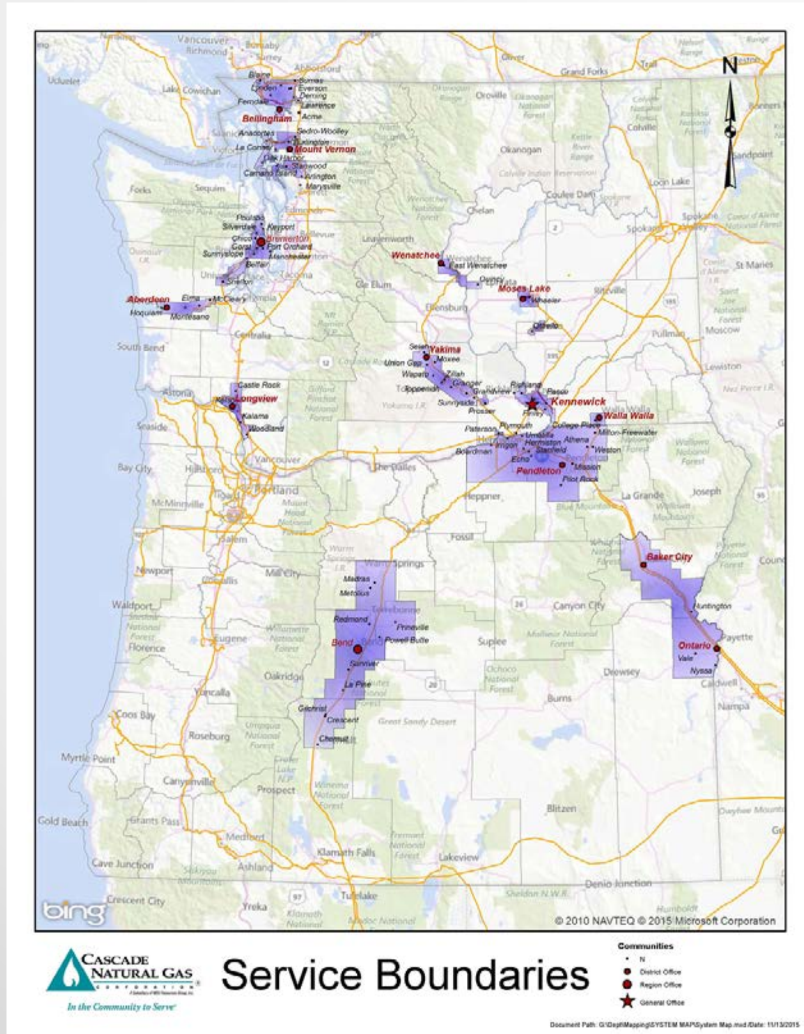
CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Agenda

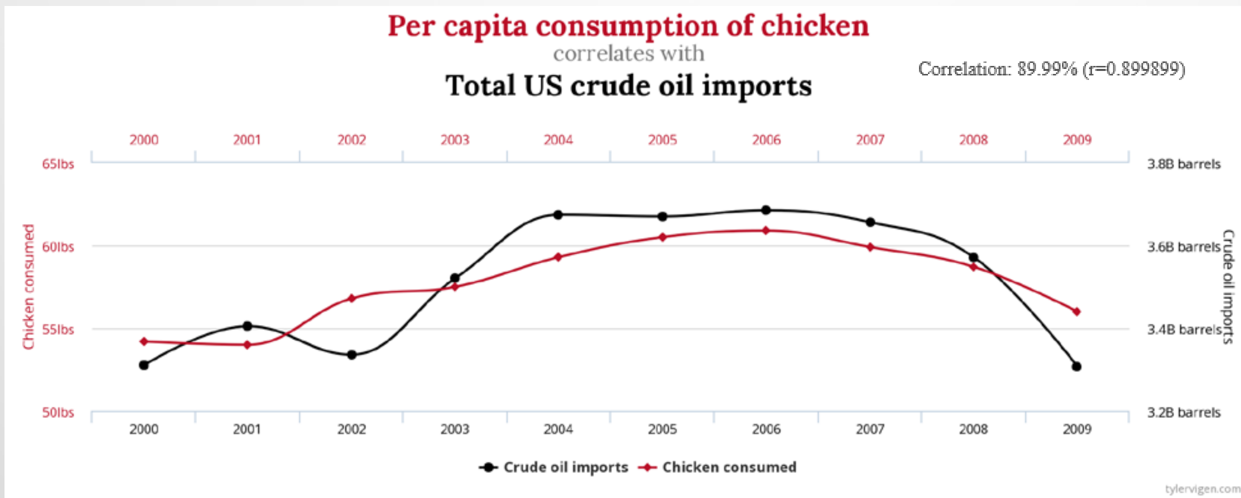
- Introductions
- Demand Forecast
- Customer Forecast
- Forecast Results
- Non-Core Outlook
- Market Outlook and Long Range Price Forecast
- 2020 IRP Remaining Schedule

Demand Forecast

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®


Service Boundaries
Cascade Natural Gas Corporation
In the Community to Serve
Communities
District Office
Region Office
General Office
Bellingham
Mount Vernon
Bremerton
Aberdeen
Longview
Wenatchee
Moses Lake
Yakima
Kennewick
Walla Walla
Pendleton
Baker City
Ontario
Bend
© 2010 NAVTEQ © 2015 Microsoft Corporation

A Little Fun with Spurious Correlations…



Demand Forecast

- The Cascade demand forecast developed for the IRP is a forecast of customers, core natural gas demand, and core peak demand for the next 20 years.
- Demand is forecasted at:
  - the citygate and citygate loop level;
  - the rate schedule level; and
  - the daily level.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Key Definitions

- AIC: The Akaike information criterion (AIC)
  - A measure of the relative quality of statistical models for a given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of the other models. Hence, AIC provides a means for model selection.
- ARIMA: Auto-Regressive Integrated Moving Average
  - Type of model that is fitted to time series data.
  - When doing regressions using time series variables, it is common for the errors (or residuals) to have a time series structure. This could mean there is a predictable structure to the errors, meaning they can also be modeled. This is where the ARIMA term comes in.
- Define weather in terms of HDDs (Heating Degree Day).
- Citygate loops are a group of citygates that service a similar area that are forecasted together due to pipeline operations.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

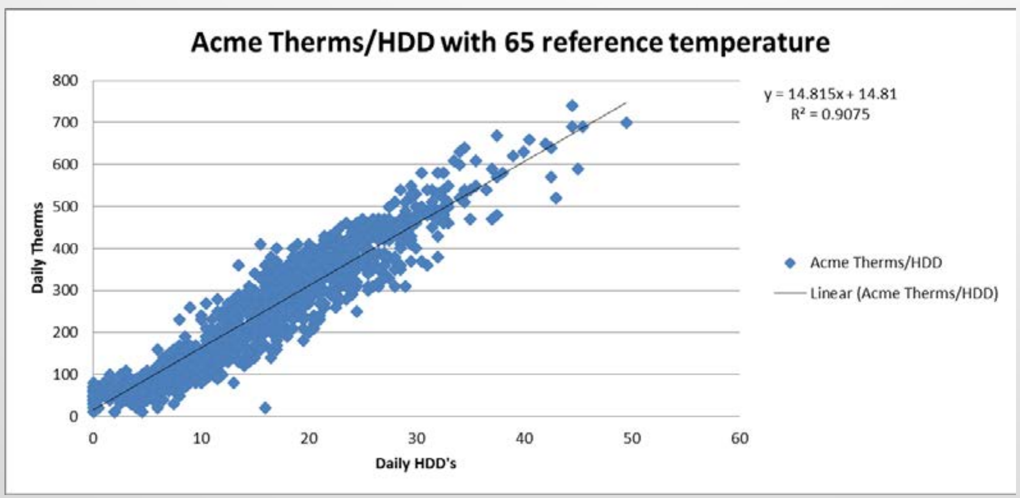
Key Assumptions

- Seven weather locations effectively cover Cascade's service territory.
- This forecast uses 30 years of recent weather history as the "normal" temperatures.
- Heating demand does not appreciatively start until average temps dip below 60° F, therefore a 60° F threshold is used to calculate heating degree days.

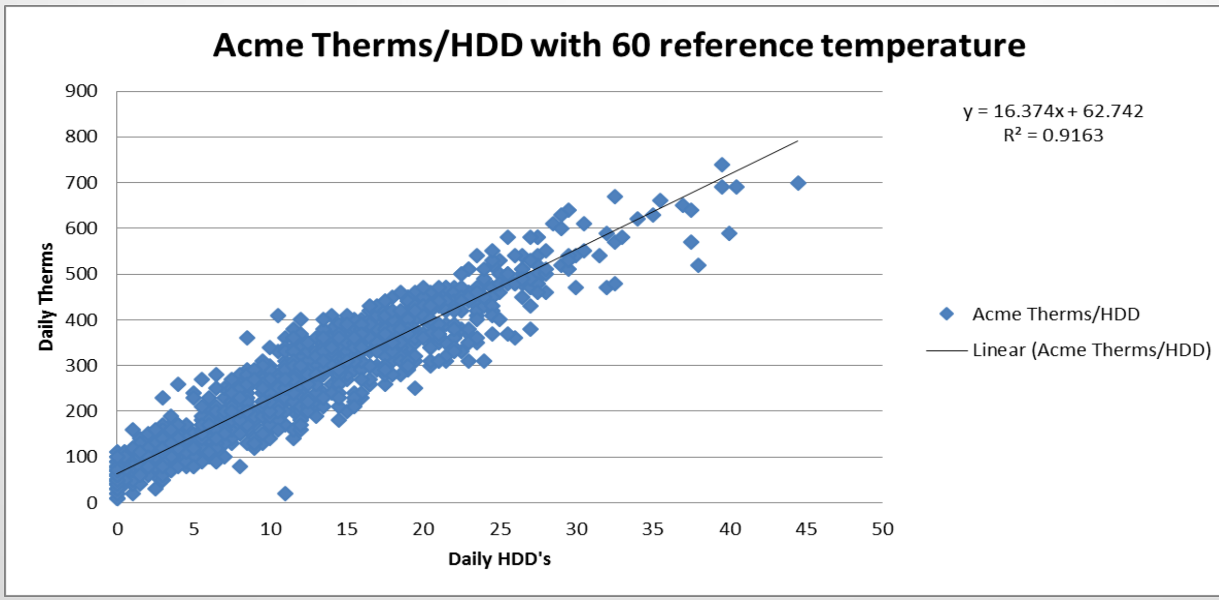
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

65 vs 60 HDD Threshold

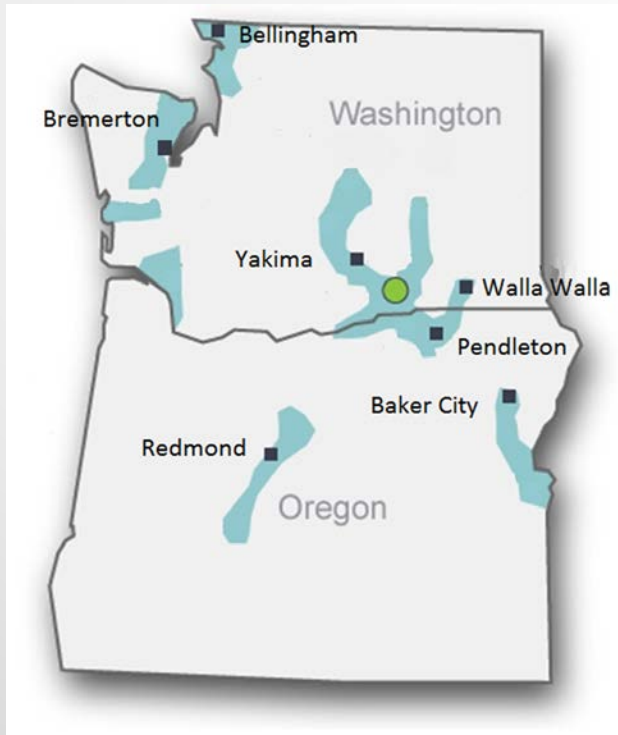
- The historical threshold for calculating HDD has been 65°F .
- It was determined that lowering the threshold to 60°F produces better results for Cascade’s service territory.
- The graph shows that heating demand does not begin to increase until an HDD of five if the traditional 65°F is utilized.



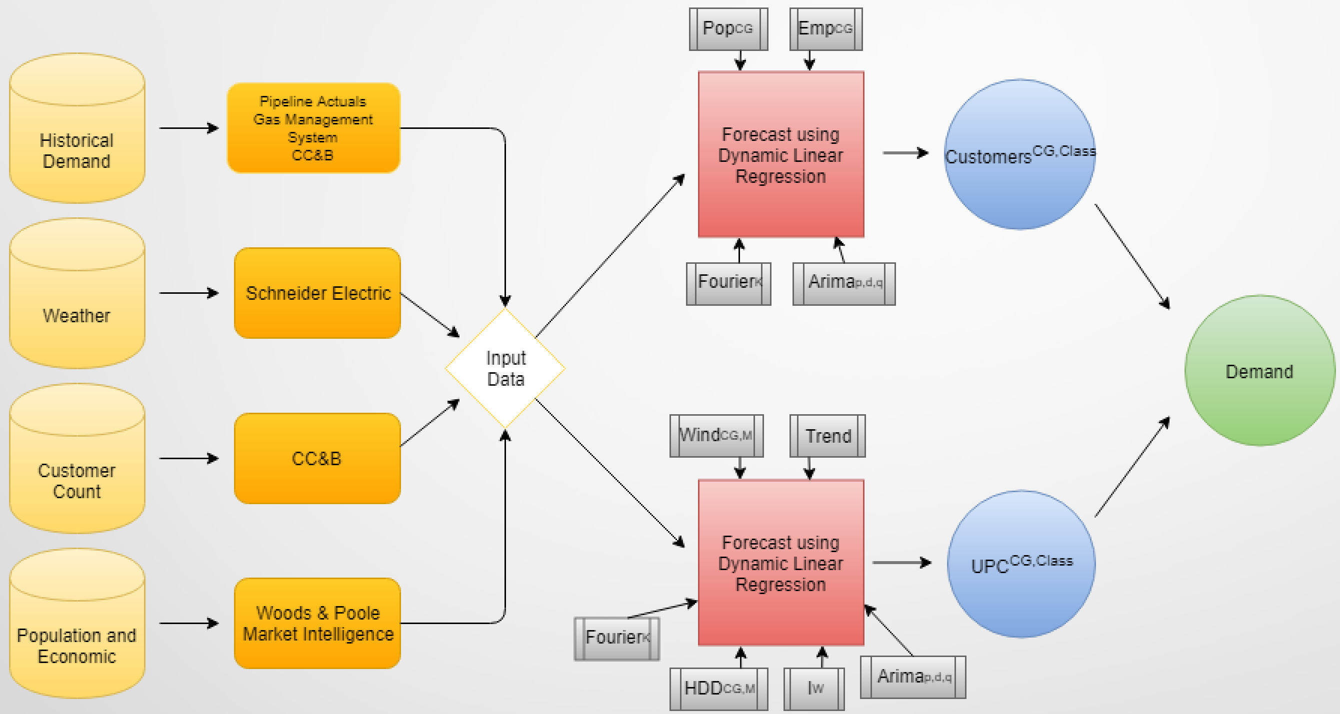
Acme Therms/HDD with 60 degree reference temperature

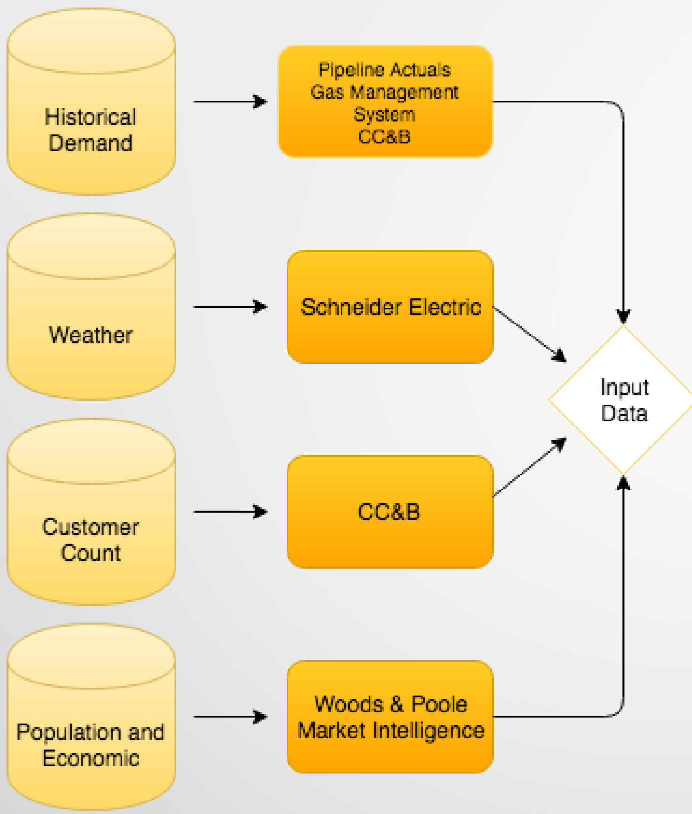


Weather Stations



Process


Historical Demand
Weather
Customer Count
Population and Economic
Pipeline Actuals
Gas Management System
CC&B
Schneider Electric
CC&B
Woods & Poole Market Intelligence
Input Data
Pop CG
Emp CG
Forecast using Dynamic Linear Regression
Fourier K
Arima p,d,q
Wind CG,M
Trend
Forecast using Dynamic Linear Regression
Fourier K
HDD CG,M
Iw
Arima p,d,q
Customers CG,Class
UPC CG,Class
Demand

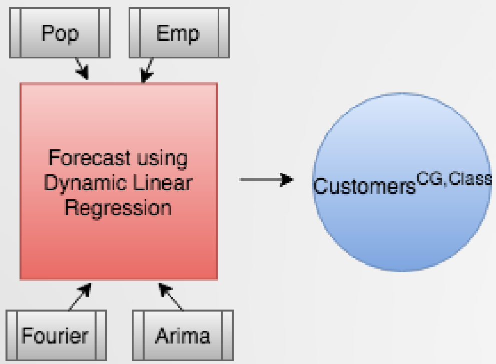


Inputs

- Pipeline actuals at Citygate level.
- Woods & Poole at county level.
- CC&B citygate allocations

Customer Forecast

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®



Customer Forecast

- $C^{CG,Class} = \alpha_0 + \alpha_1 Pop^{CG} + \alpha_2 Emp^{CG}$ + Fourier(k)+ ARIMA$\in$(p,d,q)
- Model Notes:
  - C = Customers; CG = Citygate; Class = Residential, Commercial, Industrial, or Interruptible; ARIMA$\in$(p,d,q) = Indicates that the model has p autoregressive terms, d difference terms, and q moving average terms; Pop = Population; Emp = Employment; Fourier(k) = Captures seasonality of k number of seasons.

Customer Forecast Inputs

CC&B Data

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

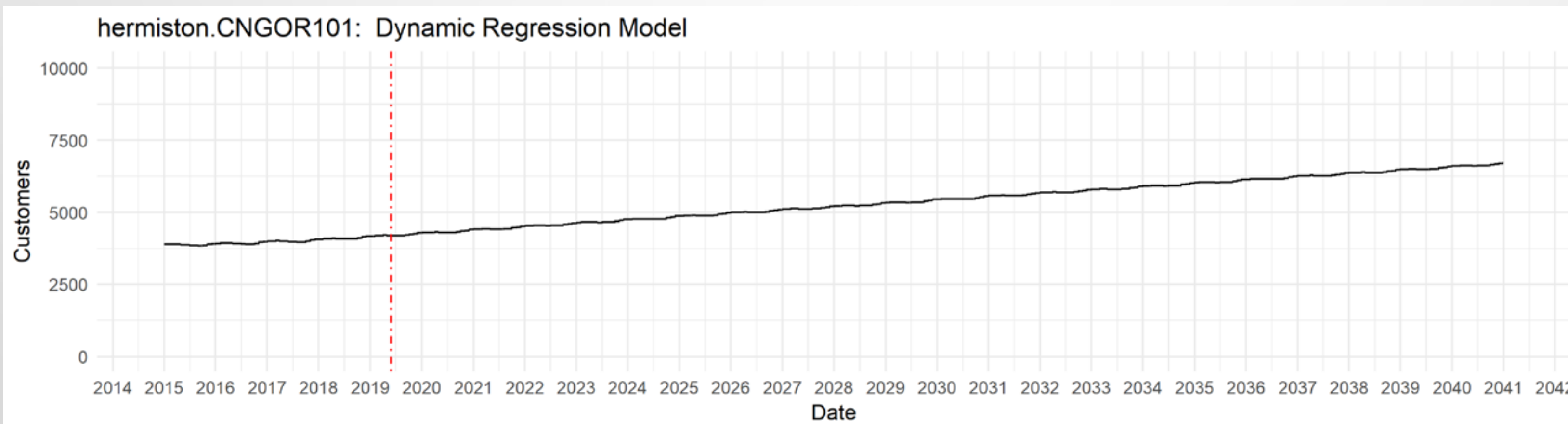
Acctg Year	Acctg Mon	Gate (Loop)	Rate	Number of Prem
2019	2	Bend/South Bend	CNGOR104	144
2015	2	Pendleton/Pilot Rock	CNGOR104	64
2018	8	Ontario/NYSSA/Vale	CNGOR101	5
2015	7	Hermiston	CNGOR101	4
2018	5	Mission	CNGOR104	18
2018	8	Gilchrist Cresent	CNGOR101	78
2016	5	Ontario/NYSSA/Vale	CNGOR104	19

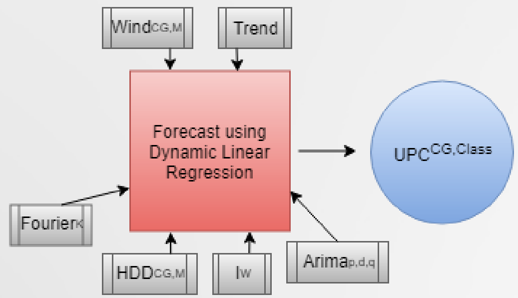
Model Selection

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

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Customer Forecast





Use Per Customer Forecast

- $\text{Therms/C}^{CG,Class} = \alpha_0 + \alpha_1 HDD^{CG,M} + \alpha_2 I_w + \alpha_4 WIND^{CG,M} + \text{Trend} + \text{Fourier}(k) + ARIMA \in (p,d,q)$
- Model Notes:
  - Therms/C = Therms per customer; CG = Citygate; Class = Residential, Commercial, Industrial, or Interruptible; HDD = Heating Degree Days; M= Month; I_w = Indicator Variable set to 1 if it is a weekend; T = Trend Variable increasing by 1 for each day forecasted; WIND = Daily average wind speed.

Bend Loop 101: $\text{Bend Loop 101} = \alpha_0 + \alpha_1 HDD^M + \alpha_2 I_W + \alpha_4 WIND^M + \text{Fourier} + \text{ARIMA}$

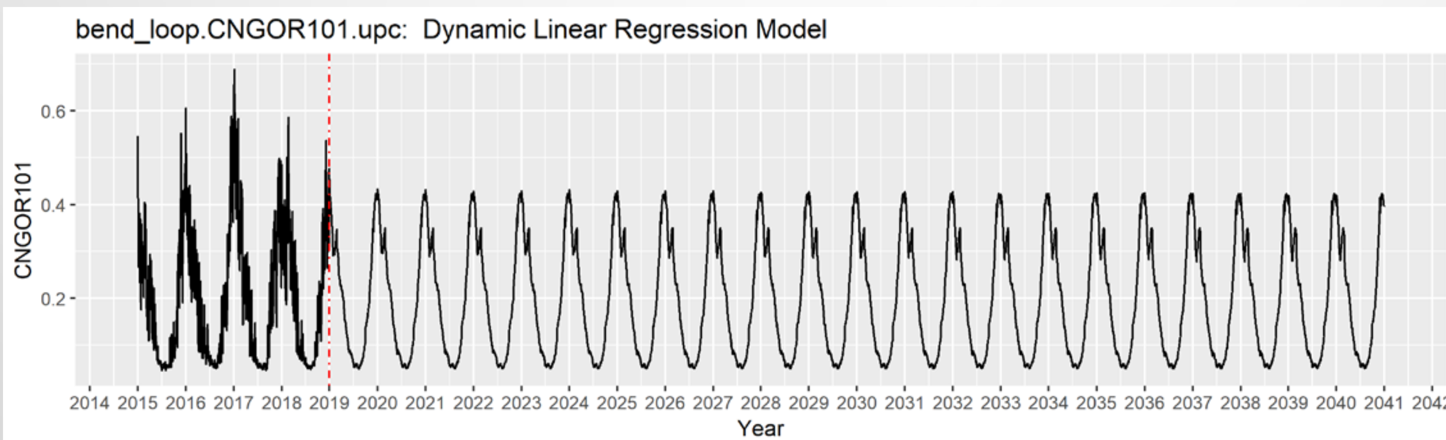
Aggregated.Locations	Year.Month.Day	CNGOR101	weekend	jan.hdd	feb.hdd	...	nov.hdd	dec.hdd	jan.wind	feb.wind	...	nov.wind	dec.wind
bend loop	1/1/2015	0.31838107	0	41.5	0	...	0	0	3	0	...	0	0
bend loop	1/2/2015	0.380307614	0	39	0	...	0	0	2	0	...	0	0
bend loop	1/3/2015	0.266972209	1	38.5	0	...	0	0	2	0	...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

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

UPC Forecast Results

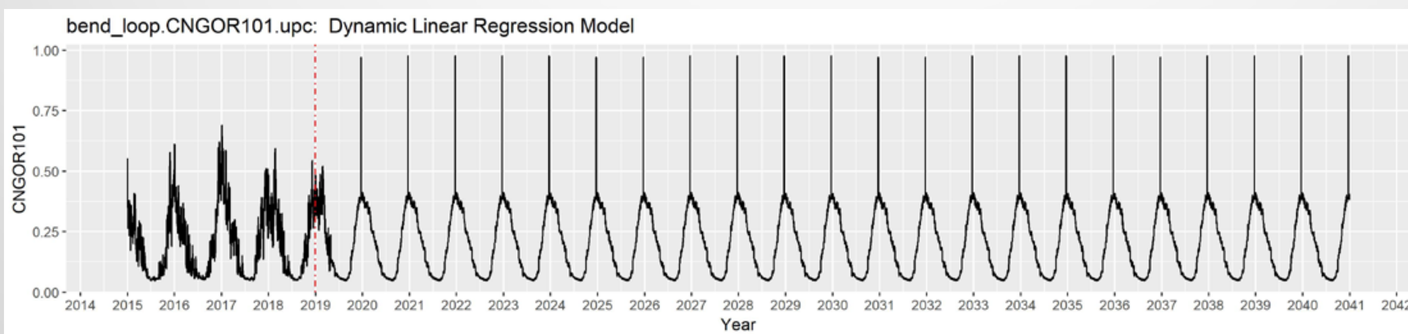
ar1	ar2	ma1	ma2	ma3	intercept	weekend	jan.hdd	feb.hdd	mar.hdd	apr.hdd	may.hdd	jun.hdd	jul.hdd	aug.hdd	sep.hdd
0.3960	0.5076	0.0884	-0.4618	-0.2056	0.1107	-0.0061	0.0068	0.0075	0.0071	0.0063	0.0056	0.0036	0.0027	0.0021	0.0027

oct.hdd	nov.hdd	dec.hdd	jan.wind	feb.wind	mar.wind	apr.wind	may.wind	jun.wind	jul.wind	aug.wind	sep.wind	oct.wind	nov.wind	dec.wind	S1-365	C1-365	S2-365	C2-365
0.0046	0.0065	0.0066	0.0024	0.0034	0.0028	0.0035	0.0013	0.0007	0.0002	0.0005	0.0006	0.0014	0.0003	0.0005	0.0052	0.0686	-0.0089	0.0233



Peak Day Use-Per-Customer

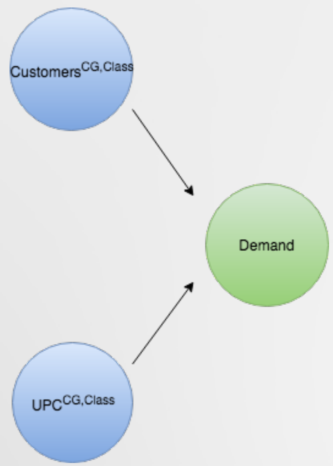
- Peak HDD: Coldest in past 30 years for each weather zone
- Peak Scenarios: Plan on running other scenarios such as 5-day peak event, 3-day peak event, coldest in 20 years, and various Monte Carlo percentiles.



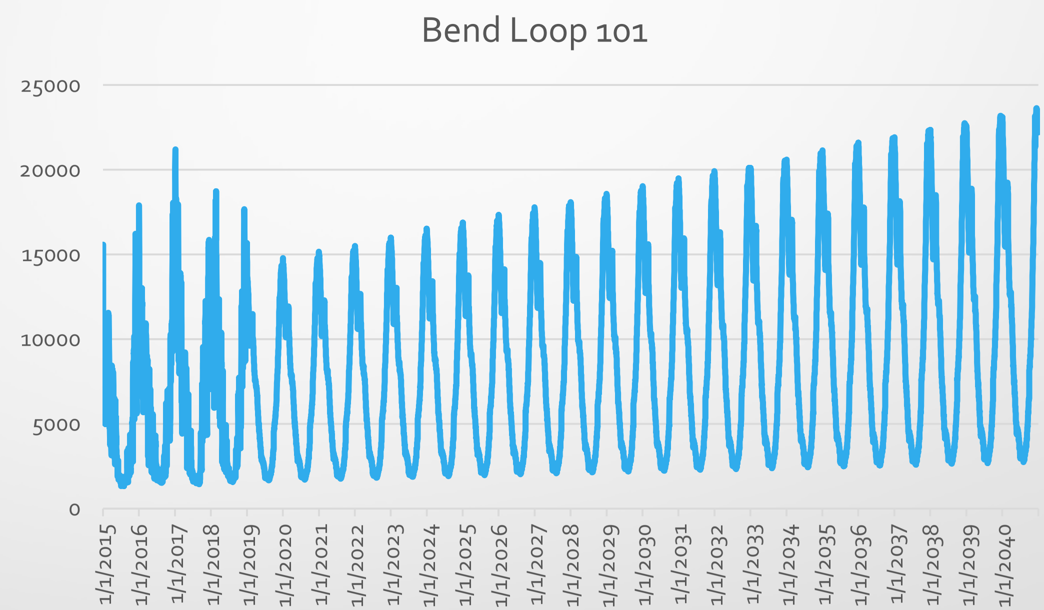
Forecast Results

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Final Demand Calculation



Gate	Date	UPC	Customers	Demand
Bend Loop	1/1/2020	0.434164028	34044	14780.68017
Bend Loop	1/2/2020	0.432175189	34044	14712.97213
Bend Loop	1/3/2020	0.430100149	34044	14642.32947
Bend Loop	1/4/2020	0.424571854	34044	14454.12419
Bend Loop	1/5/2020	0.42228356	34044	14376.22153
Bend Loop	1/6/2020	0.423215137	34044	14407.93612
Bend Loop	1/7/2020	0.420633918	34044	14320.0611



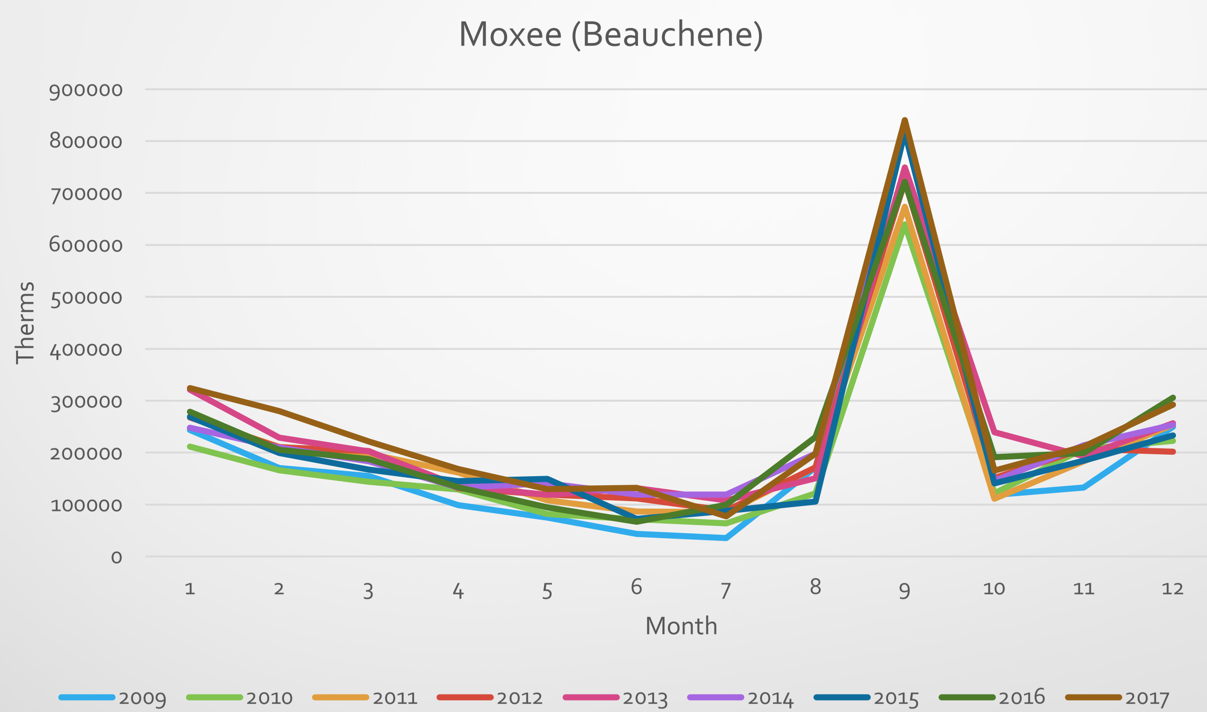
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

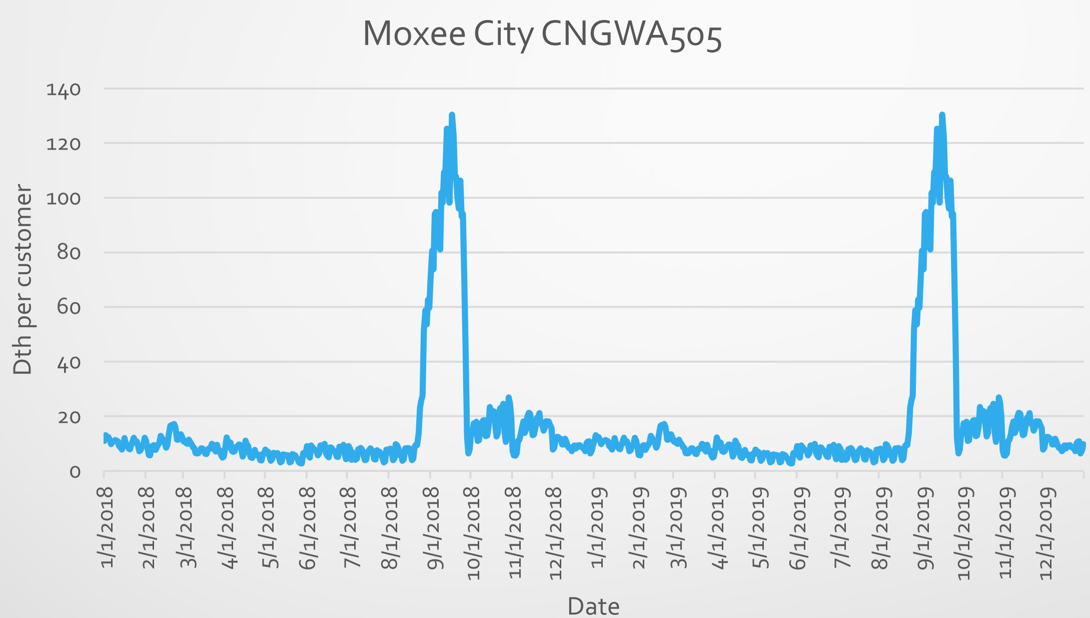
Non-Weather Dependent Demand

- Demand that is not influenced by weather.
- Typically caused by a customer who ramps up production based on the time of season.
- Previously, demand was removed prior to running the use per customer vs. weather analysis.
- Now using monthly coefficients, Cascade can run the analysis while leaving the non-weather demand in.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Moxee (Beauchene)




Moxee City CNGWA505
Dth per customer
0
20
40
60
80
100
120
140
1/1/2018
2/1/2018
3/1/2018
4/1/2018
5/1/2018
6/1/2018
7/1/2018
8/1/2018
9/1/2018
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
Date

(20
20)

Low Customer Growth Areas

Citygate	Growth
milton-freewater	0.00%
mission	0.00%
chemult	0.03%
huntington	0.03%

- Milton-Freewater is a city in Northcentral Oregon. The city has a recent job growth of -0.2%.[1] The city only has 0.3% working in the real estate profession, while the US is at 1.9%. The city has approximately the same number of customers today that it had in 2004.
- Mission is a census designated place in Northcentral Oregon near Pendleton. The area has a recent job growth of -0.18%.[1] The area only has 0% working in the real estate profession, while the US is at 1.9%. The area has seen a growth of .3% over the past 5 years.

[1] According to bestplaces.net

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Low Customer Growth Areas (Cont.)

Citygate	Growth
milton-freewater	0.00%
mission	0.00%
chemult	0.03%
huntington	0.03%

- Chemult is a city in Central Oregon approximately 65 miles south of Bend. The area has a recent job growth of -0.36%. [1] The area only has 0% working in the real estate profession, while the US is at 1.9%. Cascade's Chemult customers have fluctuated between 43 and 49 customers since 2004 and currently has the same number of customers as it did in 2005.
- Huntington is a city in Eastern Oregon near Baker City. The city has a recent job growth of -0.64%. [1] The city only has 0% working in the real estate profession, while the US is at 1.9%. Huntington has had a growth rate of 0% since 2007.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

High Customer Growth Areas

Citygate	Growth
Pronghorn	4.35%
Umatilla	3.53%
North Bend	3.41%
Redmond	2.88%
Prineville	2.45%
Bend Loop	2.27%
La Pine	2.26%

- Bend recently approved an urban growth plan that is projected to allow for the development of 2,380 acres of land. In October 2018, four developers on Bend's westside successfully negotiated a development agreement for the planning and development of more than 1,000 homes on 383 acres.
- The city of Umatilla, in conjunction with the cities of Echo and Stanfield, are in the process of executing the recommendations of their 2019 West Umatilla County Housing Study. During its August 13th Planning Commission meeting, the city discussed amending its zoning ordinances to address current future housing needs, as discussed in the Study. In 2018 the city experience a spike in permits for new homes from 17 in 2017 to 56 in 2018, a 329% increase.
- Redmond continues to be one of the strongest housing markets in Central Oregon. Home sales volume in Redmond increased by over 12% in the second quarter of 2019 year over year, while 85 new homes were built in the second quarter. The City's Planning Commission recently completed a Housing Grant Project for the Redmond Housing Needs Analysis and Buildable Lands Inventory. According to the analysis, approximately 7,000 housing units are needed over the next 20 years.

High Customer Growth Areas (Cont.)

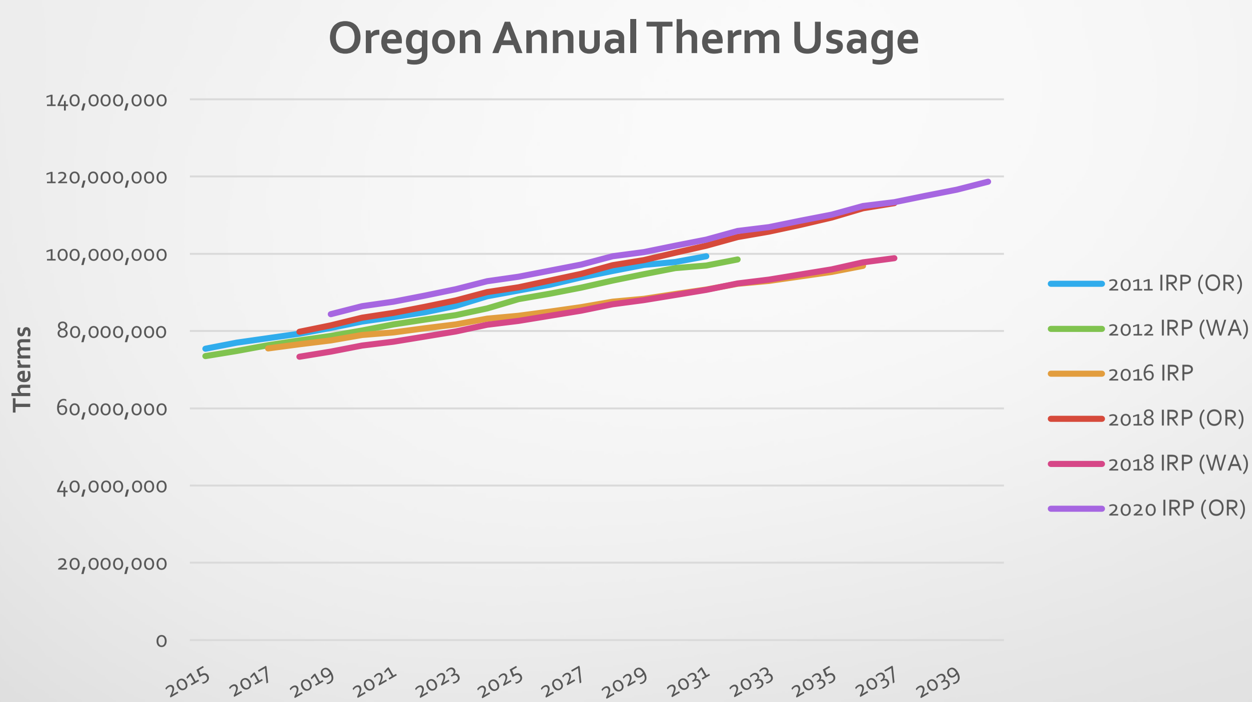
Citygate	Growth
Pronghorn	4.35%
Umatilla	3.53%
North Bend	3.41%
Redmond	2.88%
Prineville	2.45%
Bend Loop	2.27%
La Pine	2.26%

- Prineville is a major tech hub within central Oregon. In a recent ranking of the top 10 micropolitan areas, Prineville ranked 4th with 3.5% growth year over year. Additionally, in late September 2018, Facebook announced it will be spending $750 million to build two more data centers on the outskirts of Prineville. This will add as many as 100 jobs to the city, increasing Facebook's investment in Prineville to around $2 billion.

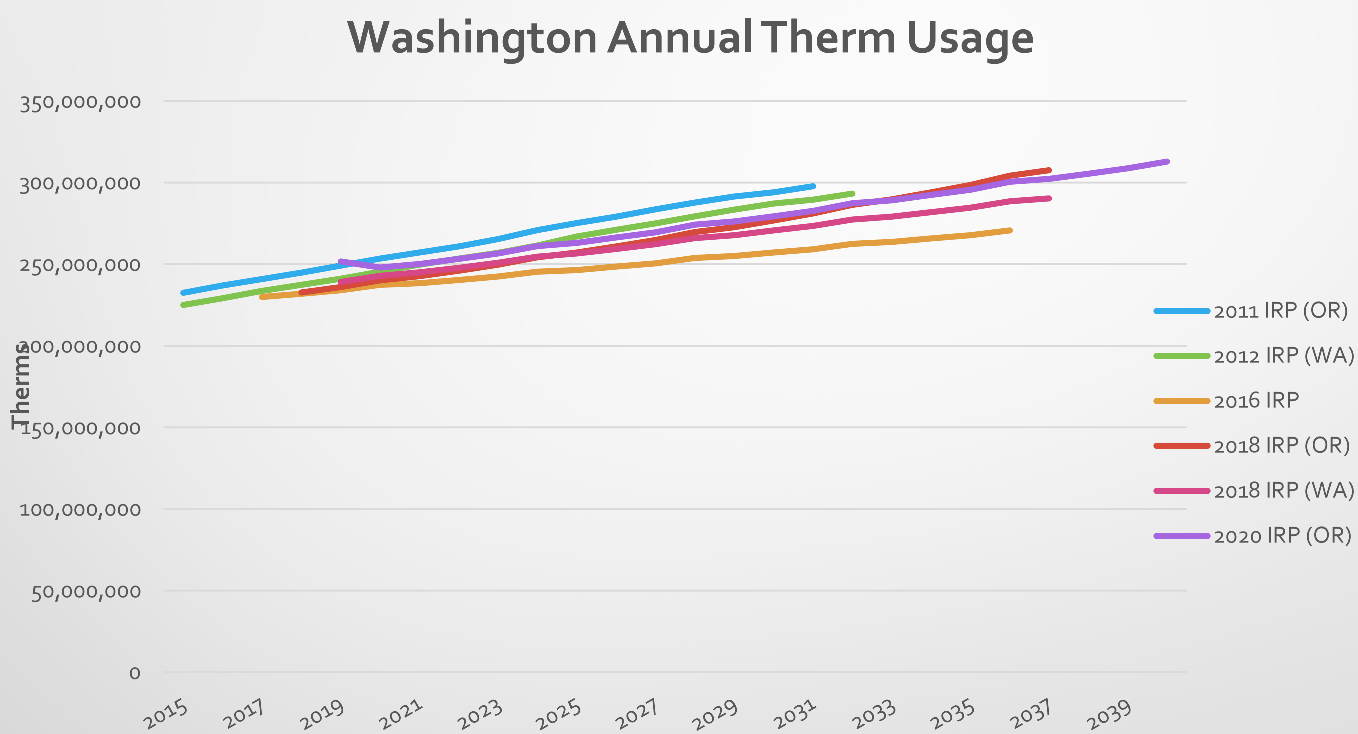
- Much of the growth around La Pine is centered around the fact that it has only recently become incorporated as an actual city. After incorporation in late 2007, the region added 400 new jobs from 2010-2017, and approximately 20 to 25 new businesses during the first half of 2018 alone

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

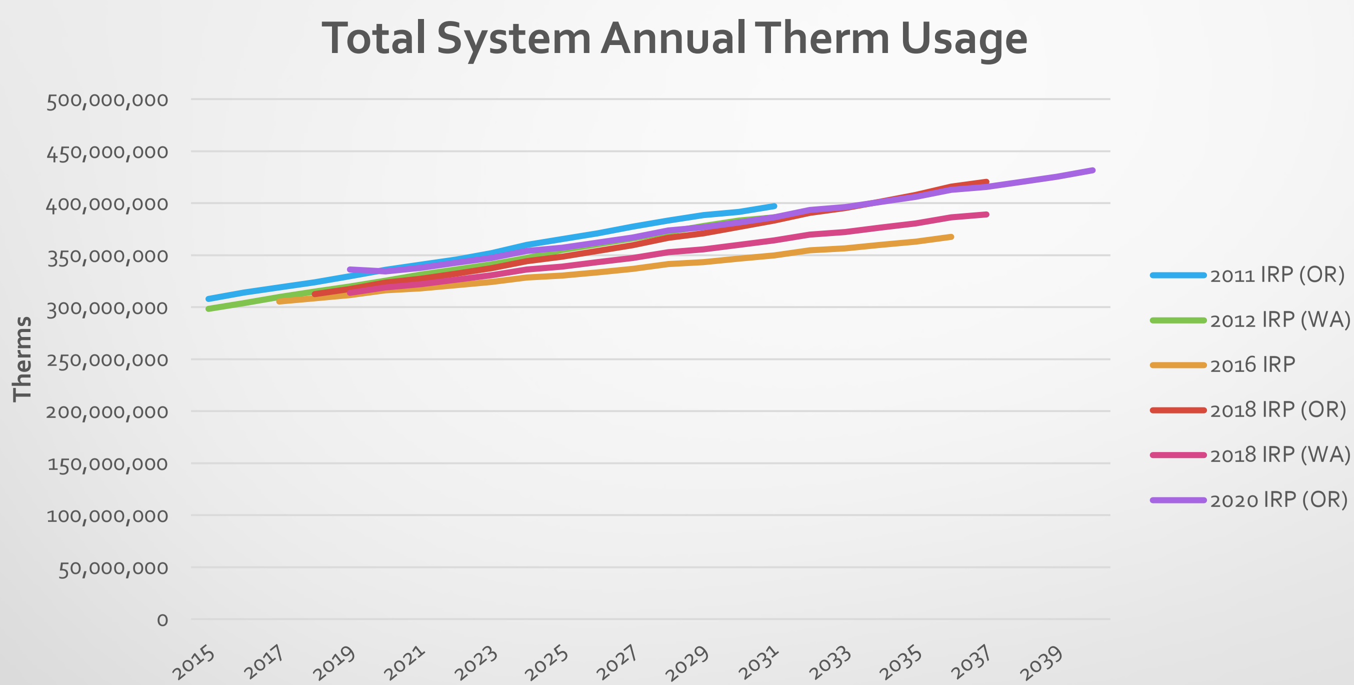
Oregon Demand



Washington Demand



Total System Demand



Non-Core Outlook

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Non-Core Outlook

- Cascade forecasts the non-core for five years.
- Unlike the core, non-core (or transportation) customers are customers who schedule and purchase their own gas, generally through a marketer, to get gas to the citygate. The customer then uses Cascade's distribution system to receive the gas.
- Cascade's transportation customers include all types of industrial customers. It includes farms that may not use any gas during the winter to food manufacturers that average 800,000 therms per month throughout the year.
- Cascade also serves an electric generation customer in Oregon. Since there is only one customer, the forecast must remain confidential.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Transportation Customers

- Cascade's transportation customer forecast increased by three from the previous forecast. The current forecast projects the customer count to be 40 in 2020 with plans to bring on 5-8 new customers over the next five years. Cascade's industrial managers are working closely with potential industrial customers.
- Cascade's projection increased by 2.5 million therms from the previous forecast. The increase is mainly a direct result from the new customers added.
- Cascade projects the transportation customers in Oregon to consume approximately 60 million therms in 2020.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Electric Generation

- Cascade also serves an electric generation customer in Oregon. Since there is only one customer, the forecast must remain confidential.
- Cascade doesn't anticipate bringing on additional electric generation over the next five years.
- Washington passed SB 5116 which would require that non-emitting electric generation and electricity from renewable resources supply one hundred percent of all sales of electricity to Washington retail electric customers by January 1, 2045. Essentially, this would phase out Washington electric generation customers that Cascade would serve.

Non-Core Forecast

- Transportation customers in Oregon forecast to use 63.5 million therms in 2020.
- Transportation customers in Washington forecast to use 498 million therms in 2020.
- Electric Generation customers forecast to use 390 million therms in 2020.
- Non-Core total forecast for 2020 is approximately 951 million therms.

Market Outlook and Long Range Price Forecast

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Long Range Market Outlook

- Natural gas consumption in the residential and commercial sectors remains largely flat because of efficiency gains and population shifts that counterbalance demand growth. [1]
- Natural gas prices that are relatively low compared with historical prices lead to growing use of natural gas across most end-use sectors.[1]

Long Range Market Outlook (Cont.)

- Natural gas production from shale gas and tight oil plays as a share of total U.S. natural gas production continues to grow in both share and absolute volume because of the sheer size of the associated resources, which extend over nearly 500,000 square miles, and because of improvements in technology that allow for the development of these resources at lower costs. [1]
- Natural gas prices in the AEO2019 Reference case remain lower than $4 per million British thermal units (Btu) through 2035 and lower than $5 per million Btu through 2050 because of an increase in lower-cost resources, primarily in tight oil plays in the Permian Basin, which allows higher production levels at lower prices during the projection period. [1]

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Long Range Price Forecast

- Cascade's long-term planning price forecast is based on a blend of current market pricing along with long-term fundamental price forecasts.
- The fundamental forecasts include sources such as Wood Mackenzie, EIA, the Northwest Power and Conservation Council (NWPCC), Bentek and the Financial Forecast Center's long-term price forecasts.
- While not a guarantee of where the market will ultimately finish, Henry Hub NYMEX is the most current information that provides some direction as to future market prices.
- Wood Mackenzie's long-term forecast is at a monthly level by basin. Cascade uses this to help shape the forecast's monthly basis pricing.
- 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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Long Range Price Forecast (Cont.)

- 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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Price Forecast Weights

- Considerations in weight assignments:
  - Cascade has modified its weighting system based on an analysis of the symmetric mean absolute percentage error (SMAPE) of its sources since 2010;
    - Wood Mackenzie (monthly, covers all basins)
    - EIA (industry barometer, annual long term)
    - NPPC (regional perspective, but recognize it is also a blend)
    - NYMEX Henry Hub
  - EIA is the only source who produces a forecast after 2037.
  - Some sources produce forecasts daily, while others are far less frequent.
    - Cascade uses an age dampening mechanism to account for this in its price forecast, reducing the impact of forecasts that do not account for more current market information.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

SMAPE to Weights

- SMAPE = |(Actual – Forecast)/((Actual + Forecast)/2)|
- Cascade calculates the weight of the inverse of the SMAPEs of each source, which are then smoothed using Holt-Winters smoothing.

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

Example of SMAPE Calculations by Source

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

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Price Forecast Weights

- In Months T+1 to T+15, Cascade uses NYMEX Forward pricing for all locations exclusively;
  - For short term forecasting, the marketplace is ideal because forward prices should reflect all current events that impact the forecast (weather, storage, etc.)
  - Long term forecasting is more concerned about the fundamental market intelligence, which is reflected in the analysis of Cascade's sources.
- Months T+16 to T +40 are used to interpolate the weights from exclusively NYMEX to the weights calculated from each source's SMAPE.
- Months T + 41 onward use the age dampened weights of each source.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Example Weights Price Forecast For 2020 IRP (Not Interpolated)

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

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Example Weights Price Forecast For 2020 IRP (Interpolated)

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

2020 IRP Remaining Schedule

Wednesday, October 30, 2019	OR	TAG 3 slides distributed to stakeholders	RPT		
Wednesday, November 6, 2019	**OR**	**TAG 3: Distribution System Planning, Planned Scenarios and Sensitivities, Alternative Resources, Price Forecast, Avoided Costs, Current Supply Resources, Transport Issues.**	**RPT/Linda/Eric W**	**Kennewick, WA - 9 am to 12 pm**	**Deschutes Room at Cascade's Kennewick General Office**
Wednesday, January 8, 2020	OR	TAG 4 slides distributed to stakeholders	RPT		
Wednesday, January 15, 2020	**OR**	**TAG 4 Carbon Impacts, Conservation (Energy Trust of Oregon), Bio-Natural Gas, Preliminary Resource Integration Results.**	**RPT/ETO/Al/Chris R/Abbie**	**Portland, OR - 9 am to 3 pm**	**Multnomah Room at Portland International Airport**
Wednesday, March 4, 2020	OR	TAG 5 slides distributed to stakeholders	RPT		
Wednesday, March 11, 2020	**OR**	**TAG 5: Final Integration Results, finalization of plan components, Proposed new 4-year Action Plan.**	**RPT**	**Salem, OR - 9 am to 12 pm**	**Meadow room at OPUC Offices**
Tuesday, May 12, 2020	OR	Draft of 2020 OR IRP distributed	RPT		
Friday, June 12, 2020	OR	Comments due on draft from all stakeholders	RPT		
Tuesday, June 30, 2020	OR	TAG 6, if needed	RPT/Other Parties	WebEx Only	
Friday, July 31, 2020	OR	IRP filing in Oregon	RPT		

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

ADDITIONAL QUESTIONS?

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

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

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

Ashton Davis – Resource Planning Analyst I: (509) 734-4520
ashton.davis@cngc.com

Bruce Folsom - Consultant

Cascade Natural Gas Corporation®
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Natural Gas Corporation

2020 OR Integrated Resource Plan
Technical Advisory Group Meeting #2

Thursday, September 5th, 2020

Public Utility Commission of Oregon

Salem, OR

OPUC Tag Meeting 2

Date & Time: 9/5/2020, 09:00 AM – 10:45 AM

Location: OPUC Offices in Salem, OR – Meadow Room

In attendance: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Ashton Davis, Anna Kim (OPUC), Dan Kirschner (NWGA), Connor Reiten (NWGA), Teresa Hagins (NWP)

Called in: Eric Wood, Kevin Connell, Carolyn Stone, Monica Cowlishaw, Bruce Folsom, Linda Offerdahl, Mike Paruszkiewicz (NWN)

Minutes by: Brian Robertson

Mark kicked off the meeting by thanking everyone that showed up. Brian asked Anna to explain fire safety of their building.

- Brian went through introductions and the agenda.
- Brian shared a map of Cascade's service territory and explained how spread out the service territory was.
- Ashton discussed the demand forecast and key assumptions regarding the demand forecast.
    - o Explained different statistics used to measure the accuracy of each model.
    - o Explained how Cascade calculates HDDs.
    - o Shared the seven different weather locations.
- Ashton then explained Cascade's process for the use per customer and the customer forecasts with multiple flow charts.
- Ashton then described the customer forecast process further.
    - o Anna asked if we were able to explain each Fourier term and Ashton responded saying yes.
- Ashton then described the use per customer forecast process further.
- Ashton talked about how Cascade, in the past, has used the coldest day in past 30-year history. Cascade mentioned looking at monte carlo scenarios for replacing the 30-year history methodology. Other stakeholders discussed using longer duration for cold weather modeling. Cascade has agreed to take a further look at long duration cold events.
- Brian discussed the forecast results as well as a non-weather dependent model and the result of those as well.
- Brian then went through some of the city's experiencing low growth as well as city's experiencing high growth.

- Brian shared the results of the forecast compared to past forecasts.
- Anna asked how new customer usage is modeled compared to older customers since newer customers usually have lower usages (more efficient houses). Brian explained the difficulties of determining the exact amount but it's definitely something on Cascade's radar.
- Brian gave an overview of the non-core outlook for Cascade. He explained how the non-core could impact the core through rate schedule changes.
- Devin discussed the market outlook and long-range price forecast.
- Devin explained how Cascade weights the different forecast sources and how we age dampen some of the forecasts.
- Brian asked if there were any questions regarding Cascade's LC-69 2018 IRP Update filing. Anna said she did not have any questions.
- Brian also asked if there were questions regarding the stakeholder engagement document and there were no questions.
- Brian then explained that Cascade needs to lock down the forecast model so any issues with the forecast model need to be brought up as soon as possible. Anna asked Cascade to discuss with ETO to ensure they understand what they are receiving when we send out forecast model.
- Brian wrapped up the meeting discussing the remaining schedule.

TAG 3 will take place on November 6th, 2019 in Kennewick, WA at Cascade's General Office Deschutes room.

The meeting was adjourned at 10:45 AM.

Cascade Natural Gas Corporation

2020 Integrated Resource Plan
Technical Advisory Group Meeting #3

Wednesday, November 6th, 2019

Cascade's Offices in Deschutes Room

Kennewick, WA

CASCADE NATURAL GAS CORPORATION

A Subsidiary of MDU Resources Group, Inc.

In the Community to Serve®

Agenda

- Introductions
- Ruby Presentation
- Distribution System Planning
- Cascade Gas Supply Overview
- Planned Scenarios and Sensitivities
- Alternative Resources
- Price Forecast Results
- Avoided Cost Methodology and Calculation
- 2020 IRP Remaining Schedule

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Ruby Pipeline Overview

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Distribution System Planning

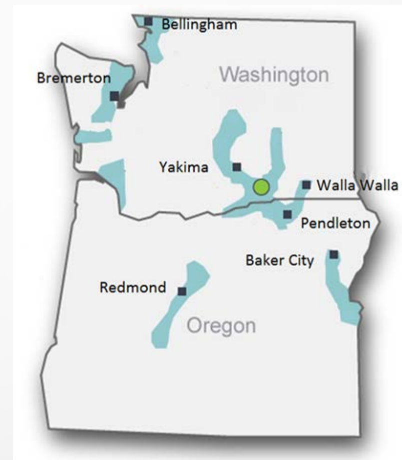
Linda Offerdahl, PE – Engineer II

Technical Advisory Group

November 6th, 2019

Summary

- System Overview
- Software Tools
- Data Gathering
- Synergi System Model
- Distribution Enhancement Options
- Project Process Flow
- Future Projects



System Overview

Pipelines:

- 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

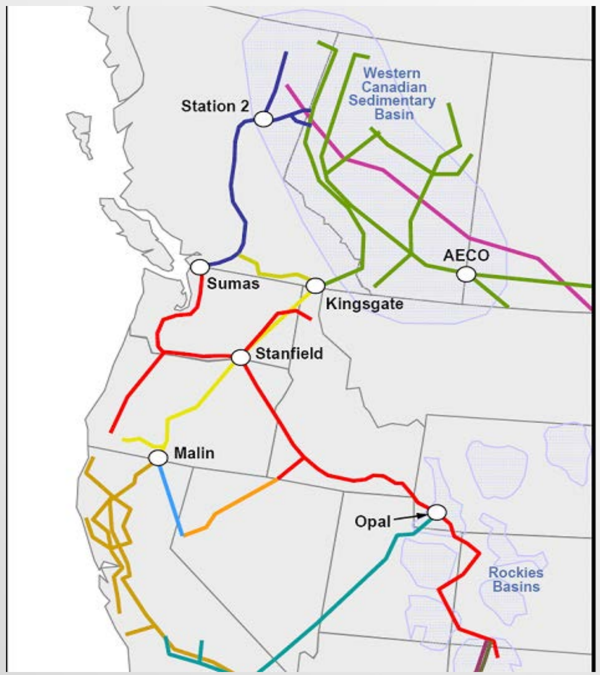
System Overview

Facilities:

- Regulator stations – Over 700
- Valves – Over 1,600
- Other equipment such as heaters, odorizers and compressors

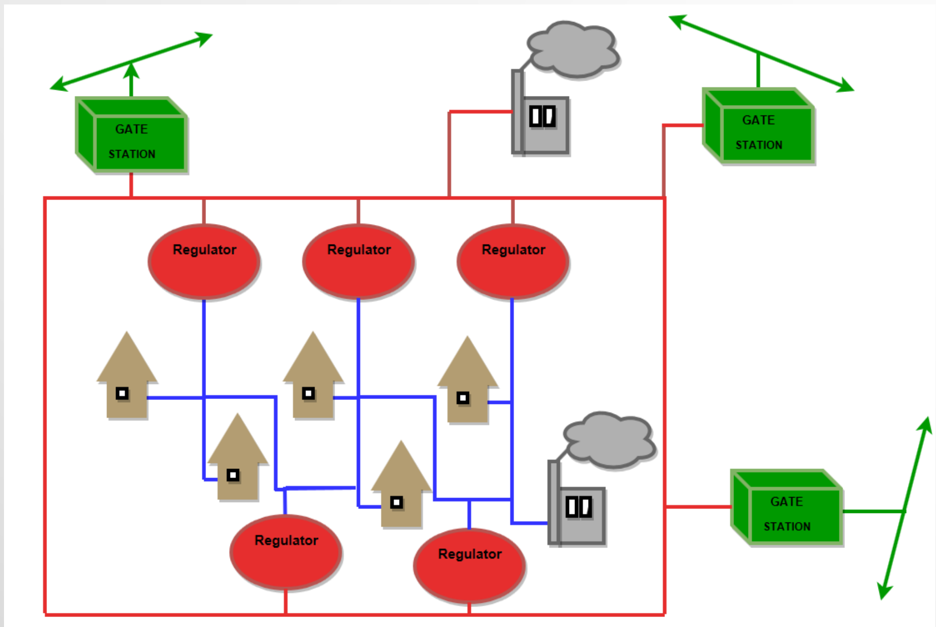
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Where do we get our gas?



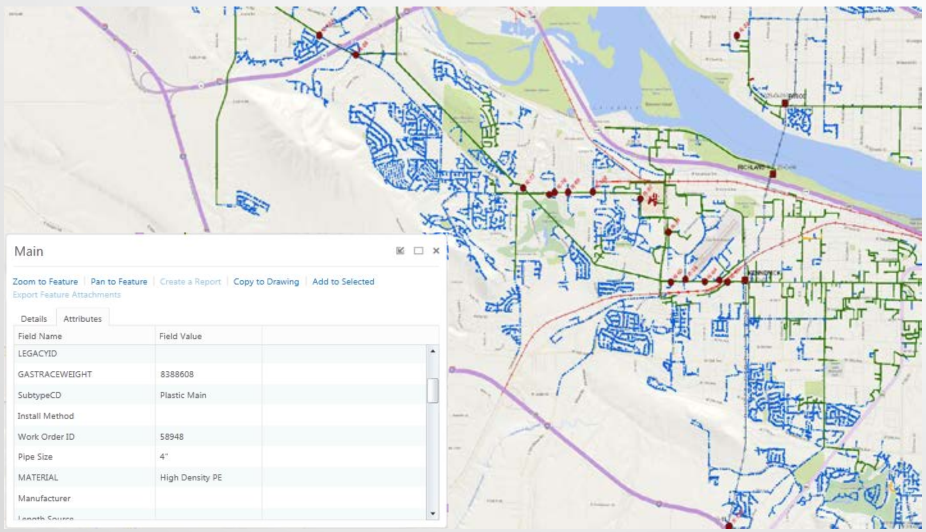
- Many interstate pipeline companies
- Williams Northwest Pipeline (red)
- TransCanada Pipelines (yellow)

Network Design Fundamentals



GIS – Geographic Information System

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



System Modeling

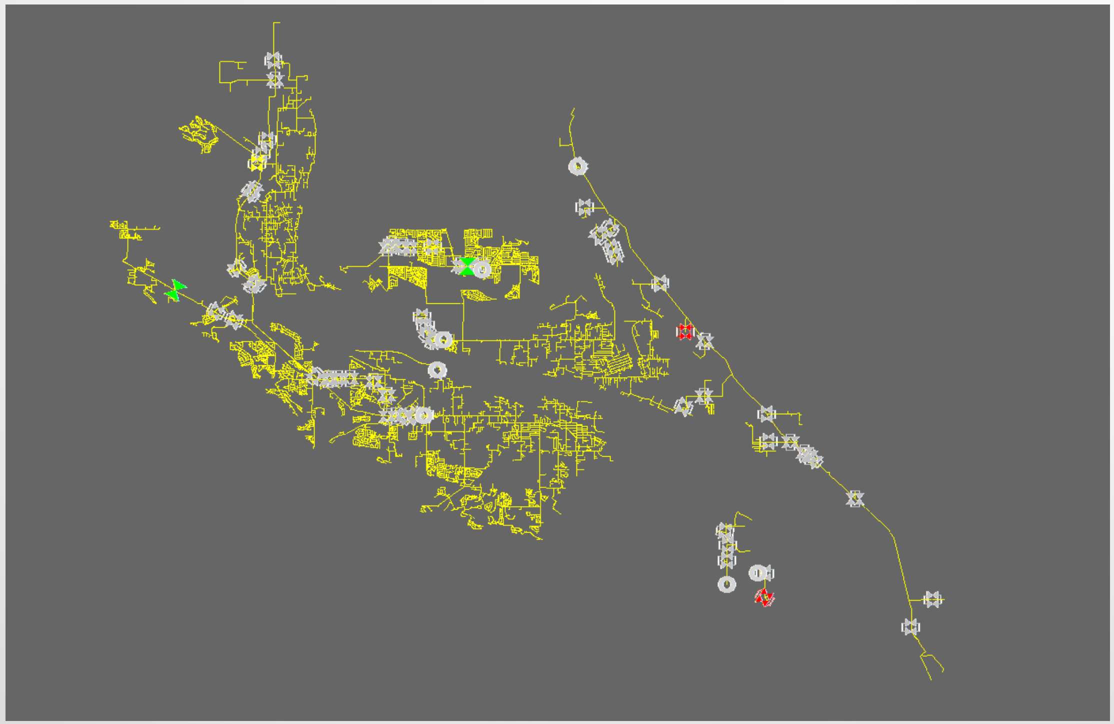
- Using internal GIS environment and other input data, CNG is able to create system models through the software – Synergi.

What is Synergi?

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

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

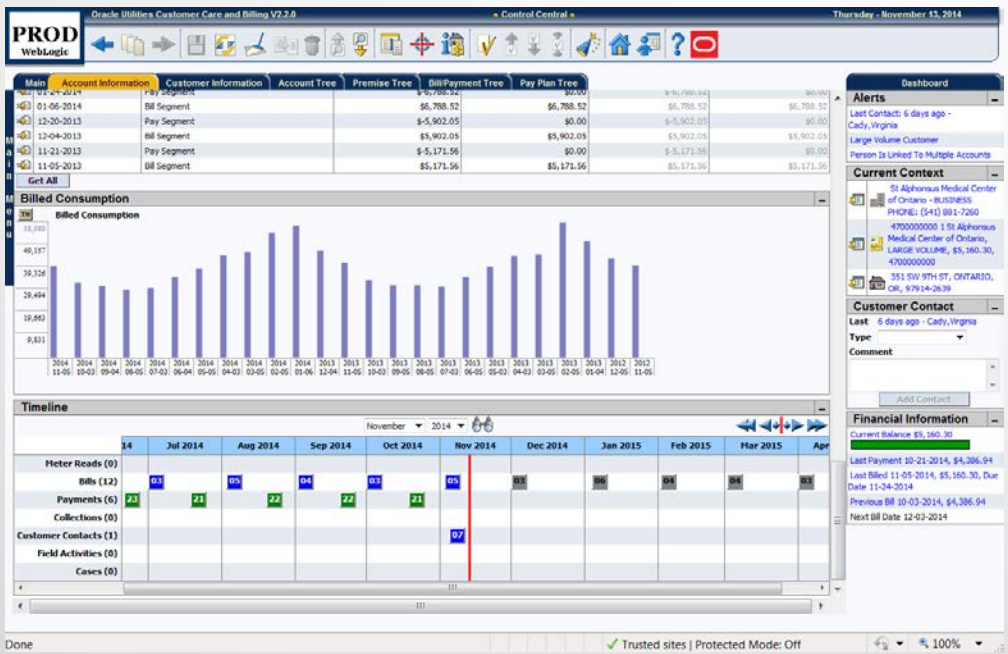
Synergi Model Example



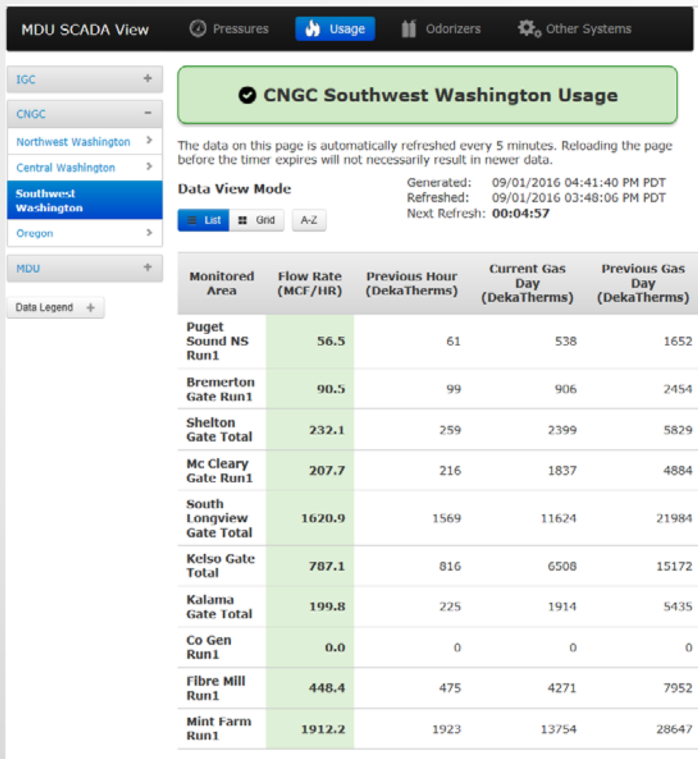
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Data Gathering

- CC&B (Customer Billing Data)



Data Gathering



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

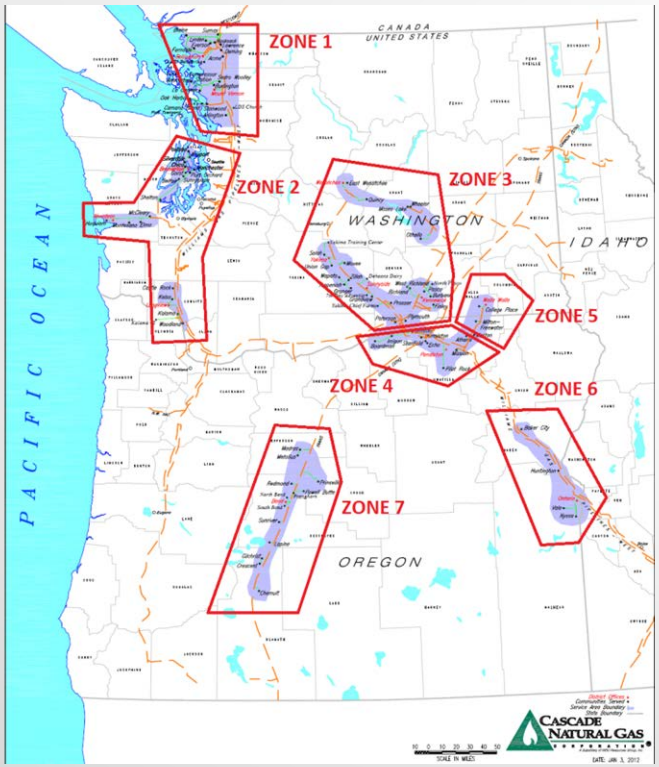
Data Gathering

- IRP Customer Growth

	Bend Loop		Madras		Stearns	
	Customers	Growth	Customers	Growth	Customers	Growth
2020	38,727	-	1,669	-	3,960	-
2021	39,808	2.79%	1,702	1.98%	4,003	1.09%
2022	40,888	2.71%	1,735	1.94%	4,046	1.08%
2023	41,968	2.64%	1,768	1.90%	4,089	1.07%
2024	43,048	2.57%	1,801	1.87%	4,133	1.06%
2025	44,128	2.51%	1,834	1.83%	4,176	1.04%
2026	45,208	2.45%	1,867	1.80%	4,219	1.03%
2027	46,288	2.39%	1,900	1.77%	4,262	1.02%
2028	47,368	2.33%	1,933	1.74%	4,305	1.01%

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Data Gathering



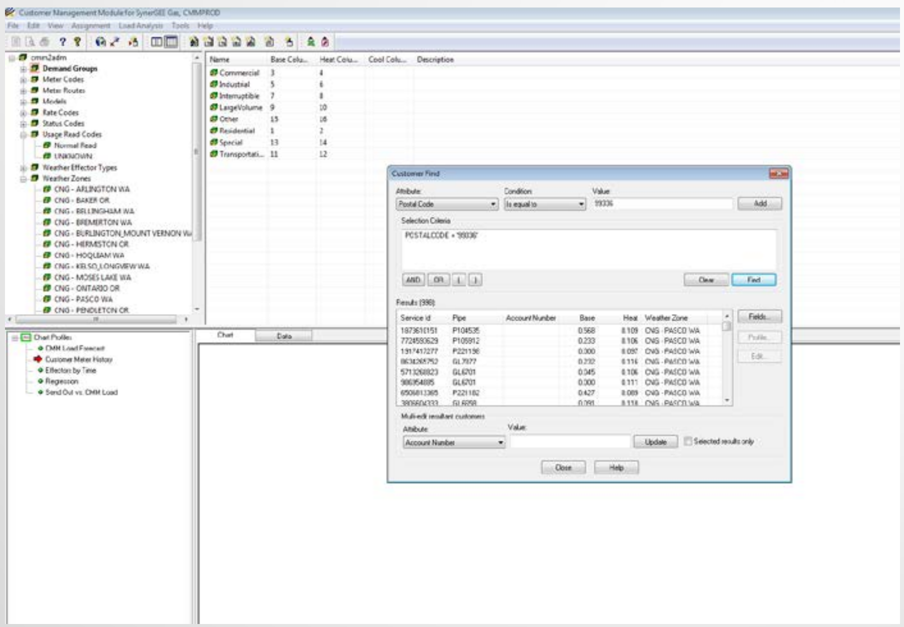
- Peak Heating Degree Day (HDD) modeled by CNG weather zone based on historical weather data

  Peak HDD = 60 – Average Daily Temp

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

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Customer Management Module (CMM)



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

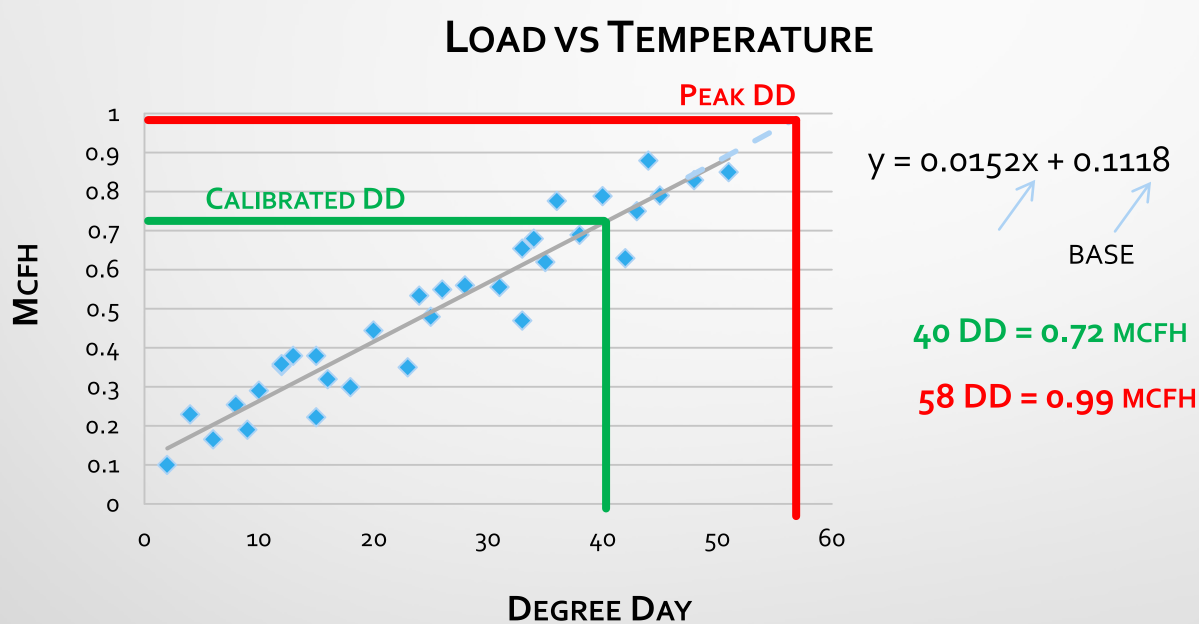
CMM → Synergi System Model

- 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 event (worst case scenario).
  - Growth Model – Uses design day model along with growth data to predict future projects.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Calibrated vs Peak Degree Day

- Different loads will be applied to each customer



Synergi System Model

- 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 distribution enhancement options

Distribution Enhancement Options

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

Pipeline Enhancements

Pros

- Reliable capacity
- Low maintenance
- Permanent

Cons

- Can be expensive
- Potential land acquisition and/or permitting issues

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Compressor Stations

Pros

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

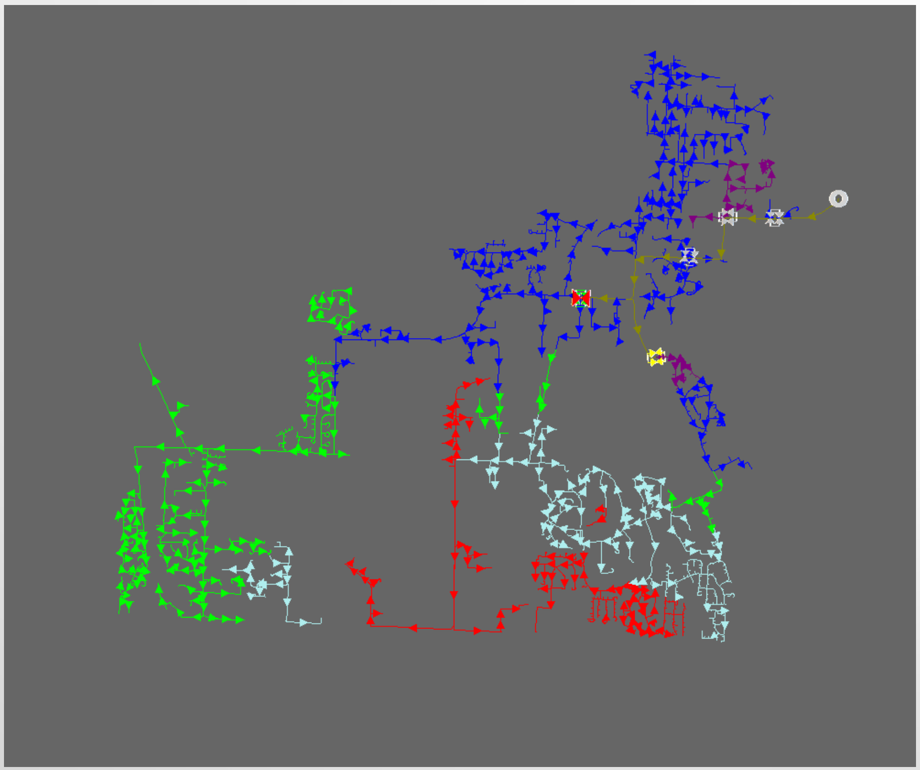
Cons

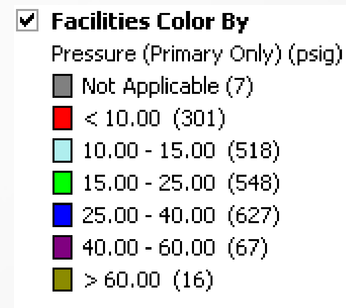
- Continuous maintenance/training
- Cost of fuel consumption
- Emissions/permitting
- Beneficial only on transmission/HP lines

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Distribution Enhancement Options

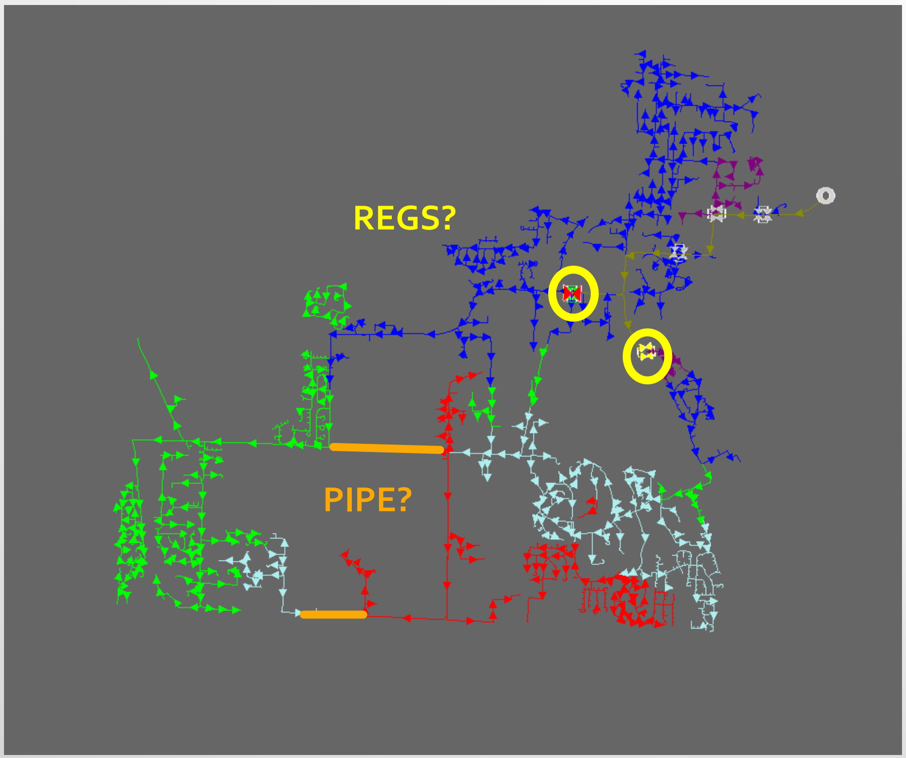
- Theoretical low pressure scenario





Distribution Enhancement Options

- Low pressure scenario



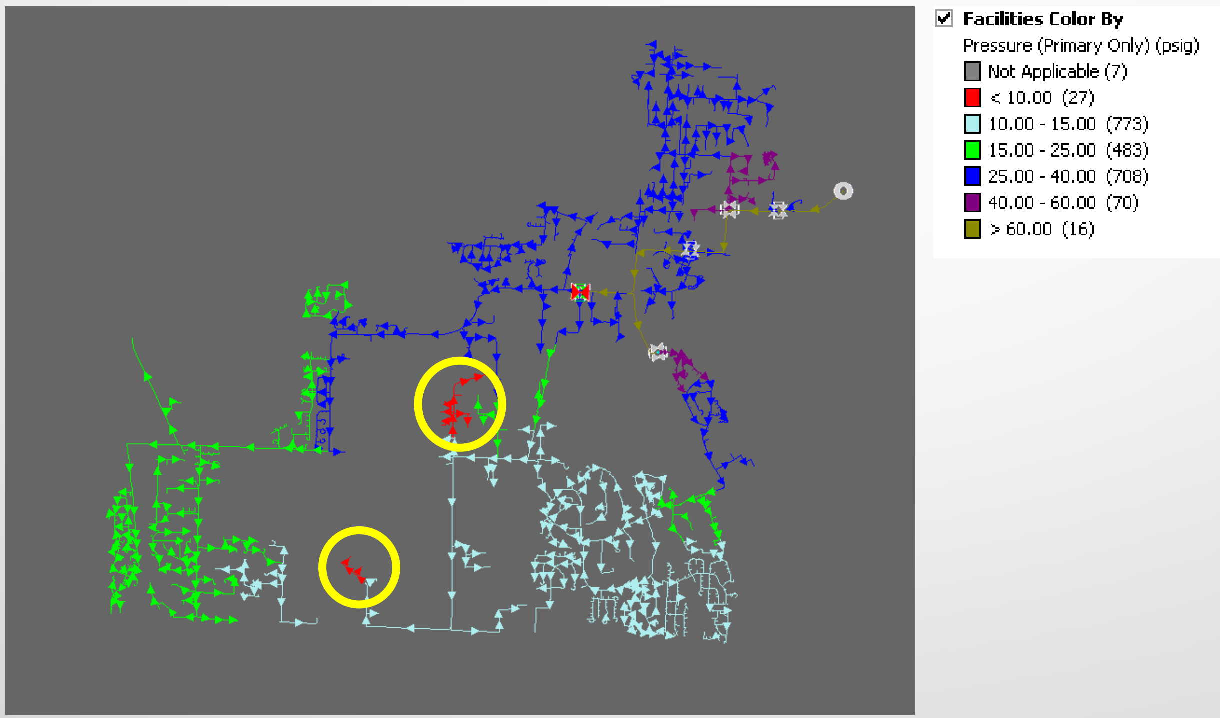
Facilities Color By

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)

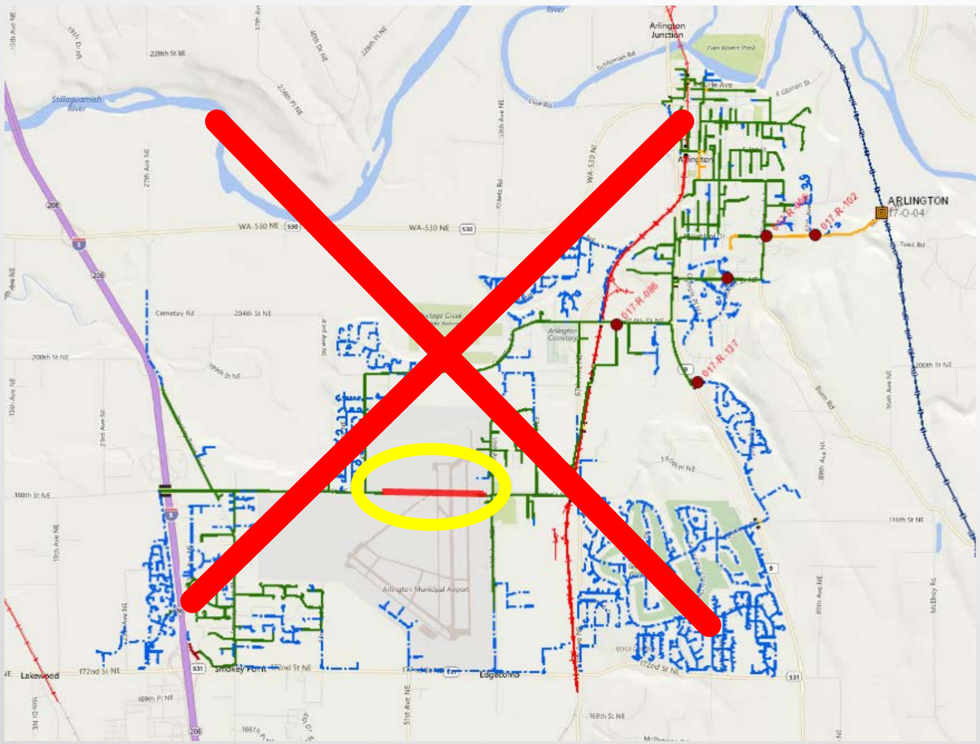
Distribution Enhancement Options

- Possible solutions – raising reg station set points



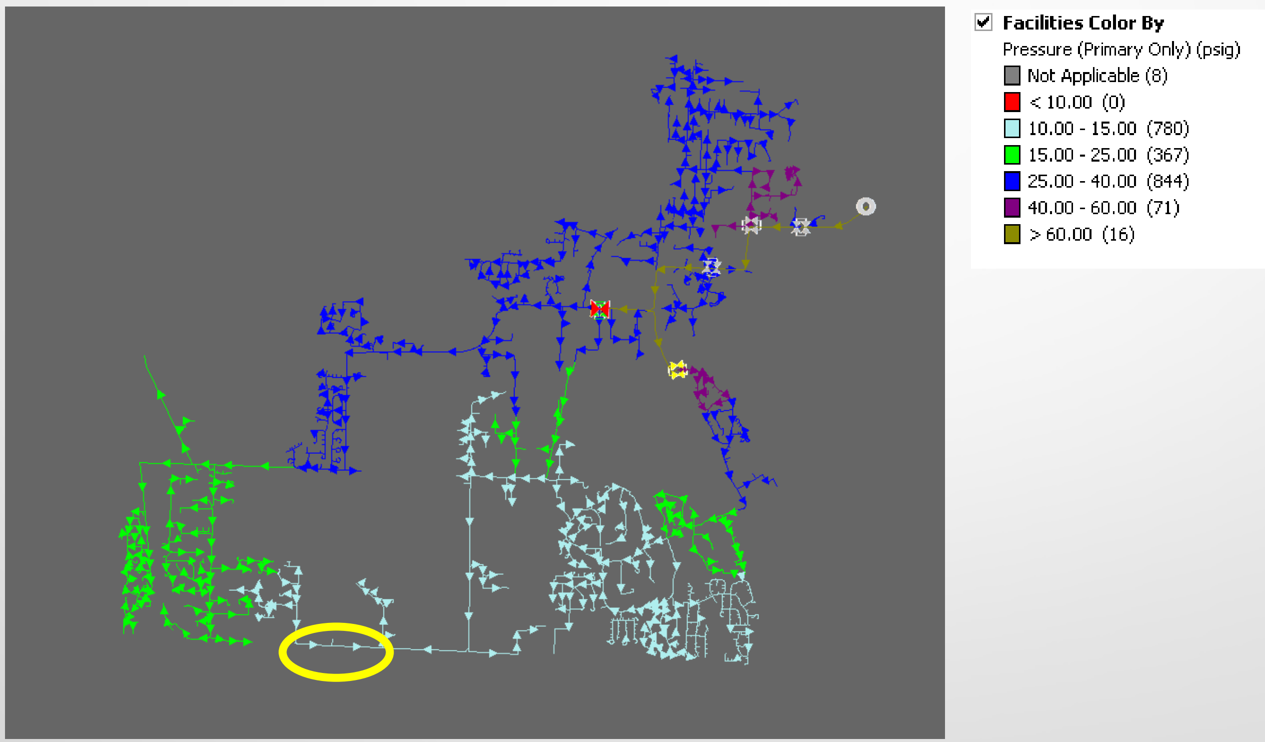
Distribution Enhancement Options

- Reinforcement option #1

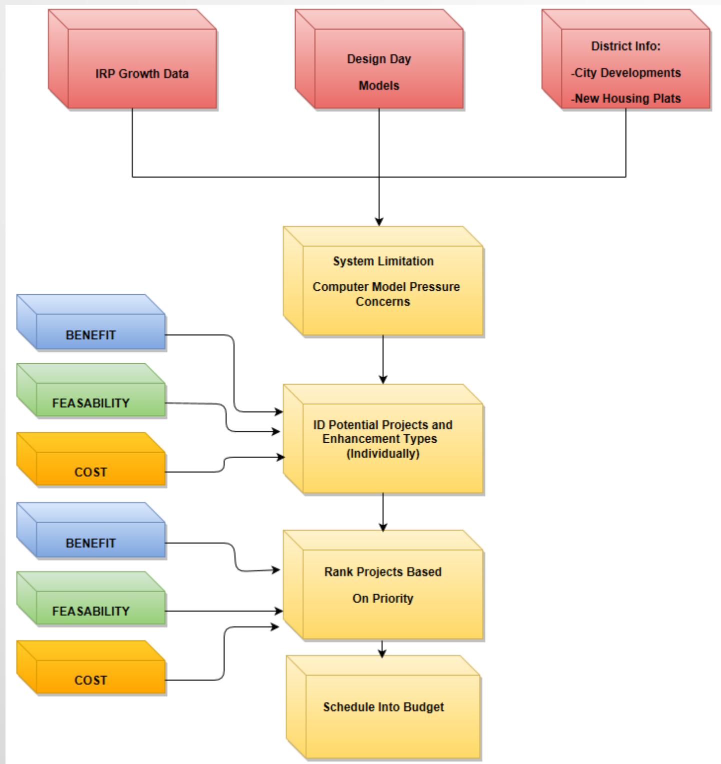


Distribution Enhancement Options

- Reinforcement option #2



Project Process Flow



Project & Schedules

Future Projects

- Planned distribution enhancement projects in Oregon for next 4 years:
  - Pendleton 4" IP & HP Reinforcements Ladow Rd
  - Pendleton 4" IP Reinforcement Korvola Rd
  - South Hermiston HP Reinforcement Feedville Rd
  - Bend 8" HP Reinforcement Bear Ck Rd
  - Bend Gate Station Rebuild
  - Redmond 6" HP Reinforcement Veterans Way
  - Bend 6" HP Reinforcement Shevlin Pk
  - Bend 6" IP Reinforcement Ponderosa St
  - Baker Gate Station Rebuild
  - Prineville Gate Station Rebuild

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Conclusion

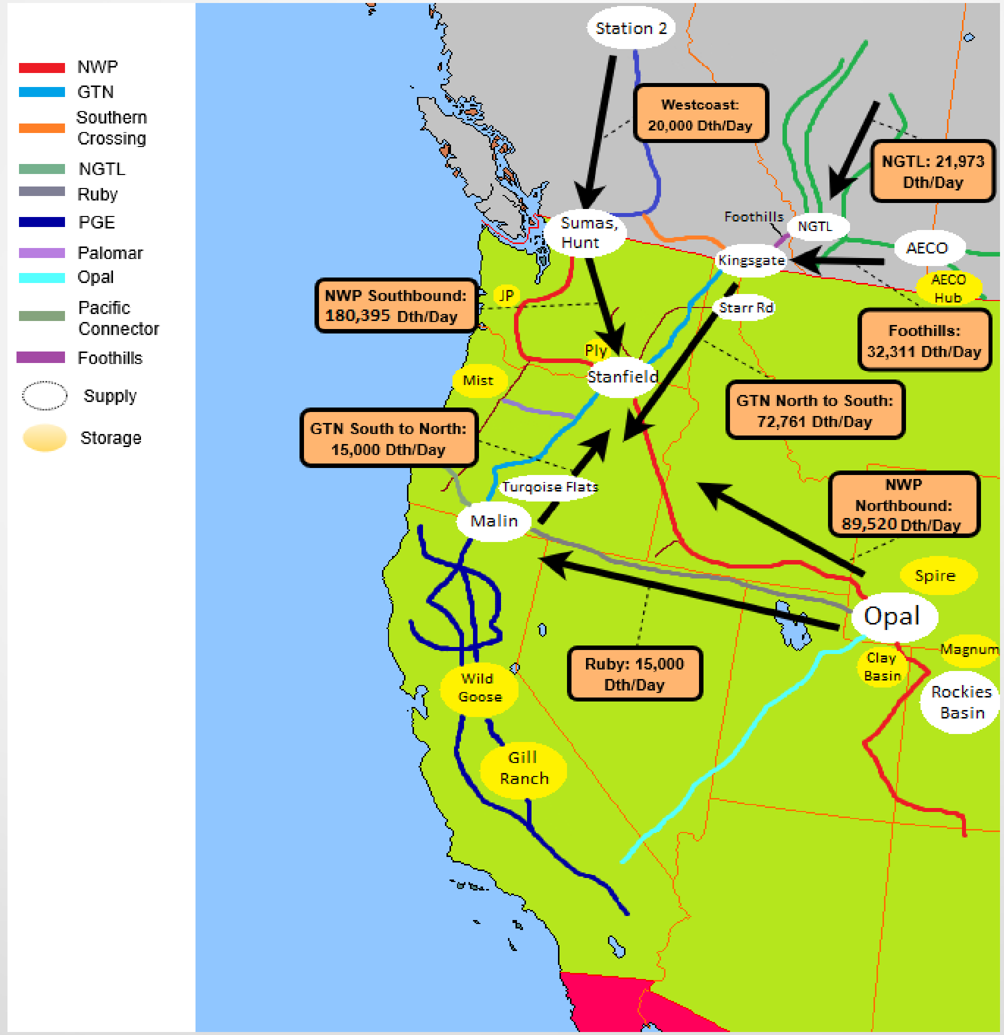
- CNG strives to use technology to gather data, analyze, plan, and design a reliable, safe, and economical distribution system.

Questions ?

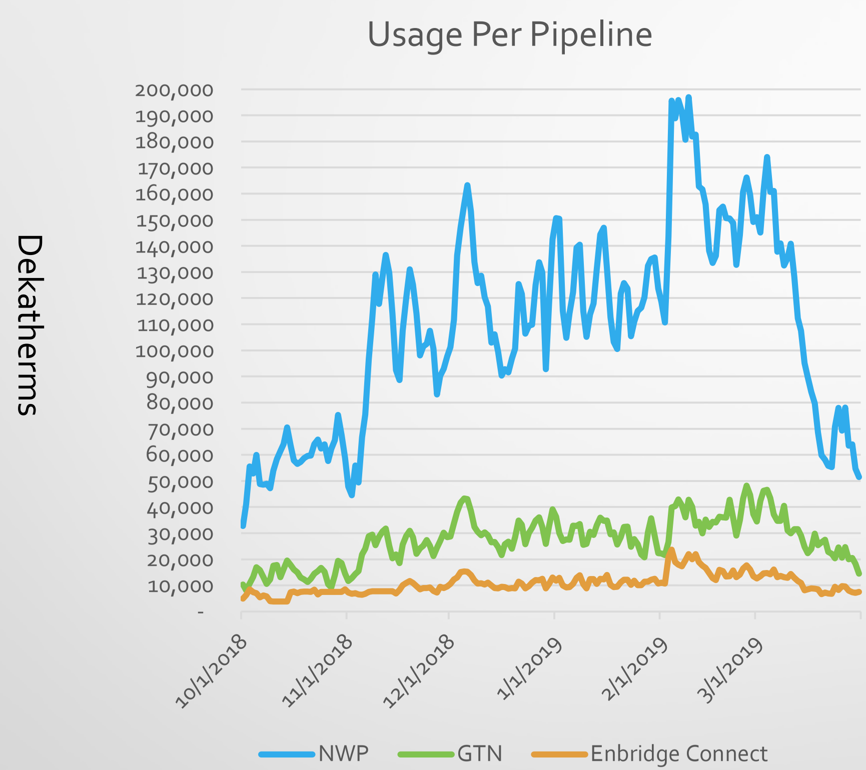
Cascade Gas Supply Overview

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

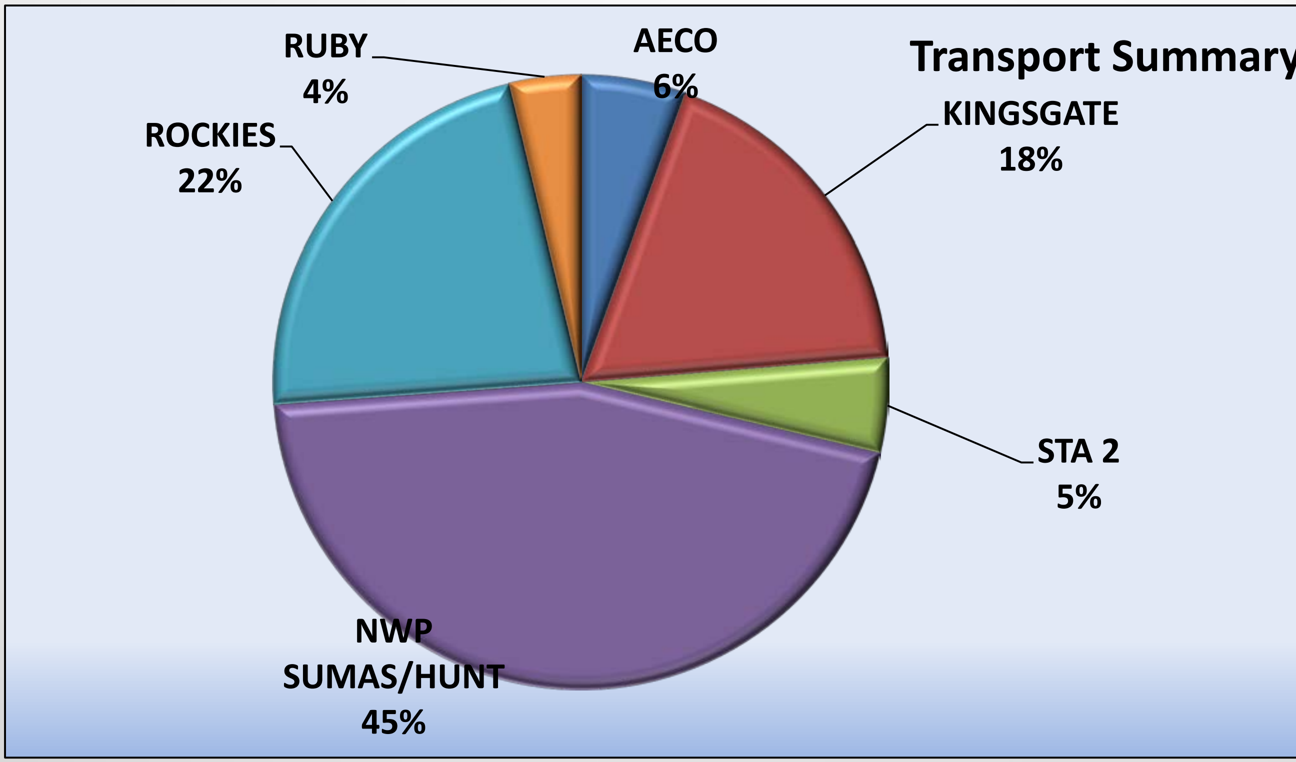
Pipeline transport flow



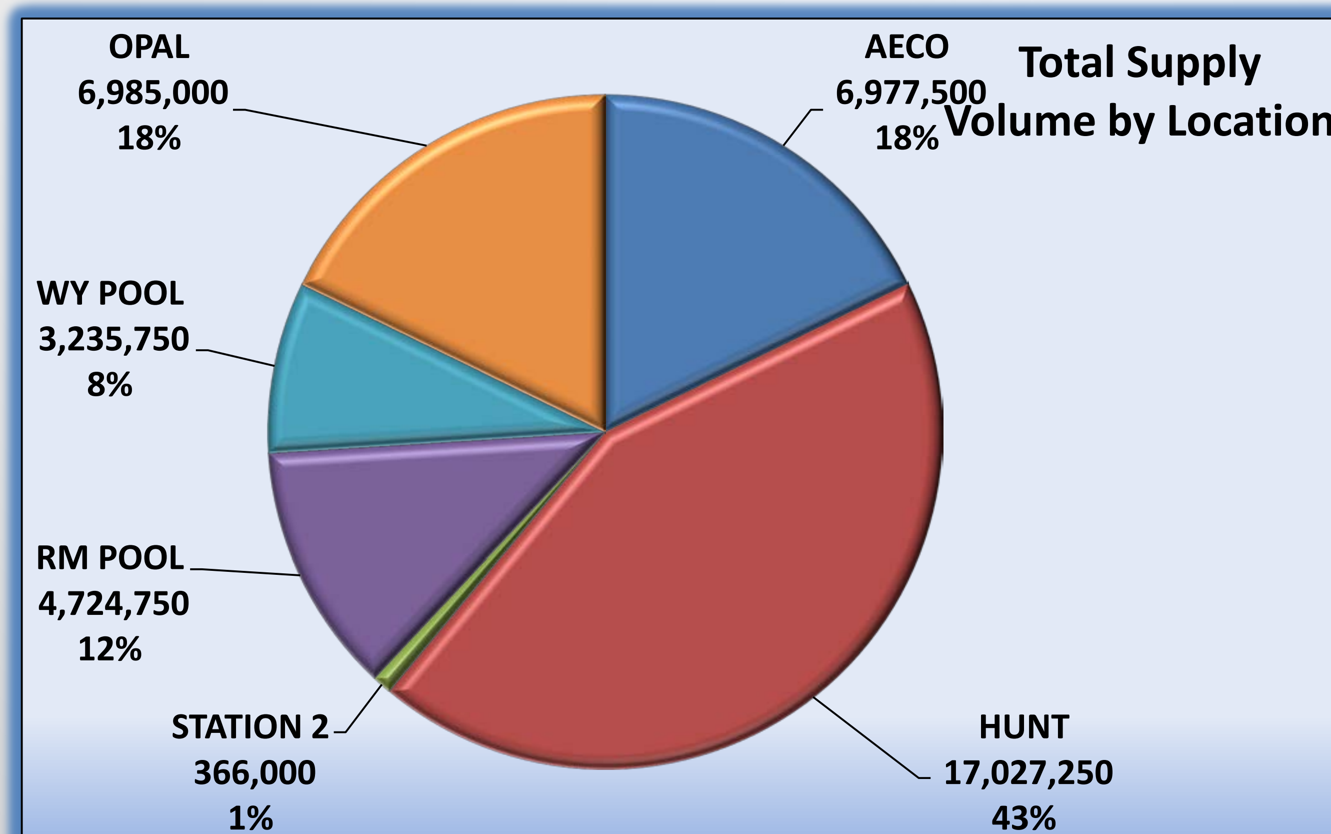
Winter Usage



Transport Summary



Supply Summary

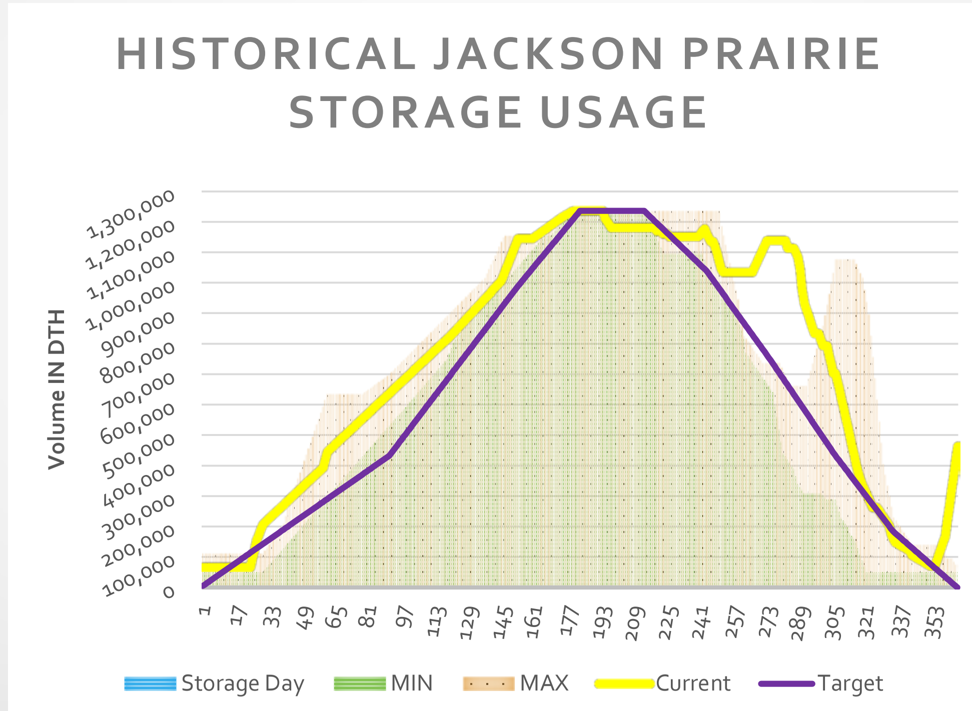


Storage Resources

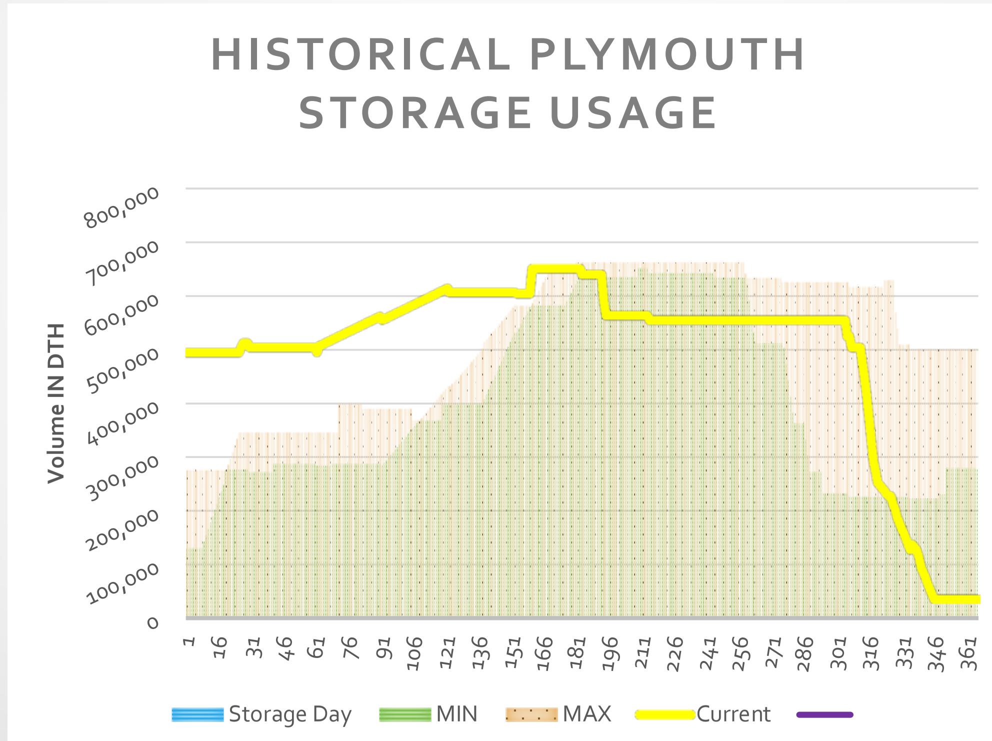
- Jackson Prairie
  - 4 accounts with 1,235,593 dth capacity, 56,366 dth of demand
  - CNGC cycled approximately 95% of Jackson Prairie storage over the past winter season
  - CNGC targets cycling Jackson Prairie
- Plymouth
  - 2 accounts with 662,200 dths capacity, 78,125 dth of demand
  - In addition to above we have TF-2 (Firm Redelivery Transportation) of 10,675 dths
  - CNGC remains committed to using Plymouth as a peaking resource
- MIST
  - Added in the spring of 2019
  - 600,000 dth of capacity, 30,000 dth of demand

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

2018/2019 JP Storage Utilization



2018/2019 Plymouth Storage Utilization

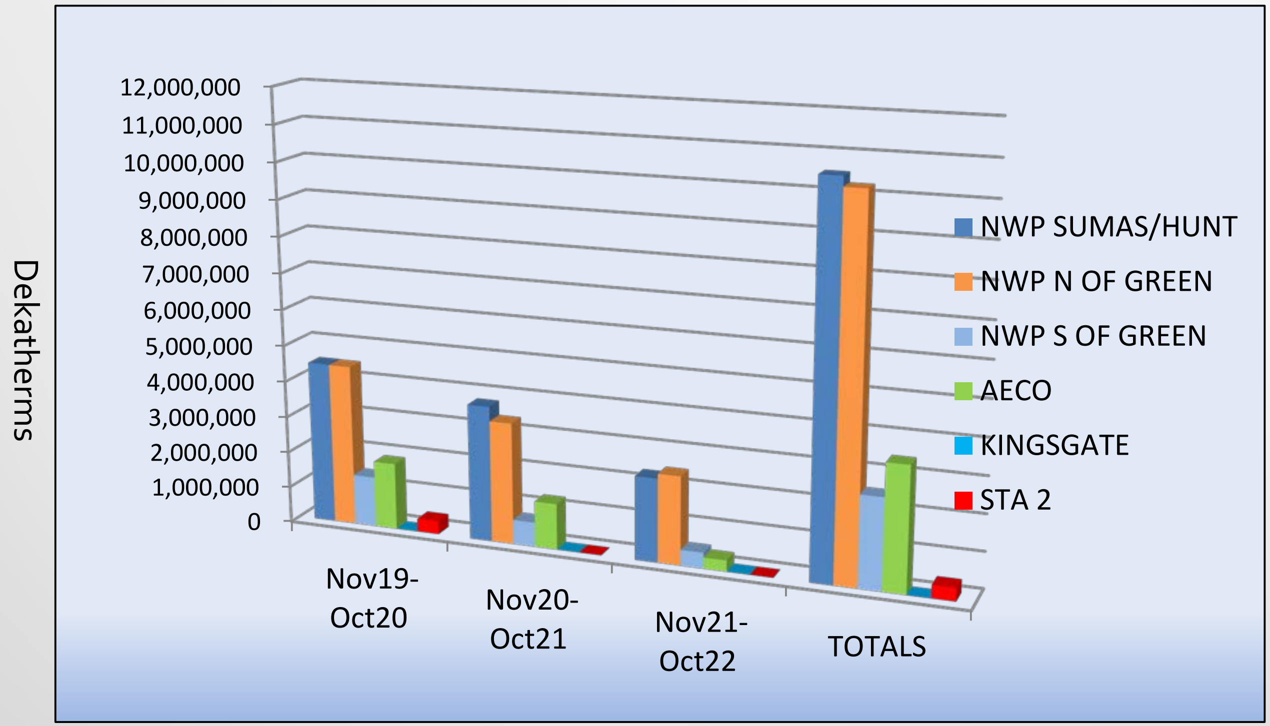


HIGHLIGHTS FOR THE 2019 PORTFOLIO DESIGN

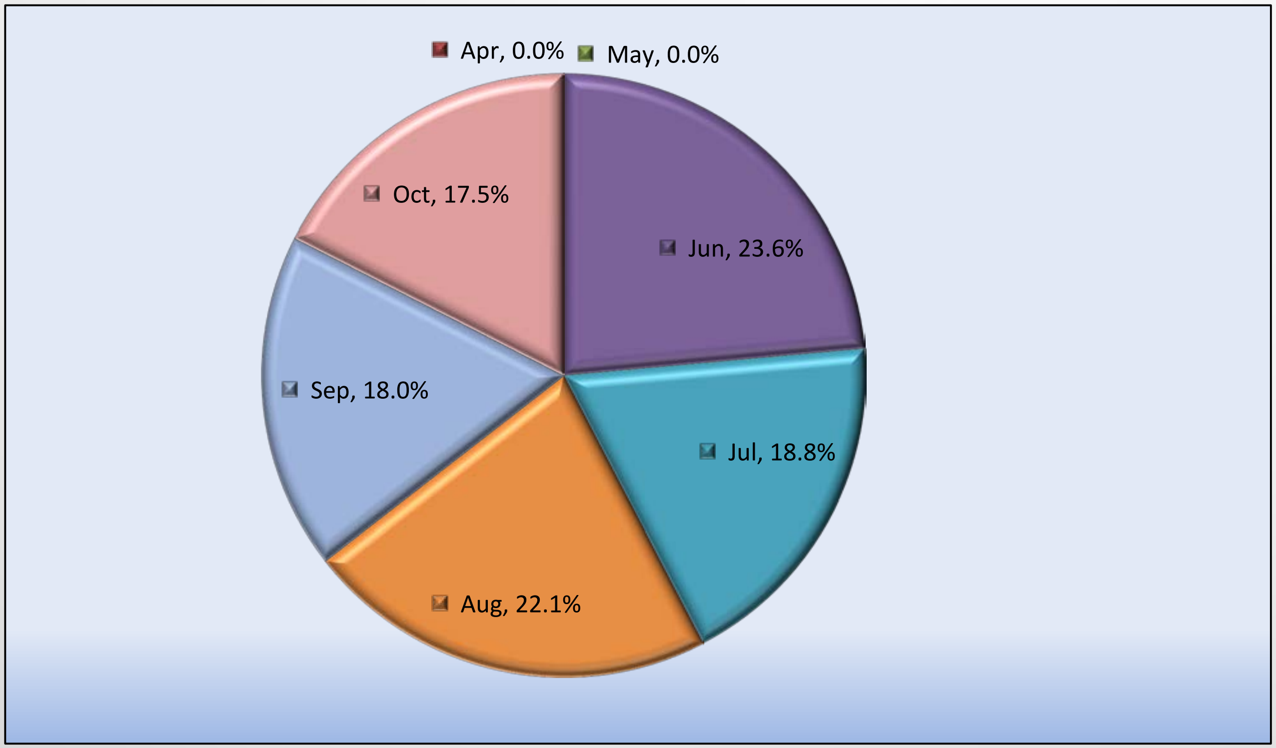
- PORTFOLIO PROCUREMENT DESIGN BASED ON A DECLINING PERCENTAGE EACH YEAR, ACCORDINGLY: Year 1: Approximately 80% of annual requirements; Year 2: 40%, Year 3: 20%.
  - 80% allows more flexibility operationally
  - Allows us to be in the market monthly through FOM purchase or Day Gas purchases
- Hedged Percentages (fixed-price physical) Currently max 60% of annual requirements. Second year max is set at 40%, and 20% hedged volumes for year three. GSOC bumped up the 1st year percentage to mitigate upside risk at Sumas/Hunt .
  - Cascade has executed on one Financial Swap in Year 2.
  - 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 34,000,000 dths, consistent with recent load history.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

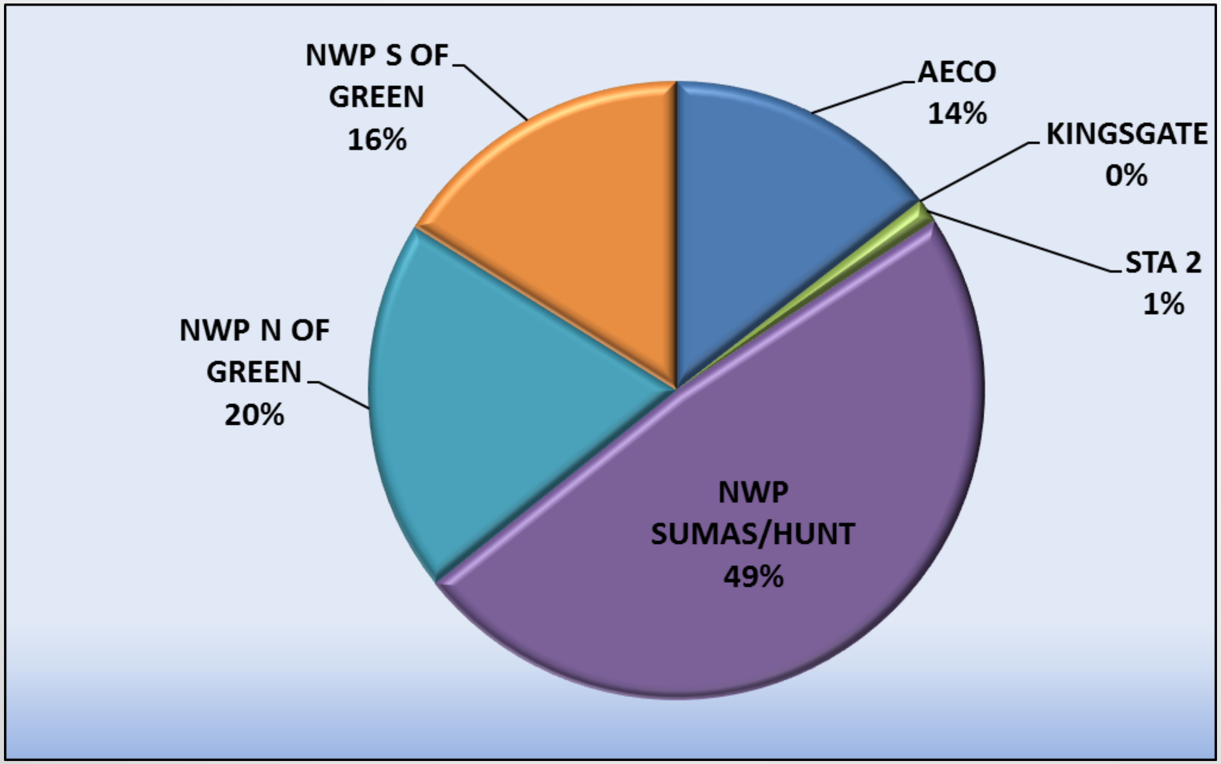
Total RFPs


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
Nov19-Oct20
Nov20-Oct21
Nov21-Oct22
TOTALS
NWP SUMAS/HUNT
NWP N OF GREEN
NWP S OF GREEN
AECO
KINGSGATE
STA 2

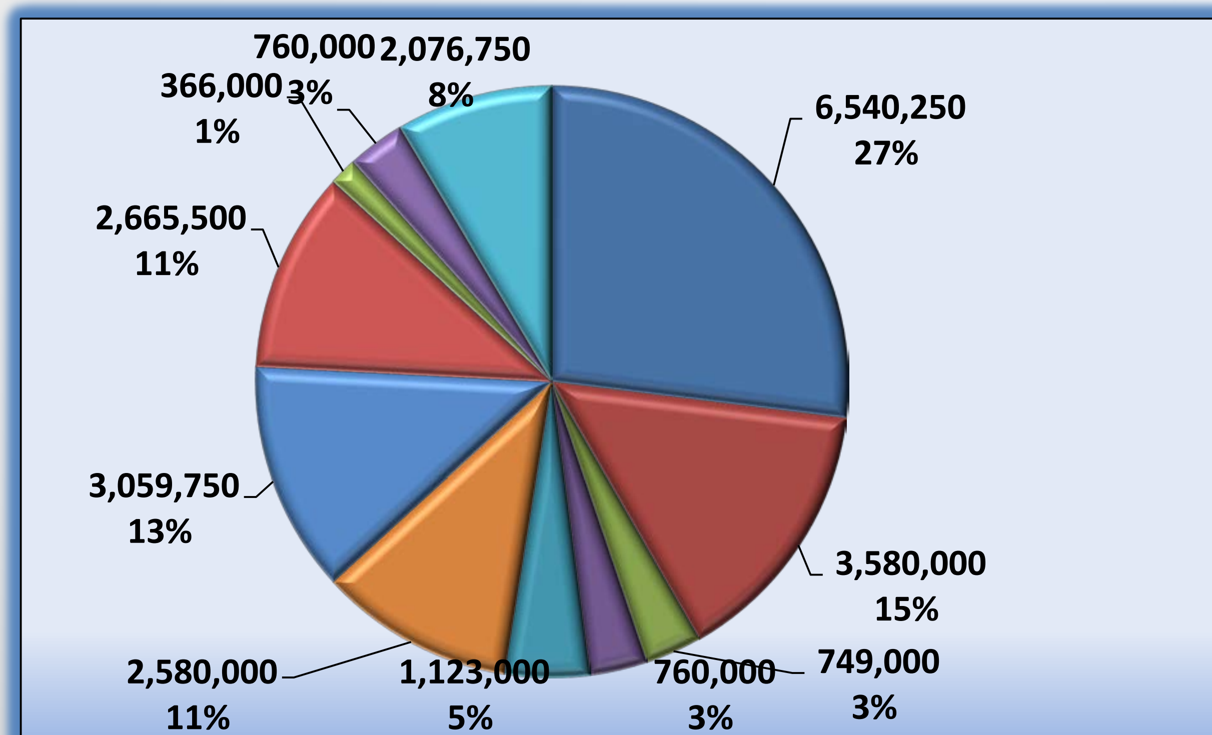
RFP Percentage by Month



RFP Percentage By Basin

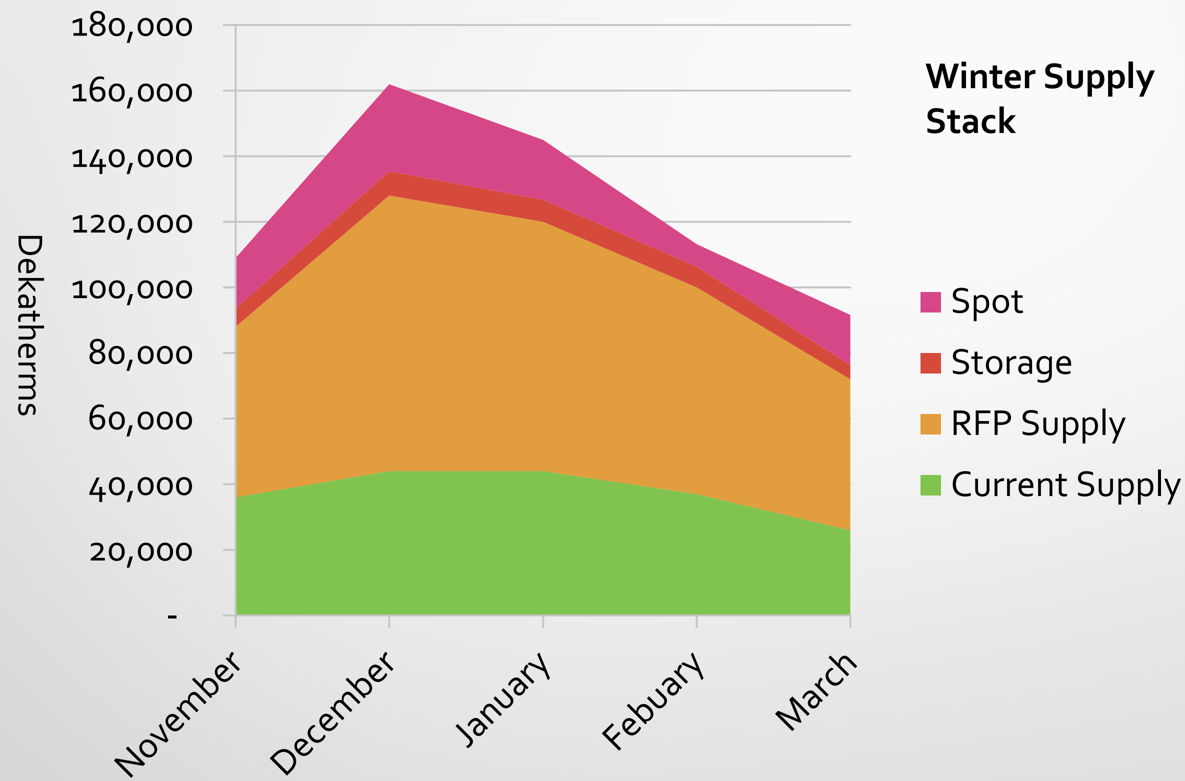


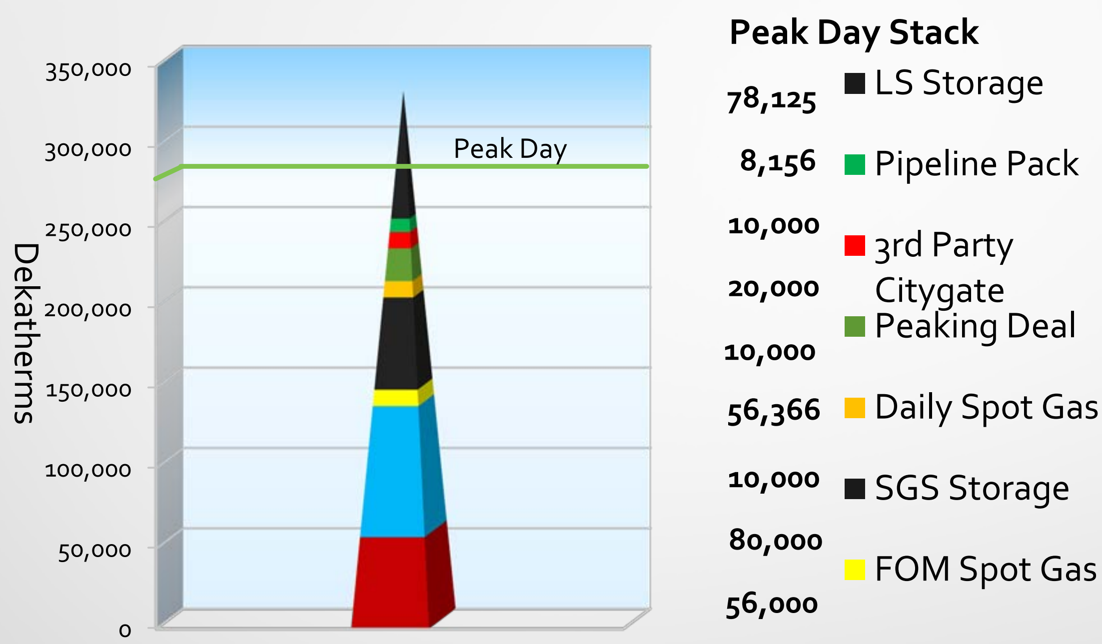
Current Supply Percentage by Supplier



Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Winter Supply Stack




Dekatherms
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Peak Day
Peak Day Stack
78,125
8,156
10,000
20,000
10,000
56,366
10,000
80,000
56,000
LS Storage
Pipeline Pack
3rd Party Citygate Peaking Deal
Daily Spot Gas
SGS Storage
FOM Spot Gas

Planned Scenarios and Sensitivities

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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.

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

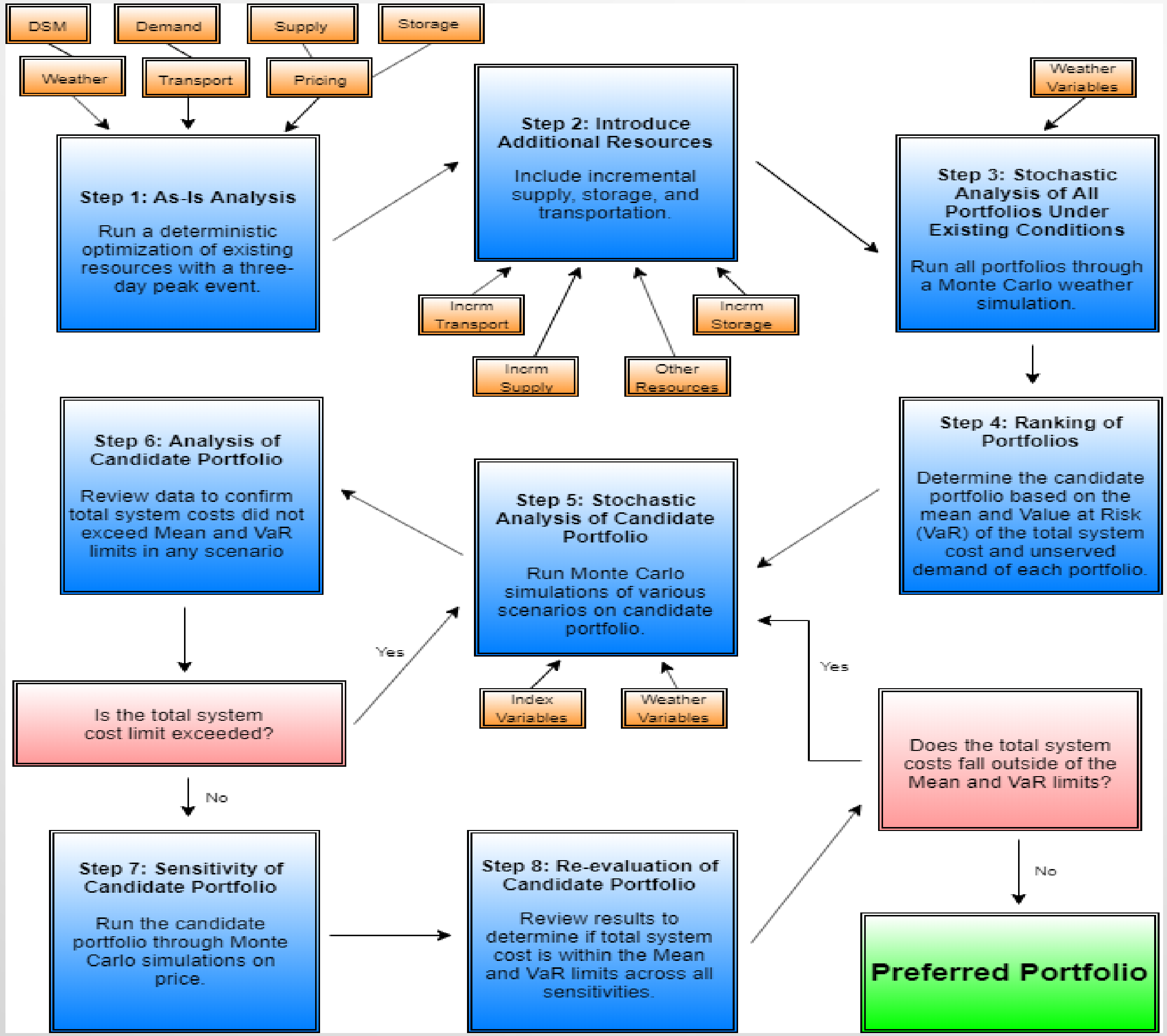
- **Step 1: As-Is Analysis**
  - Run a deterministic optimization of existing resources with a three-day peak event to uncover timing and quantity of resource deficiencies.
- **Step 2: Introduce Additional Resources**
  - Include incremental supply, storage, and transportation to derive a deterministic 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.

CASCADE NATURAL GAS CORPORATION®
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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.

Supply Resource Optimization Process Flow Chart



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?

Scenarios and Sensitivities

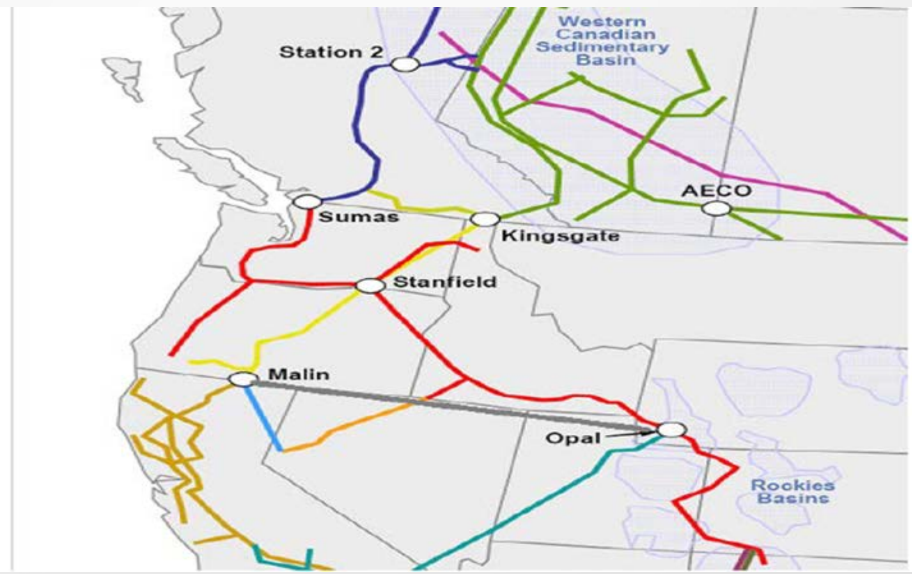
- Scenario:
  - Change in projected demand
  - Change in availability of existing resources to serve demand
  - Change in availability of supply

- Change in price forecast
- Change in environmental adder
- Change in carbon forecast

Both carry the same importance, failure to pass either of them can lead to a portfolio being rejected

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** **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***



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

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.		
Low Growth	**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		
	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.		
High Growth	**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***

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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.		
	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*
Limit BC	*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.		
	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*
Limit	*Incremental GTN N-S*	*Gill Ranch Storage*	*BioNaturalGas*
Alberta	*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		

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.		
	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***
Limit Canada	***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.		
	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***
Limit Rockies	***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		

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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		

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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.		
	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***
Limit Storage - Both	***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.		
	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***
No Storage - JP	***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		

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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.		
	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
No Storage - Ply	***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.		
	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
No Storage - Both	***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		

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Sensitivities Analyses

Sensitivities		Assumpitons
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
Env. Adder	0%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with No 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
Carbon Adder	Various	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with Various Potential Carbon Futures Modeled

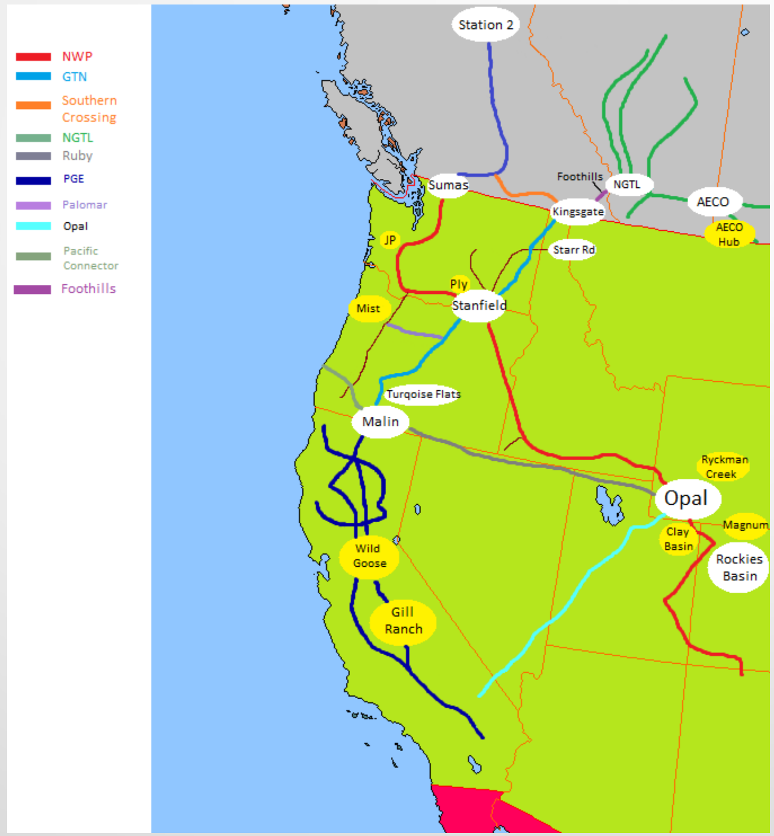
Alternative Resources

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Major resource issues on the horizon

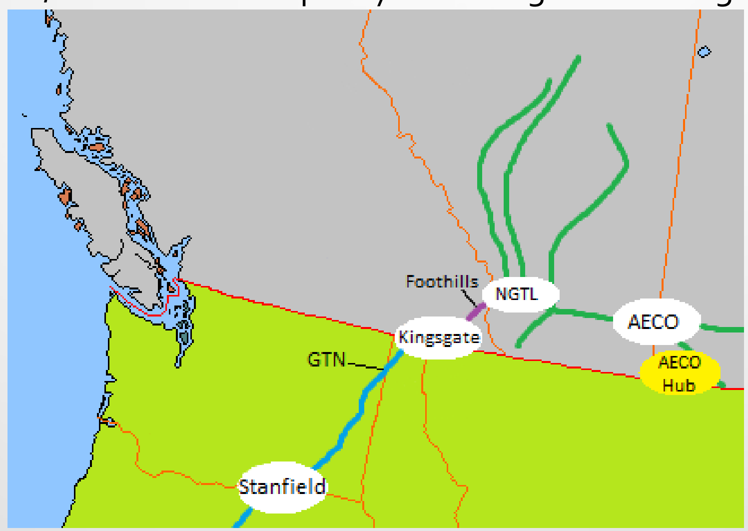
- Once a deficiency is identified, Cascade must analyze potential solutions to ensure service over the planning horizon.
- Conversations with partners at various pipelines, storage facilities, new supply sources.
- SENDOUT® is used to ultimately derive the optimal mix of resources, referred to as the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

Location of Current & Alternative Resources



Incremental Transport – North to South

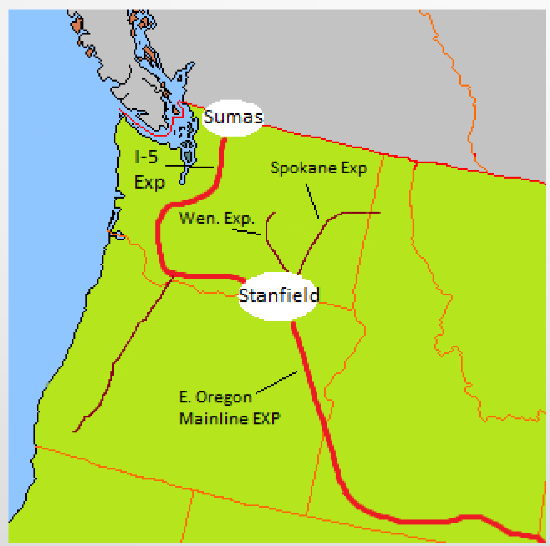
- Incremental NGTL – Additional capacity to move gas from AECO basin to Alberta/BC border
- Incremental Foothills – Additional capacity to move gas from Alberta/BC border to Kingsgate
- Incremental GTN N/S – Additional capacity to move gas from Kingsgate to various citygates along GTN



CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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

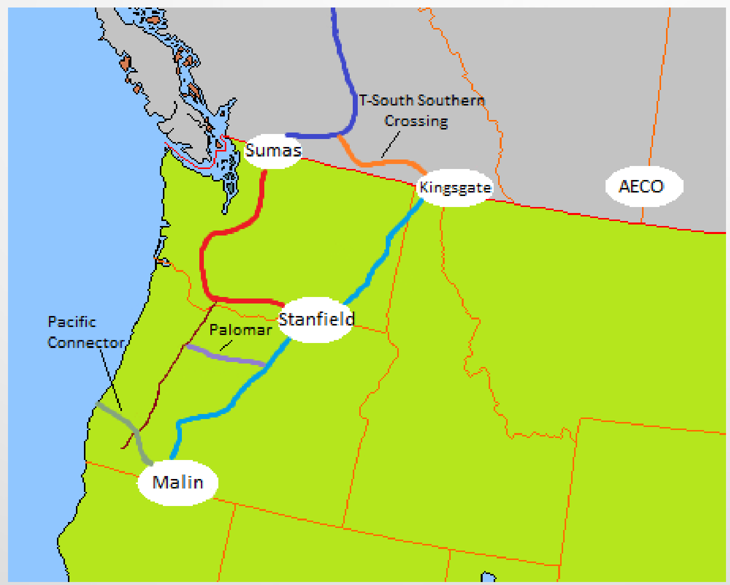


Incremental Transport – South to North

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

Incremental Transport – Bilateral

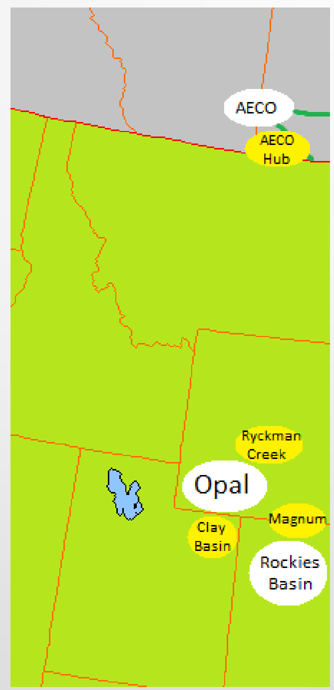
- T-South Southern Crossing – Price arbitrage opportunity to move gas between Sumas and AECO basins bilaterally
- Trails West (Palomar) – Additional capacity to move Rockies gas to the I-5 corridor
- Pacific Connector – Pipeline that will feed LNG facility on Oregon coast, increasing liquidity at Malin



CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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



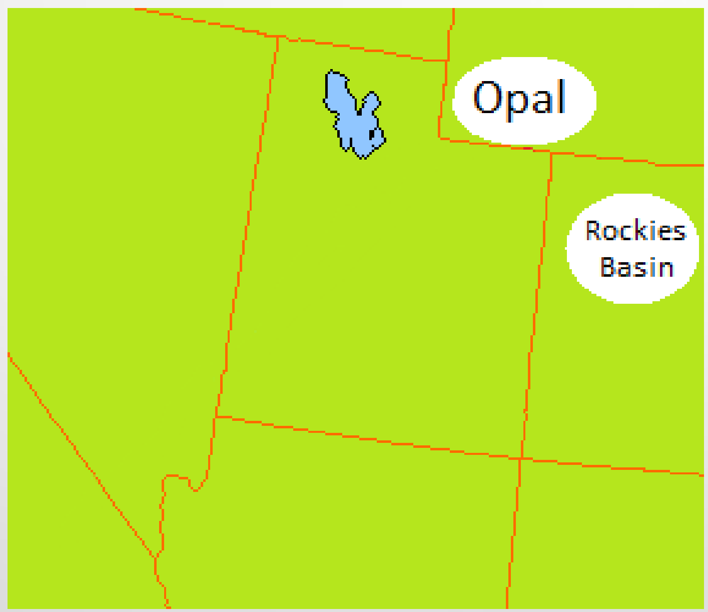
Incremental Storage - South and West

- 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

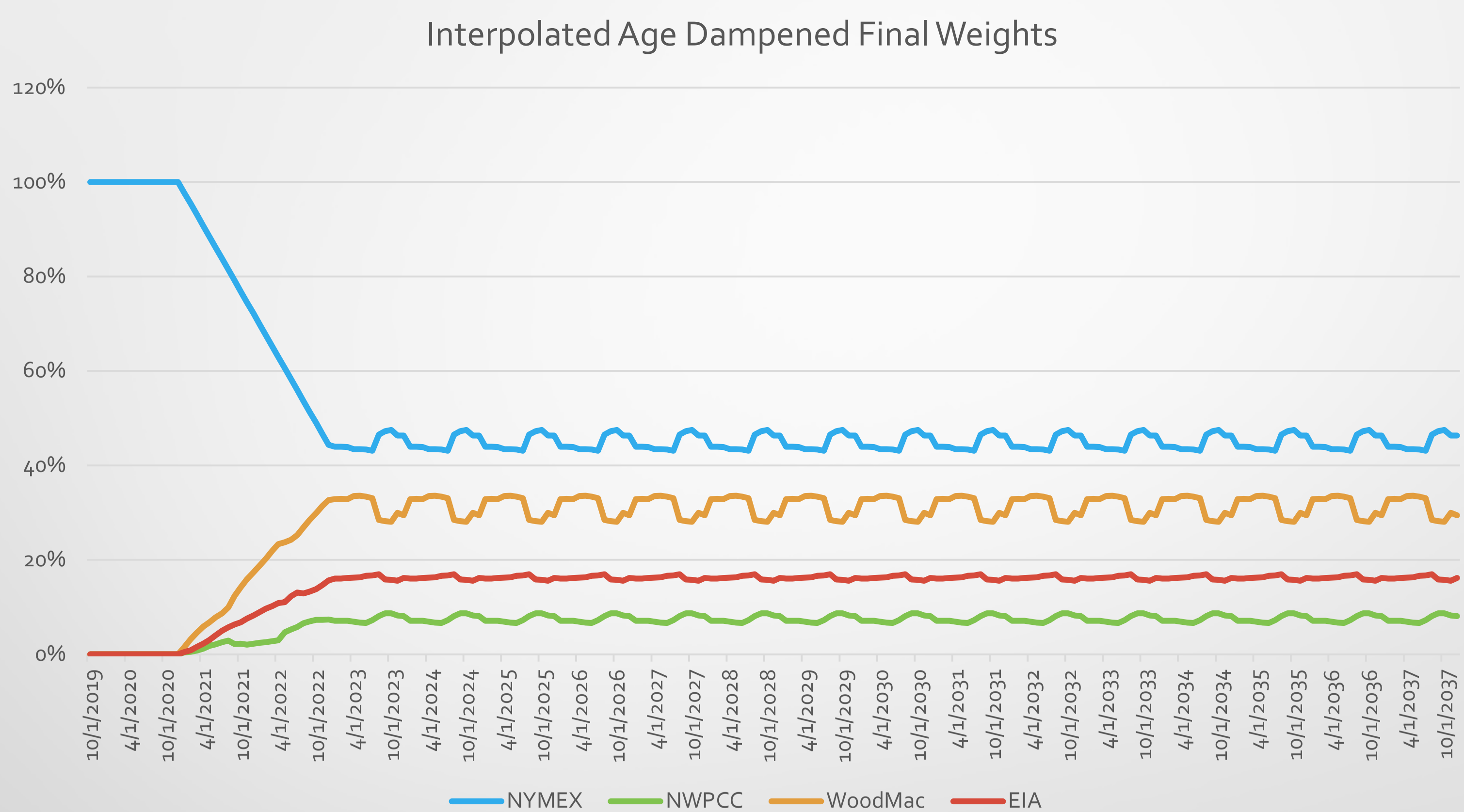
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Incremental Supplies

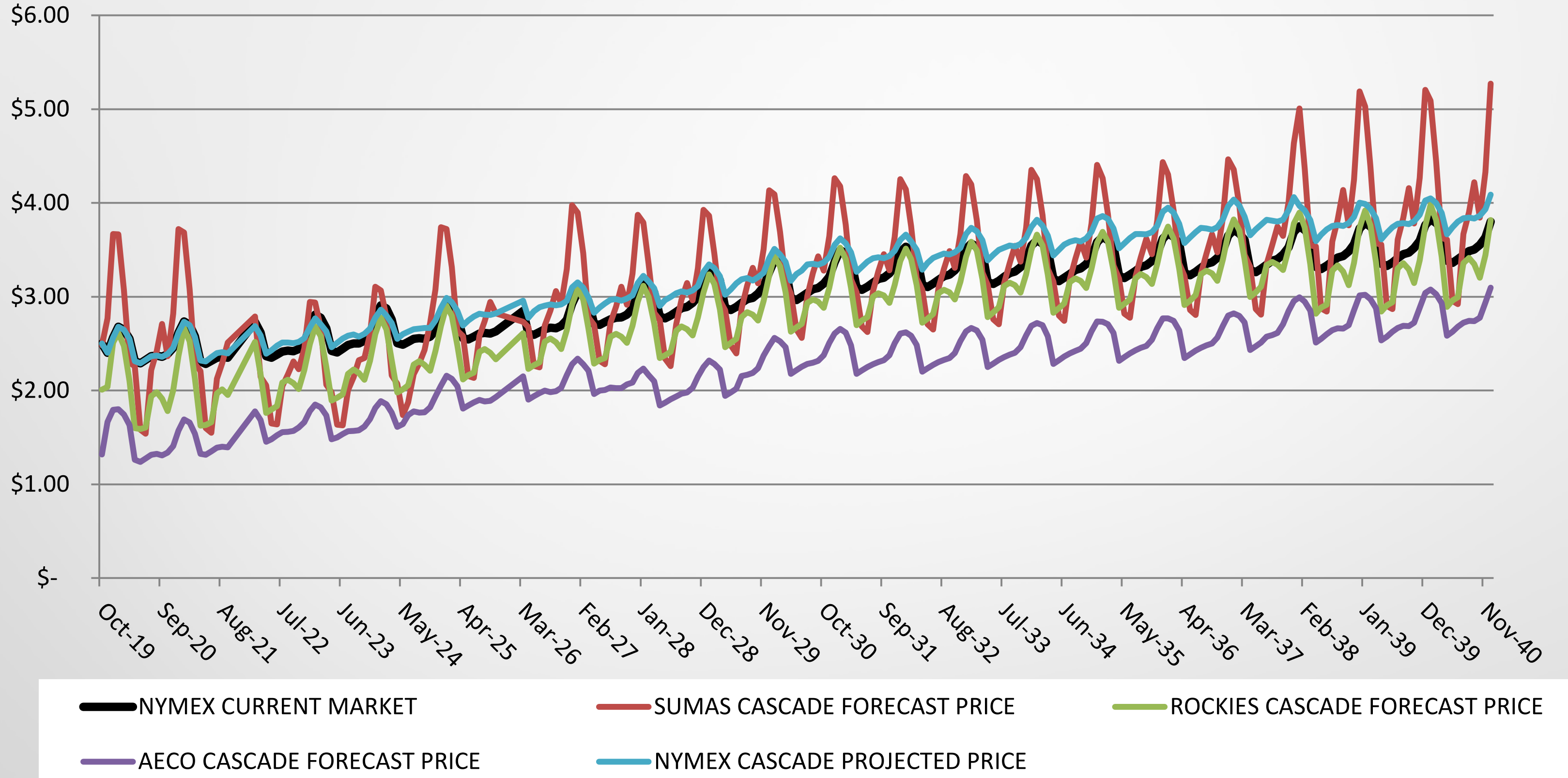
- Incremental Opal Supply – Additional supply around the Rockies Basin
- Renewable Natural Gas – Incremental biogas supply directly to distribution system



Price Forecast Results


Interpolated Age Dampened Final Weights
120%
100%
80%
60%
40%
20%
0%
10/1/2019
4/1/2020
10/1/2020
4/1/2021
10/1/2021
4/1/2022
10/1/2022
4/1/2023
10/1/2023
4/1/2024
10/1/2024
4/1/2025
10/1/2025
4/1/2026
10/1/2026
4/1/2027
10/1/2027
4/1/2028
10/1/2028
4/1/2029
10/1/2029
4/1/2030
10/1/2030
4/1/2031
10/1/2031
4/1/2032
10/1/2032
4/1/2033
10/1/2033
4/1/2034
10/1/2034
4/1/2035
10/1/2035
4/1/2036
10/1/2036
4/1/2037
10/1/2037
NYMEX
NWPCC
WoodMac
EIA

CNGC Price Forecast as of 09/30/2019



Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Avoided Cost Methodology and Calculation

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Avoided Cost Overview

- As part of the IRP process, Cascade produces a 20-year price 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 NATURAL GAS CORPORATION®
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

- For the 2020 IRP, Cascade has continued to evolve its avoided cost formula to create a more transparent and intuitive final number.
  - Cascade has also calculated distribution system costs and a risk premium for the first time in the 2020 OR IRP
- 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.
- The Company produces an expected avoided cost case based on peak day and, in the case of distribution system costs, peak hour.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Avoided Cost Formula

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

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

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+inflation rate)^Years from the reference year.
- TC_v = Variable Transportation Costs
- SC_v = Variable Storage Costs
- CC = Commodity Costs
- C_{tax} = Carbon Tax
- E_{adder} = Environmental Adder, as recommended by the Northwest Power and Conservation Council
- DSC = Distribution System Costs
- RP = Risk Premium

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 are only captured if there is an avoidable future storage cost (ie. On system storage).
- Commodity Costs are taken from Cascade's 20-year price forecast.
- Risk Premium is the cost associated with hedging.
- Distribution System Costs only look at costs associated with growth. Pipeline integrity cannot be avoided.

Methodology - Carbon

- Modeling carbon compliance costs is a challenge because the future of carbon is uncertain.
- As discussed during scenarios and sensitivities, Cascade will model the impact of a variety of potential carbon pathways.
- Cascade's primary carbon forecast is based on the California Cap and Trade marketplace. This is not an endorsement of this policy, but rather a qualitative assessment of what the resource planning team believes is the most probable carbon future in the state of Oregon.

Methodology – Distribution System Costs

- Cascade's distribution system costs are calculated as a function of the Company's authorized margin, weighted by the load share of each rate class.
  - Authorized margin is defined as the applicable cost of service including authorized rate of return.
- The weighted margin number is then multiplied by the percentage of projects of Cascade budgeted projects specifically related to growth.
- Since Avoided Cost is based on peak day, the margin calculation is then multiplied by the ratio of peak day demand to an average day's demand to get the margin impact on peak day.
- Distribution system analysis is concerned with the pressure during peak hour, so the daily number must then be multiplied by the ratio of peak hour demand to that day's total demand.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Example of Distribution Cost Calculation

Data Item	Value
Weighted Margin (Dth)	0.084967
* Growth Share (37%)	0.031438
*Peak Day Impact (Peak Demand/Average Demand)	0.119075
*Peak Hour Impact (Peak Hour/Peak Day Demand)	0.006112

Methodology – Risk Premium

- Cascade defines risk premium as the additional cost the Company would have to pay for a fixed price to fully hedge its portfolio versus open market FOM prices.
- Theoretical fixed pricing comes from the company's AMA Partner, Tenaska Marketing Ventures.
- Pricing is received at all three basins Cascade purchases gas from, and then blended based on expected supply needs at the basins.
- Following regional best practices, if this value is negative the Company records the risk premium as zero, as described in the following table.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

2020 Avoided Cost Risk Premium

Year #	Calendar Year	Risk Reduction Value (Real $/Dth)
1	2020	-$0.159
2	2021	-$0.139
3	2022	-$0.108
4	2023	-$0.067
5	2024	-$0.104
6	2025	-$0.245
7	2026	-$0.301
8	2027	-$0.221
9	2028	-$0.109
10	2029	-$0.078
11	2030	-$0.105
12	2031	-$0.069
13	2032	$0.000
14	2033	-$0.001
15	2034	-$0.016
16	2035	-$0.030
17	2036	-$0.057
18	2037	-$0.141
19	2038	-$0.459
20	2039	-$0.304

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Avoided Cost - Conclusion

- Cascade has filed its new avoided cost inputs as a proposed alternative in its UM 1893 filing.
- Cascade has also provided current avoided cost inputs to the Energy Trust of Oregon, who will be sending back a conservation potential assessment based on these inputs.
- Annualized avoided cost in real 2019 dollars range from \$2.49/dth in a non-carbon environment to \$7.93 in a carbon environment in 2040.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve

2020 IRP Remaining Schedule

Date (Subject to change)	State	Process Element	Location (Subject to change)	Notes
Wednesday, January 8, 2020	OR	TAG 4 slides distributed to stakeholders		
Wednesday, January 15, 2020	**OR**	**TAG 4 Carbon Impacts, Conservation (Energy Trust of Oregon), Bio-Natural Gas, Preliminary Resource Integration Results.**	**Portland, OR - 9 am to 3 pm**	
Wednesday, March 4, 2020	OR	TAG 5 slides distributed to stakeholders		
Wednesday, March 11, 2020	**OR**	**TAG 5: Final Integration Results, finalization of plan components, Proposed new 4-year Action Plan.**	**Salem, OR - 9 am to 12 pm**	**Meadow room at OPUC Offices**
Tuesday, May 12, 2020	OR	Draft of 2020 OR IRP distributed		
Friday, June 12, 2020	OR	Comments due on draft from all stakeholders		
Tuesday, June 30, 2020	OR	TAG 6, if needed	WebEx Only	
Friday, July 31, 2020	OR	IRP filing in Oregon		

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

ADDITIONAL QUESTIONS?

mark.sellers-vaughn@cngc.com

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

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

Ashton Davis – Resource Planning Analyst I: (509) 734-4520
ashton.davis@cngc.com

irp@cngc.com

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Natural Gas Corporation

2020 Integrated Resource Plan

Technical Advisory Group Meeting #3

Wednesday, November 6th, 2019

Cascade's Offices in Deschutes Room

Kennewick, WA

CASCADE NATURAL GAS CORPORATION

A Subsidiary of MDU Resources Group, Inc.

In the Community to Serve®

OPUC Tag Meeting 3

Date & Time: 11/6/2019, 09:00 AM – 12:00 PM

Location: Cascade Natural Gas General Office in Kennewick, WA – Deschutes Room

In attendance: Mark Sellers-Vaughn, Brian Robertson, Devin McGreal, Ashton Davis, Linda Offerdahl, Mike Parvinen, Eric Wood, Tom Pardee (Avista)

Called in: Bruce Folsom, Monica Cowlishaw, Garrett Senger, Jim Cordaro (Ruby), Mark Iverson (Ruby), Mike Paruszkiewicz (NWN), Anna Kim (OPUC)

Minutes by: Brian Robertson

Mark Sellers-Vaughn kicked off the meeting by thanking everyone that showed up. Brian went over fire safety of the building, introductions and the agenda.

- Jim and Mark from Kinder Morgan gave a presentation of the Ruby Pipeline as well as their view of the current energy market.
- Linda Offerdahl then presented Cascade's Distribution System Planning.
  - Discussed System Overview.
  - Discussed the Synergy modeling and how it works.
  - Explained the data gathering process and how it's implemented into Synergy.
  - Linda explained the pros and cons of several different solutions to pipeline pressure issues.
  - Anna asked how the new pipe size is determined if old pipe needs to be replaced. Linda responded and said it depends on future growth in the area.
  - Linda explained that the engineers put together the projects and shows other alternative projects. Management then decides which projects go in.
  - Linda then shared future projects that are currently planned in the state of Oregon.
- Eric Wood then described Cascade's Gas Supply Overview.
  - Eric discussed the Company's transportation, supply, and storage in depth.
  - Highlighted Cascade's 2020 portfolio design.
  - Eric presented a peak day example for Cascade. Anna asked if that was the case for all peak events. Eric said no, there are many different ways to supply gas. Anna would like to see different examples added to the IRP.
- Brian Robertson then discussed Cascade's SENDOUT modeling.
  - Brian shared the challenges of modeling as well as how SENDOUT has perfect knowledge.

  - Brian discussed the Resource Optimization Process. Brian noted that more information would be discussed at TAG 4.
  - Brian then explained how Cascade defines scenarios vs sensitivities.
- Ashton Davis presented alternative resources for Cascade.
  - These resources include incremental transportation, supply, and storage.
- Devin McGreal presented Cascade's price forecast and avoided cost.
  - Devin shared the formula that Cascade is using for the 2020 avoided cost calculation.
  - Devin went in depth on several of the avoided cost inputs, such as carbon, distribution system planning, and risk premium.
  - Anna noted that Cascade's carbon sensitivity was higher than other LDCs in UM-1893. Cascade will discuss this further at TAG 4.
- Brian wrapped up the meeting discussing the remaining schedule.

TAG 4 will take place on January 15th, 2020 at the Portland International Airport - Umatilla room.

The meeting was adjourned at 12:00 PM.

Cascade Natural Gas Corporation

2020 Integrated Resource Plan
Technical Advisory Group Meeting #4

Wednesday, Jan. 15th, 2020

Portland International Airport

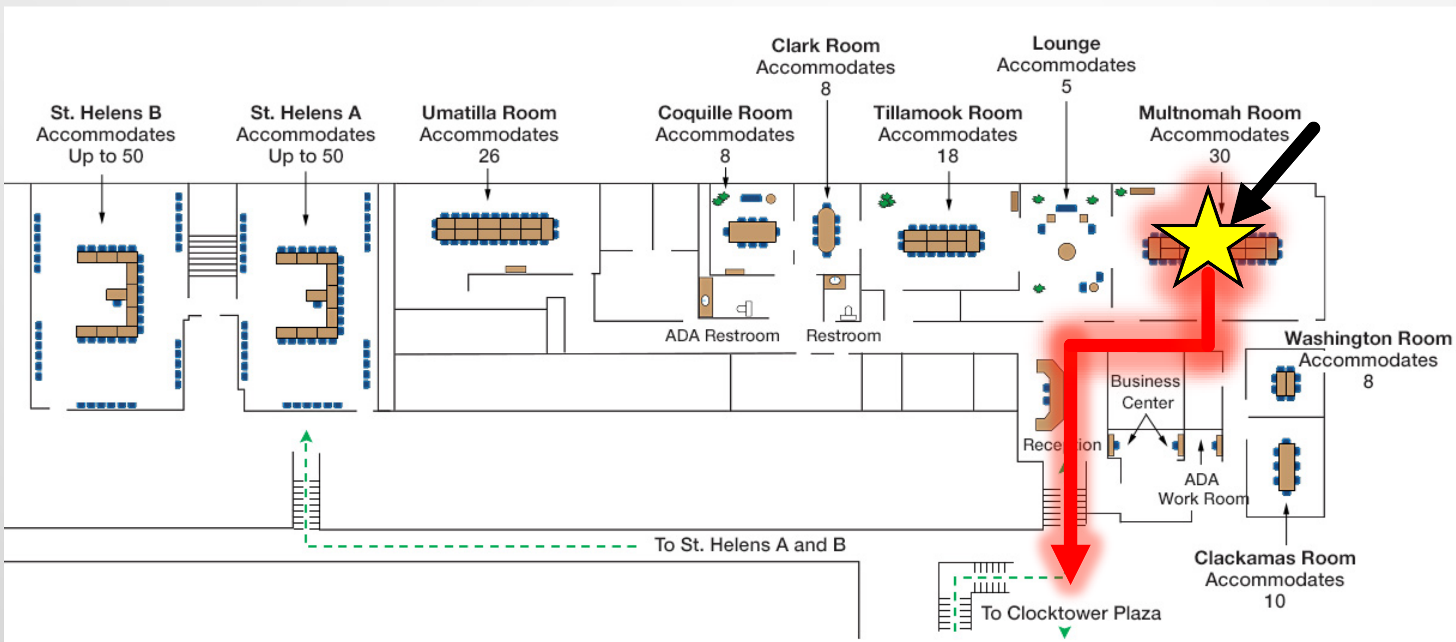
Portland, OR

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Agenda

- Introductions
- Safety Moment
- Renewable Natural Gas
- Energy Trust of Oregon Presentation
- Carbon Impacts
- SENDOUT Modeling
- Preliminary Modeling Results
- Upcoming Schedule
- Questions

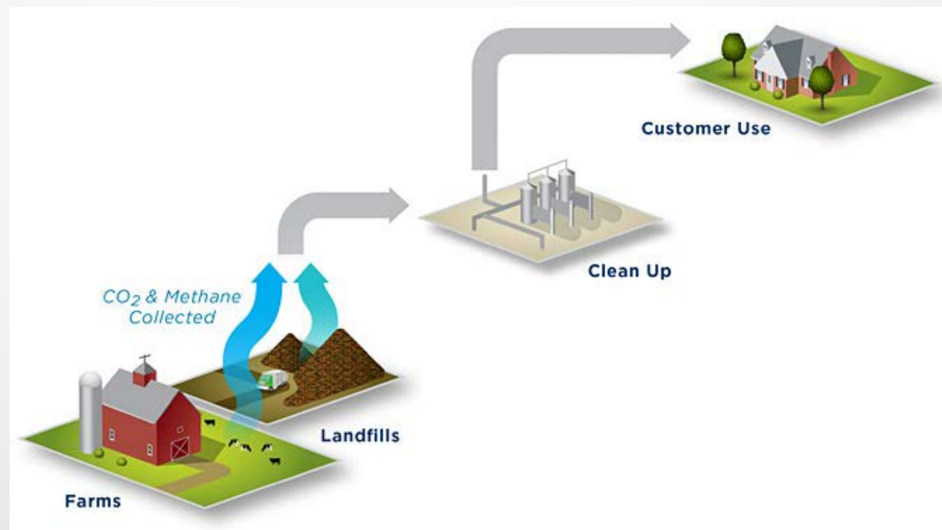
Safety!


St. Helens B
Accommodates
Up to 50
St. Helens A
Accommodates
Up to 50
Umatilla Room
Accommodates
26
Coquille Room
Accommodates
8
Clark Room
Accommodates
8
Tillamook Room
Accommodates
18
Lounge
Accommodates
5
Multnomah Room
Accommodates
30
ADA Restroom
Restroom
Washington Room
Accommodates
8
Business
Center
ADA
Work Room
Clackamas Room
Accommodates
10
To St. Helens A and B
To Clocktower Plaza

Renewable Natural Gas

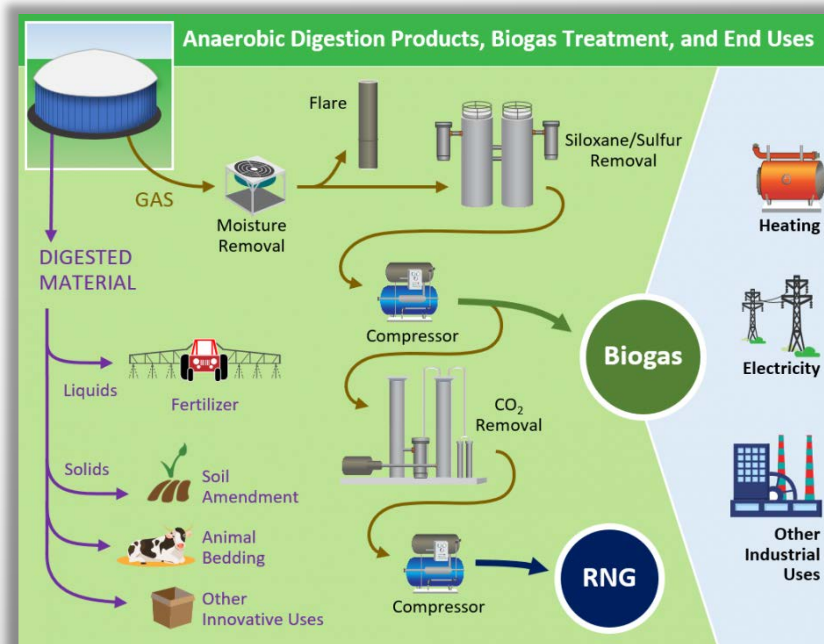
What is Renewable Natural Gas (RNG)?

- RNG is pipeline quality natural gas produced from various biomass sources through biochemical processes such as anaerobic digestion or gasification.[1]



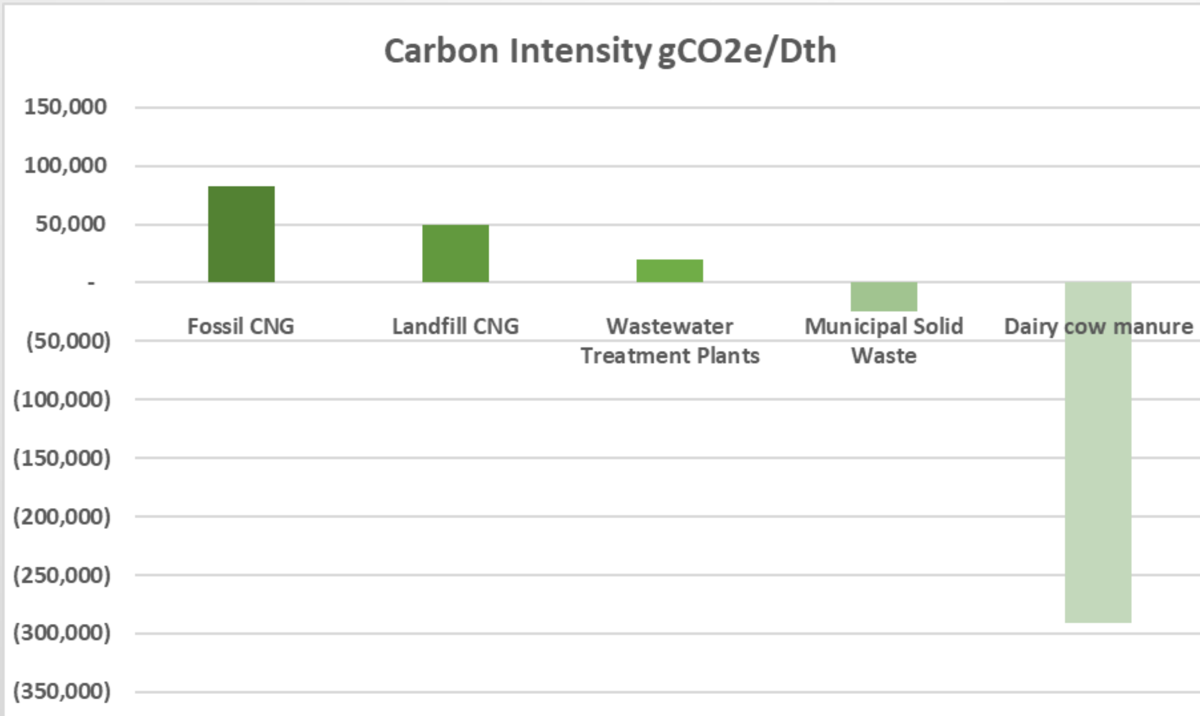
Renewable Natural Gas

- Examples:
  - Biogas from Landfills
    - Collect waste from residential, industrial, and commercial entities.
    - Digestion process takes place in the ground, rather than in a digester.
  - Biogas from Livestock Operations
    - Collects animal manure and delivers to anaerobic digester.
  - Biogas from Wastewater Treatment
    - Produced during digestion of solids that are removed during the wastewater treatment process.
  - Other sources include organic waste from food manufacturers and wholesalers, supermarkets, restaurants, hospitals, and more.[1]



Renewable Natural Gas

Carbon Intensity



Regulatory Matters Regarding RNG

- AR 632 and UM 2030
  - AR 632 is an open docket regarding RNG Rulemaking. The most recent meeting was held December 13, 2019. Rules are likely to be adopted by July 31, 2020. A few key points for IRPs:
    - IRPs should include an RNG-specific chapter.
    - RNG projects will likely need to be acknowledged in IRPs.
  - UM 2030 is an open docket for determining the cost-effectiveness of RNG resources for Northwest Natural. Cascade is aware of this docket and is an active participant.
- SB 98 in Oregon
  - SB 98 requires the Public Utility Commission to adopt by rule renewable natural gas program for natural gas utilities to recover prudently incurred qualified investments in meeting certain targets for including renewable natural gas in gas purchases for distribution to retail natural gas customers.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Regulatory Matters Regarding RNG (Cont'd)

- HB 1257 in Washington
  - HB 1257 Section 13 states that a natural gas company may propose a renewable natural gas program under which the company would supply renewable natural gas for a portion of the natural gas sold or delivered to its retail customers. Section 14 states that each gas company must offer by tariff a voluntary renewable natural gas service available to all customers to replace any portion of the natural gas that would otherwise be provided by the gas company.
- Cascade is aware of the Washington State University Study on Renewable Natural Gas
  - A study around what RNG is and a possible roadmap of RNG in WA State.
- Treatment of Carbon Intensity
  - Cascade understands there are differing schools of thought for how to record Carbon Intensity of different sources of RNG and will continue to monitor the related legislative efforts.
- Any other items Cascade should be following?

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Market Research

- Options for securing RNG will involve purchase and/or participation in infrastructure.
- No "spot market" for RNG at this point due to long off-take commitments.
- Lead times on new RNG projects up to 36 months.
- Landfill projects are typically the largest RNG opportunity at 1,000-7,000 dth/day and usually require lowest capital investment.
- Digester projects, due to higher carbon intensity, do very well in the Renewable Identification Numbers (RINs) market and run 50-500 dth/day (expensive to operate).
- Food waste/wastewater treatment projects seen as an ideal option for utilities as they have low RINs and Low Carbon Fuel Standards (LCFS) potential.
- $10-$30/dth long-term off-take deals.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Market Research (Cont'd)

- New landfill projects typically command $10-$19/dth with environmental attributes and facility investment recovery.
- Digesters need $15-$20/dth off-take deals.
- Dairy projects can be $25-$30/dth.
- Fortis B.C. has 9 Bcf/yr of RNG under contract.
- Some surveys have found customers will not pay more than $7/dth to natural gas.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

What is Cascade doing?

- **RNG planning**

  Internal Attendees
  - Regulatory
  - Business Development – Oregon & Washington
  - Energy Efficiency
  - Public Affairs
  - Resource Planning Team
  - Gas Supply

  External Attendees
  - Lobbyists
  - NWGA
  - Other LDC's located in Oregon & Washington

  Climate Action Plan Support
  - Inclusion of biogas and offset program exploration as part of City of Bend's Climate Action Plan

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade's RNG Goals

- The Company's long-term view and approach to RNG
- Roles and Responsibilities
- RNG Policy – federal, state and local guidelines and requirements
    - Electrification and RNG parity
- Voluntary Programs/Offsets
- Energy Efficiency & RNG
- Future opportunities
- Standards

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Potential RNG Projects in Cascade's Service Territory

- Working with municipals, wastewater treatment plants, biodigesters with industrial customers, and landfills.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Energy Efficiency Resource Assessment for CNG’s 2020 IRP

January 15th, 2020

Energy Trust of Oregon

Agenda

- About Energy Trust
- Energy Trust's Resource Assessment Model Overview and Methodology
- IRP Savings Projection Overview
  - The Deployment of Cost-Effective Achievable Savings
- Forecast Results
- Scenarios Results

About Energy Trust of Oregon

Independent nonprofit

Serving 1.6 million customers of Portland General Electric, Pacific Power, NW Natural, Cascade Natural Gas and Avista

Providing access to affordable energy

Generating homegrown, renewable power

Building a stronger Oregon and SW Washington

Energy Trust’s Resource Assessment Model Overview

Resource Assessment (RA) Purpose

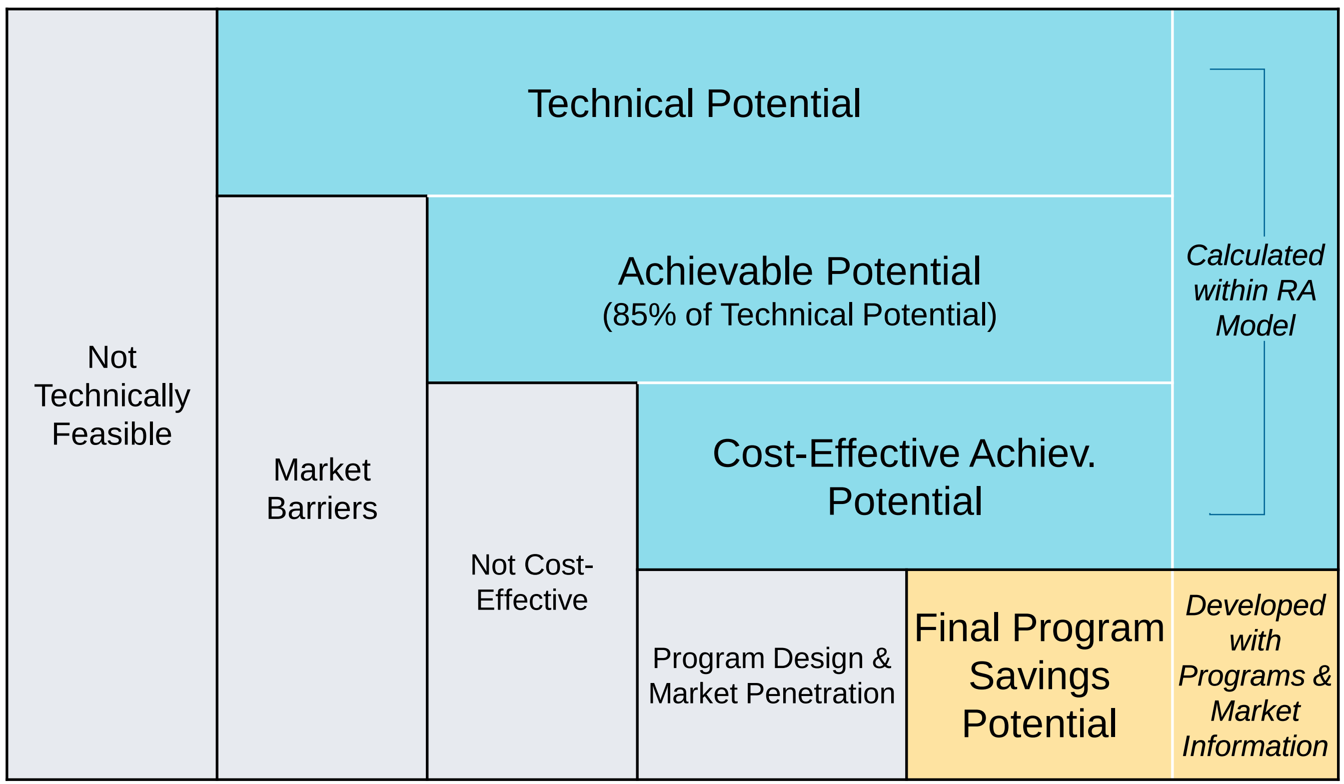
- Informs utility Integrated Resource Planning (IRP)
- Provides estimates of 20-year energy efficiency potential and the associated load reduction
- Helps utilities to strategically plan future investment in both demand and supply side resources

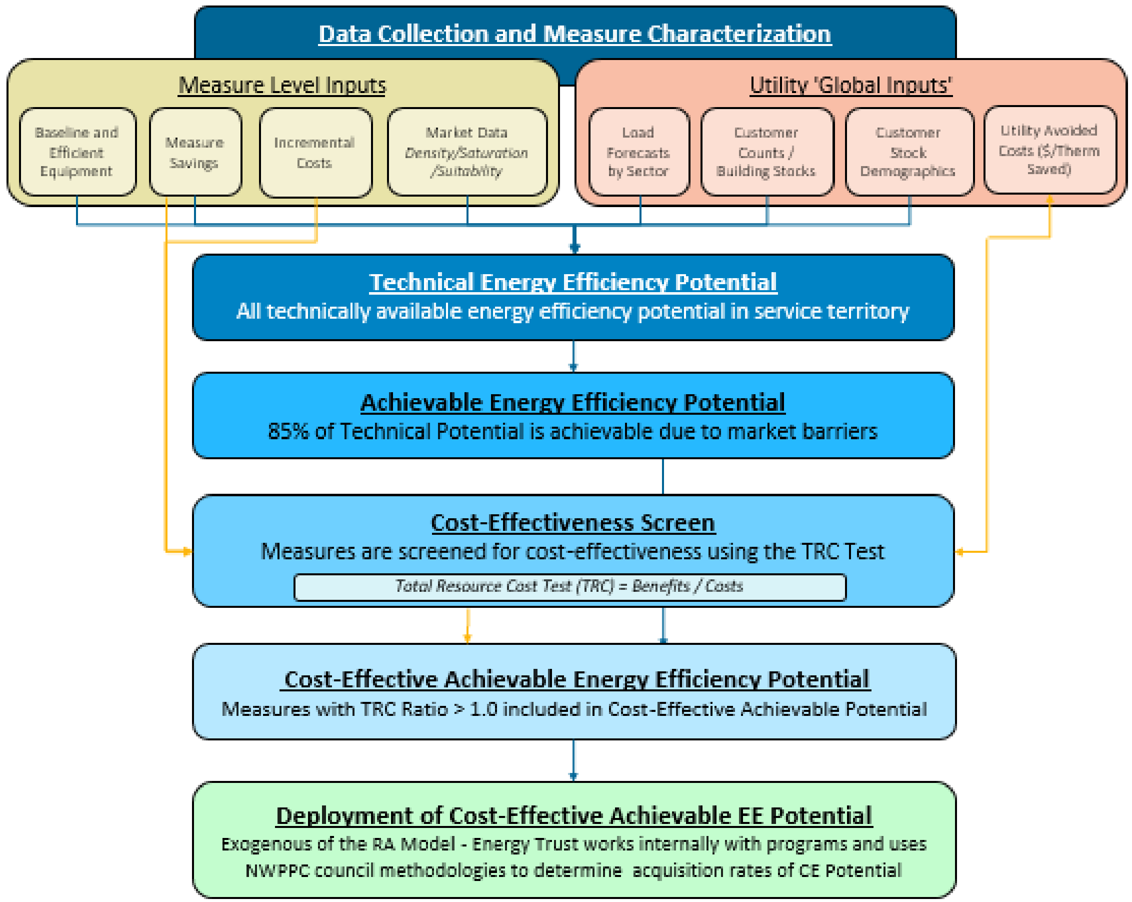
RA Model Background

- 20-year energy efficiency potential estimates
- “Bottom-up” modeling approach – measure level inputs are scaled to utility level efficiency potential
- Energy Trust uses a model in *Analytica* that was developed by Navigant Consulting in 2014
  - The *Analytica* RA Model calculates Technical, Achievable and Cost-Effective Achievable Energy Efficiency Potential.
  - Final program/IRP targets are established via a deployment protocol exogenous of the model.
- Inputs refreshed to reflect most up to date assumptions according to IRP schedules
- A “living model” and is constantly being improved

Changes to Modeling Since 2018 IRP

- Stakeholder workshop in Fall of 2017 and implemented several methodology changes:
  - Inclusion of Large Project Adder
  - Align to NWPCC method for deployment ramping to 100% of total cost-effective achievable potential
    - Exceptions: emerging techs and hard to reach measures
- Understand load forecasts better to provide most accurate forecast of what will come off the system
  - Cost-effective potential may be realized through programs or codes and standards.
  - Unclaimed savings adder
- Scenario Runs


Not Technically Feasible
Technical Potential
Market Barriers
Achievable Potential
(85% of Technical Potential)
Not Cost-Effective
Cost-Effective Achiev. Potential
Program Design & Market Penetration
Final Program Savings Potential
Calculated within RA Model
Developed with Programs & Market Information


Data Collection and Measure Characterization
Measure Level Inputs
Baseline and Efficient Equipment
Measure Savings
Incremental Costs
Market Data Density/Saturation /Suitability
Utility 'Global Inputs'
Load Forecasts by Sector
Customer Counts / Building Stocks
Customer Stock Demographics
Utility Avoided Costs ($/Therm Saved)
Technical Energy Efficiency Potential
All technically available energy efficiency potential in service territory
Achievable Energy Efficiency Potential
85% of Technical Potential is achievable due to market barriers
Cost-Effectiveness Screen
Measures are screened for cost-effectiveness using the TRC Test
Total Resource Cost Test (TRC) = Benefits / Costs
Cost-Effective Achievable Energy Efficiency Potential
Measures with TRC Ratio > 1.0 included in Cost-Effective Achievable Potential
Deployment of Cost-Effective Achievable EE Potential
Exogenous of the RA Model - Energy Trust works internally with programs and uses NWPPC council methodologies to determine acquisition rates of CE Potential

Methodology Overview

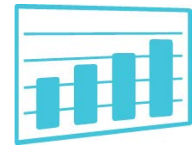
‘Bottom-up’ modeling approach:

1. Measure inputs are characterized per unit
2. Number of units per scaling basis are estimated
   - *Residential*: # of Homes Served
   - *Commercial*: 1000s of Sq. Ft. Served
   - *Industrial*: Customer Segment Load Forecasts
3. The savings and costs of each measure are scaled to the utility level based on scaling basis inputs provided by CNG

Simple Example *(Illustrative Numbers)*

Eff. Gas Furnace – 100 Therms Savings	1 Gas Furnace per home and 50% at baseline efficiency	25,000 Homes served by utility	100 x 1 x 0.50 x 25,000 = 1,250,000 savings potential
•Measure Data	•Market Data	•Utility Data	•Total Potential

RA Model inputs



Measure Level Inputs

Measure Definition and Application:
- Baseline/efficient equip. definition
- Applicable customer segments
- Installation type (RET/ROB/NEW)*
- Measure life

Measure Savings

Measure Cost
- Incremental cost for ROB/NEW measures
- Full cost for retrofit measures

Market Data (for scaling)
- Density
- Baseline/efficient equipment saturations
- Suitability

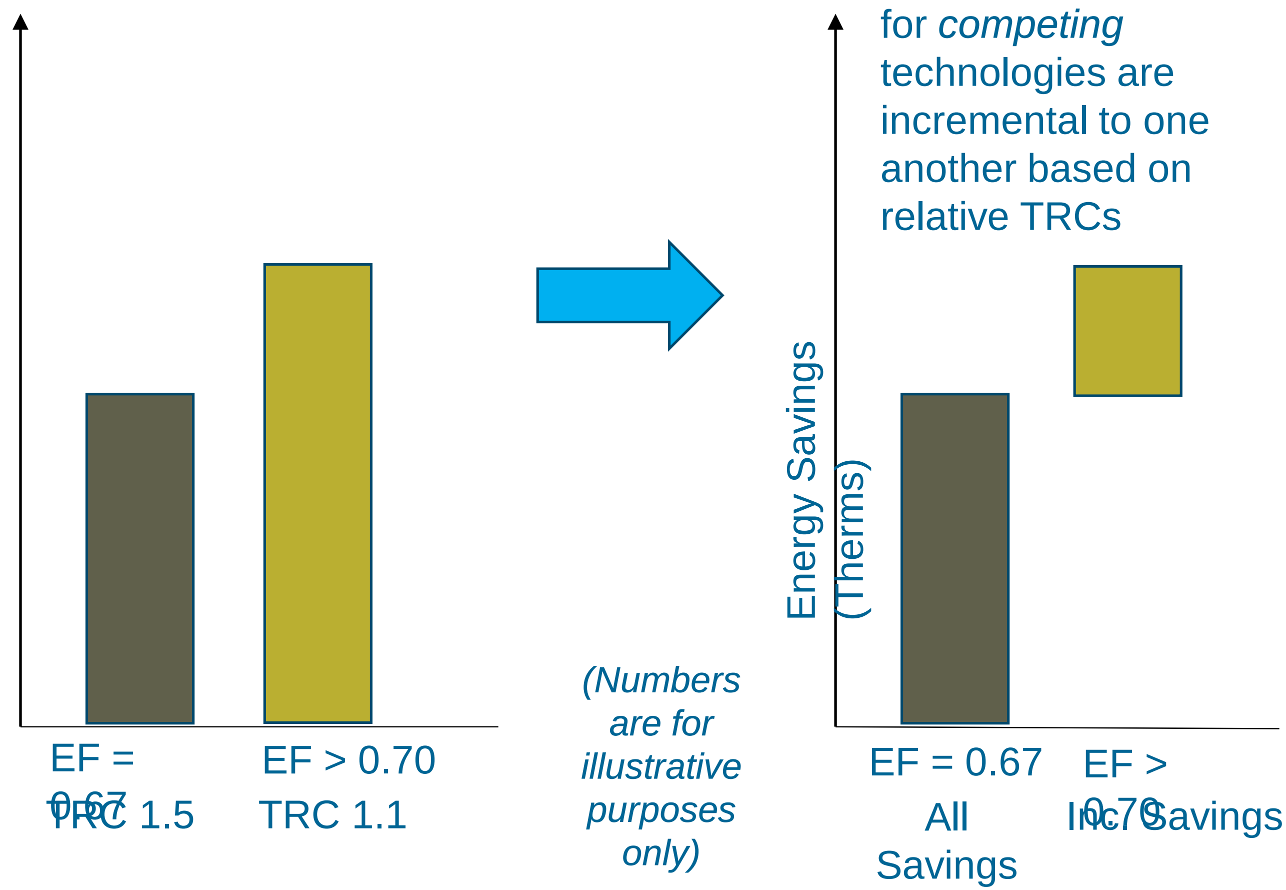
Utility 'Global' Inputs

Customer and Load Forecasts
- Used to scale measure level savings to a service territory
  - Residential Stocks: # of homes
  - Commercial Stocks: 1000s of Sq.Ft.
  - Industrial Stocks: Customer load

Avoided Costs (provided by utilities)

Customer Stock Demographics:
- Heating fuel splits
- Water heat fuel splits

Incremental Measure Savings Approach (Competition groups – Gas water heaters)



Savings potential for *competing* technologies are incremental to one another based on relative TRCs

Cost-Effectiveness Screen

- Energy Trust utilizes the Total Resource Cost (TRC) test to screen measures for cost effectiveness

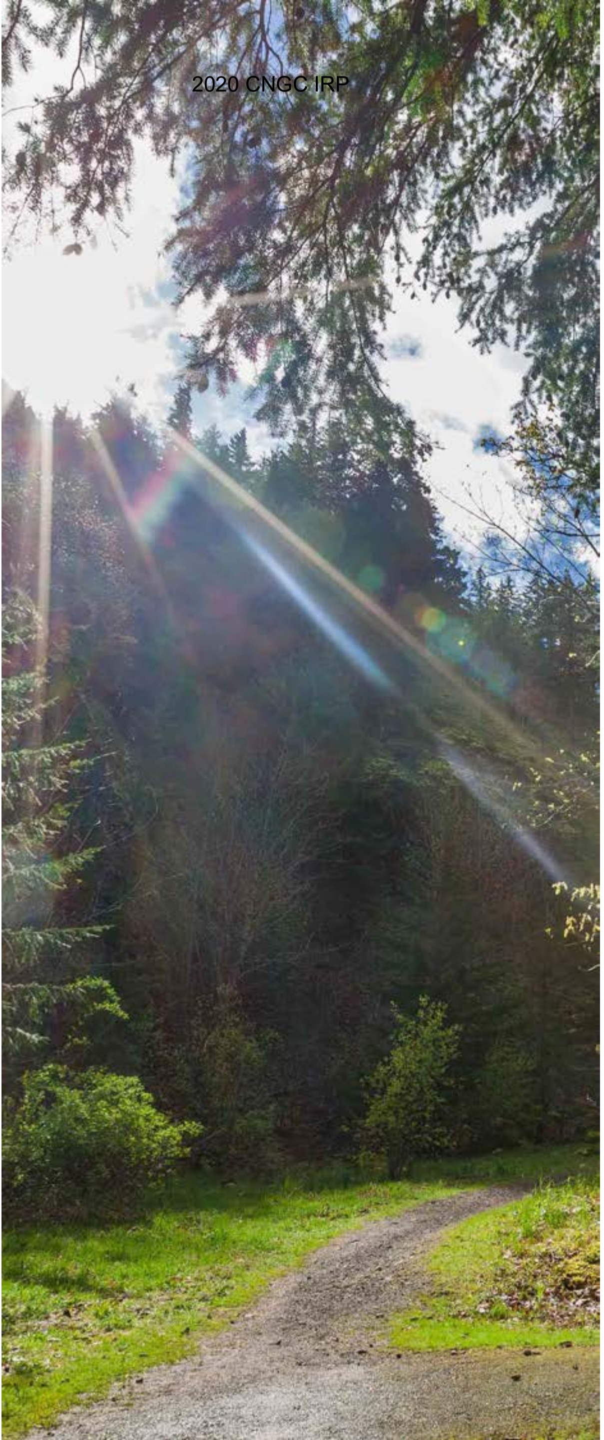
$$\text{TRC} = \frac{\textit{Measure Benefits}}{\textit{Total Measure Cost}}$$

- If TRC is > 1.0, it is cost-effective

- Measure Benefits:
  - Avoided Costs (provided by Cascade)
    - Annual measure savings x NPV avoided costs per therm
  - Quantifiable Non-Energy Benefits
    - Water savings, etc.

Total Measure Costs:

- The customer cost of installing an EE measure (full cost if retrofit, incremental over baseline if replacement)



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 Energy Trust programs.

Reasons:

1. Blended avoided costs may produce different results than utility specific avoided costs
2. Measures offered under an OPUC exception per UM 551 criteria.

The following measures had the CE override applied (all under OPUC exception):

- Res Insulation (ceiling, floor, wall)
- Res Tank Water Heater (0.67-0.69 only)

Emerging Technologies/Risk Factors

Residential	Commercial	Industrial
• Path 5 Emerging Super Efficient Whole Home • Window Replacement (U<.20), Gas SH • Absorption Gas Heat Pump Water Heaters • Advanced Insulation	• Advanced Ventilation Controls • DOAS/HRV - GAS Space Heat • DHW Circulation Pump • Gas-fired HP HW • Gas-fired HP, Heating • Zero Net Energy Path	• Gas-fired HP Water Heater • Wall Insulation- VIP, R0-R35

- Model includes savings potential from emerging technologies
- Factors in changing performance, cost over time
- Utilize risk factors to hedge against uncertainty
    - Market, technical and data source risk are assessed.

	Risk Factors for Emerging Technologies				
Risk Category	**10%**	**30%**	**50%**	**70%**	**90%**
Market Risk (25% weighting)	Requires new/changed business model Start-up, or small manufacturer Significant changes to infrastructure Requires training of contractors. Consumer acceptance barriers exist.		Training for contractors available. Multiple products in the market.	Trained contractors Established business models Already in U.S. Market Manufacturer committed to commercialization	
Technical Risk (25% weighting)	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	Proven technology in target application. Multiple potentially viable approaches.
Data Source Risk (50% weighting)	Based only on manufacturer claims	Manufacturer case studies	Engineering assessment or lab test	Third party case study (real world installation)	Evaluation results or multiple third party case studies

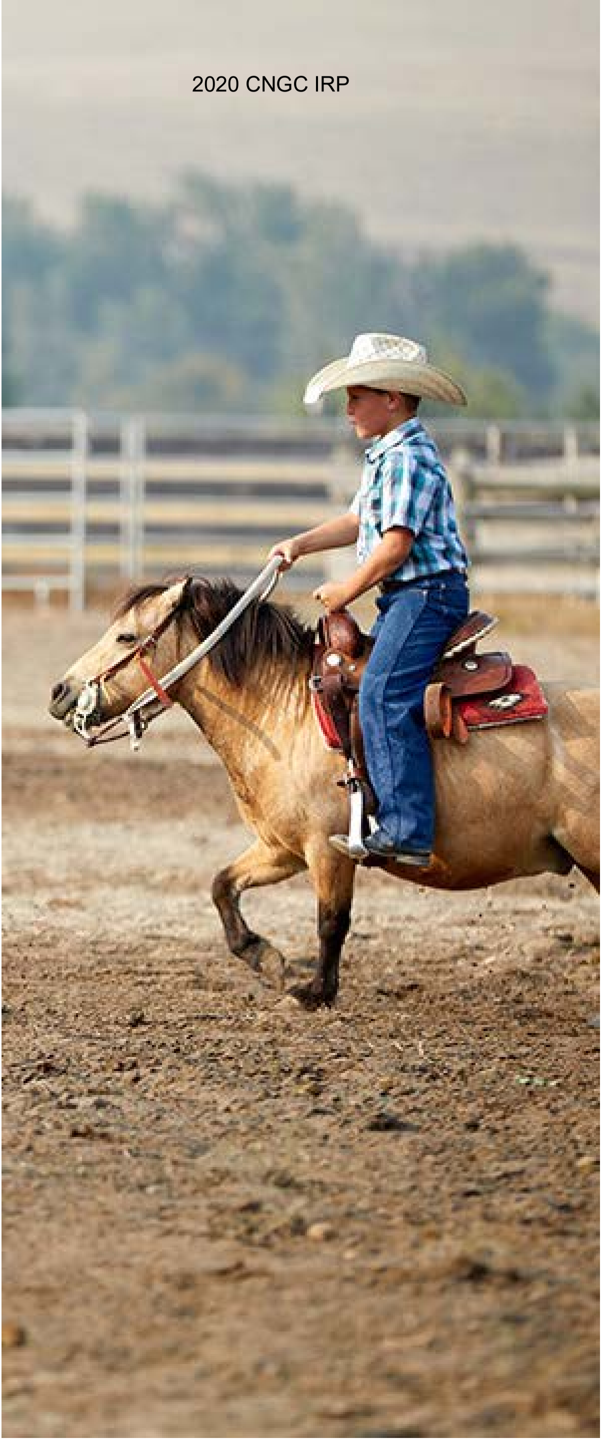
3
1

Model Outputs

- Types of Potential:
  - Technical
  - Achievable
  - Cost-Effective Achievable
- Levelized Cost
- Measure Costs & Benefits
- Supply Curves

IRP Savings Projections:

Methodology to Deploy Cost-Effective Achievable Potential



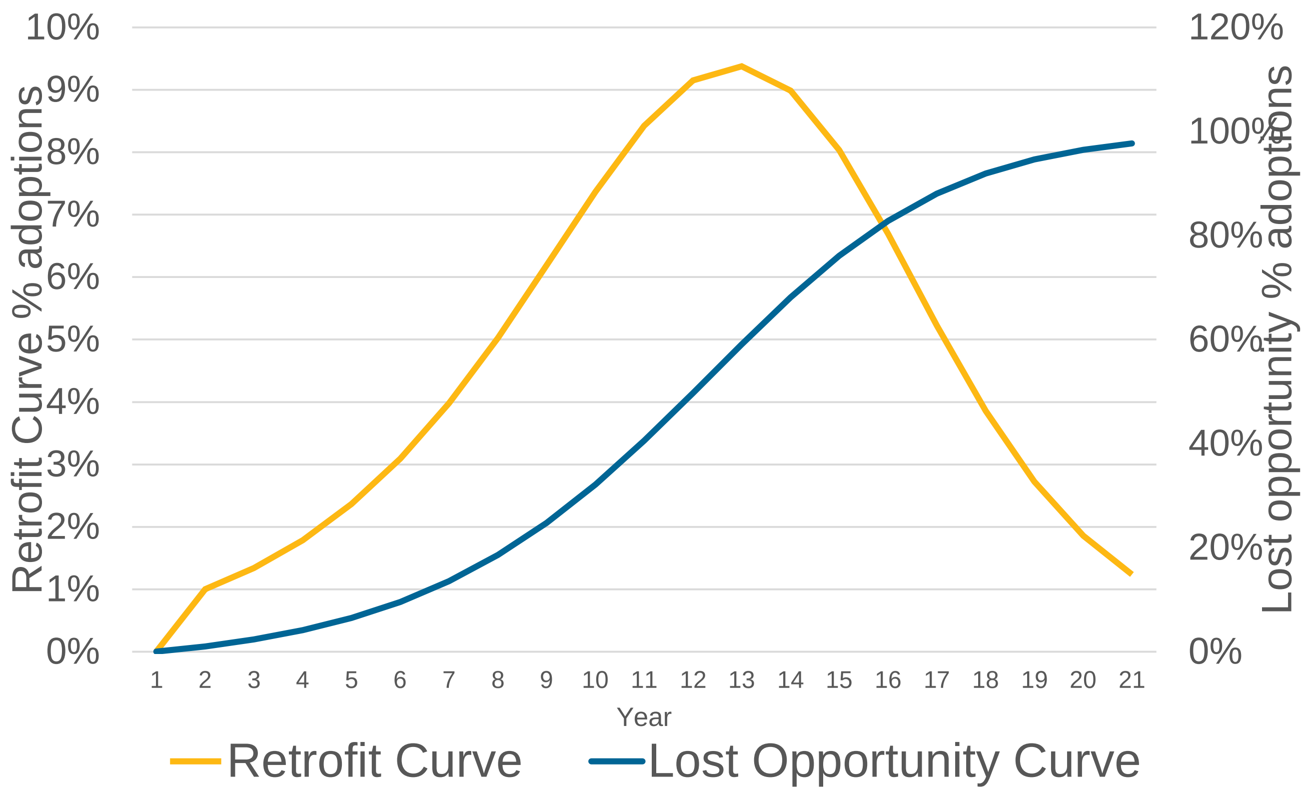
Why Deploy?

- The RA model results represent the maximum savings potential in a given year.
- Ramp rates are an estimate of how much of that available potential will come off CNG's system.
- Energy Trust ramp rates are based on NWPCC methods and ramp rates, but calibrated to be specific to Energy Trust.

Ramp Rate Overview

- Total RA Model cost-effective potential is different depending on the measure type.
  - **Retrofit measure savings** are 100% of all potential in every year, therefore must be distributed in a curve that adds to 100% over the forecast timeframe (bell curve)
  - **Lost opportunity measure savings** are the savings available in that year only and deployment rates are what % of that available potential rate can be achieved – results in an s-curve
- Generally follows the NWPCC deployment methodology
  - 100% cumulative penetration for retrofit measures over 20-year forecast
  - 100% annual penetration for lost opportunity by end of 20-year forecast (program or code achieved)
  - Hard to reach measures or emerging technologies do not ramp to 100%

Ramp Rate Examples



Ramp Rate Calibration

Years 1-2

- Program forecasts – they know what is happening short

Years 3-5

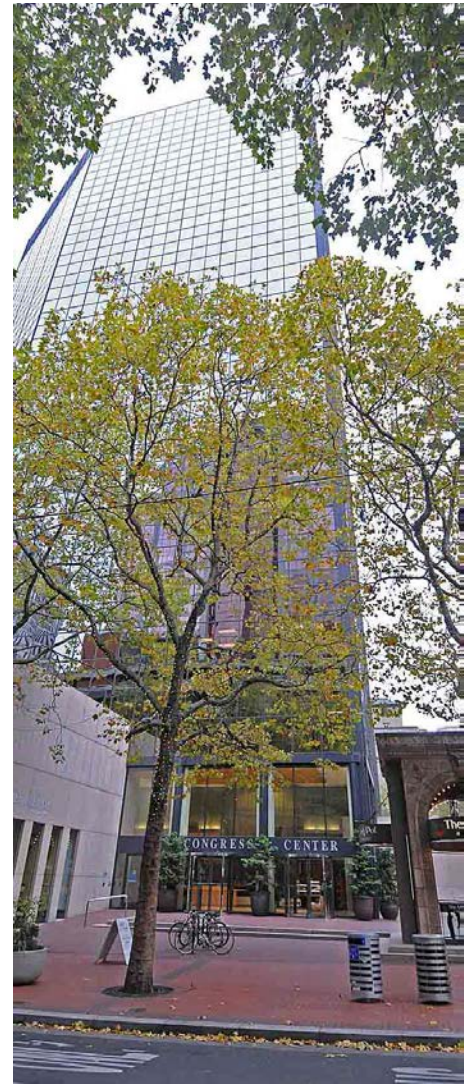
- Planning and Programs work together to create forecast

Years 6-20

- Planning forecasts long-term acquisition rate to generally align

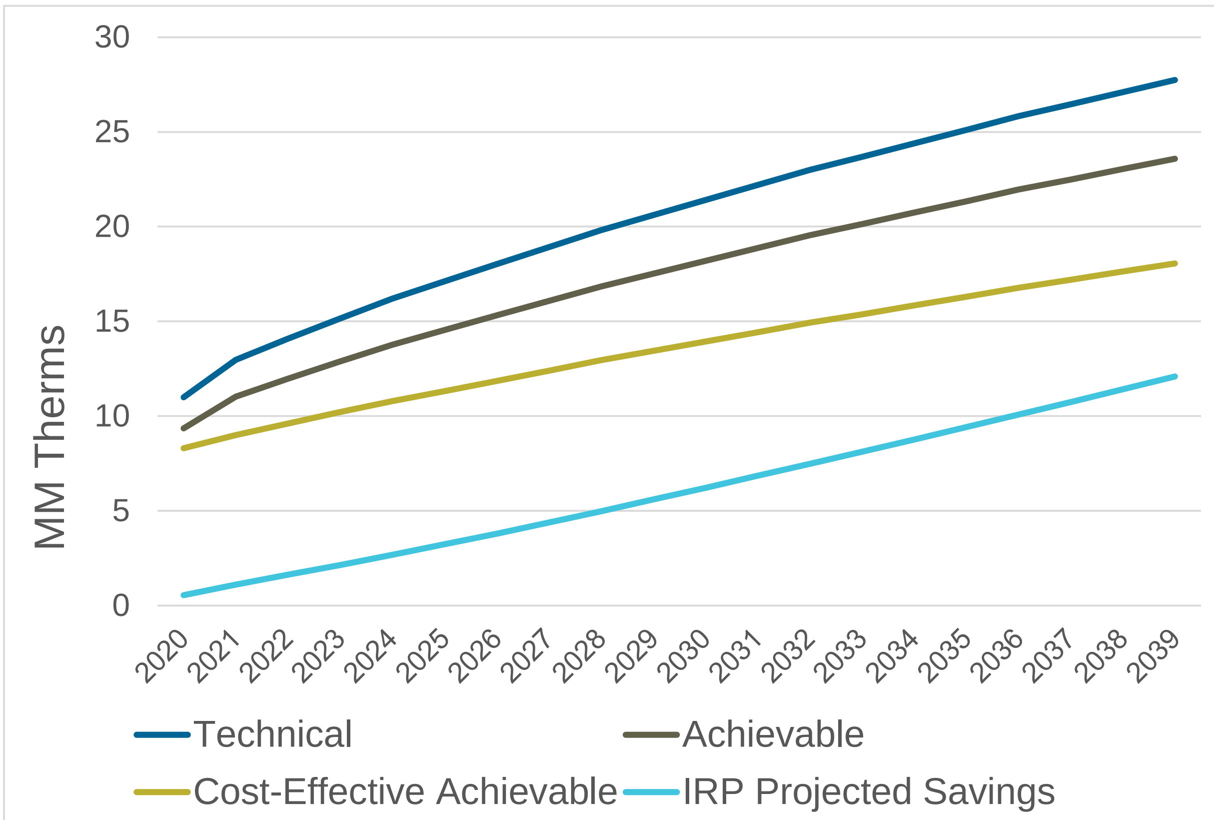
Application of Ramp Rates & Relation to RA Model Results

- Energy Trust's calibration process means ramp rates are not the same as the NWPCC, but follow similar methods.
- Ramp rates are specific to CNG.
- The application of these ramp rates is the reason why not all of the RA Model Cost-Effective Achievable Potential is forecasted to be acquired.
- The deployment process is done exogenously of the RA Model.

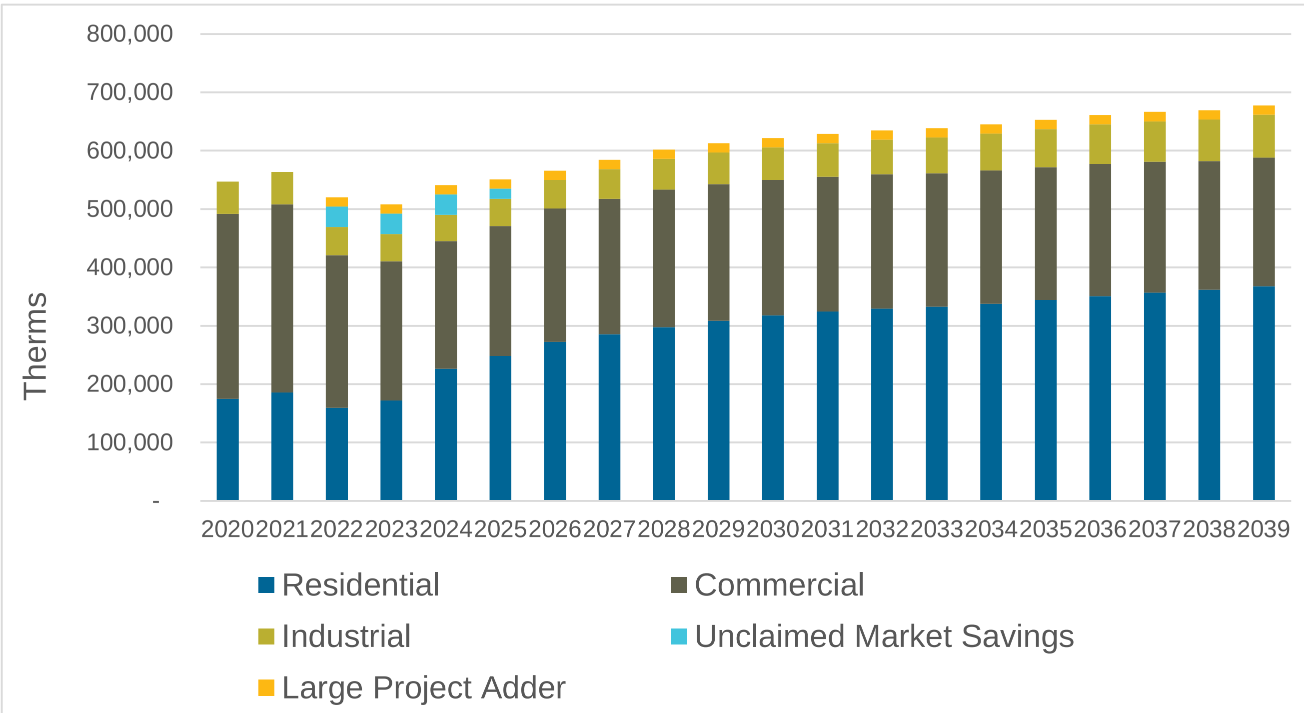


CNG’s 2020 IRP Results

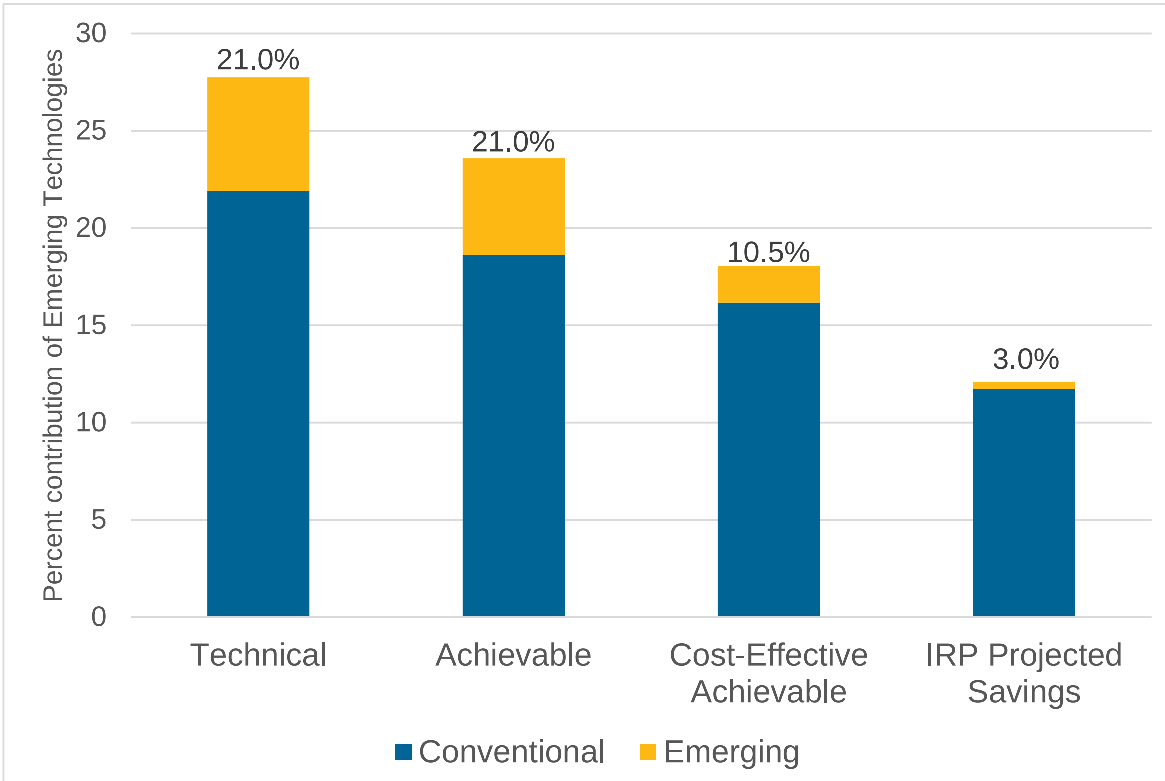
Cumulative Savings by Type and Year



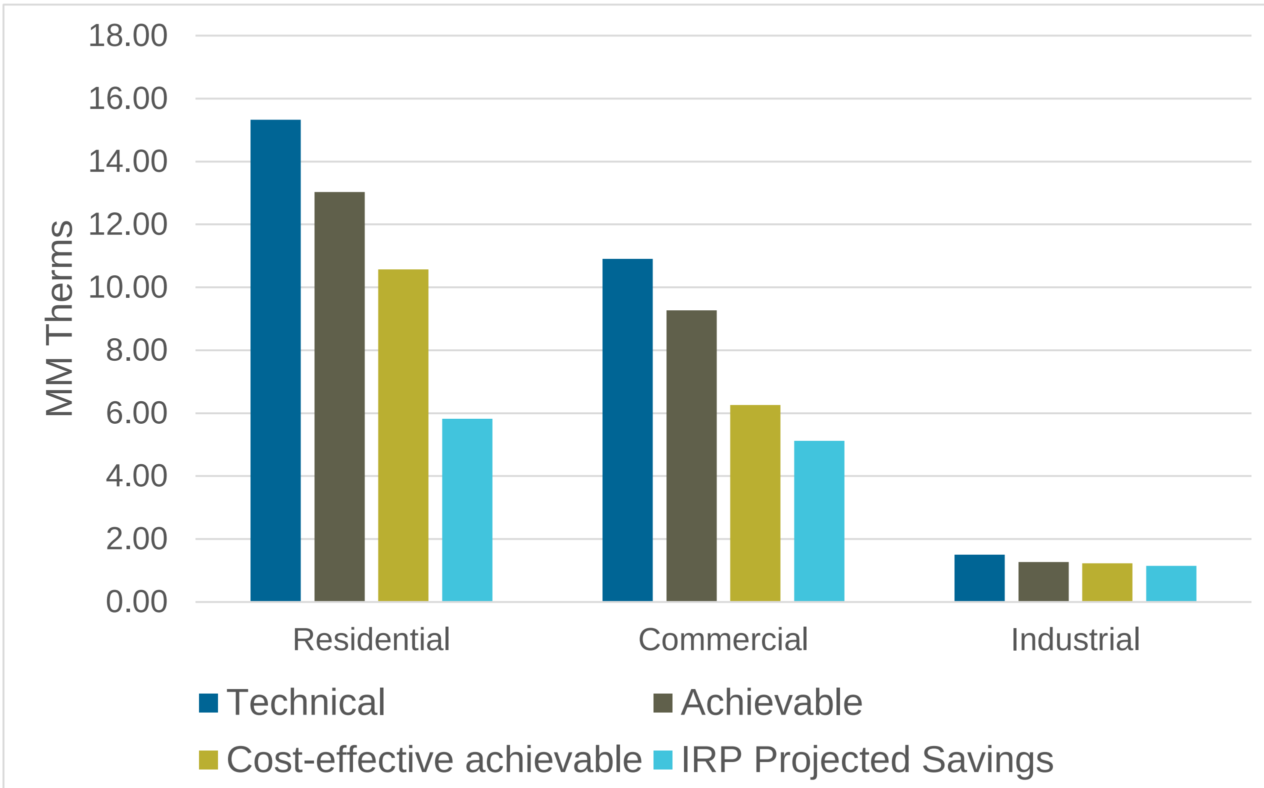
Annual Deployed IRP Forecasted Savings



Cumulative Contribution of Emerging Technologies



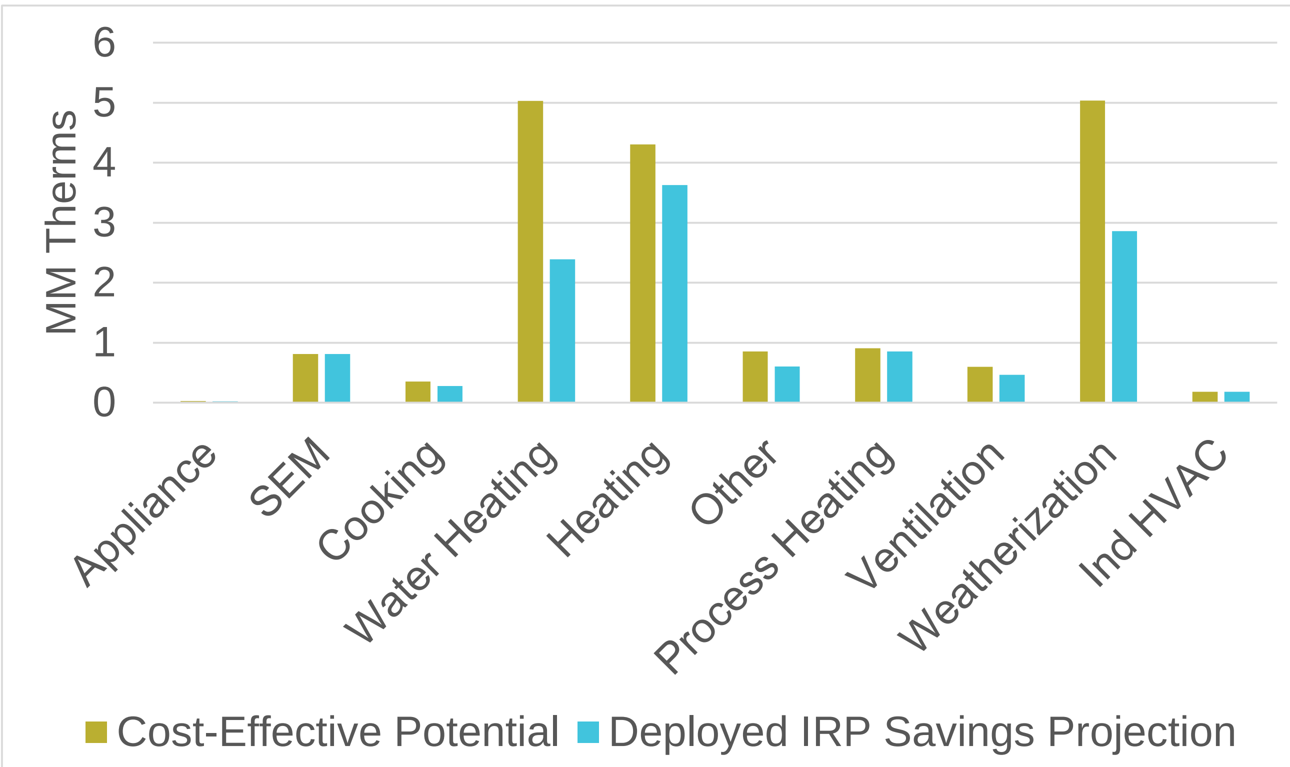
Cumulative Savings by Sector and Type



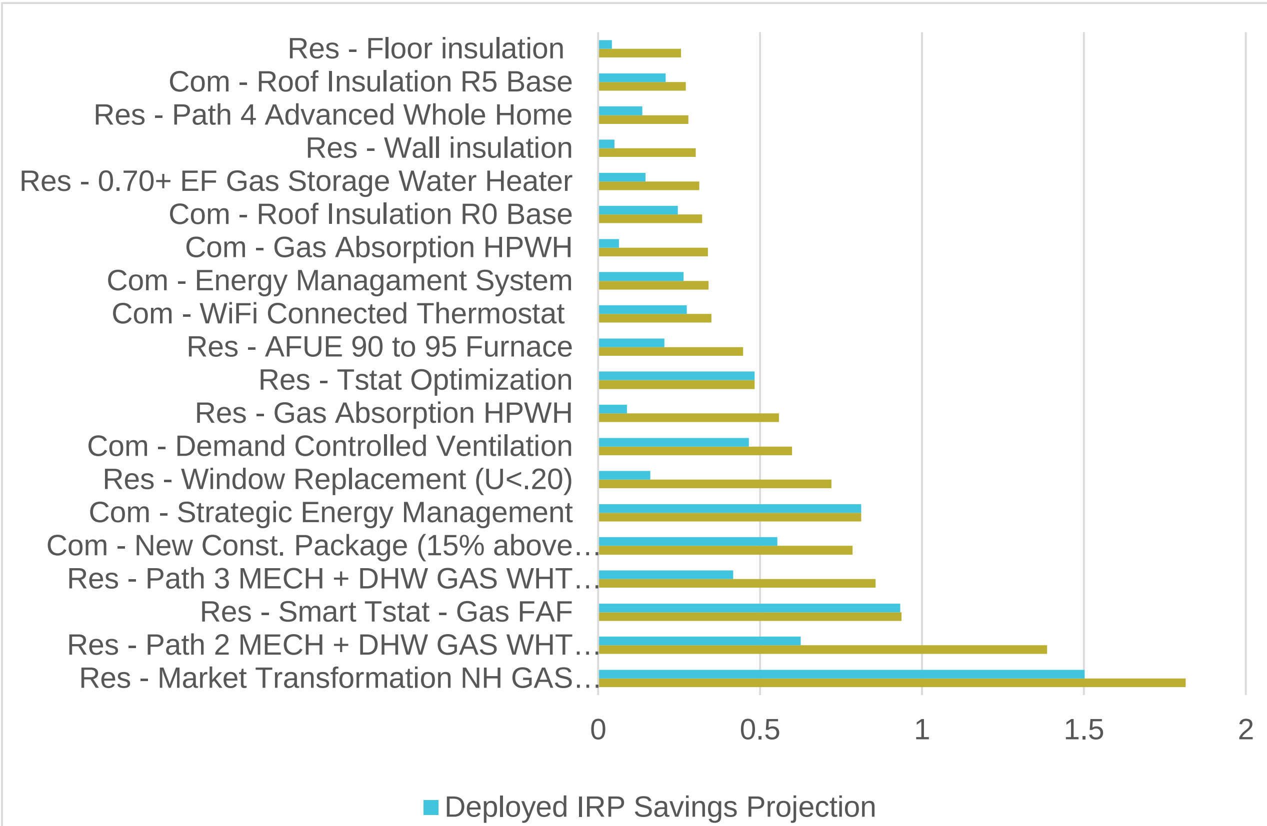
Cumulative Savings by Sector and Type (Therms)

	Residential	Commercial	Industrial	All Sectors
Technical Potential	15,330,968	10,907,894	1,495,547	27,734,409
Achievable Potential	13,031,322	9,271,710	1,271,215	23,574,247
Cost-effective Achievable Potential	10,567,961	6,259,466	1,229,985	18,057,412
IRP Projected Savings	5,823,039	5,121,593	1,148,116	12,092,748

Cumulative Cost-Effective Savings & IRP Savings Projections by End-Use Compared



Top 20 Measures: Cumulative Cost-Effective Savings & IRP Savings Projections Compared



Cost Effective Override Effect

Energy Trust applied this feature to measures found to be NOT Cost-Effective in the model but are offered through Energy Trust programs under OPUC Exception

Total Cumulative Potential	Cost-Effective Potential	Deployed IRP Savings Projection
Savings with CE Override (MM Therms)	18.06	12.09
Savings with NO CE Override (MM Therms)	17.08	11.93
Variance (MM Therms)	0.98	0.17
CE Overridden % of Total Potential	**5.4%**	**1.4%**

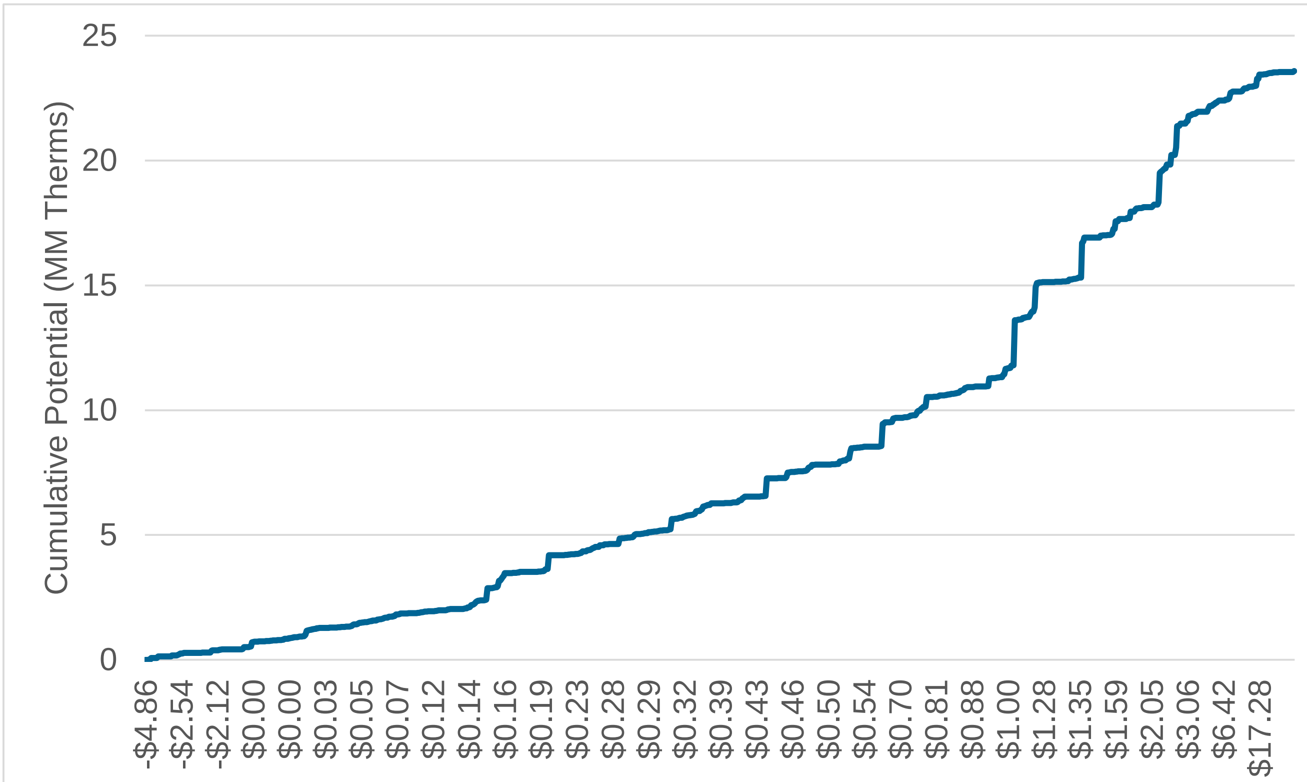
Measures that are Overridden	Override Applied?	Notes
Res - Attic/Ceiling insulation	TRUE	OPUC Exception
Res - Floor insulation	TRUE	OPUC Exception
Res - Wall insulation	TRUE	OPUC Exception
Res - 0.67/0.69 EF Gas Tank Water Heater	TRUE	OPUC Exception

Peak Day Factors and Cumulative Peak Day Savings Estimates

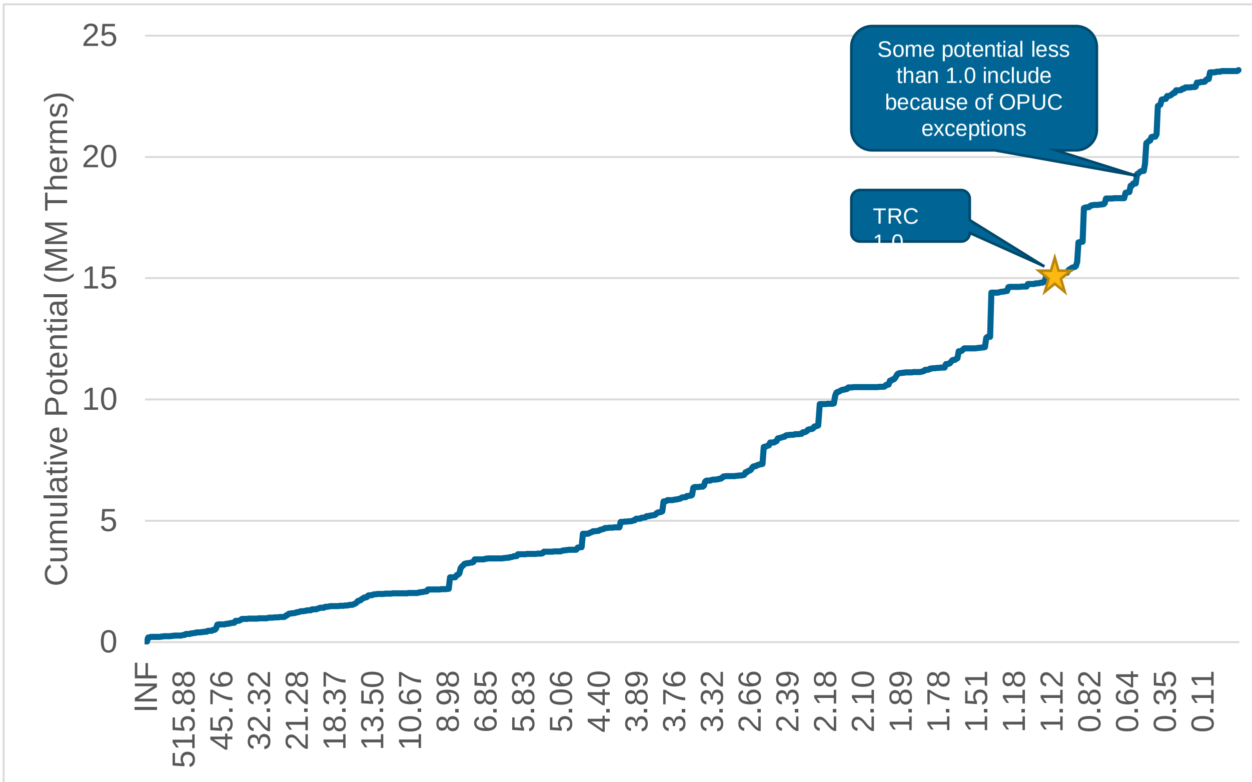
- Energy Trust also provides estimates of a peak day reduction in peak day consumption
- Peak Day factors derived from Energy Trust avoided cost calculations

	Peak Day Factor	CE Potential Peak Day Therms (cumulative)	IRP Savings Targets Peak Day Therms (cumulative)
Cooking	0.30%	1,099	863
Com Heating	1.80%	89,959	73,216
Domestic Hot Water	0.40%	10,249	4,791
FLAT	0.30%	2,545	2,344
Res Heating	2.10%	192,531	110,512
Res Clotheswasher	0.20%	6	3

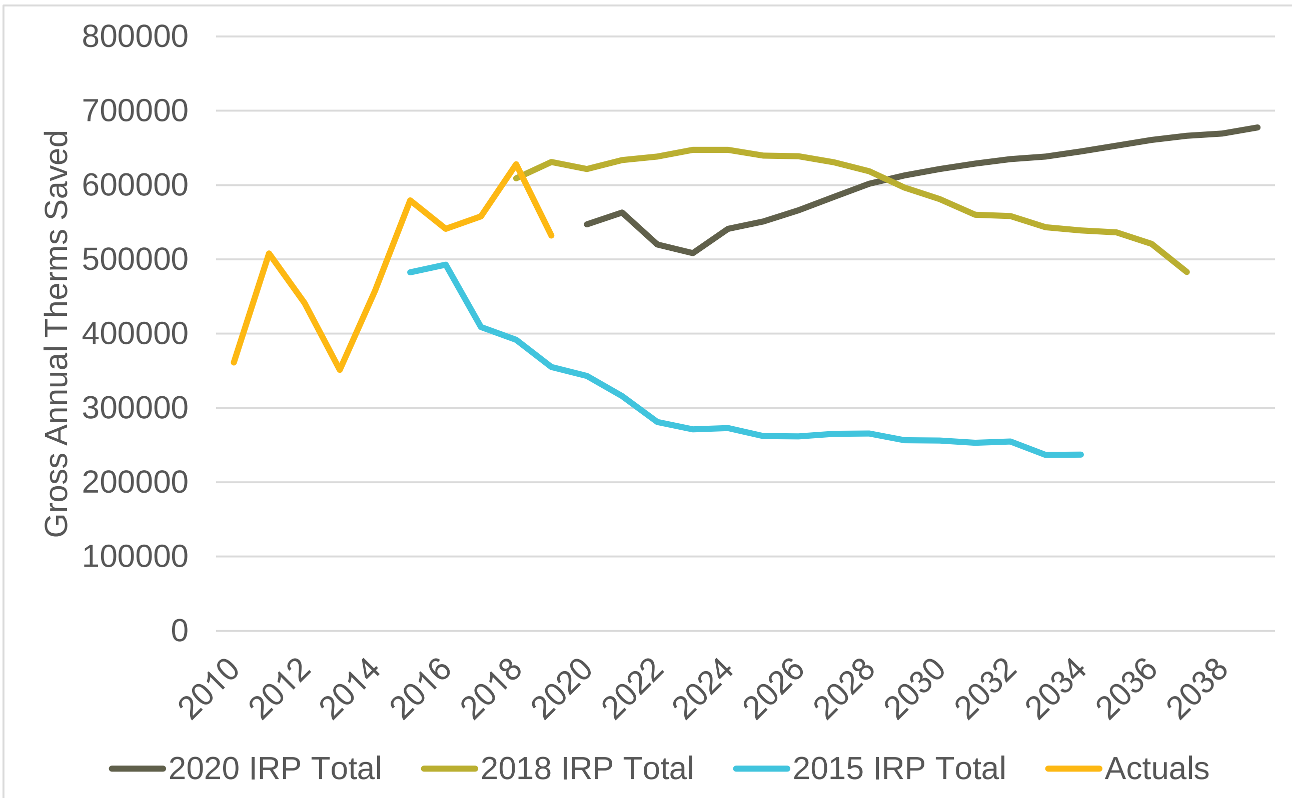
Supply Curve by Levelized Cost (20 year Cumulative Achievable Potential)



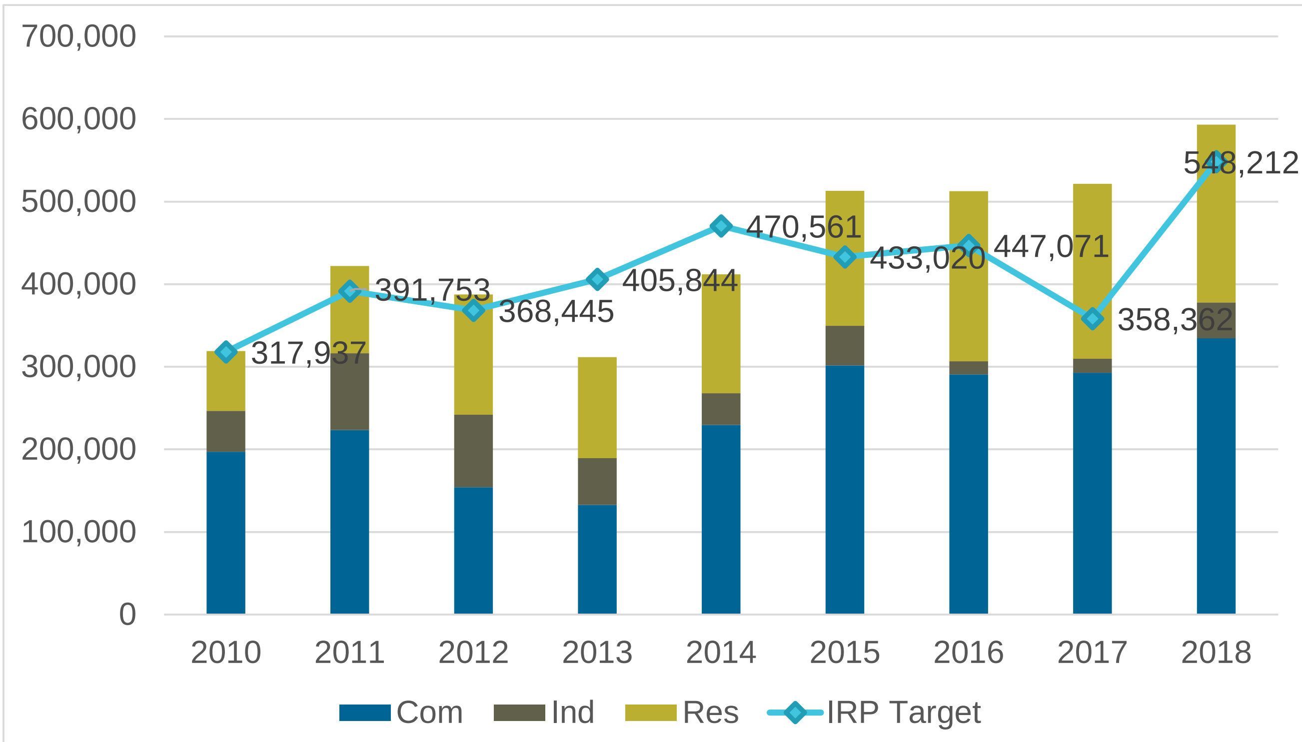
Supply Curve by TRC Ratio (20 year Cumulative Achievable Potential)



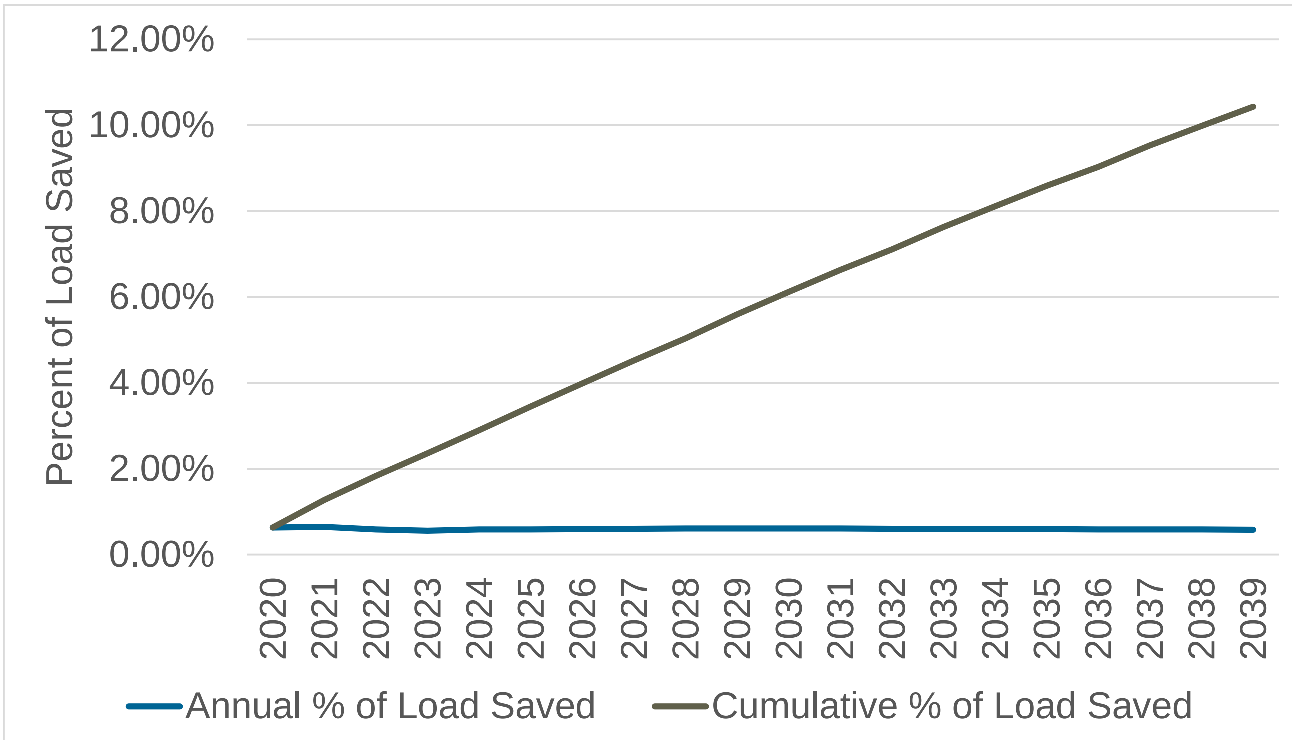
IRP Forecasts Compared to Actual Savings (Annual Gross Therms)



Historical Performance compared to IRP targets (Annual *Net* Therms)



Savings as a Percent of Load Forecast



Scenario Runs

Scenarios Overview

- Ran 4 scenarios for CNG’s 2018 IRP
  - Scenario 1:
    - Base Case Ramp Rates / Social Cost of Carbon Avoided Costs
  - Scenario 2:
    - Base Case Ramp Rates / Market Price of Carbon Avoided Costs
  - Scenario 3:
    - Low Ramp Rates / Reference Case Avoided Costs
  - Scenario 4:
    - High Ramp Rates / Reference Case Avoided Costs

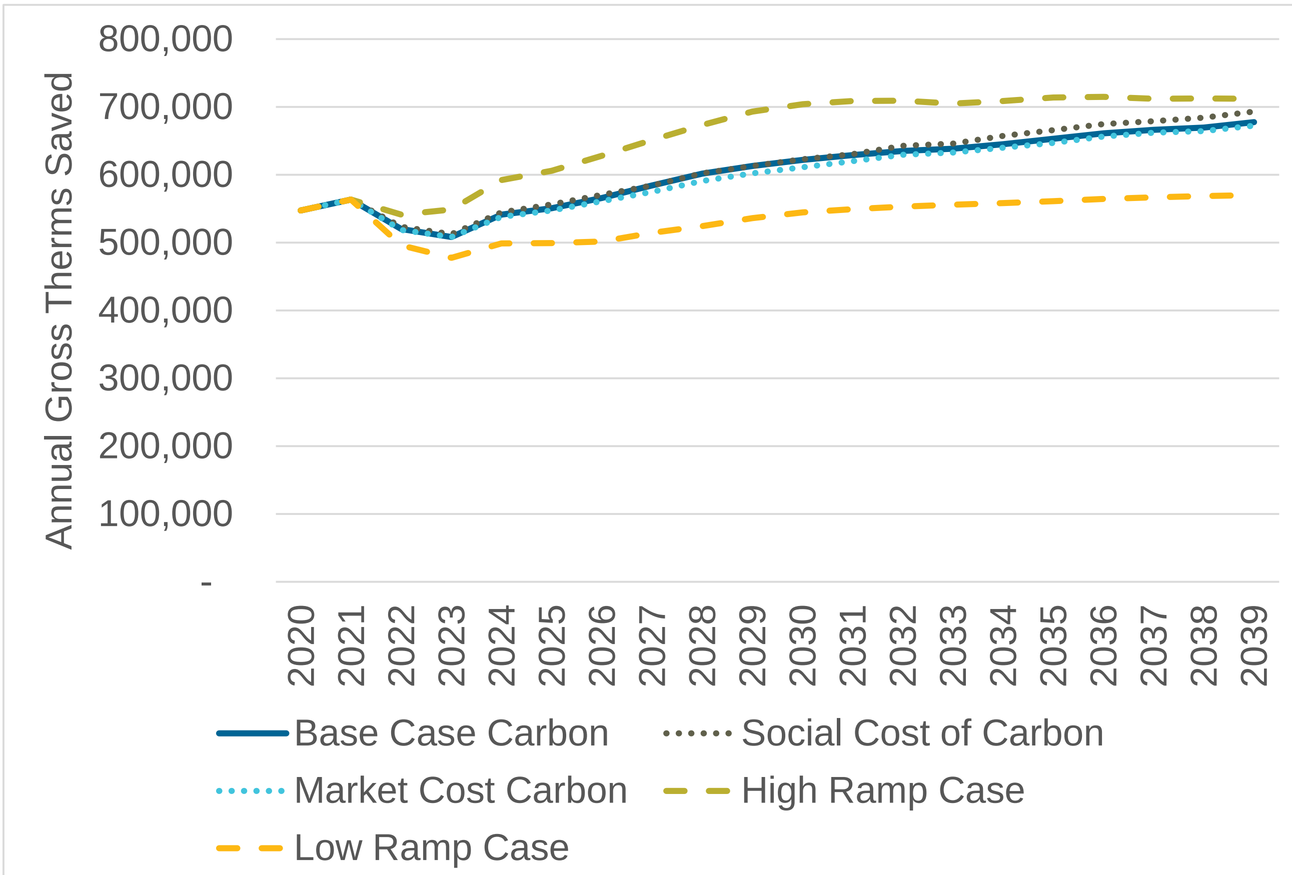
Carbon Scenarios Methodology

- Utilized two different carbon price forecasts in the modeled avoided costs
  - Social Cost of Carbon (higher than base case (Cap & Trade) carbon assumption)
  - Market Cost of Carbon (lower than the base case (Cap & Trade) carbon assumption)
- Ran model with updated avoided costs
- Input CE results into deployment tool and did not change ramp rates except for years 1 and 2 to reflect current budget goals for 2020/2021

High/Low Ramp Scenarios Methodology

- These both utilize the base case avoided costs
- These scenarios front load savings potential or slow it down.
  - High Ramp Methodology:
    - Reaching 100% of available Replacement/New measures earlier in the forecast (about 5 years)
    - Front load some of the retrofit savings
    - Applying a faster adoption curve of emerging technologies
  - Low Ramp Methodology:
    - Reaching only 85% of the available Replacement/New measures in the forecast (instead of 100% by the end of the forecast as in the base case)
    - Reaching only 85% of total Retrofit achievable potential deployed in the base case
    - Slower adoption curve for emerging technologies.

Scenario Analysis Results (Annual Therms)



Carbon Scenarios Discussion

- Carbon price has a minimal effect on the overall deployed cost effective potential
  - These scenarios only look at the incremental differences in cost-effective potential, not customer adoption elasticity
  - There are very few measures that are on the margin (just below 1.0 TRC) in terms of cost-effectiveness
  - CE is tested for each year in the model, so measures on the margin just shift when they become cost effective

High/Low Ramp Scenarios Discussion

- Energy Trust's influence on outcomes is uncertain
- Could be the result of one or a combination of the following factors:
  - Increased incentives from higher avoided costs due to carbon
  - Economic booms or slowdowns
  - Increased awareness of carbon and therefore increased interest in EE adoption (or the opposite)
  - Increased or decreased funding of energy efficiency in Oregon
  - Carbon legislation or other legislation
  - Customer behavior or interest in certain technologies

Thank you

Jack Cullen

Sr. Project Manager, Planning

Jack.Cullen@energytrust.org

503.548.1596

Carbon Impacts

Carbon Discussion

- Purpose of this section is to discuss the rationale and decision-making process behind Cascade's carbon modeling.
- Intended to be a collaborative discussion so questions are particularly encouraged.

Base Case Carbon Forecast – Cap and Trade Market

- Cascade's resource planning team worked closely with its internal environmental analysts to make a qualitative decision as to the most probable carbon future in Oregon, which they believe to be a Cap and Trade marketplace analogous to the California marketplace.
- Cascade chose to continue using a deterministic approach to carbon compliance forecasting to be consistent with Cascade's other modeling methodologies, as well as to avoid having to make subjective probabilistic assumptions about future carbon costs.
- Sensitivity analysis, both deterministic and stochastic, helps the Company quantify the uncertainty around carbon compliance costs.

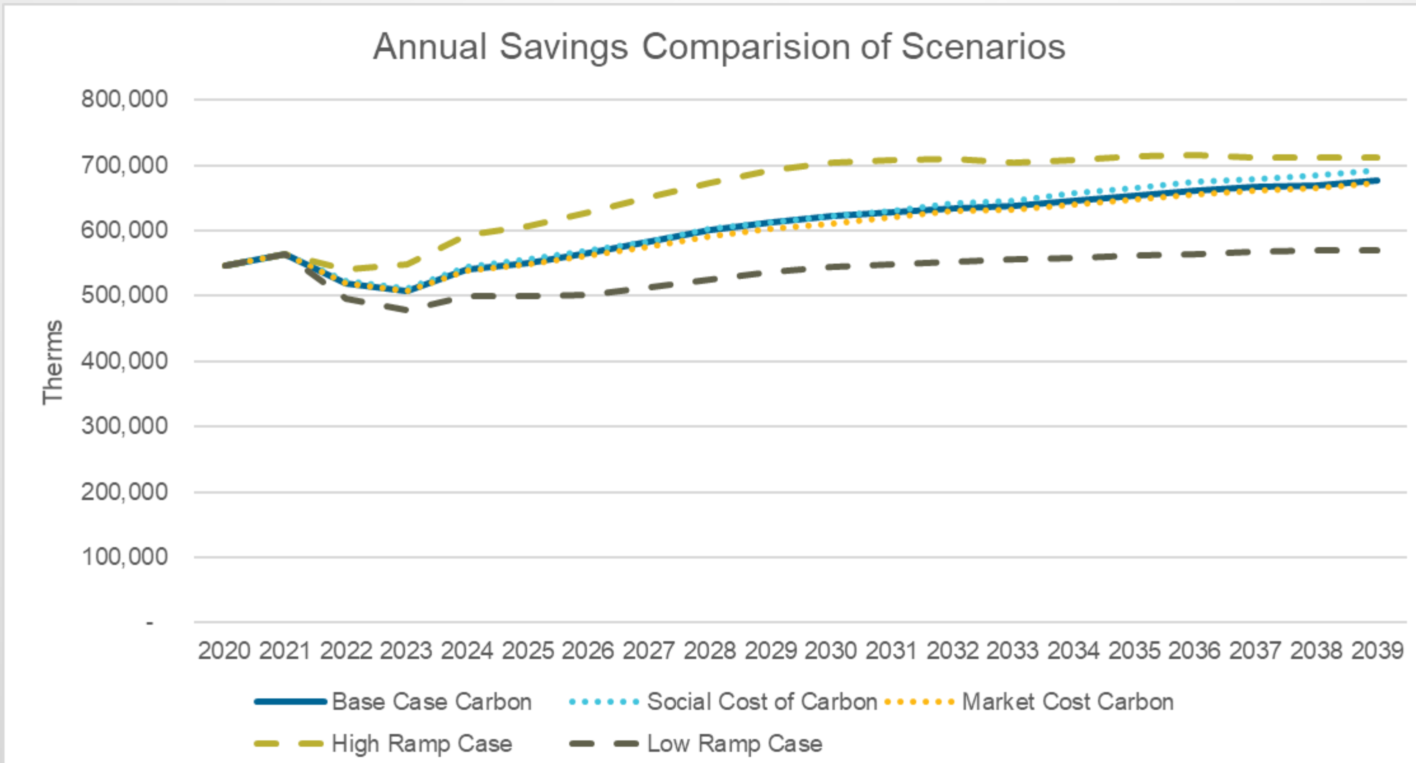
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Alternative Carbon Forecasts

- Cascade will run deterministic sensitivity analysis on two alternative carbon futures: Social Cost of Carbon and a 2018 national proposal titled Market Choice.
- Cascade will also run a stochastic sensitivity analysis of all potential carbon futures and include the results in the 2020 OR IRP.
- Ultimately, according to an analysis performed by ETO, the difference in carbon forecasts are not nearly as impactful to conservation potential as ramp rates are.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

CPA Comparison: Scenarios vs Ramp Rate



SENDOUT® Optimization Modeling

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 recognize that linear programming analysis provides helpful but not perfect information to guide decisions.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Modeling Transportation In SENDOUT® is a Balancing Act

- Start with a point in time look at each jurisdiction's resources
- Use the Nov19-Oct20 PGA portfolio
- Contracts –Receipt and Delivery Points
- We start with current transport contracts, using centralized receipts and approximately 67 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?

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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

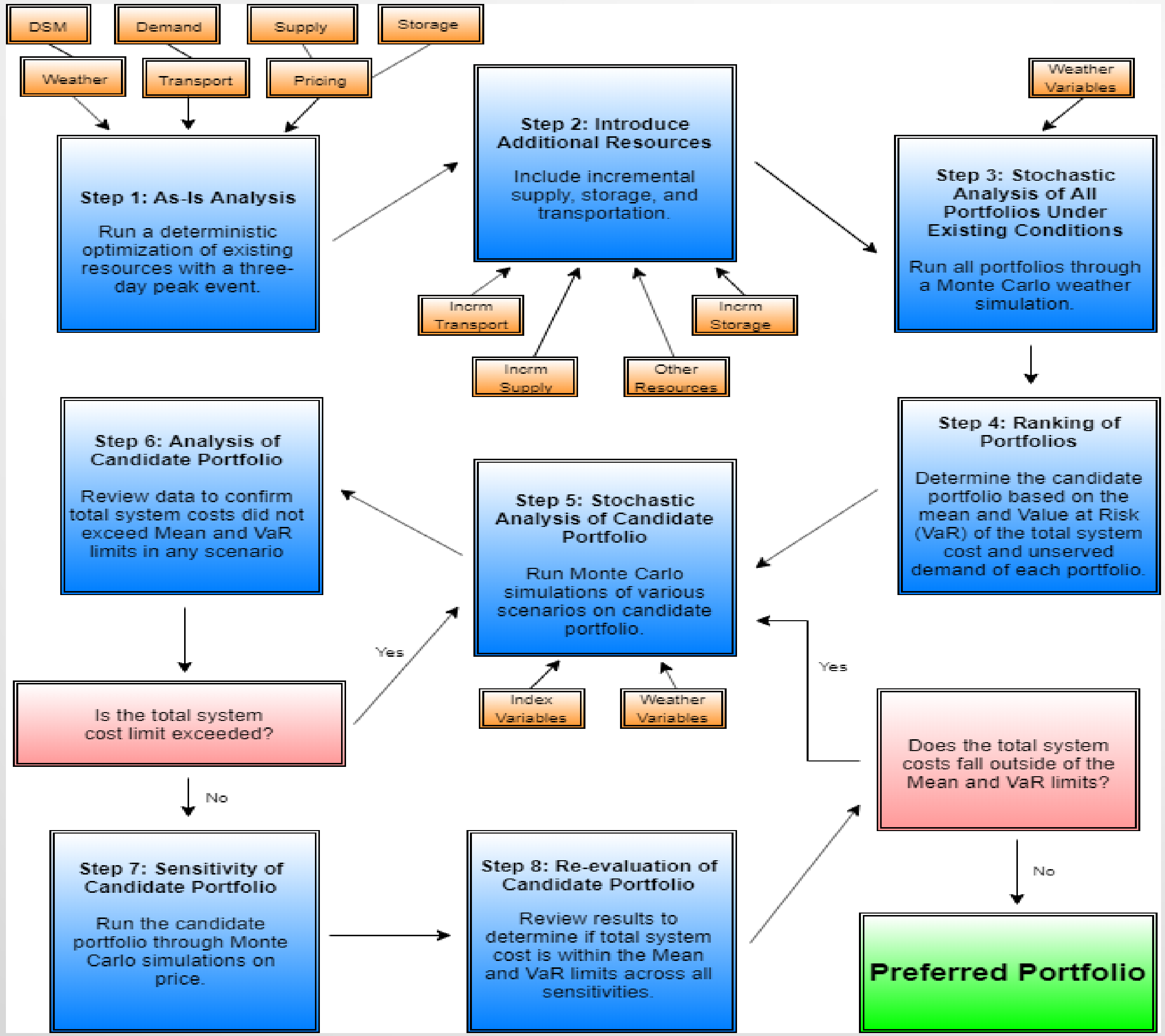
- **Step 1: As-Is Analysis**
  - Run a deterministic optimization of existing resources with a three-day peak event to uncover timing and quantity of resource deficiencies.
- **Step 2: Introduce Additional Resources**
  - Include incremental supply, storage, and transportation to derive a deterministic 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 candidate 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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Supply Resource Optimization Process (Cont'd)

- **Step 5: Stochastic Analysis of Candidate Portfolio**
  - Run Monte Carlo simulations of various scenarios on candidate portfolio; comparing Mean and VaR to a managerial limit.
- **Step 6: Analysis of Candidate 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 Candidate Portfolio**
  - Run the candidate 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 Candidate 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 until preferred portfolio is confirmed.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

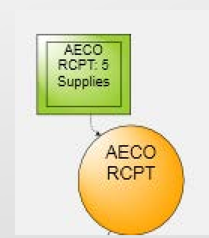

DSM
Demand
Supply
Storage
Weather
Transport
Pricing
Step 1: As-Is Analysis
Run a deterministic optimization of existing resources with a three-day peak event.
Step 2: Introduce Additional Resources
Include incremental supply, storage, and transportation.
Incrm Transport
Incrm Supply
Other Resources
Incrm Storage
Weather Variables
Step 3: Stochastic Analysis of All Portfolios Under Existing Conditions
Run all portfolios through a Monte Carlo weather simulation.
Step 4: Ranking of Portfolios
Determine the candidate portfolio based on the mean and Value at Risk (VaR) of the total system cost and unserved demand of each portfolio.
Step 5: Stochastic Analysis of Candidate Portfolio
Run Monte Carlo simulations of various scenarios on candidate portfolio.
Index Variables
Weather Variables
Step 6: Analysis of Candidate Portfolio
Review data to confirm total system costs did not exceed Mean and VaR limits in any scenario
Is the total system cost limit exceeded?
Yes
No
Step 7: Sensitivity of Candidate Portfolio
Run the candidate portfolio through Monte Carlo simulations on price.
Step 8: Re-evaluation of Candidate Portfolio
Review results to determine if total system cost is within the Mean and VaR limits across all sensitivities.
Does the total system costs fall outside of the Mean and VaR limits?
Yes
No
Preferred Portfolio

Base Case Sendout Inputs

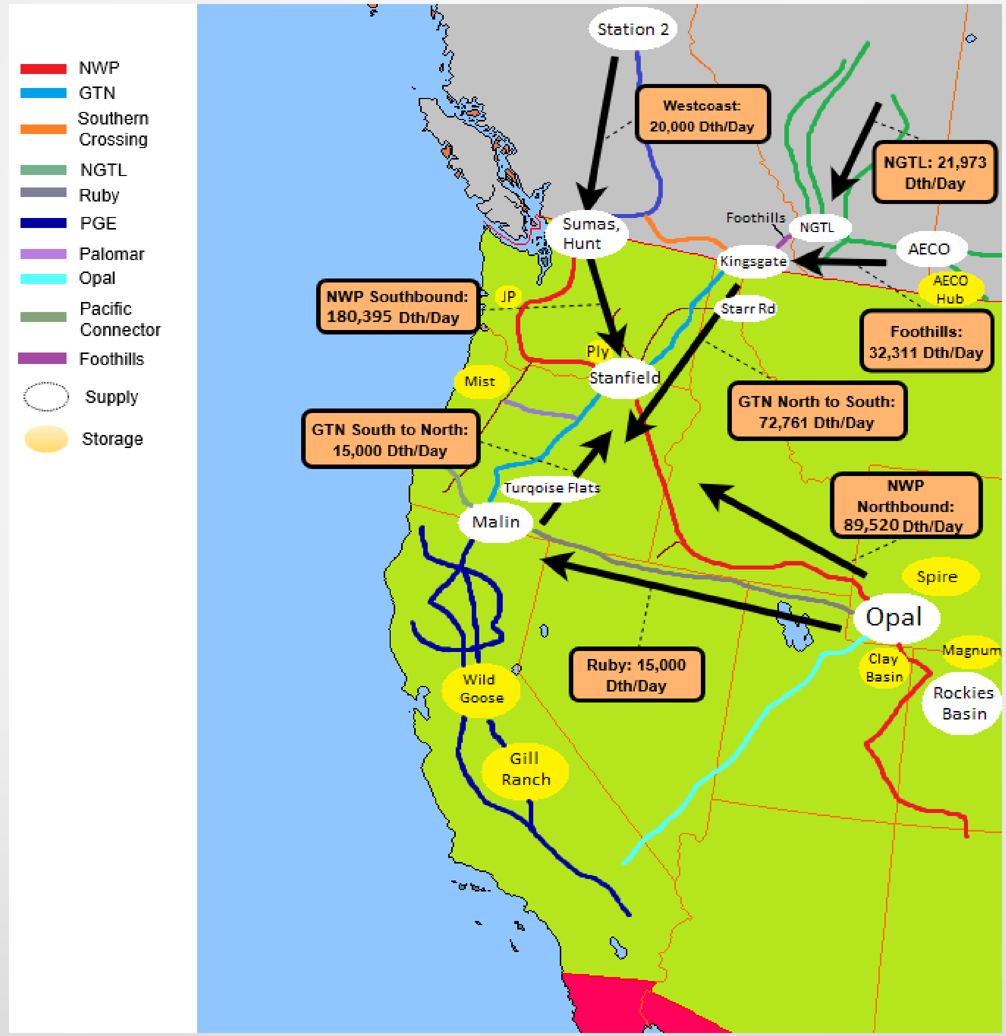
- Supply
- Storage
- Transportation
- Constraints
- Demand
- Weather
- Price Forecast

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.



Supply


NWP
GTN
Southern Crossing
NGTL
Ruby
PGE
Palomar
Opal
Pacific Connector
Foothills
Supply
Storage
Station 2
Westcoast: 20,000 Dth/Day
NGTL: 21,973 Dth/Day
Foothills
NGTL
AECO
AECO Hub
Sumas, Hunt
Kingsgate
Starr Rd
Foothills: 32,311 Dth/Day
NWP Southbound: 180,395 Dth/Day
JP
Ply
Stanfield
Mist
GTN North to South: 72,761 Dth/Day
GTN South to North: 15,000 Dth/Day
Turqoise Flats
Malin
NWP Northbound: 89,520 Dth/Day
Spire
Opal
Magnum
Clay Basin
Rockies Basin
Ruby: 15,000 Dth/Day
Wild Goose
Gill Ranch

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.

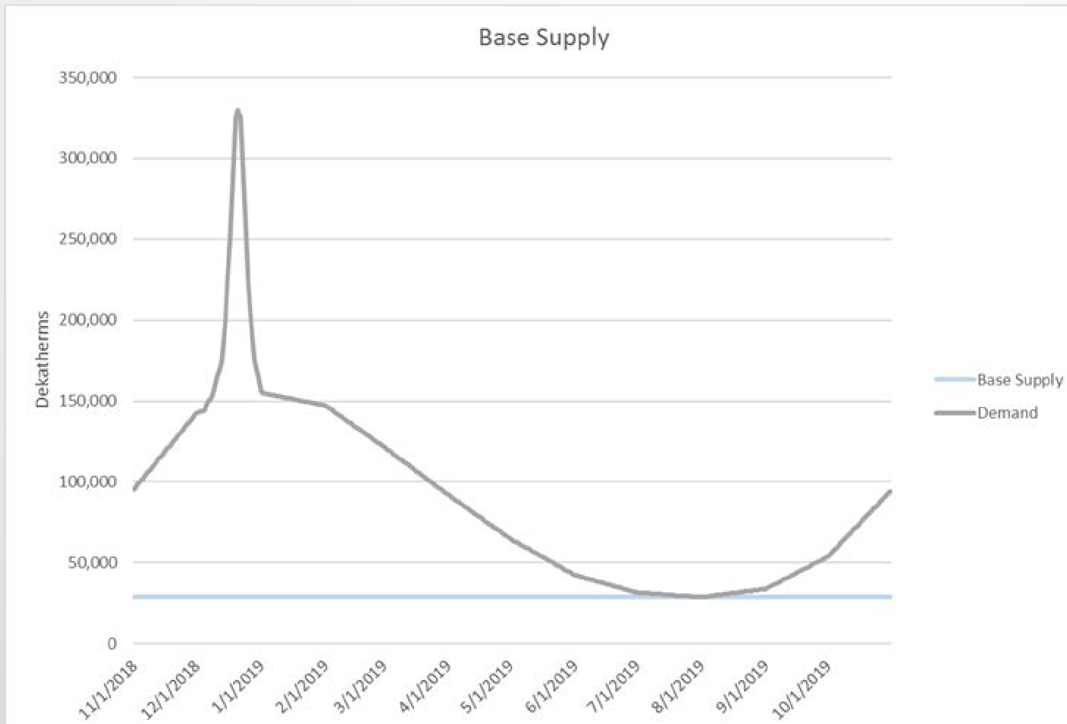
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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	Multiplier
*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					

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Base Supply (Cont'd)

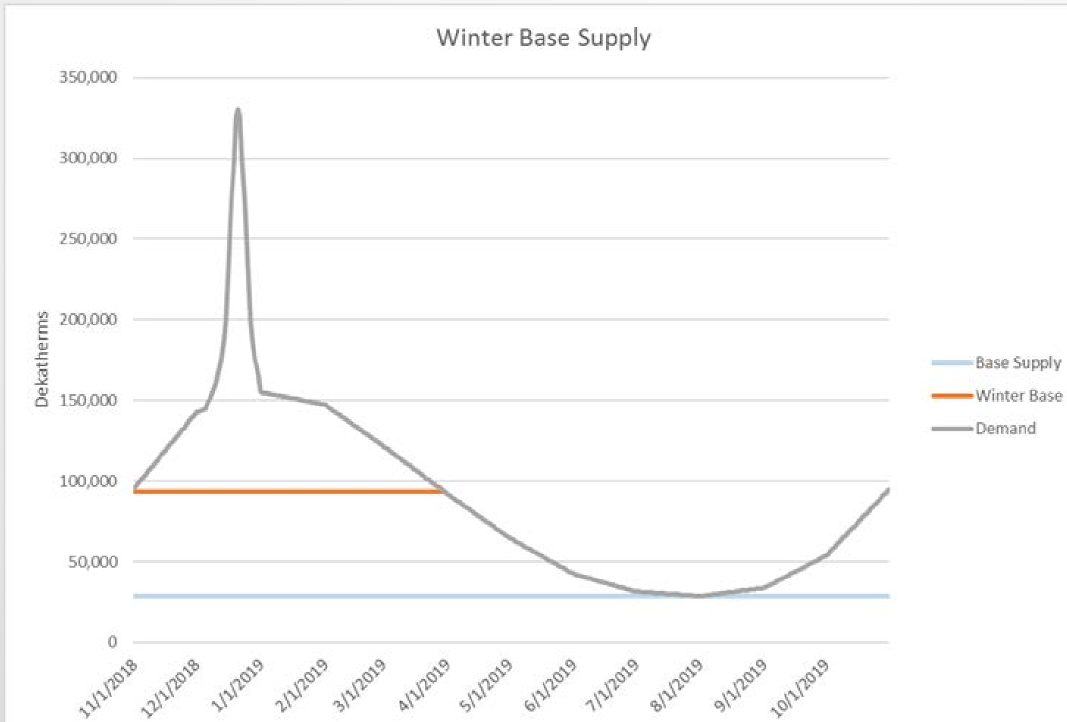


Winter base Supply

- 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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Winter Base Supply (Cont'd)

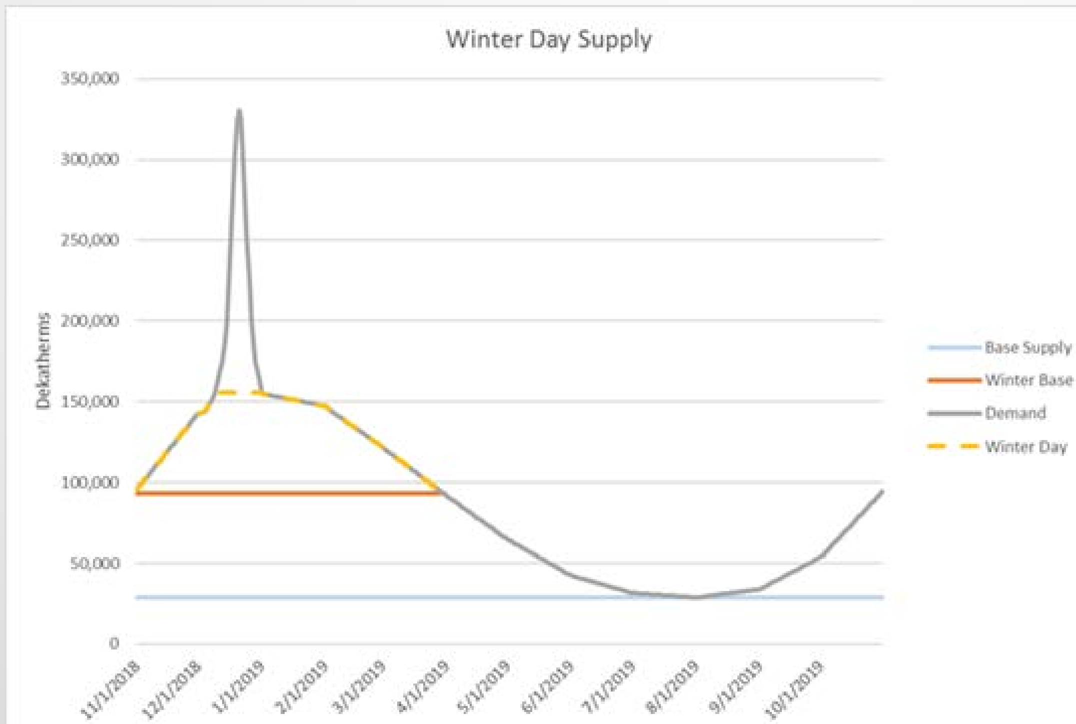


Day Supply (Winter)

- 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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

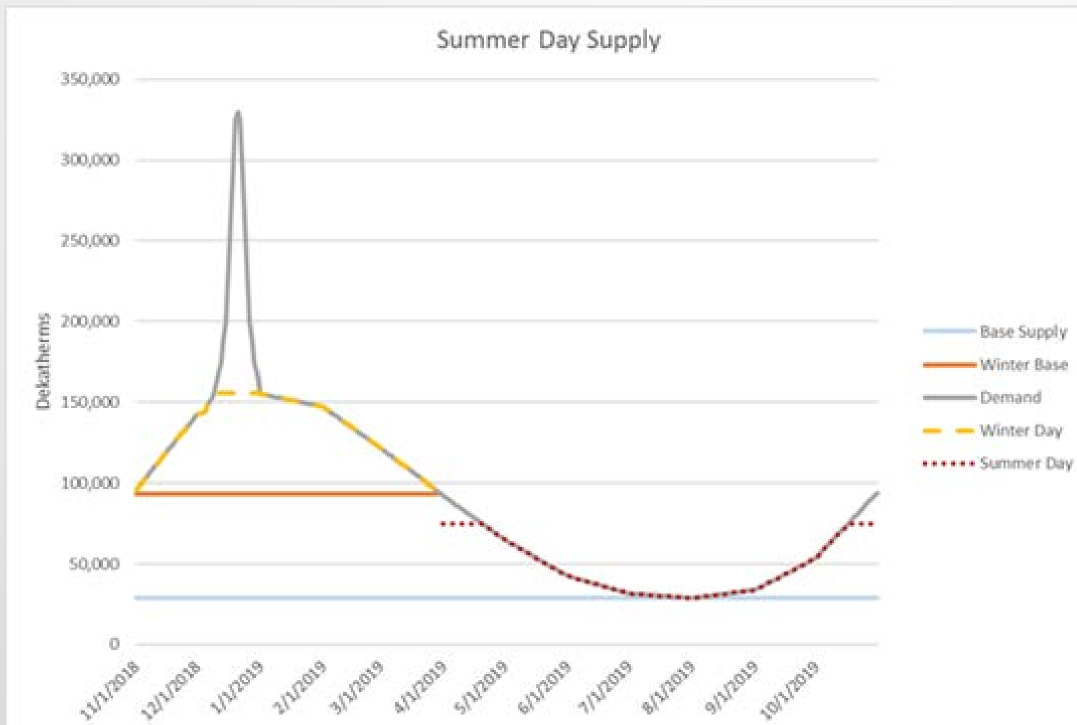
Winter Day Supply (Cont'd)



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.

Day Supply (Summer)

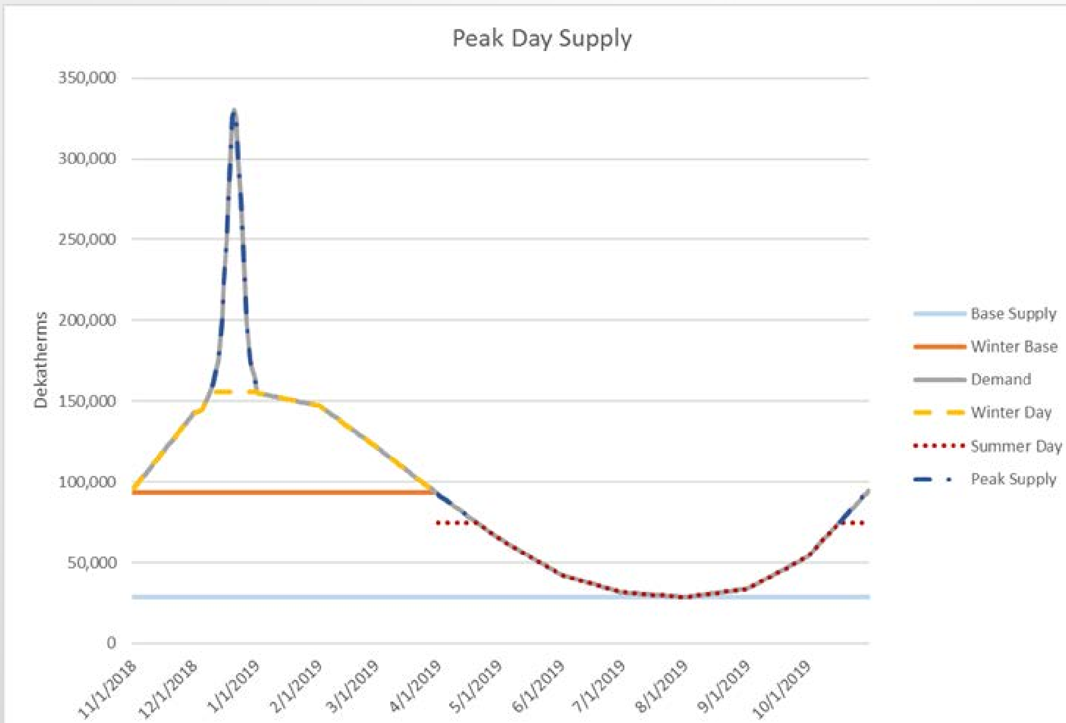


Peak Supply

- 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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

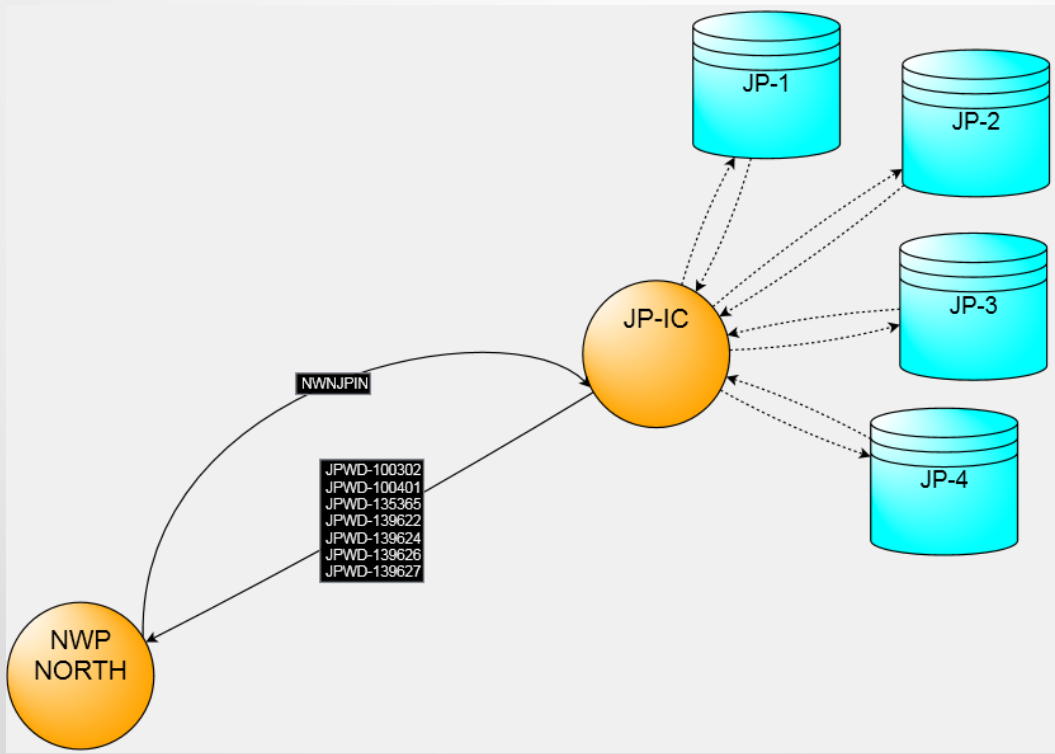
Total Supply



Storage

- Cascade leases storage at 3 locations: Jackson Prairie (JP), Plymouth (Ply), and Mist.
- Cascade has 4 storage contracts with JP, 2 contracts with Plymouth, and 1 with Mist.
- 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, 78,000 dth per day from Plymouth, and 30,000 Dth per day from Mist for a total of approximately 164,000 dth per day.

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		

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.

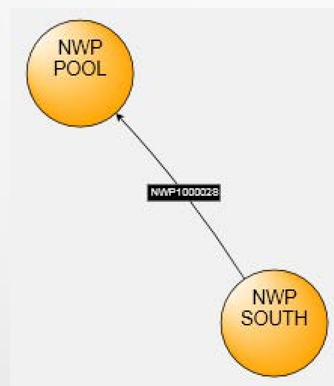
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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		DaysInMontl

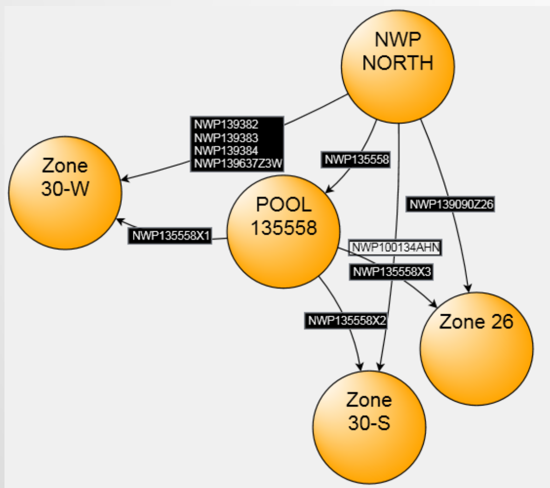
CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Delivery Rights vs Receipt Rights

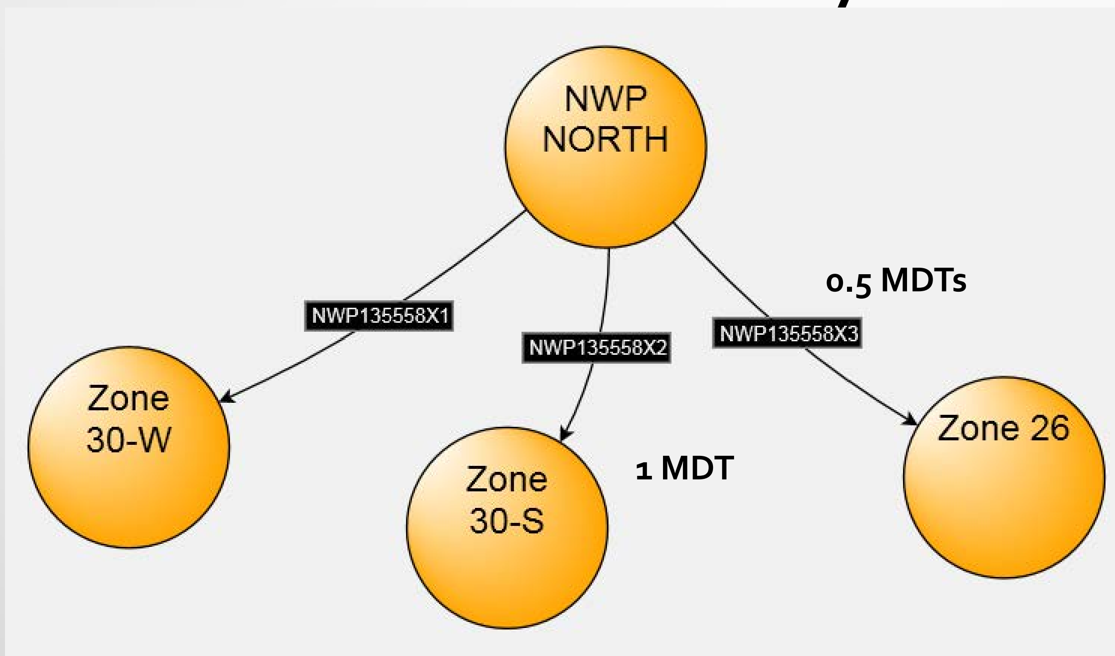
- Cascade has more Delivery Rights than Receipt Rights.
- Approximately 457,000 Dth of Delivery Rights.
- Approximately 360,000 Dth of Receipt Rights.
- The excess Delivery Rights allow Cascade to be flexible with the 360,000 Dth of Receipt Rights.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Example of delivery right flexibility



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.

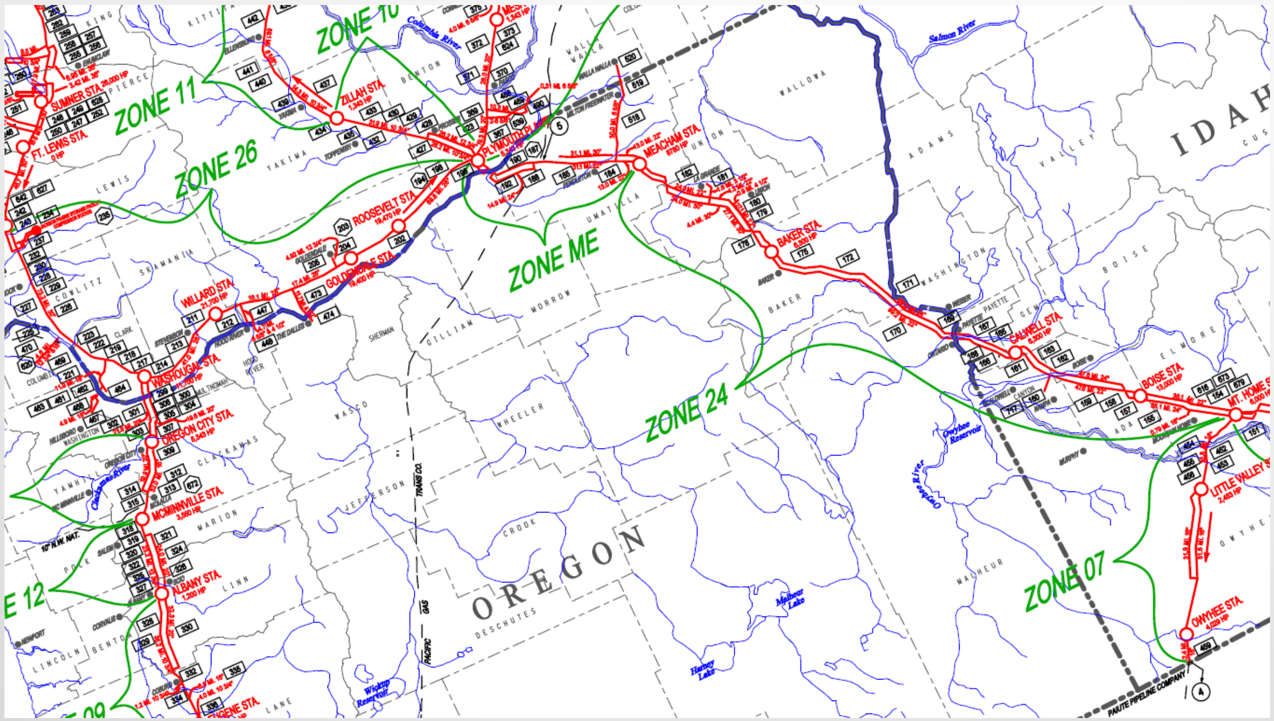
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Transport Constraints Example

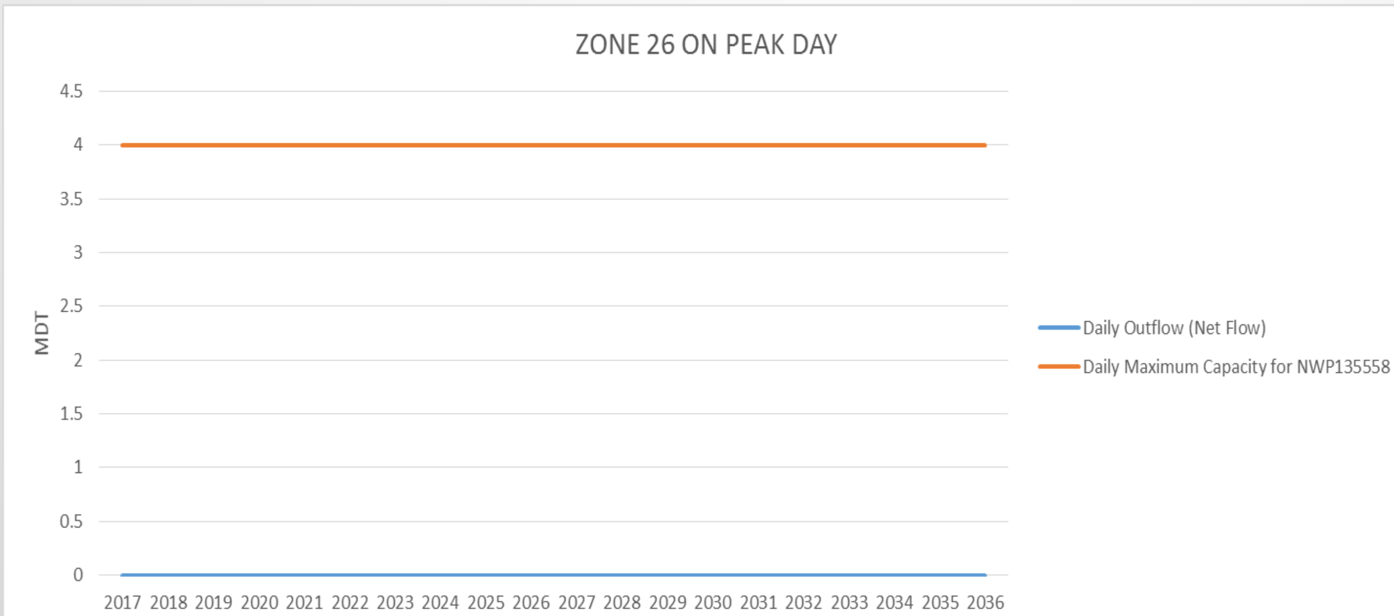
	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option
Annual Max										Same
Annual Min Percent										Same
Seasonal Max										Same
Seasonal Min Percent										Same
Monthly Max										Same
Monthly Min Percent										Same
*Daily Max	47603									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

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Location of Zones (Source: NWP)

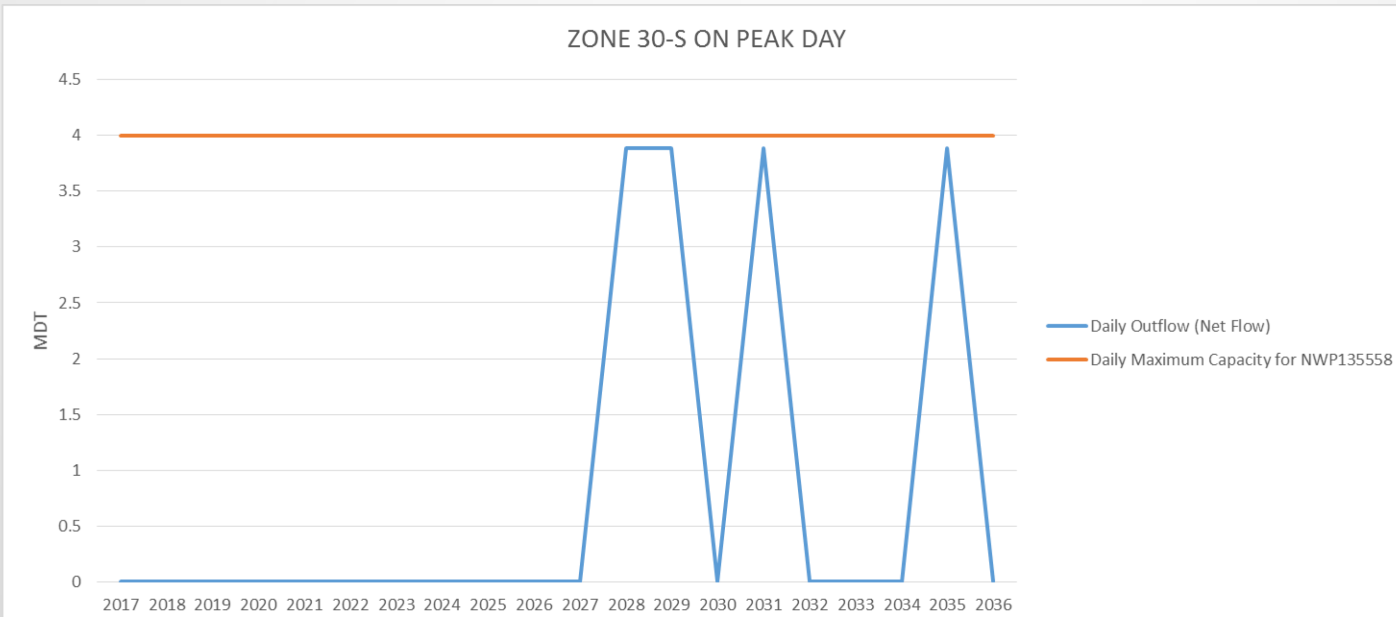


Zone 26 on Peak Day for Transport 135558

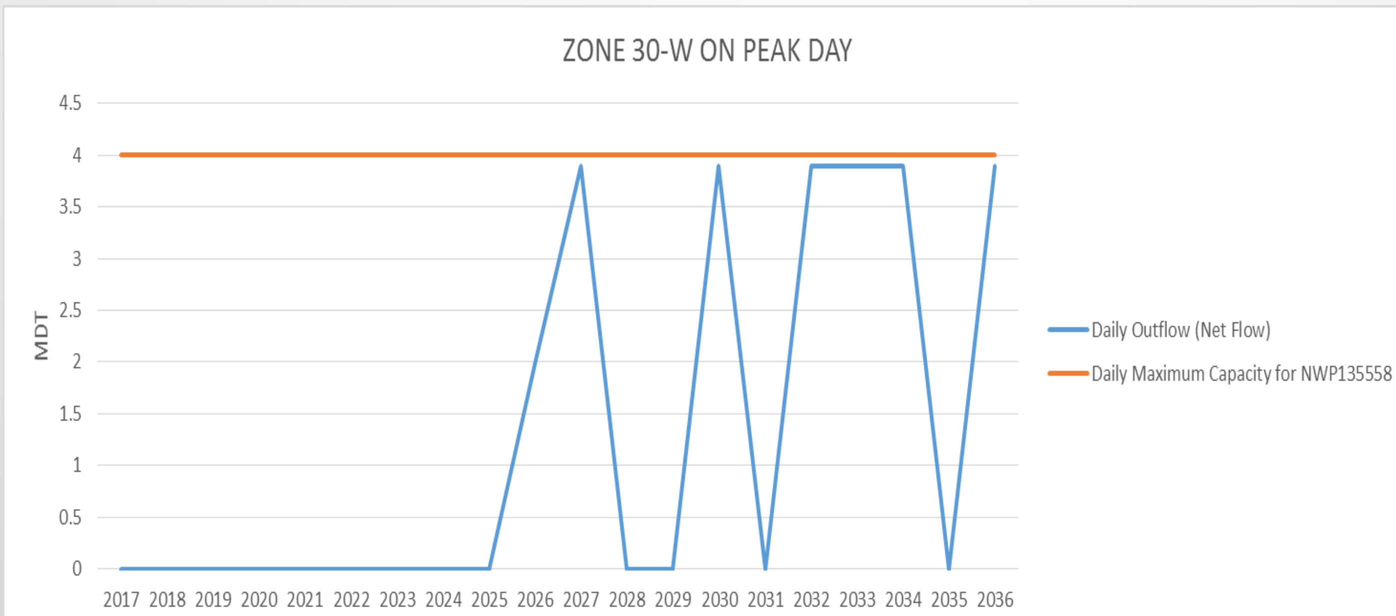


Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

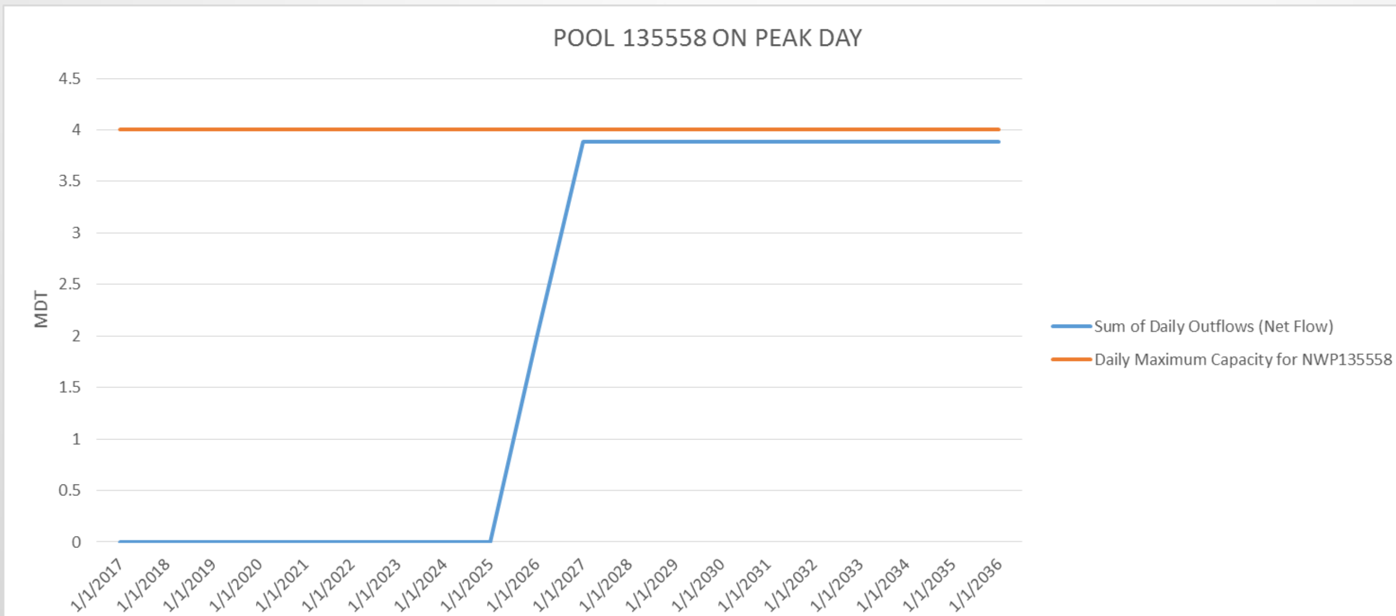
Zone 30-S on Peak Day for Transport 135558



Zone 30-W on Peak Day for Transport 135558



Transport Contract 135558 on Peak Day



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.
- Some towns can be served by multiple pipelines and the mix can change over time.

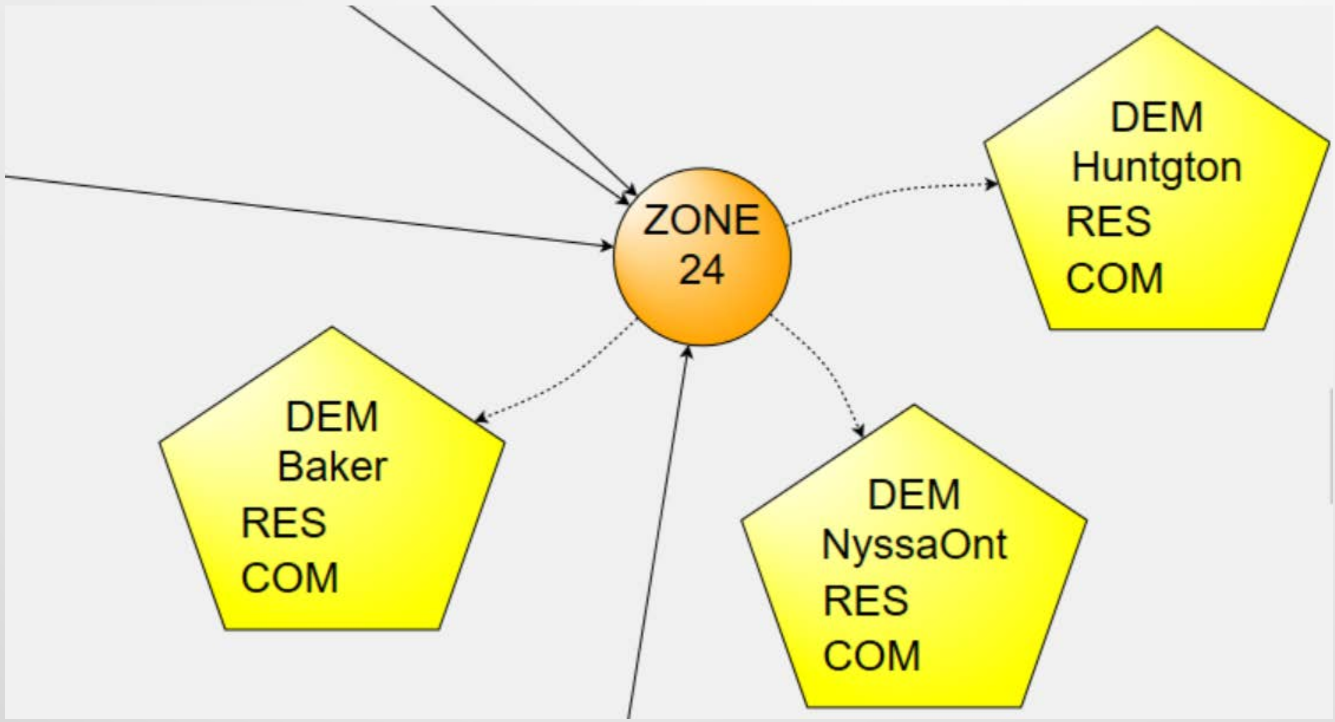
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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 2020 demand for that month with a growth factor.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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					

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

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 (1989-2019).

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						

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Preliminary Modeling Results

No DSM (Dth)																				
Demand Group	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Sunnyside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	399	1,427	910
Yakima Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	197	2,870	-
Kennewick Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	240	3,726
Nyssa Ontario	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	947	792	1,084	997	1,133
Longview South Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	82	82	82
Bremerton Shelton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,603	528	4,939	4,302	4,774
Sumas Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,306	1,553	4,603
Bend Loop	-	1,154	2,769	-	-	-	-	-	-	-	-	-	-	542	2,158	3,773	4,290	7,005	8,620	10,236
Walla Walla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,464	2,524	2,690

DSM (Dth)																				
Demand Group	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Sunnyside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yakima Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kennewick Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa Ontario	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Longview South Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bremerton Shelton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sumas Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bend Loop	-	-	1,160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walla Walla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Served   Unserved   Unserved Covered by 3rd Party Citygate Supply

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

2020 IRP Timeline

Wednesday, March 4, 2020	OR	TAG 5 slides distributed to stakeholders		
Wednesday, March 11, 2020	**OR**	**TAG 5: Final Integration Results, finalization of plan components, Proposed new 4-year Action Plan.**	**Salem, OR - 9 am to 12 pm**	**Meadow room at OPUC Offices**
Tuesday, May 12, 2020	OR	Draft of 2020 OR IRP distributed		
Friday, June 12, 2020	OR	Comments due on draft from all stakeholders		
Tuesday, June 30, 2020	OR	TAG 6, if needed	WebEx Only	
Friday, July 31, 2020	OR	IRP filing in Oregon		

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Questions?

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Natural Gas Corporation

2020 Integrated Resource Plan

Technical Advisory Group Meeting #4

Wednesday, Jan. 15th, 2020

Portland International Airport

Portland, OR

OPUC Tag Meeting 4

Date & Time: 1/15/2020, 09:00 AM – 12:30 PM

Location: Portland International Airport and Conference Center – Multnomah Room

In attendance: Brian Robertson, Ashton Davis, Devin McGreal, Alyn Spector, Bruce Folsom, Brian Cunnington, Linda Offerdahl, Anna Kim (OPUC), Jack Cullen (ETO), Bob Jenks (CUB), Sudeshna Pal (CUB)

Called in: Mike Parvinen, Abbie Krebsbach, Kevin Connell, Eric Wood, Chanda Marek, Chris Robbins, Monica Cowlishaw, Carolyn Stone, Tom Pardee (Avista), Mark Iverson (Kinder Morgan), Chad Stokes (Cable Huston)

Minutes by: Brian Robertson

Brian Robertson kicked off the meeting by thanking everyone that showed up. Brian went over fire safety of the building, introductions and the agenda.

- Brian Robertson discussed what Renewable Natural Gas (RNG) is for slides 4-7.
- Cascade mentioned that the Carbon Intensity factor is a topic that is being discussed intently in both OR and WA. The Company is involved in these discussions.
- Brian Robertson then discussed regulatory matters regarding RNG. Cascade is involved in the AR 632 and UM 2030 dockets in Oregon. The Company is also aware of SB 98 in OR and HB 1257 in WA as well as a few other documents.

Brian Robertson asked a question about expectations in the IRP regarding an IRP chapter. Anna Kim said Cascade should follow SB 98 rules and also noted that our IRP will be filed prior to SB 98 rules go in effect. Bob Jenks said since Cascade is a small utility that there isn't a requirement to include RNG, but if Cascade plans to have RNG added as a resource then Cascade needs to introduce it in the IRP.

- Brian Cunnington then discussed market research, Cascade's RNG goals, steps Cascade has taken so far, and a description of several options the Company has in its service territory.
- Jack Cullen presented Energy Trust of Oregon's Energy Efficiency Resource Assessment (RA) and results.
- Jack discussed the purpose and background of the RA model. Bruce asked if the RA model and CPA, that's done in Washington, are the same. Jack said essentially, yes.

A question was asked regarding the discount rate and Cascade noted that the Company is required to use the after-tax marginal weighted-average cost of capital. Another question was asked if the discount rate was too high. The resource planning team said in our opinion, no.

- Jack Cullen continued presenting the RA Model inputs and results. Jack discussed the different types of carbon scenarios Cascade and ETO were going to model. Jack also talked about the impacts of ramp rates and how ramp rate changes would have a bigger impact on savings than carbon scenarios would.
- Devin McGreal gave a short presentation on the carbon scenario impacts from Cascade's perspective. Bob Jenks asked Cascade to also include a no carbon scenario.
- Devin continued and discussed SENDOUT® and Cascade's resource optimization process.
- Ashton Davis discussed SENDOUT Supply and Storage inputs.
- Brian Robertson then talked about the transportation, constraints, demand, weather, and price in regard to SENDOUT inputs.
- Brian then shared Cascade's preliminary results.
- Brian then discussed the remaining 2020 OR IRP schedule.

TAG 5 will take place on March 11th, 2020 at the OPUC offices in Salem, OR - Meadow room.

The meeting was adjourned at 12:30 PM.

Cascade Natural Gas Corporation

2020 Integrated Resource Plan
Technical Advisory Group Meeting #5

March 11, 2020

Oregon Public Utility Commission

Salem, OR

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Agenda

- Introductions
- Safety Moment
- Summary of Alternative Resources
- Components and Ranking of Candidate Portfolios
- New Stochastic Methodology
- Scenario and Sensitivity Results
- Proposed Four-Year Action Plan
- 2020 IRP Remaining Schedule
- Questions

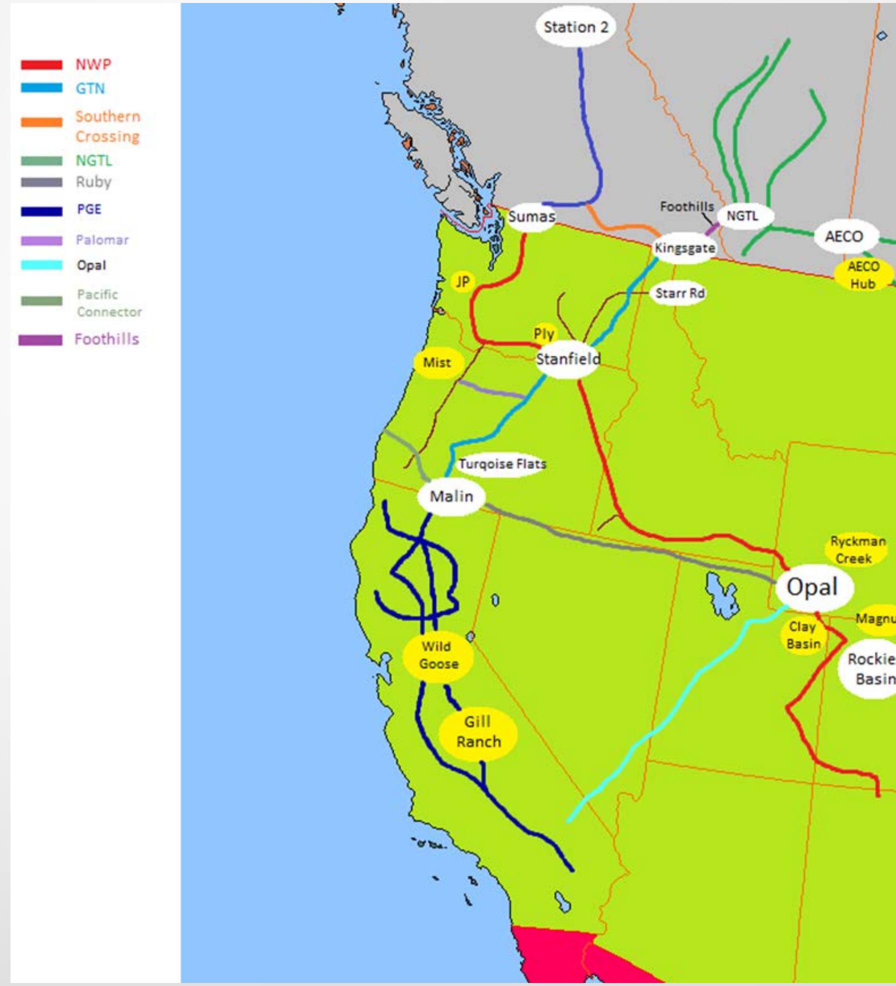
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Summary of Additional Resources

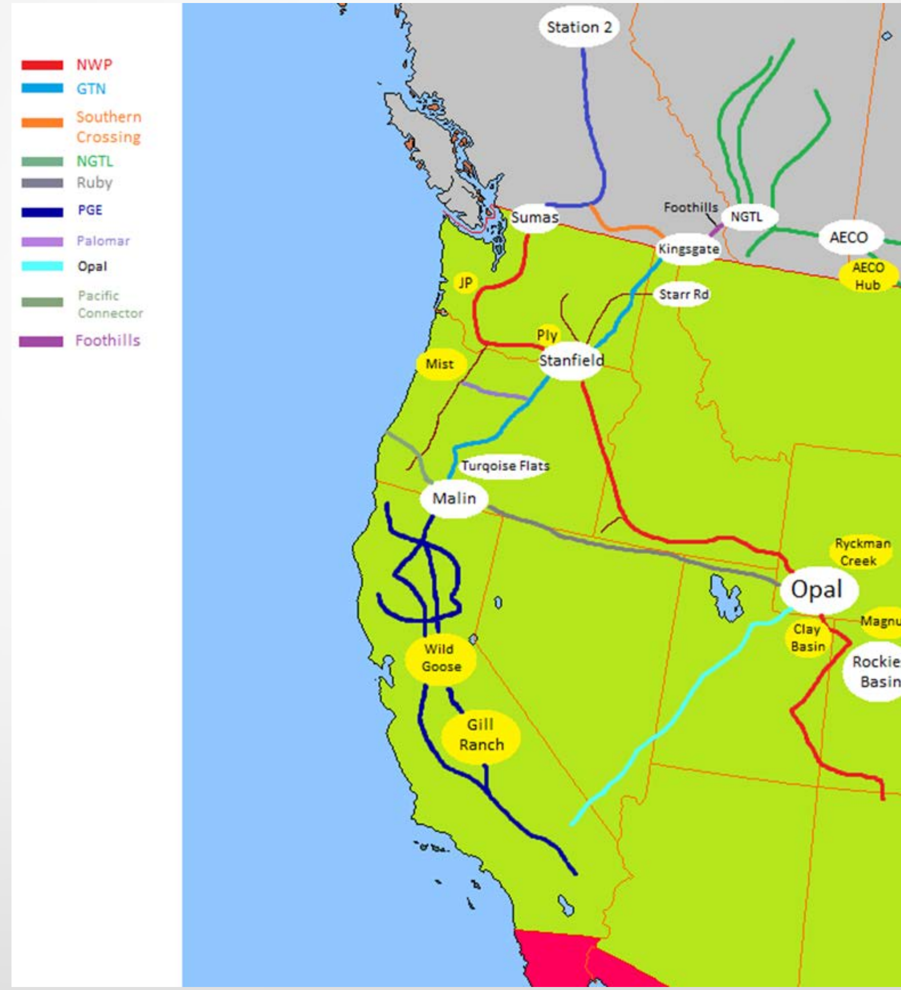
CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Additional Potential Resources

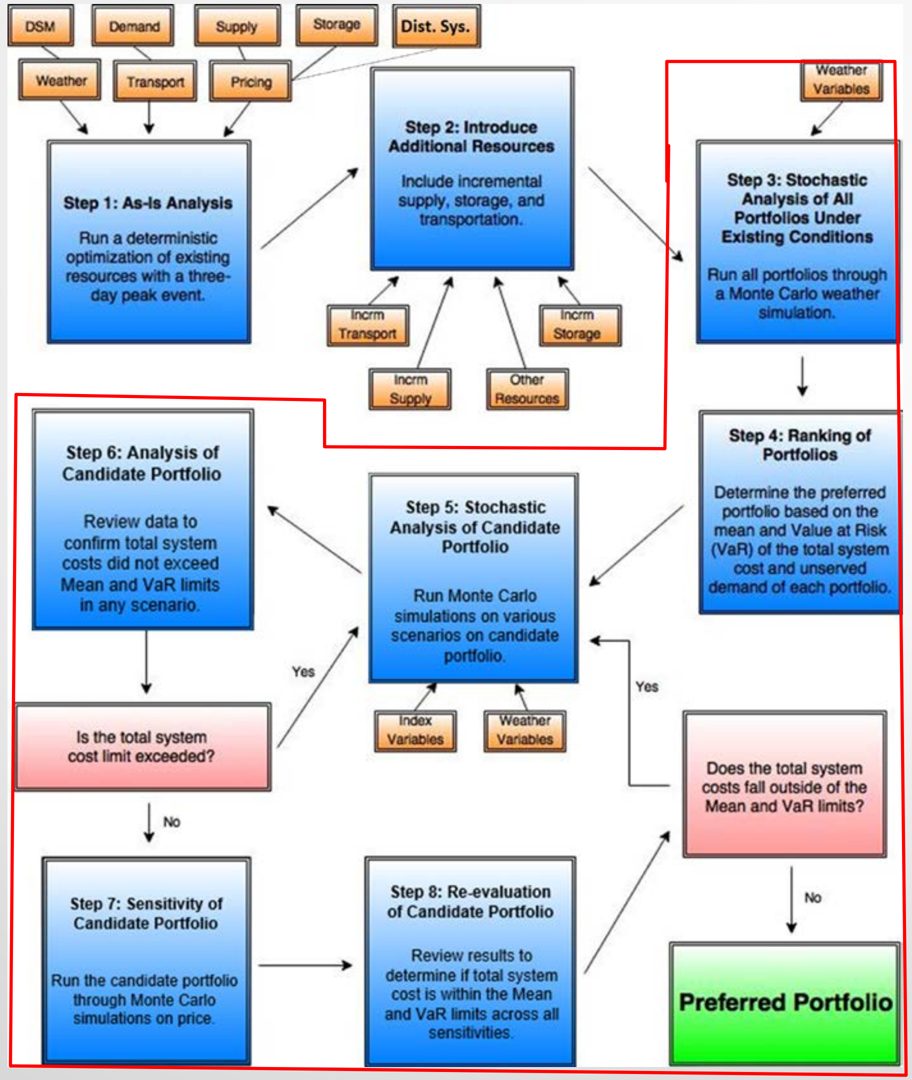
- Incremental Transport – North to South
- Incremental Transport – Northwest Pipeline
- Incremental Transport – South to North
- Incremental Transport – Bilateral



- Incremental Storage - North and East
- Incremental Storage - South and West
- Renewable Natural Gas



Components of Candidate Portfolios



CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Recap – As-Is Shortfalls (Dth)

No DSM (Dth)																				
Demand Group	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Sunnyside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	399	1,427	910
Yakima Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	197	2,870	-
Kennewick Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	240	3,726
Nyssa Ontario	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	947	792	1,084	997	1,133
Longview South Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	82	82	82
Bremerton Shelton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,603	528	4,939	4,302	4,774
Sumas Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,306	1,553	4,603
Bend Loop	-	1,154	2,769	-	-	-	-	-	-	-	-	-	-	542	2,158	3,773	4,290	7,005	8,620	10,236
Walla Walla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,464	2,524	2,690

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

List of Candidate Portfolios

- All-In Portfolio
- All-In less DSM option
- GTN Only Portfolio
- GTN Plus Storage Portfolio
- NWP Only Portfolio
- NWP Plus Storage Portfolio
- Storage Only Portfolio

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

All-In Portfolio

- Best deterministic mix of all alternative resources considered:
  - Incremental Transport – North to South
  - Incremental Transport – Northwest Pipeline
  - Incremental Transport – South to North
  - Incremental Transport – Bilateral
  - Incremental Storage – North and East
  - Incremental Storage – South and West
  - DSM

All-In Portfolio – SENDOUT® Suggested Resource Mix

- DSM – 254,620 dth in 2020 ramping up to a cumulative figure of 6,072,310 dth in 2039 for Cascade's service territory. On peak day the impact is 2,350 dth in 2020 ramping up to a cumulative figure of 54,530 dth in 2039.
- 3rd party citygate supply – 1,160 dth in 2022.

All-In less DSM Portfolio

- Best deterministic mix of all alternative resources considered:
  - Incremental Transport – North to South
  - Incremental Transport – Northwest Pipeline
  - Incremental Transport – South to North
  - Incremental Transport – Bilateral
  - Incremental Storage – North and East
  - Incremental Storage – South and West

All-In less DSM Portfolio – SENDOUT® Suggested Resource Mix

- Incremental GTN North to South – 2,506 dth by 2029 and 9,976 dth by 2039.
- Incremental I-5 mainline – 4,555 dth by 2039.
- Spokane Lateral Expansion – 8,865 dth by 2039.
- Wenatchee Lateral Expansion – 1,173 dth by 2039.

GTN Only Portfolio

- Best deterministic mix of all potential resources available on GTN:
  - Incremental Transport – North to South
  - Incremental Transport – South to North
  - Incremental Transport – Bilateral via Southern Crossing

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

GTN Only Portfolio – SENDOUT® Suggested Resource Mix

- Incremental GTN North to South – 2,506 dth by 2029 and 9,976 dth by 2039.

GTN Plus Storage Portfolio

- Best deterministic mix of all potential resource available on GTN plus storage:
  - Incremental Transport – North to South on GTN
  - Incremental Transport – South to North on GTN
  - Incremental Transport – Bilateral via Southern Crossing
  - Incremental Storage – North and East
  - Incremental Storage – South and West

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

GTN Plus Storage Portfolio – SENDOUT® Suggested Resource Mix

- Incremental GTN North to South – 2,506 dth by 2029 and 9,976 dth by 2039.
- Spire Storage – 1,000 Dth beginning in 2020.

NWP Only Portfolio

- Best deterministic mix of all potential resources available on NWP:
  - Incremental Transport – North to South
  - Incremental Transport – Northwest Pipeline
  - Incremental Transport – Bilateral via Trail West

NWP Only Portfolio – SENDOUT® Suggested Resource Mix

- Spokane Lateral Expansion – 14,296 dth by 2039.
- Wenatchee Lateral Expansion – 301 dth by 2039.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

NWP Plus Storage Portfolio

- Best deterministic mix of all potential resources available on NWP plus Storage:
  - Incremental Transport – North to South
  - Incremental Transport – Northwest Pipeline
  - Incremental Transport – Bilateral via Trail West
  - Incremental Storage – North and East
  - Incremental Storage – South and West

NWP Plus Storage Portfolio – SENDOUT® Suggested Resource Mix

- Spokane Lateral Expansion – 10,364 dth by 2039.
- Wenatchee Lateral Expansion – 4,233 dth by 2039.
- Spire Storage – 1,000 Dth beginning in 2020.

Storage Only Portfolio

- Best deterministic mix of all potential storage resources available:
  - Incremental Storage – North and East
  - Incremental Storage – South and West

Storage Only Portfolio – SENDOUT® Suggested Resource Mix

- Spire Storage – 1,000 Dth beginning in 2020.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Summary of – SENDOUT® Suggested Resources by Portfolio

	All-In Less DSM	All-In	NWP Only	NWP + Storage	GTN	GTN + Storage	Storage Only
Incremental NGTL							
Incremental Foothills							
Incremental GTN N/S							
I-5 Mainline Exp.							
Wenatchee Lateral Exp.							
Spokane Lateral Exp.							
Eastern OR Mainline Exp.							
Incremental Opal							
Incremental GTN S/N							
Incremental Ruby							
T-South Southern Crossing							
Trail West							
Pacific Connector							
Spire Storage							
AECO Hub Storage							
Clay Basin Storage							
Gill Ranch Storage							
Wild Goose Storage							
Mist Storage							
DSM							

Legend	
	Selected resource for the portfolio
	Considered but not selected resource
	Not considered for the portfolio

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Methodology Behind Ranking of Portfolios

- New to the 2018 OR IRP, Cascade will be using deterministic results to identify the intrinsic value of a portfolio, and Value at Risk (VaR) analysis to capture the extrinsic value.
- Additionally, portfolios will be ranked primarily on their peak day unserved demand, and secondarily on their total system costs.
- Deterministic results are given 75% weight, and stochastic results 25% weight. This is known as the risk-adjusted cost metric.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Final Ranking of Portfolios

	Deterministic		Stochastic		Risk Adjusted Results	
Portfolio	Unserved Demand (DT)	Total System Cost ($000)	Unserved Demand (DT)	Total System Cost ($000)	Risk Adjusted Unserved Demand (DT)	Risk Adjusted Total System Cost ($000)
All-In	-	4,279,132	0	4,398,492	-	4,308,972
All-In Less DSM	-	4,282,291	0	4,422,989	-	4,317,466
NWP + Storage	13,686	4,299,105	0	4,422,992	10,264.50	4,330,076
NWP	13,686	4,301,075	0	4,424,828	10,264.50	4,332,013
GTN + Storage	18,179	4,294,023	0	4,437,641	13,634.25	4,329,928
GTN	18,179	4,295,876	0	4,439,678	13,634.25	4,331,827
Storage Only	28,155	4,282,291	0	4,437,522	21,116.25	4,321,099

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Top Ranked Candidate Portfolio Components

- DSM – 254,6200 dth in 2020 ramping up to a cumulative of 6,072,310 dth in 2039 for Cascade's service territory.
- 3rd party citygate supply – 1,160 dth in 2022.

Unserved for Top Ranked Candidate Portfolio

DSM (Dth)																				
Demand Group	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Sunnyside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yakima Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kennewick Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa Ontario	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Longview South Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bremerton Shelton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sumas Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bend Loop	-	-	1,160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walla Walla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Served

Unserved

Unserved Covered by 3rd Party Citygate Supply

New Stochastic Methodology

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Stochastic Weather Methodology

- In previous IRPs, Cascade used the Monte Carlo functionality within SENDOUT® to run its stochastic analyses.
- SENDOUT® has computational limitations related to the number of draws it can perform, and the time it takes to complete those draws.
- For the 2020 IRP, Cascade has enhanced its methodology to allow for a more robust Monte Carlo simulation.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade's New Methodology

- This year, Cascade will be performing a 10,000 draw Monte Carlo Simulation of weather using Excel and R.
- For each weather location Cascade records daily mean temperatures, standard deviations, and the largest 1 day jump to have historically occurred in that month.
- Cascade also records the correlations on a monthly level of each weather station to each other. This data is all loaded into R.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade's New Methodology

- First, Cascade runs 1 draw of its Monte Carlo simulation for its first weather location.
- The normal random seed used each day for that draw is then run through a Cholesky decomposition matrix, which uses the correlations between each location to correlate the random variables for that first draw across all weather locations.
- This process is repeated 10,000 times, with the calculated HDDs from each draw stored in a separate matrix.

Cholesky Decomposition Matrix - January

	Baker City	Bellingham	Bremerton	Pendleton	Redmond	Walla Walla	Yakima
Baker City	1						
Bellingham	0.6338301	0.7734723					
Bremerton	0.6584770	0.5837664	0.4749998				
Pendleton	0.7024465	0.3681832	0.0469737	0.6072920			
Redmond	0.7173640	0.3985243	0.1196151	0.2324631	0.5081539		
Walla Walla	0.7105065	0.3561187	0.0338146	0.5396395	0.0173972	0.2751418	
Yakima	0.6697351	0.3483110	0.0817184	0.3160165	-0.0036761	0.1685445	0.5432948

Cascade's New Methodology

- Cascade calculates a system weighted HDD for each draw, identifying the draw that results in the 99th percentile of stochastic weather.
- The daily HDDs of each weather location in this draw are then loaded into SENDOUT®, which allows the Company to capture the costs and unserved demand of a given portfolio under extreme conditions.
- A similar process is undertaken for Monte Carlo simulations on price.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Stochastic Price Methodology

- Similar to weather, Cascade used the Monte Carlo functionality within SENDOUT® to run its stochastic analyses in previous IRPs.
- Due to the SENDOUT® computational limitations as mentioned above, Cascade has taken the analysis outside of SENDOUT and has enhanced the methodology to allow for a more robust Monte Carlo simulation.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade's New Methodology

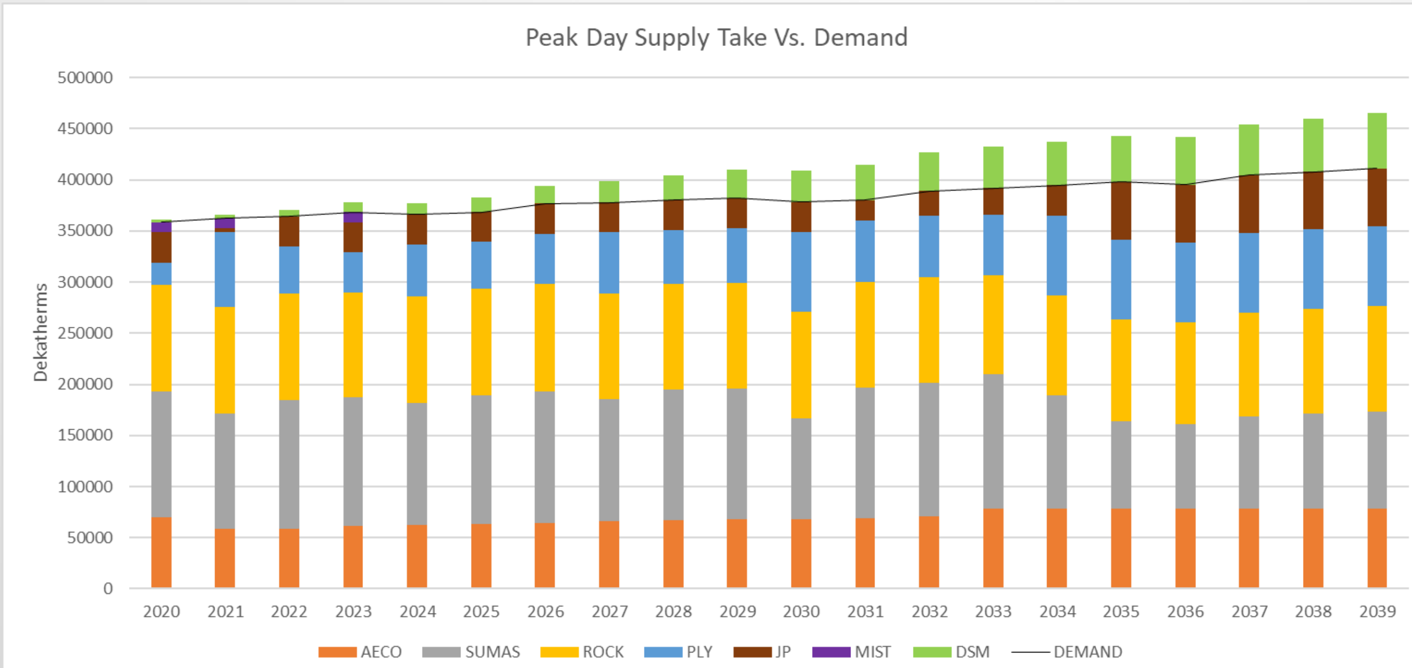
- This year, Cascade will be performing a 10,000 draw Monte Carlo Simulation of price using Excel and R.
- Cascade models price movements with a Geometric Brownian Motion stochastic process. For each of its 10,000 draws, the month over month price change is determined by 2 elements: a drift term and a shock term.
  - The drift term is the expected movement of NYMEX, derived from the Company's price forecast.
  - The shock term is the main stochastic element, which takes the month over month return variance and multiplies it by a random normal variable to create a normal distribution of price movements for a given month, and a lognormal distribution of prices.
- Similar to how weather is correlated between weather stations, Cascade correlates the supply basins using the Cholesky decomposition matrix.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

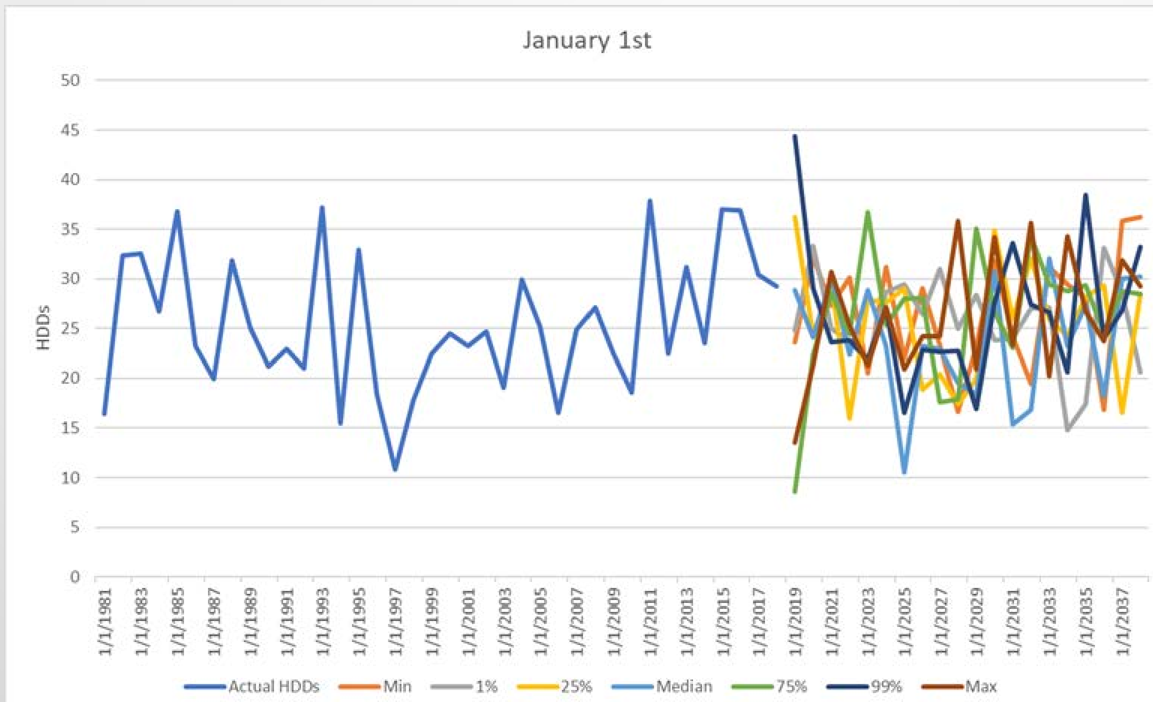
Scenario and Sensitivity Results

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

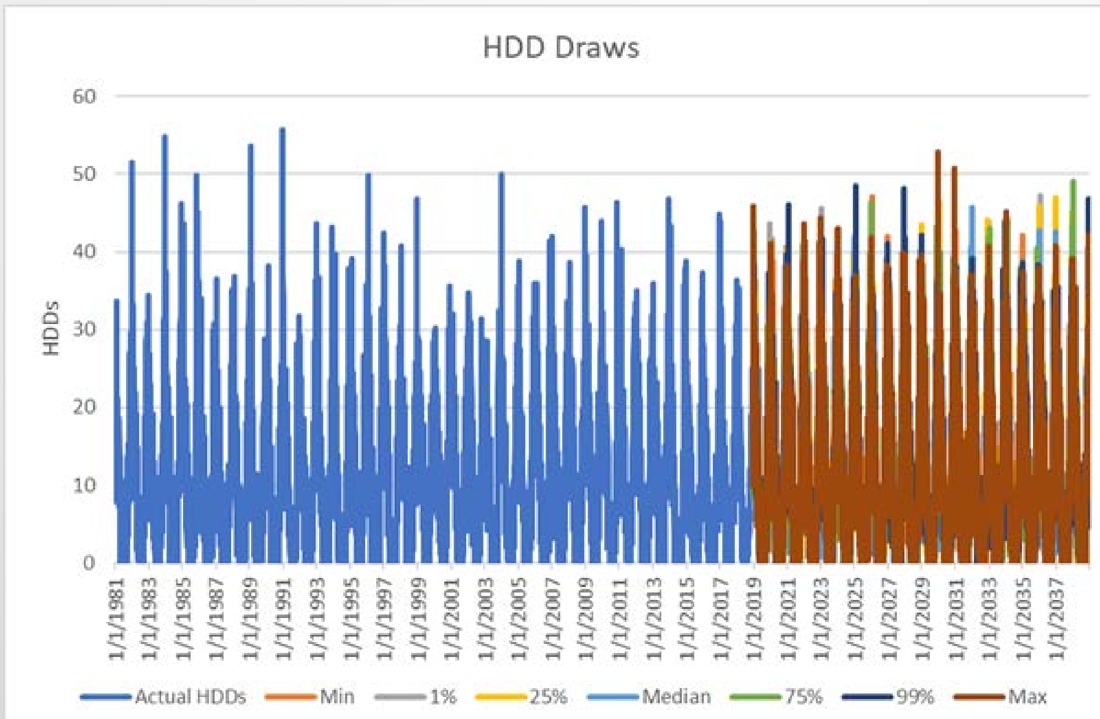
Peak Day Take Vs. Demand



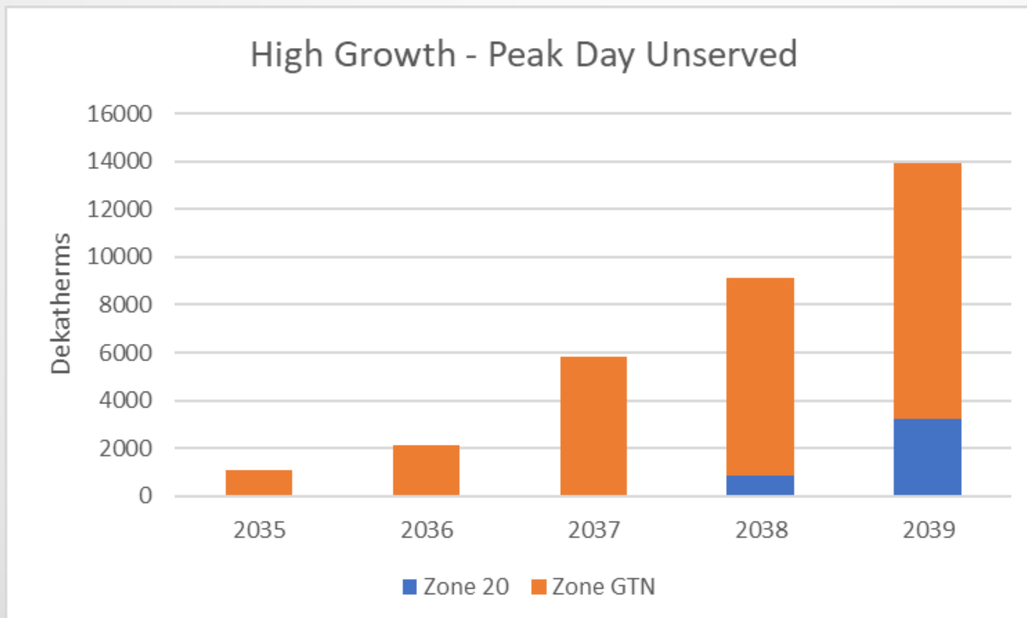
HDD Draw Graph – January 1^{st}



HDD Draw Graph – All Days



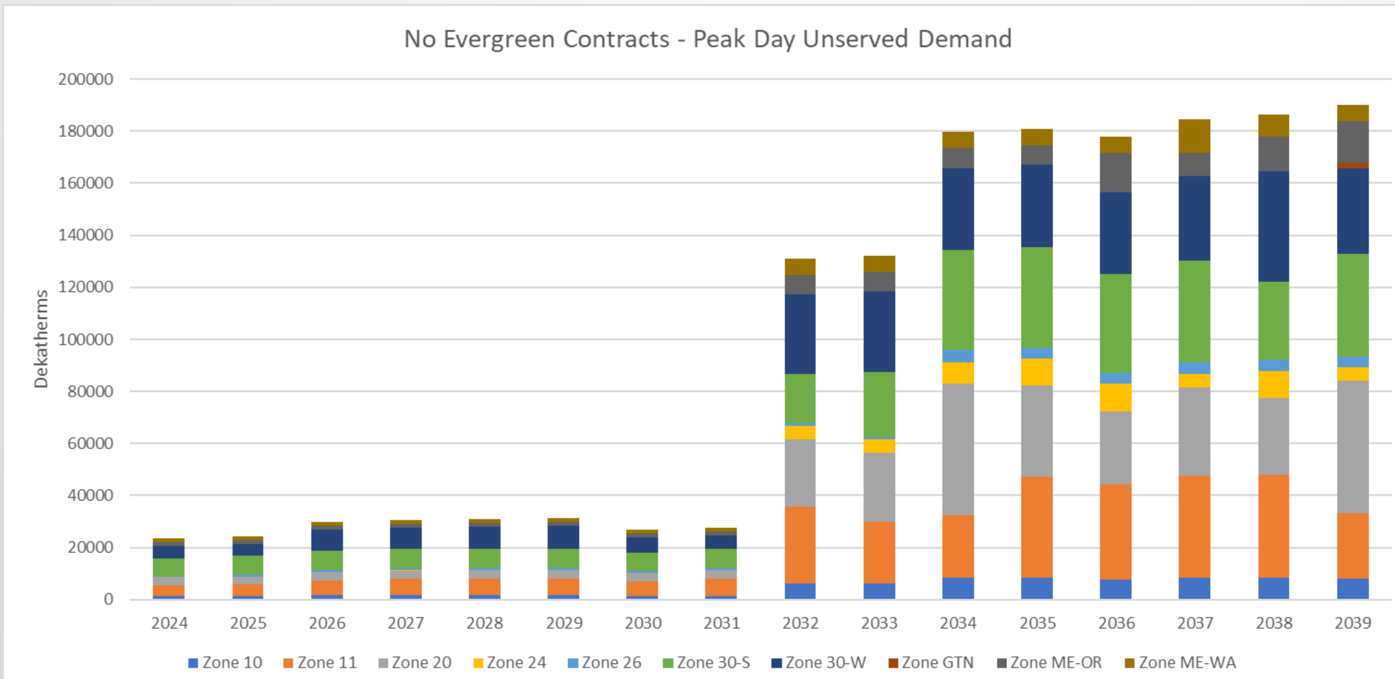
High Growth – Peak Day Unserved Demand



High Growth – Discussion

- In this scenario, the Company identifies minor potential shortfalls in Oregon and Central Washington, starting in 2035, under stochastic conditions.
- This does not invalidate the top ranked candidate portfolio, but provides a point of reference if weather and growth are unexpectedly high.
- Total system cost for this scenario was $4.63B, which does not exceed the VaR limit.

No Evergreen – Peak Day Unserved Demand



No Evergreen Contracts – Discussion

- In this scenario, the Company identifies potential shortfalls across its service area starting in 2024 under stochastic conditions.
- This does not invalidate the top ranked candidate portfolio, but rather reinforces Cascade's practice of modeling and evaluating each of its contracts prior to their expiration.
- Without access to a significant portion of its contracts, SENDOUT® found the optimization to be infeasible.

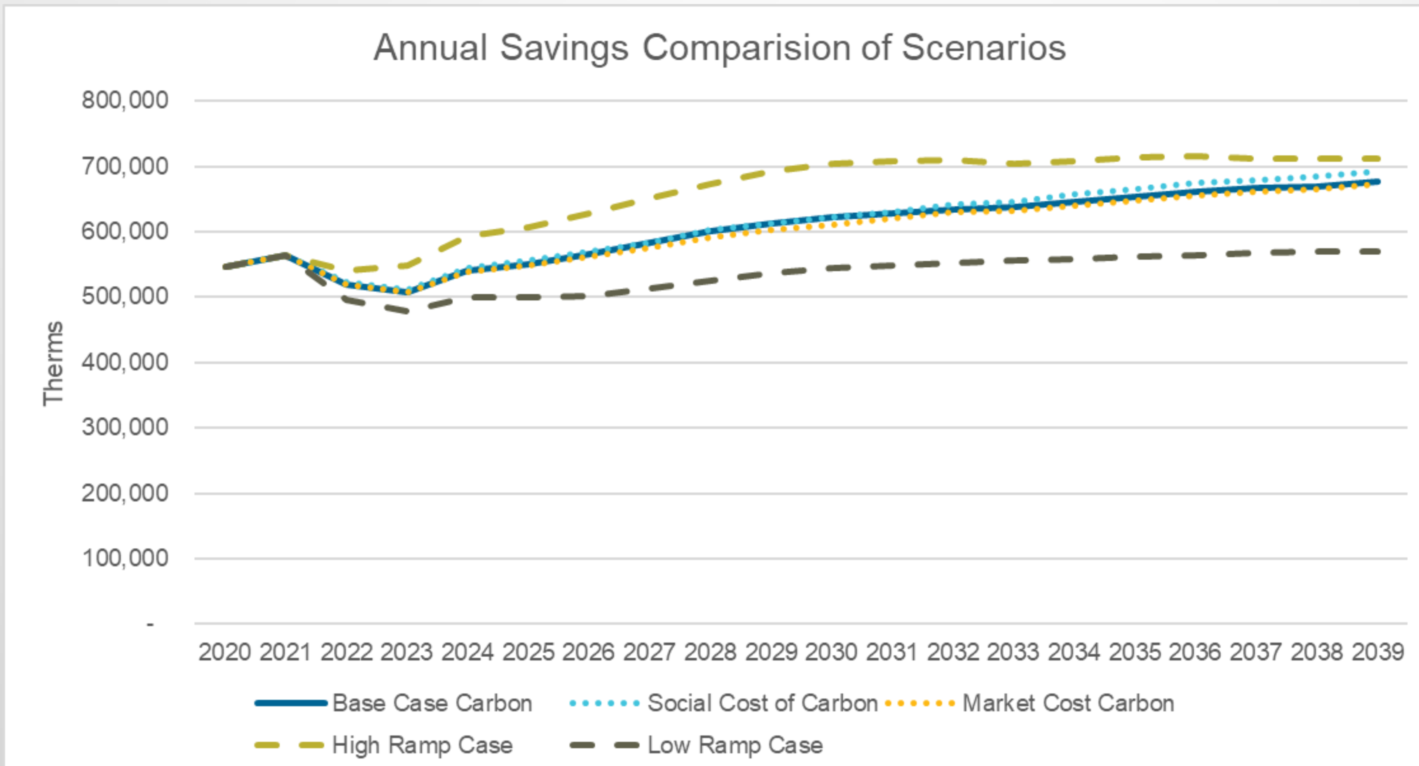
Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Carbon Sensitivity Discussion

- Cascade will include an analysis of three carbon sensitivities in its IRP, as discussed in TAG 4:
  - Social Cost of Carbon
  - House of Representatives Market Choice
  - No Carbon
- New to the 2020 OR IRP, Cascade will be including a stochastic carbon analysis. On January of each year, each draw allows for the possibility of a random carbon forecast to be included in the forecasted price of gas. If a carbon forecast is selected, the draw stays on that carbon path for the duration of the planning horizon.
- Cascade's modeling has determined that its conservation programs are robust and comprehensive enough to meet projected DSM savings even at a lower than expected carbon future.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

CPA Comparison: Scenarios vs Ramp Rate



Scenario/Sensitivities versus Cost Limit

Scenario	Total System Cost ($000)	Unserved Start Year
VaR Limit	**5,367,644**	N/A
No Carbon Forecast	4,067,388	N/A
SCC Carbon Forecast	4,291,633	N/A
Market Choice Carbon Forecast	4,219,313	N/A
Price Forecast High	4,348,336	N/A
Environmental Adder 0%	4,200,421	N/A
Environmental Adder 20%	4,402,809	N/A
Environmental Adder 30%	4,498,902	N/A
No Evergreen	N/A*	2024
Low Growth	4,094,227	N/A
High Growth	4,627,197	2035
Limit BC	4,470,642	N/A
No BC	N/A*	2020
Limit Alberta	4,234,825	N/A
No Alberta	4,441,634	2020
No Rockies	4,543,428	2021
Limit Rockies	4,259,653	N/A
Limit Canada	4,419,800	N/A
No Canada	N/A*	2020
No Plymouth	4,384,592	2037
Limit Plymouth	4,372,424	N/A
Limit JP	4,397,880	N/A
No JP	4,421,787	N/A
Limit Mist	4,338,902	N/A
No Mist	4,339,958	N/A

* Note - SENDOUT® is unable to calculate costs for infeasible Scenarios/Sensitivities

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Conclusion

- Cascade has identified potential shortfalls at the gates served by GTN in Oregon, starting in 2033.
- The top-ranking candidate portfolio included DSM and 3rd party citygate deliveries.
- Under expected conditions, this portfolio would eliminate the potential GTN shortfall.
- Additionally, the top-ranked portfolio, which is the all-in portfolio, passes all scenario and sensitivity testing. It is Cascade's Preferred Portfolio.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Preferred Portfolio Results

DSM (Dth)																				
Demand Group	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Sunnyside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yakima Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kennewick Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa Ontario	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Longview South Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bremerton Shelton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sumas Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bend Loop	-	-	1,160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walla Walla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Served   Unserved   Unserved Covered by 3rd Party Citygate Supply

Proposed Four-Year Action Plan

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Environmental Policy

- Continue to support the City of Bend's Climate Action Plan efforts which were approved by the City Council on December 4, 2019.
- Participate in City of Bellingham Climate Action Plan discussions.
- Monitor service areas for potential GHG reduction goal development relating to energy delivery and supply.
- Monitor carbon pricing and policy developments nationally and statewide (i.e., OR ballot measure, 2020 carbon tax or cap and trade bills, Social Cost of Carbon, Market Choice, The Clean Future Act, etc.).
- Monitor federal and state GHG regulation development for energy industry.
- Continuation of our current emission reduction and monitoring endeavors (i.e., Methane Challenge Program, Renewable Natural Gas studies).

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

DSM

- The Company will examine the impact that changes such as revised building codes, OPUC exemptions granted for non-cost-effective measures, and changes to avoided cost calculations may have on the Company's long- and short-term conservation potential. Success shall be measured by the following:
  - The Company shall hold at least one meeting with the Energy Trust to discuss any changes that might affect the Company's energy efficiency therm savings targets, and, if applicable, what actions may need to be taken to comply with or adapt to the changes.
  - Cascade will provide a summary of its meeting with the Energy Trust in its 2021 IRP Annual Update. In compliance with OAR 860-021-0400(9), the Company will file an update as soon as is reasonably possible if any changes result in a significant deviation from the 2020 IRP.
- The Company will work with the Energy Trust of Oregon to identify potential areas for expanded engagement in support of local communities' climate action planning goals. These discussions could include consideration of biogas engagement where cost-effective and regulatorily permitted. Findings on how to best support local climate plans will be included in the next IRP.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

DSM (Cont'd)

- Cascade will strive to acquire the following amount of cost-effective gas therm savings over the next two years:

	2020	2021
Oregon	547,244	563,251
Washington	726,625	853,253
Total	**1,273,869**	**1,416,504**

- The Company will acquire cost-effective therm savings by partnering with Energy Trust in Oregon and by delivering programs under the oversight of the Company's Conservation Advisory Group in Washington. Short-term annual therm savings targets are refined annually in Oregon by the Energy Trust through the budgeting process and in Cascade's Conservation Plan, which the Company files each December 1st in Washington.

CASCADE NATURAL GAS CORPORATION
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Demand

- Include wind in the stochastic weather analysis.
- Look into a new methodology of peak day. Cascade's peak day is currently the coldest day in past 30 years. Beginning with the 2022 IRP, Cascade's current peak day will fall outside of the 30-year range.

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Resource Planning

- Cascade recognizes the importance of gathering best practices from its fellow local distribution companies (LDCs). To that end, the Company will participate in the IRP process of at least three regional utilities over the course of the next two years with the objective of incorporating aspects that may enhance Cascade's IRP.
- Cascade will continue to work with Northwest Pipeline to pursue opportunities to better align MDDOs contract delivery rights at no incremental costs to customers through the use of segmentation or other.
- Cascade will determine if the temporary Jackson Prairie account JP3 release from PSE should be made permanent.
- Cascade will continue to work on developing scenarios to replicate potential supply and transport impacts for pipeline operational flow orders (OFO) and consideration of other strategies to minimize OFO impacts.
- To better improve the alignment of resources/costs between the PGA and the IRP, Cascade will continue to develop SENDOUT direct models for gas cost workbooks provided to commissions during PGA filings.
- Cascade will develop more scenarios to specifically address potential Canadian supply market changes such as diversion of Station 2 supplies to LNG and/or NGTL., impact of the new federal fuel charge on the price and potential switching of supply basins utilization/needs of upstream pipeline transportation over time.

Cascade Natural Gas Corporation®
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Distribution System Planning

- Cascade has identified engineering projects to be put into the IRP. The projects as well as the costs will be provided in the draft IRP under confidential treatment.

Remaining Schedule

Date (Subject to change)	State	Process Element
Tuesday, May 12, 2020	OR	Draft of 2020 OR IRP distributed
Friday, June 12, 2020	OR	Comments due on draft from all stakeholders
Tuesday, June 30, 2020	OR	TAG 6, if needed
Friday, July 31, 2020	OR	IRP filing in Oregon

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

ADDITIONAL QUESTIONS?

mark.sellers-vaughn@cngc.com

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

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

Ashton Davis – Resource Planning Analyst I: (509) 734-4520
ashton.davis@cngc.com

Bruce Folsom - Consultant

Cascade Natural Gas Corporation
A Subsidiary of MDU Resources Group, Inc.
In the Community to Serve®

Cascade Natural Gas Corporation

2020 Integrated Resource Plan
Technical Advisory Group Meeting #5

March 11, 2020

Oregon Public Utility Commission

Salem, OR

OPUC Tag Meeting 4

Date & Time: 3/11/2020, 09:00 AM – 10:30 PM

Location: OPUC offices in Salem, OR – Meadow Room

In attendance: Brian Robertson, Ashton Davis, Devin McGreal, Alyn Spector, Mike Parvinen, Mark Sellers-Vaughn, Nicholas Colombo (OPUC)

Called in: Kevin Connell, Eric Wood, Bruce Folsom, Carolyn Stone, Tom Pardee (Avista), Sudeshna Pal (CUB), Mike Paruszkiewicz (NWN)

Minutes by: Brian Robertson

Brian Robertson kicked off the meeting by thanking everyone that showed up. Brian went over fire safety of the building, introductions and the agenda.

- Brian Robertson quickly summarized alternative resources options Cascade has to add on the upstream side.
- Brian then reviewed Cascade's Supply Resource Optimization Process that was presented at TAG 4. This was discussed in depth as it was Nicholas' first exposure to Cascade's process. Brian also recapped Cascade's potential shortfalls from the as-is case.
- Ashton Davis then discussed Cascade's list of candidate portfolios. Cascade's candidate portfolios are as such:
  - All-In
  - All-In less DSM
  - GTN transportation Only
  - GTN Plus Storage
  - NWP transportation Only
  - NWP Plus Storage
  - Storage Only

Brian asked if there were any suggestion for other portfolios. Nicholas said it would be a good idea to add an RNG portfolio in future IRPs.

- Devin McGreal presented the methodology behind ranking of portfolios. Devin also discussed the risk-adjusted cost metric that Cascade utilizes to rank portfolios. Devin then shared the portfolios and their ranking.
- Devin discussed the top ranked candidate portfolio components and how it solves shortfalls.

- Brian then discussed the new stochastic methodology Cascade used for the weather and price Monte Carlo simulations. For weather, Cascade utilized the Cholesky Decomposition Matrix (CDM). For price, Cascade utilized the Geometric Brownian Motion as well as the CDM.
- Devin then presented the Company's Scenario and Sensitivity Results. This included a discussion on High Growth and No Evergreen results. Both cases showed unserved demand, which was a red flag to Cascade. In both cases, Cascade found that these are scenario's that the Company will want to monitor but it does not cause us to reject the candidate portfolio.
- Devin shared the unserved and cost results of all the scenarios and sensitivities discussed earlier.
- In Conclusion, the Company is satisfied with the results that all shortfalls will be served by DSM and 3rd party citygate deliveries. Cascade presented a slide showing Cascade does not anticipate any shortfalls under the preferred portfolio.
- Alan Spector discussed the four-year action plan for Environmental Policy as well as DSM.
- Brian Robertson discussed the four-year action plan for Demand, Resource Planning, and Distribution System Planning.
- Brian discussed the remaining 2020 OR IRP schedule and adjourned the meeting.

Cascade will file the draft IRP on May 12 and has a TAG 6 scheduled for June 30th, if needed.

The meeting was adjourned at 10:30 PM.