CASCADE NATURAL GAS CORPORATION®

A Subsidiary of MDU Resources Group, Inc.

In the Community to Serve®

Integrated Resource Plan (OR) Technical Advisory Group Meeting #5

NOVEMBER 9, 2022

MICROSOFT TEAMS/TELECONFERENCE

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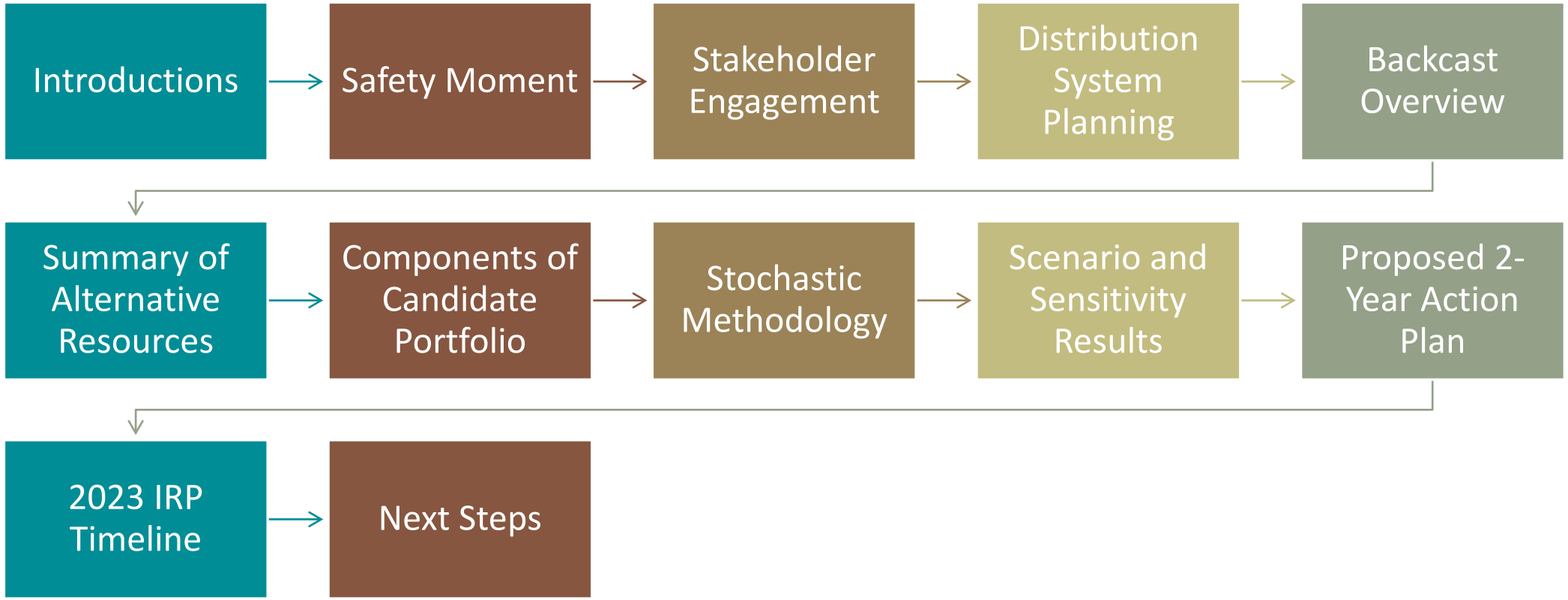
Agenda

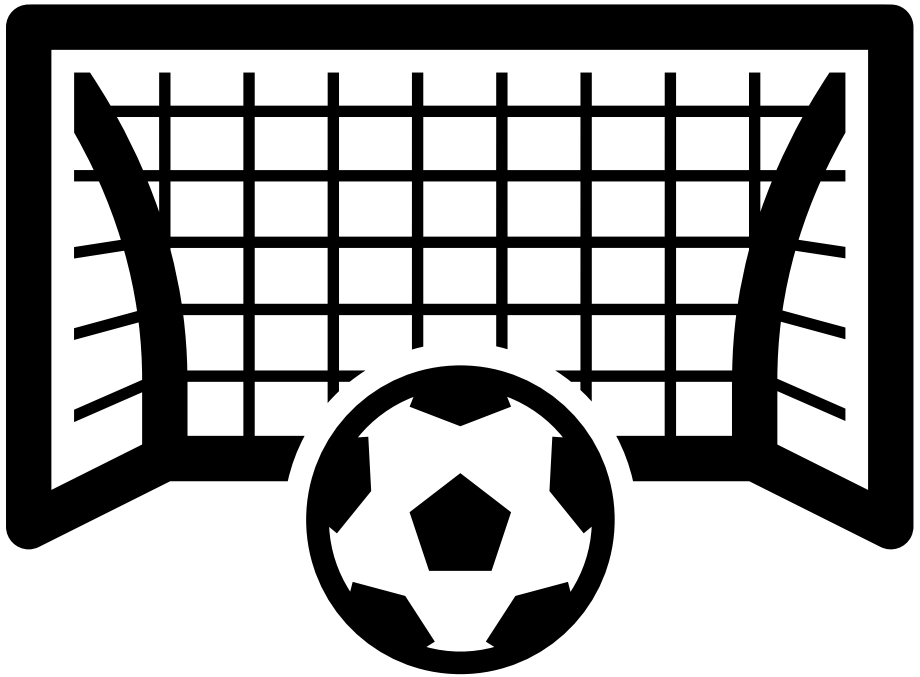

Introductions
Safety Moment
Stakeholder Engagement
Distribution System Planning
Backcast Overview
Summary of Alternative Resources
Components of Candidate Portfolio
Stochastic Methodology
Scenario and Sensitivity Results
Proposed 2-Year Action Plan
2023 IRP Timeline
Next Steps

How to Relieve Stress

Stress can have a negative impact on bodies and overall health.
Here are some tips to relieve it:

- **Listen to Music** – Playing calm, meditative, relaxing music can help lower blood pressure. This can include listening to ocean waves or nature sounds.
- **Talk to Someone** – Take a break and talk to a friend or a counselor. When you are under a lot of stress a reassuring voice can help put everything into a better perspective.
- **Healthy Eating** – Try to avoid sugary and fatty snack foods. Eating fruits, vegetables, and fish with high Omega-3 fatty acids are a better alternative and have been shown to reduce stress symptoms.
- **Laugh** – Laughter they say is the best medicine and when it comes to stress, this is true. Laughing releases endorphins that decrease the levels of stress hormones. Laughing tricks your brain into making you happy.
- **Drink Tea** – Avoid coffee and caffeinated drinks; these beverages cause a short-term spike in blood pressure. Green tea has less caffeine and contains amino acids that have a calming effect.
- **Exercise** – Exercising, even for a short walk around the office or simply standing up and stretching will get your blood moving and release endorphins to immediately provide some relief to a stressful moment.
- **Breathe** – Taking deliberate, slow, deep breaths helps to center your body, clear your mind, and slow your heart rate. Understanding stress and how it effects your body can help you understand the right steps you need to take to help relieve it.

Safety Moment



Stakeholder Engagement[1]

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.

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1: SEE STAKEHOLDER ENGAGEMENT DESIGN DOCUMENT AT OREGON INTEGRATED RESOURCE PLAN - CASCADE NATURAL GAS CORPORATION (CNGC.COM)

Distribution System Planning

KATHLEEN CAMPBELL, PE – SENIOR ENGINEER

OREGON

NOVEMBER 9TH, 2022

Presentation will cover:

1. Distribution system modeling process
2. Identification of system deficits/constraints
3. Distribution enhancements/reinforcements options to address deficits
4. Enhancement review and selection process to capital budget
5. Enhancement/reinforcements identified in 2023-2027 capital budget
6. Iterative process of IRP

Distribution System Modeling

System Dynamics:

Piping:

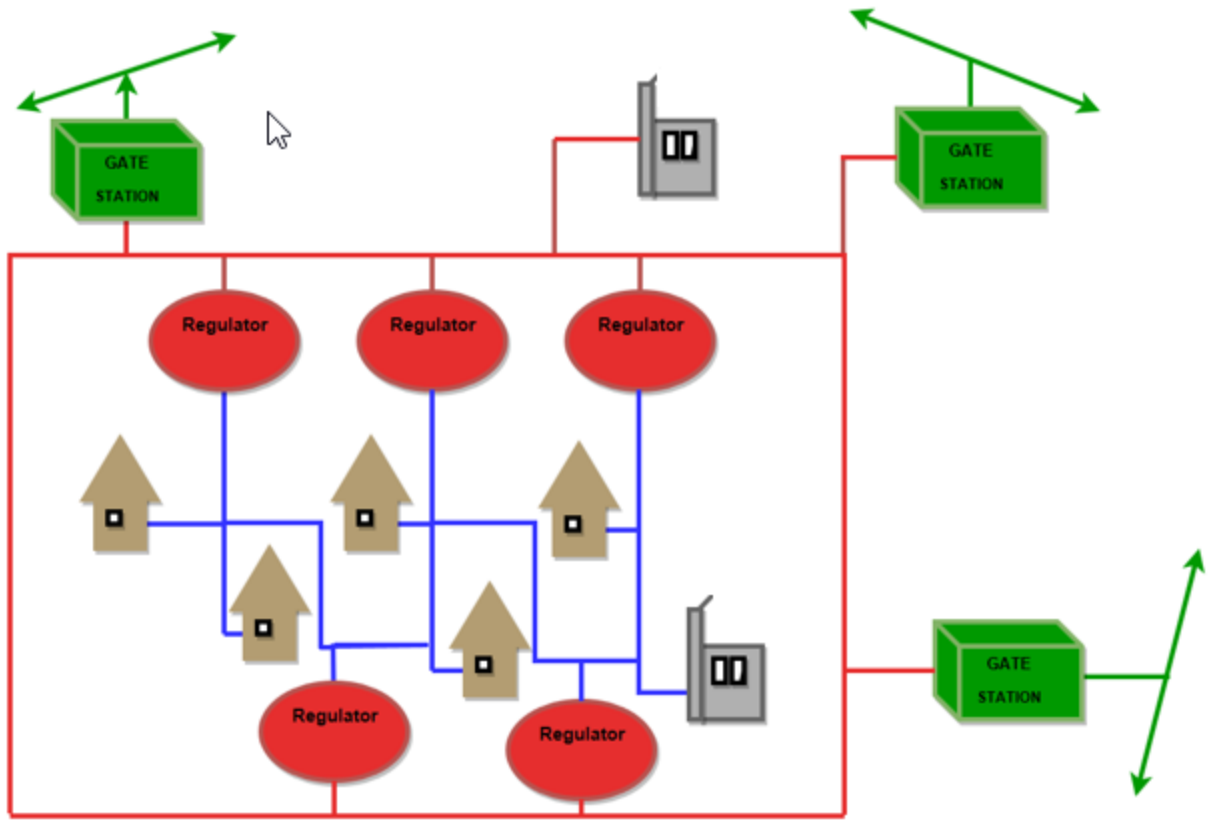
- Diameter – ½” to 20”
- Material – Polyethylene and Steel
- Operating Pressure – 20 psi to 900 psi
- Washington – approx. 4,893 miles of distribution & 170 miles of transmission
- Oregon – approx. 1,710 miles of distribution & 107 miles of transmission

System Dynamic's Cont.

Facilities:

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

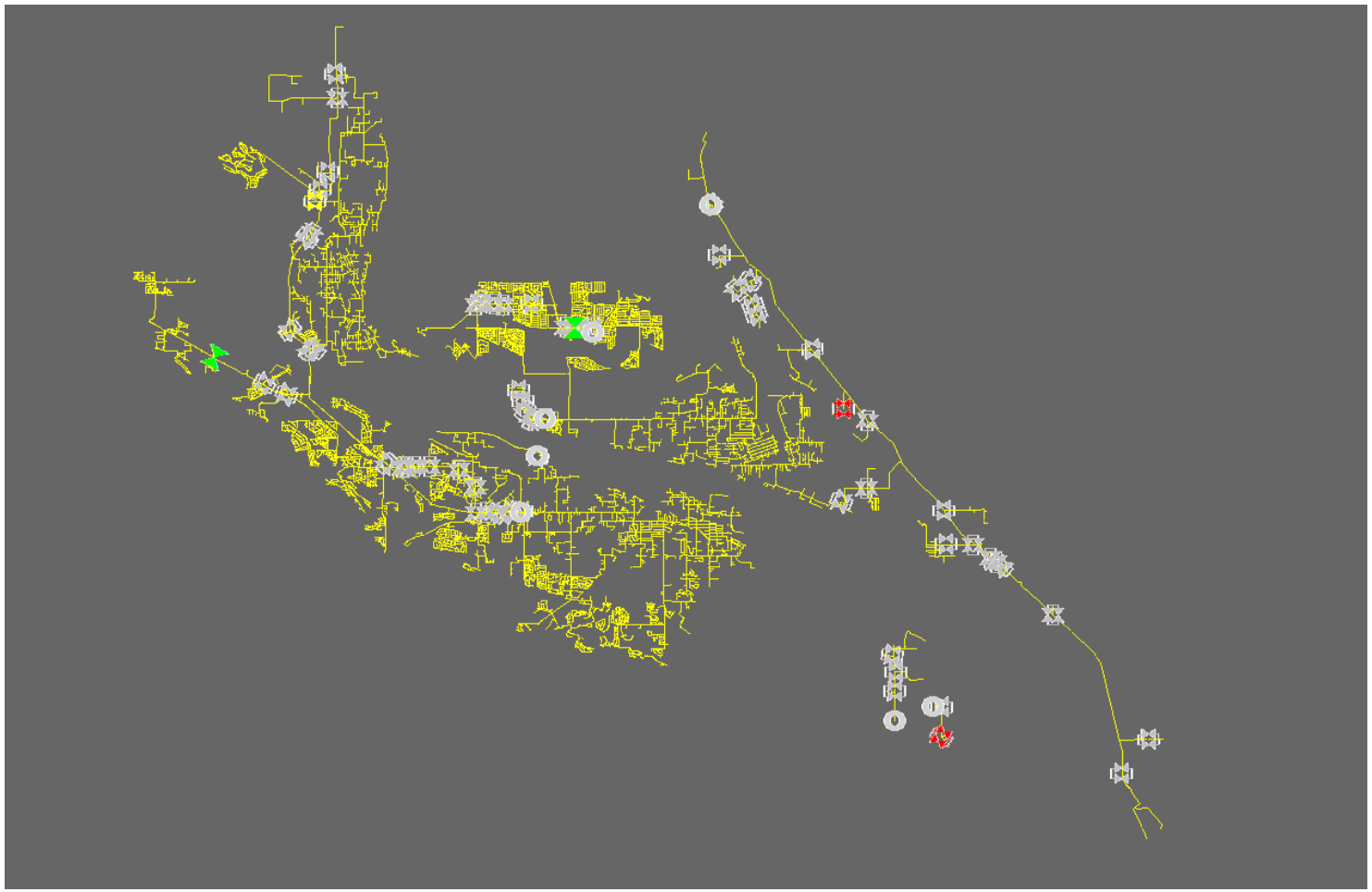
System Design



Synergi Gas Modeling

- To evaluate our systems for growth and potential future deficits we use our gas modeling software, Synergi Gas
- Distributed and supported by DNV GL
- Models incorporates:
  - Total customer loads
  - Existing pipe and system configurations
- Hydraulic modeling software that allows us to predict flows and pressures on our system based on gas demands predicted during a peak weather event.
- Models are updated every three years and maintained between rebuilds

Synergi Model Example



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Model Building Process

Synergi models are completely rebuilt every three years and maintained/updated between rebuilds

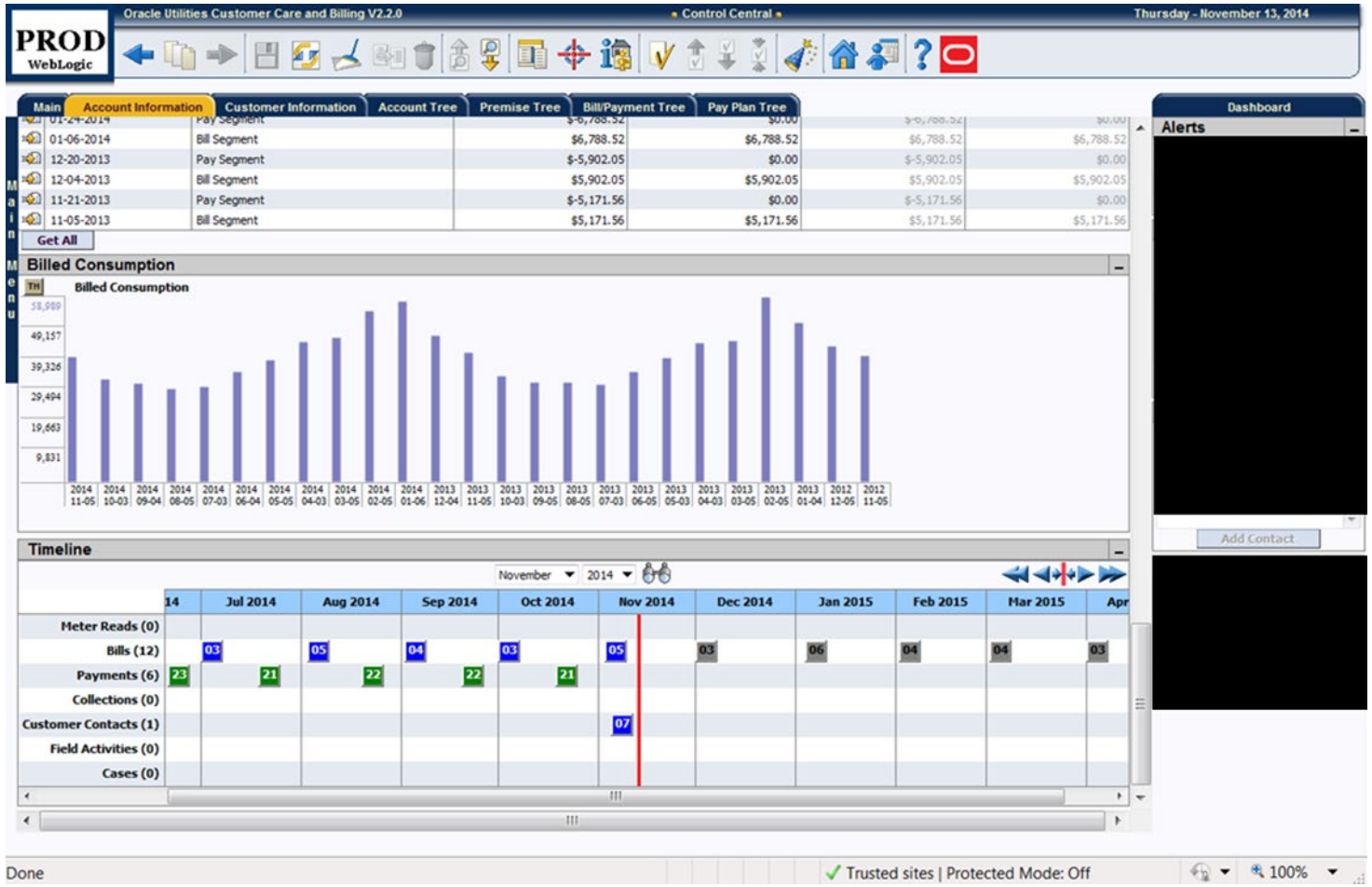
When models are rebuilt

- We export current GIS data to build spatial model
- We export current CC&B billing data to CMM to create an updated demands file
- We validation and calibrate each district model to a recent low-pressure event using existing data (ERXs/pressure charts/SCADA/metertek/LV usage)
- We create a design day model based on the updated heating degree day determined by gas supply (determined by trending historical weather events)

CNG models were rebuilt in 2021

Data Gathering

CC&B (Customer Billing Data)



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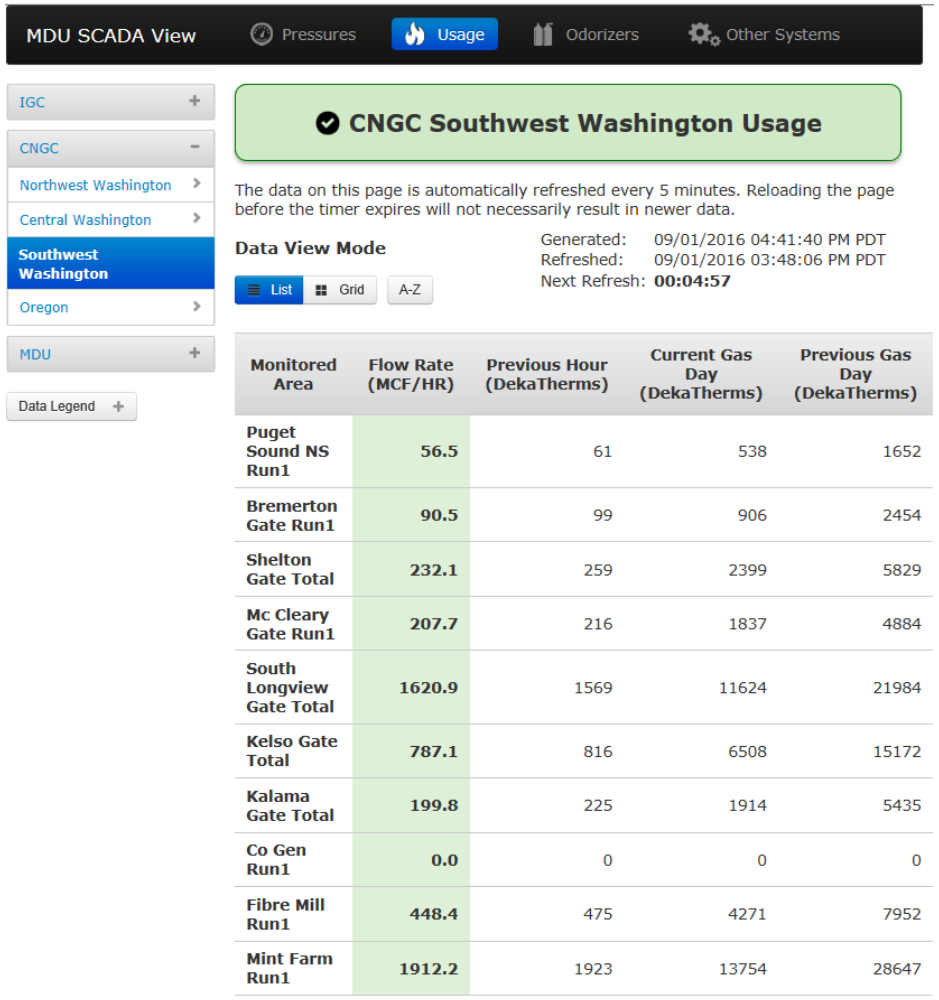
Data Gathering



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

SCADA Data

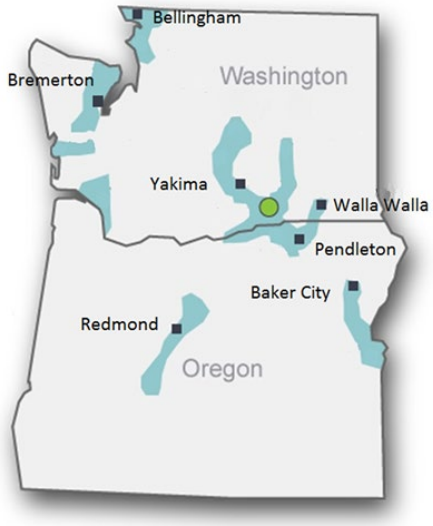
Real time and historical flow characteristics at specific locations in the system

Data Gathering

District	HDD	Avg Daily Temperature (°F)
Aberdeen	46	14
Bellingham	47	13
Bend	71	-11
Bremerton	46	14
Eastern Oregon	73	-13
Kennewick	65	-5
Longview	46	14
Mt Vernon	47	13
Pendleton	67	-7
Walla Walla	66	-6
Wenatchee	65	-5
Yakima	65	-5

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

Peak HDD = 60 – Average Daily Temp



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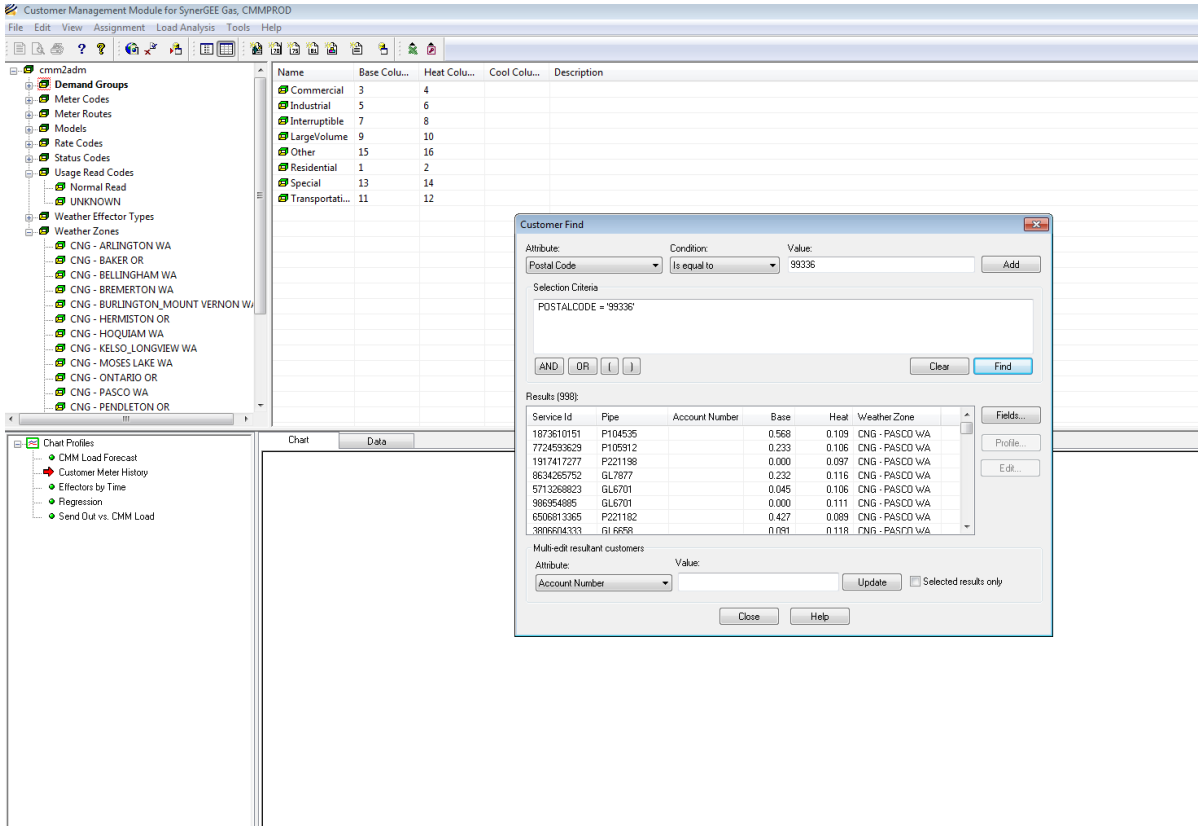
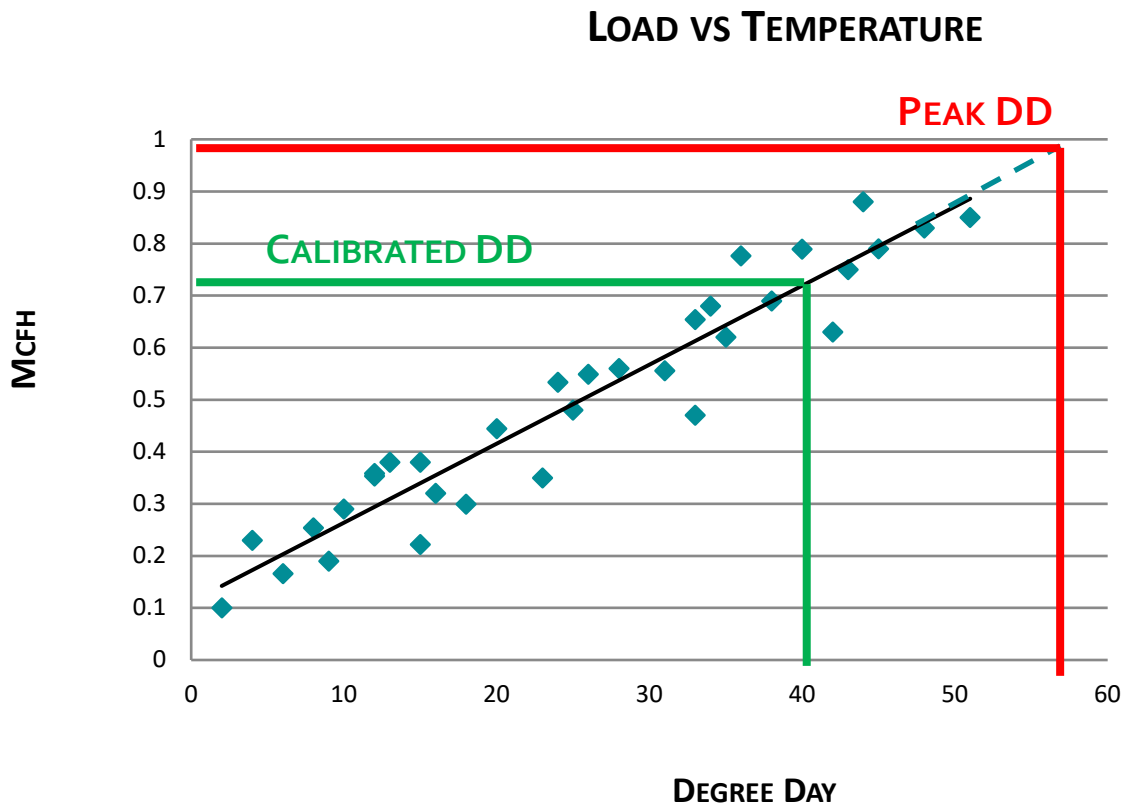
Customer Management Module (CMM)



Brings CC&B customer data into Synergi as demands file

Demand file applies load spatially in the model.

Calibrated vs Peak Degree Day



$y = 0.0152x + 0.1118$

HEAT BASE

40 DD = 0.72 MCFH

58 DD = 0.99 MCFH

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Identification of system deficits/constraints

Synergi Modeling Capabilities:

- Review Large Volume Customer requests
- Model RNG
- Supports design/sizing of pipe and pipeline components (regulator stations, compressors)
- Future planning
- Model IRP predicted growth
- Identify deficiencies
- Determine system reliability
- Optimize distribution enhancement options
- Cold Weather Action Plans and Modeling Curtailments/Interruptible Customers

What is a capacity deficit?

A deficit is defined as a critical system that is at or limiting capacity.

Critical system examples include:

- Pipeline bottlenecks
- Minimum inlet pressure to a regulator station or HP system
- Not meeting a required customer delivery pressure
- Component limiting capacity

Distribution System Modeling Process to ensure we can meet IRP growth predictions

As part of the IRP process, we complete a comprehensive review of all of our distribution system models every two years to ensure that we can maintain reliable service to our customers during peak low temperature events.

With our capital budget cycle, we also complete system reviews on an annual basis.

If a deficit is predicted the system is evaluated and a reinforcement/enhancement is proposed and selected based on alternative analysis considerations and placed into the capital budget based on timing needs of the predicted deficit.

Distribution Enhancement/Reinforcement Options to address deficits

Enhancement Options

Pipeline:

- Replacements
- Reinforcements
- Loops & Back feeds
- Pressure Increases
- Uprates

Facility Upgrades

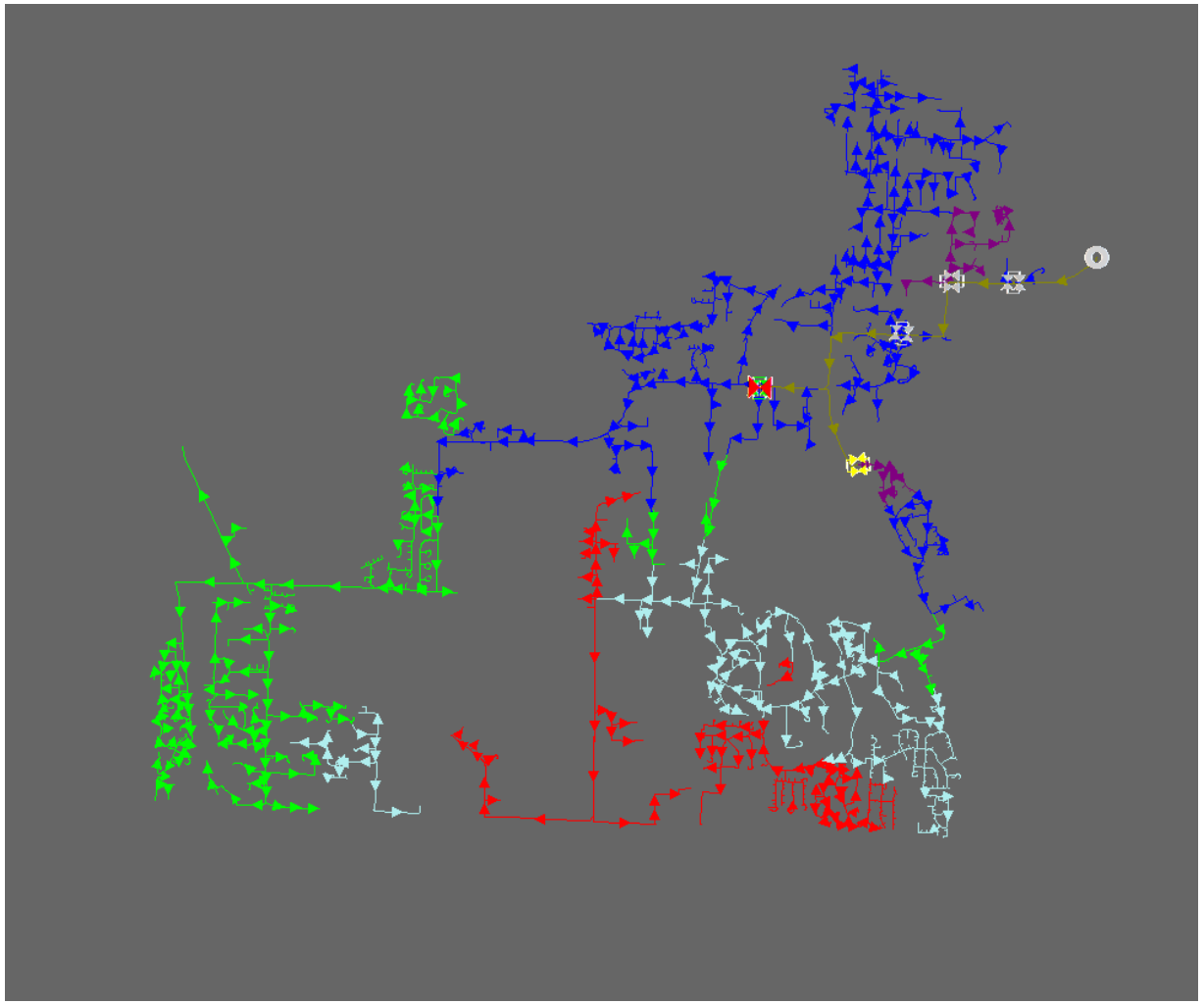
Additional Regulator Stations feeding the distribution system

New Strategically placed Gate Stations

Compressor Stations

Distribution Enhancement Example

Theoretical low-pressure scenario



Facilities Color By

Pressure (Primary Only) (psig)

- Not Applicable (7)
- < 10.00 (301)
- 10.00 - 15.00 (518)
- 15.00 - 25.00 (548)
- 25.00 - 40.00 (627)
- 40.00 - 60.00 (67)
- > 60.00 (16)

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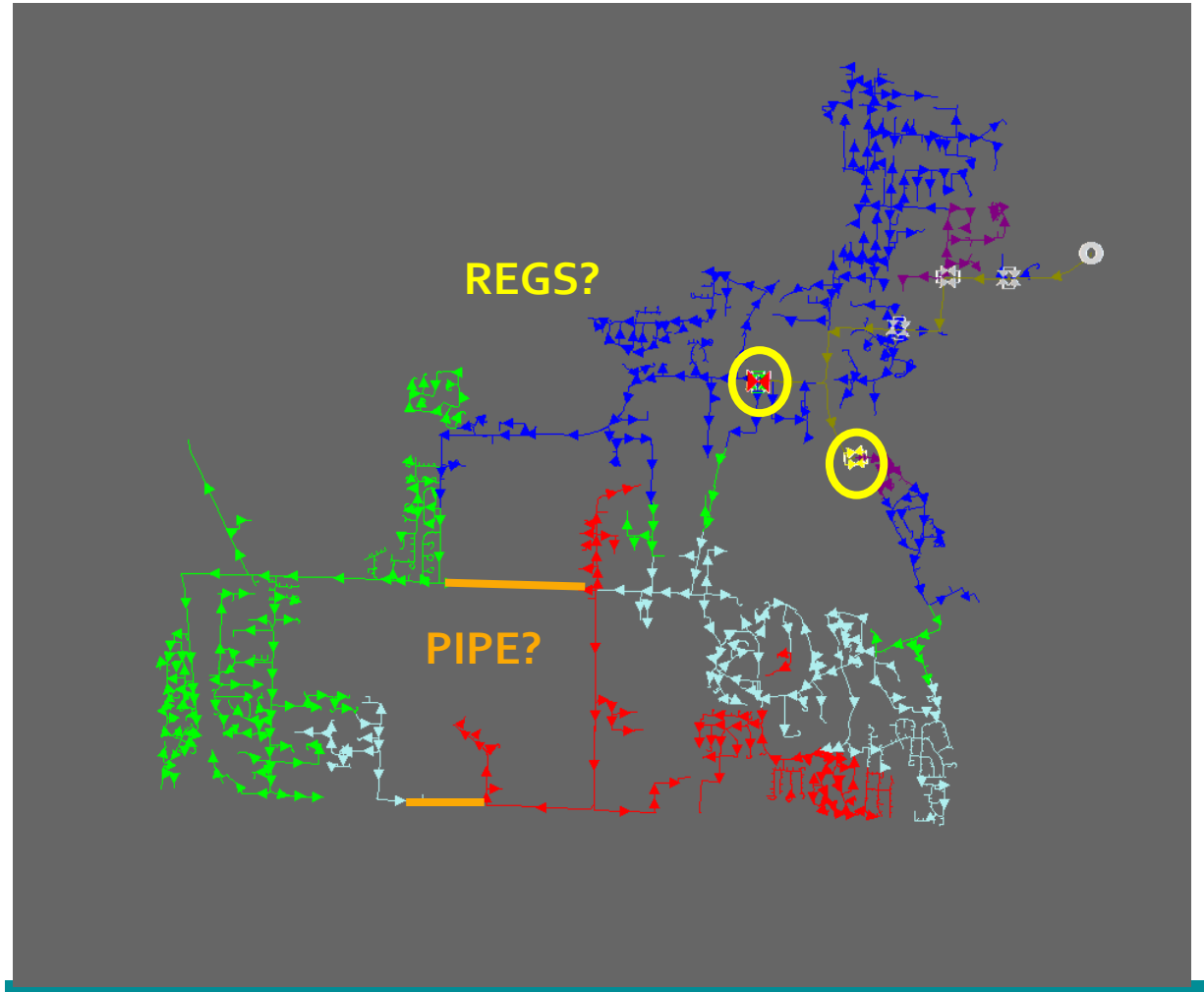
Distribution Enhancement Options

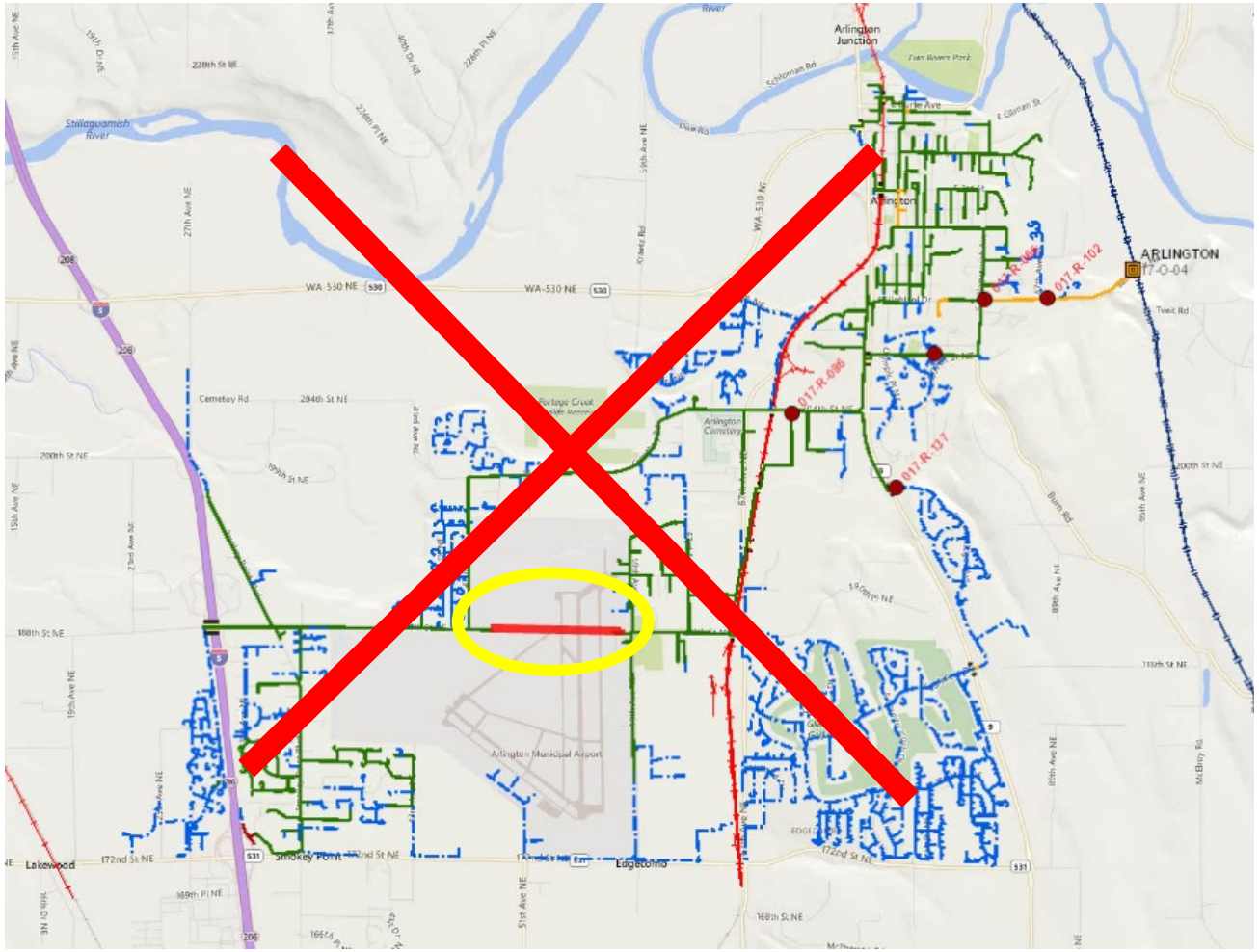
Low pressure scenario



- Compressor station infeasible
- Other Solutions?

Distribution Enhancement Options

Reinforcement option #1



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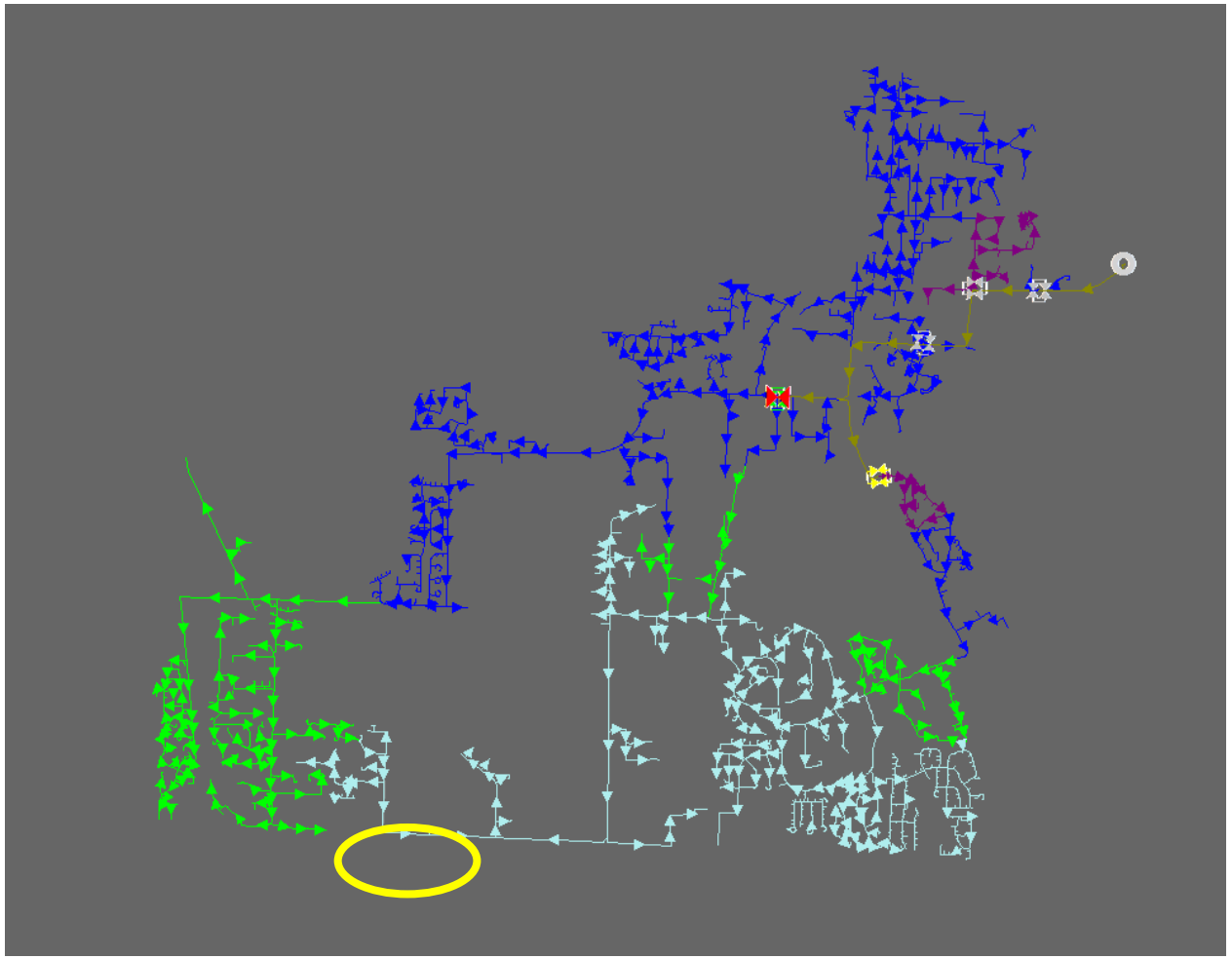
Distribution Enhancement Options

Reinforcement option #2



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Enhancements Considerations

Scope

Cost

Capacity Increase

Timing

System Benefits

Alternative Analysis

Feasibility

Demand Side Management Pilot Program

- Working with Energy Trust Oregon to develop a pilot program for Baker City and Ontario
- Will be doing targeted demand side management to offset growth demand increases predicted to see if we can avoid the proposed reinforcement
- We have determined that Baker City is a good candidate for a pilot program city since we have time before we need the reinforcement.
- Per Oregon Trust we would like 5 years to be able to get a program in place and be able to see its effectiveness.
- If DMS does not offset enough load a reinforcement may still need to be completed.

Enhancement Review and Selection Process to Capital Budget

Enhancement Selection Guidelines:

Shortest segment of pipe that addresses deficiency

Segment of pipe with the most favorable construction conditions

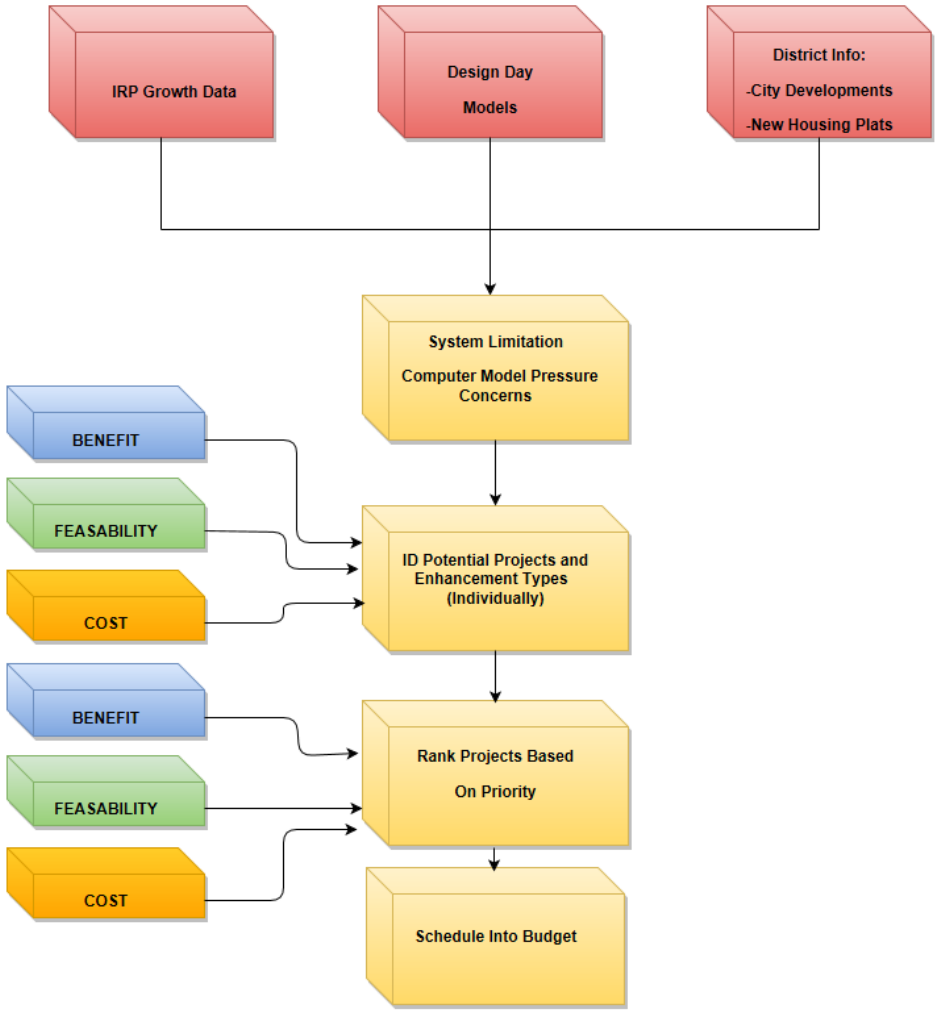
Segment of pipe that minimizes environmental concerns and impacts to the community

Segment of pipe that provides opportunity to add additional customers

Total construction cost including restoration

Demand Side Management if load reduction will eliminate need for reinforcement and we have time to see impacts

Enhancement Selection Process:



Info & Data

Project & Schedules

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Enhancements/Reinforcements Identified in 2023-2027 Capital Budget

2023-2027 OR Distribution Enhancements:

- Prineville Gate Upgrade
- Baker City Reinforcement and New Gate Station
- Bend Shelvin Park Reinforcement
- Ontario Reinforcement

Prineville Gate Upgrade

Scope: Gate capacity upgrade, CNG and TransCanada gates will be rebuilt

Cost:

- GTN Gate Upgrade: $1.008M
- CNG Gate Upgrade: $1.6M

Timing:

- 2023 Design and Permitting
- 2024 Construction

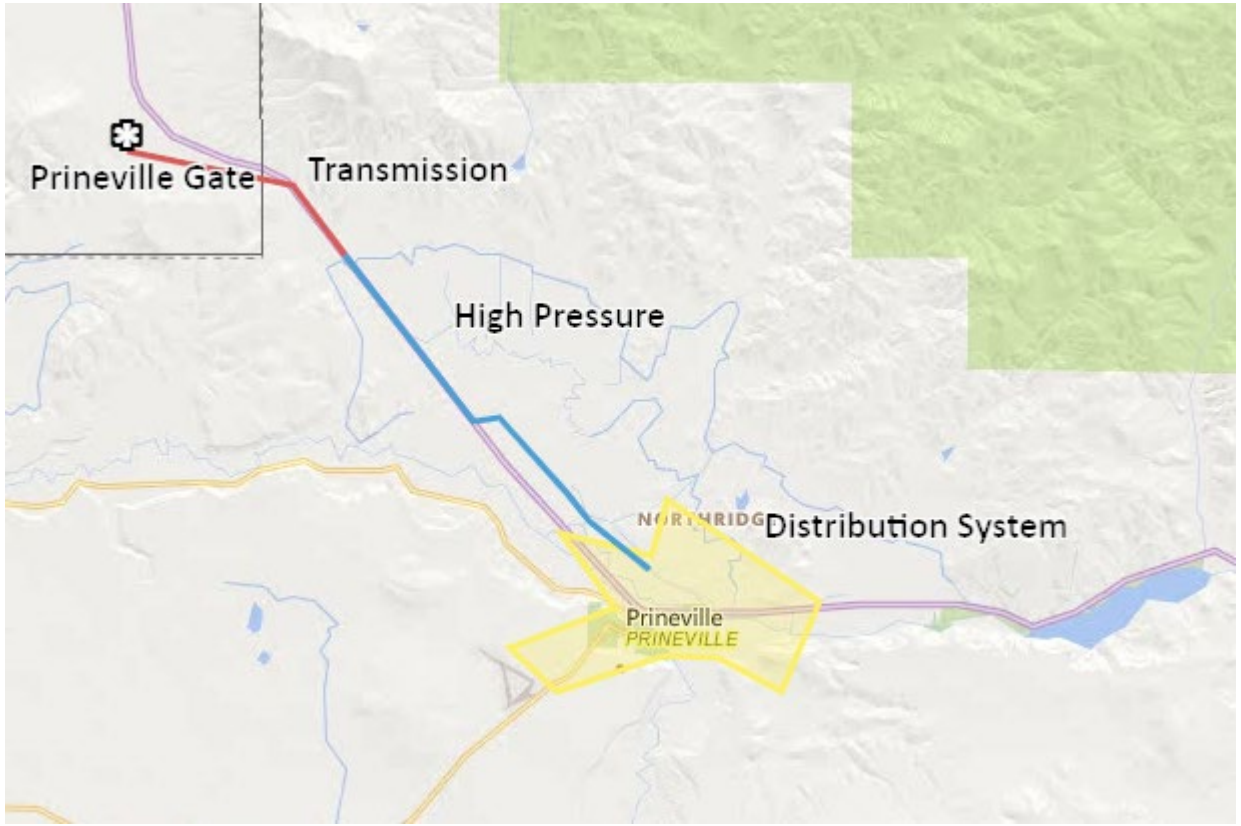
Prineville Gate Upgrade Cont.

Benefits:

- CNG will take over regulation and will have the ability to bypass.
- Current gate station will be replaced with larger piping and facilities that will allow the gate station to meet current demand and provide more reliable delivery pressures from the gate to the transmission and high-pressure systems.
  - On several occurrence's during peak demand, we have experienced gas control alarms with 30 psig of droop out of the station.

Alternative Considered: None, existing gate needs additional capacity.

- DSM not considered due to urgent timing needs of project
- Interruptible customer consideration
  - Prineville has 2 RS-163 customers, interrupting these customers when the outlet pressure is compromised will not delay the gate upgrade.



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Baker City Reinforcement and New Gate Station

Scope: New gate station on the eastside of Baker City with a 1,200 foot 6-inch PE reinforcement tied into the existing distribution system.

Cost:

- GTN Gate Cost: $1.4M
- CNG Gate Cost: $525K
- 6-inch PE Reinforcement: $356K

Timing: 2023 Construction (proposed to be pushed to 2024/2025 for DSM)

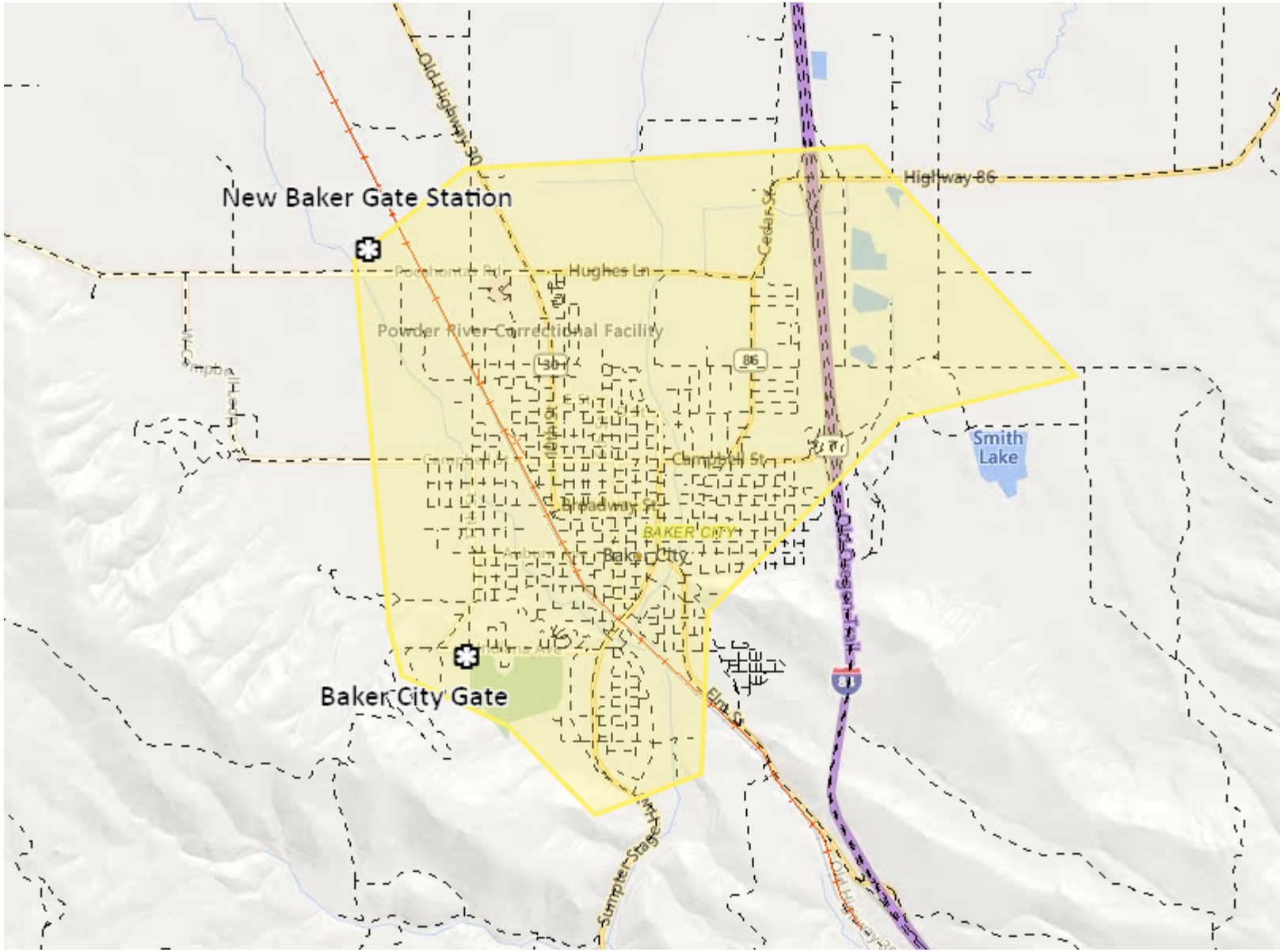
Baker City Reinforcement and New Gate Station Cont.

Benefits:

- New gate station provides a secondary/redundant feed to Baker City
- Reinforcement provides additional capacity to support growth in Baker City
- Reinforcement boosts design day pressures on the east side of Baker City

Alternatives Considered:

- Increasing the capacity of the existing gate station and then completing reinforcements from the gate to the east side of Baker City to carry pressures and flows deeper into the distribution system.
- Targeted DSM in Baker City



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Bend Shelvin Park Reinforcement

Scope: High pressure main extension and new regulator station on the westside of Bend. Project will consist of extending 1.8 miles of 6-inch steel high pressure pipe.

Cost: $1.76M in 2022 (could be shifted to 2023 if not completed in 2022)

Timing:

- 2022 Design and Permitting
- 2022 or 2023 Construction

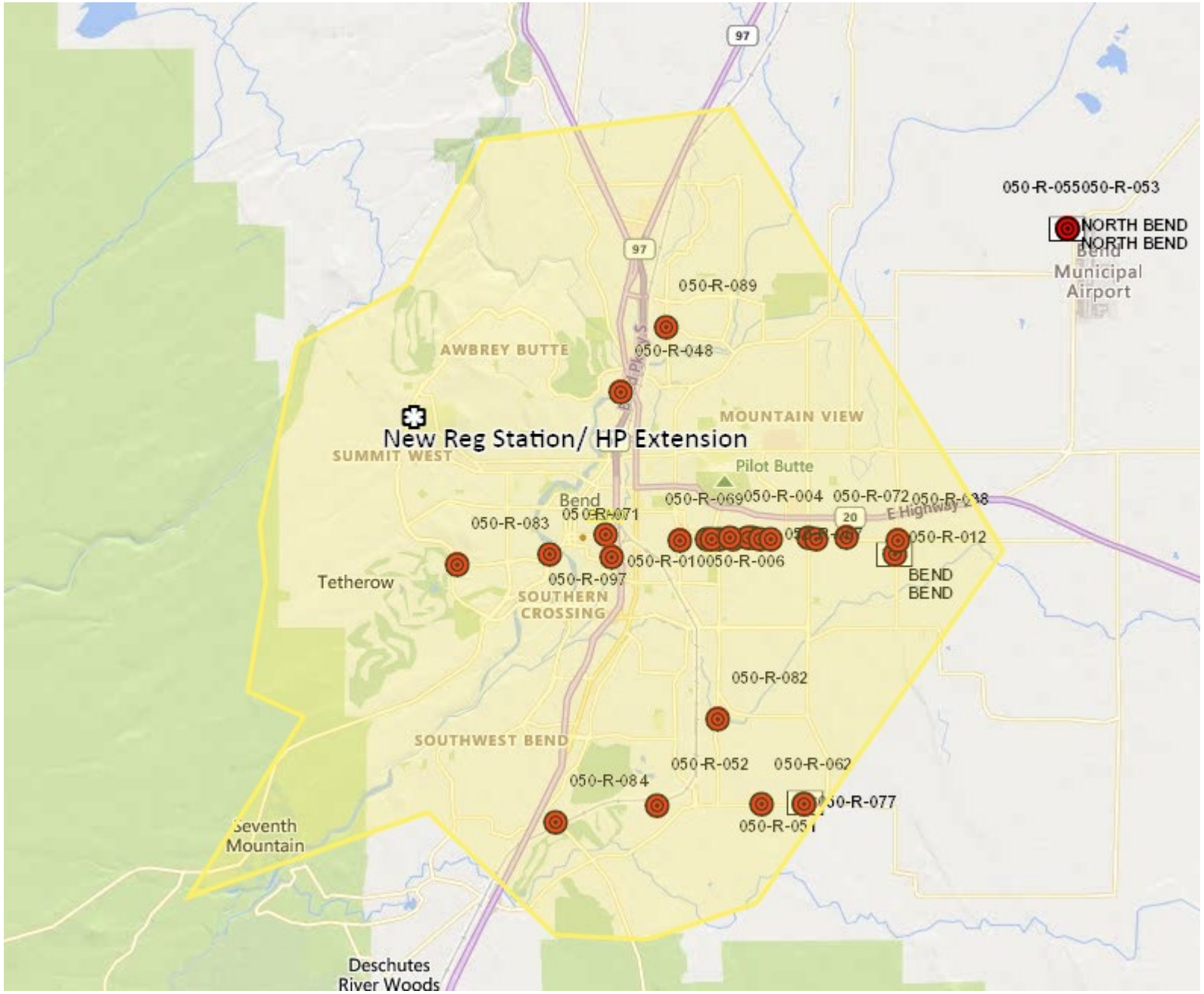
Bend Shelvin Park Reinforcement Cont.

Benefits:

- Will extend high pressure into the westside of Bend
- Will eliminate the need to bypass during cold weather events, in the past couple of years the west side of Bend has experienced significant pressures issues requiring manual bypassing to maintain pressure.
  - Western edge of Bend system got down to 0.5 psig on 2/23/2022 when the Avg daily temperature was 13 ^{o} F. Bend design day average temperature is -11^{o}F.
- New regulator station boosts distribution pressure on the west side of Bend.
- Reinforcing the west side of Bend will support the significant growth we have seen and expect to see on the west side of Bend.

Alternatives Considered:

- Would need to complete significant distribution pressure system reinforcements as an alternative
- DSM not considered due to urgent timing needs of project



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Ontario Reinforcement

Scope: Install new regulator station and 6,000 ft of 4-inch PE

Cost: $1.18M in 2023 (proposed to be pushed to 2024/2025 for DSM)

Timing: 2023 Construction

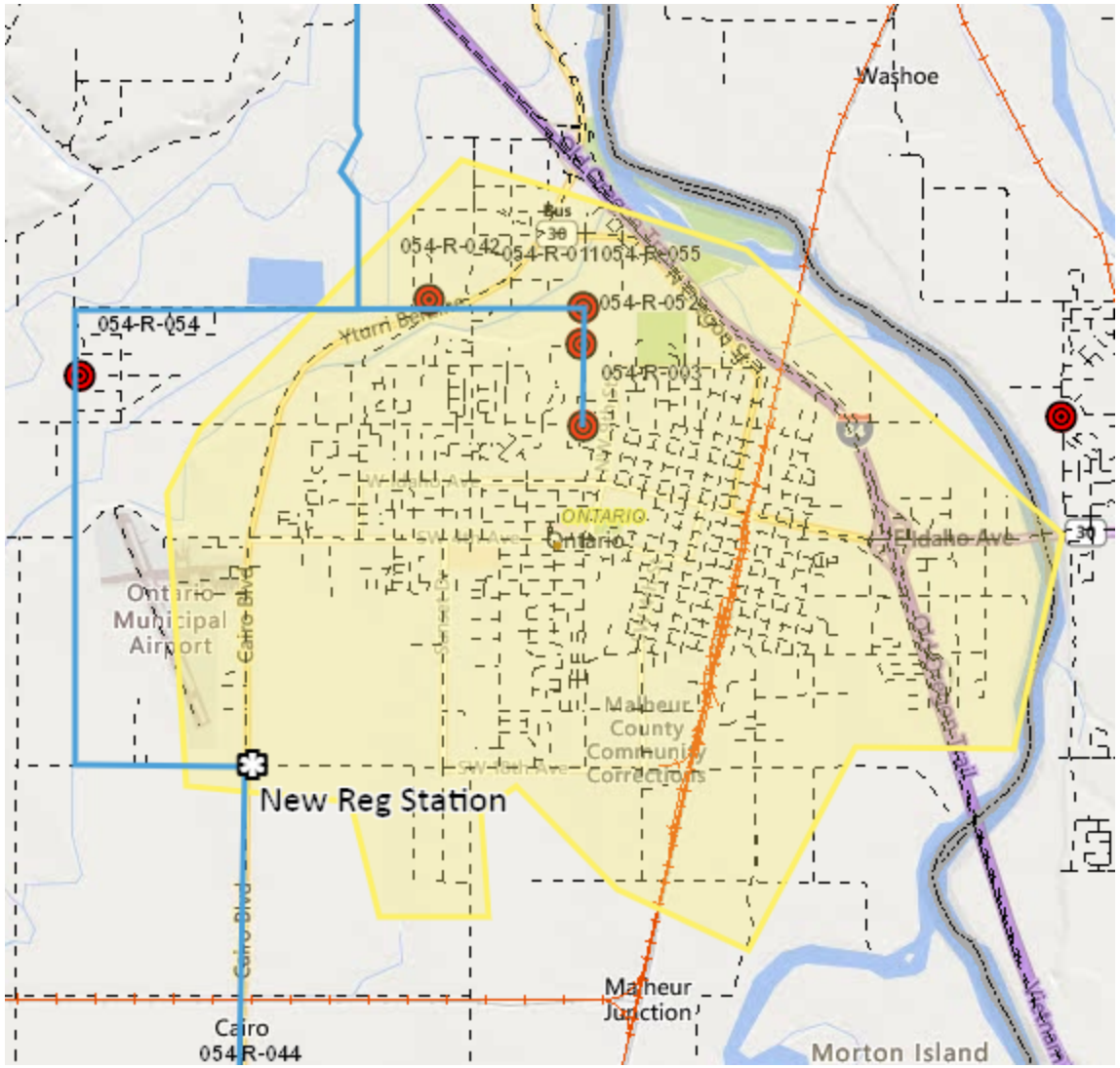
Ontario Reinforcement Cont.

Benefits:

- New regulator station and 4 in PE trunkline boosts pressure and flows to the south and east side of Ontario.
- New regulator station will provide a second feed to the Ontario distribution system from the south.
- This reinforcement will allow for smaller reinforcements to support growth to the south and east side of Ontario.

Alternatives Considered:

- Installing a larger sized trunk line from the existing regulator station to the south side of Ontario
- HP extension not considered due to higher cost
- Targeted DSM in Ontario



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Iterative process of IRP and changing dynamics

Changing Dynamics

RENEWABLE NATURAL GAS (RNG)

HYDROGEN BLENDING

BUILDING CODES

ELECTRIFICATION

DEMAND SIDE MANAGEMENT (DSM)

ENERGY EFFICIENCY

TARGETED LOAD MANAGEMENT

Changing Dynamics and Impacts to Distribution System Modeling

RENEWABLE NATURAL GAS (RNG)

HYDROGEN BLENDING

BUILDING CODES

ELECTRIFICATION

DEMAND SIDE MANAGEMENT (DSM)

ENERGY EFFICIENCY

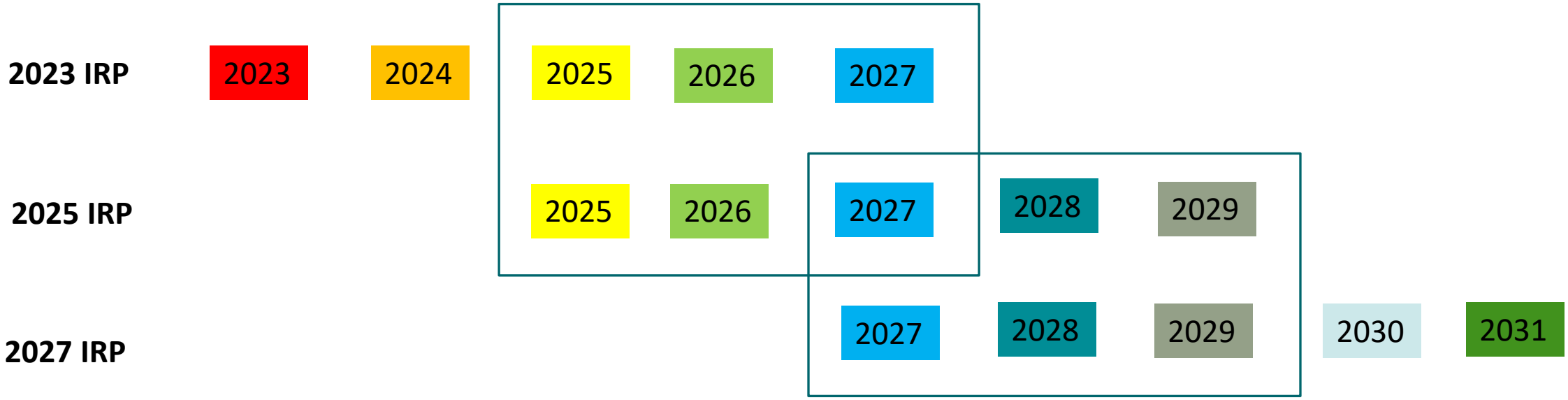
TARGETED LOAD MANAGEMENT

Sources as applicable can modeled in Synergi

Accounted for in updated Synergi models and growth predictions

Accounted for in updated CC&B Billing Data (lagging indicator) and growth predictions

Iterative Process of IRP



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Questions?

Backcast Overview

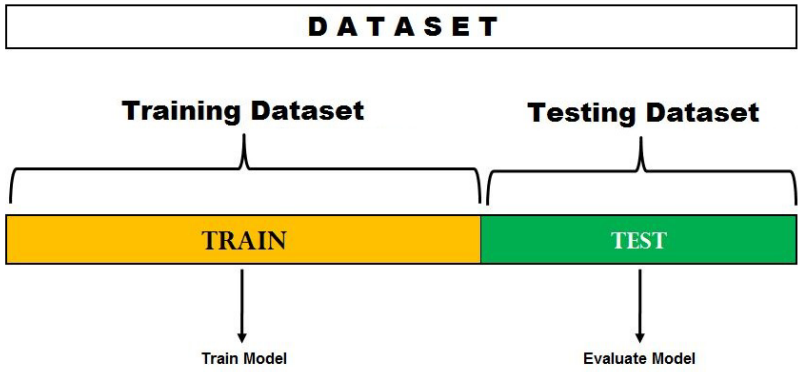
Backcasting (Cross-validation)

Cross-validation:

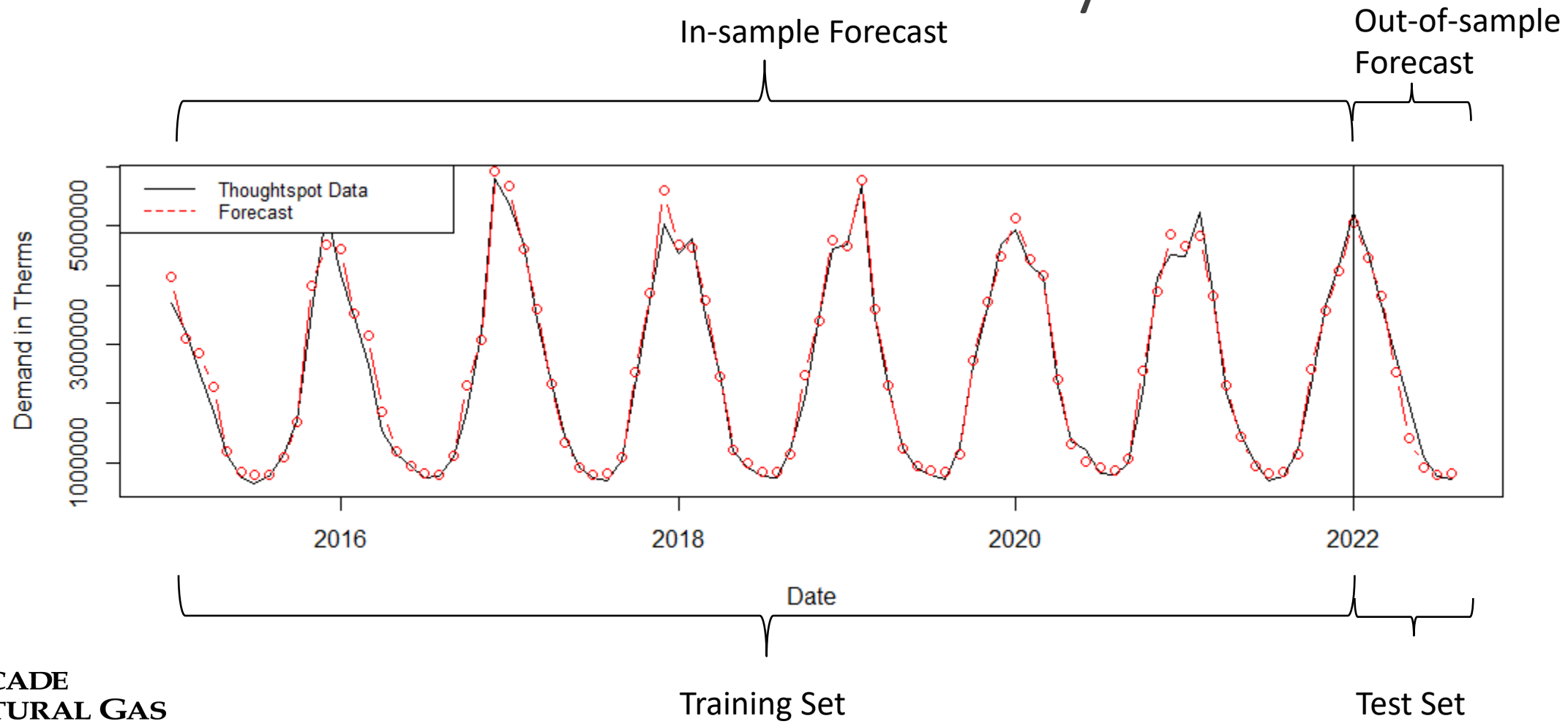
- Estimates the skill of a model on unseen data.
- Flags problems like overfitting, sampling bias…

Hold out cross validation:

- Data is split into “training” and “test” sets
- Model is fit to “training” set
- Model’s forecast is compared to “test” set for accuracy



Breakdown of a forecast analysis



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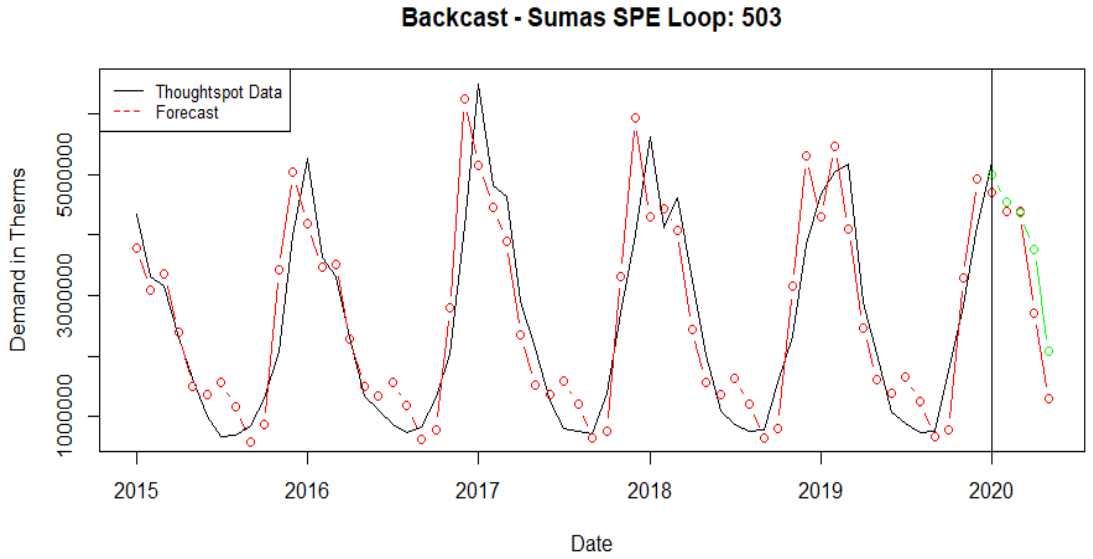
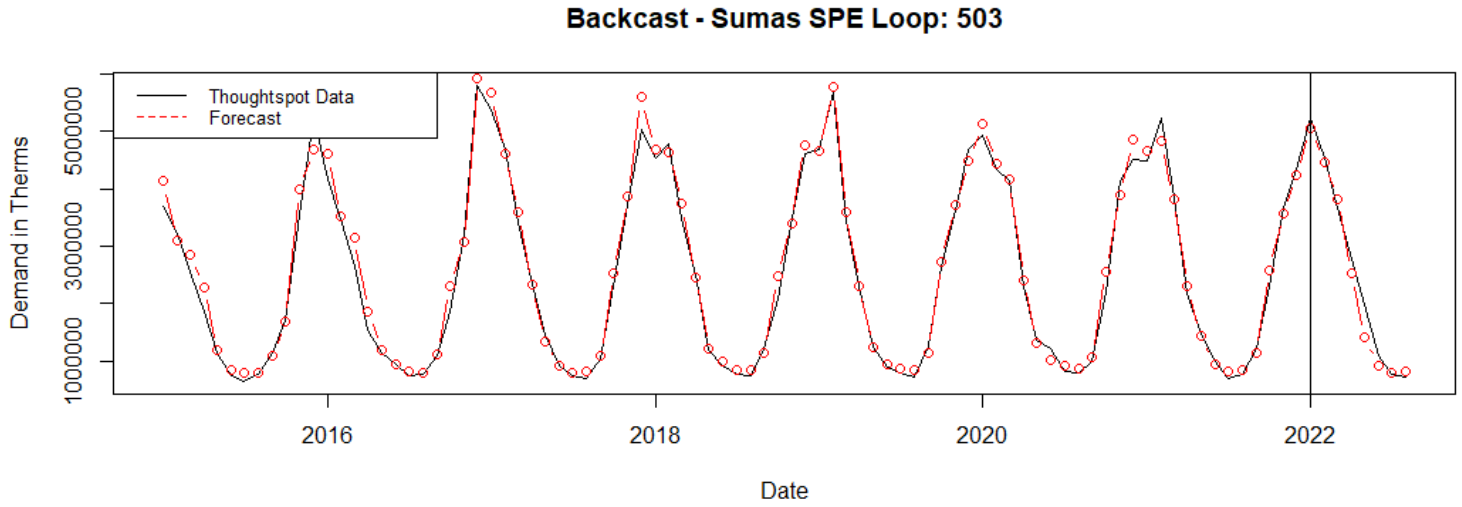
Sumas SPE Loop: 503 (Residential)

Last cross-validation:



Current cross-validation:



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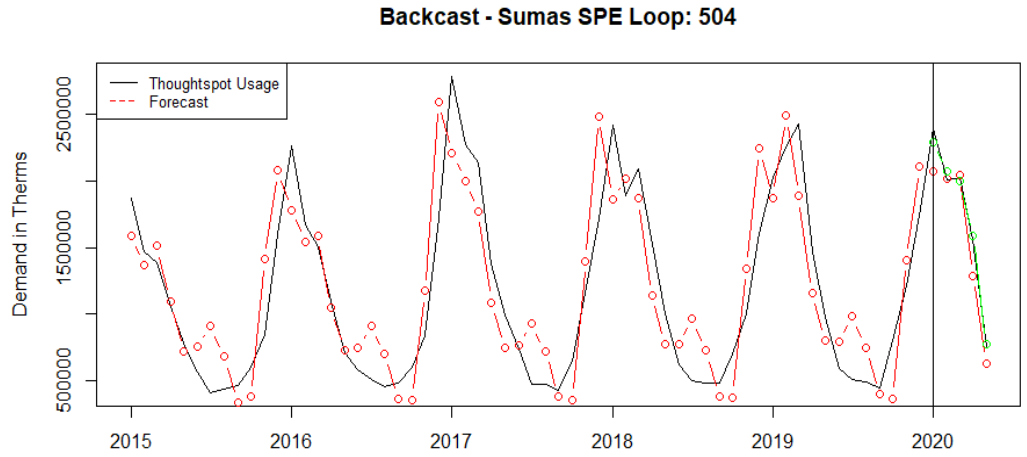
Sumas SPE Loop – 504 (Commercial)

Last cross-validation:



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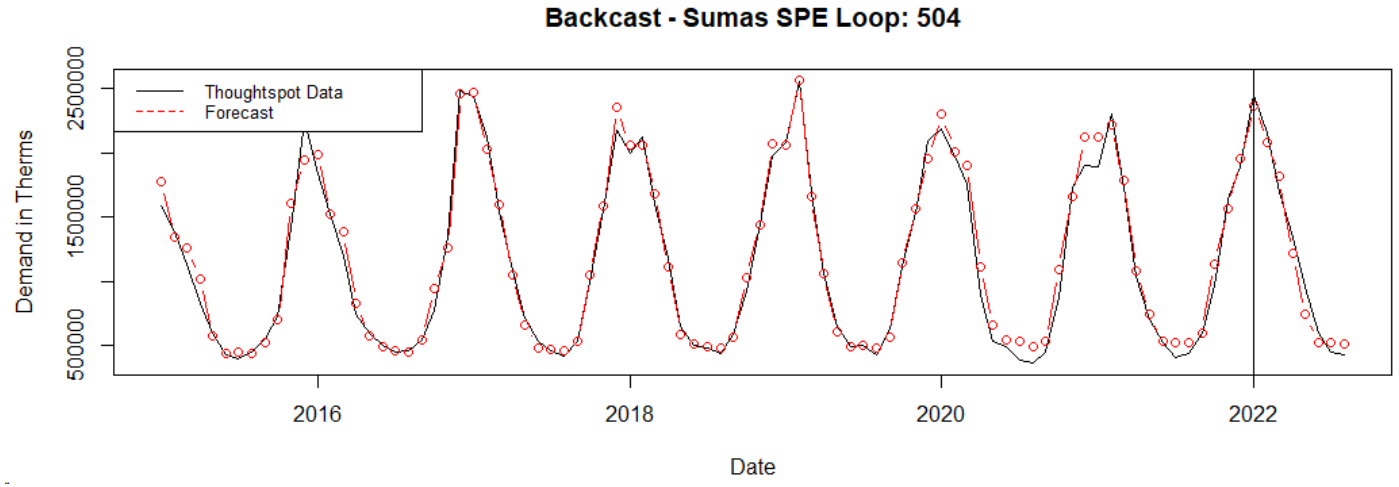

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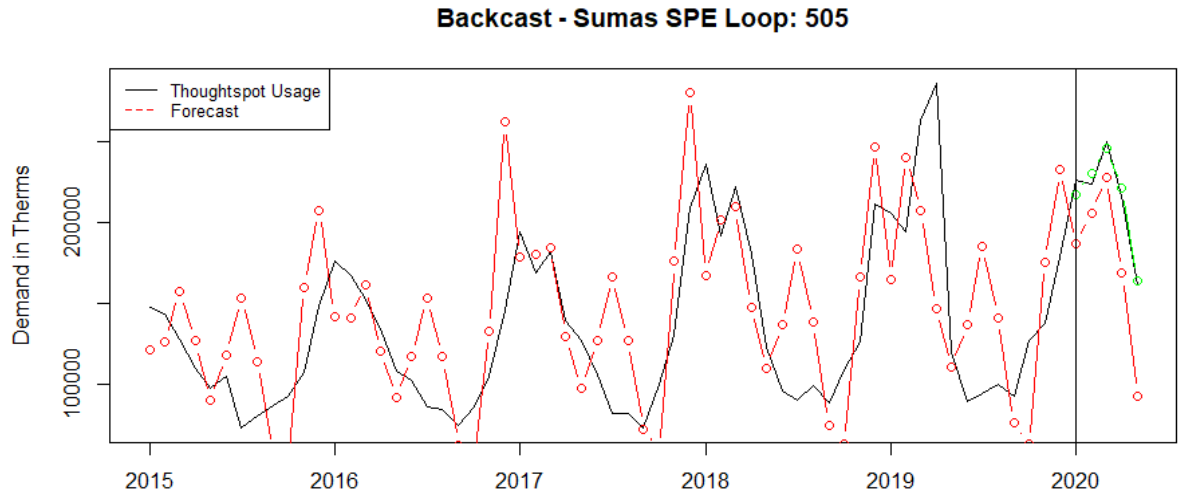
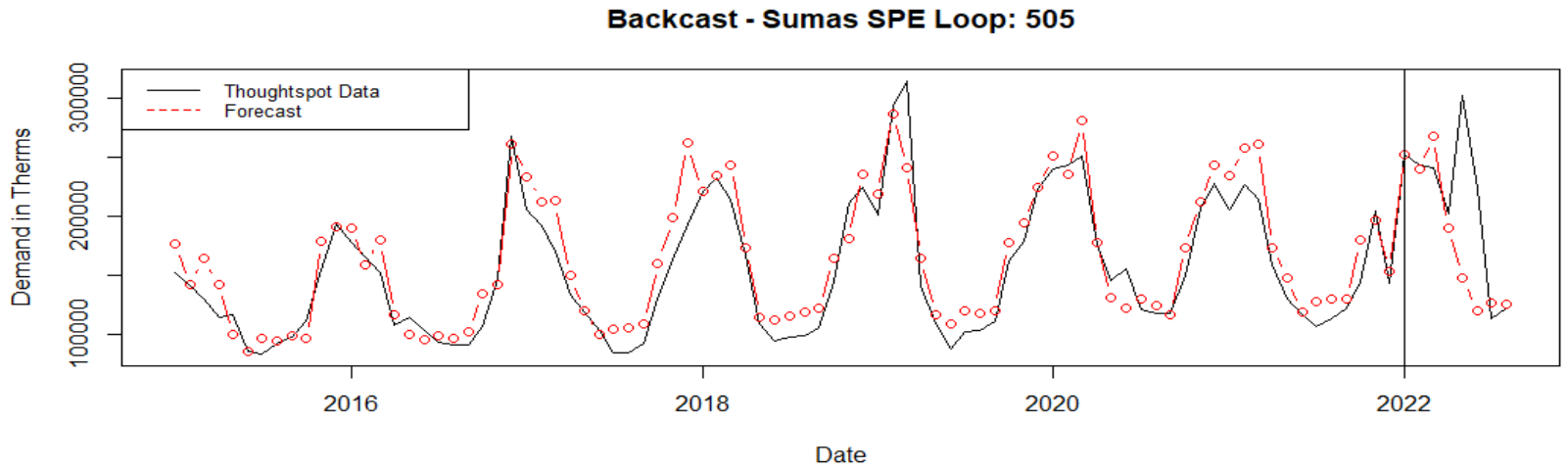
Sumas SPE Loop – 505 (Industrial)

Last cross-validation:



Current cross-validation:



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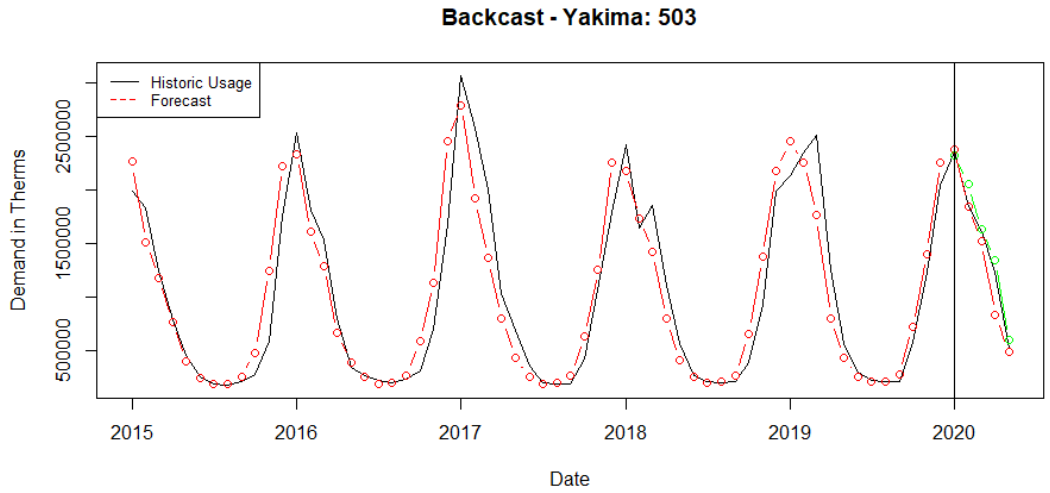
Yakima 503

Last cross-validation:



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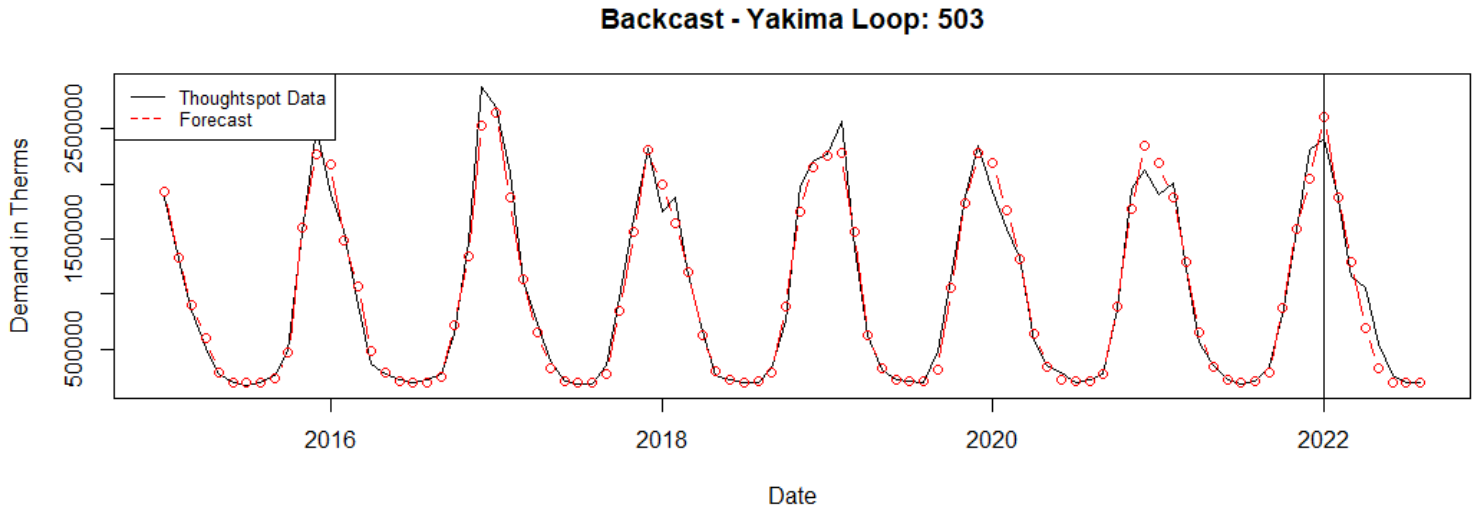

Yakima 504

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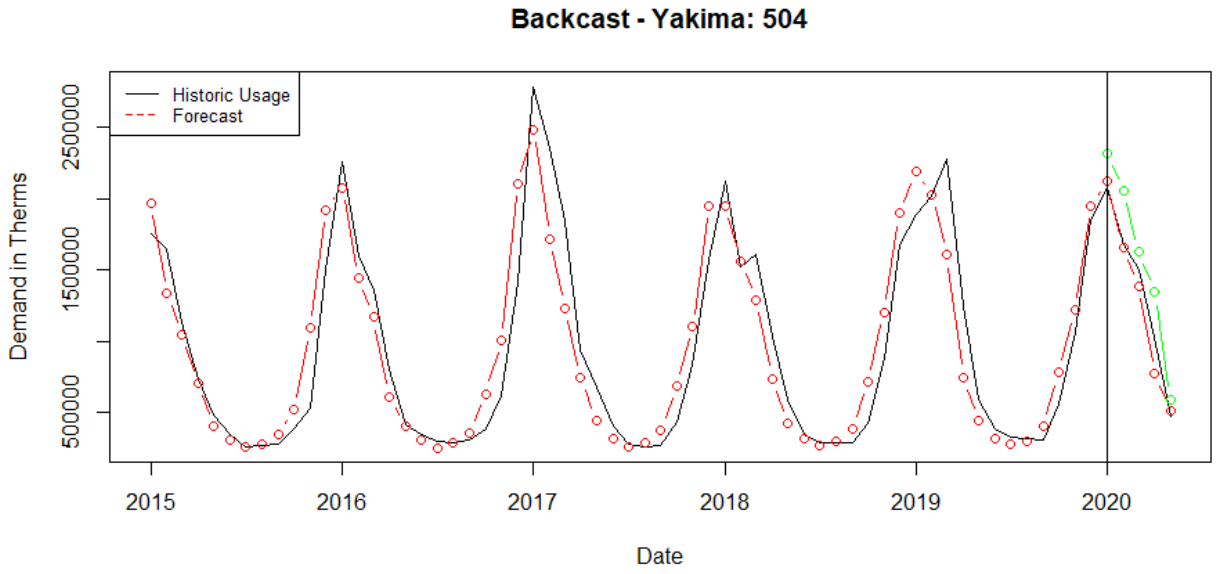

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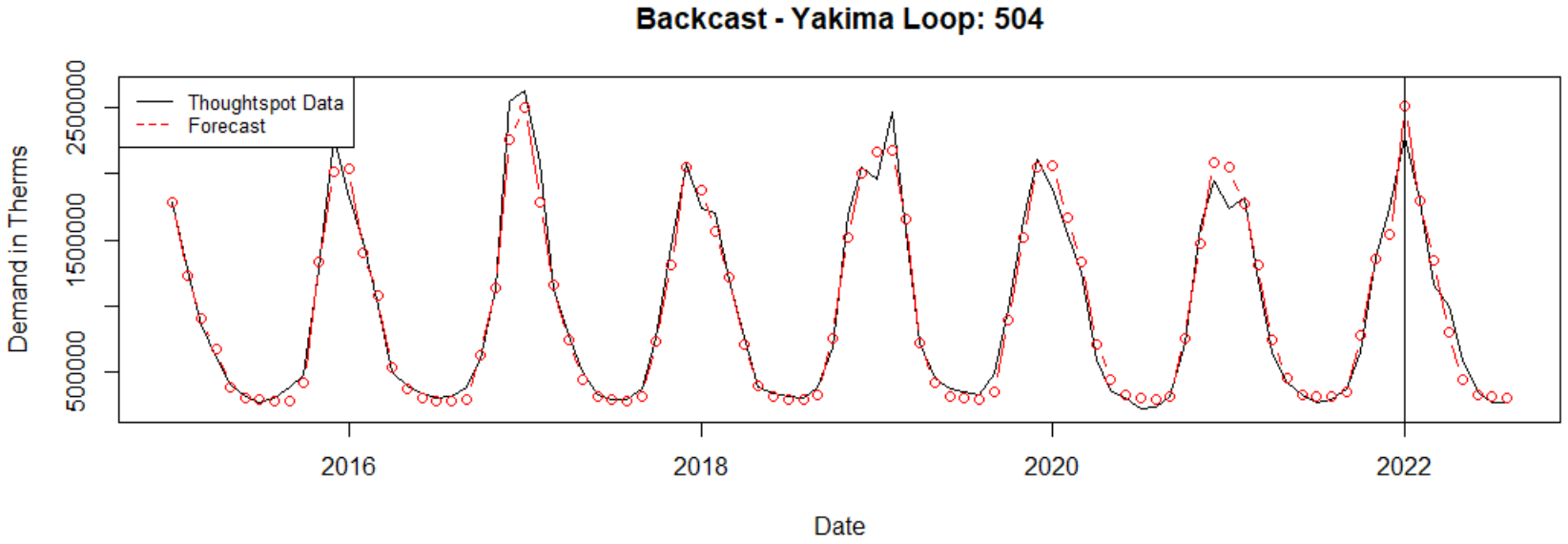
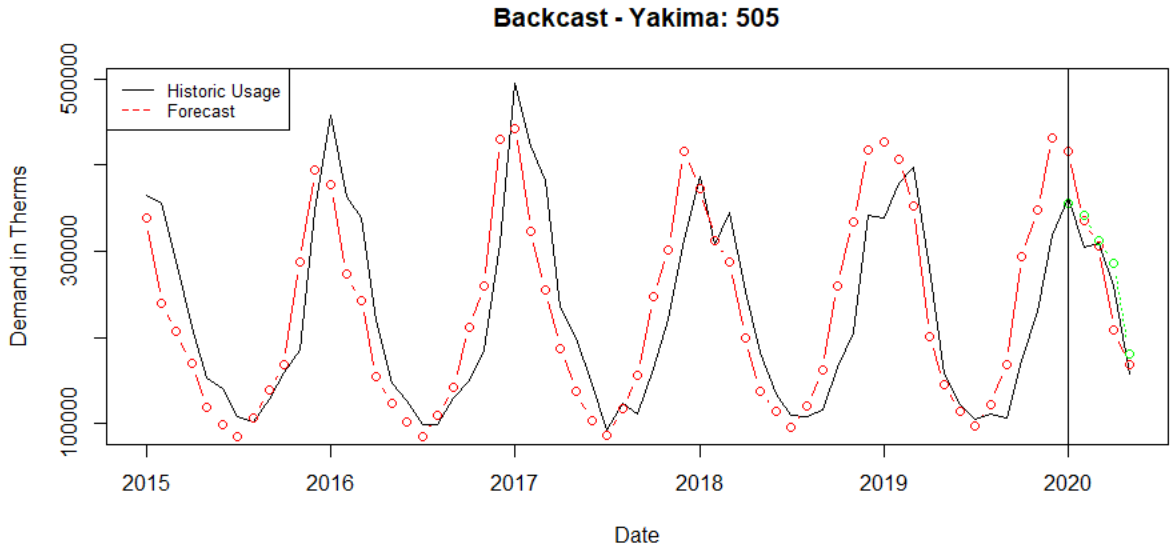


Yakima 505

Last cross-validation:



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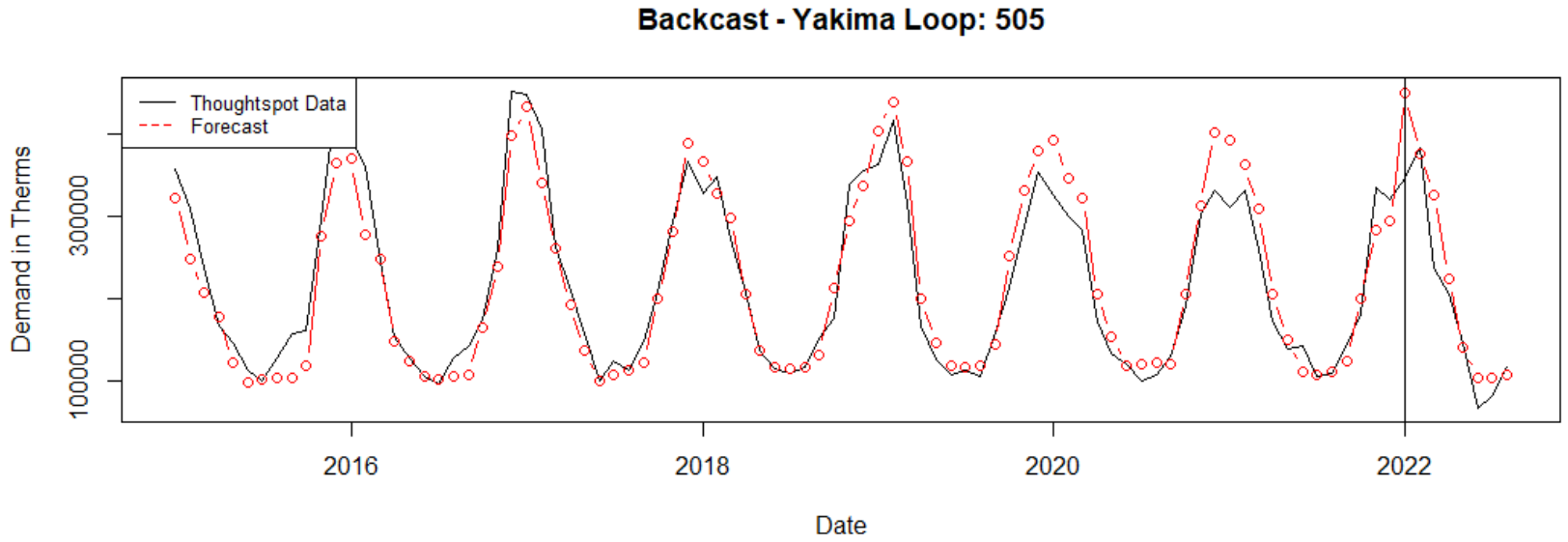
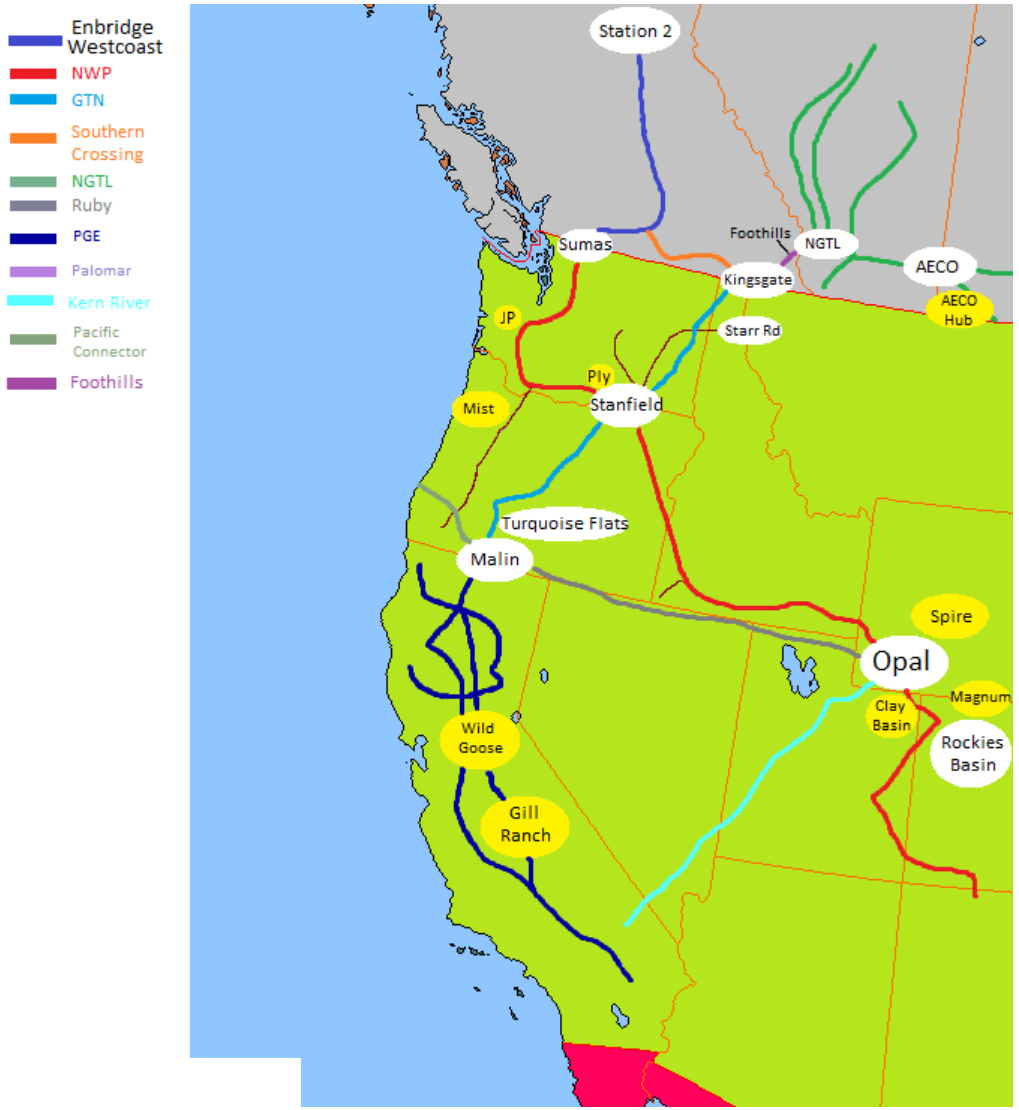


Next Steps:

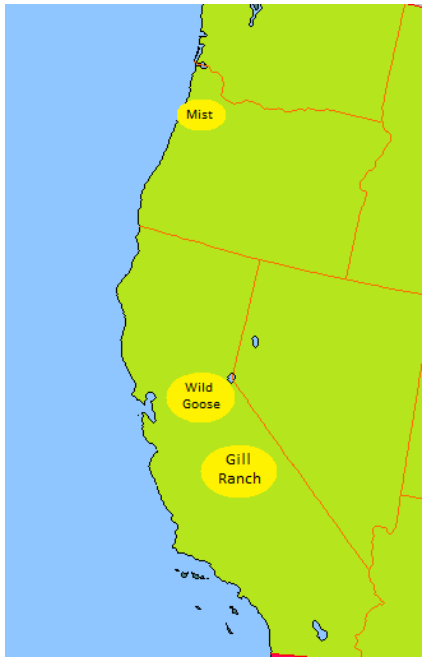
- Investigate industrial regressors to improve forecasts
- Build script for faster cross-validation

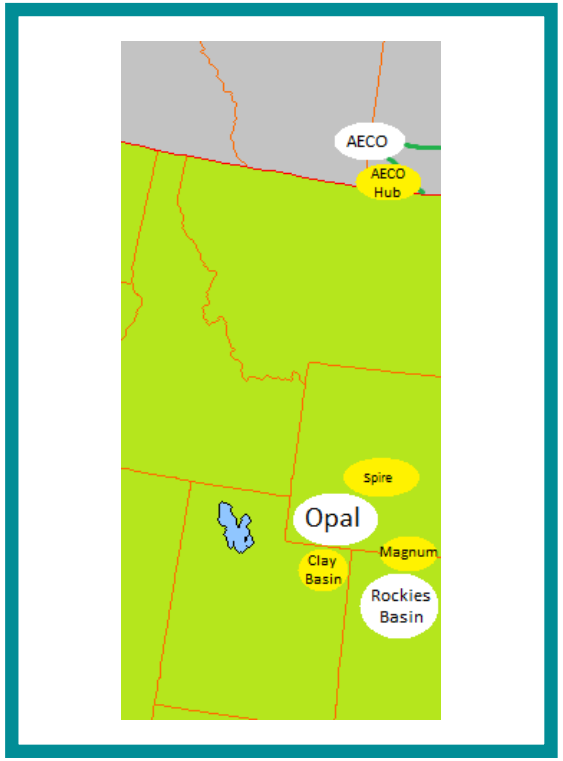
Summary of Alternative Resources



Incremental Transport

- Incremental Transport – Northwest Pipeline Bilateral
- Incremental Transport – North to South GTN
- Incremental Transport – South to North GTN
- Incremental Transport – T-South/Pacific Connector





Incremental Storage

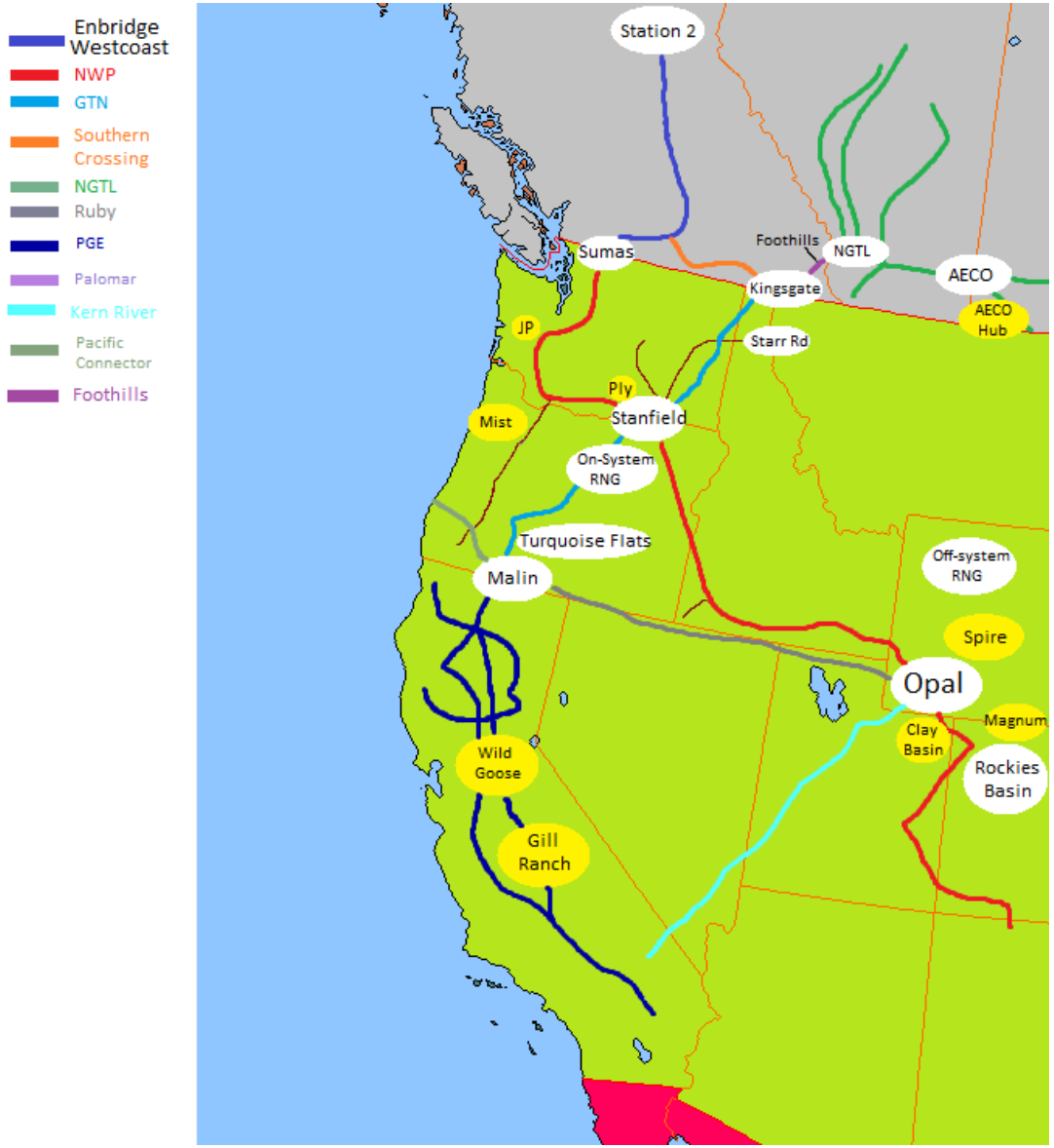
- Incremental Storage - North and East
- Incremental Storage - South and West

Incremental Supplies

Incremental Opal Supply – Additional supply around the Rockies Basin

Renewable Natural Gas – Incremental biogas supply directly to distribution system

Hydrogen – Incremental Hydrogen supply directly to distribution system



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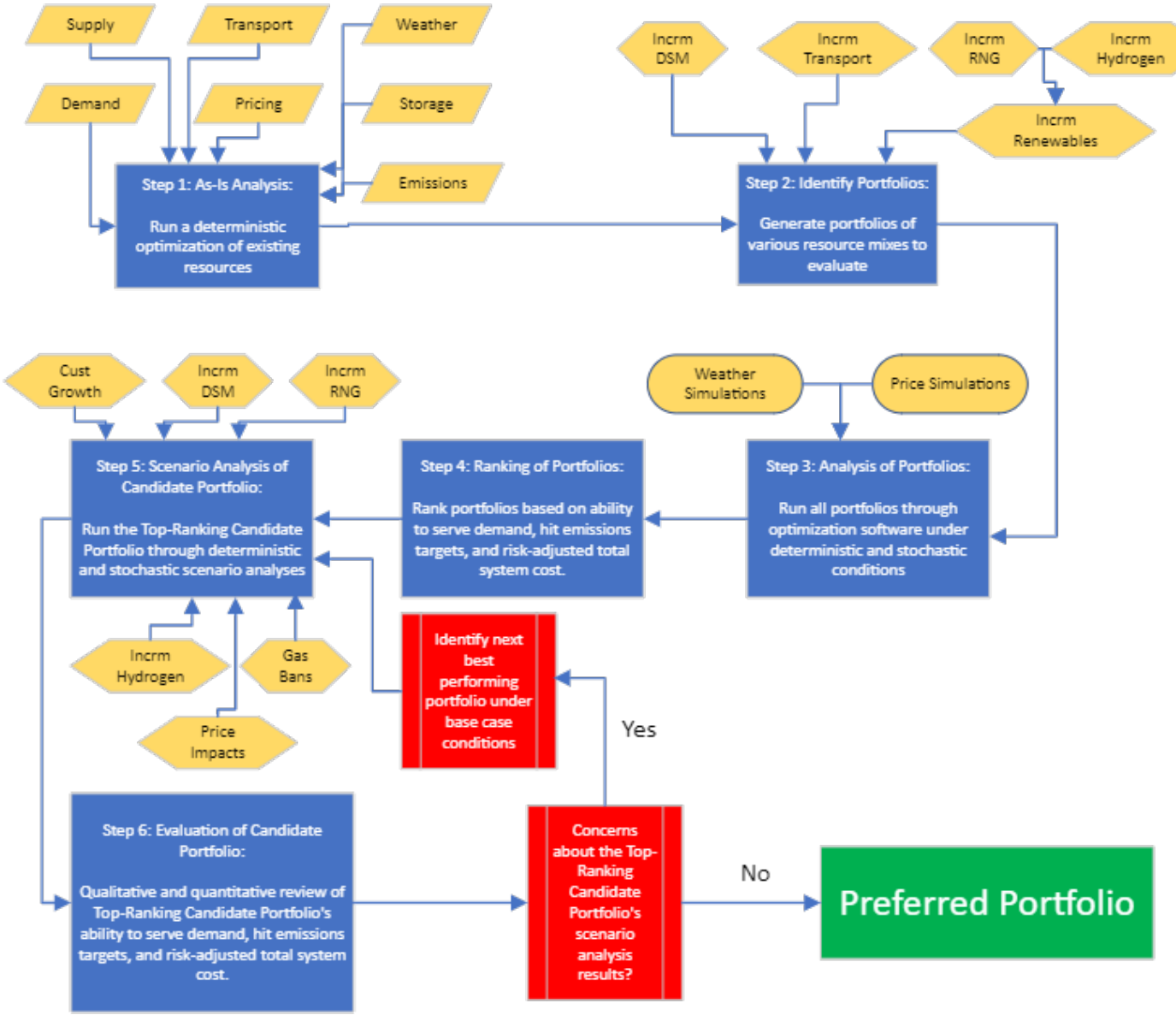
Components of Candidate Portfolios



Supply Resource Optimization Process Flow Chart

Supply Resource Optimization Process

Step 1: As-Is Analysis

- Run a deterministic optimization of existing resources to uncover timing and quantity of resource deficiencies.

Step 2: Identify Portfolios

- Cascade will be evaluating six different portfolios of incremental resources for the 2023 IRP. Each will be a mix of various incremental resources, including transportation capacity, RNG, Hydrogen, and DSM.

Step 3: Analysis of Portfolios

- Each portfolio will be run through the Plexos optimizer under expected conditions (see Base Case scenario.) The portfolios will be evaluated under deterministic and stochastic weather/pricing, and the timing/quantity if applicable of unserved demand and emissions reductions shortfalls will be recorded. Cascade will also record the risk-adjusted total system cost of each portfolio.

Supply Resource Optimization Process Cont.

Step 4: Ranking of Portfolios

- The Top Ranking Candidate Portfolio will be the portfolio that is able to serve all forecasted demand over the planning horizon while hitting all emissions reductions goals. In the case of multiple portfolios accomplishing this, the portfolio that does it with the lowest risk-adjusted total system cost will be the Top-Ranking Candidate Portfolio.

Step 5: Scenario Analysis of Candidate Portfolio

- The Top Ranking Candidate Portfolio is re-run through the Plexos optimizer under five scenarios. These scenarios will provide sensitivity testing of customer growth, energy efficiency, RNG, hydrogen, Natural Gas bans, and Natural Gas pricing. The portfolio will be evaluated under deterministic and stochastic weather/pricing, and the timing/quantity if applicable of unserved demand and emissions reductions shortfalls will be recorded. Cascade will also record the risk-adjusted total system cost of each portfolio.

Step 6: Evaluation of Candidate Portfolio

- Cascade performs a qualitative and quantitative review of Top-Ranking Candidate Portfolio's ability to serve demand, hit emissions targets, and the risk-adjusted total system cost of the portfolio under the scenarios evaluated. If there are concerns about the portfolio’s ability to hit these metrics, or the cost of hitting these metrics, the Company may loop back to Step 5 with a new portfolio that might be more insulated against identified risks. Otherwise, the portfolio is named Cascade’s Preferred Portfolio.

Recap – As-Is Analysis

Cascade has finalized its load forecast for the 2023 OR IRP.

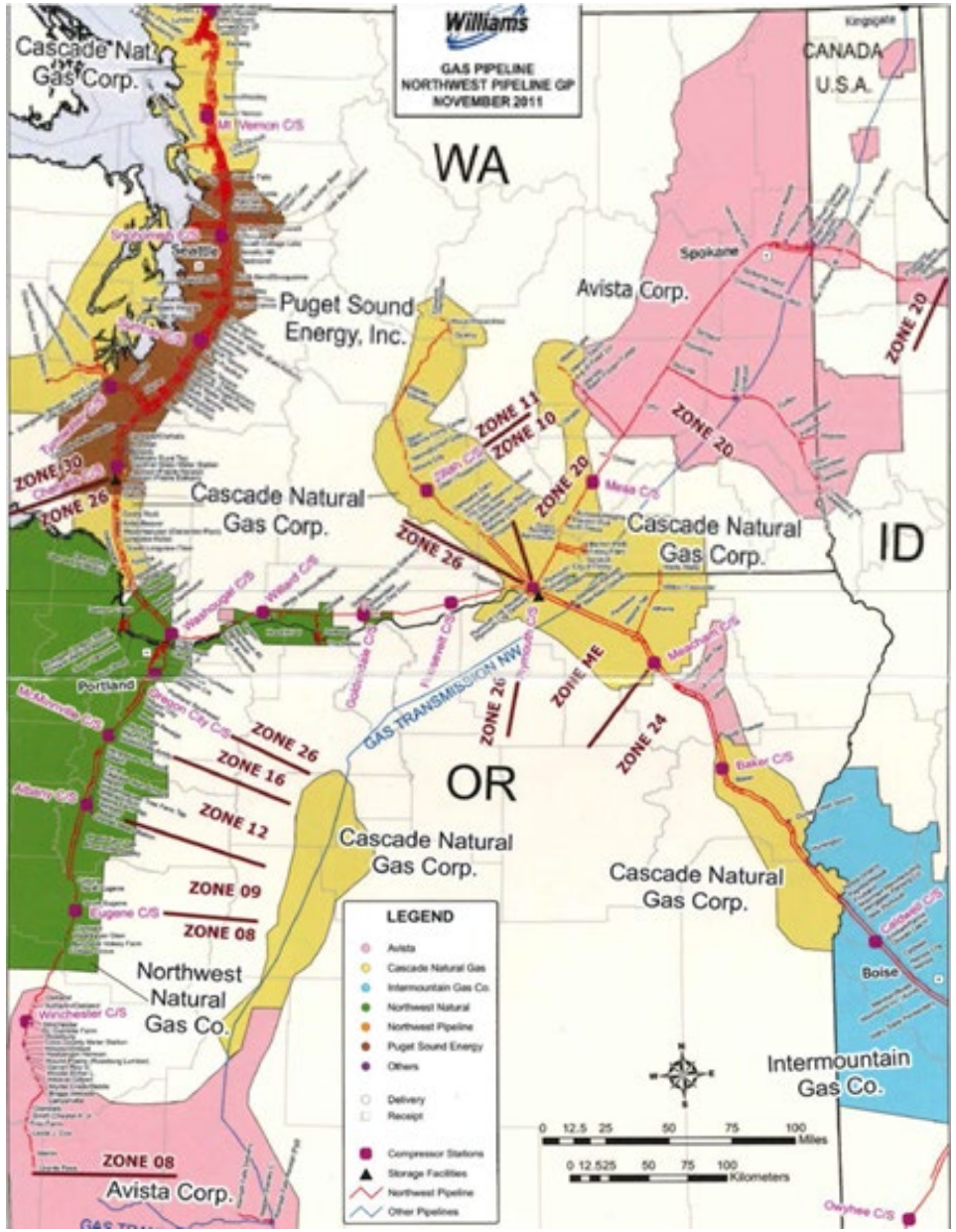
All of Cascade's existing resources have been run through PLEXOS® to complete the Company's As-Is analysis as discussed in Step 1 of the Supply Resource Optimization Process.

- Assuming contracts evergreen.
- Assuming emissions reduction requirements as outlined in the CPP and CCA, but no usage of compliance instruments.
- These preliminary results do not include the impacts of incremental DSM beyond existing installed measures.

Recap – As-Is Shortfalls

Transport (Dth)		
	First Year Shortfall	Max Shortfall
Zone 11	2034	7,570
Zone ME-WA and GTN	2038	20,390

Emissions (Dth)		
	First Year Shortfall	Max Shortfall
Washington	2024	40,047,090
Oregon	2023	17,114,540



List of Candidate Portfolios

All-In Portfolio

All-In Portfolio Less DSM

Transportation Only Portfolio

Offsets Only Portfolio

RNG Only Portfolio

Hydrogen Only Portfolio

RNG and Hydrogen (Renewables) Only Portfolio

All-In Portfolio

Best deterministic mix of all alternative resources considered:

- Incremental Transport Resources
- Incremental Storage Resources
- Cost Effective DSM from CPA
- Incremental RNG
- Incremental Hydrogen
- Compliance Instruments

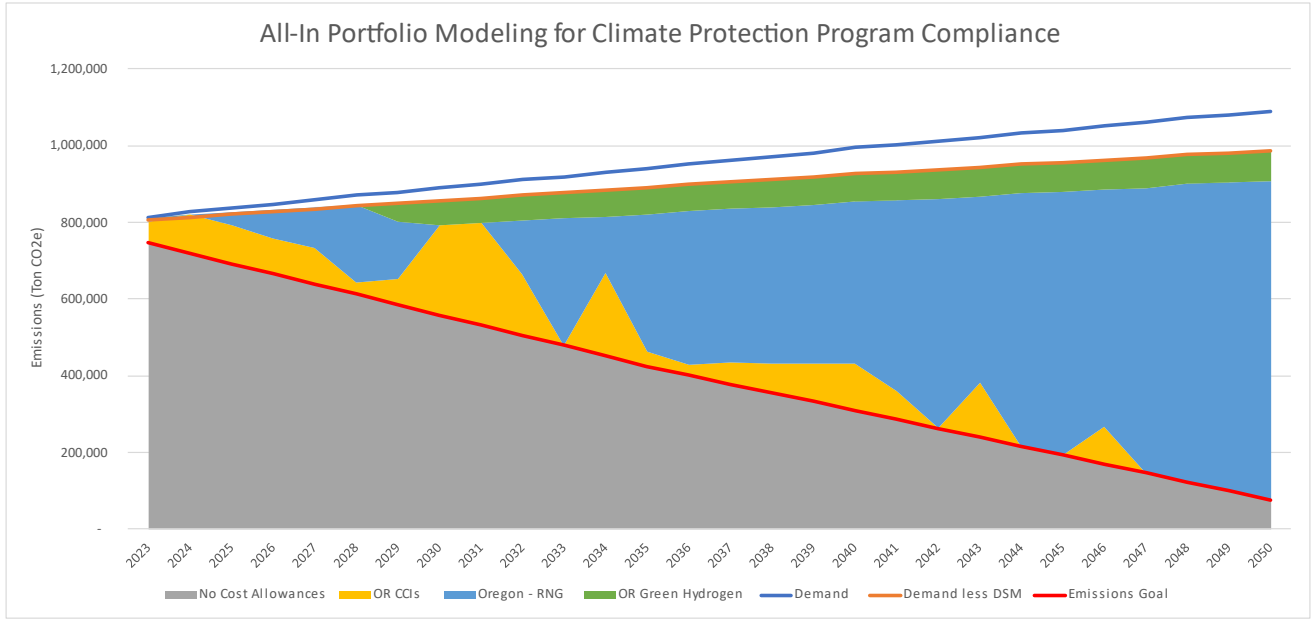
All-In Portfolio – PLEXOS® Suggested Resource Mix

All Cost-Effective DSM

Incremental RNG – Utilized mostly in Oregon, 154,210 Dth starting in 2023, up to 15,635,780 Dth by 2050

Incremental Hydrogen – 90,970 Dth starting in 2029, up to 524,700 Dth by 2050

Compliance Instruments – Utilized as needed, exact number discussed under confidential treatment in IRP



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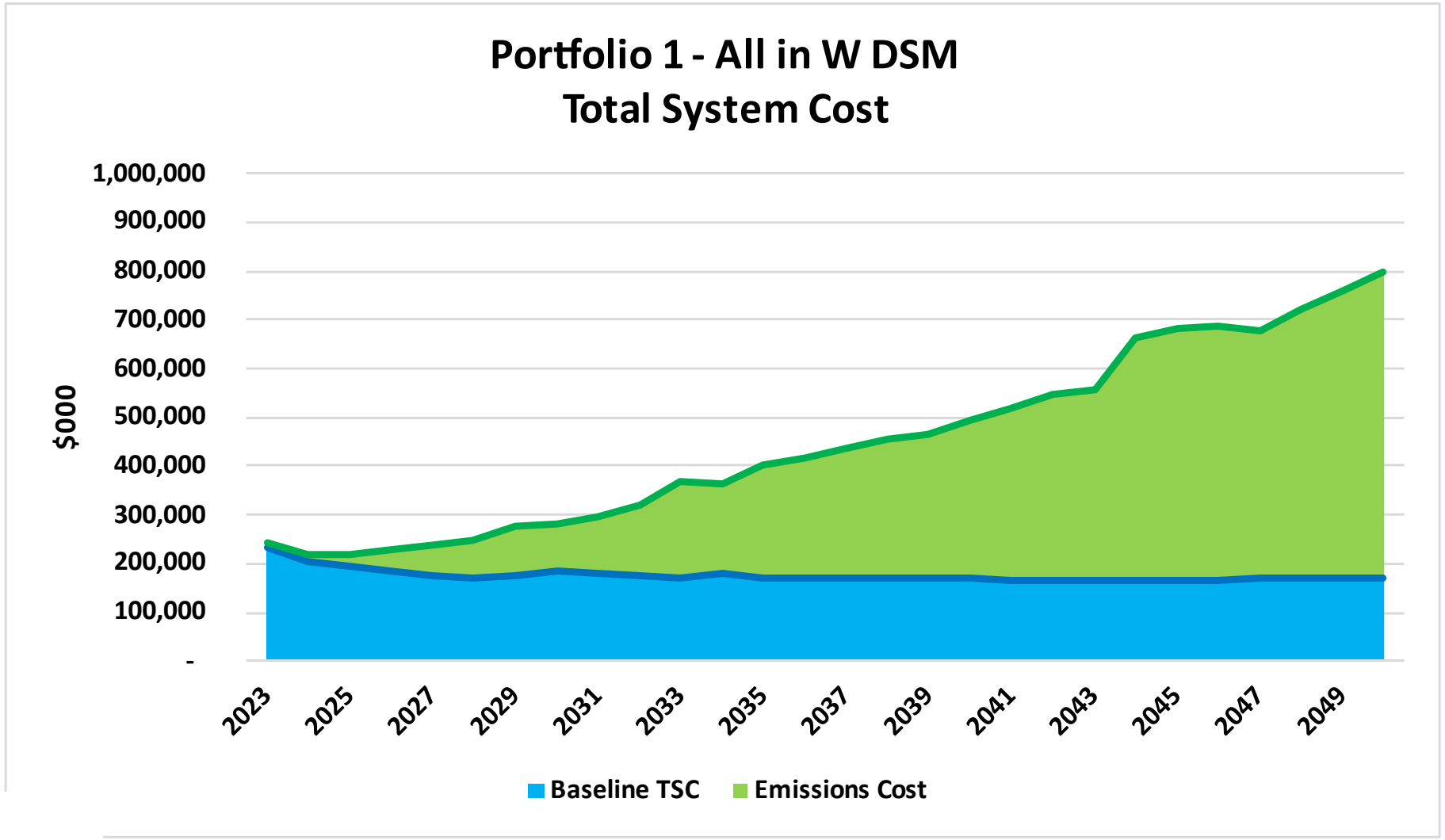

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All-In Less DSM Portfolio

Best deterministic mix of all alternative resources considered:

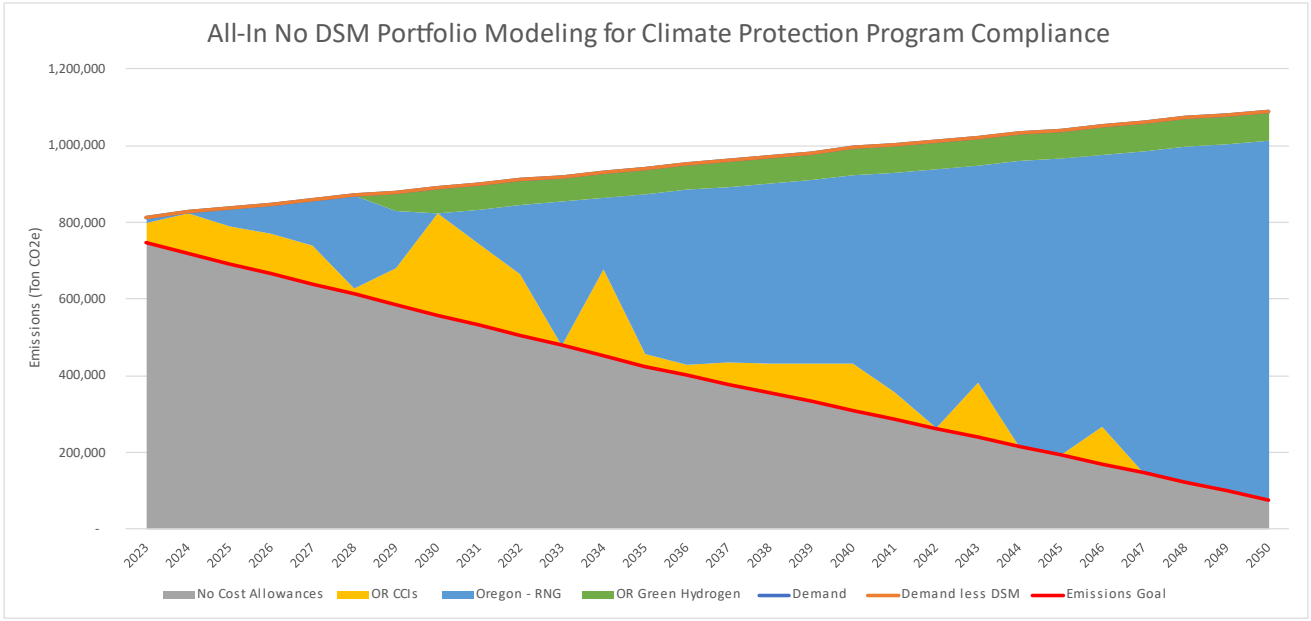
- Incremental Transport Resources
- Incremental Storage Resources
- Incremental RNG
- Incremental Hydrogen
- Compliance Instruments

All-In Less DSM Portfolio – PLEXOS® Suggested Resource Mix

Incremental RNG – Utilized mostly in Oregon, 298,180 Dth starting in 2023, up to 17,591,130 Dth by 2050

Incremental Hydrogen – 90,970 Dth starting in 2029, up to 524,700 Dth by 2050

Compliance Instruments – Utilized as needed, exact number discussed under confidential treatment in IRP



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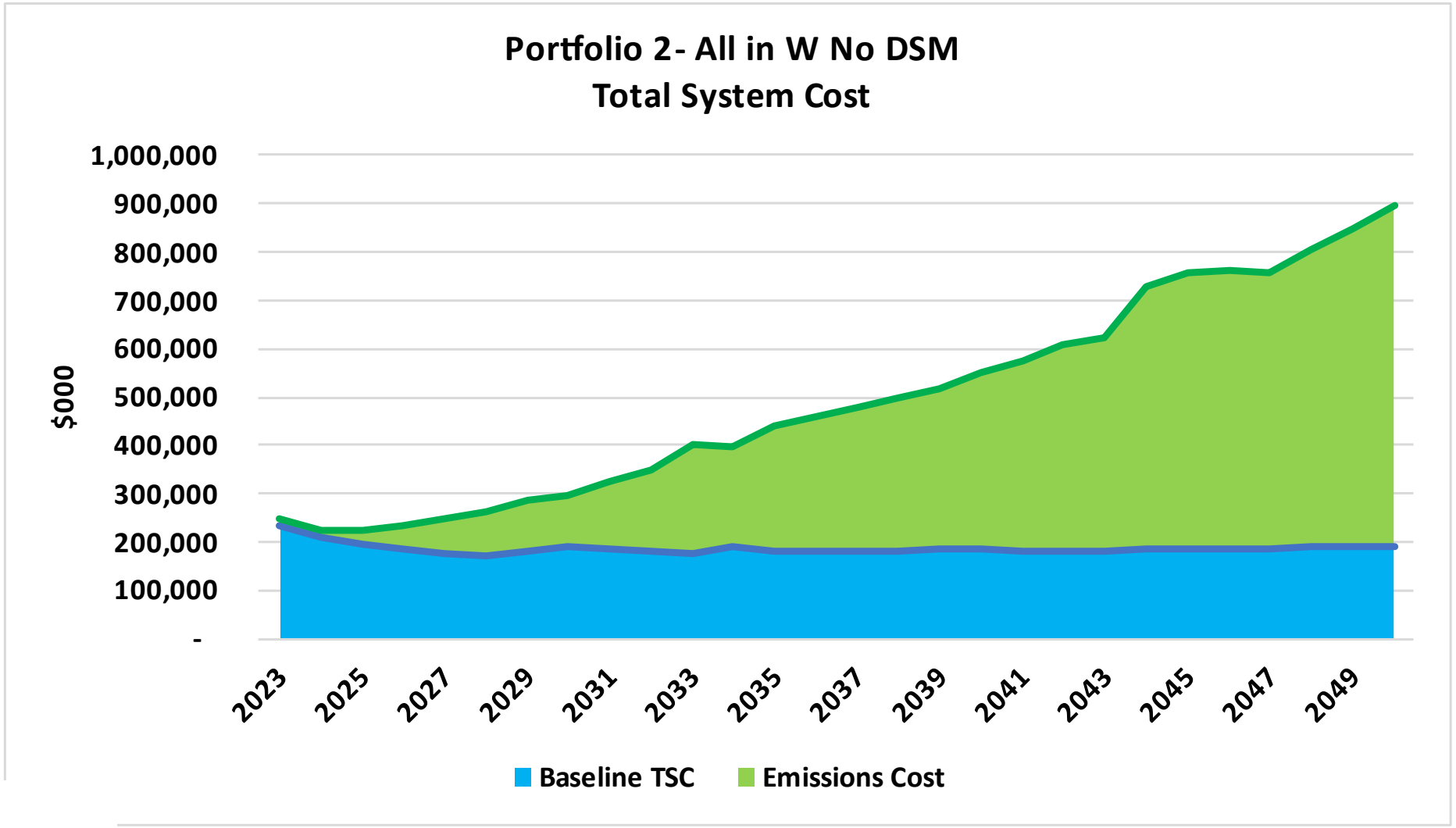
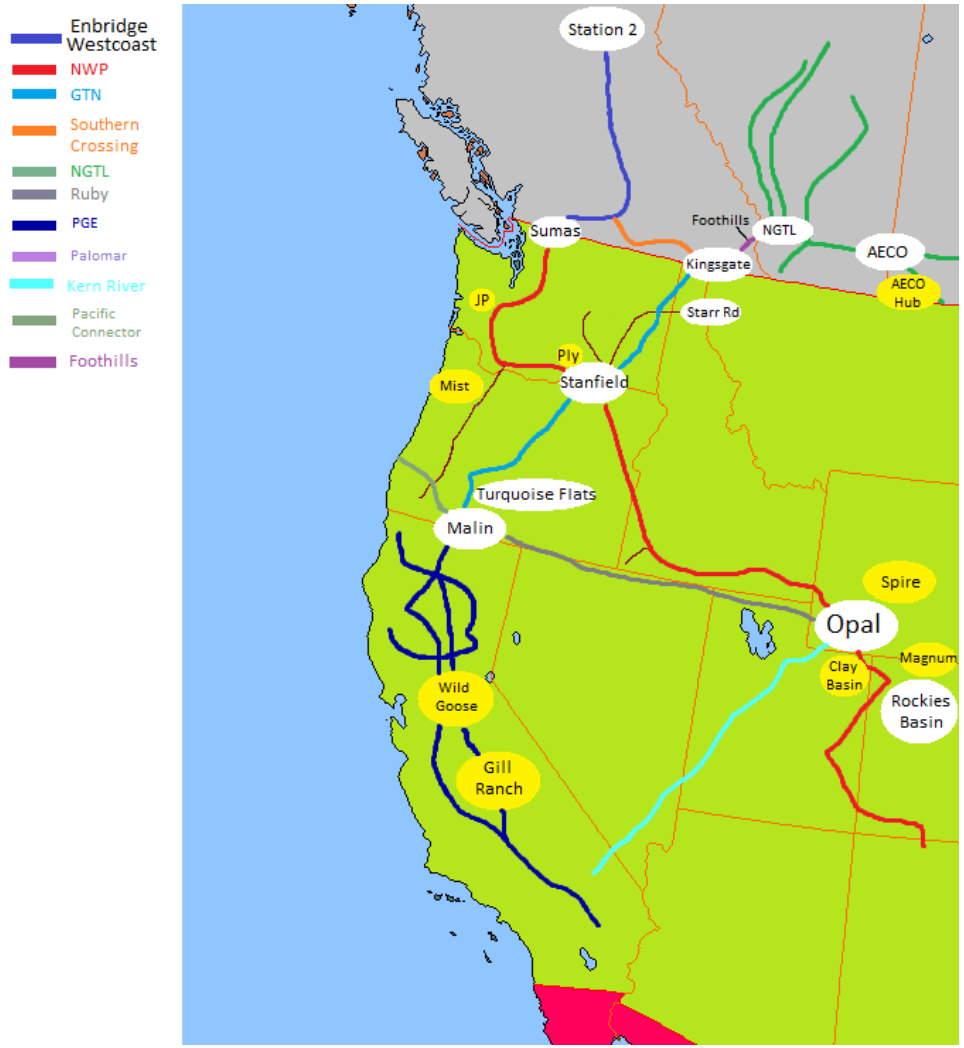

Portfolio 2- All in W No DSM
Total System Cost
$000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
2049
Baseline TSC
Emissions Cost

Incremental Transportation Only Portfolio

Cost Effective DSM from CPA

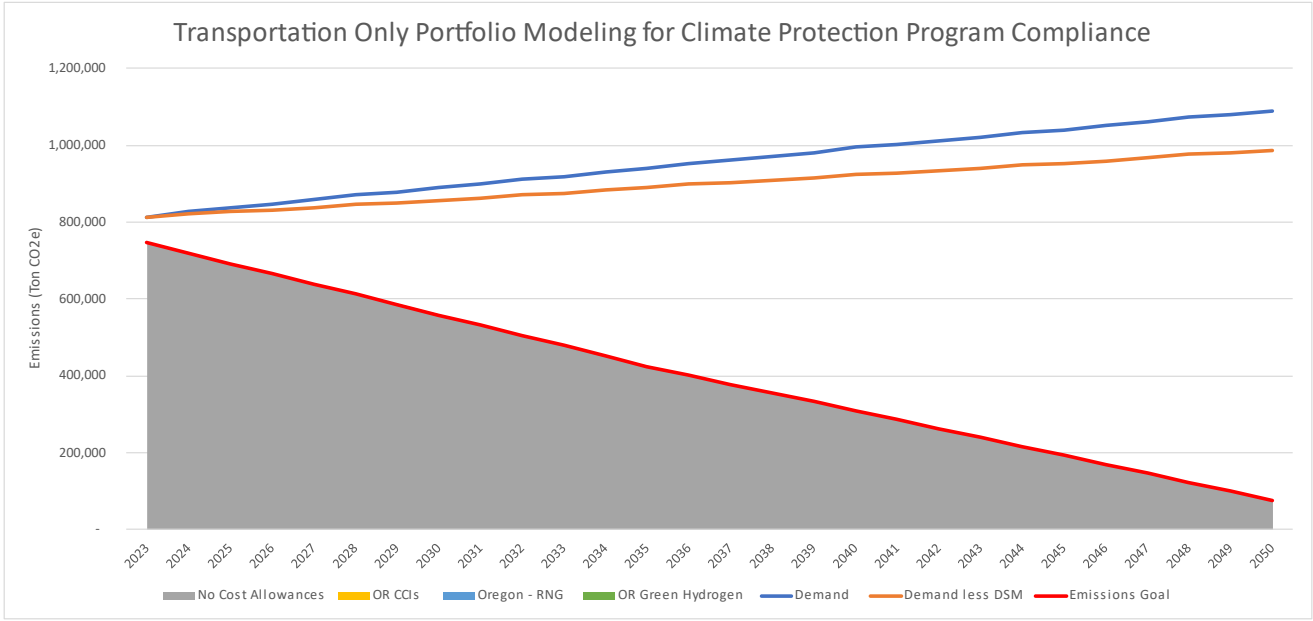
Best deterministic mix of all Transportation Resources:

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



Incremental Transportation Only Portfolio – PLEXOS® Suggested Resource Mix

All Cost-Effective DSM



*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls

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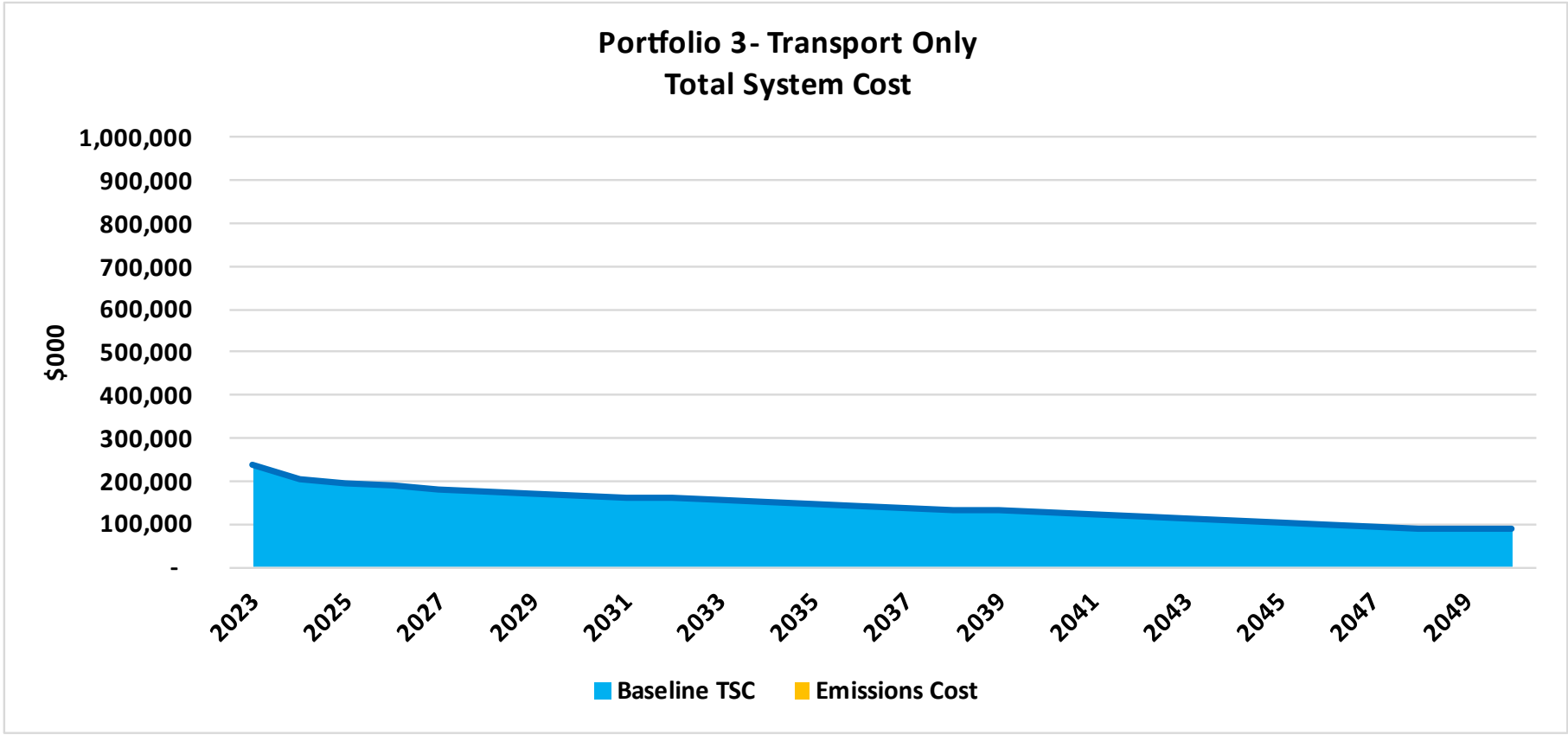
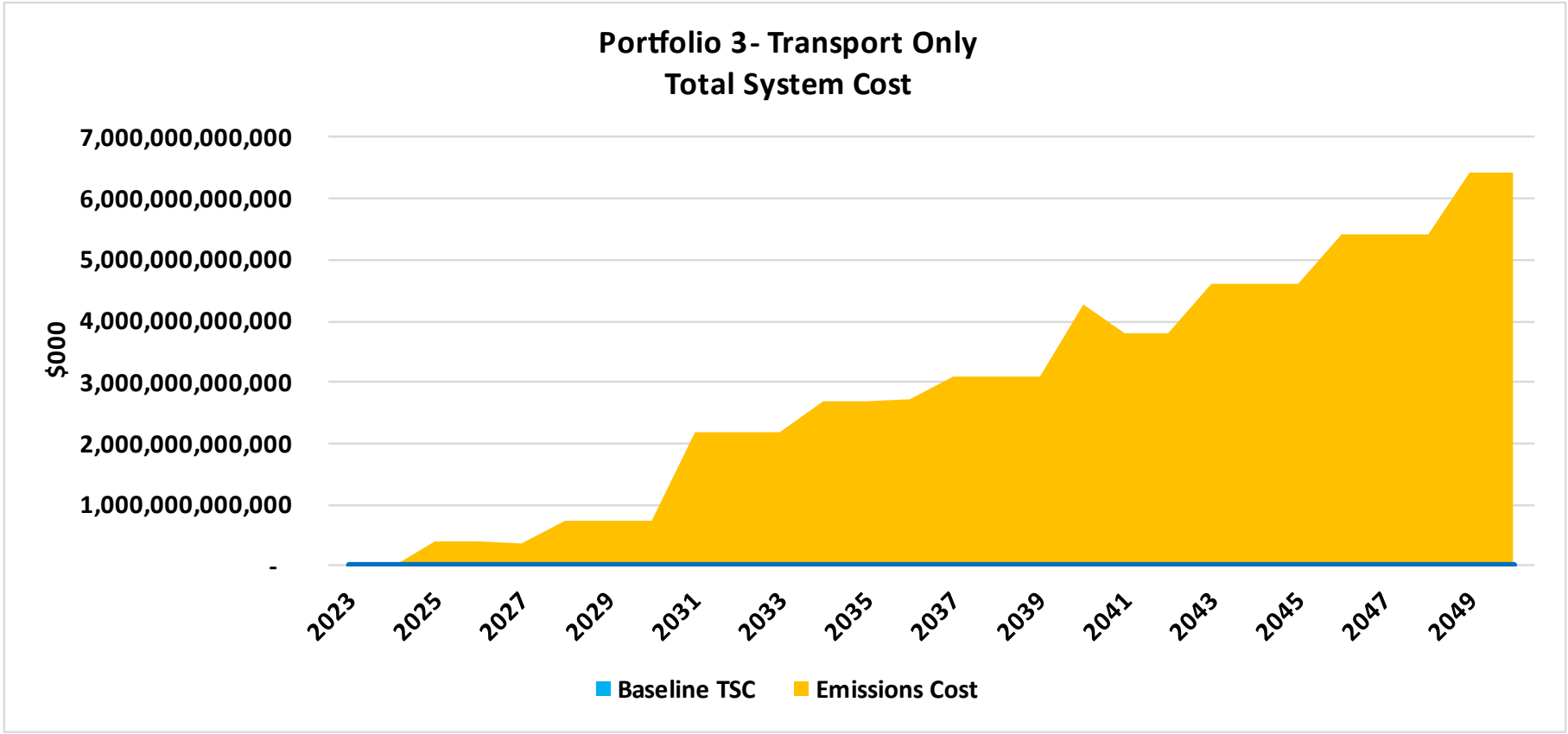


*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls


Portfolio 3- Transport Only
Total System Cost
$000
7,000,000,000,000
6,000,000,000,000
5,000,000,000,000
4,000,000,000,000
3,000,000,000,000
2,000,000,000,000
1,000,000,000,000
-
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
2049
Baseline TSC
Emissions Cost

Offsets Only Portfolio

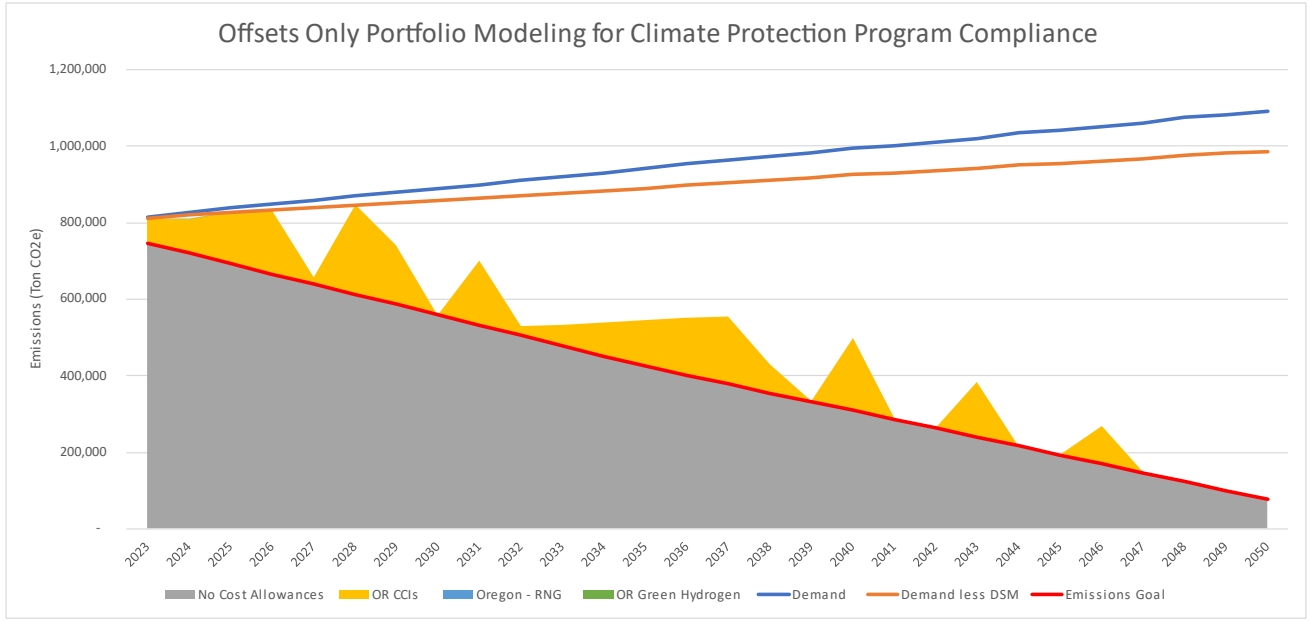
Cost Effective Demand Side Management from Conservation Potential Assessment

Best deterministic mix of Community Climate Investments (CCI) in Oregon, and Auction Allowances and Offsets in Washington

Offsets Only Portfolio – PLEXOS® Suggested Resource Mix

All Cost-Effective DSM

Compliance Instruments – Maximum possible utilization with no other emissions reduction resource



*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls in Oregon

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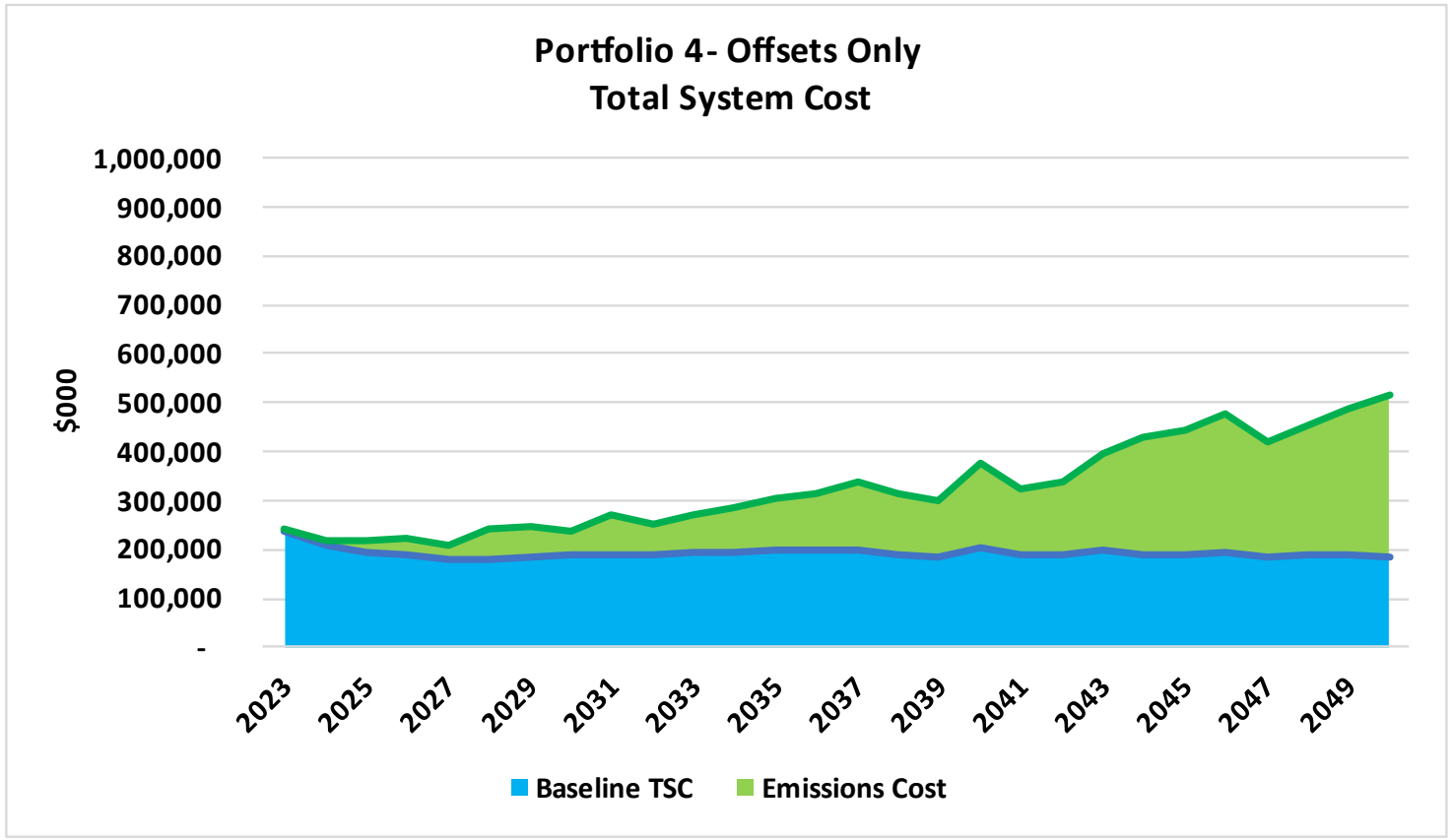


*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls

RNG Only Portfolio

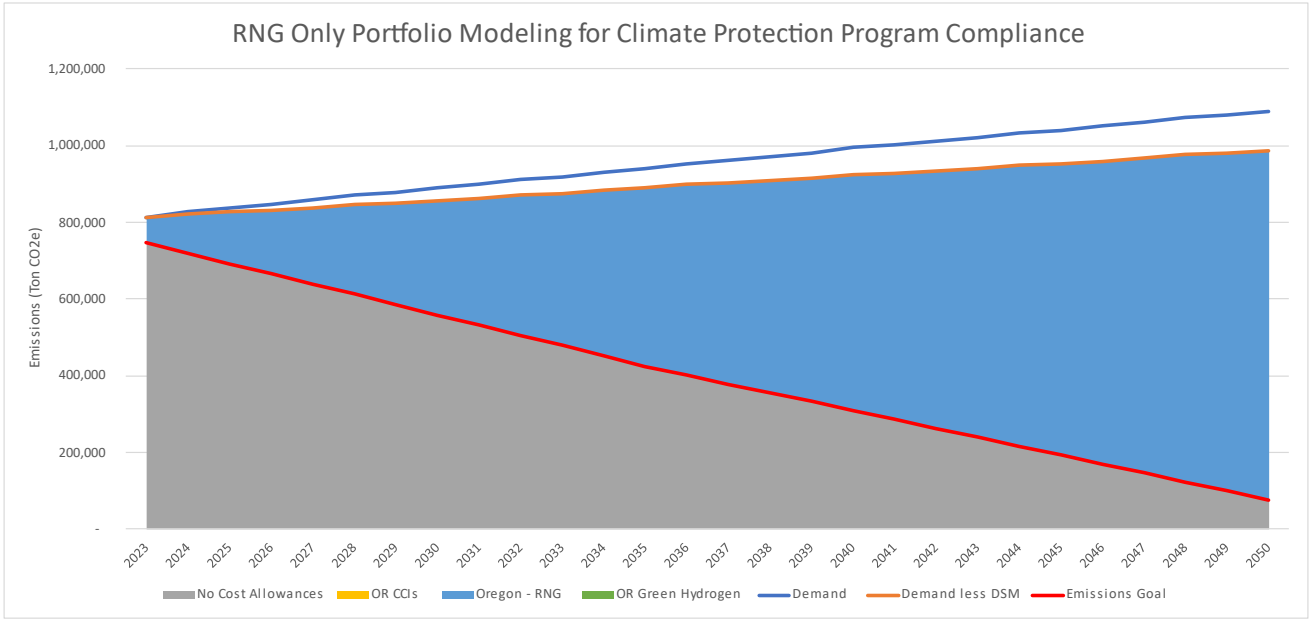
Cost Effective DSM from CPA

Incremental RNG

RNG Only Portfolio – PLEXOS® Suggested Resource Mix

All Cost-Effective DSM

Incremental RNG – Utilized mostly in Oregon, 1,218,140 Dth starting in 2023, up to 17,264,820 Dth by 2050



*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls in Washington

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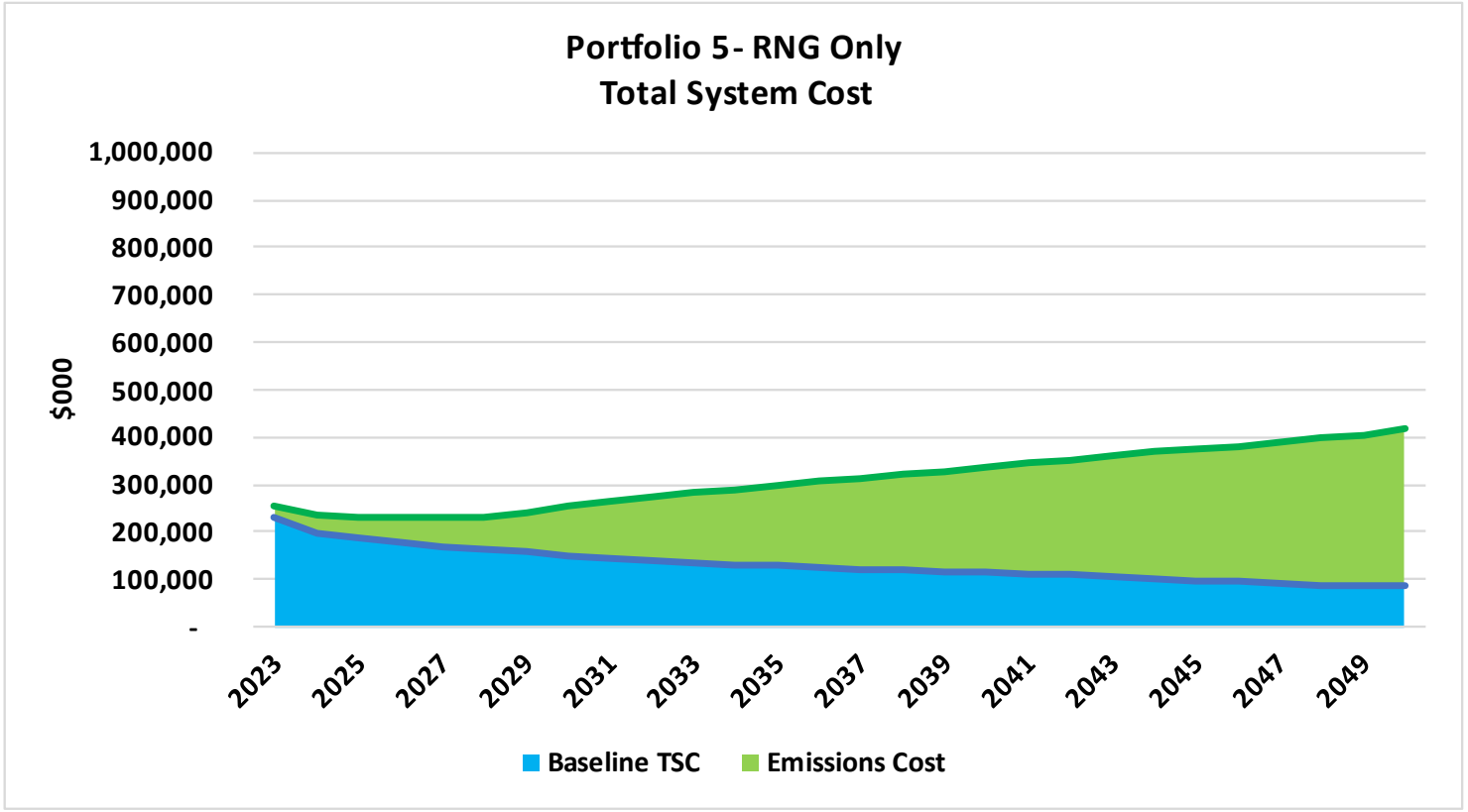


*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls

Hydrogen Only Portfolio

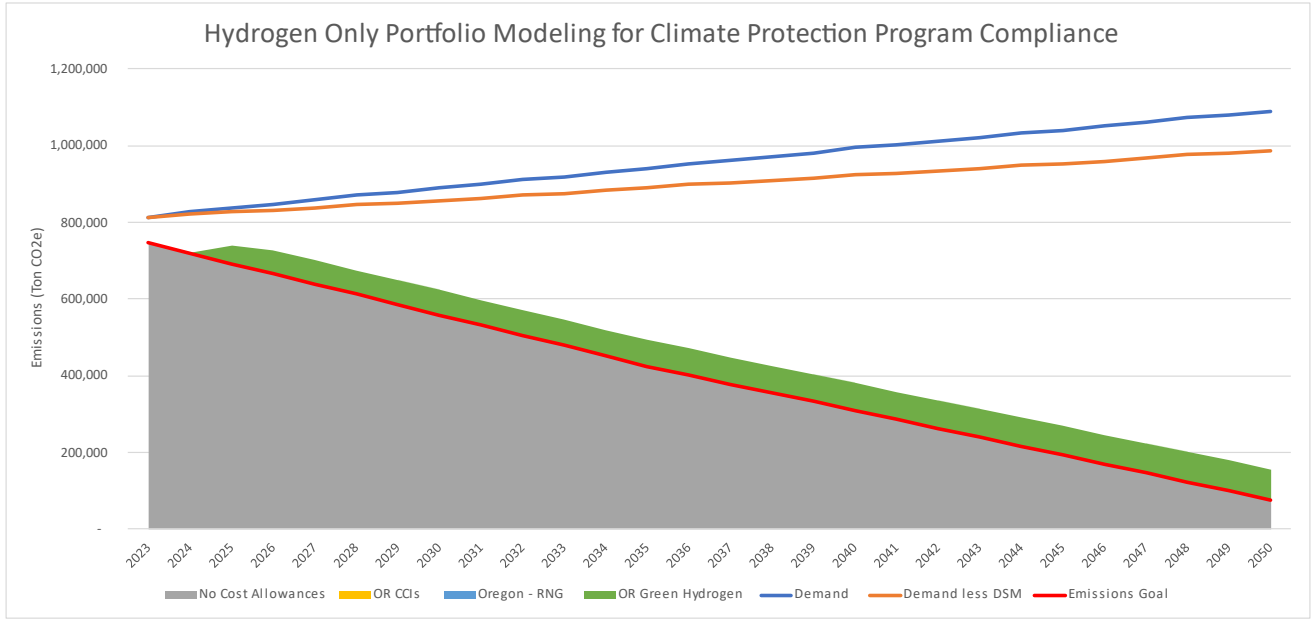
Cost Effective DSM from CPA

Incremental Hydrogen

Hydrogen Only Portfolio – PLEXOS® Suggested Resource Mix

All Cost-Effective DSM

Incremental Hydrogen – 3,029,770 Dth starting in 2023, up to 5,260,150 Dth by 2050



*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls

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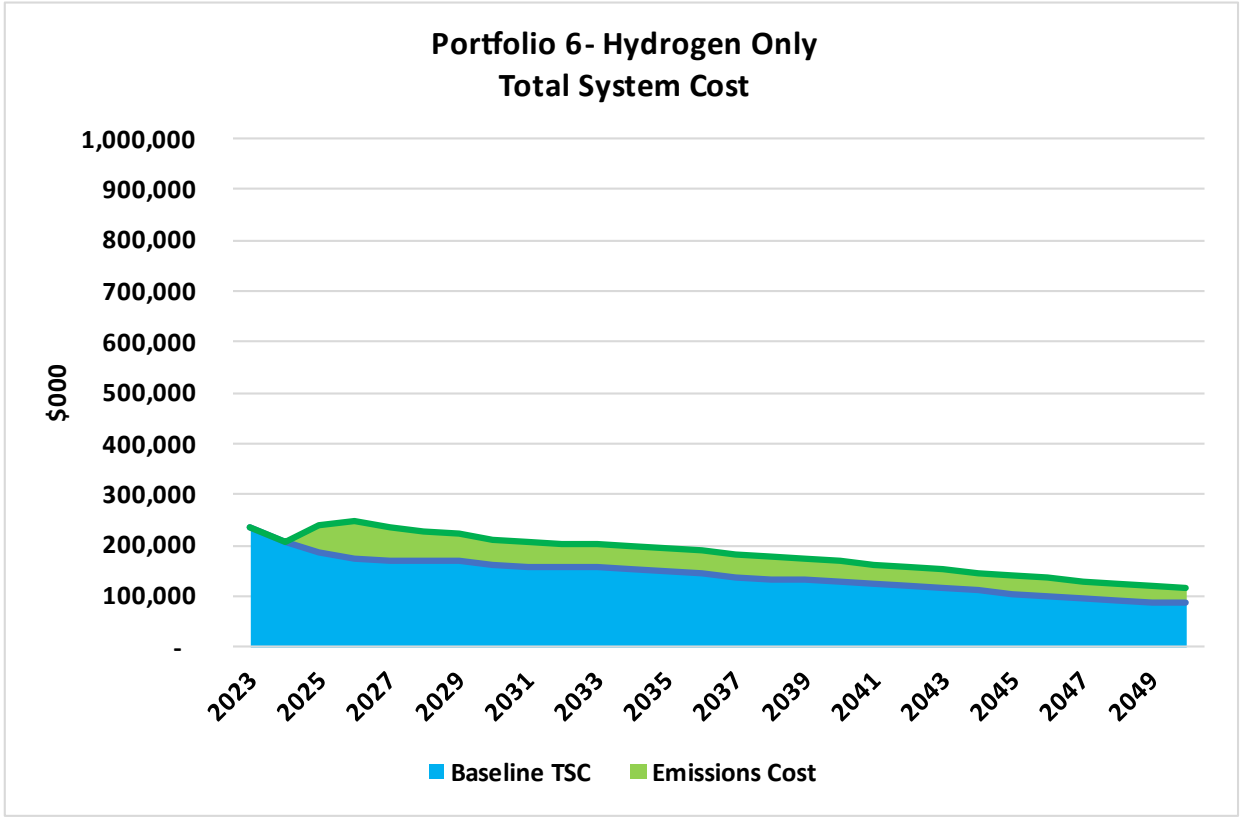


*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls

Renewables Only Portfolio

Cost Effective DSM from CPA

Incremental RNG

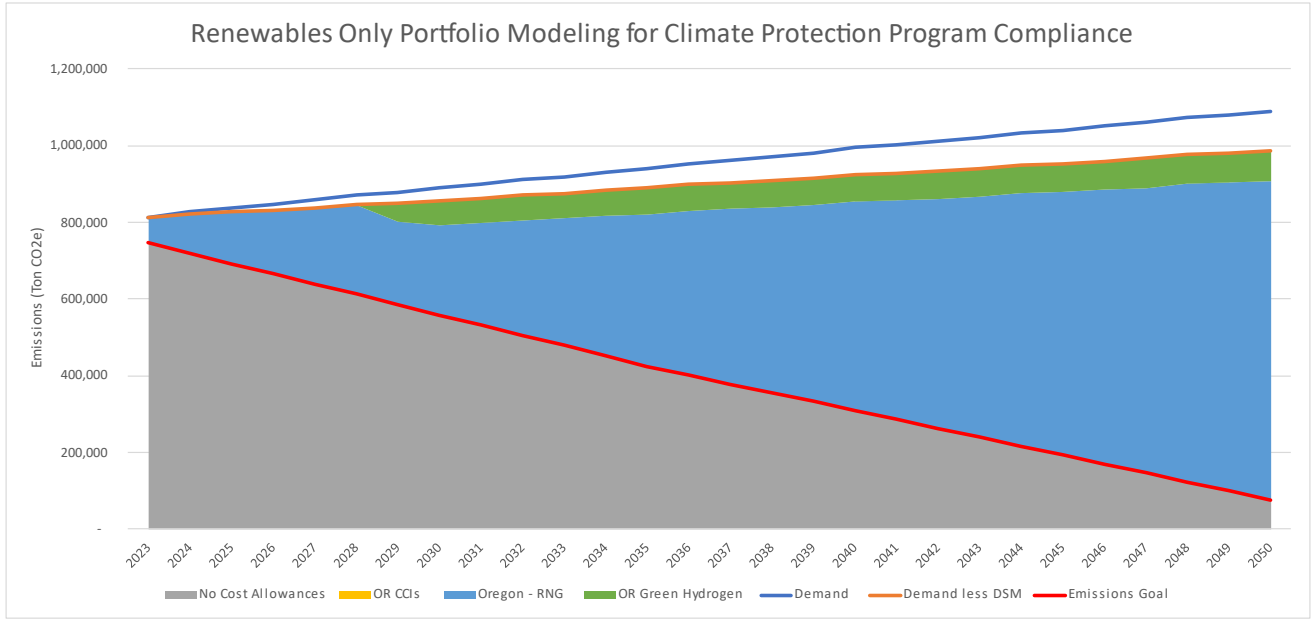
Incremental Hydrogen

Renewables Only Portfolio – PLEXOS® Suggested Resource Mix

All Cost-Effective DSM

Incremental RNG – Utilized mostly in Oregon, 1,218,400 Dth starting in 2023, up to 15,768,420 Dth by 2050

Incremental Hydrogen – 2,167,550 Dth starting in 2023, up to 5,427,200 Dth by 2050



*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls in Washington

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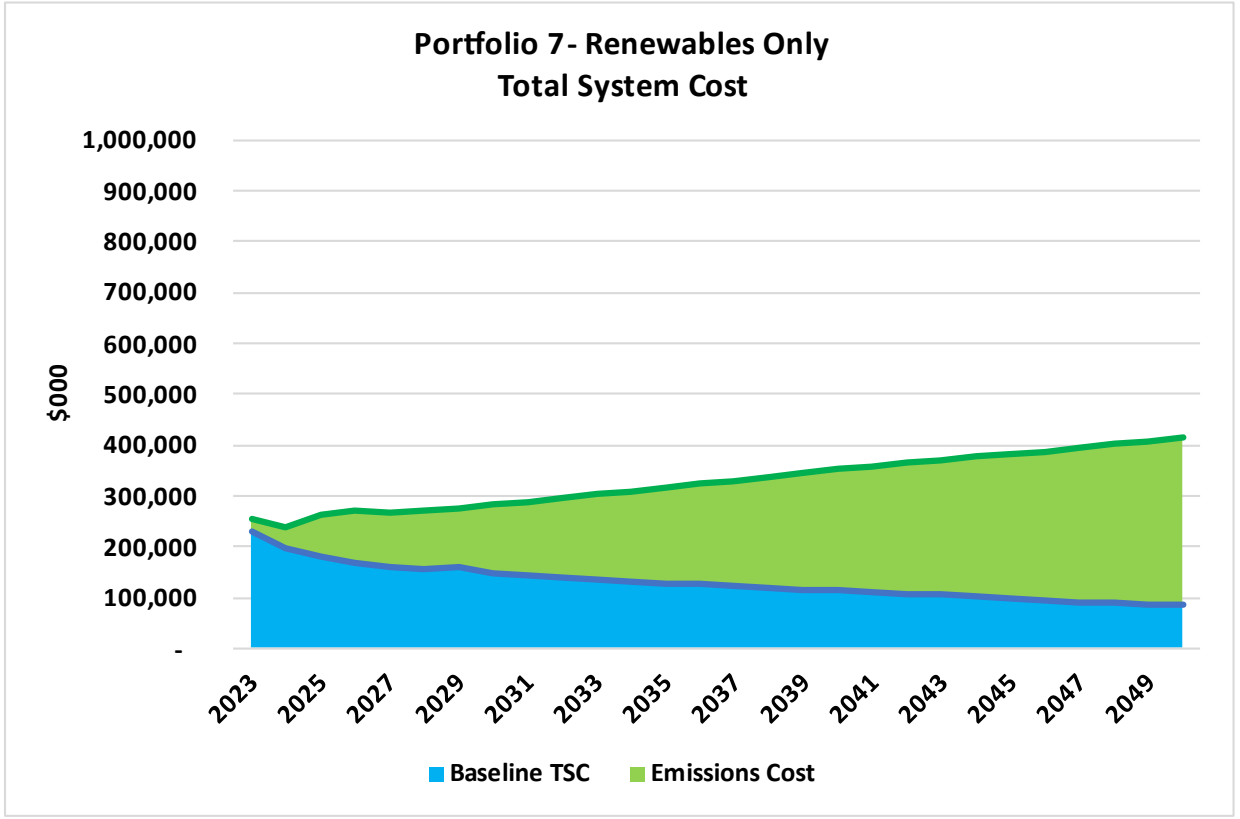


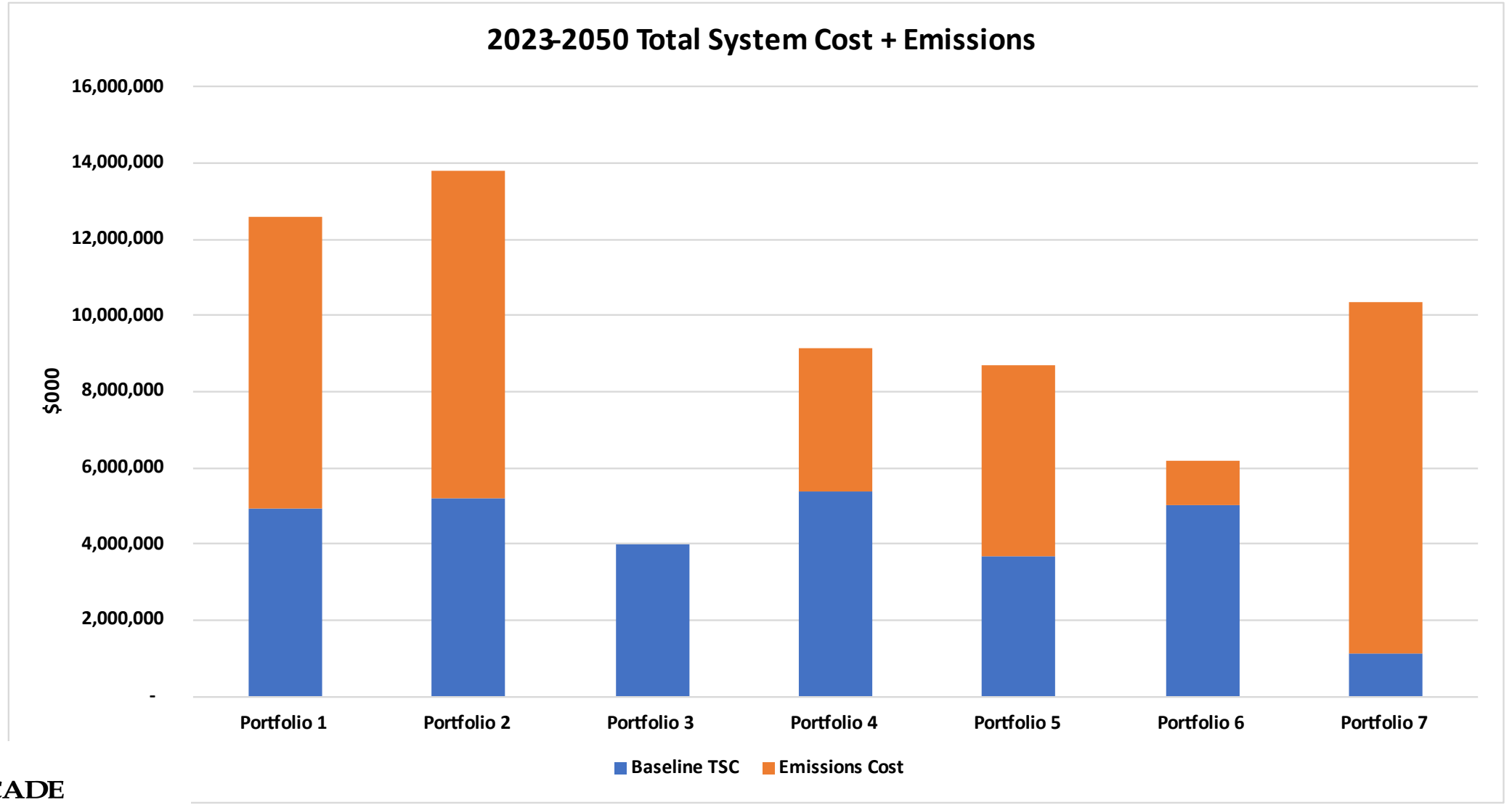
*Not Considered as a Candidate Portfolio due to emissions reductions shortfalls

Methodology Behind Ranking of Portfolios

Cascade uses deterministic results to identify the intrinsic value of a portfolio, and Value at Risk (VaR) analysis to capture the extrinsic value.

Additionally, portfolios are 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. The concluding values are Cascade's Risk-Adjusted Results.



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Final Ranking of Portfolios

Portfolios with deterministic Emissions Reduction Shortfalls will not be considered for Preferred Portfolio

Portfolio	Total System Cost ($000)	Emissions Reduction Shortfalls?
All-In	12,597,464	No
All-In Less DSM	13,801,375	No
Transportation Only	4,006,652	Yes
Offsets Only	9,143,372	Yes
RNG Only	8,708,882	Yes
Hydrogen Only	6,172,433	Yes
Renewables Only	10,340,747	Yes

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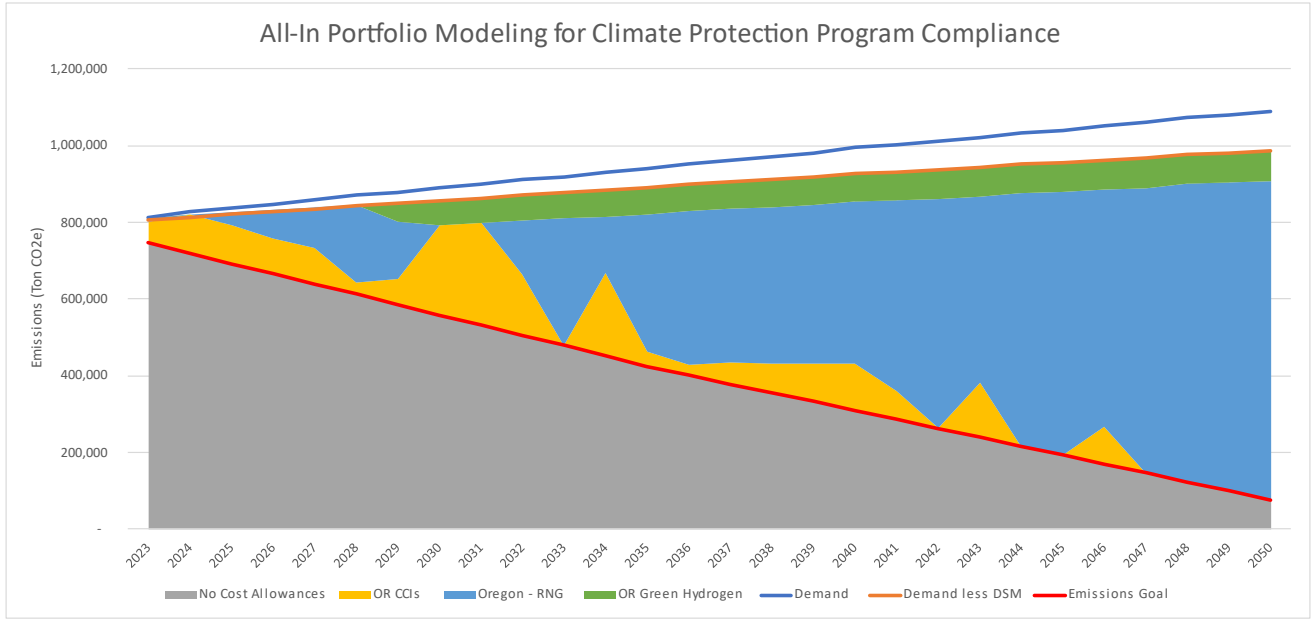
Top Ranked Candidate Portfolio Components

All Cost-Effective DSM

Incremental RNG – Utilized mostly in Oregon, 154,210 Dth starting in 2023, up to 15,635,780 Dth by 2050

Incremental Hydrogen – 90,970 Dth starting in 2029, up to 524,700 Dth by 2050

Compliance Instruments – Utilized as needed, exact number discussed under confidential treatment in IRP



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Stochastic Methodology

Stochastic Model Methodology

Prior to the 2018 IRP, 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 2018 IRP, Cascade enhanced its methodology to allow for a more robust Monte Carlo simulation on weather and price.

For the 2020 IRP, Cascade has further enhanced the Monte Carlo simulation's basin correlations regarding price and weather is correlated between weather stations.

For the 2023 IRP, Cascade has kept the same Monte Carlo simulation process. Prices are correlated between basins and weather is correlated between weather stations.

Cascade's Methodology (Cont'd)

Cascade will continue to perform a 10,000 draw Monte Carlo Simulation of weather and price using R.

For each weather location Cascade records daily mean temperatures, standard deviations, correlations, and the largest 1 day jump to have historically occurred in that month.

For each basins' pricing, Cascade records historic averages, lows, highs, standard deviations, and correlations.

This data is all loaded into R where R can perform 10,000 28-year (2023-2050) unique weather patterns and price paths.

Cascade's Methodology

First, Cascade runs 1 draw of its Monte Carlo simulation for its first weather location.

The remaining weather locations are then run for draw 1 but correlated to the first weather location's results using a mathematical process called Cholesky Decomposition. This process helps create a more realistic simulation for each draw.

This process is repeated 10,000 times, with the calculated HDDs from each draw stored in a separate matrix.

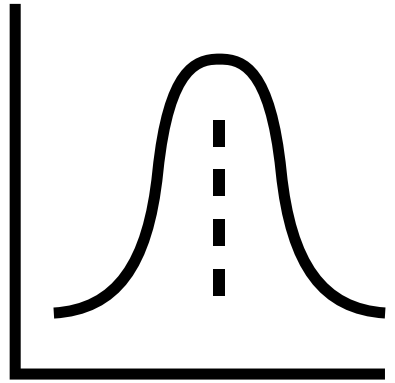
A similar process is followed for price.

Cascade's Methodology (Cont'd)

Historical Correlated Weather							
City	Baker City	Bellingham	Bremerton	Pendleton	Redmond	Walla Walla	Yakima
Baker City	1.00000						
Bellingham	0.63383	1.00000					
Bremerton	0.65848	0.86889	1.00000				
Pendleton	0.70245	0.73001	0.69979	1.00000			
Redmond	0.71736	0.76293	0.76183	0.79743	1.00000		
Walla Walla	0.71051	0.72579	0.69180	0.95952	0.78995	1.00000	
Yakima	0.66974	0.69391	0.68315	0.79445	0.70062	0.81950	1.00000

Non-Adjusted Correlations from Random Monte Carlo Variables							
City	Baker City	Bellingham	Bremerton	Pendleton	Redmond	Walla Walla	Yakima
Baker City	1.00000						
Bellingham	-0.02544	1.00000					
Bremerton	0.06280	0.17484	1.00000				
Pendleton	0.00031	-0.13384	-0.05538	1.00000			
Redmond	0.03081	0.09014	0.10164	-0.02054	1.00000		
Walla Walla	-0.00535	-0.18812	0.07940	0.06387	0.03300	1.00000	
Yakima	-0.00832	-0.09987	-0.01647	-0.03853	0.17427	0.12550	1.00000

Cholesky Adjusted Correlations from Cholesky Adjusted Monte Carlo Variables							
City	Baker City	Bellingham	Bremerton	Pendleton	Redmond	Walla Walla	Yakima
Baker City	1.00000						
Bellingham	0.58003	1.00000					
Bremerton	0.59590	0.87959	1.00000				
Pendleton	0.67497	0.64893	0.62268	1.00000			
Redmond	0.68570	0.76602	0.77980	0.72101	1.00000		
Walla Walla	0.68806	0.60883	0.60391	0.95098	0.70710	1.00000	
Yakima	0.67272	0.60801	0.62417	0.76391	0.63660	0.79252	1.00000



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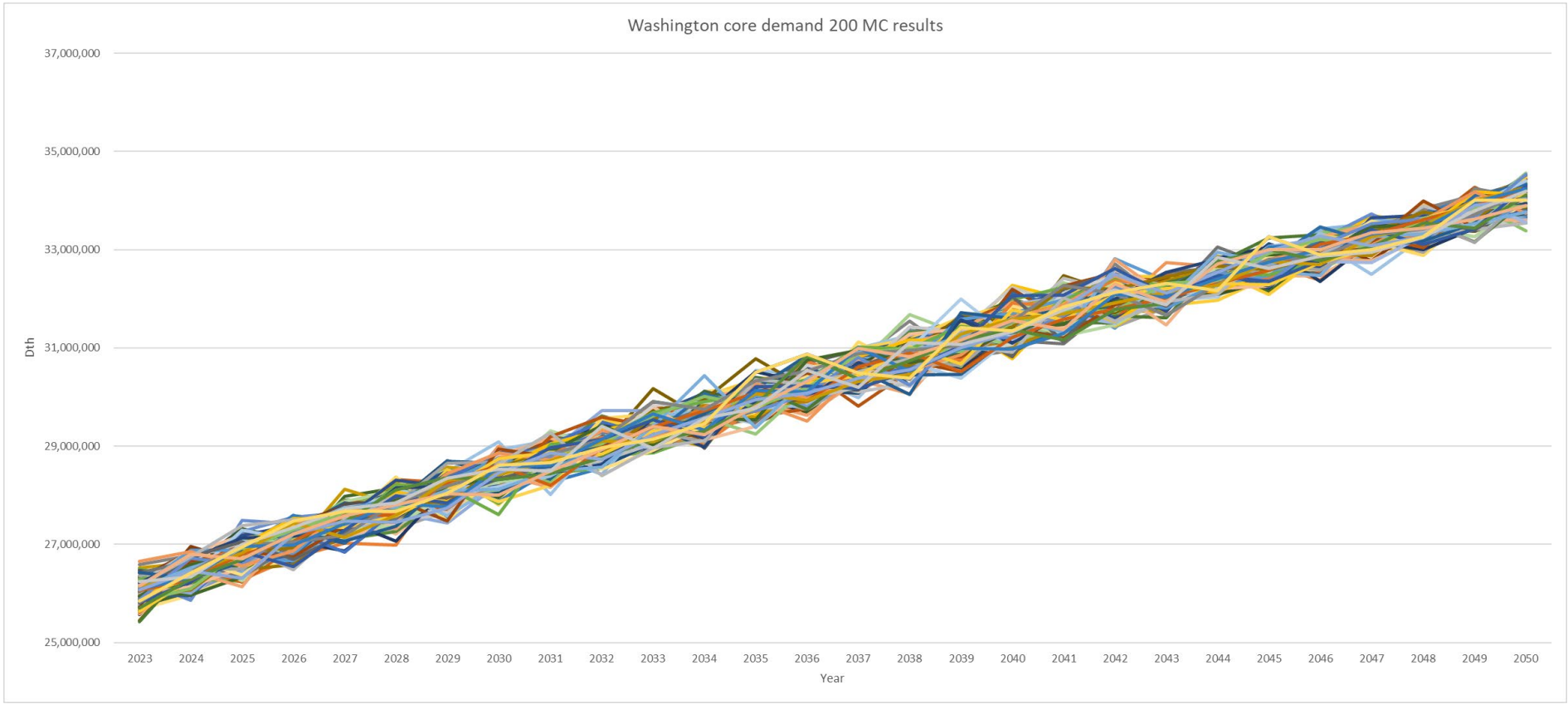
Cascade's Methodology

In the previous IRP, Cascade calculated 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.

In the current IRP, Cascade loaded in 200 random draws into PLEXOS® so Cascade's integrated model can optimize around 200 different weather and price paths.

Monte Carlo Demand Results



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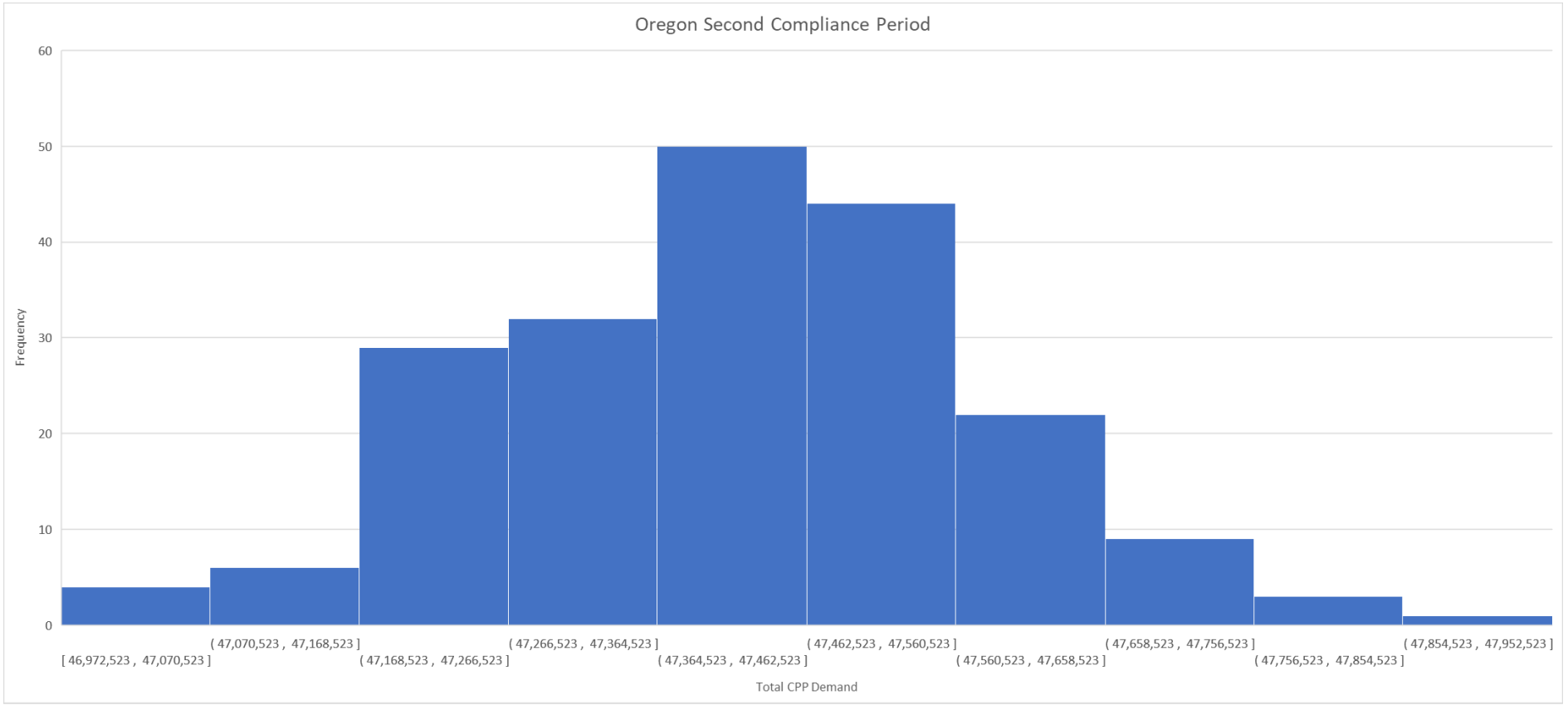
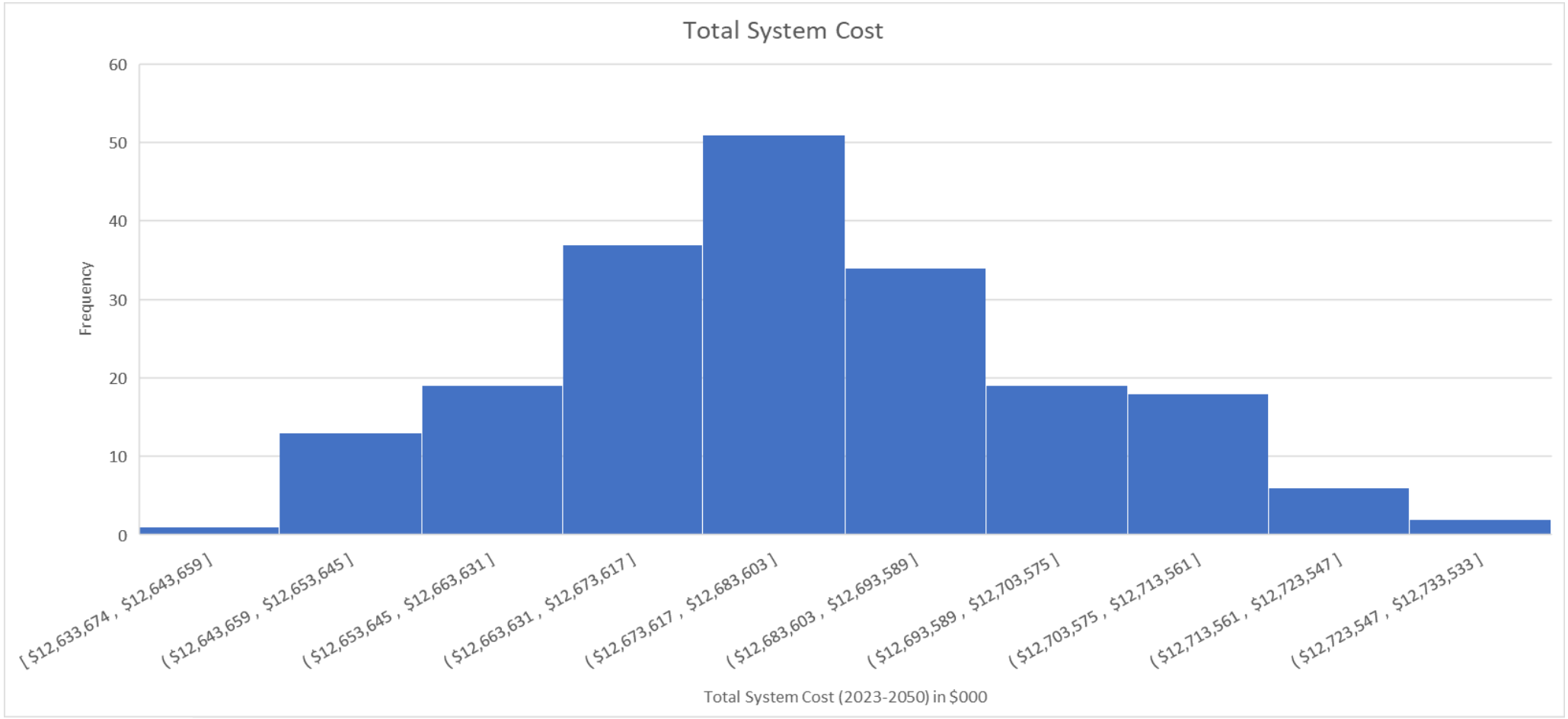
Oregon Second Compliance Period Demand

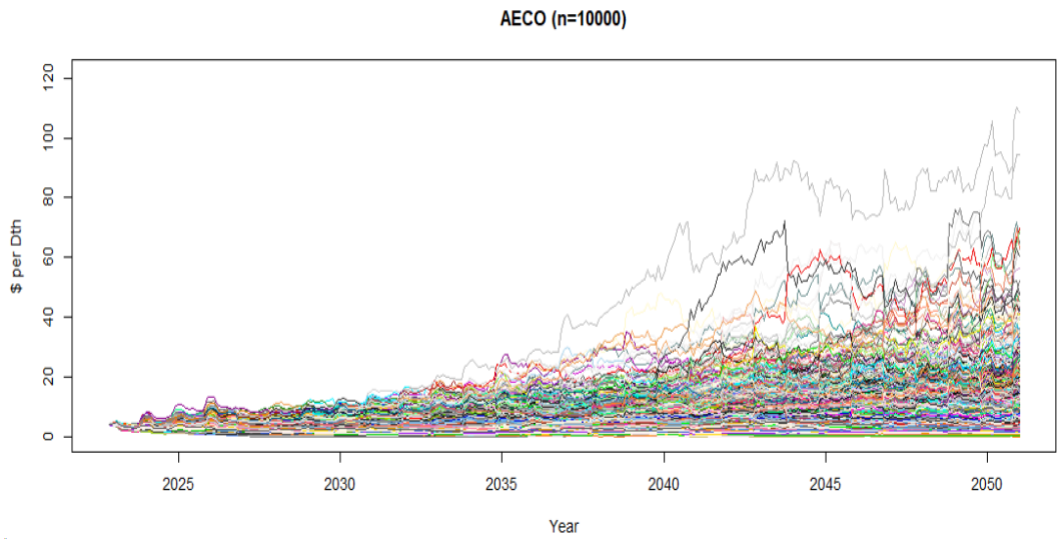


Total System Cost (2023-2050)

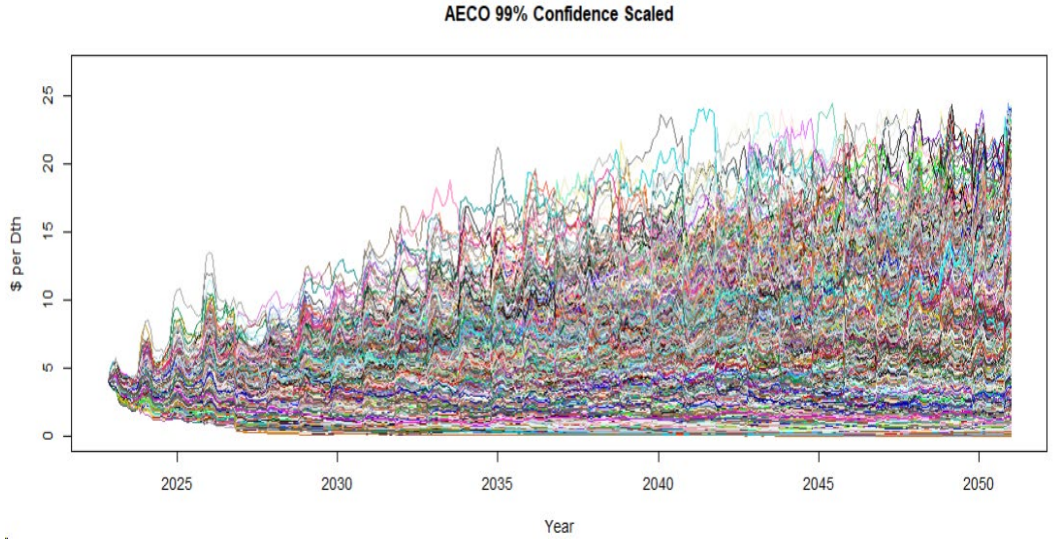


AECO Price Simulations

10,000 Simulations

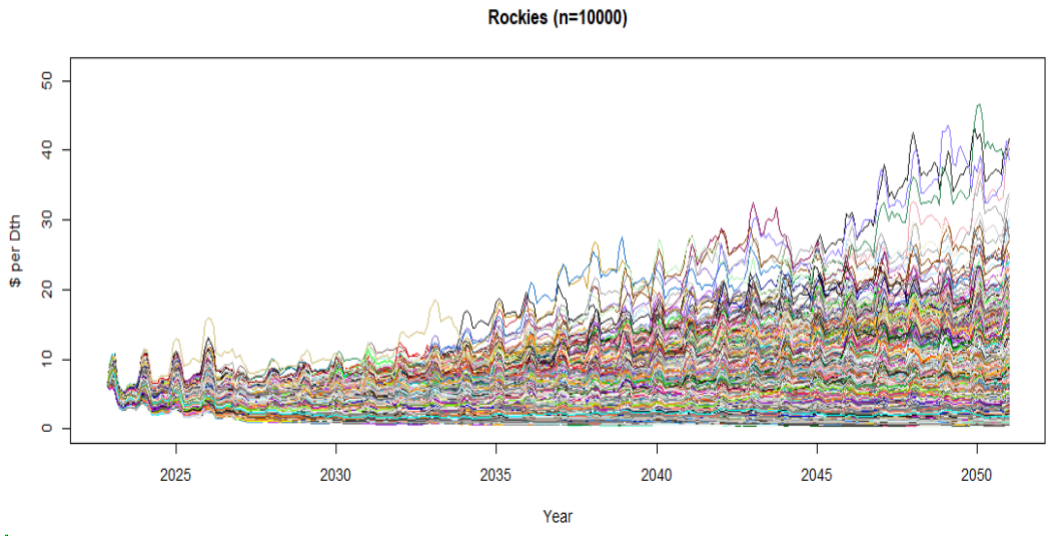


99th Percentile

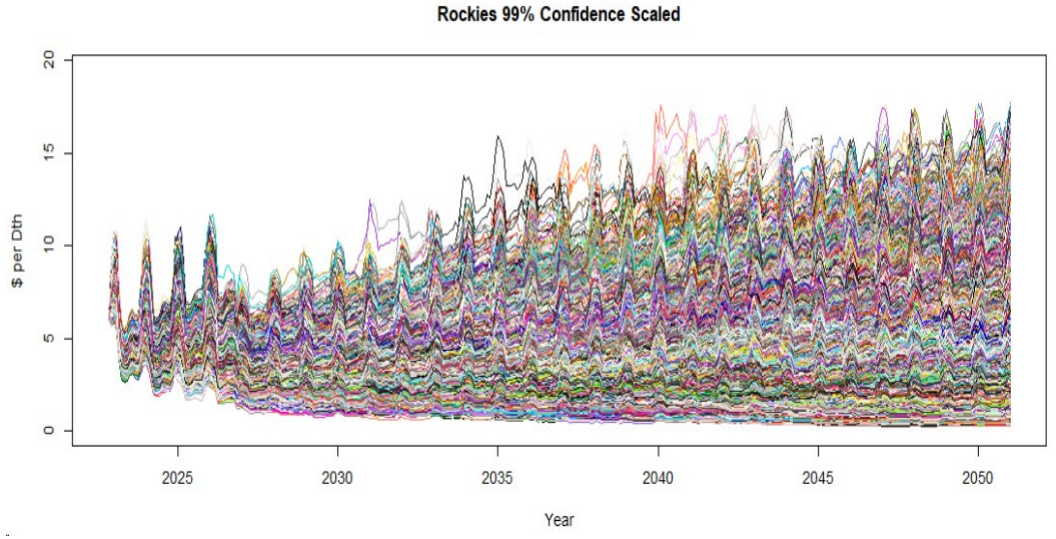


Rockies Price Simulations

10,000 Simulations

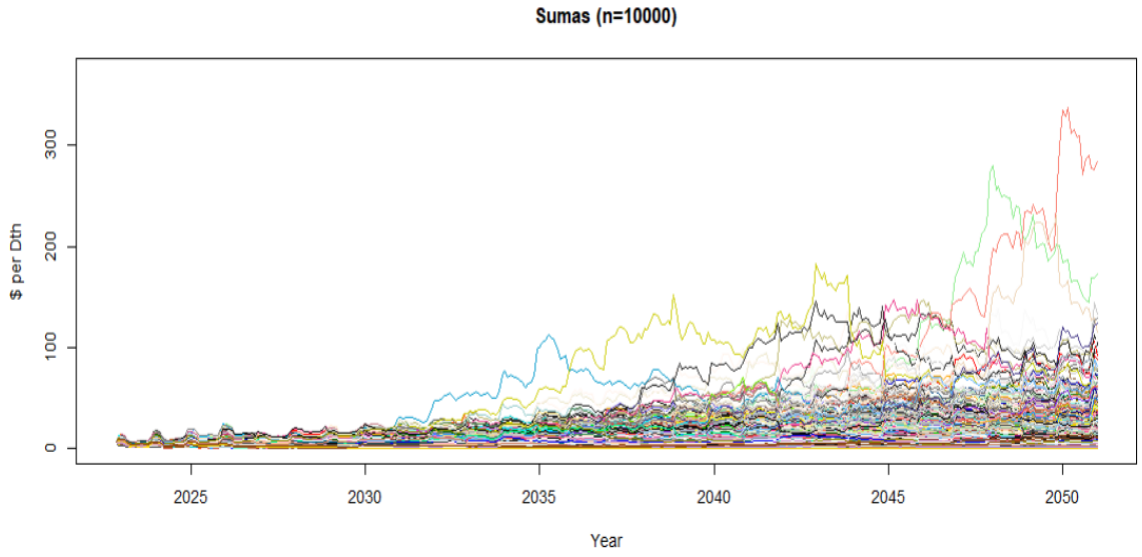


99th Percentile

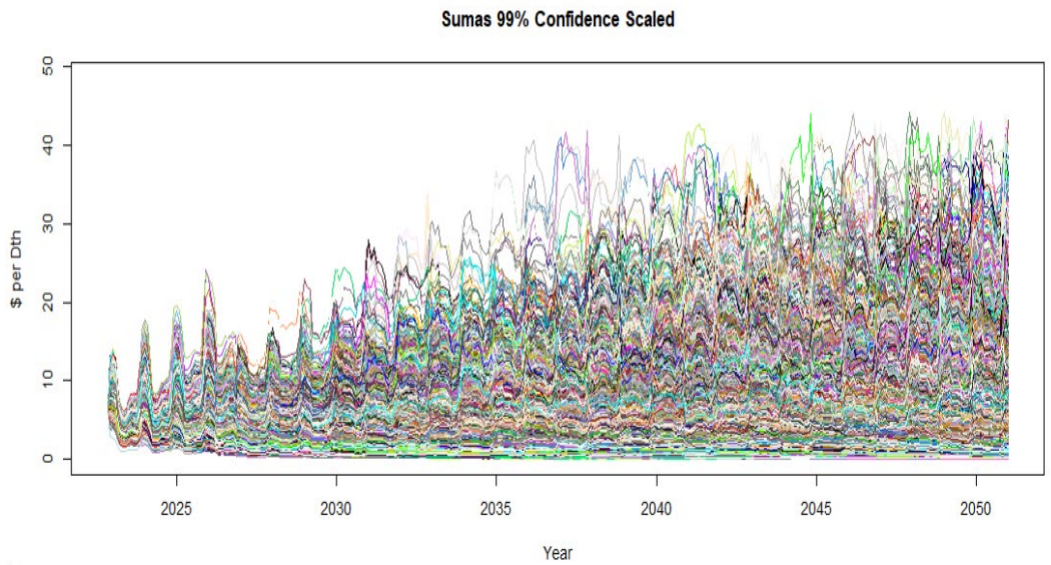


Sumas Price Simulations

10,000 Simulations



99th Percentile



Scenario and Sensitivity Results

New Philosophy Behind Scenario/Sensitivity Modeling

In previous IRPs, Cascade modeled a wide breadth of scenarios and sensitivities that, according to some stakeholder feedback, may have been too expansive for the IRP

- Pro – Allowed the Company to analyze the impact of a wide number of externalities
- Con – Time constraints do not allow for a deep analysis of the results of scenario modeling

For the 2023 IRP, Cascade had reduced the number of scenarios run to five, but each scenario will include a robust quantitative and qualitative analysis of the expected changes to costs and ability to meet emissions reduction requirements under the scenario.

Scenario – A series of assumptions (sensitivities) that differ from the Company's base case modeling

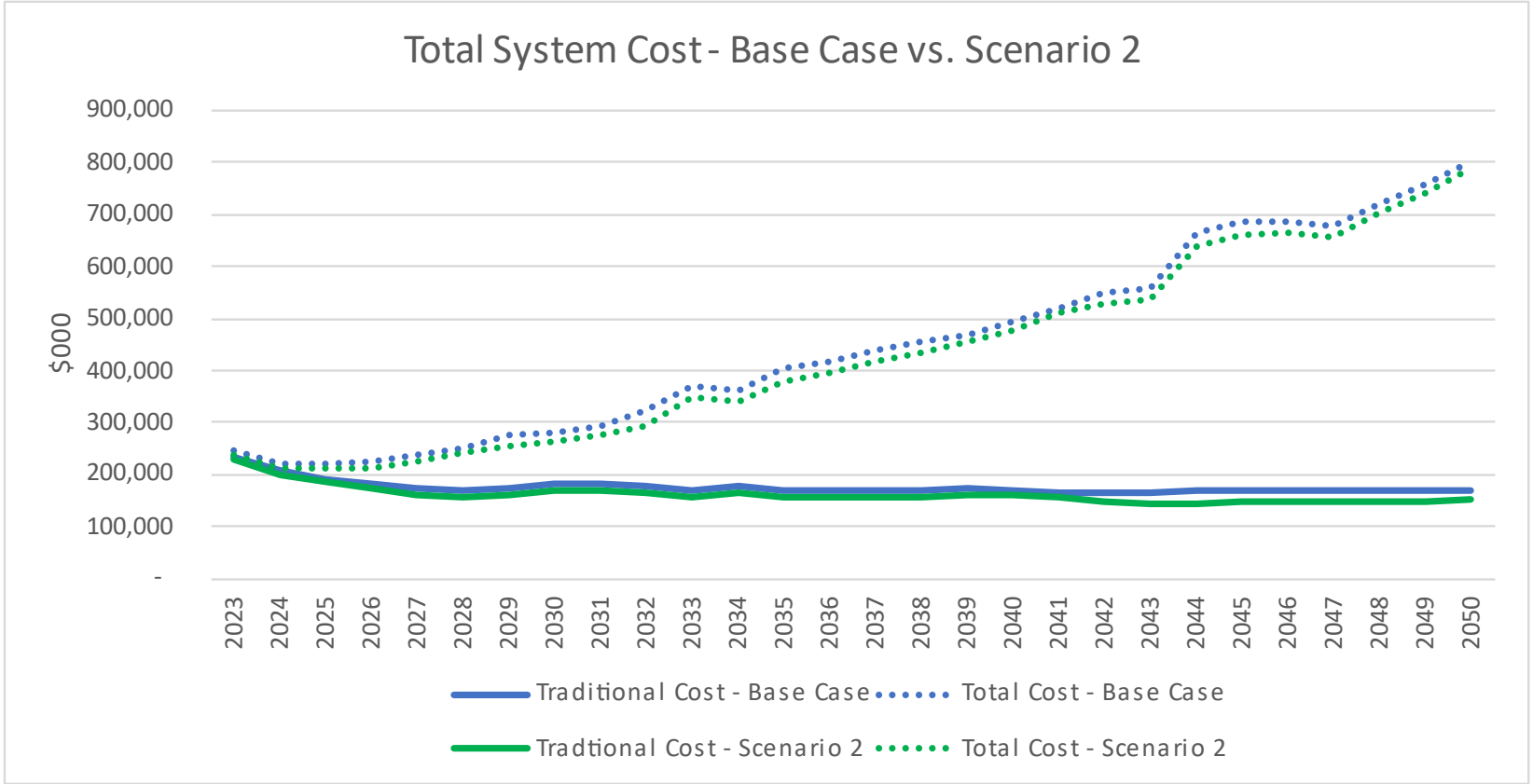
Sensitivity – A variable within a given scenario that may be modified to reflect the assumptions of that scenario

2023 IRP Proposed Scenarios	Scenario						
	Base Case - OR-CPP and WA-CCA	**Carbon Neutral by 2050**	**Limited RNG availability**	**Electrification**	**High Customer Case**	**High Price - Interrupted Supply**	**Other?**
Customer Growth	Current Expectations			No new customers after 2030	High Customer Counts	Current Expectations	
Energy Efficiency	CPA Projections	Scenario 2 CPA Projections				CPA Projections	
Renewable Natural Gas	Expected Availability	Expected - High Avail.	Low Availability	Expected - High Avail.		Expected Availability	
Hydrogen	Expected Availability	Expected - High Avail.	Low Availability	Expected - High Avail.		Expected Availability	
Natural Gas Bans	Current Bans			Additional Bans	Current Bans		
Natural Gas Price	Expected Price	Adjusted Price?	Expected Price	Adjusted Price?		High Price	

Scenario 2 – Carbon Neutral by 2050

- Main Element: Zero CO2e emissions by 2050 as per CCA/CPP guidelines
- Customer Growth: Based on 2023 IRP Load Forecast
- Energy Efficiency: Based on adjusted 2023 CPAs from Cascade (WA) and ETO (OR) using higher commodity cost as input into avoided cost
- RNG Availability: Cascade weighted share of technical potential of American Gas Foundation/ICF Study
- Hydrogen Availability: Maximum blend of 30% supply by volume
- Natural Gas Bans: Consideration of all expected bans in load forecast
- Natural Gas Price: 10% downward adjustment to 2023 IRP Price Forecast, higher price of RNG volumes above and beyond base case, capped at $26/dth

Scenario 2 – Carbon Neutral by 2050 Cost Comparison



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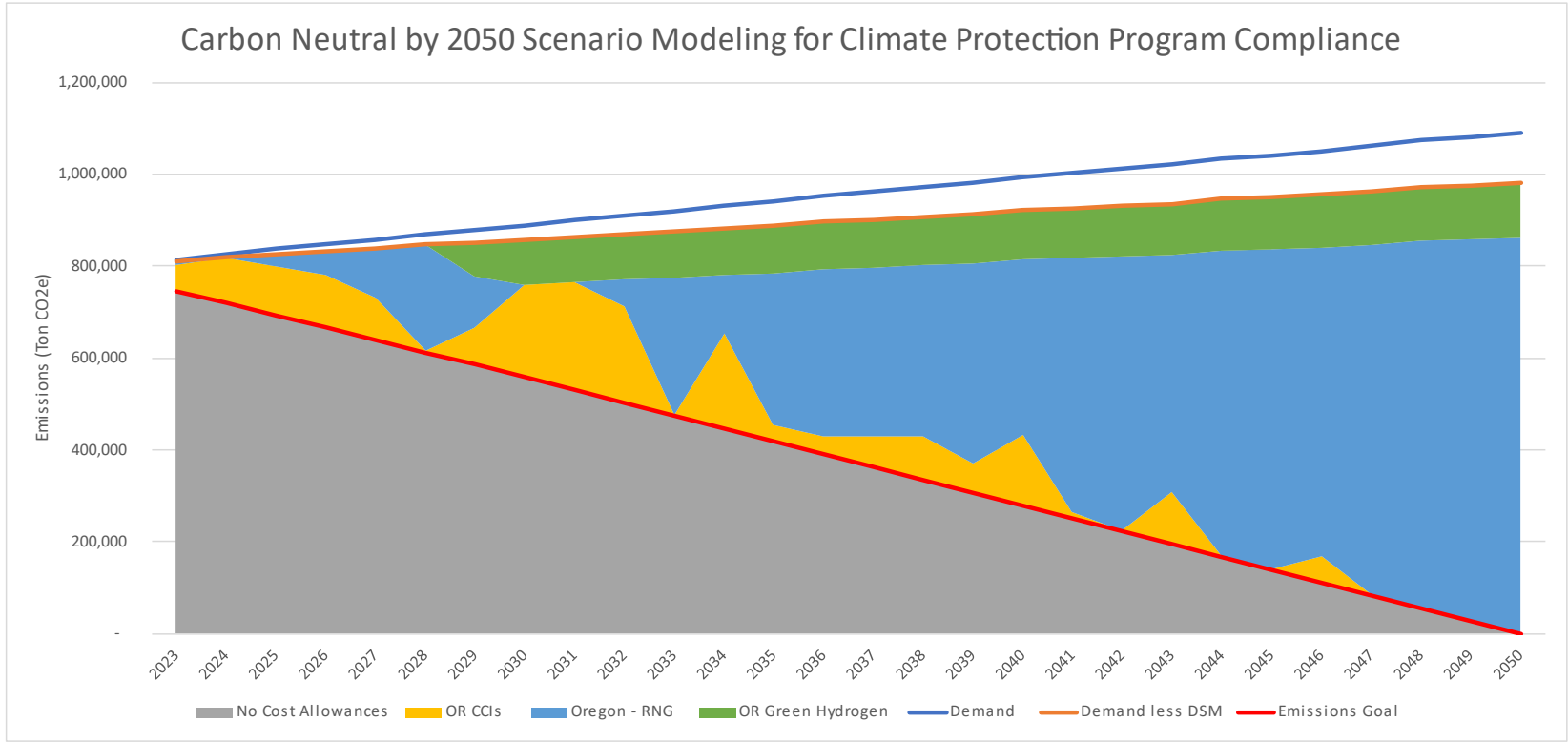
Scenario 2 – Carbon Neutral by 2050 Resource Stack



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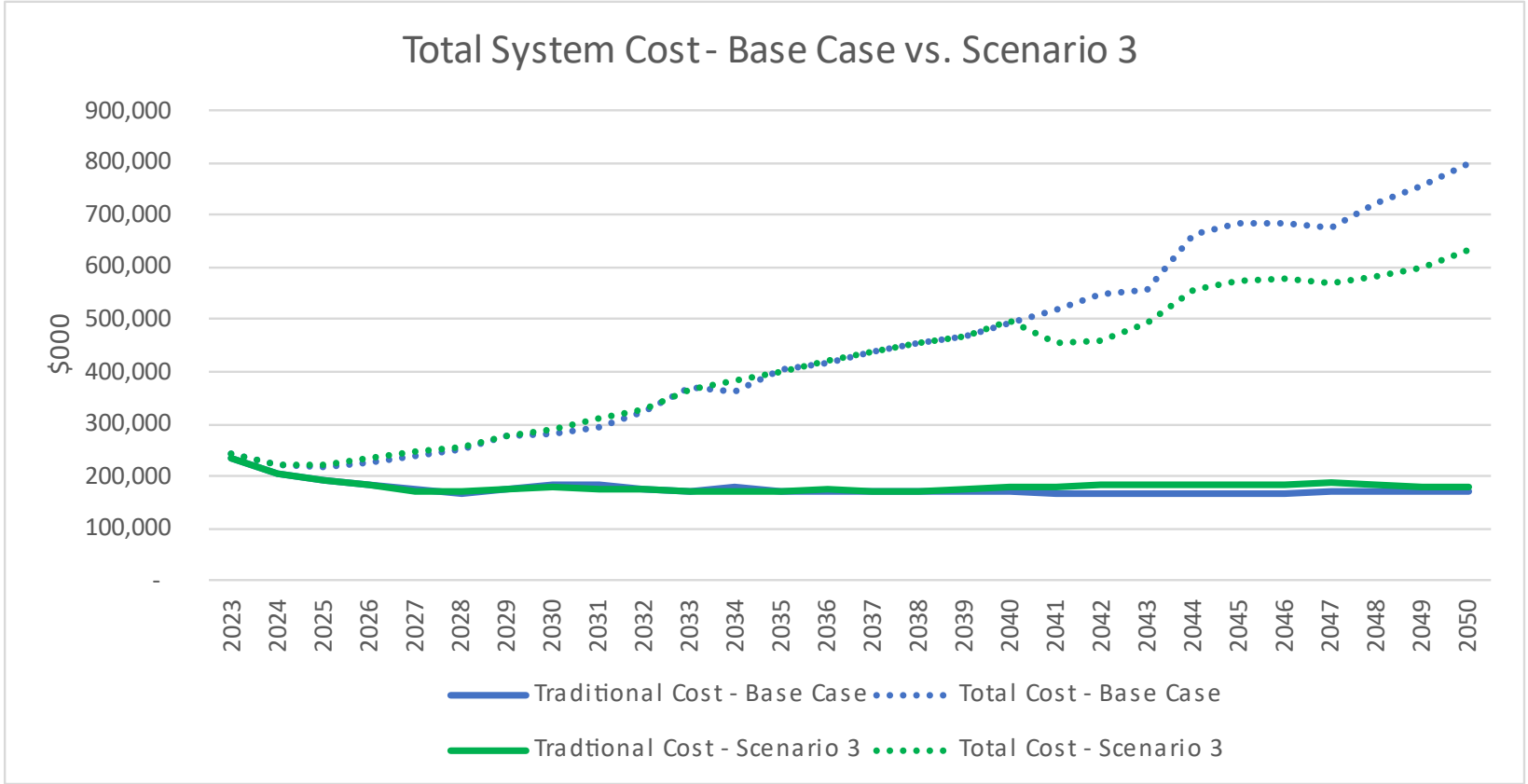
Scenario 2 – Key Takeaways

- Cascade does believe it would be able to hit emissions reduction goals even in a Carbon Neutral by 2050 scenario.
- Aggressive utilization of green Hydrogen is key to the Company's success in this scenario.
- If market conditions were to manifest as modeled (lower price of traditional natural gas due to presumed regional effort at carbon neutrality, declining pricing of hydrogen) cost would not be a barrier to accomplishing this goal.

Scenario 3 – Limited RNG Availability

- Main Element: Competition and stagnating technology leads to lower than expected RNG availability, conservative approach to hydrogen blending
- Customer Growth: Based on 2023 IRP Load Forecast
- Energy Efficiency: Based on adjusted 2023 CPAs from Cascade (WA) and ETO (OR) using higher commodity cost as input into avoided cost
- RNG Availability: Cascade weighted share of low potential of AGF/ICF Study
- Hydrogen Availability: Maximum blend of 5% supply by volume
- Natural Gas Bans: Consideration of all expected bans in load forecast
- Natural Gas Price: Geologic gas based 2023 IRP Price Forecast.

Scenario 3 – Limited RNG Availability Cost Comparison



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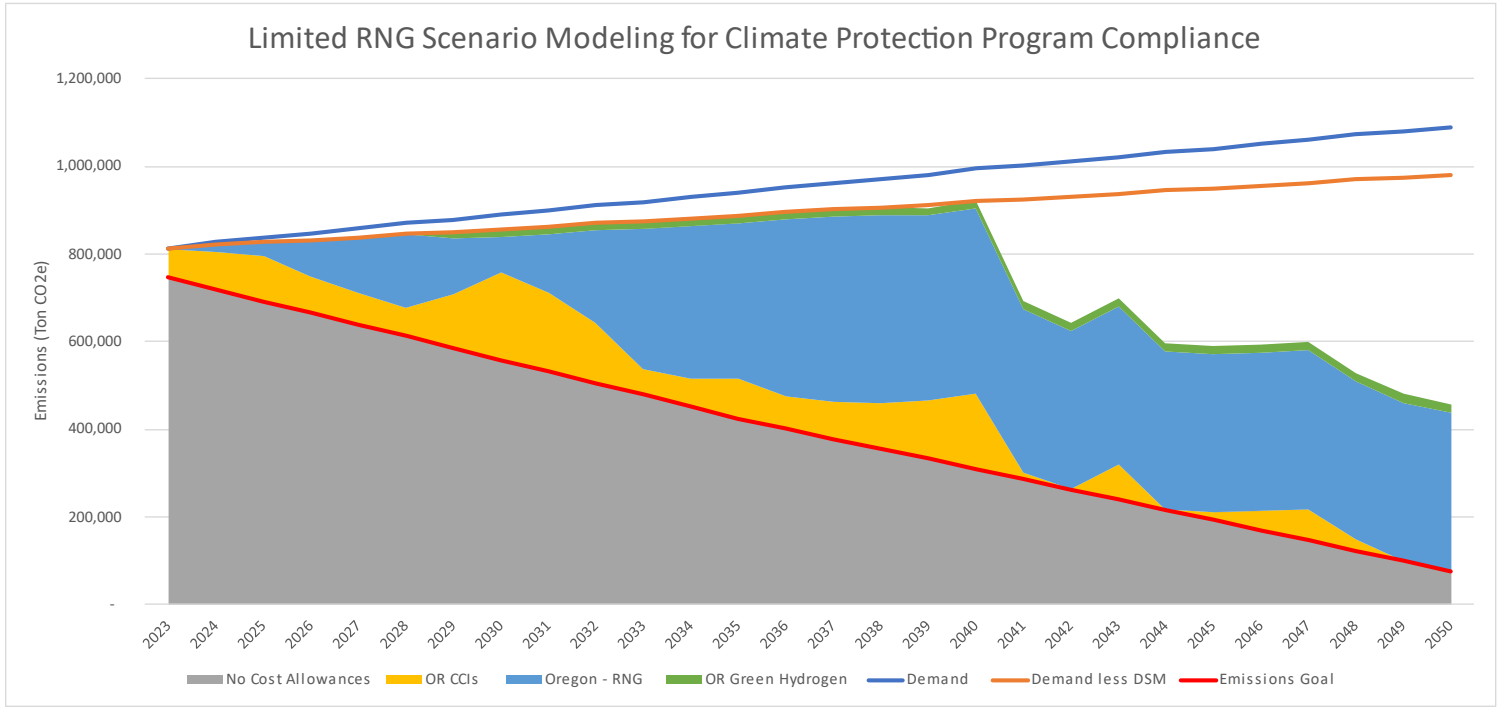
Scenario 3 – Limited RNG Availability Resource Stack



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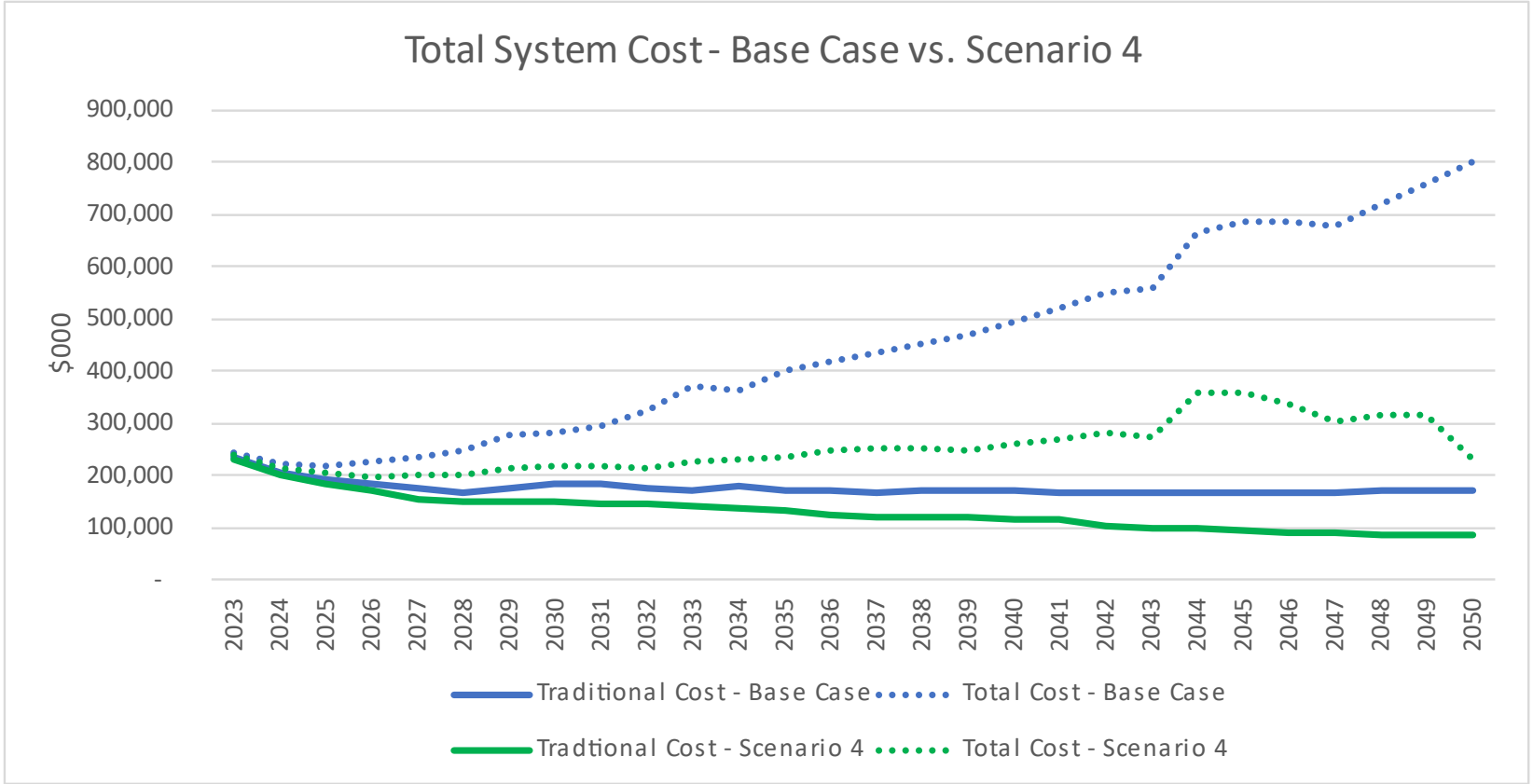
Scenario 3 – Key Takeaways

- Cascade does believe it would be able to hit emissions reduction goals in a low RNG environment in Washington, but will be challenged to be successful in meeting its goals in Oregon
- Aggressive pursuit of RNG will be vital to the Company's success
- While in compliance, costs were typically higher in a limited RNG scenario, but not prohibitively so.

Scenario 4 – Increased Electrification

- Main Element: Lower than expected load projections due to both discretionary electrification and increased regulatory bans on natural gas.
- Customer Growth: customer growth in Cascade's residential and commercial rate classes gradually slows to zero growth in 2025 and afterwards, residential and commercial customer count reduced to 10% by 2050.
- Energy Efficiency: Based on adjusted 2023 CPAs from Cascade (WA) and ETO (OR) using higher commodity cost as input into avoided cost.
- RNG Availability: Cascade weighted share high/technical blend of AGF/ICF Study.
- Hydrogen Availability: Maximum blend of 20% supply by volume.
- Natural Gas Bans: Consideration of all expected and proposed bans in load forecast.
- Natural Gas Price: 10% downward adjustment to 2023 IRP Price Forecast.

Scenario 4 – Increased Electrification Cost Comparison



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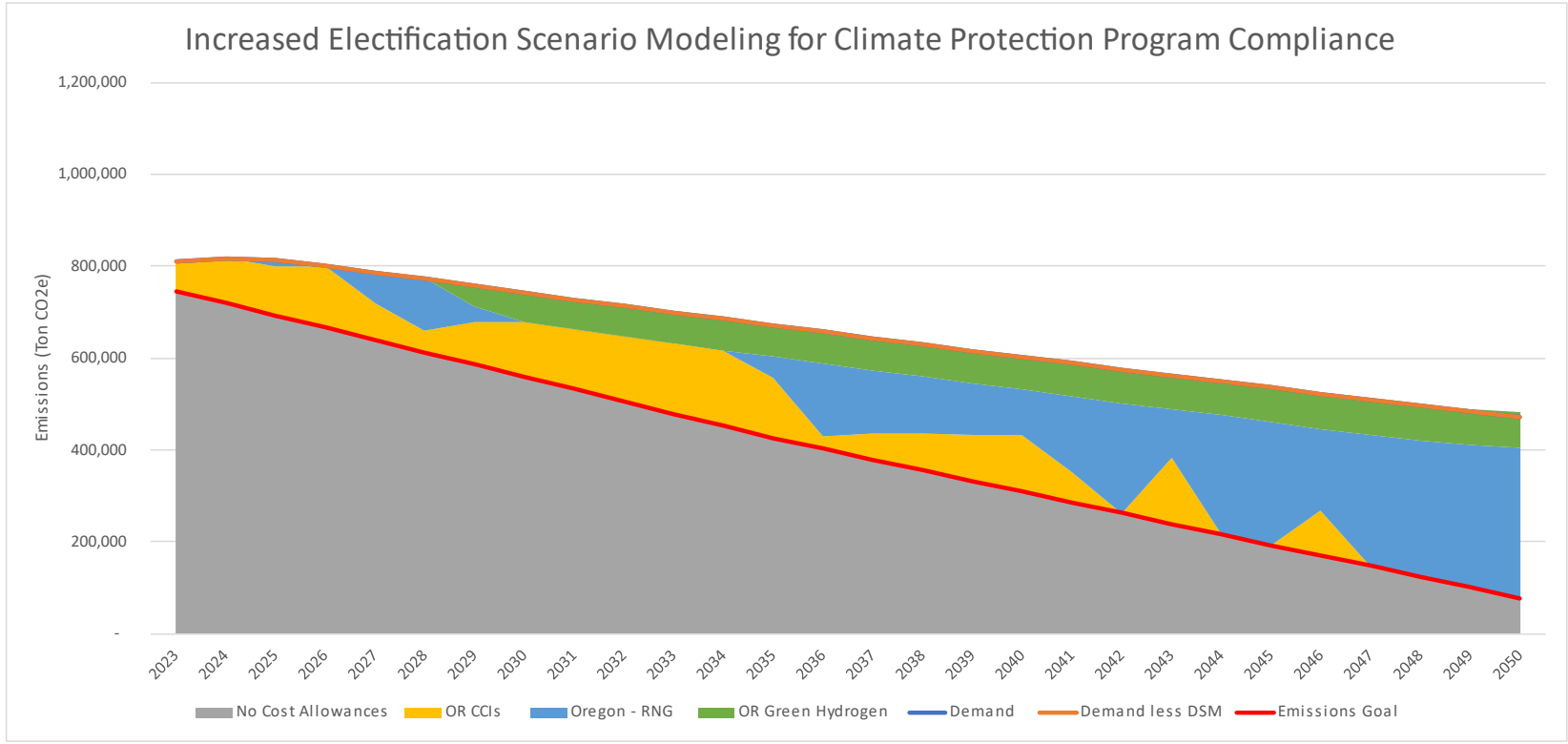
Scenario 4 – Increased Electrification Resource Stack



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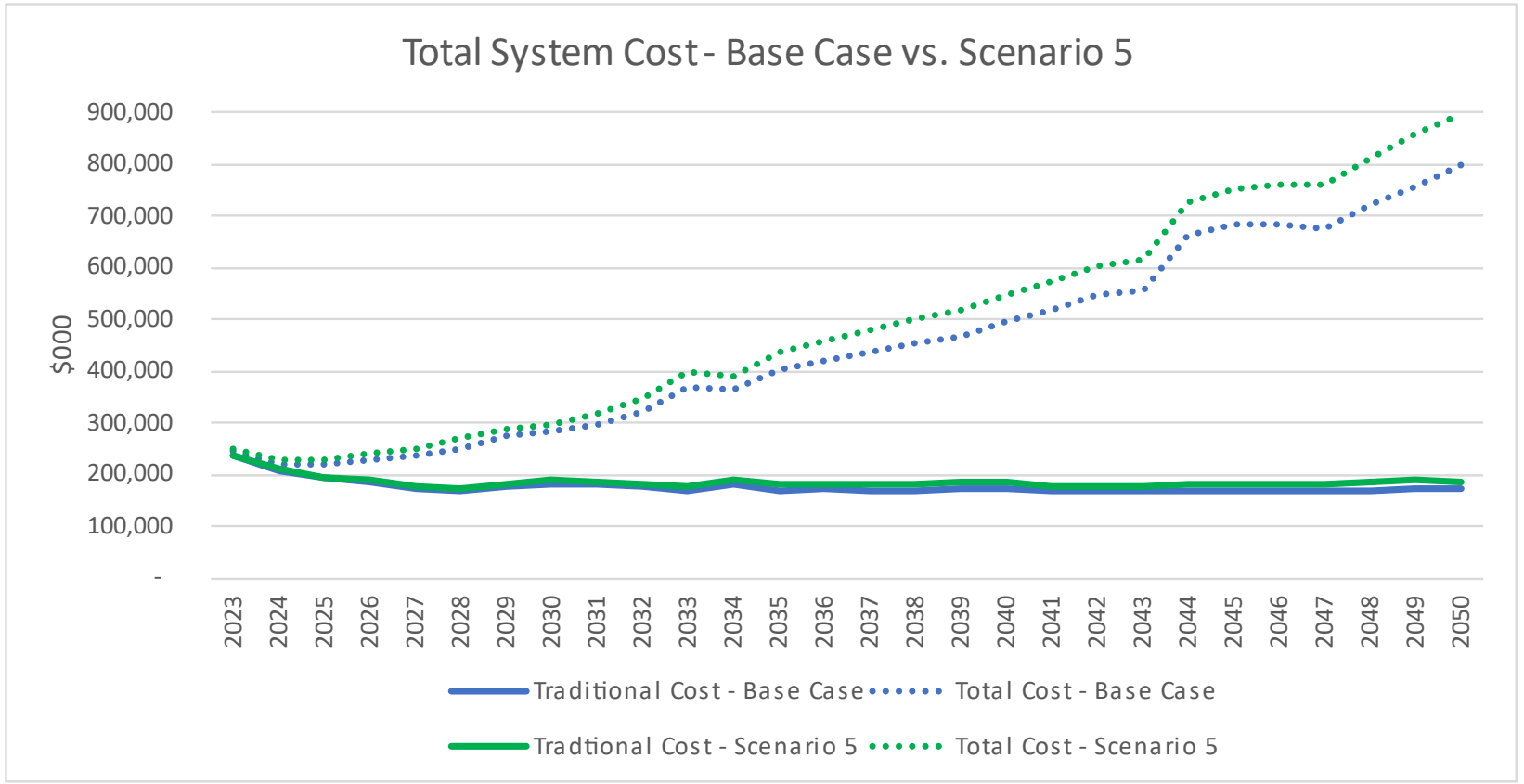
Scenario 4 – Key Takeaways

- Increased electrification would make compliance with emissions reduction requirements far easier.
- Costs under electrification are significantly lower ***to Cascade,*** but this is a result of those costs being shifted elsewhere. Before any policy decisions can be made based on this, an apples to apples comparison of what the resulting cost increases to customers would be must be performed.
- Lower costs do not necessarily reflect lower rates to customers, as lower customer counts may lead to higher costs per customer. Cascade will be performing rate impact analysis to be included in the final IRP.

Scenario 5 – High Customer Growth

- Main Element: Higher than expected customer growth, with the same emissions reduction requirements in the CPP/CCA
- Customer Growth: Based on high growth projections of the 2023 IRP Load Forecast
- Energy Efficiency: Based on adjusted 2023 CPAs from Cascade (WA) and ETO (OR) using higher commodity cost as input into avoided cost
- RNG Availability: Cascade weighted share of the technical potential in the AGF/ICF Study
- Hydrogen Availability: Maximum blend of 30% supply by volume
- Natural Gas Bans: Consideration of all expected bans in load forecast
- Natural Gas Price: 10% upward adjustment to 2023 IRP Price Forecast, higher price of RNG volumes above and beyond base case, capped at $26/dth

Scenario 5 – High Customer Growth Cost Comparison



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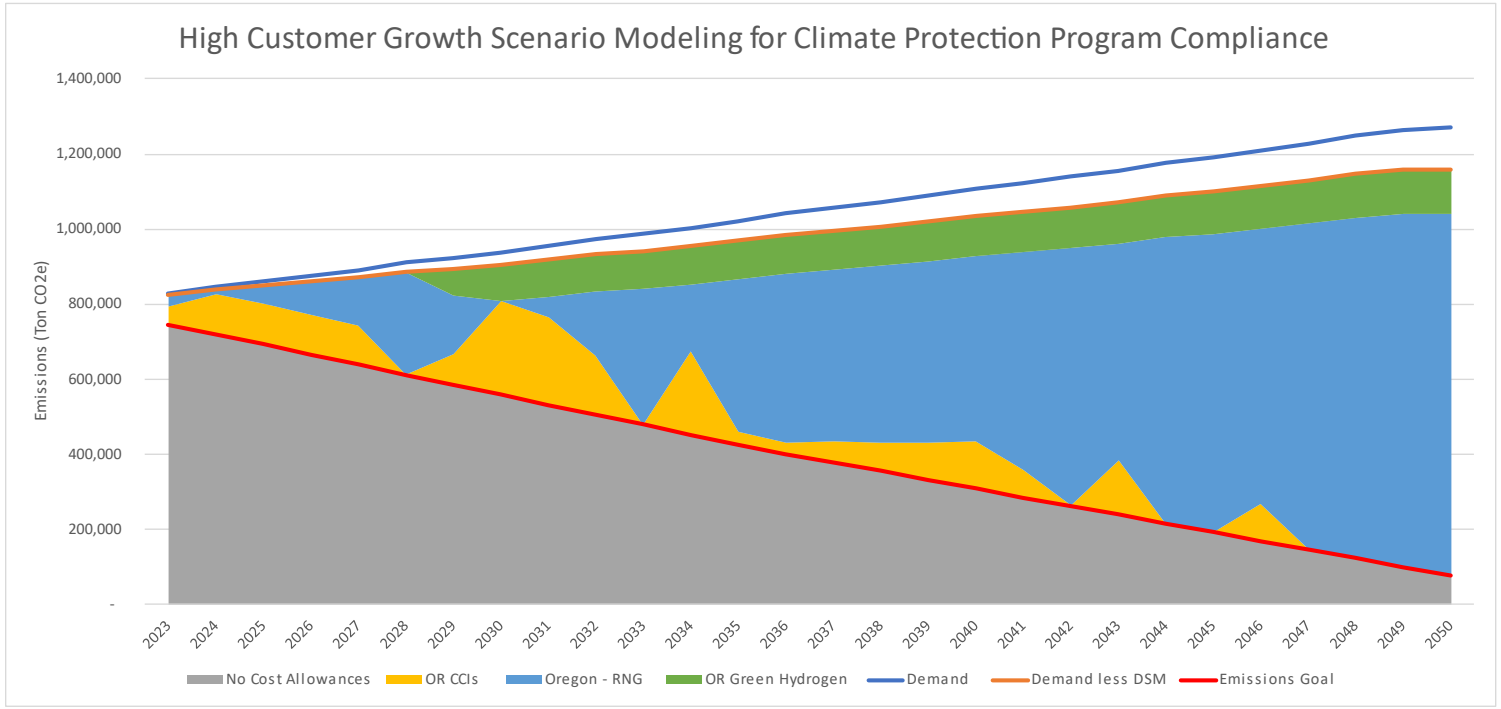
Scenario 5 – High Customer Growth Resource Stack



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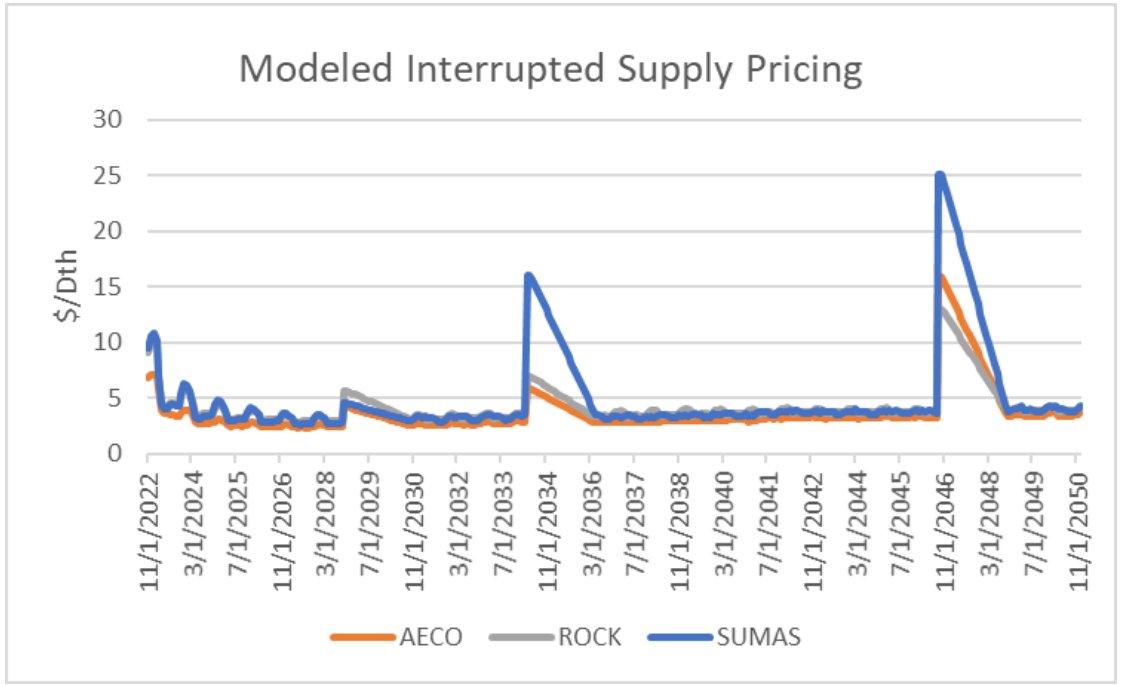
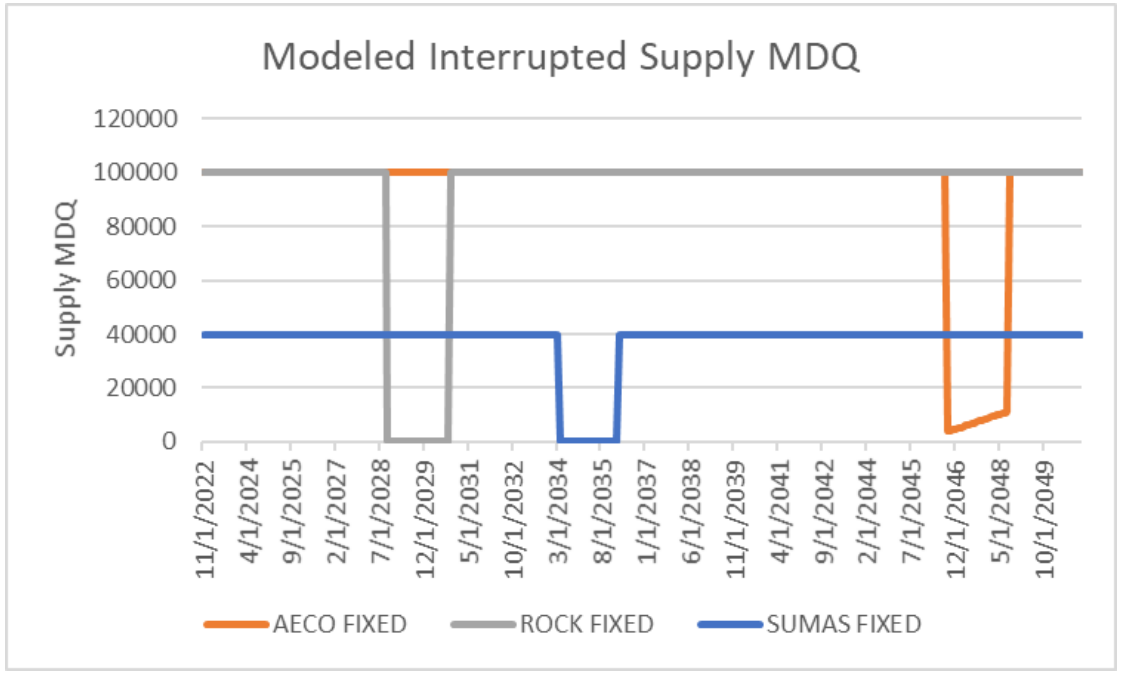
Scenario 5 – Key Takeaways

- Cascade is pleased to see that Company expects to be able to meet customer demand and reach emissions reductions goals in a high growth scenario.
- Aggressive participation in WA allowance auction, including the use of price ceiling allowances when needed, will be vital to the Company's success, along with aggressive RNG acquisition in Oregon.
- As expected, costs will be higher under a high growth scenario, mostly driven by increased costs related to emissions reduction requirements. These costs do not appear to be cost prohibitive under deterministic modeling.

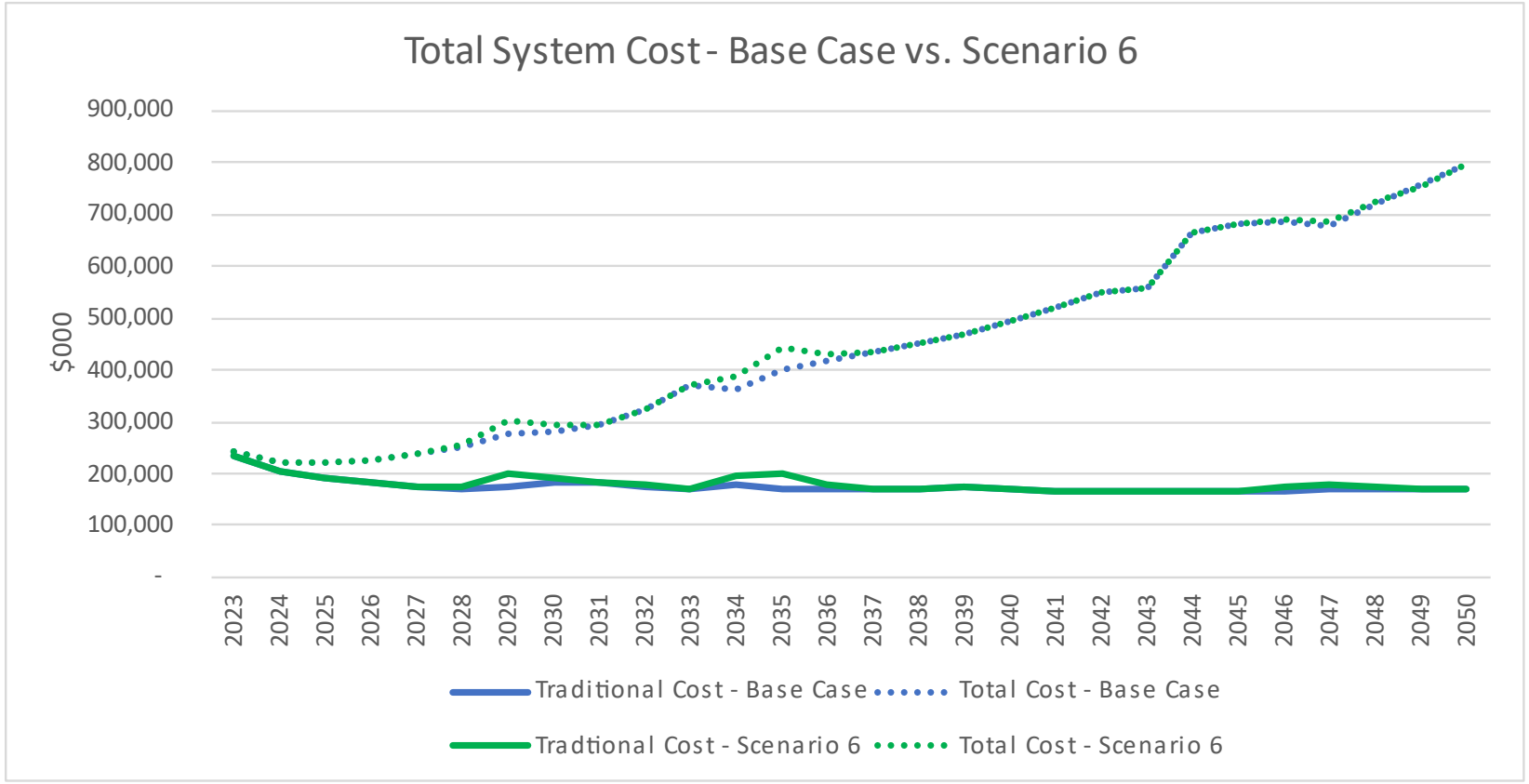
Scenario 6 – High Price – Interrupted Supply

- Main Element: Indiscriminate, stochastically derived incidents cause disruptions in availability of geologic gas at specific basins
- Customer Growth: Based on high growth projections of the 2023 IRP Load Forecast
- Energy Efficiency: Based on 2023 CPAs from Cascade (WA) and ETO (OR)
- RNG Availability: Cascade weighted share high/technical blend of AGF/ICF Study
- Hydrogen Availability: Maximum blend of 20% supply by volume
- Natural Gas Bans: Consideration of all expected bans in load forecast
- Natural Gas Price: During incidents, price at other basins spike to 99th percentile stochastic pricing


Modeled Interrupted Supply Pricing
$/Dth
30
25
20
15
10
5
0
11/1/2022
3/1/2024
7/1/2025
11/1/2026
3/1/2028
7/1/2029
11/1/2030
3/1/2032
7/1/2033
11/1/2034
3/1/2036
7/1/2037
11/1/2038
3/1/2040
7/1/2041
11/1/2042
3/1/2044
7/1/2045
11/1/2046
3/1/2048
7/1/2049
11/1/2050
AECO
ROCK
SUMAS


Modeled Interrupted Supply MDQ
Supply MDQ
120000
100000
80000
60000
40000
20000
0
11/1/2022
4/1/2024
9/1/2025
2/1/2027
7/1/2028
12/1/2029
5/1/2031
10/1/2032
3/1/2034
8/1/2035
1/1/2037
6/1/2038
11/1/2039
4/1/2041
9/1/2042
2/1/2044
7/1/2045
12/1/2046
5/1/2048
10/1/2049
AECO FIXED
ROCK FIXED
SUMAS FIXED

Scenario 6 – High Price/Interrupted Supply Cost Comparison



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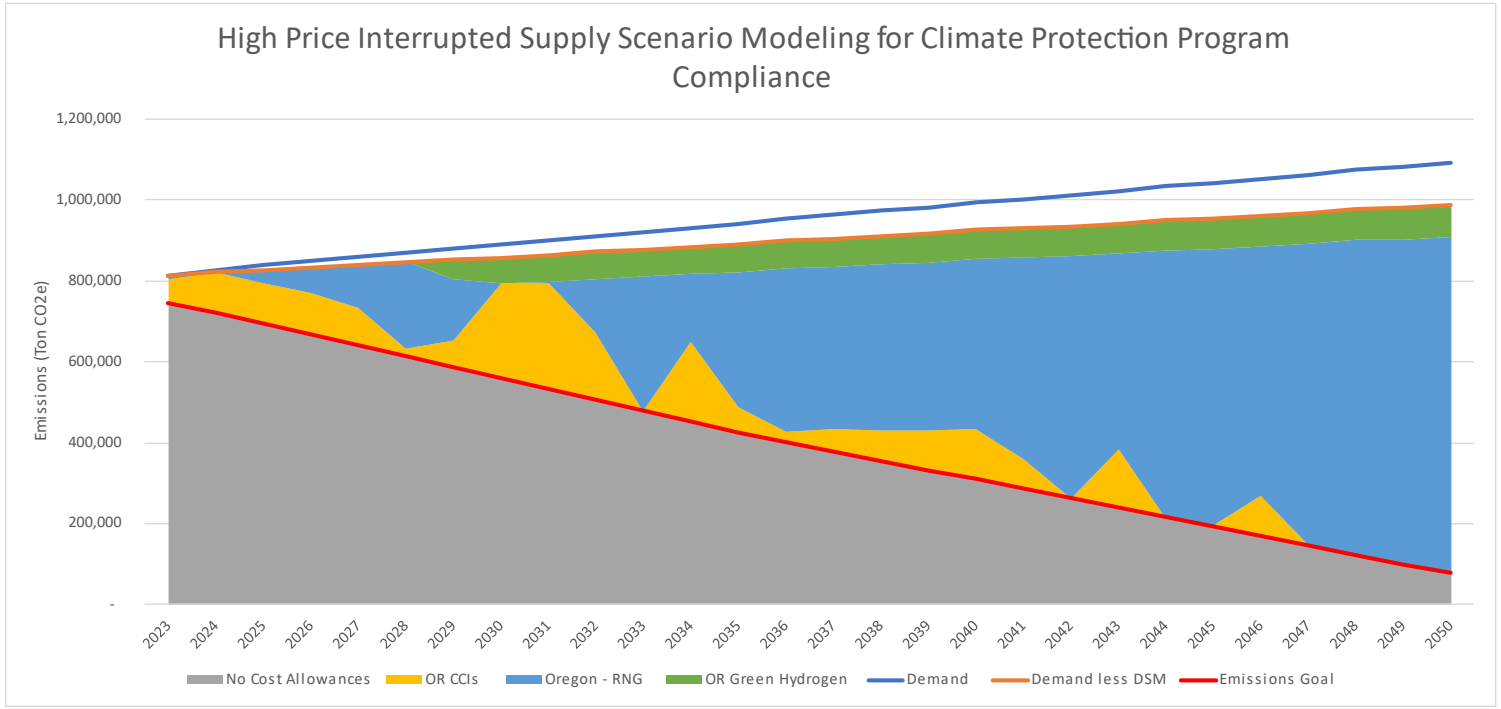
Scenario 6 – High Price/Interrupted Supply Resource Stack



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Scenario 6 – Key Takeaways

- Cascade is able to meet emissions reductions targets, but has identified a potential shortfall in serving load in 2034 during the modeled Sumas incident
  - Cascade will include discussion in the narrative about how an incident like this would be handled, including lessons learned from prior instances.
- Cascade's participation in hydrogen markets is largely dependent on when pricing becomes attractive. Interrupted supply modeling indicates that price shocks from incidents could accelerate Cascade's entry into these markets as short term hedges/protection against these price movements.
- As expected, costs will be higher during price shock incidents, but not as significantly as the Company initially expected.

Proposed Two-Year Action Plan

Two-Year Action Plan

- Demand:
  - Incorporate end use forecasting in the load forecast model
- Avoided Cost:
  - Investigate incorporating a separate avoided cost for transportation (non-core) customers
  - Explore how environmental compliance costs from the CPP/CCA impact the avoided cost
- Demand Side Management:
  - Continue to work with Energy Trust of Oregon (ETO) in an effort to create a DSM program for non-core customers.
  - In coordination with ETO, Cascade will strive to acquire the projected cost-effective gas savings over the next two to four years.
  - Cascade will coordinate with ETO in 2023 to include targeted load management for Baker City and Ontario distribution system projects.
  - Cascade will coordinate with ETO in 2023 to include targeted load management for the city of Bend.

Two-Year Action Plan (Cont'd)

- Compliance:
  - Acquire the number of offsets and allowances needed to meet compliance under the Climate Protection Program.
  - Acquire on-system RNG (System resource that will be utilized in OR and WA as needed).
  - Continue to participate in the local climate community action plans around Cascade's service territory.
- Distribution System Planning:
  - Prineville Gate Upgrade
  - Shelvin Park Reinforcement
  - Targeted load management on Baker City and Ontario Projects

2023 IRP Remaining Schedule

Process Items	Process Elements	Date
Draft of 2022 IRP distributed (WA)	Filing of Draft IRP	11/23/2022
Draft of 2022 IRP distributed (OR)	Filing of Draft IRP	1/5/2023
Comments due on draft from all stakeholders (WA)	Comments due from Stakeholders	1/13/2023
Comments due on draft from all stakeholders (OR)	Comments due from Stakeholders	2/24/2023
TAG 6, if needed (WA)	An additional TAG if needed based on comments from Stakholders	2/1/2023
TAG 6, if needed (OR)	An additional TAG if needed based on comments from Stakholders	3/15/2023
IRP filing (WA)	IRP Final Filing	2/24/2023
IRP filing (OR)	IRP Final Filing	4/14/2023

Questions/Next Steps

Review Plans for Draft IRP

- OR Draft IRP will be filed Thursday, January 5
- WA Draft IRP will be filed Wednesday, November 23

Contact Information

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Integrated Resource Plan (OR) Technical Advisory Group Meeting #5

NOVEMBER 9, 2022

MICROSOFT TEAMS/TELECONFERENCE

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