Low Carbon Gas Evaluation Methodology & Emissions Compliance Mechanisms for the 2022 IRP- Technical Working Group

Low Carbon Gas Evaluation Methodology & Emissions Compliance Mechanisms and System Resource Model (IRP-TWG #6)

June 1, 2022

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Forward Looking Statement

This and other presentations made by NW Natural from time to time, may contain forward-looking statements within the meaning of the U.S. Private Securities Litigation Reform Act of 1995. Forward-looking statements can be identified by words such as “anticipates,” “intends,” “plans,” “seeks,” “believes,” “estimates,” “expects,” will and similar references to future periods. Examples of forward-looking statements include, but are not limited to, statements regarding the following: including regional third-party projects, storage, pipeline and other infrastructure investments, commodity costs, competitive advantage, customer service, customer and business growth, conversion potential, multifamily development, business risk, efficiency of business operations, regulatory recovery, business development and new business initiatives, environmental remediation recoveries, gas storage markets and business opportunities, gas storage development, costs, timing or returns related thereto, financial positions and performance, economic and housing market trends and performance shareholder return and value, capital expenditures, liquidity, strategic goals, greenhouse gas emissions, carbon savings, renewable natural gas, hydrogen, gas reserves and investments and regulatory recoveries related thereto, hedge efficacy, cash flows and adequacy thereof, return on equity, capital structure, return on invested capital, revenues and earnings and timing thereof, margins, operations and maintenance expense, dividends, credit ratings and profile, the regulatory environment, effects of regulatory disallowance, timing or effects of future regulatory proceedings or future regulatory approvals, greenhouse gas emissions and modeling related thereto, regulatory prudence reviews, effects of regulatory mechanisms, including, but not limited to, SRRM and the Company’s infrastructure investments, effects of legislation, including but not limited to bonus depreciation and PHMSA regulations, and other statements that are other than statements of historical facts.

Forward-looking statements are based on our current expectations and assumptions regarding our business, the economy and other future conditions. Because forward-looking statements relate to the future, they are subject to inherent uncertainties, risks and changes in circumstances that are difficult to predict. Our actual results may differ materially from those contemplated by the forward-looking statements, so we caution you against relying on any of these forward-looking statements. They are neither statements of historical fact nor guarantees or assurances of future performance. Important factors that could cause actual results to differ materially from those in the forward-looking statements are discussed by reference to the factors described in Part I, Item 1A “Risk Factors,” and Part II, Item 7 and Item 7A “Management’s Discussion and Analysis of Financial Condition and Results of Operations,” and “Quantitative and Qualitative Disclosure about Market Risk” in the Company’s most recent Annual Report on Form 10-K, and in Part I, Items 2 and 3 “Management’s Discussion and Analysis of Financial Condition and Results of Operations” and “Quantitative and Qualitative Disclosures About Market Risk”, and Part II, Item 1A, “Risk Factors”, in the Company’s quarterly reports filed thereafter.

All forward-looking statements made in this presentation and all subsequent forward-looking statements, whether written or oral and whether made by or on behalf of the Company, are expressly qualified by these cautionary statements. Any forward-looking statement speaks only as of the date on which such statement is made, and we undertake no obligation to publicly update any forward-looking statement, whether as a result of new information, future developments or otherwise, except as may be required by law.

Today's Agenda

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- Procedures and Introductions
- RNG Evaluation Methodology and Incremental Cost Calculation
- Lunch Break (12pm-1pm)
- Review of System Resource Planning Model

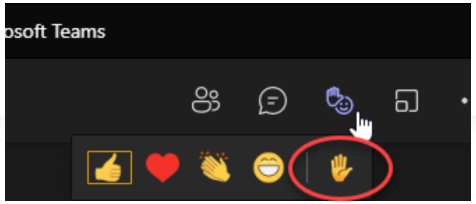
Procedures for Participation

- Please mute your microphones during the presentation, except when commenting and or asking a question
- All participants are muted upon entry into the meeting

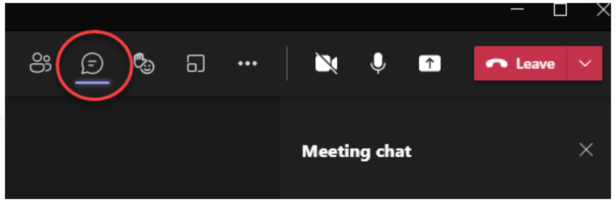
- Cameras are optional and up to each participant to use
- All participant cameras are set to off upon entry into the meeting

- Add a comment or question at any time using the “raised hand” or the chat box

Raised hand function is found in the reactions

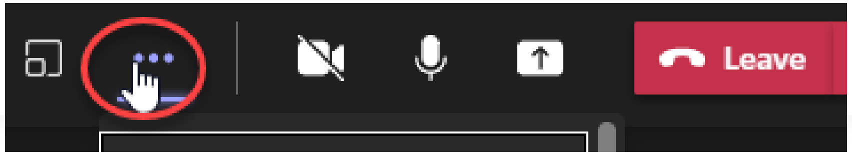


Chat box will open when you click on the conversation bubble



- Microsoft Teams has a live caption function for any participant to use

Click the ellipses, then chose “turn on live captions”



2 Minutes for Safety:

Electrical Safety- in the home & office

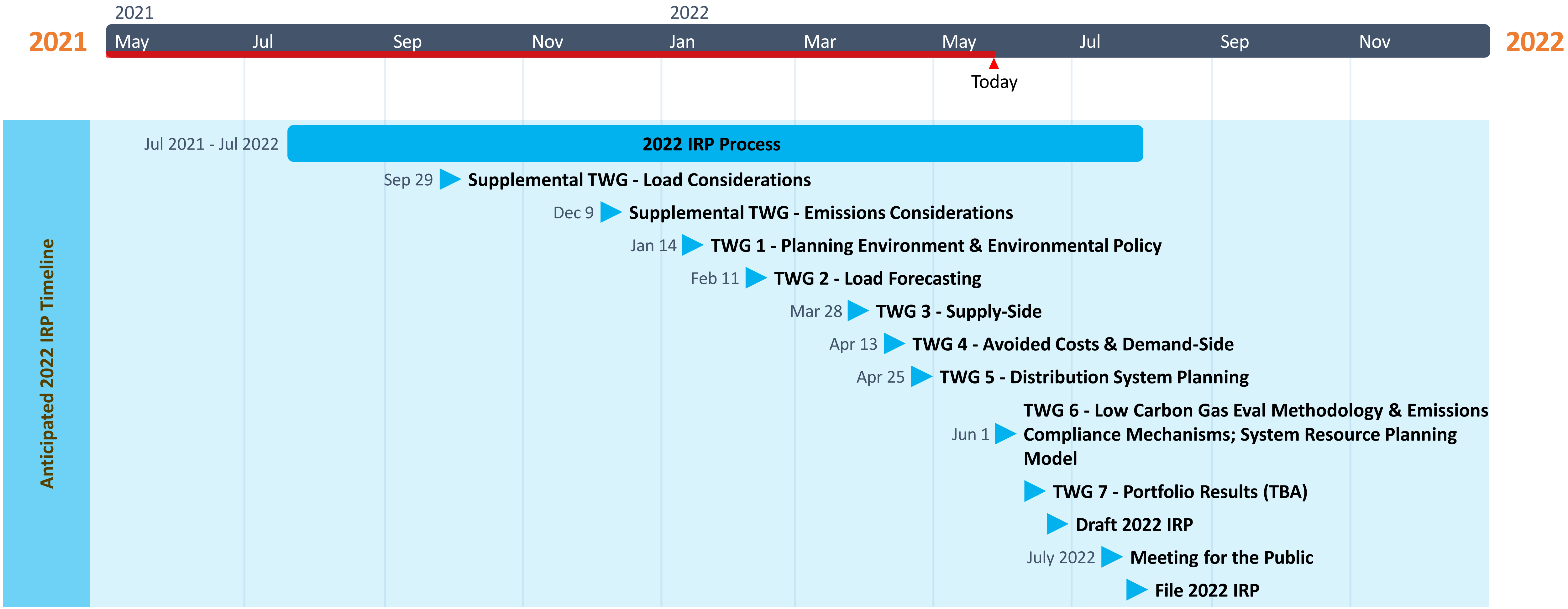
Do:

- Use care with cords – in storage & during use
- Inspect cords regularly for damage & replace frayed, cracked, or otherwise damaged cords
- Use a firm grip when unplugging devices
- Unplug/disconnect appliances when not in use
- Cover/guard exposed electrical components

Don't:

- Overload outlets and circuits
- Run cords in areas where they could become a tripping hazard
- Plug in more than one high-wattage device into an outlet or plug multi-outlet bars or surge protector into other ones
- Use electrical appliances with wet hands &/or near wet surfaces or water
- Ignore the warning signs! (ex. smoke, odor, unusual noise)

2022 IRP Anticipated Timeline



IRP on the NW Natural website

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Find information about NW Natural's IRP on our website

- Integrated Resource Plan page: https://www.nwnatural.com/about-us/rates-and-regulations/resource-planning

Integrated Resource Plan

- Resource planning process +
- IRP working groups & public meetings +
- Current and previous IRPs +
- 2018 IRP - letter from David H. Anderson, NW Natural President and CEO +

Click the tabs to expand each section

IRP working groups & public meetings –

Please feel free to get in touch with us with questions about the IRP, or to be added to a workshop or Technical Working Group (TWG) for our next plan.

All meetings listed below are tentative and subject to change.

Workshops
TBD

2022 IRP Technical Working Groups (TWG)	Date
TWG 1 - Planning Environment and Environmental Policy Presentation - TWG 1 (.pdf) Erratum Notice (.pdf)	January 14, 2022
TWG 2 - Load Forecasting Presentation - TWG 2 (.pdf) Erratum Notice (.pdf)	February 11, 2022
TWG 3 - Avoided Costs and Demand-Side Resources	April 13, 2022
TWG 4 - Supply-Side Resources	March 28, 2022
TWG 5 - Distribution System Planning	April 25, 2022
TWG 6 - Portfolio Results & Actions	May 9, 2022

IRP Process, Objectives, and Evolution

The IRP process is a public process, and we welcome your feedback and participation!

- IRP participants come to the process with varying backgrounds and familiarity with IRP planning, and that is ok! Our IRP benefits from diverse perspectives
- We strive to strike the right balance in terms of the technical material presented, but are always evaluating the appropriate level of detail and might not always get it right

NW Natural's views on scope and role of the IRP:

- Rules and guidelines from the legislature and our regulatory commissions define the scope and purpose of IRPs and are grounded in a least cost-least risk approach to utility resource planning
- IRP rules and guidelines require robust planning that is highly complex and requires advanced modeling techniques and tools that are critical to serving our customers' needs as best we can
- IRPs assess the implications of the policy and market environment and how changes to that environment would impact meeting customer needs
- The IRP process is not a policy *making* process nor the best forum to discuss what policies should (or should not) be adopted

NW Natural acknowledges that IRPs are evolving and the active discussions about the role of IRPs and ways to make the process more inclusive and transparent as well as coordinate work across utilities

- We are proactively looking at ways to improve our IRP process and outreach and are excited to be able to lean on the experience and expertise of the Community and Equity Advisory Group NW Natural is forming moving forward

We value open and constructive discussion and IRP workshops are *LONG* meetings; we are bound to misspeak from time to time and we apologize in advance!

Overview of Previous TWG

TWG #1- Planning Environment & Environmental Policy – Presentation Topics

NW Natural 101: Introduction to NW Natural's IRP

- The IRP team provided an overview of:
  - NW Natural as a Company, including gas purchases, customer types and rate schedules, emissions context, system capacity resources, and distribution system planning options
  - NW Natural's view on the scope and role of the IRP, regulatory basis for IRP process, IRP timelines, least cost-least risk considerations, and the interplay of parts within the Planning Environment which culminate in the Action Plan.
  - Updates on actions since the 2018 IRP and 2018 IRP Update, and new challenges for the 2022 IRP

Planning Environment & Scenario Discussion

- The IRP team reviewed changes in the policy landscape which impact the IRP in either or both OR & WA. Discussed the challenges associated with new policies and the compliance mechanisms associated with each.
- Discussion regarding the development of scenarios and analysis within each. Reviewed scenario analysis used in the 2018 IRP and presented draft scenarios for the 2022 IRP. Stakeholder feedback requested on scenarios by February 4, 2022.

Overview of Previous TWG

TWG #2- Load Forecasting – Presentation Topics

Load Forecasting

- The IRP team discussed the goals, purpose, and framework within which load forecasts are developed, including the differences in the 2022 IRP compared to previous years.
- The TWG focused on understanding several concepts about load forecasting including:
  - When forecasting there is a trade-off between model parsimony and accuracy/precision
  - Historical trends establish our reference case, which is a key starting point for understanding how structural changes to customer growth and stock turnover of end-use equipment impact overall demand
  - The importance for peak planning in IRPs and the trade-off of between costs for reliable service and the risks of resource constraints during an extreme cold event
  - Load uncertainty and an overview of stakeholder feedback on draft scenarios as well as a preview of the draft load forecasts within such scenarios
- The IRP team reviewed the reference case for the expected weather load forecast and the design weather load forecast (inclusive of a cold event and peak day load forecast)
- Each part of load forecast modeling was reviewed with detailed discussion related to each section including the differences between the types of load forecasts.
  - Residential and commercial customer count and use per customer (UPC)
  - Industrial, large commercial, and compressed natural gas (CNG)
  - Accounting for impacts from energy efficiency
  - Total sales and transportation load

Overview of Previous TWG

TWG #3- Supply Side Resources – Presentation Topics

Scenario Feedback

- The IRP team reviewed, at a high level, feedback received from stakeholders on the 2022 IRP scenarios and NW Natural's proposal to utilize the average of simulation draws as the base case to account for uncertainty in load scenarios.

Focus on Supply-side Resources

- Differences and overlap between gas supply capacity and distribution capacity resources
- Existing supply-side resources and an overview of conventional market fundamentals
- Portland LNG contribution to serving current load
  - Overview of the required cold box to continue operations at Portland LNG
  - Overview of alternatives to the cold box to maintain reliable service for current peak day operations
- ICF reviewed and discussed the availability of Renewable Natural Gas (RNG) and hydrogen resources at a national level
- Policy environment and markets for RNG and Hydrogen, as well as current NW Natural projects
- A brief overview of NW Natural's methodology for evaluating the incremental cost of RNG resources

Overview of Previous TWG

TWG #4- Avoided Costs and Demand-Side Resources – Presentation Topics

Avoided Costs

- The first portion of the TWG focused on understanding several concepts about Avoided Costs including:
  - What are avoided costs?
  - Principles of and standard industry approaches to avoided costs
  - Applications of avoided costs in cost-effectiveness evaluations, as well as the components of avoided costs and their associated resource option application
  - Energy and environmental related avoided costs including CPP and CCA compliance costs and calculating GHG price components
  - Risk Reduction Value and commodity price risk reduction costs
  - Infrastructure and capacity avoided costs including their relation to peak load and peak savings
- The IRP team shared avoided cost results by end-use for both OR and WA

OR And WA Conservation Potential Assessment (CPA)

- Energy Trust of Oregon (ETO) presented a section on OR CPA for Sales Customers, including forecast results
- Applied Economic Group (AEG) presented a section on WA CPA for Transport Customers, including draft conservation potential results
- The IRP team reviewed the WA CPA for sales load completed by AEG in 2021 and presented results for CPA for WA Transport Customers also conducted by AEG in 2021

Emerging Technology

- GTI gave a presentation on thermal (gas) heat pumps and the status of new technologies coming to the market for residential and/or commercial customers
- NEEA spoke to market transformation and the partnerships between various organization which can accelerate the adoption of emerging technology

Overview of Previous TWG

TWG #5- Distribution System Planning – Presentation Topics

The IRP team reviewed distribution system planning processes, modeling, and standards as they are applied within the IRP process. This includes the deployment of both "pipeline" and "non-pipeline" solutions. The Technical Working Group focused on:

- Peak Hour Demand: Design of system is based on peak hour customer demand; peak hour load forecast methodology reviewed in detail including how weather is a major driver
- Non-Pipeline Solutions: Such as targeted demand response and the criteria they must meet in order to be an alternative distribution system resource; Criteria includes the ability to serve or reduce load during a peak event
  - There is an important distinction between reductions in overall emissions through statewide demand-side programs vs geographically targeted reduction to peak demand using demand-side non-pipeline solution (e.g., GeoTEE)
  - Outages on the gas system have significant consequences, which includes loss of heat during the coldest times of the year and can last multiple days before being able to return service to all customers
  - This underpins the importance of maintaining reliable service to mitigate risk of outages
- Distribution System Planning (DSP) Objectives: Meeting peak hour requirements, addressing localized system needs, and choose the cost-effective alternative, while accounting for risk
  - NW Natural's (DSP) is in a transition from a "just-in-time" planning process to a forward-looking planning process
  - This transition is assisted by the improvements in system modeling through the Customer Management Module (CMM) project
  - Reviewed system modeling and planning tools and how they work together; SCADA, Synergi Gas, GIS, Electronic Portable Pressure Recorders (EPPRs), and Billing Data;
  - Reinforcement Standards: Including differences in low- and high-pressure systems, and the flow and pressure parameters
- Alternative Analysis: Process for reviewing distribution system resource options
- Geographically Targeted Energy Efficiency (GeoTEE) Pilot: Objectives, timelines, and how to evaluate GeoTEE as a distribution system planning resource option
- Forest Grove Feeder: Proposed system reinforcement project based upon principles and modeling as discussed

Low GHG Gas Evaluation Methodology

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IRP Activities Since Filing 2018 IRP

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IRP Activities Since Filing 2018 IRP

- 2019 — **2018 IRP Recognized to Meet Rules by WUTC**
- 2019 — **2018 IRP Acknowledged by OPUC**
- 2019 — **2018 IRP Update #1 Filed**
- 2019 — **2018 IRP Update #2 Filed**
- 2020 — **2022 IRP Delay Approved by OPUC & WUTC**
- 2021 — **2018 IRP Update #3 TWG**
- 2021 — **2018 IRP Update #3 Draft**
- 2021 — **2018 IRP Update #3 Filed**

2019 | 2019 Jan | May | Sep | 2020 Jan | May | Sep | 2021 Jan | **2021**

Policies Impacting Resource Planning

- 2019 — **WA HB1257 EE Bill Passes**
- 2019 — **OR SB 98 RNG Bill Passes**
- 2020 — **EO 20-04 Issued GHG Order**
- 2020 — **OPUC AR 632 Rules Issued**
- 2020 — **OPUC UM 2030 RNG Methodology Approved**

Renewable Resource Evaluation Methodology History

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- In Oregon and Washington specific resources evaluated in Integrated Resource Plans (IRPs)
- Opportunities to acquire specific RNG resources do not align with infrequent IRP timing
- Low-GHG gas supply resources are evaluated using NW Natural's renewable resource evaluation methodology
  - First proposed in 2018 Integrated Resource Plan (Included as Appendix H in 2018 IRP)
    - Discussed at stakeholder workshops held by NW Natural
    - Deliberated in rounds of comments informed by data request process
  - Methodology updated and approved in Oregon Public Utility Commission (OPUC) Docket No. UM 2030
    - Stakeholder workshops held by Oregon Public Utility Commission
    - Updated proposal presented by NW Natural
    - Further deliberation and rounds of comments and data requests
  - OPUC rules resulting from RNG bill SB 98 require methodology to be updated in each IRP
  - NW Natural is now using methodology to evaluate RNG resources and procuring RNG
  - Small modifications to streamline implementation are being proposed in 2022 IRP

Oregon SB 98 Rules (AR 632)

- OAR 860-150-0200 Incremental Costs
- (1) For the purposes of ORS 757.396, a large natural gas utility must calculate its total incremental annual cost as follows: (a) A large natural gas utility must apply a cost-effectiveness calculation to all RNG that the utility acquires for its retail natural gas customers. The cost-effectiveness calculation must be consistent with the methodology used to evaluate RNG resources in the utility's most recently acknowledged integrated resource plan, or integrated resource plan update, or as the utility may otherwise be directed by order of the Commission;
- (b)-(e) For each purchase of RNG …. the dollar value of the difference between the levelized cost of the purchased RNG and the levelized cost of a … purchase of a comparable quantity of geologic natural gas of the same vintage and contract duration represents the incremental cost of that purchased RNG

Key Aspects of RNG Evaluation Methodology

- Application of numerous resource planning and rate-making concepts and accounting:
  - Comparing resources on a fair and consistent basis
  - Least cost/least risk planning standard
  - Incremental costs
  - Avoided costs
  - Cost of service
  - Levelized costs
  - Accounting for risk/risk-adjustment

Key Terms

- **RNG** = Renewable Natural Gas
  - While this methodology is a way to evaluate all low-GHG sources of gas including biofuels, clean hydrogen and synthetic methane, to avoid using the mouthful "low-GHG gas supply evaluation methodology" we will colloquially refer to the methodology as the RNG methodology in this presentation (noting that definitions for "RNG" sometimes means biofuels and sometimes can include other sources of renewable gases)
- **RTC** = Renewable thermal certificate
  - An RTC is a *sole* claim to the environmental benefits of a decatherm of RNG, separate from the physical gas of RNG (i.e. **unbundled RNG**)
  - Gaseous fuel version of electric REC (renewable energy credit)
- **Bundled RNG** = RNG including the physical gas molecule (i.e. physical gas molecules + RTC)
- **Brown Gas** = The physical gas product from an RNG project where the environmental attributes have been separated and the RTC is not included
  - Note brown gas not RNG even though it comes from an RNG project as the environmental claims are not included. Brown gas is equivalent to conventional gas on the natural gas market
- **Book and Claim Accounting-** recognition that environmental attributes (e.g. RTCs) can be separated from physical product and possession of environmental attribute can be used to deliver sustainable product
  - Relative to RNG this means that "retirement" of an RTC represents delivery of a unit RNG to customers
- **Common Carrier Pipeline**- a pipeline that is connected to the continent-wide natural gas pipeline grid

Project Types of Low-GHG Resources

- There can be many variations of these general groupings of RNG project types:

	RTC Acquired	Attach physical gas to obtain bundled RNG for Incrmental Cost	Sale of "Brown" gas	Avoided Commodity Costs	Avoided Capacity Costs
Unbundled Environmental Attribute (RTC) Purchase	✓	✓			
Bundled RNG Delivered to NW Natural's System	✓			✓	
Bundled RNG with Brown Gas Sales	✓	✓	✓	✓*	
On-System Bundled RNG	✓		✓	✓	✓

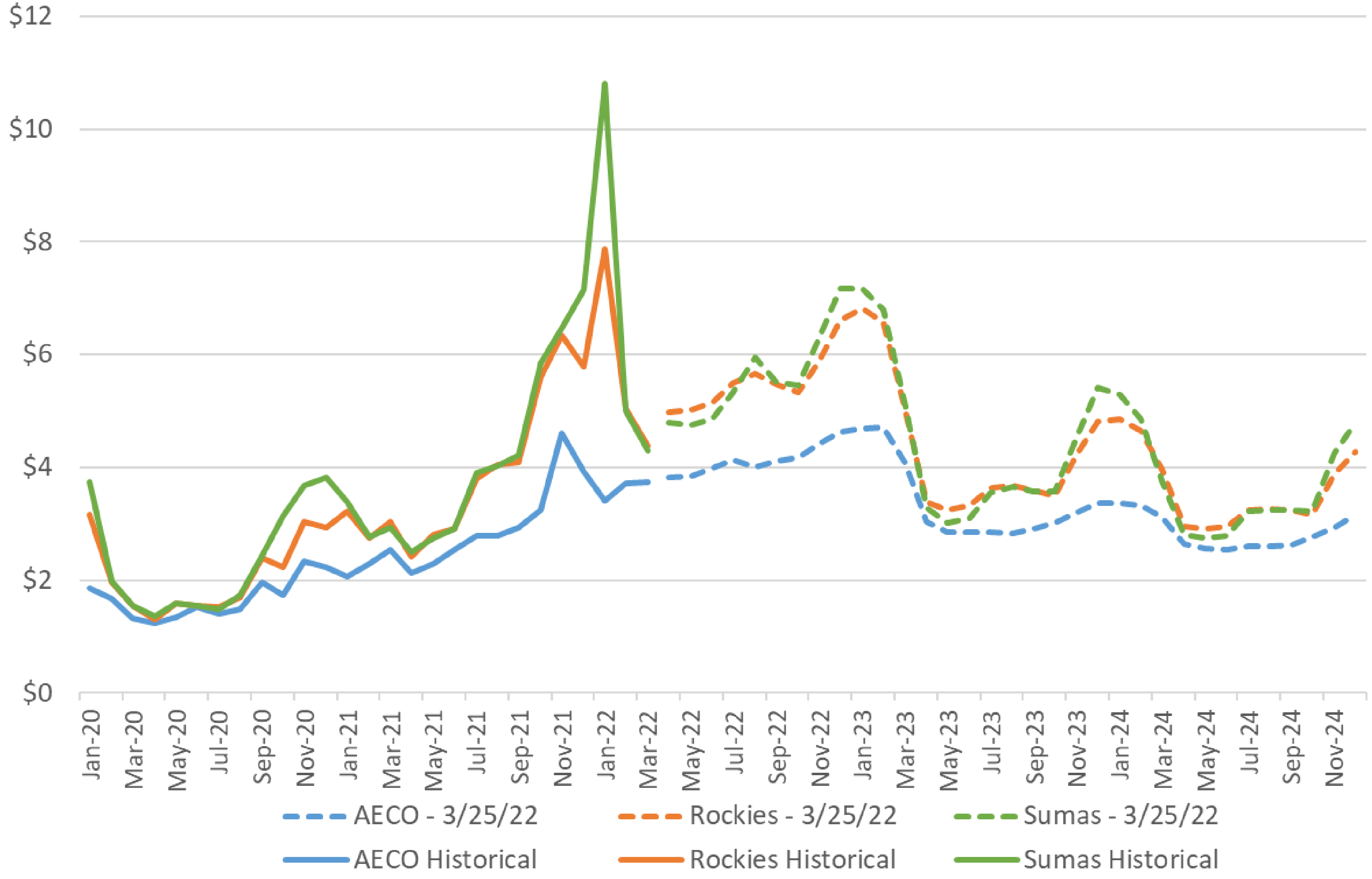
*net impact to customers is the difference between the price of the marginal unit of conventional gas purchased by NW Natural to serve its load and the price of the brown gas sold from the bundled RNG

Avoided Costs Are Applied Consistently

- The avoided costs presented at TWG #4 are used for all resources, including RNG:

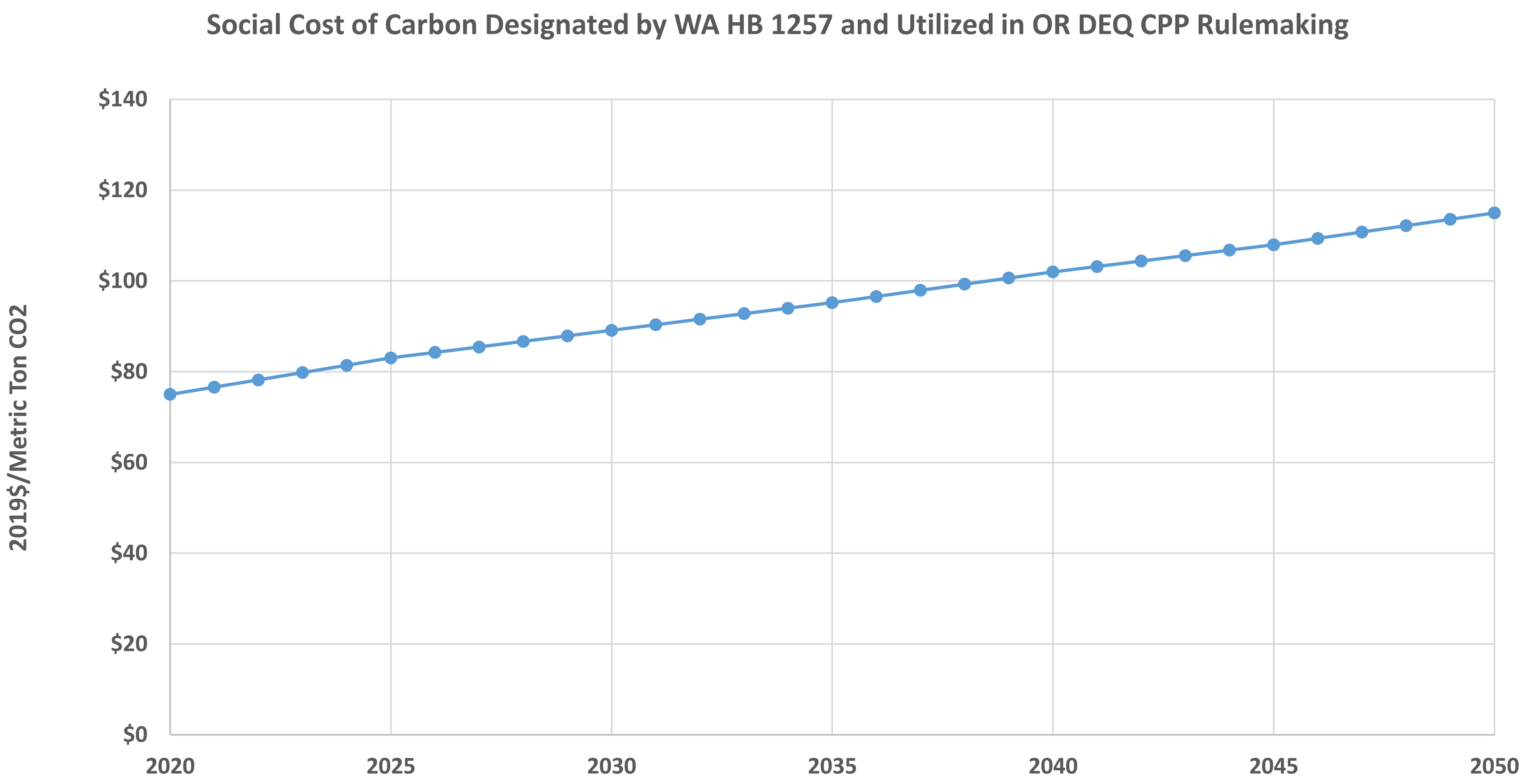
Costs Avoided		Resource Option Application					
		Demand-Side Resources			Supply-Side Resources		
			Demand Response		Low-Carbon Gas Supply		
		Energy Efficiency	Interruptible Schedules	Other DR	On-System Resources	Off-System Resources	Recall Agreements
Commodity Related Avoided Costs	Natural Gas Purchase and Transport Costs	✓			✓	✓	
	Greenhouse Gas Compliance Costs	✓			✓	✓	
	Commodity Price Risk Reduction Value	✓			✓	✓	
Infrastructure Related Avoided Costs	Supply Capacity Costs	✓	✓	✓	✓		✓
	Distribution System Costs	✓	✓	✓	✓		
Unquantified Conservation Costs	10% Northwest Power & Conservation Council Credit	✓			?	?	

Energy and Transport Costs Avoided



Avoided energy costs on each day is the associated with the **marginal** purchase on that day

Avoided Greenhouse Gas Compliance Costs



https://www.utc.wa.gov/regulatedIndustries/utilities/Pages/SocialCostofCarbon.aspx

Infrastructure Costs Avoided with Peak Saving

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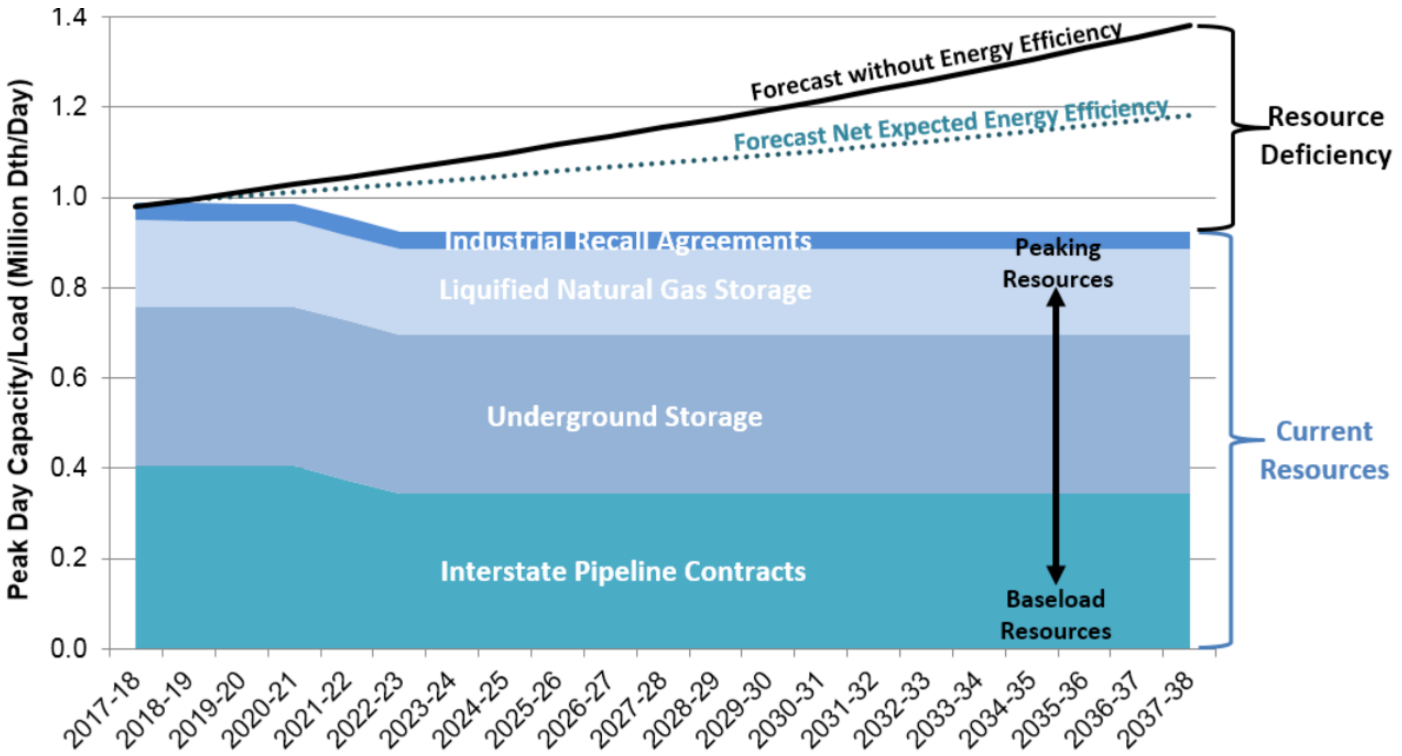
Supply Capacity Resources & Peak Day Forecast (2018 IRP Update)



- Capacity resources are procured based upon peak day (supply capacity) and peak hour (distribution capacity) needs

  Gas injected onto or delivered on the system on a peak day contributes to capacity resource portfolio and avoids infrastructure costs

- Often referred to as a "capacity deferral"

Comparing the Cost of RNG with Conventional Gas

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- **All-in Cost of Gas= Commodity cost of gas + GHG Compliance costs + Supply Infrastructure Costs + Distribution System Capacity Costs**

- The first inclination in comparing the cost of RNG with the cost of conventional gas is to compare the commodity cost of the two types of natural gas
- This is not a complete comparison, as energy, *environmental and capacity costs* should be considered and account for risk
- Comparing the "all-in" cost of different natural gas supply resources is more appropriate
- "All-in" cost represents the total cost to deliver a unit of natural gas to customers (i.e. what customers pay for a unit of gas)
- Comparing the "all-in" cost of different gas resources complies with IRP Guidelines
- Incremental cost of RNG = All-in cost of RNG – All-in Cost of Conventional Gas

Cost Calculations

- In general, "all-in costs" of RNG projects calculated with the following equation:

Annual all-in cost of RNG (R) = Cost of biomethane (M) + Emissions compliance costs (E) – Avoided infrastructure costs (I)

- Calculation will examine the entire lifespan of the project with the simplified equation:

$$R_T = M_T + E_T - I_T$$

Cost (M_T)

Cost/Benefit (E_T)

Benefit* (I_T)

*I_T=0 for Off-system RNG

Detailed Methodology and Tools

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- Summary equation:

$$R_T = M_T + E_T - I_T$$

- Detailed RNG cost equation is with substitution:

$$R_T = X_T - S_T A_T - DH_T + \sum_{t=1}^{365} [P_{T,t} + Y_{T,t}^{RNG} + N^{RNG} G_T] Q_{T,t}$$

All-in Costs

- Compared to the conventional supply:

$$C_T = \sum_{t=1}^{365} [V_{T,t} + Y_{T,t}^{CONV} + N^{CONV} G_T] Q_{T,t}$$

All-in Costs

Commodity Costs

Components Zoomed In

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Term	Units	Description	Source	Project Specific?	Input or Output of Optimization?	Treated as Uncertain?
R	$/Year	Annual all-in cost of prospective renewable natural gas project	Output of RNG evaluation process	Yes	Output	Yes
C	$/Year	Annual all-in cost of conventional natural gas alternative	Output of RNG evaluation process	Yes	Output	Yes
M	$/Year	Annual costs of natural gas and the associated facilities and operations to access it	Output of RNG evaluation process	Yes	Output	Yes
E	$/Year	Annual greenhouse gas emissions compliance costs	Output of RNG evaluation process	Yes	Output	Yes
I	$/Year	Annual infrastructure costs avoided with on-system supply	Output of RNG evaluation process	Yes	Output	Yes
Q	Dth	Expected or contracted daily quantity of RNG supplied by project	Project evaluation or RNG supplier counterparty	Yes	Input	If no contractual obligation
P	$/Dth	Contracted or expected volumetric price of RNG	Project evaluation or RNG supplier counterparty; Max cost-effective price determined in SENDOUT if NWN initiating negotiations	Yes	Input if responding to offer, Output if NWN initiating offer	If no contractual obligation
T	Year	Year relative to current year, where the current year T = 0, next year T = 1, etc.	Project evaluation or RNG supplier counterparty	Yes	Input if responding to offer, Output if NWN initiating offer	If no contractual obligation
k	Year	When the RNG purhcase starts in # of years in the future; k = RNG start year - current year	Project evaluation or RNG supplier counterparty	Yes	Input if responding to offer, Output if NWN initiating offer	If no contractual obligation

Components Zoomed In

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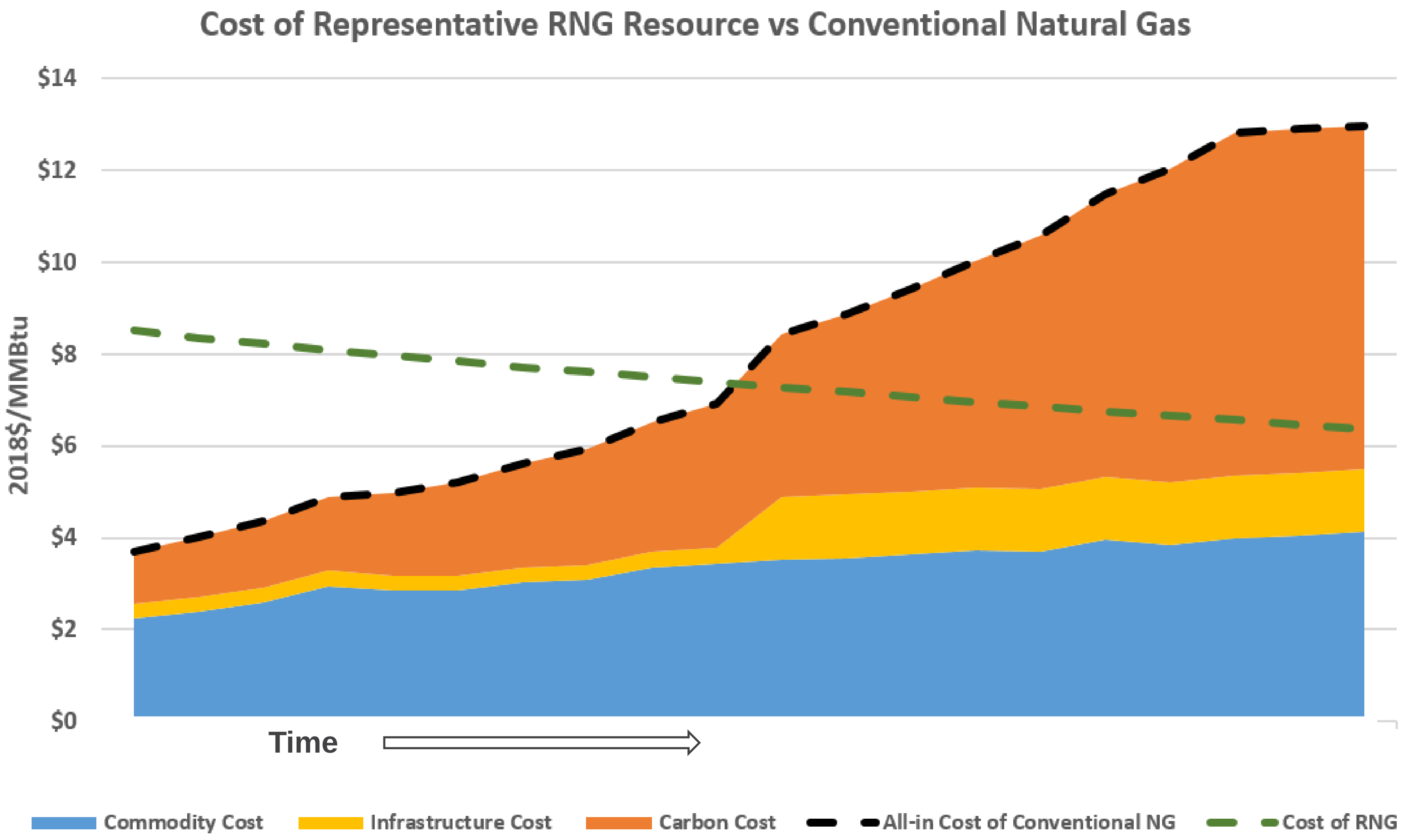
Term	Units	Description	Source	Project Specific?	Input or Output of Optimization?	Treated as Uncertain?
z	Years	Duration of RNG purchase in years	Project evaluation or RNG supplier counterparty	Yes	Input if responding to offer, Output if NWN initiating offer	If no contractual obligation
t	Days	Day number in year ***T*** from 1 to 365	N/A	No	Input	No
V	$/Dth	Price of conventional gas that would be displaced by RNG project	Average price of last ***Q*** quantity of conventional gas dispatched in SENDOUT run without RNG project	Yes	Output	Yes
Y	$/Dth	Variable transport costs to deliver gas to NWN's system; superscripted with R for RNG	*For off-system RNG* - based upon geographic location of project; *For conventional gas* - determined from last gas dispatched in SENDOUT	Yes	Output	No
X	$/Year	Annual revenue requirement of capital costs to access resource	Engineering project evaluation or RNG supplier counterparty	Yes	Input	If no contractual obligation
N	TonsCO_2e /Dth	Greenhouse gas intensity of natural gas being considered	From actual project certification if available, from California Air & Resources Board by biogas type if no certification has been completed	Yes	Input	No
G	$ /TonCO_2e	Volumetric Greenhouse gas emissions compliance costs/price	Expected greenhouse gas compliance costs from the most recently acknowledged IRP	No	Input	Yes
S	$/Dth	System supply capacity cost to serve one Dth of peak DAY load	Calculated within SENDOUT based upon marginal supply capacity resource that is being deferred using Base Case resource availability from the last IRP	No	Output	Yes
A	Dth	Minimum natural gas supplied on a peak DAY by project	Project evaluation or contractual obligation from RNG supplier counterparty	Yes	Input	If no contractual obligation
D	$/Dth	Distribution system capacity cost to serve one DTH of peak HOUR load	Distribution system cost to serve peak hour load from avoided costs in most recently acknowledged IRP	No	Input	No
H	Dth	Minimum natural gas supplied on a peak HOUR by project	Project evaluation or contractual obligation from RNG supplier counterparty	Yes	Input	If no contractual obligation
d	% rate	Discount Rate	Discount rate from most recently acknowledged IRP	No	Input	No

Comparing RNG vs Conventional Gas Costs: Accounting for Time



Incremental Cost: Accounting for Risk

- Mathematically, the incremental cost of the RNG project is represented by:

$$\boldsymbol{Incremental\ Cost(IC) = PVRR(R) - PVRR(C)}$$

- PVRR = present value of revenue requirement
- While the base case estimate of incremental cost is the best estimate of the cost of the project and is used for RNG portfolio cost estimates and SB 98 compliance filings, prospective projects are compared for decision making using risk-adjusted incremental costs

Accounting for Risk Cont.

- Stochastic simulation (Monte Carlo) is used to estimate 500 incremental costs for each RNG project
- NW Natural's risk-adjusted metric based upon assumption that customers are risk-averse in terms of their utility bills
- RALIC = [Base Case IC x 0.75] + [95^{th} Percentile IC x 0.25]

Risk-Adder

- RALIC= Risk-adjusted Levelized Incremental Cost
- Prospective projects are compared against each other using first-year RALIC (FYRALIC) for decision making purposes
- Note it is always the case the RALIC > IC
- It is not always possible to

Risks Accounted for in RNG Methodology

- There are two main types of risks for NW Natural's customers
  1. Market Risks
  2. Policy Risks

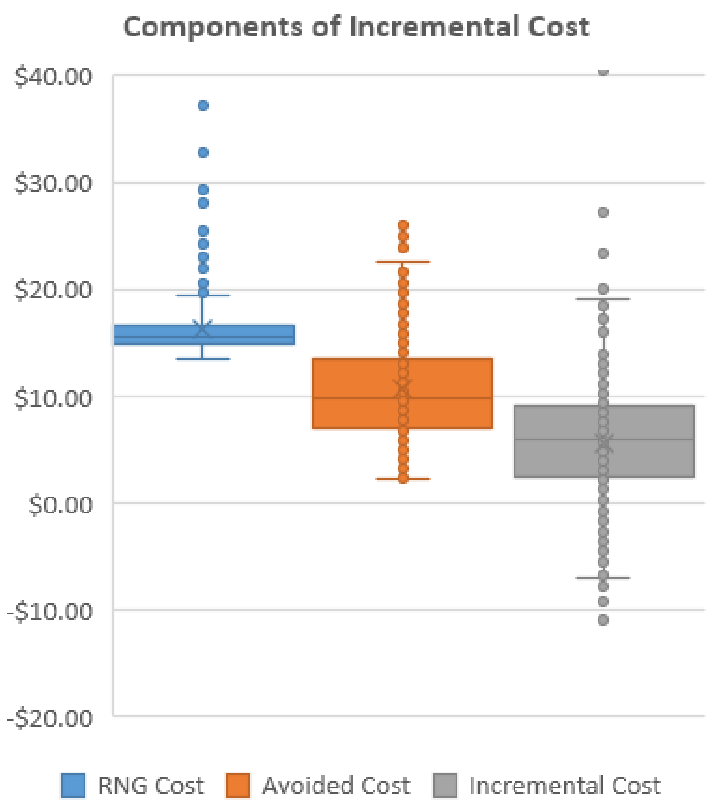
Market risks are easier to quantify and include:

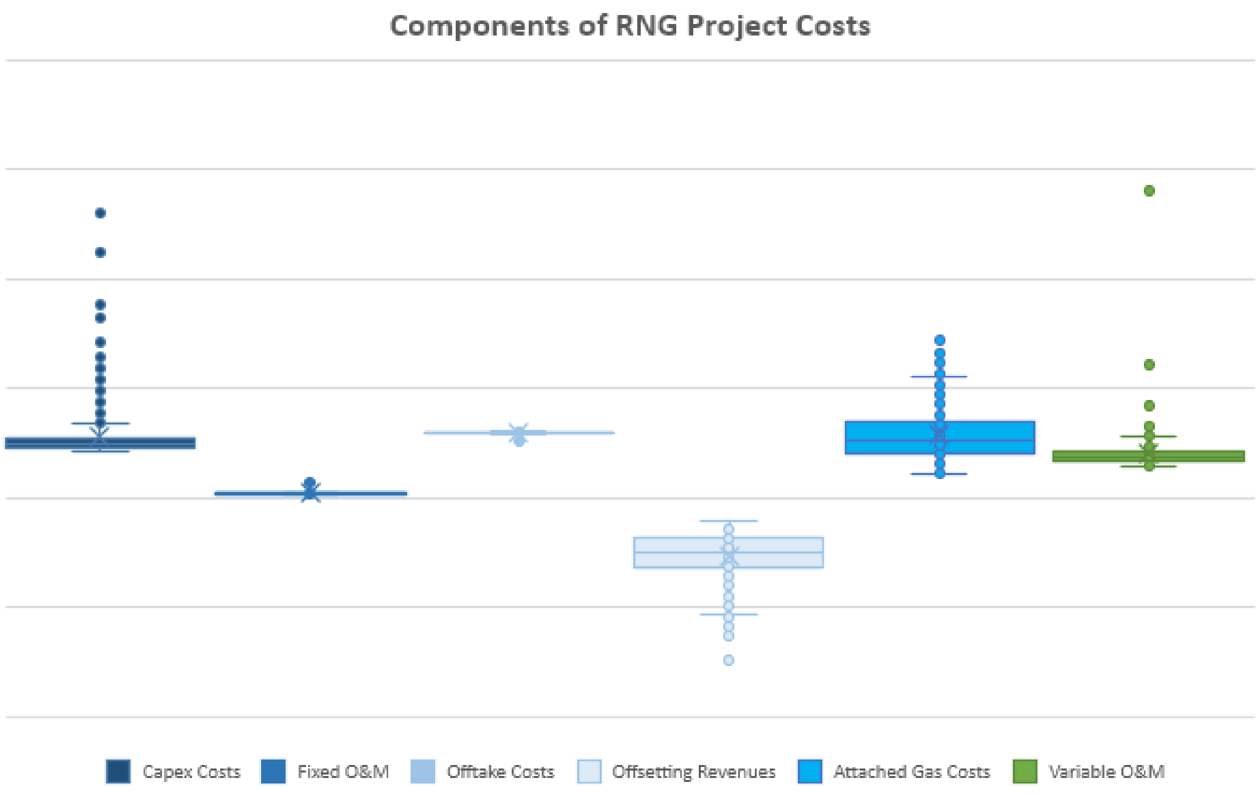
		Risk	Source of Base Case	Source of Risk Distribution
Market Risks	RNG Project	RNG Volumes/Production	Contract/Renewables Team	Renewables Team
		Project Delay	Contract/Renewables Team	Renewables Team
		Early Project Closure	Contract/Renewables Team	Renewables Team
		Capital Investment Costs	Contract/Renewables Team	Renewables Team
		Price of Brown Gas Sales	3rd Party Consultant	Historic Data per IRP
		Biogas Supply/Offtake Price	Contract/Renewables Team	Renewables Team
		Fixed O&M Costs	Contract/Renewables Team	Renewables Team
		Variable O&M Costs	Contract/Renewables Team	Renewables Team
	Avoided Costs	Price of Conventional Gas	3rd Party Consultant	Historic Data per IRP
		GHG Compliance Costs	CPP and CCA Rules Forecast	Scenarios per IRP
		Capacity Costs	Avoided Costs in IRP	Historical Data

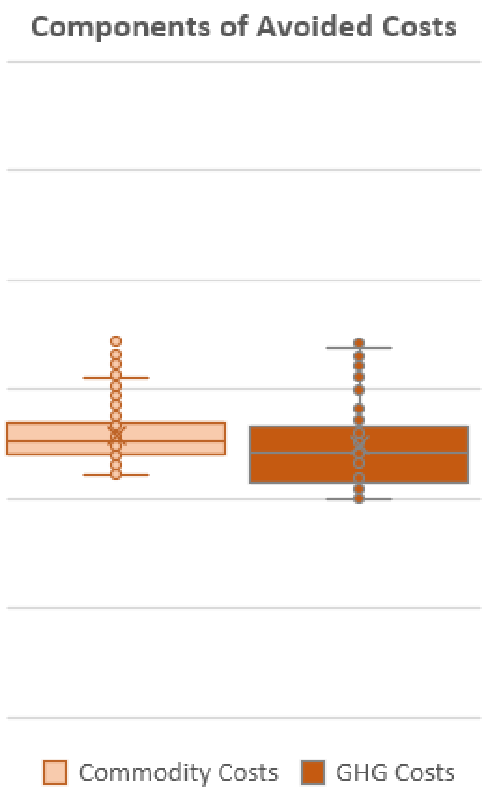
- Unresolved policy decisions also represent risk to NW Natural customers and are generally around complicated issues regarding "carbon" accounting

Accounting for Uncertainty

All components that are not contractually obligated are treated as uncertain







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Methodology Implementation

- Key Questions:
  - How do we align the evaluation methodology with a RNG resource decision process that works in the RNG market?
  - How do compare potential RNG resources while maintaining an updated comparison that is on an apples-to-apples basis?
- The Low-GHG Gas Supply Resource Incremental Cost Evaluation Model was developed to apply the concepts just discussed and align with RNG resource decision making while allowing for many resources to be evaluated and compared at any given time

RNG Evaluation Methodology in Practice- Model Demonstration

NW Natural®

Yellow cells Indicate cells that need to be populated for each project by the Renewables team
Green cells indicate key outputs
Project Name
Spreadsheet Modeler
Project Description
$30 million capex
Source of Project Inputs
Modeler Direction Attestation
I have read the directions and notes.
Type of Project
RNG with Sale of Brown Gas - Choose Sales Hub
Brown Gas Sales Trading Hub
SoCaliforniaBorder

Incremental Cost ($/Dth)		
1st Year Levelized (Base Case)	$4.11	
1st Year Risk-Adjusted Levelized	$6.28	
Sensitivity Based Upon CI	$7.31	
Sensitivity w/ No Carbon Price	$10.52	
Avg Share of Revenue Req	0.24%	
1st Year Share of Revenue Req	0.66%	
Other Important Results		
Average Share of Sales Load	0.85%	
Average Cost of RNG	$14.75	
Carbon Intensity (g CO2e/MJ)		
Expected CI of Project	28	
Risk Analysis Key Inputs		
RNG Volume Uncertainty		
Annual Prob RNG Supply Ceases	0.5%	
Prob of Delay (1 and 2 year	30%	5%
% Δ From Base Case	5th %	95th %
Project Volume Output	-20%	10%
Project Cost Uncertainty		
% Δ From Base Case	5th %	95th %
Carbon Intensity	-15%	15%
Payments to Investments	-5%	30%
Other non-output costs	-3%	5%
Non-offtake Variable Costs	-20%	30%
Offtake/Biogas Price	0%	0%
Other Offsetting Revenues	-12%	30%

Project Costs- In Terms of Revenue Requirement to be Put in Rates (Nom $)							
Year	Payments to Invesements (e.g. equipment capex)	Other Costs that do not vary with output (e.g. fixed O&M)	Non-Offtake Output Dependent Variable Costs	Offtake or Biogas Purchase Price ($/Dth)	Offsetting Revenues: Brown Gas	Offsetting Revenues: Other	Total Revenue Requiremen
2021							
2022							
2023	2,076,593	$250,000	$2,500,000	$5.00	$1,739,088		$5,837,505
2024	3,919,444	$250,000	$2,500,000	$5.10	$1,936,081		$7,538,364
2025	3,787,534	$250,000	$2,500,000	$5.20	$2,058,865		$7,339,769
2026	3,659,930	$250,000	$2,500,000	$5.31	$2,153,042		$7,175,210
2027	3,536,311	$250,000	$2,500,000	$5.41	$2,171,319		$7,091,680
2028	3,416,378	$250,000	$2,500,000	$5.52	$2,261,673		$6,940,927
2029	3,299,854	$250,000	$2,500,000	$5.63	$2,623,704		$6,804,637
2030	3,186,484	$250,000	$2,500,000	$5.74	$2,809,537		$6,573,004
2031	3,074,875	$250,000	$2,500,000	$5.86	$2,935,382		$6,404,471
2032	2,963,517	$250,000	$2,500,000	$5.98	$2,949,071		$6,349,724
2033	2,852,160	$250,000	$2,500,000	$6.09	$3,016,184		$6,242,960
2034	2,740,803	$250,000	$2,500,000	$6.22	$3,110,684		$6,110,242
2035	2,629,445	$250,000	$2,500,000	$6.34	$3,843,037		$6,133,784
2036	2,518,088	$250,000	$2,500,000	$6.47	$3,967,983		$5,989,429
2037	2,406,731	$250,000	$2,500,000	$6.60	$3,974,298		$5,965,543
2038	2,295,373	$250,000	$2,500,000	$6.73	$4,253,165		$5,670,981
2039	2,184,016	$250,000	$2,500,000	$6.86	$4,671,741		$5,238,623
2040	2,072,659	$250,000	$2,500,000	$7.00	$4,929,514		$4,969,020
2041	1,961,301	$250,000	$2,500,000	$7.14	$4,957,928		$4,930,766
2042	1,849,944	$250,000	$2,500,000	$7.28	$5,260,172		$4,620,713
2043							
2044							
2045							
2046							
2047							

Project RNG Volumes	
Year	Dth/Year
2021	
2022	
2023	550,000
2024	550,000
2025	550,000
2026	550,000
2027	550,000
2028	550,000
2029	600,000
2030	600,000
2031	600,000
2032	600,000
2033	600,000
2034	600,000
2035	725,000
2036	725,000
2037	725,000
2038	725,000
2039	725,000
2040	725,000
2041	725,000
2042	725,000
2043	
2044	
2045	
2046	
2047	

Year	Incremental Cost For Filing in Year X ($/Dth)	Share of Sales Load (%)	Incrementa l Share of Rev Req (%)
2021			
2022			
2023	$4.11	0.756%	0.45%
2024	$3.96	0.750%	0.66%
2025	$3.55	0.746%	0.61%
2026	$3.14	0.743%	0.56%
2027	$2.73	0.739%	0.53%
2028	$2.31	0.737%	0.49%
2029	$1.87	0.802%	0.41%
2030	$1.50	0.800%	0.36%
2031	$1.13	0.798%	0.32%
2032	$0.76	0.795%	0.29%
2033	$0.36	0.795%	0.26%
2034	-$0.06	0.793%	0.22%
2035	-$0.50	0.959%	0.10%
2036	-$0.81	0.957%	0.06%
2037	-$1.14	0.957%	0.04%
2038	-$1.52	0.957%	-0.02%
2039	-$1.91	0.956%	-0.09%
2040	-$2.21	0.955%	-0.14%
2041	-$2.47	0.957%	-0.16%
2042	-$2.83	0.957%	-0.21%
2043			
2044			
2045			
2046			
2047			

System Resource Planning Model – PLEXOS

Resource Venn Diagram

NW Natural®

Demand-side Resources

Resources that reduce annual, seasonal or peak demand or annual compliance obligations

PLEXOS

Supply-side Resources

Resources that provide annual, seasonal or peak natural gas deliveries or emissions compliance credits to customers

Gas Supply Resources

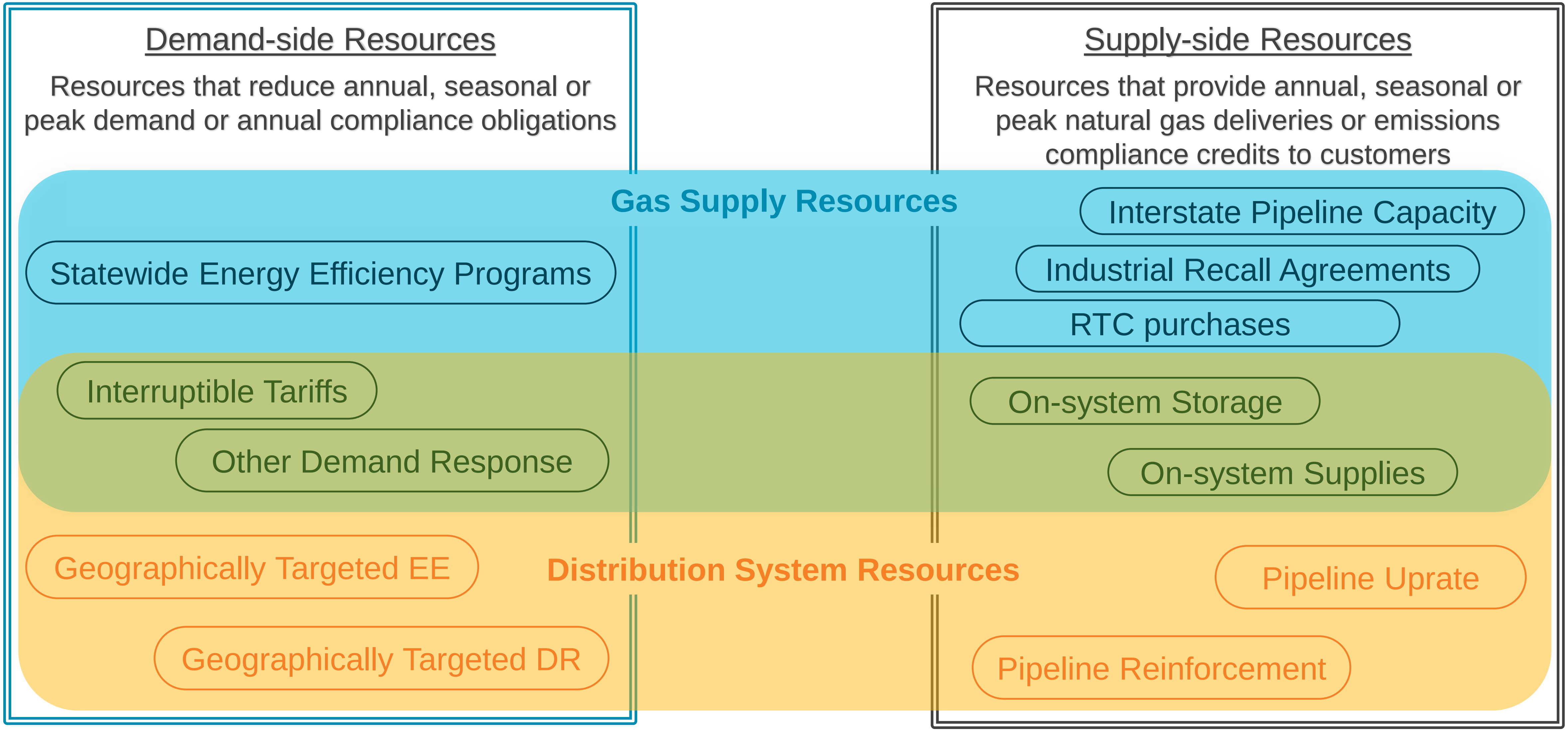
Demand-side or supply-side resources required to provide energy services and emissions compliance for all NW Natural customers across the whole system

Gas Supply/Distribution System Resource Overlap

Distribution System Resources

Demand-side or supply-side distribution resources required to provide energy services to NW Natural customers in a specific area on NW Natural's distribution system

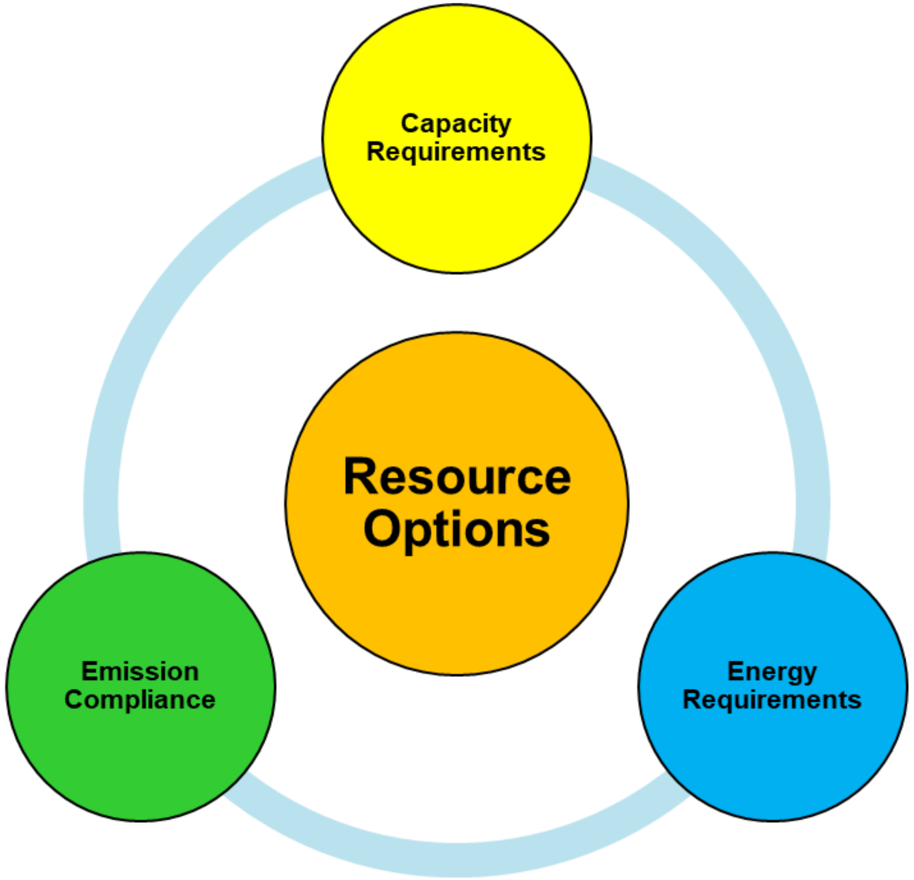
Resource Venn Diagram



Not an Exhaustive List of Resources

Resource Portfolio Selection Under Emissions Compliance

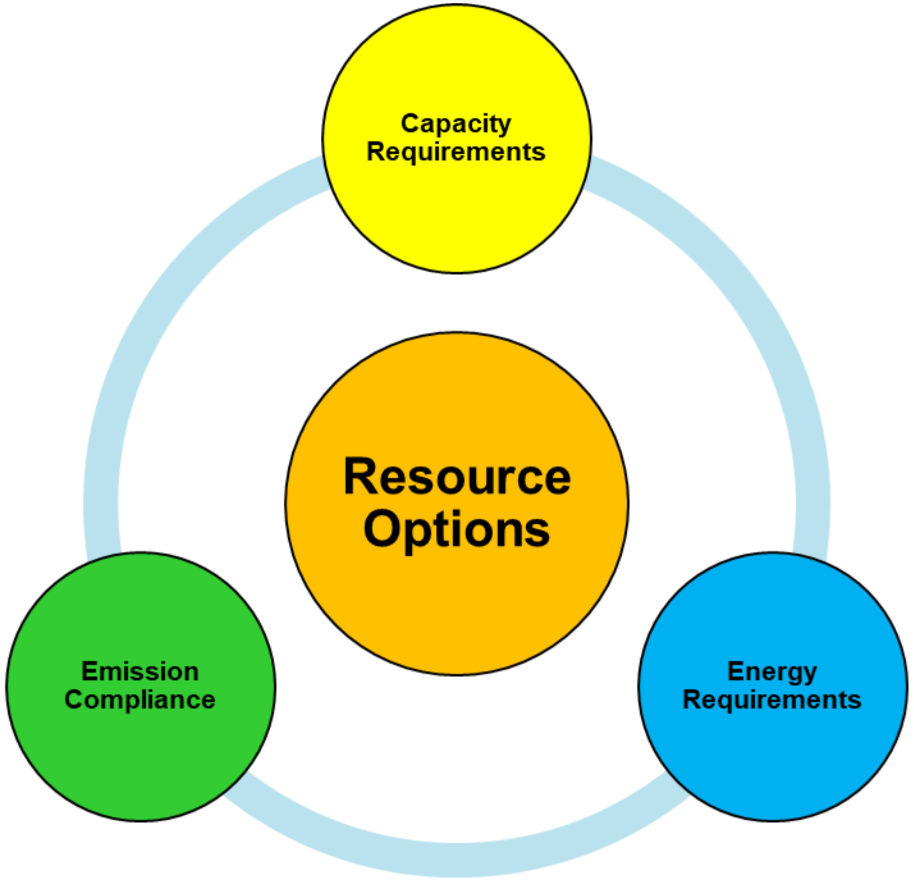
- Previous IRPs we needed to plan for capacity and energy requirements
  - Historically, the capacity requirement was the primary driver for resource acquisition
- Now NW Natural will need to plan resources for emissions compliance for the Climate Protection Plan (CPP) in Oregon and the Climate Commitment Act (CCA) in Washington
- Modeling for carbon compliance is <u>not</u> new to this IRP
  - NW Natural has modeled carbon compliance as a carbon adder to the price of conventional gas for several IRPs
  - This IRP is the first time we've modeled emissions compliance as a <u>quantity</u> constraint on emissions from conventional natural gas



Resource Portfolio Selection Under Emissions Compliance

Type of Requirement	Load Forecast
Emissions Compliance	Plan resources based on expected weather annual load forecast
Capacity Requirement	Plan resources based on design peak day load forecast
Energy Requirement	Plan resources based on design weather annual load forecast

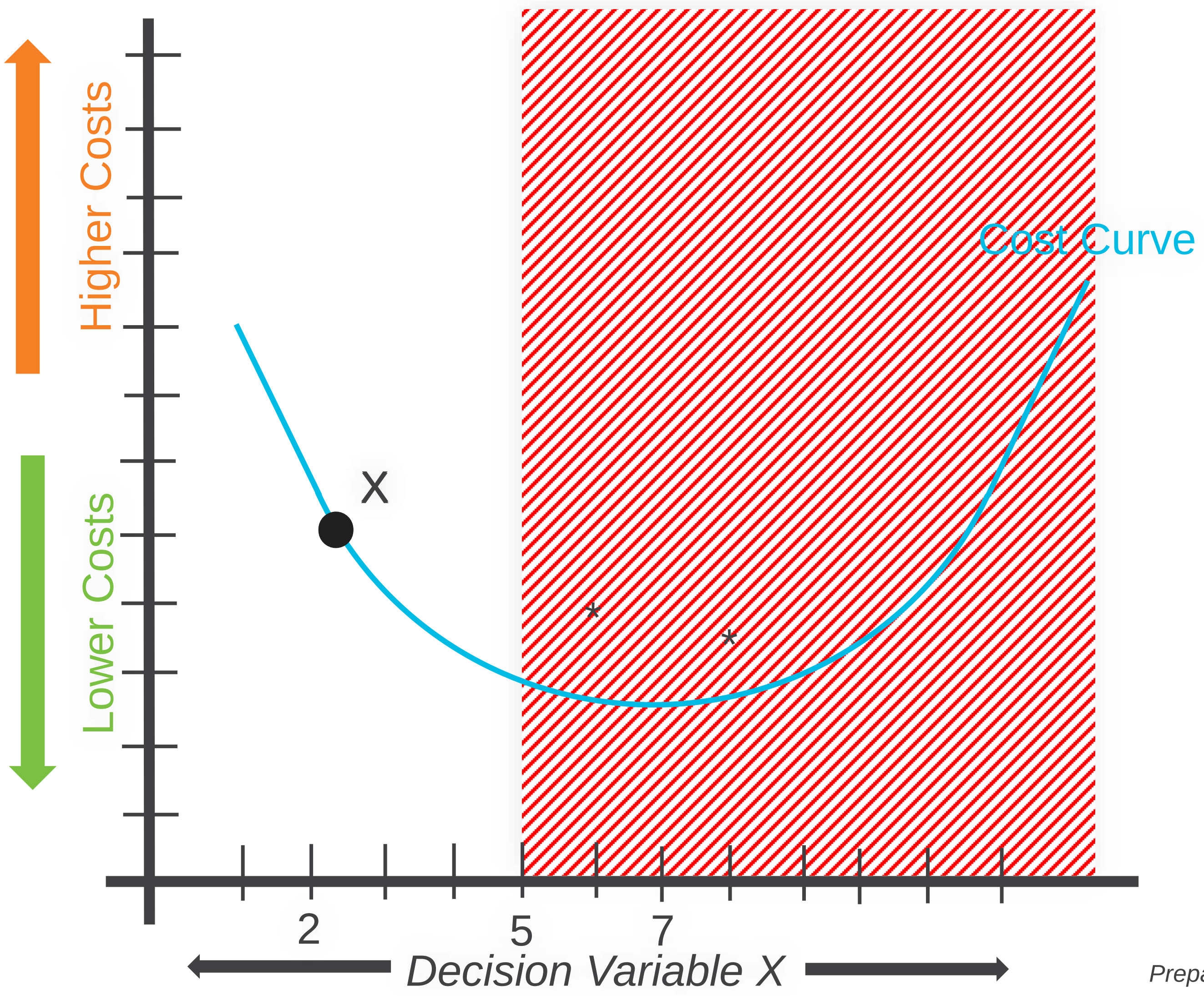
- In previous IRPs, the capacity requirement was the primary driver for resource acquisition
- Resource acquisition for emissions compliance will be another primary driver and a major focus for this IRP
- In order to ensure the model selects resources, which will comply with Oregon's and Washington's emissions targets and be able to meet the capacity requirements for peak demand, we are using expected weather load forecast, but inserting the single peak day demand on February 3rd for each year
- We will use design weather load forecast to test for energy adequacy and if the resource plan raises any annual energy requirements concerns, especially within the Action Plan window of the IRP



PLEXOS

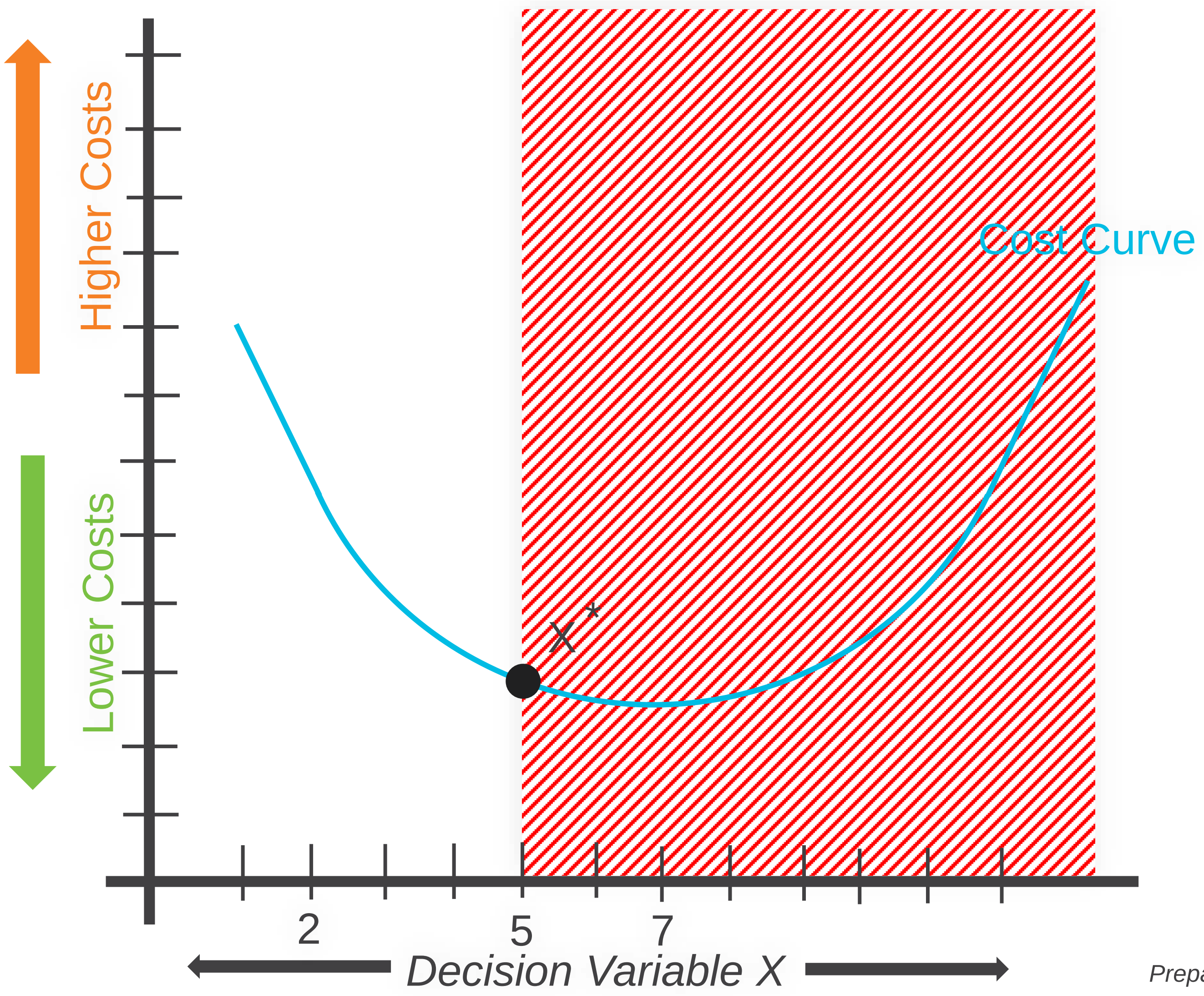
- Software owned and licensed by Energy Exemplar
  - Same company that owns and licenses Aurora software, often used by electric utilities for dispatch analysis
- Sophisticated software that implements *Operations Research* techniques (e.g., linear and non-linear programming) for constrained optimization
- Uses computer algorithms to solve for the optimal dispatch of resources, which minimizes the net present value costs over a specified planning horizon
- PLEXOS is replacing SENDOUT for NW Natural's IRP
  - PLEXOS has the flexibility needed to model emissions compliance with the CPP and CCA
  - Energy Exemplar issues updates to the PLEXOS software on a regular basis and provides reliable technical and modeling support, and expertise

2-Dimensional Constrained Optimization



- Costs are a function of a decision (X); therefore, a cost curve exists that varies depending on the value of X that you choose
- We can minimize cost along the cost curve by adjusting the decision variable X
- Costs are minimized when we choose X=7
- However; we may face a constraint
  - Model is subject to: X ≤ 5
- Then in this simple model with one decision variable and one constraint, costs will be minimized at X=5

2-Dimensional Constrained Optimization



- In the PLEXOS model decision variables include:
  - Daily amount of gas (conventional, RNG, or compliance credits) to purchase at each available location
  - Daily amount of gas to inject or withdraw from storage assets
  - Daily decisions to build additional resources needed to meet demand requirements
- There are roughly 40,000 decision variables for storage decisions alone over the IRP planning horizon
  - [4 facilities **x** 365 days **x** 28 years]
- The PLEXOS Model contains hundreds of thousands decision variables and 100 times as many more constraints
- Requires computer algorithms to solve these complex constrained optimization problems
  - The algorithms that are being implemented through the software are not unique to PLEXOS or even the energy industry

PLEXOS

NW Natural®

Objective Function:

$$Minimize \sum NPV(Cost_t)\ \forall\ daily\ costs\ t = [2022 - 2050]$$

Subject To:

- Demand is met
- Pipeline Constraints
- Storage Constraints
- Supply Constraints
- Emissions Constraints

Decisions Variables

- How much RNG, hydrogen, synthetic methane and conventional gas is bought and where it is bought
- Acquisition of resources required to serve demand
- Storage operations (injections and withdrawals)

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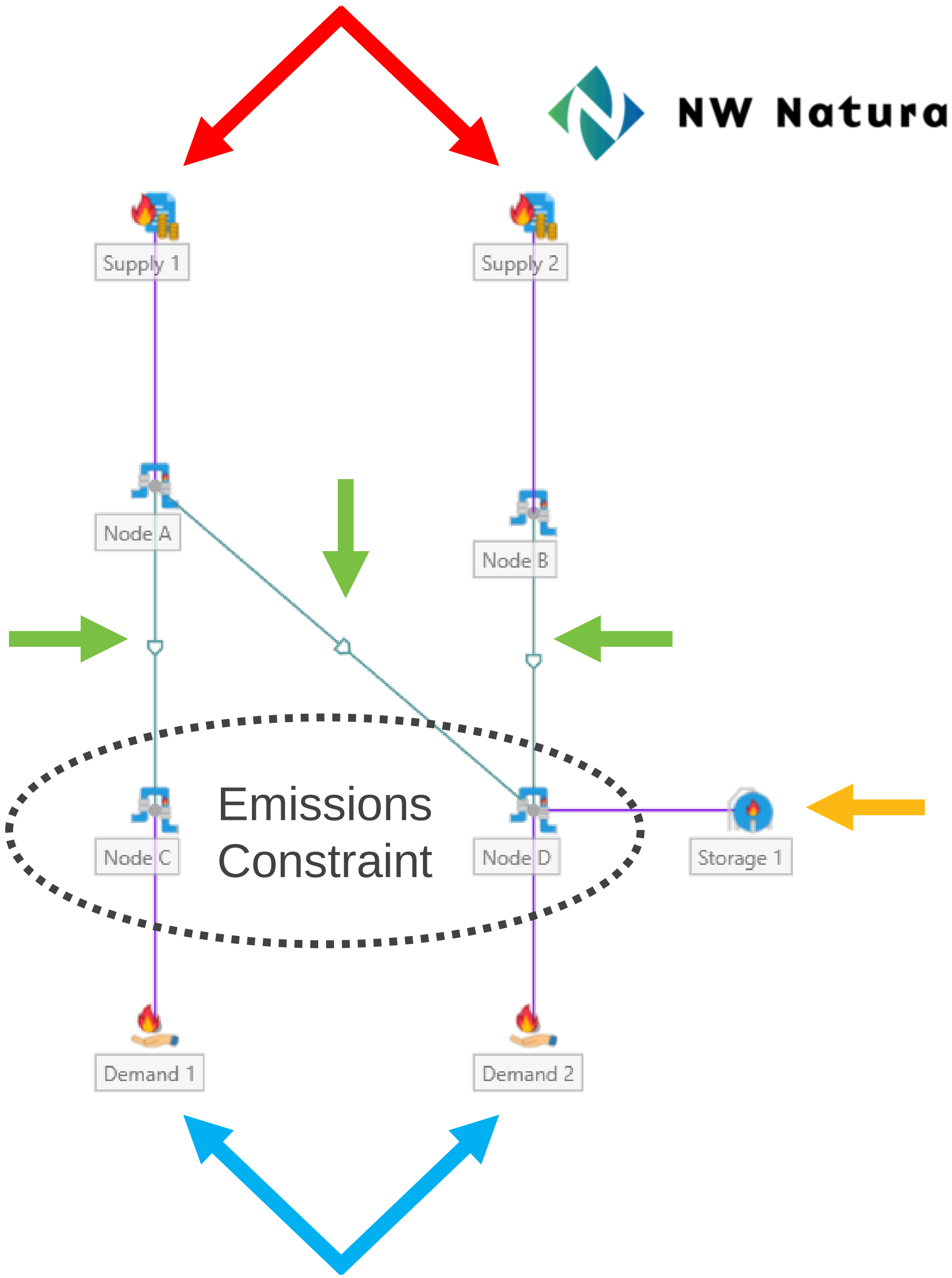
PLEXOS Simple Model

- PLEXOS models NW Natural's system resources through a network model consisting of four primary objects
  - Supply contracts
  - Pipelines
  - Storage Facilities
  - Demand Areas
- These 4 objects must be linked in the model by a fifth object called "Nodes"
- Nodes can be thought of as geographic locations
- Emissions constraints can be applied to gas flowing through any one node or an aggregate of multiple nodes in the model



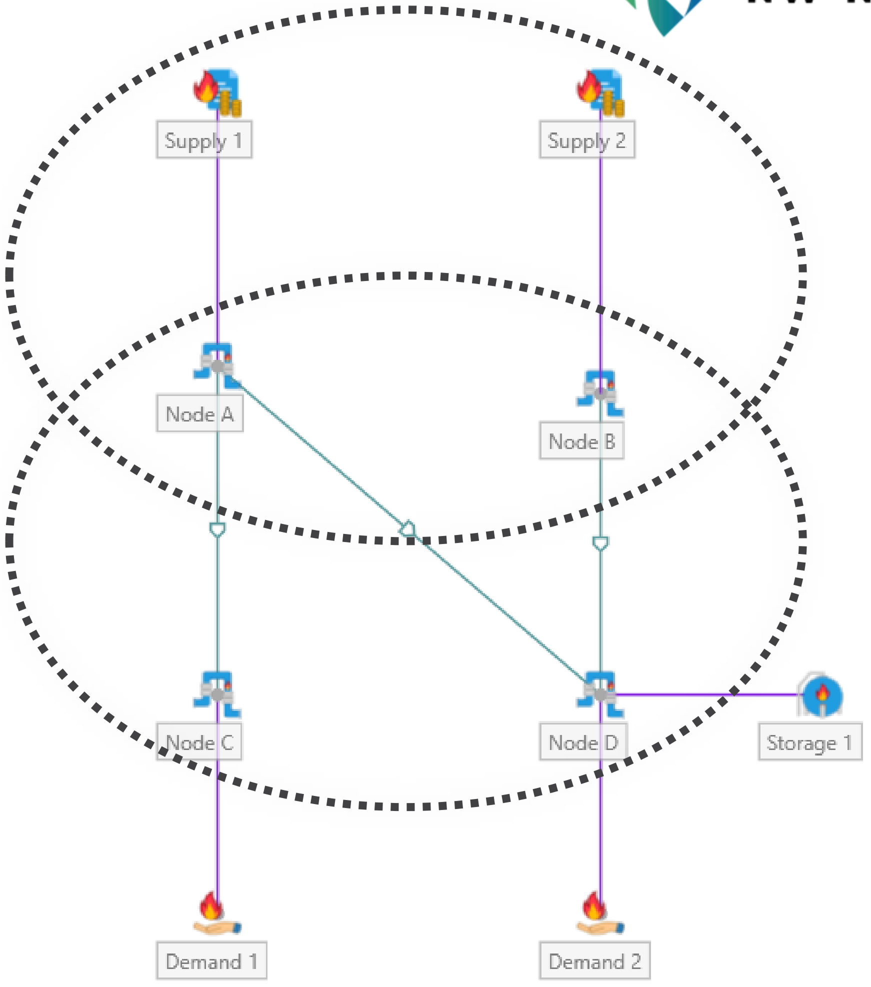
PLEXOS Simple Model

In this simple model gas can be purchased from:

- “Supply 1” and put into the system at “Node A”; ***or***
- “Supply 2” and put into the system at “Node B”

3 Pipelines are modeled as directional and

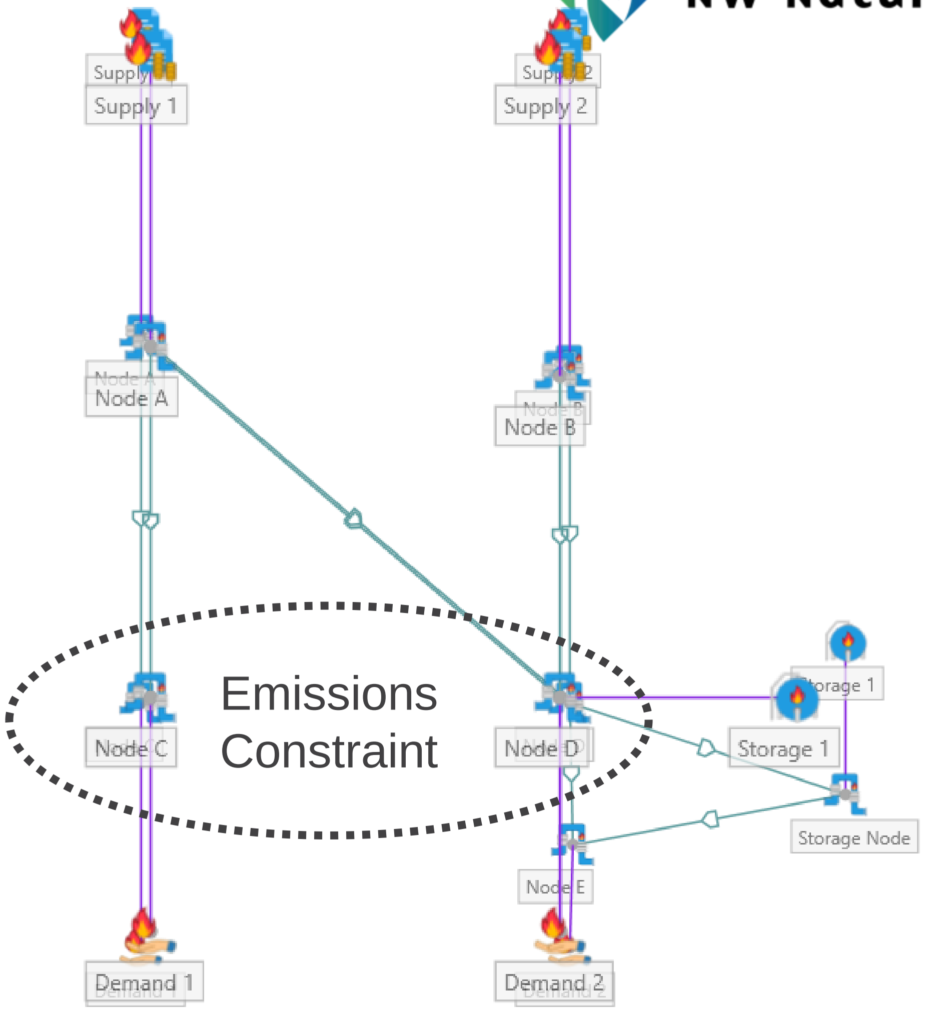
- connect Node A to both Node C and Node D; ***and***
- connect Node B to only Node D
  - Gas from Supply 1 can serve both Demand 1 and 2 and inject into Storage 1
  - Gas from Supply 2 can serve only Demand 2 and inject into Storage 1
  - Gas withdrawn from Storage can only be used to serve Demand 2



PLEXOS Simple Model

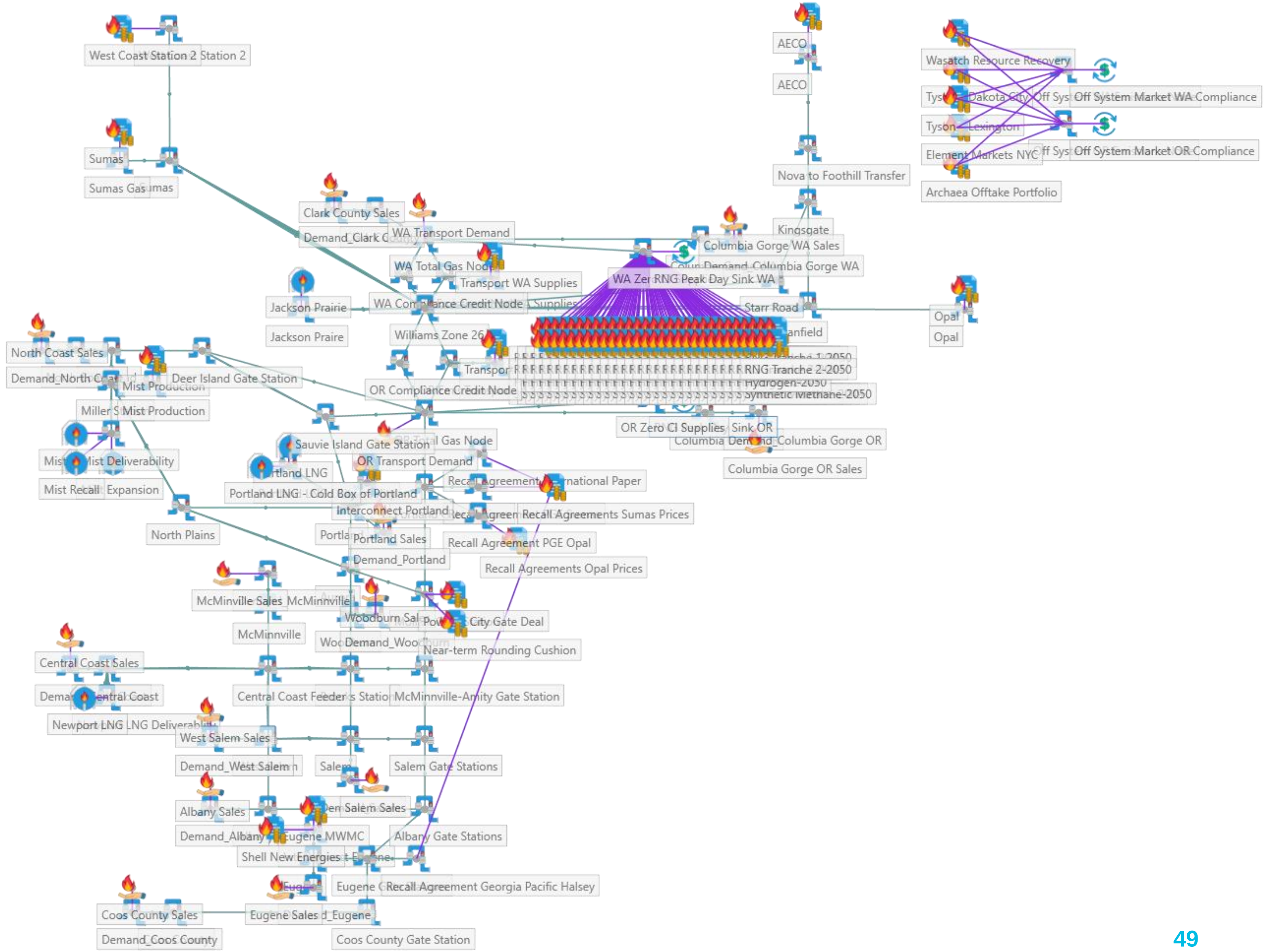
If an emissions constraint is applied to Node C and Node D, it would limit the gas flowing through those nodes to an emissions cap…Can you spot the issue with the current set up?

- Emissions for gas flowing in and out of *Storage 1* would be double counted
- In order to not double count gas flowing in and out of storage the emissions constraint requires adding 3 additional pipelines and 2 additional nodes
- NW Natural's model becomes complex very quickly



NW Natural PLEXOS System Model

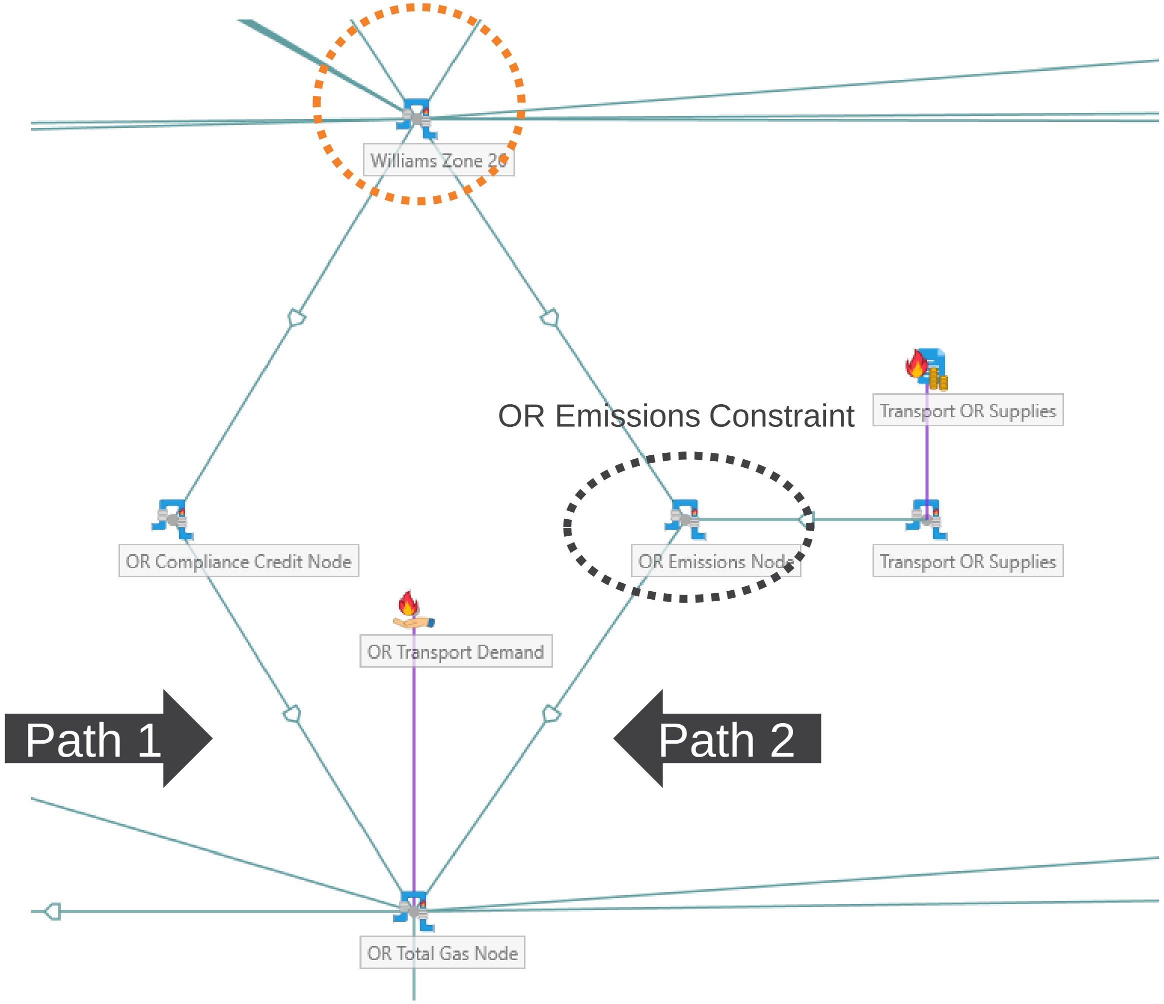
- This diagrams shows the relationships between the various objects, but for ***each*** object there are several properties that are assigned to that specific object
- For example, each pipeline has
  - Maximum Daily Quantity (MMBtu)
  - Reservation Charges (i.e., fixed charges)
  - Variable Costs
  - Fuel Costs



What is new with PLEXOS and this IRP?

- Previous model SENDOUT, required a fixed resource portfolio across Monte Carlo runs
  - PLEXOS optimizes resource selection for each draw in the Monte Carlo
- PLEXOS can implement an emissions constraint
  - Previous IRPs have included a price constraint (i.e., a carbon price adder to conventional gas)
  - Now we are modeling a quantity constraint, so the resource selection model chooses resources to meet demand and emissions
- This IRP model includes our 5 current RNG projects
  - Do not provide gas to the system, since these are off-take agreements
  - Count negatively towards the emission cap
- Also includes 3 on-system brown gas interconnects;
  - Do count positively towards the emissions cap as NW Natural is currently only buying the “brown gas”
  - Do help with peak day gas supply since they are on-system resources

Oregon Compliance Pathways Modeling



- All conventional gas comes to NW Natural's system via Williams NW Pipeline (*Williams Zone 26 Node*)
- Conventional gas can flow onto NW Natural's OR system via 1 of 2 pathways

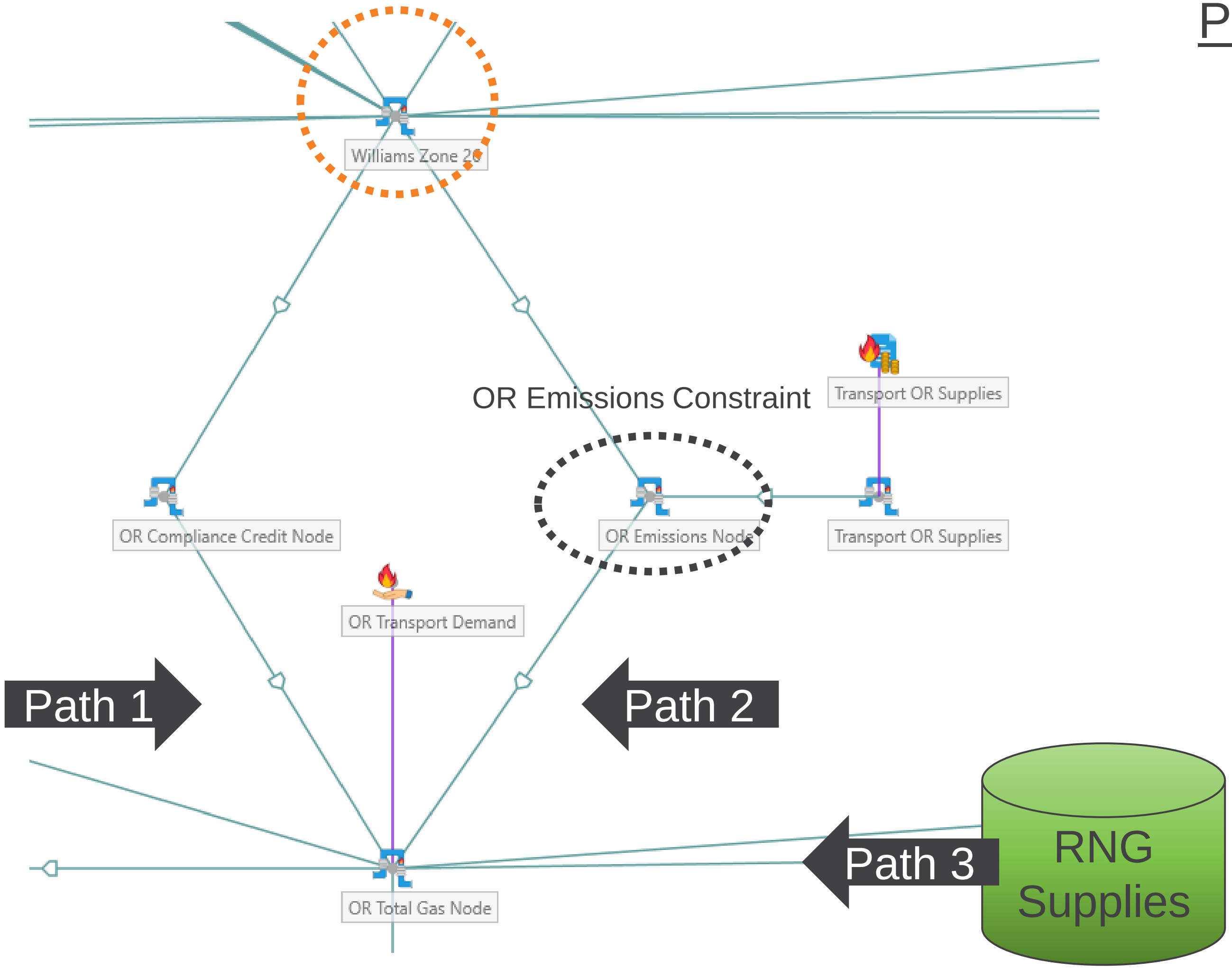
Path 1

- Gas flowing through the *OR Compliance Credit Node* incurs a variable charge equal to the cost of CCIs
- Total gas within a compliance period is constrained to be ≤ CCI's allowed within a compliance period

Path 2

- Gas flowing through *OR Emissions Node* is counted toward OR emissions cap
- Gas flowing through Path 2 incurs a variable charge equal to the social cost of carbon
- *Transport OR Supplies = OR Transport Demand*

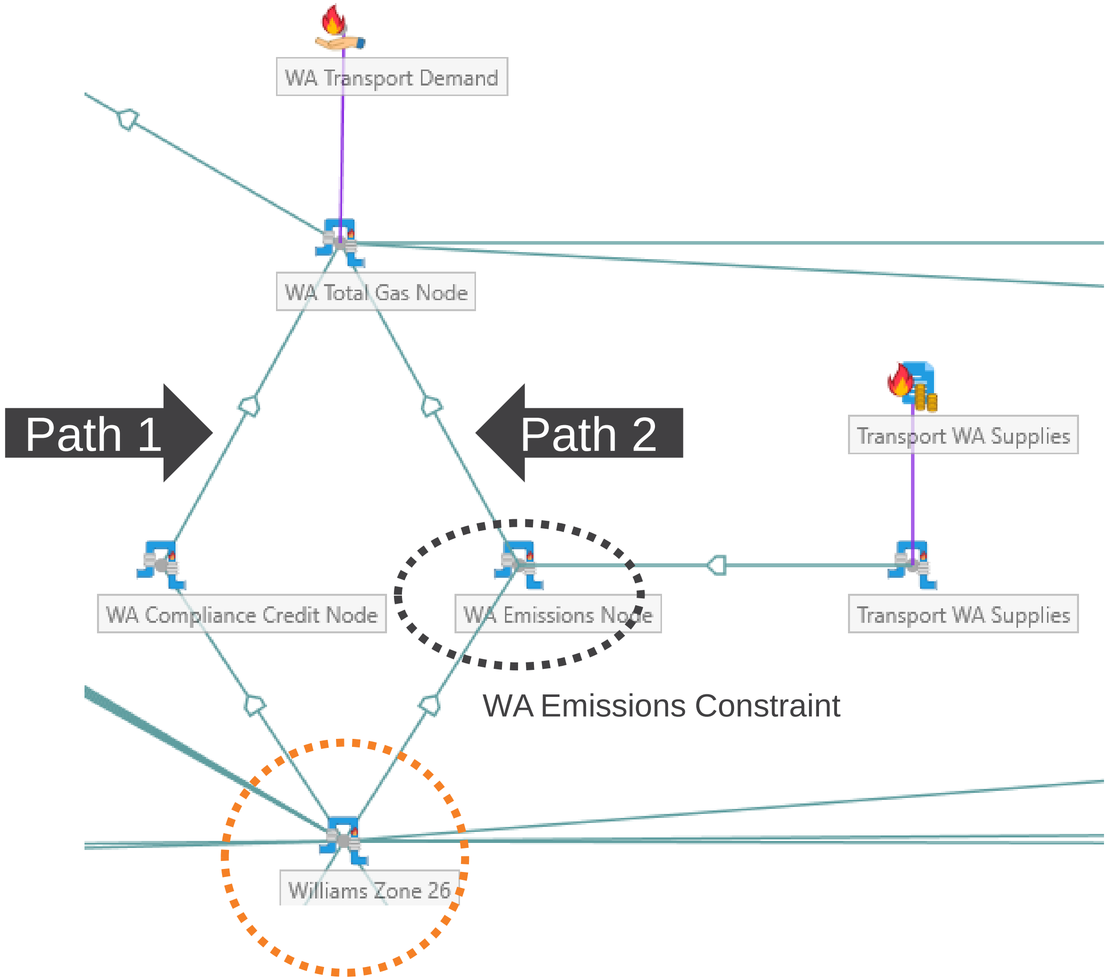
Oregon Compliance Pathways Modeling



Path 3

- RNG Tranche 1, RNG Tranche 2, Hydrogen, Synthetic Methane
- RNG supplies flow onto to the system downstream of the emissions constraint
- RNG resources are considered to have a carbon intensity of zero
- SB 98 – the sum of all OR RNG supplies into each year ≥ SB 98 RNG target for that year
- These are predicted to be long term contracts; therefore, once a level of RNG is selected within a year it remains at that level for the rest of the planning horizon

Washington Compliance Pathways Modeling



- All conventional gas comes to NW Natural's system via Williams NW Pipeline (*Williams Zone 26 Node*)
- Conventional gas can flow onto NW Natural's OR system via 1 of 2 pathways

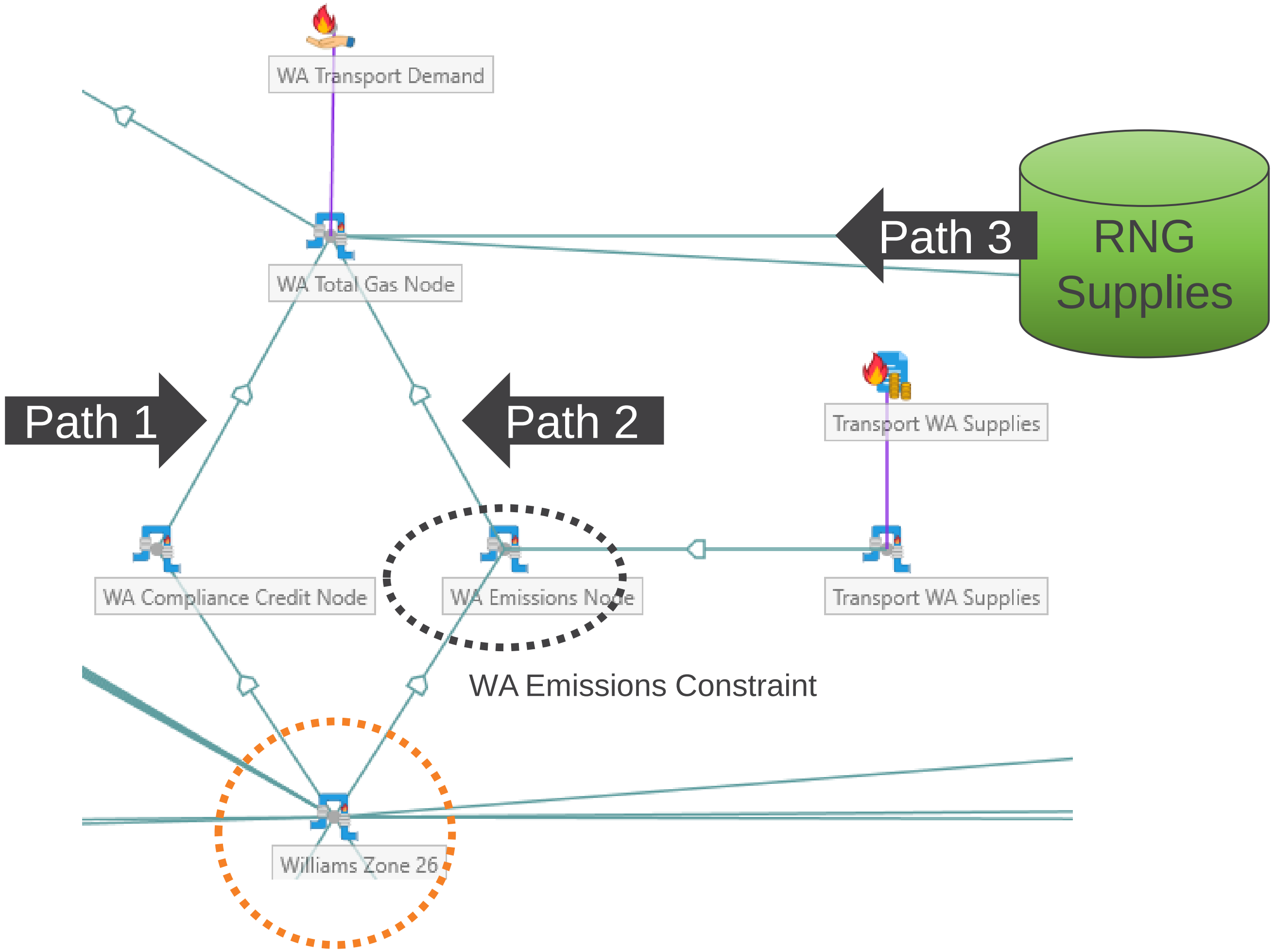
<u>Path 1</u>

- Gas flowing through the *WA Compliance Credit Node* incurs a variable charge equal to maximum of the social cost of carbon or expected allowance compliance cost
- Currently no quantity constraints on this path (will update as rules develop)

<u>Path 2</u>

- Gas flowing through *WA Emissions Node* is counted toward WA free allowance allocation
- Gas flowing through Path 2 also incurs a variable charge equal to the social cost of carbon
- *Transport WA Supplies = WA Transport Demand*

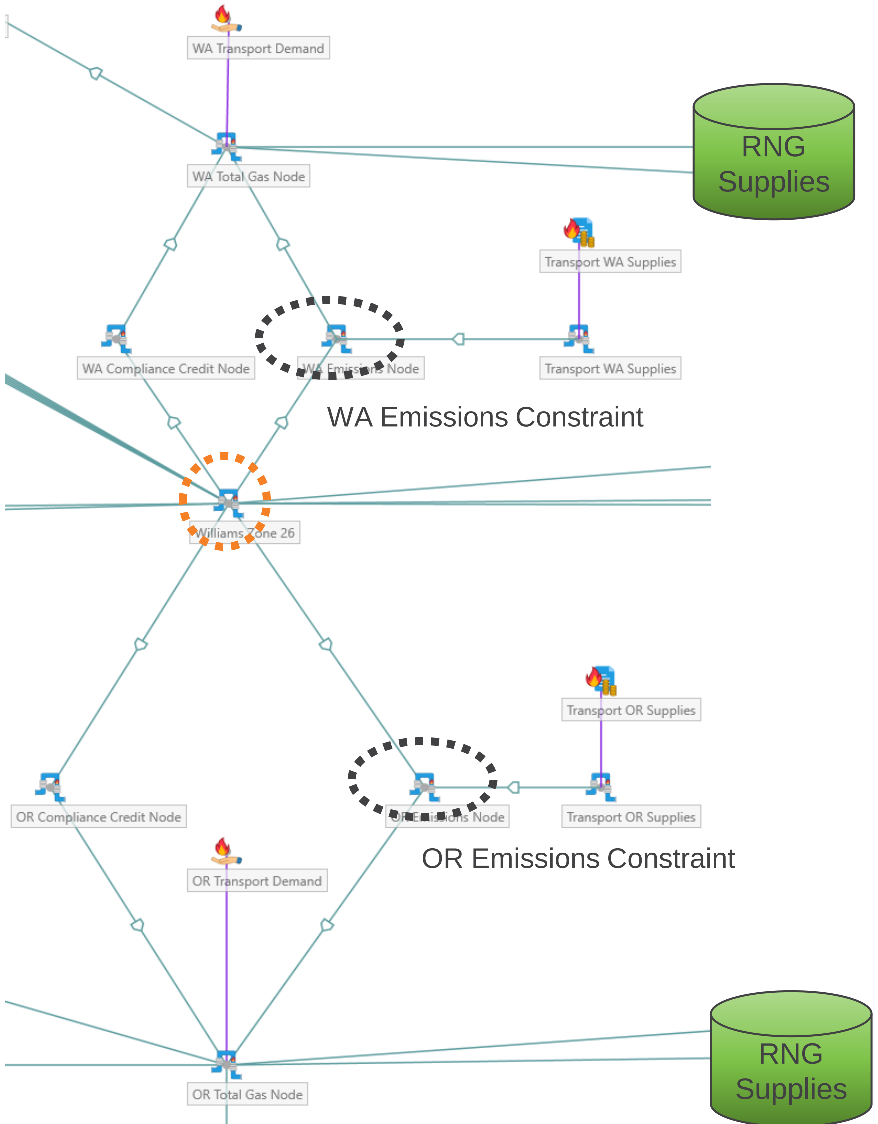
Washington Compliance Pathways Modeling



Path 3

- RNG Tranche 1, RNG Tranche 2, Hydrogen, Synthetic Methane
- RNG supplies flow onto to the system downstream of the emissions constraint
- RNG resources are considered to have a carbon intensity of zero
- These are predicted to be long-term contracts; therefore, once a level of RNG is select within a year it remains at that level for the rest of the planning horizon

System Compliance Pathways Modeling

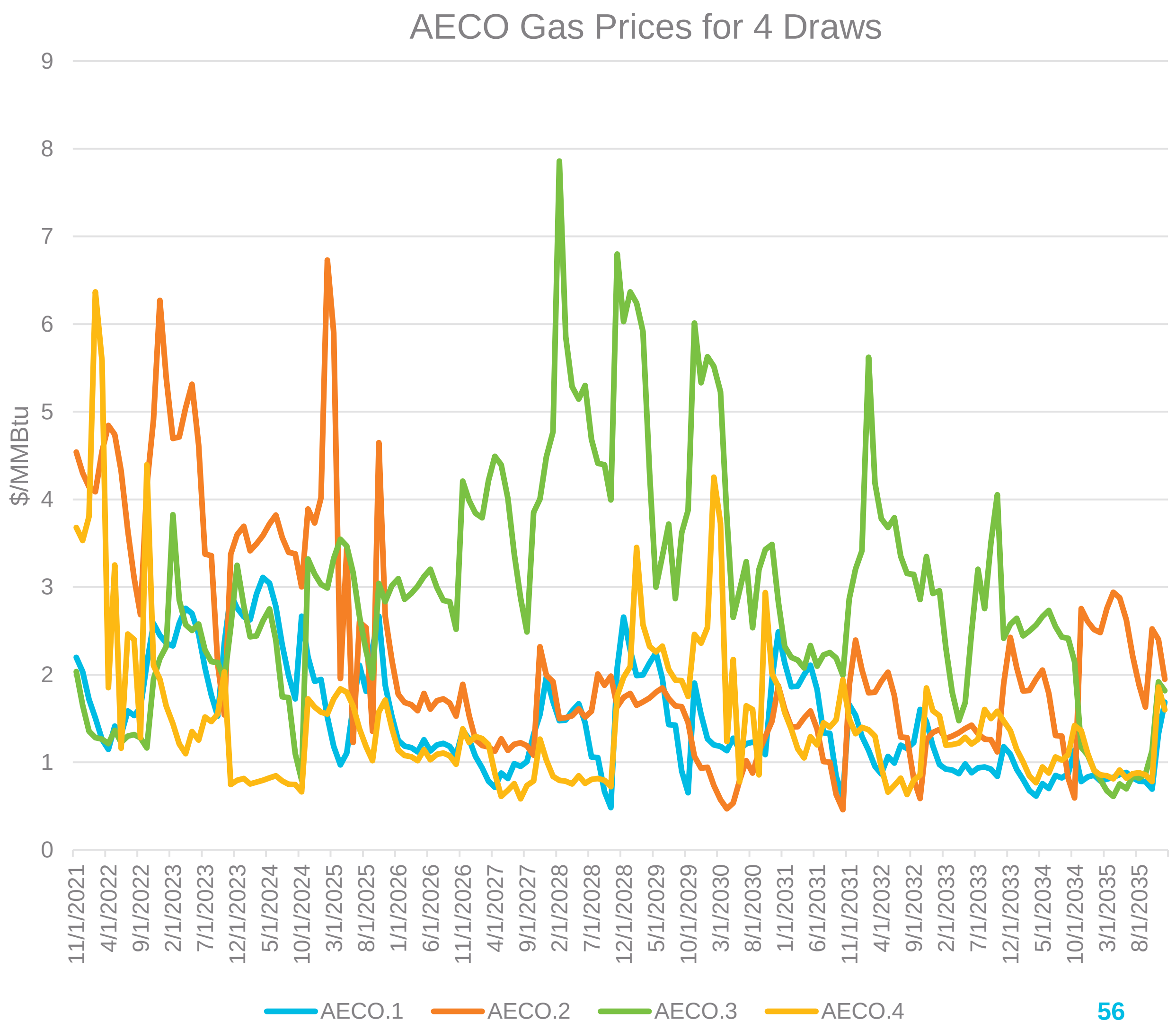


System Constraints

- Hydrogen supplies ≤ 20% of System demand
- Sum of RNG Tranche 1 supplies ≤ 13,000,000 MMBtu / year
- Sum of RNG Tranche 2 supplies ≤ 27,000,000 MMBtu / year

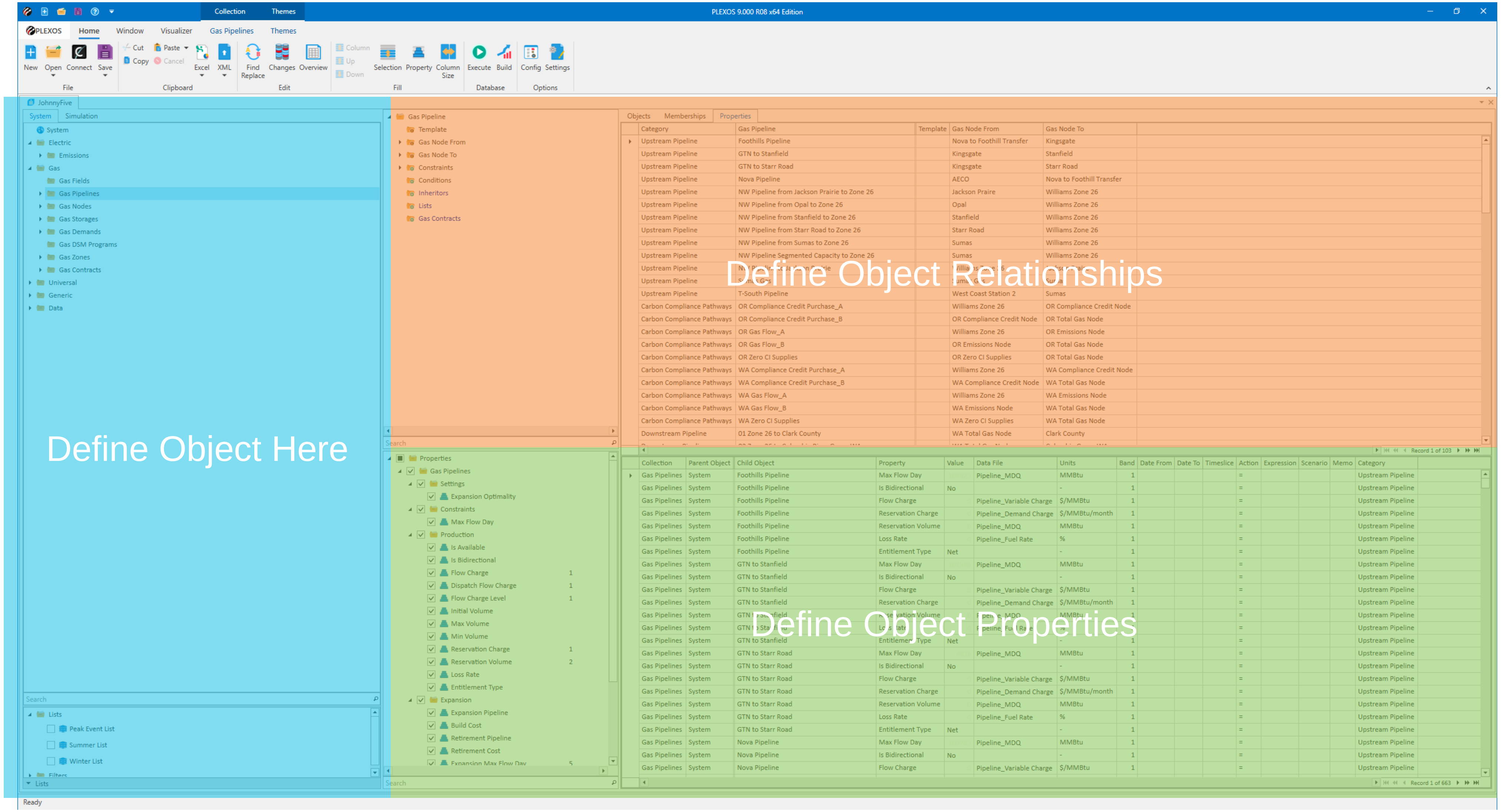
Monte Carlo Simulation Review

- In previous IRPs we've included variation in:
  - Gas prices (graph to the right)
  - Demand (generated through a weather simulation)
  - Resource fixed costs
  - Emission compliance costs
- The transition PLEXOS allows for more uncertainties to be captured within the optimization
  - Quantity of RNG resource available
  - RNG cost
- PLEXOS optimizes resource selection for each draw in the Monte Carlo
  - The model has perfect foresight



PLEXOS Demonstration

Graphical User Interface (GUI)



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Questions/Feedback

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