Cascade Natural Gas Corporation

2020 Integrated Resource Plan
Technical Advisory Group Meeting #4

Wednesday, Jan. 15th, 2020

Portland International Airport

Portland, OR

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Agenda

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

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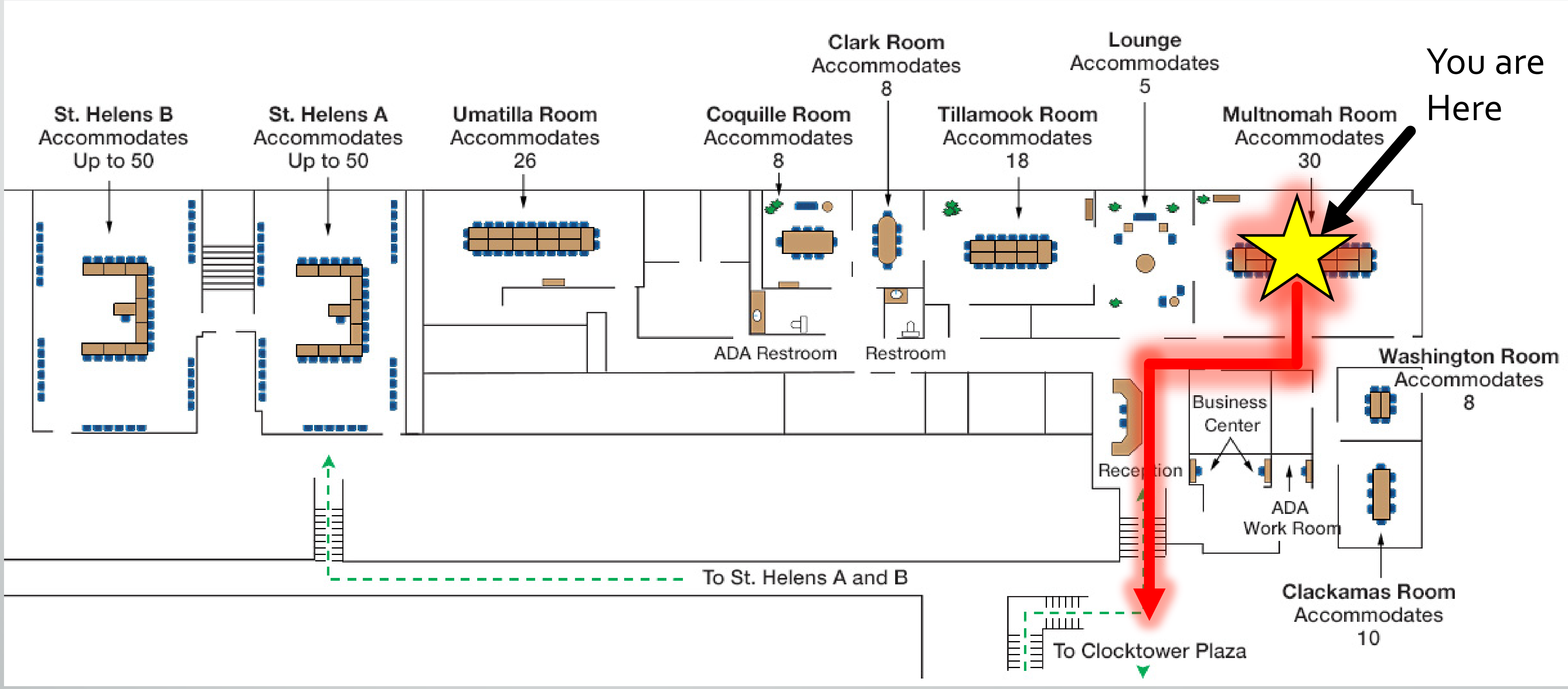
Safety!



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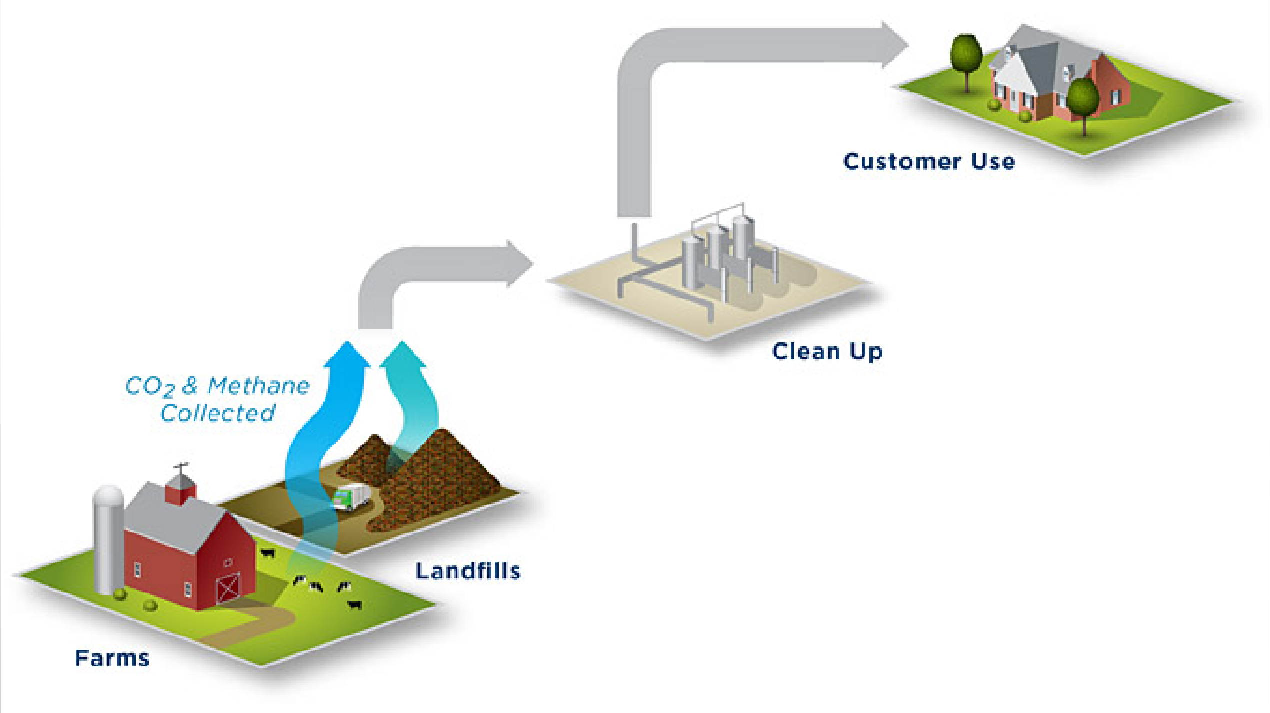
Renewable Natural Gas

What is Renewable Natural Gas (RNG)?

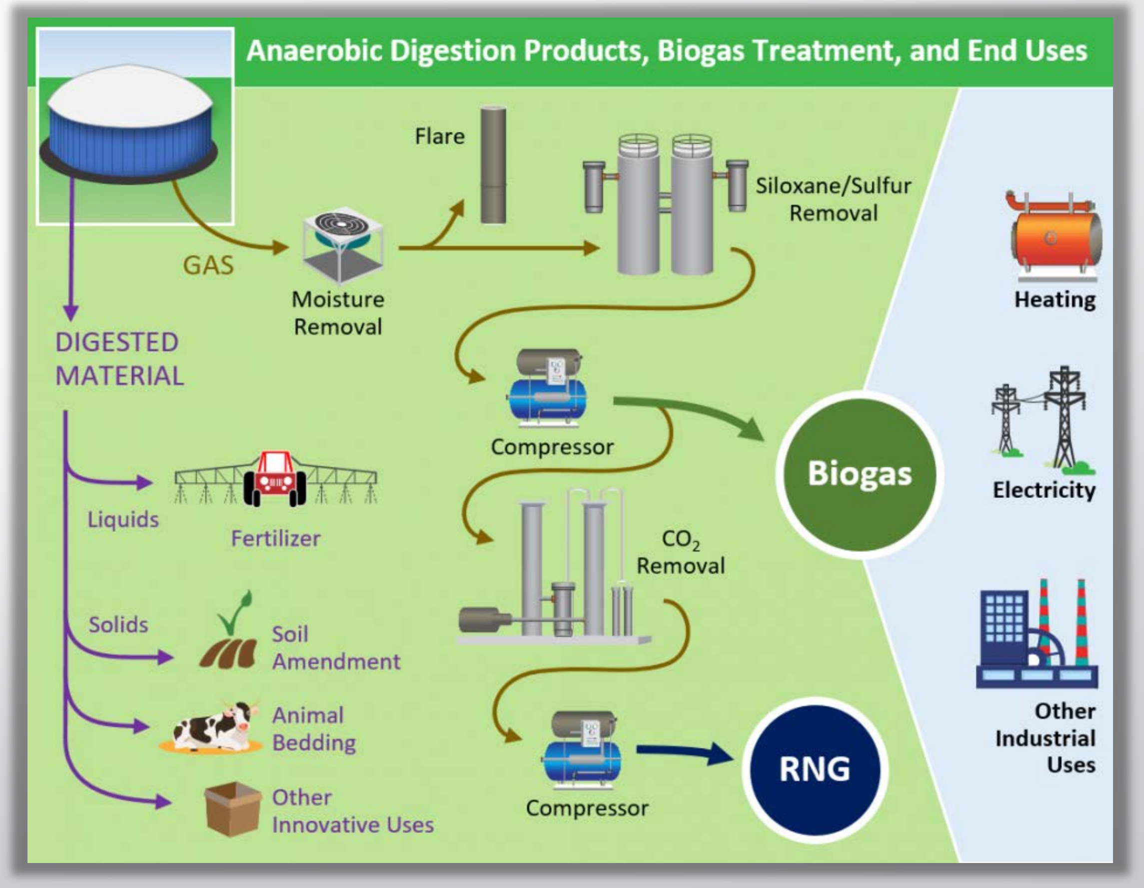
- RNG is pipeline quality natural gas produced from various biomass sources through biochemical processes such as anaerobic digestion or gasification.[1]



[1] U.S. Department of Energy, Alternative Fuels Data Center, Renewable Natural Gas

Renewable Natural Gas

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



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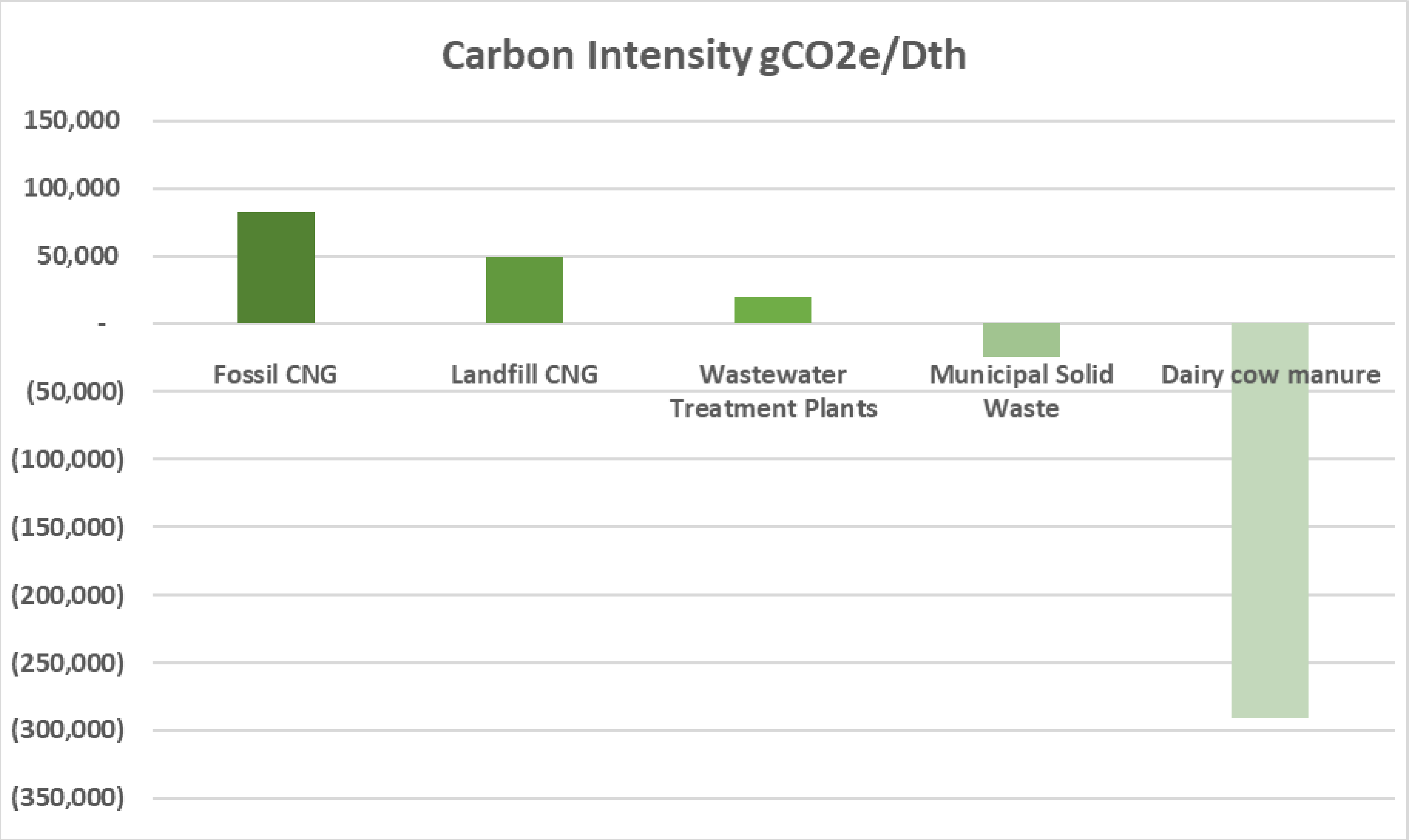
[1] U.S. Department of Energy, Alternative Fuels Data Center, Renewable Natural Gas

Renewable Natural Gas

- Video for TAG presentation (Was removed from distribution deck as it was too large to send via email.)

Carbon Intensity



Source: Institute of Transportation Studies at UC Davis, Research Report 16-20, June 2016.

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Regulatory Matters Regarding RNG

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

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Regulatory Matters Regarding RNG (Cont'd)

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

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Cascade Market Research

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

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Cascade Market Research (Cont'd)

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

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What is Cascade doing?

- **RNG planning**
  - Internal Attendees
    - Regulatory
    - Business Development – Oregon & Washington
    - Energy Efficiency
    - Public Affairs
    - Resource Planning Team
    - Gas Supply
  - External Attendees
    - Lobbyists
    - NWGA
    - Other LDC's located in Oregon & Washington
  - **Climate Action Plan Support**
    - Inclusion of biogas and offset program exploration as part of City of Bend's Climate Action Plan

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Cascade's RNG Goals

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

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Potential RNG Projects in Cascade's Service Territory

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

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Energy Efficiency Resource Assessment for CNG's 2020 IRP

January 15th, 2020

Energy Trust of Oregon

Agenda

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

About Energy Trust of Oregon

Independent nonprofit

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

Providing access to affordable energy

Generating homegrown, renewable power

Building a stronger Oregon and SW Washington

Energy Trust’s Resource Assessment Model Overview

Resource Assessment (RA) Purpose

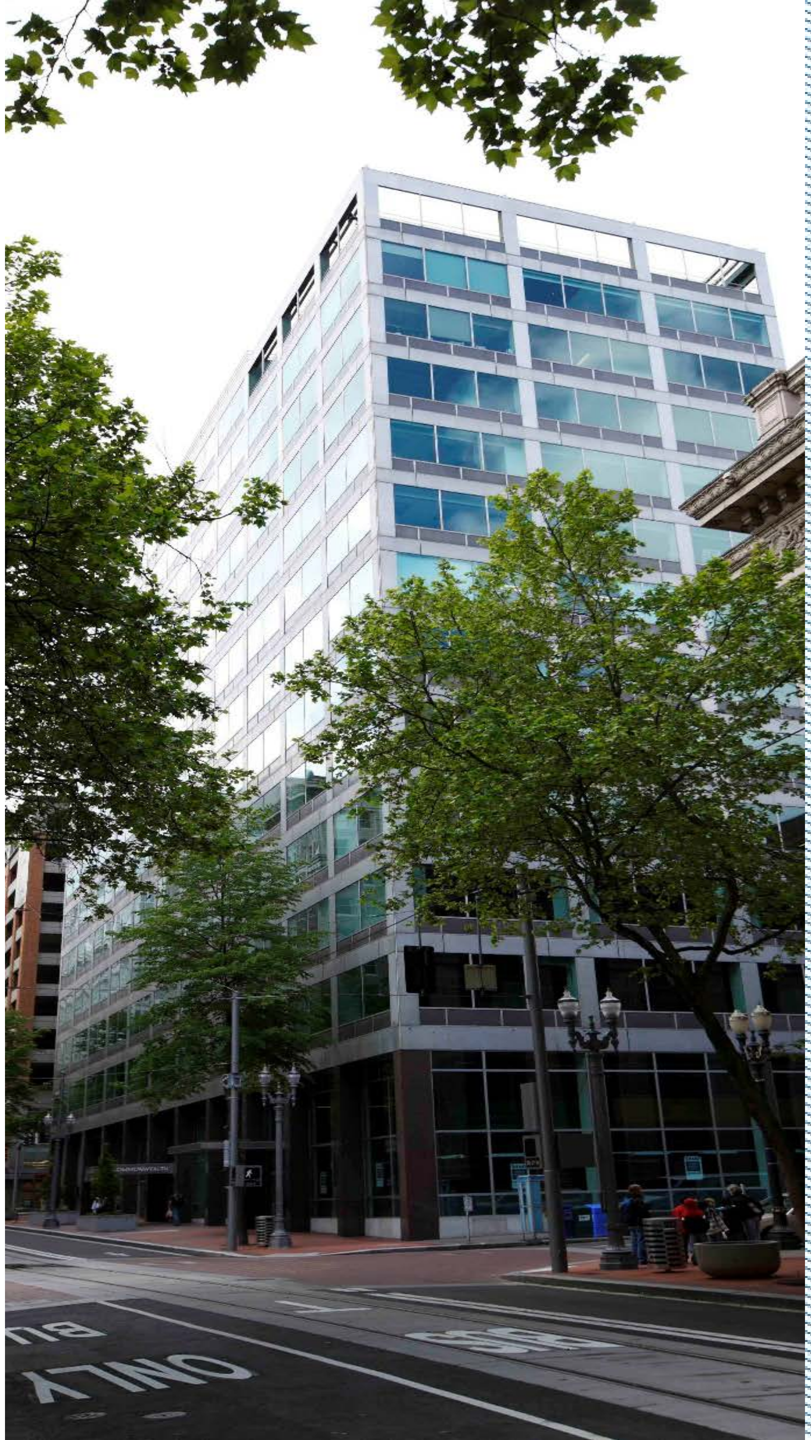
- Informs utility Integrated Resource Planning (IRP)
- Provides estimates of 20-year energy efficiency potential and the associated load reduction
- Helps utilities to strategically plan future investment in both demand and supply side resources

RA Model Background

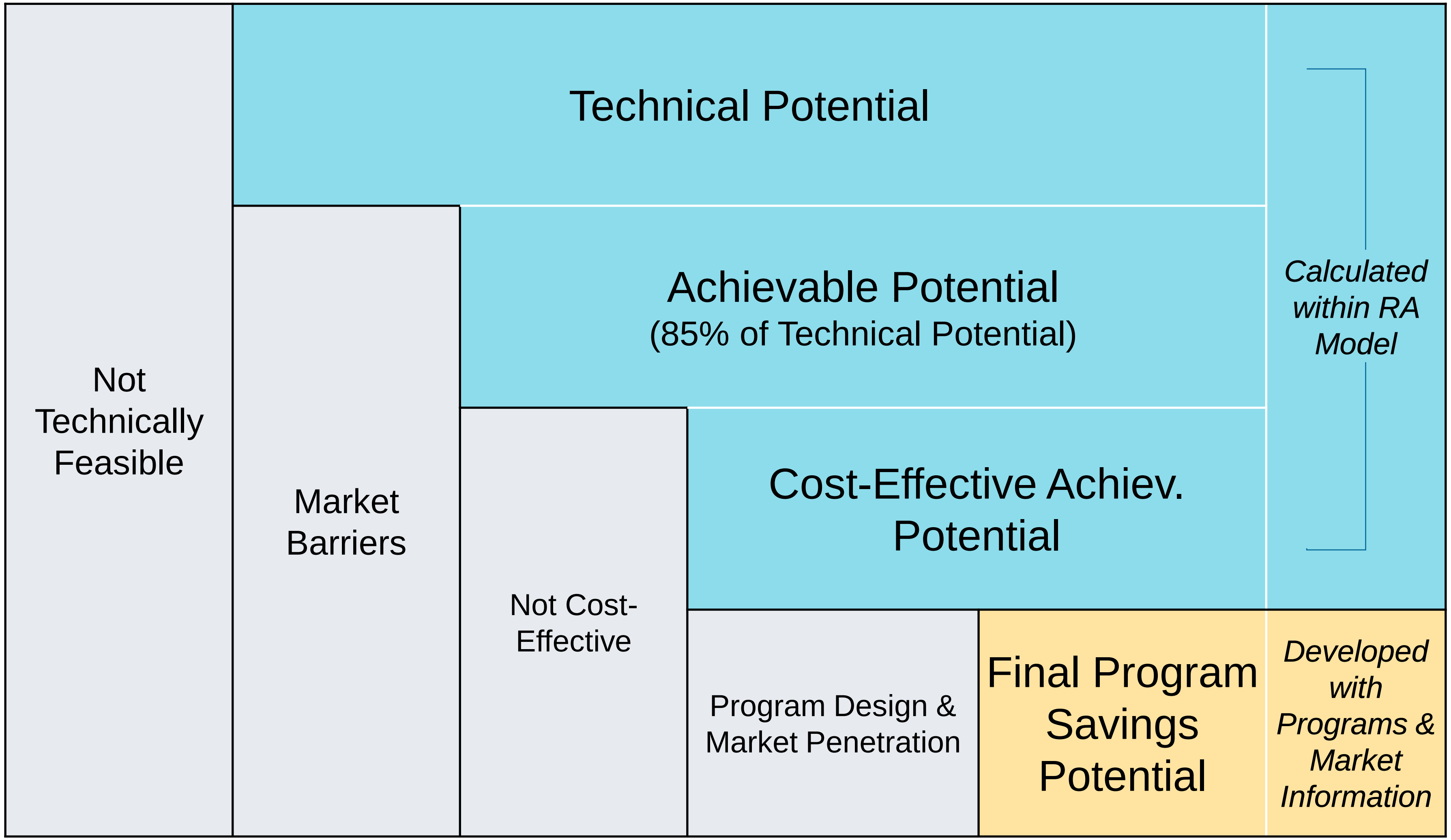
- 20-year energy efficiency potential estimates
- “Bottom-up” modeling approach – measure level inputs are scaled to utility level efficiency potential
- Energy Trust uses a model in *Analytica* that was developed by Navigant Consulting in 2014
  - The *Analytica* RA Model calculates Technical, Achievable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

Changes to Modeling Since 2018 IRP

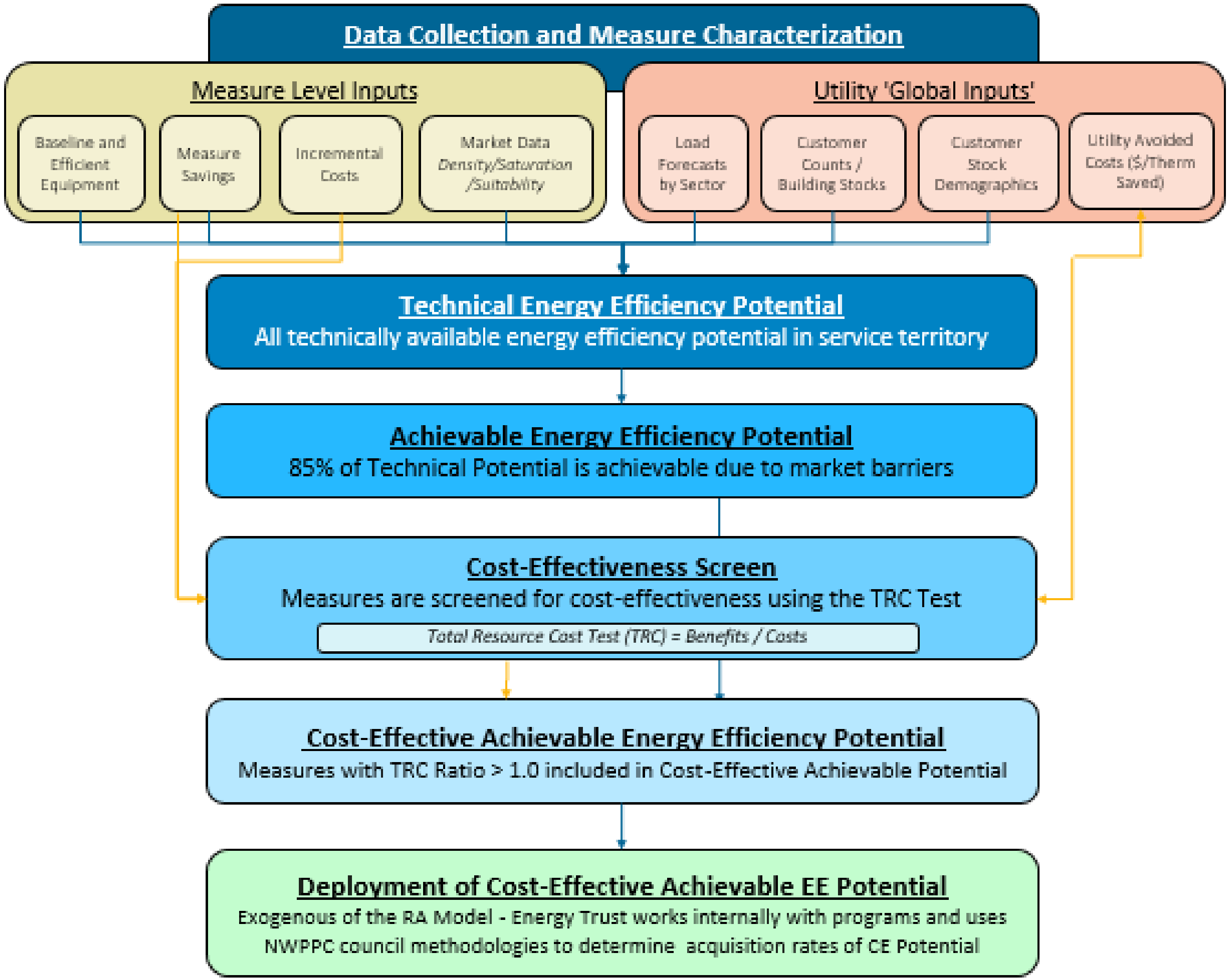
- Stakeholder workshop in Fall of 2017 and implemented several methodology changes:
  - Inclusion of Large Project Adder
  - Align to NWPCC method for deployment ramping to 100% of total cost-effective achievable potential
    - Exceptions: emerging techs and hard to reach measures
- Understand load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



Forecasted Potential Types



20-Year IRP EE Forecast Flow Chart



Methodology Overview

‘Bottom-up’ modeling approach:

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

Simple Example *(Illustrative Numbers)*

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

RA Model inputs

Measure Level Inputs

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

Measure Savings

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

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

Utility 'Global' Inputs

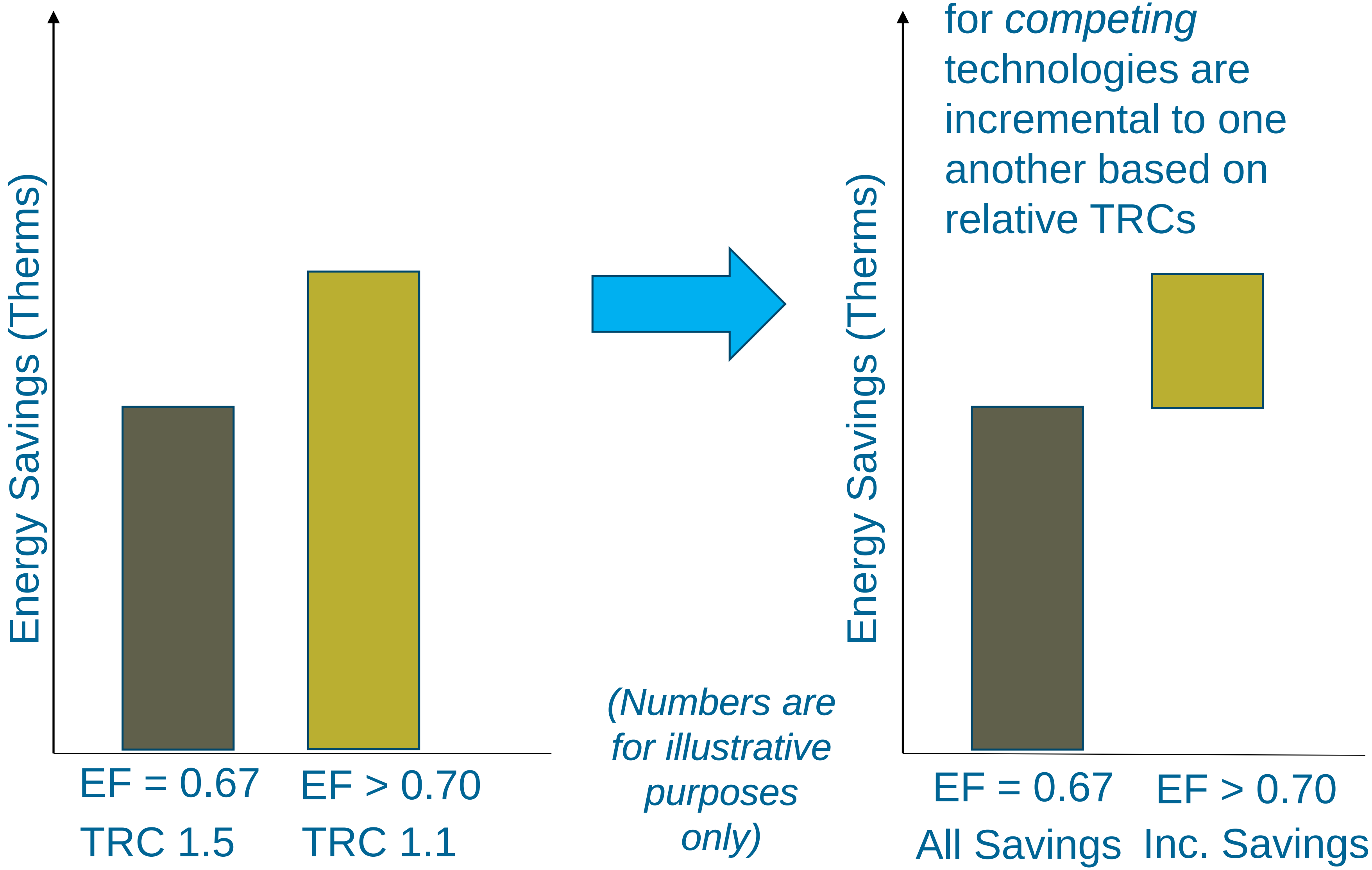
Customer and Load Forecasts
- Used to scale measure level savings to a service territory
  - Residential Stocks: # of homes
  - Commercial Stocks: 1000s of Sq.Ft.
  - Industrial Stocks: Customer load

Avoided Costs (provided by utilities)

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

** RET = Retrofit; ROB = Replace on Burnout; NEW = New Construction*

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



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

(Numbers are for illustrative purposes only)

Cost-Effectiveness Screen

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

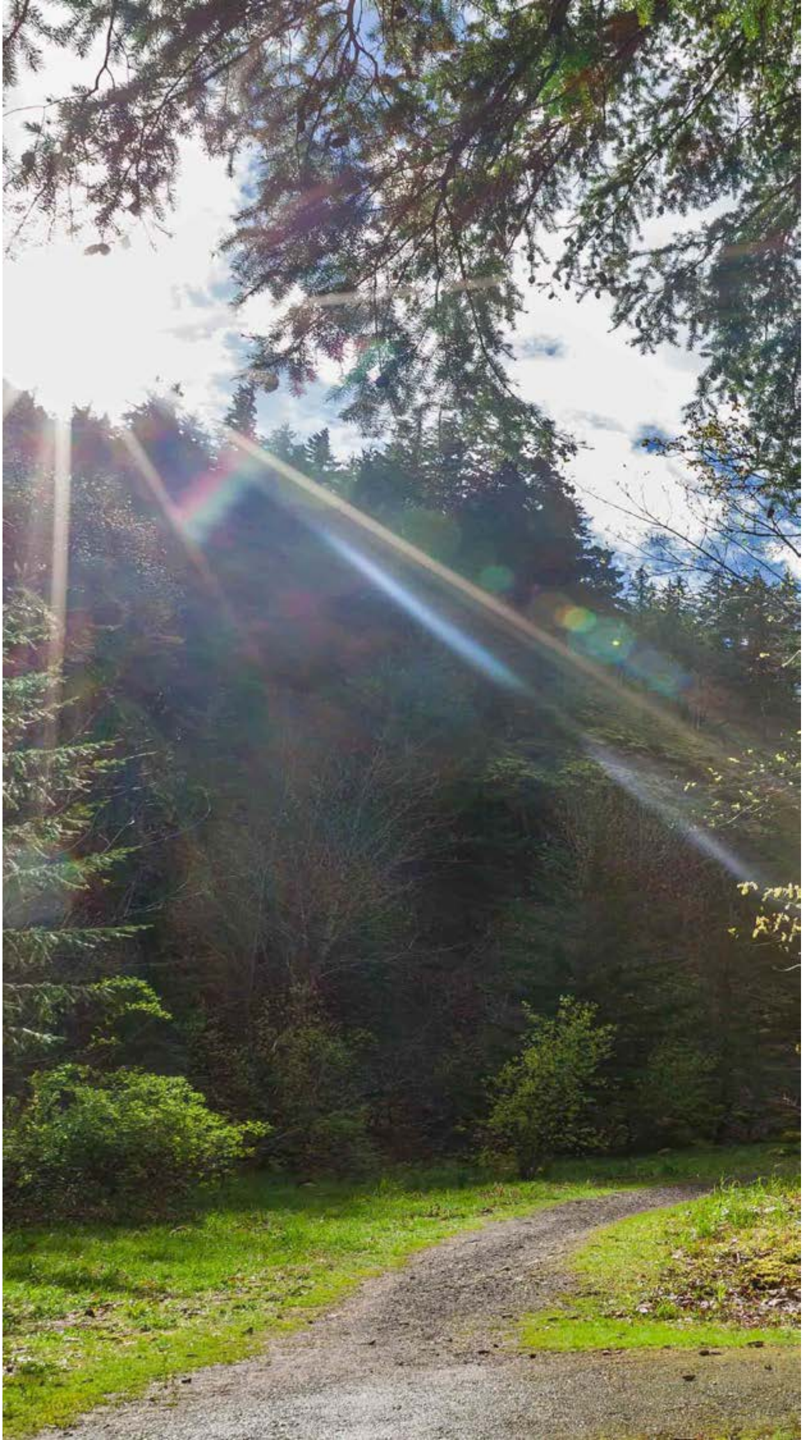
$$\text{TRC} = \frac{\textit{Measure Benefits}}{\textit{Total Measure Cost}}$$

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

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

Total Measure Costs:

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



Cost-Effectiveness Override in Model

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

Reasons:

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

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

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

Emerging Technologies/Risk Factors

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

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

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

Model Outputs

Types of Potential:
- Technical
- Achievable
- Cost-Effective Achievable

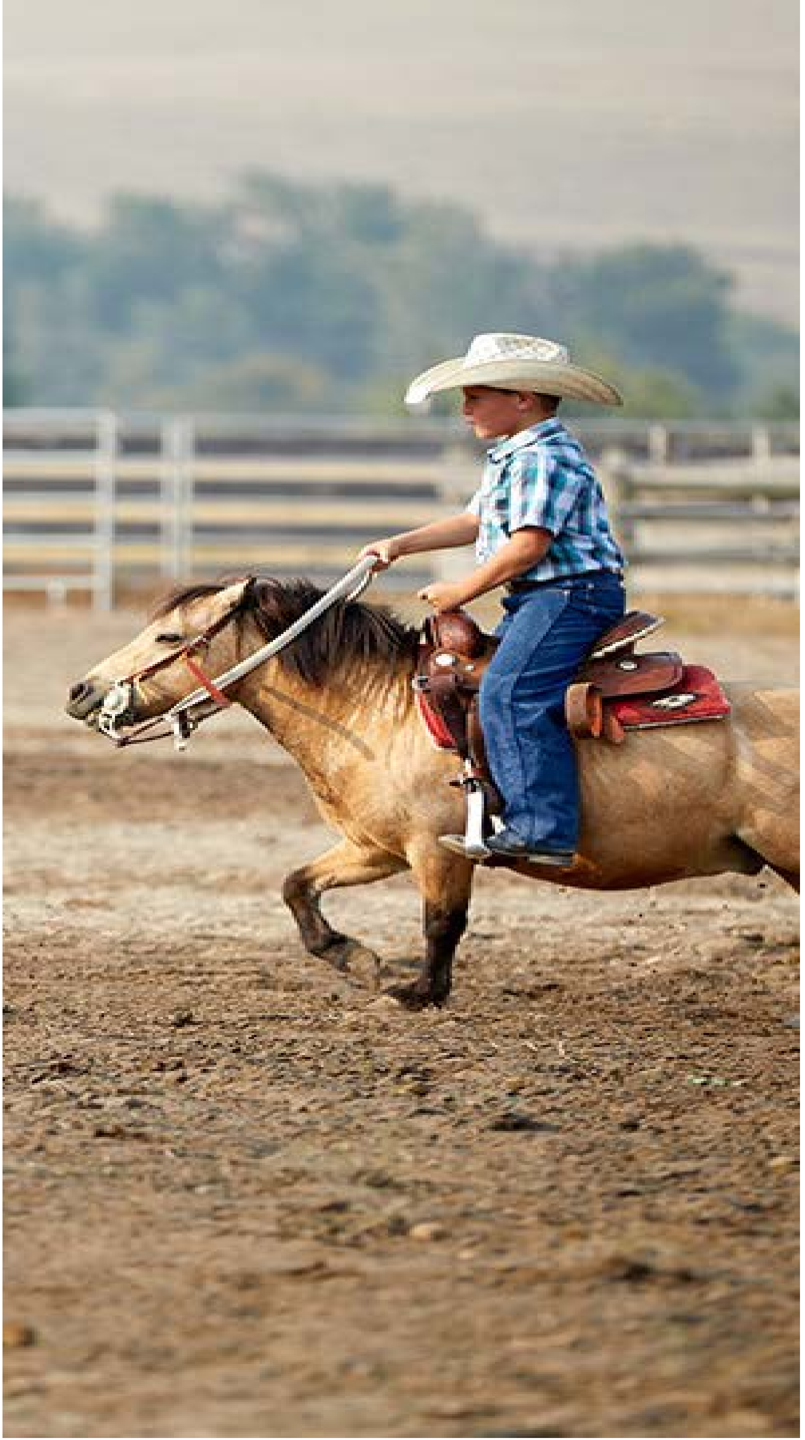
Levelized Cost

Measure Costs & Benefits

Supply Curves

IRP Savings Projections:

Methodology to Deploy Cost-Effective Achievable Potential



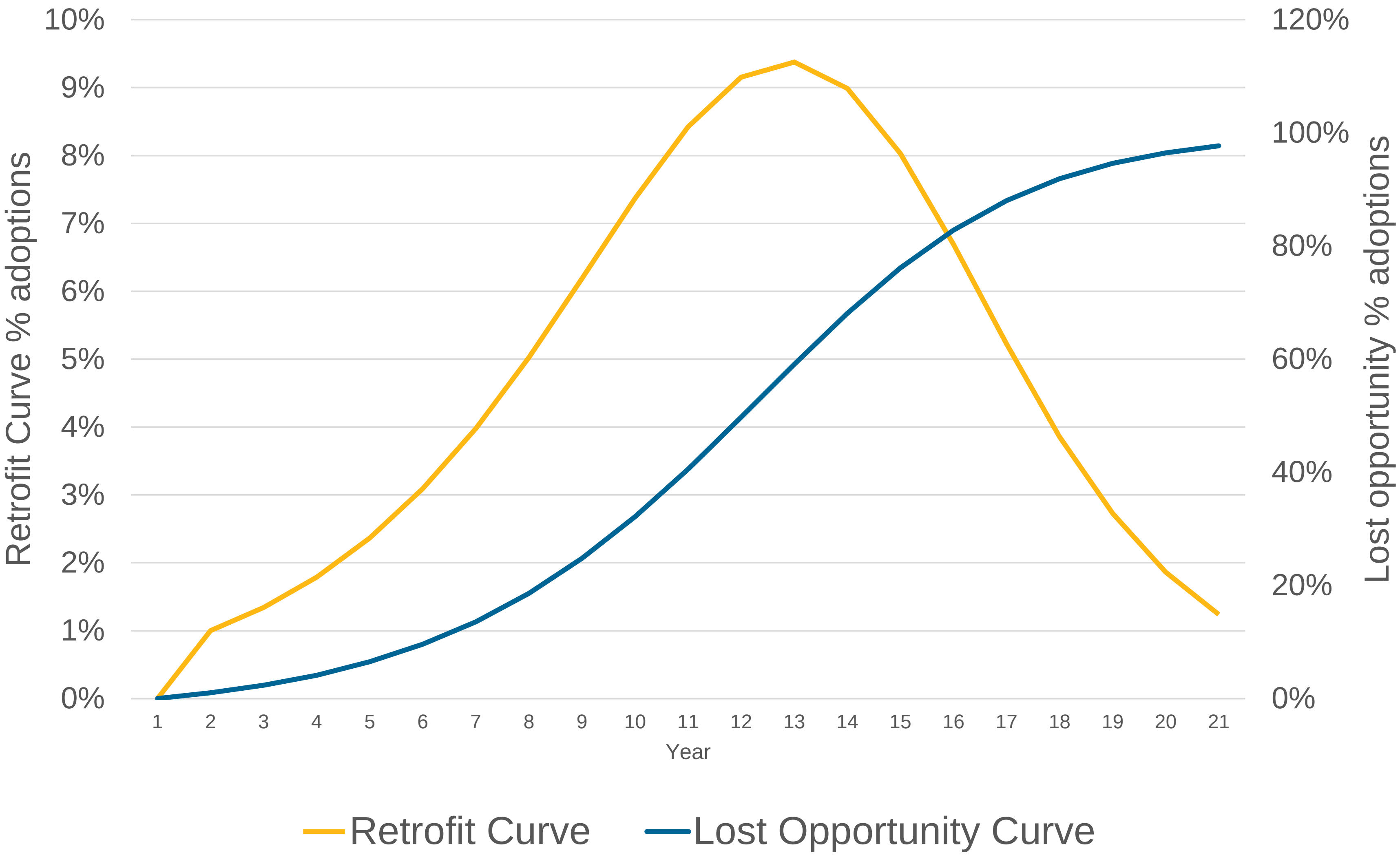
Why Deploy?

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

Ramp Rate Overview

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

Ramp Rate Examples



Ramp Rate Calibration

Energy Trust calibrates the first five years of energy efficiency acquisition ramp rates to program performance and budget goals.

Years 1-2

- Program forecasts – they know what is happening short term best

Years 3-5

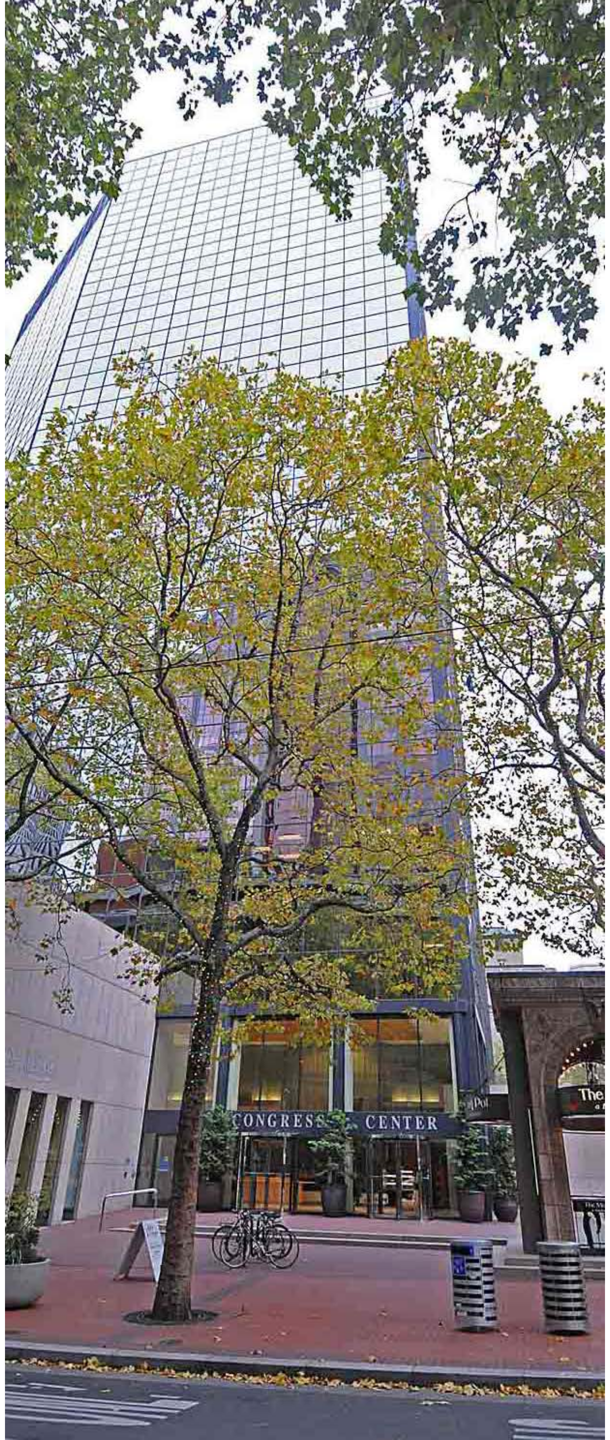
- Planning and Programs work together to create forecast

Years 6-20

- Planning forecasts long-term acquisition rate to generally align NWPCC

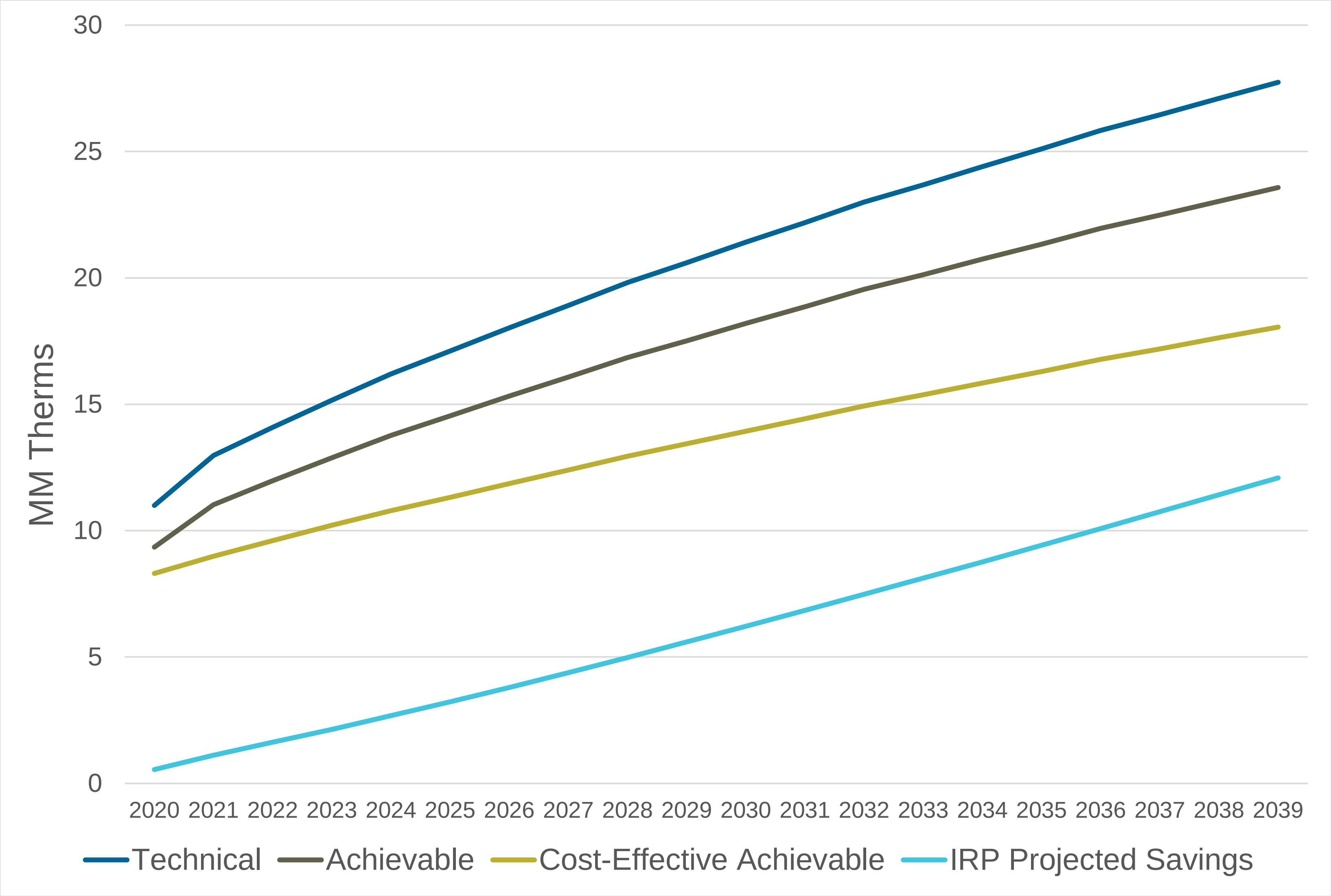
Application of Ramp Rates & Relation to RA Model Results

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

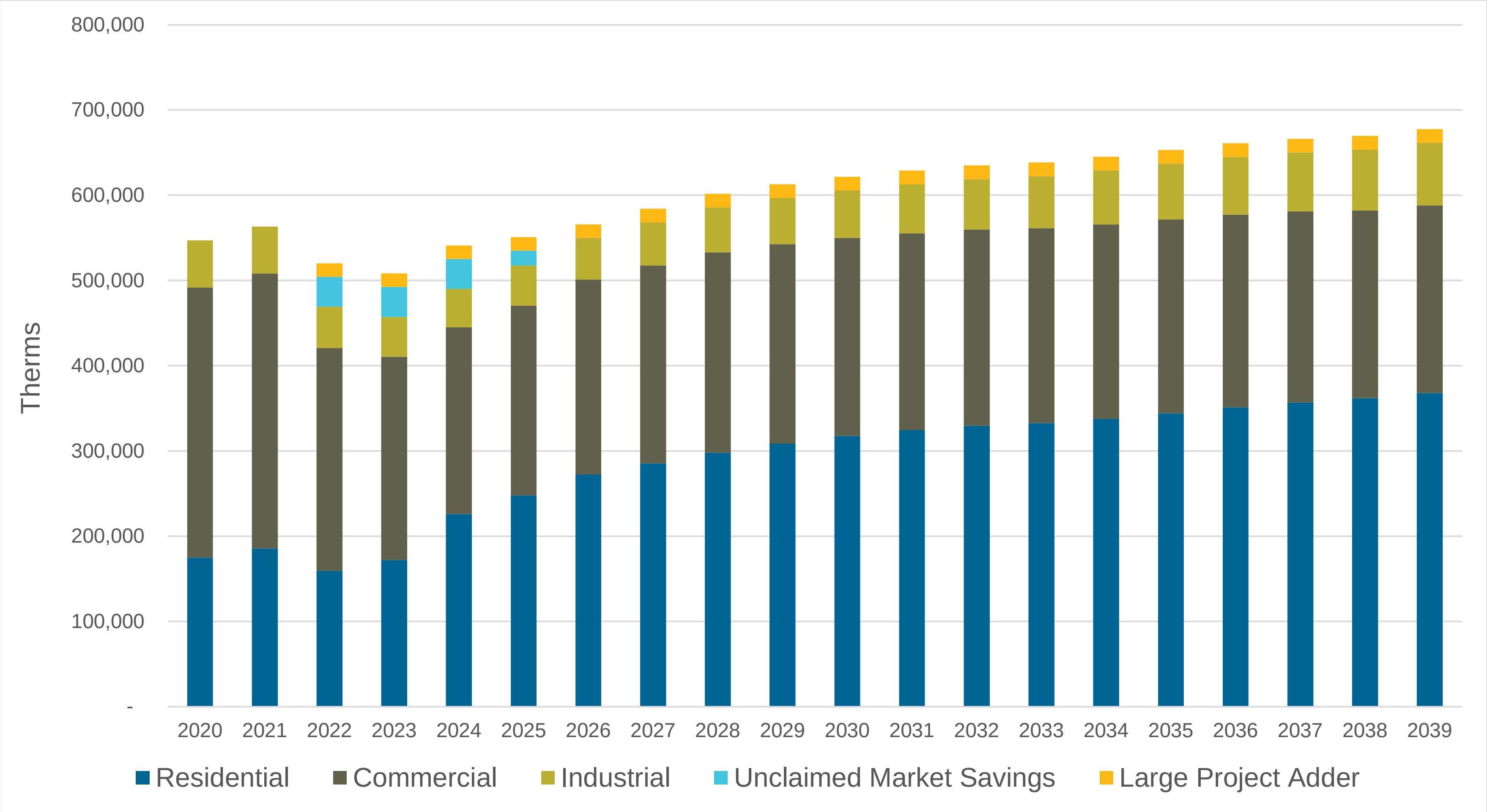


CNG’s 2020 IRP Results

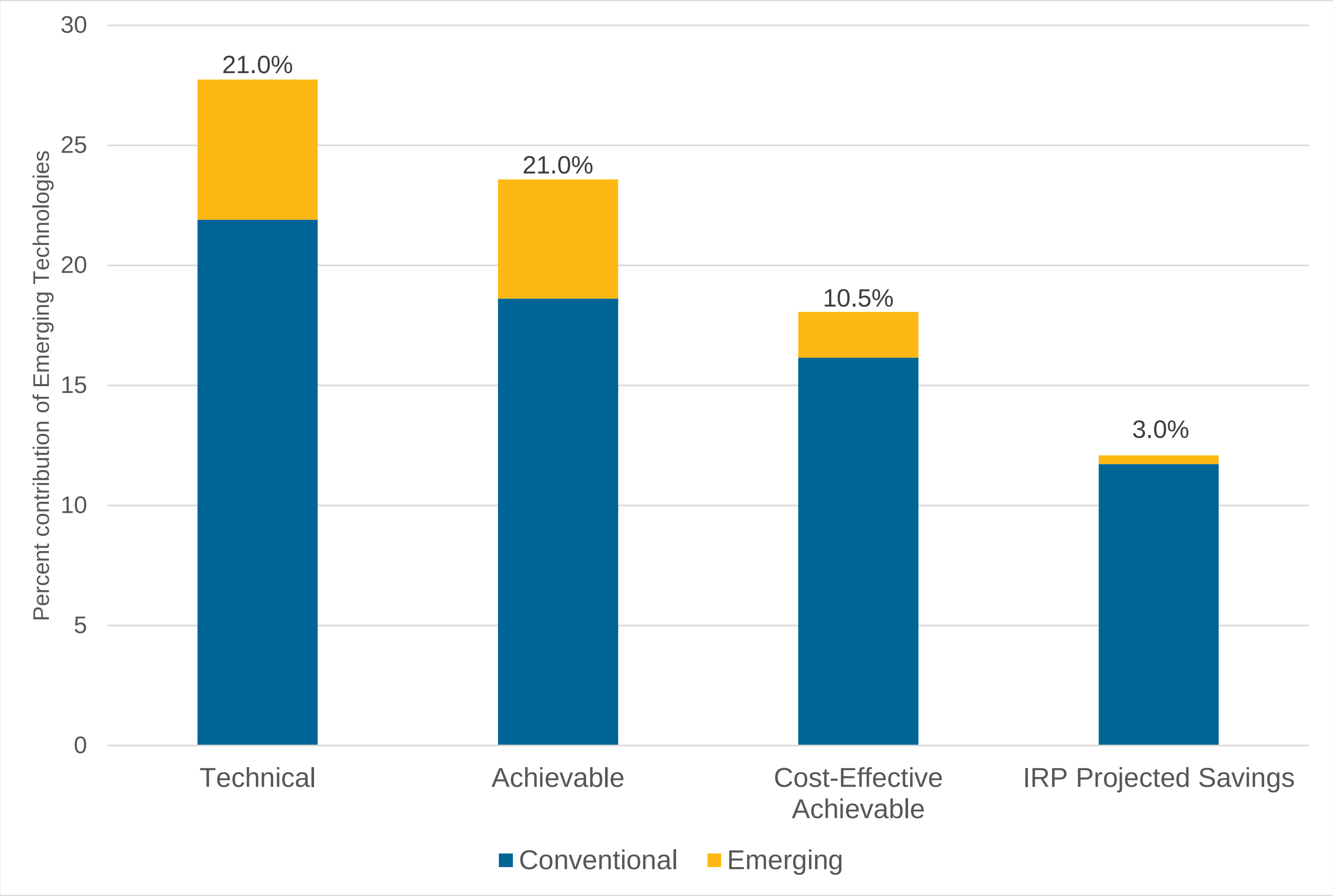
Cumulative Savings by Type and Year



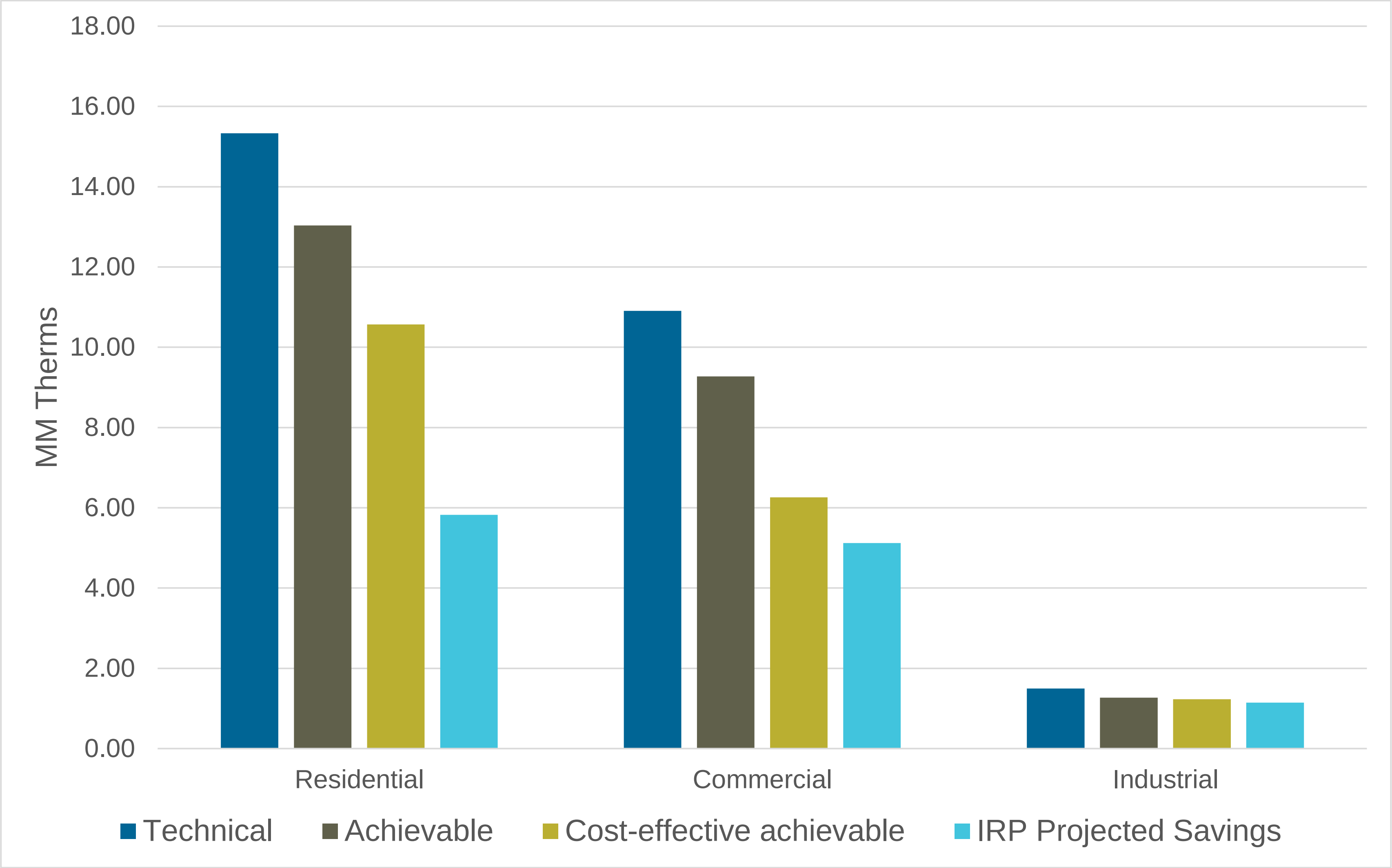
Annual Deployed IRP Forecasted Savings



Cumulative Contribution of Emerging Technologies



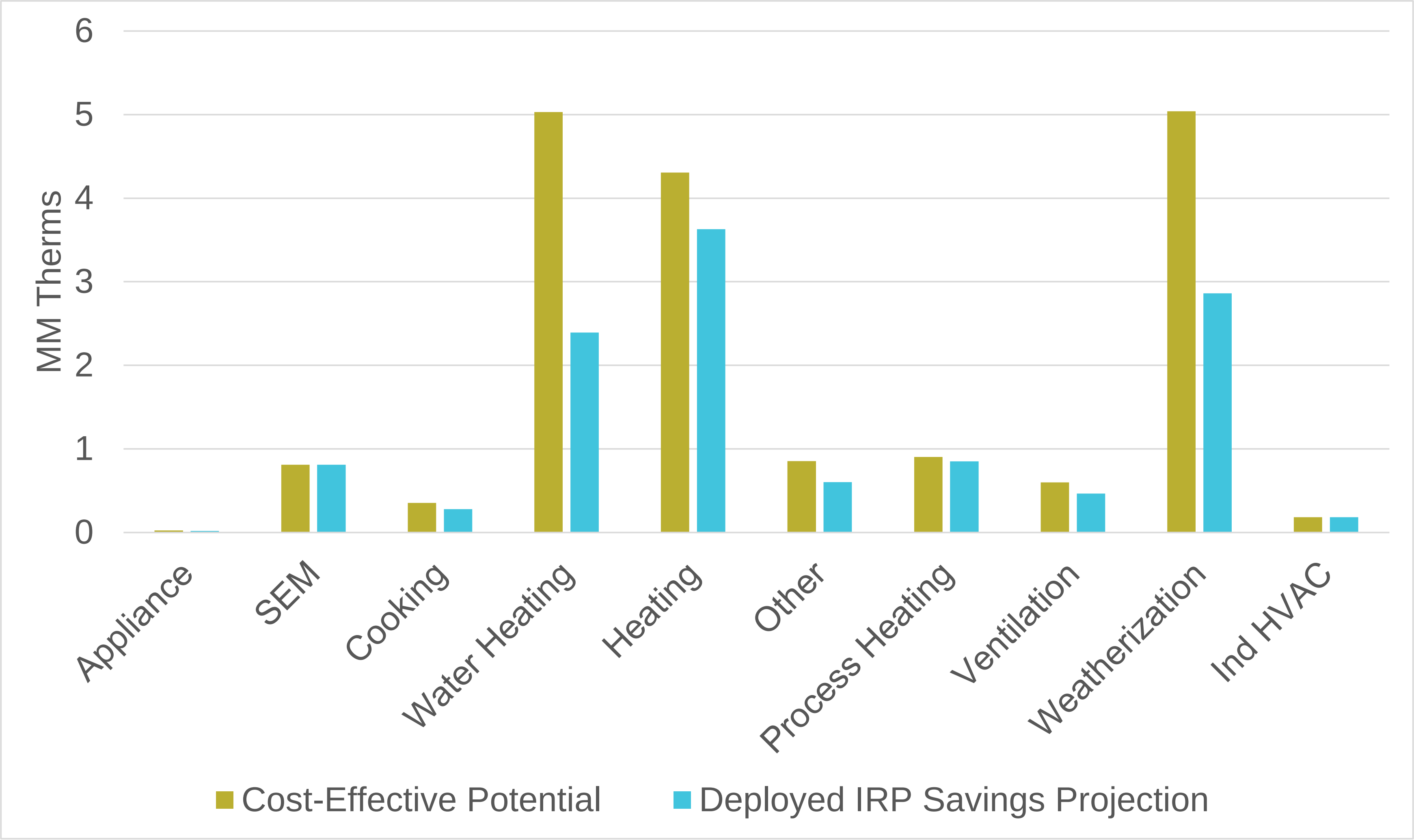
Cumulative Savings by Sector and Type



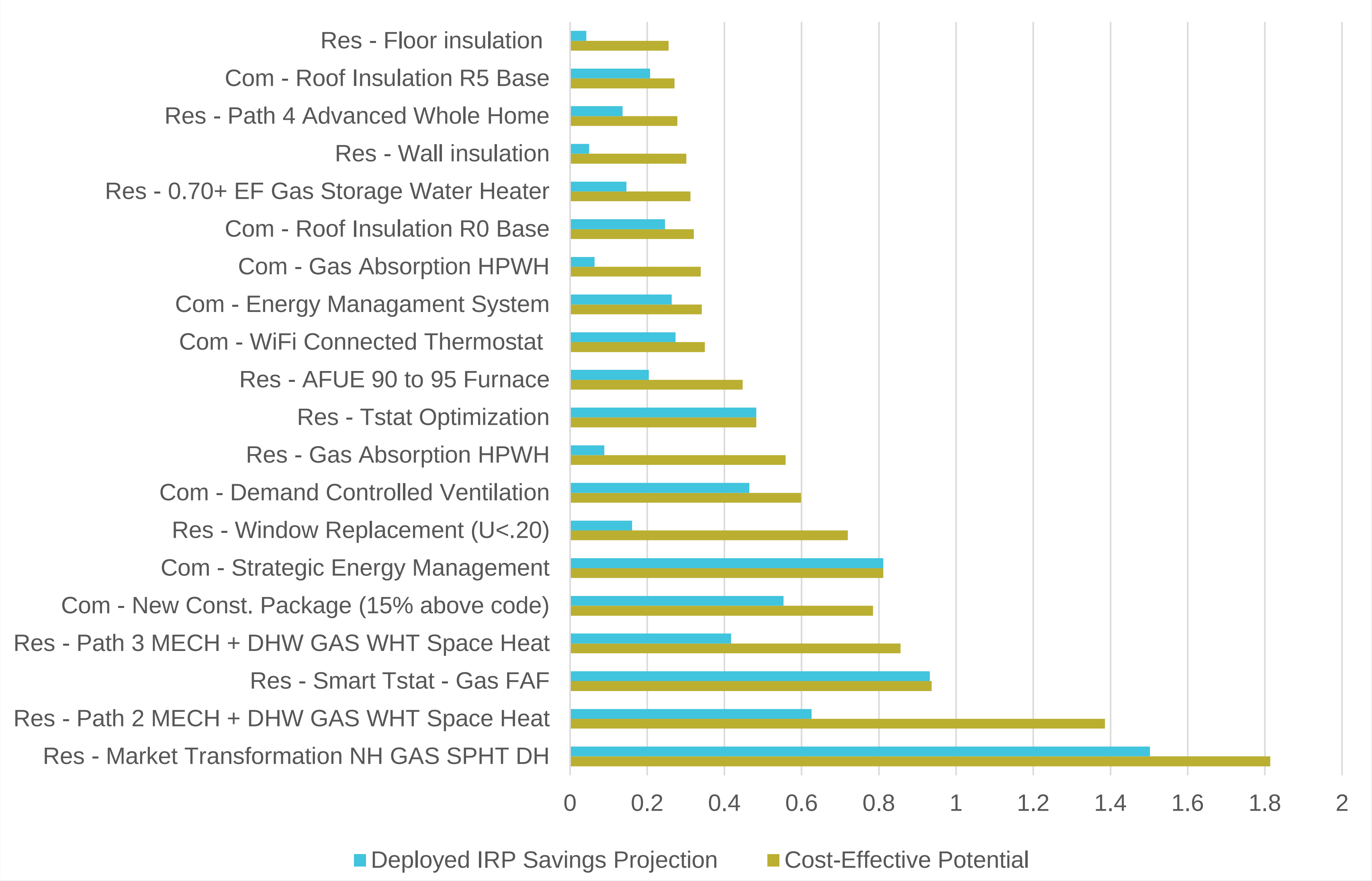
Cumulative Savings by Sector and Type (Therms)

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

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



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



Cost Effective Override Effect

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

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

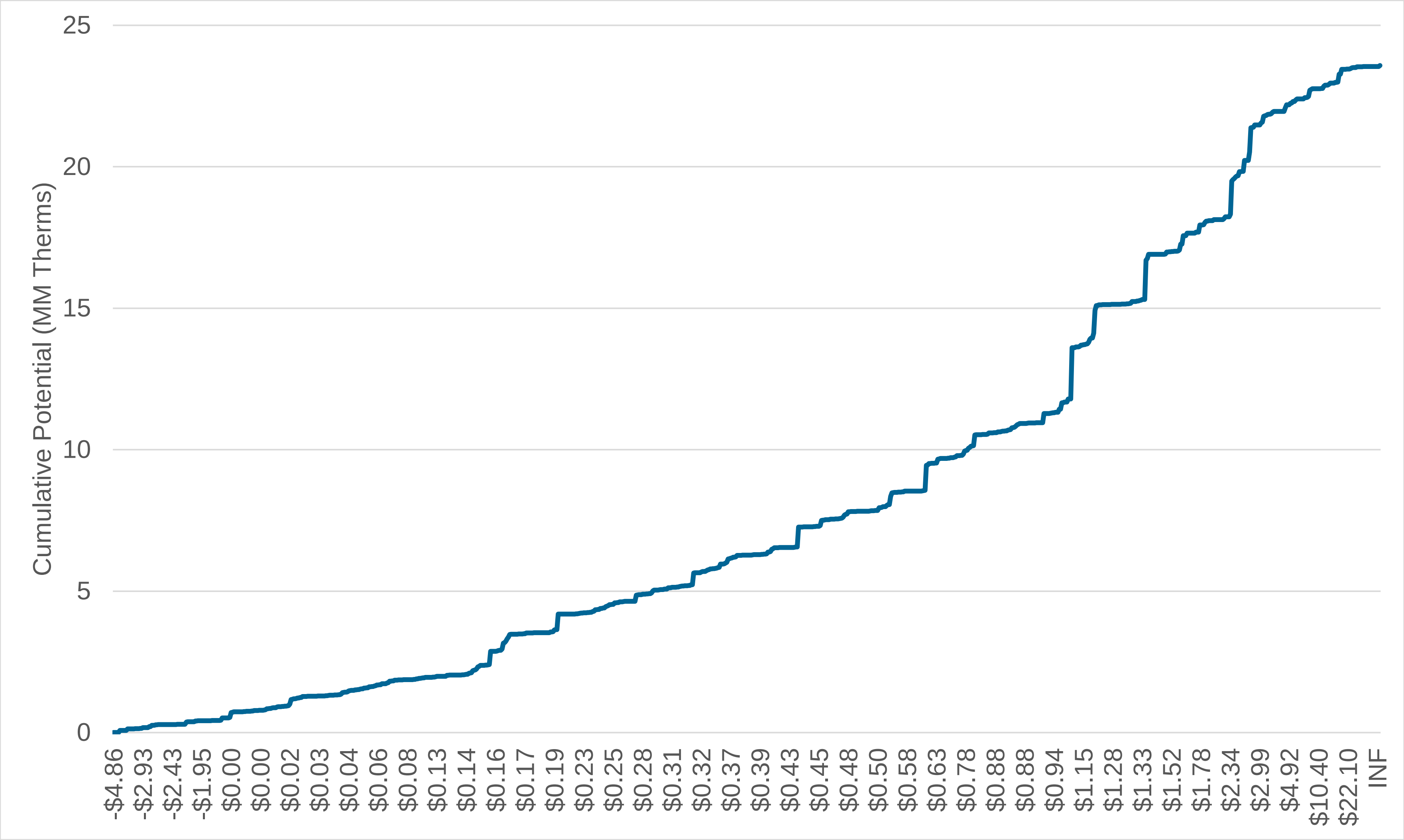
Measures that are Overridden	Override Applied?	Notes
Res - Attic/Ceiling insulation	TRUE	OPUC Exception
Res - Floor insulation	TRUE	OPUC Exception
Res - Wall insulation	TRUE	OPUC Exception
Res - 0.67/0.69 EF Gas Tank Water Heater	TRUE	OPUC Exception

Peak Day Factors and Cumulative Peak Day Savings Estimates

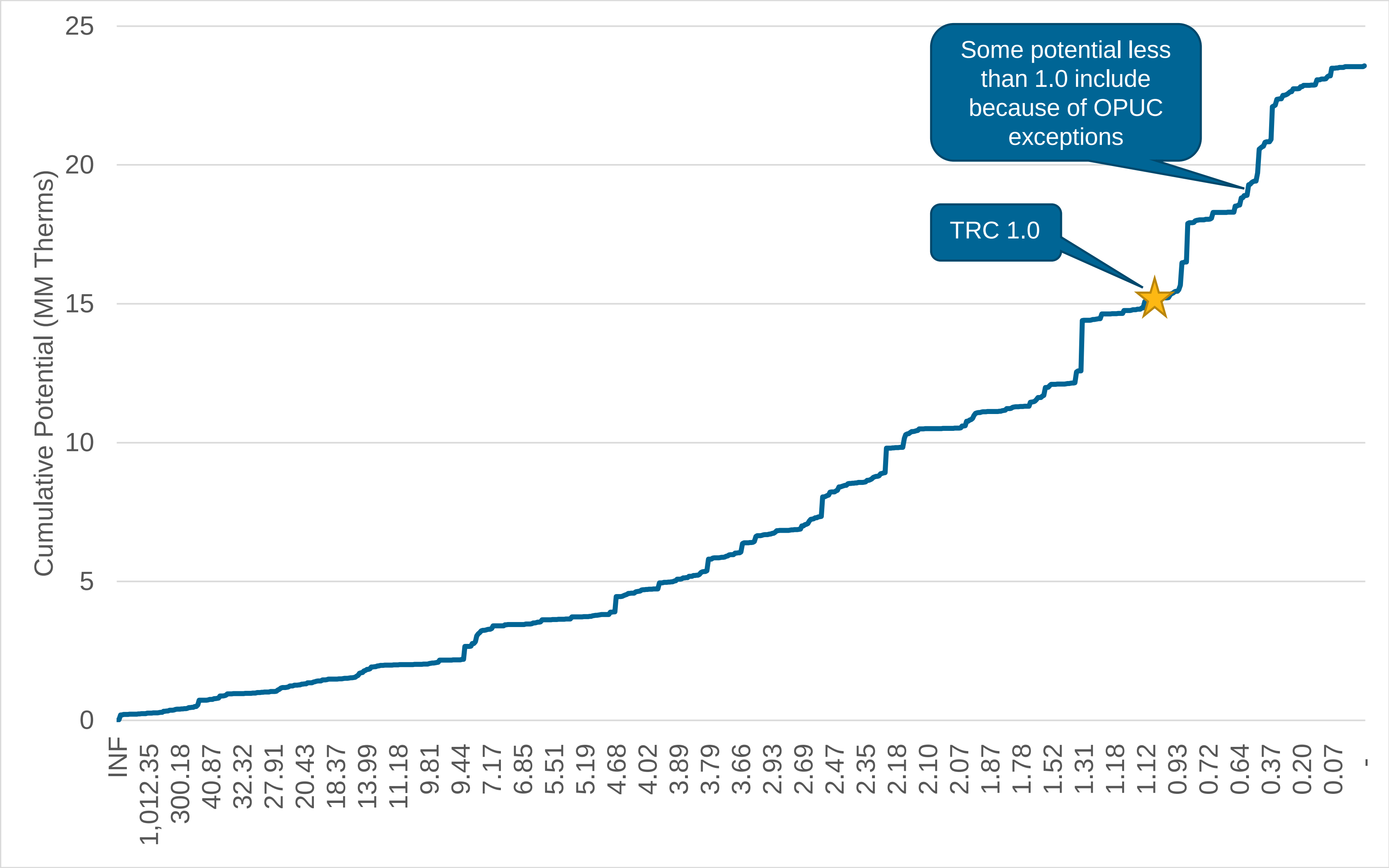
- Energy Trust also provides estimates of a peak day reduction in peak day consumption
- Peak Day factors derived from Energy Trust avoided cost calculations

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

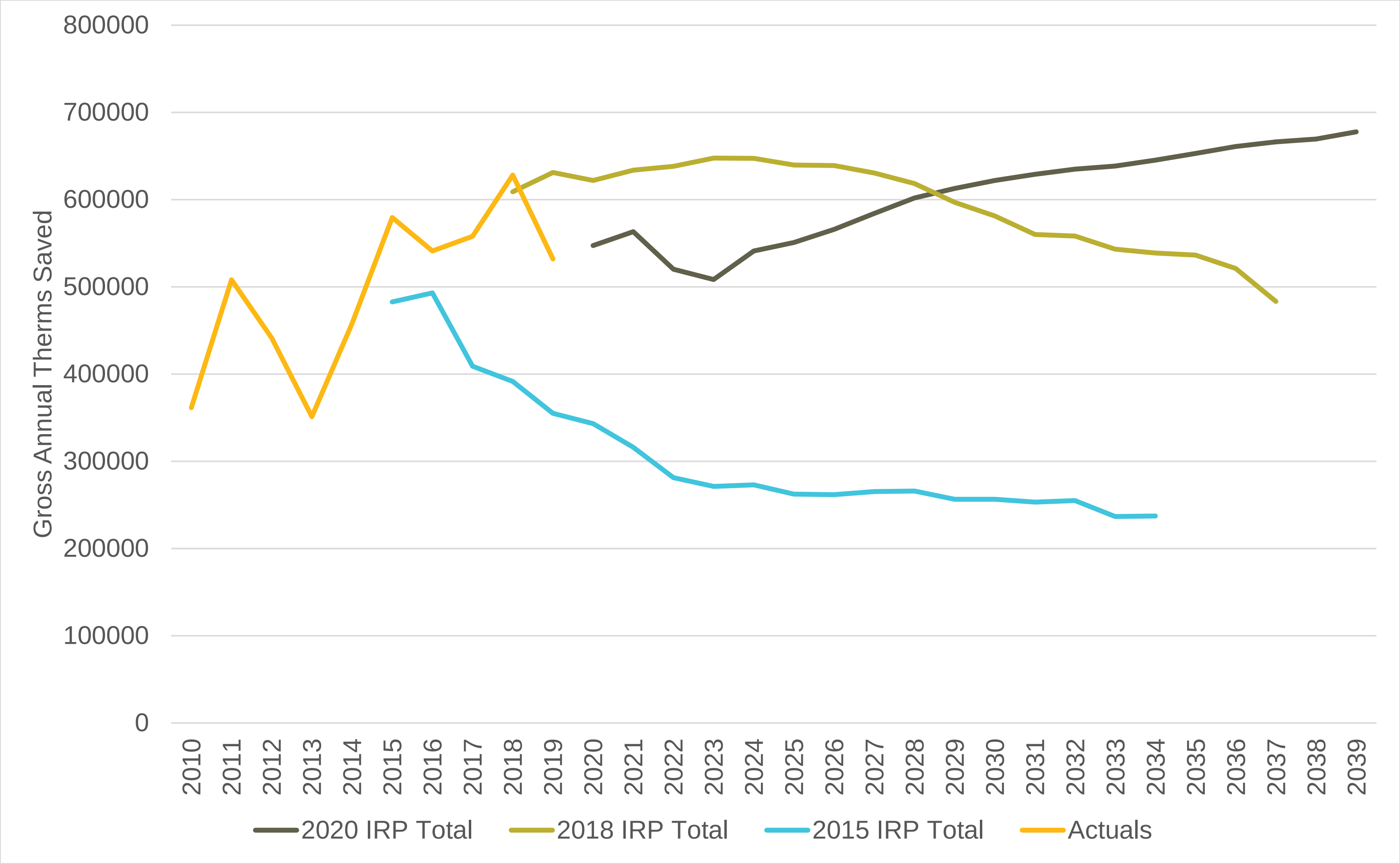
Supply Curve by Levelized Cost (20 year Cumulative Achievable Potential)



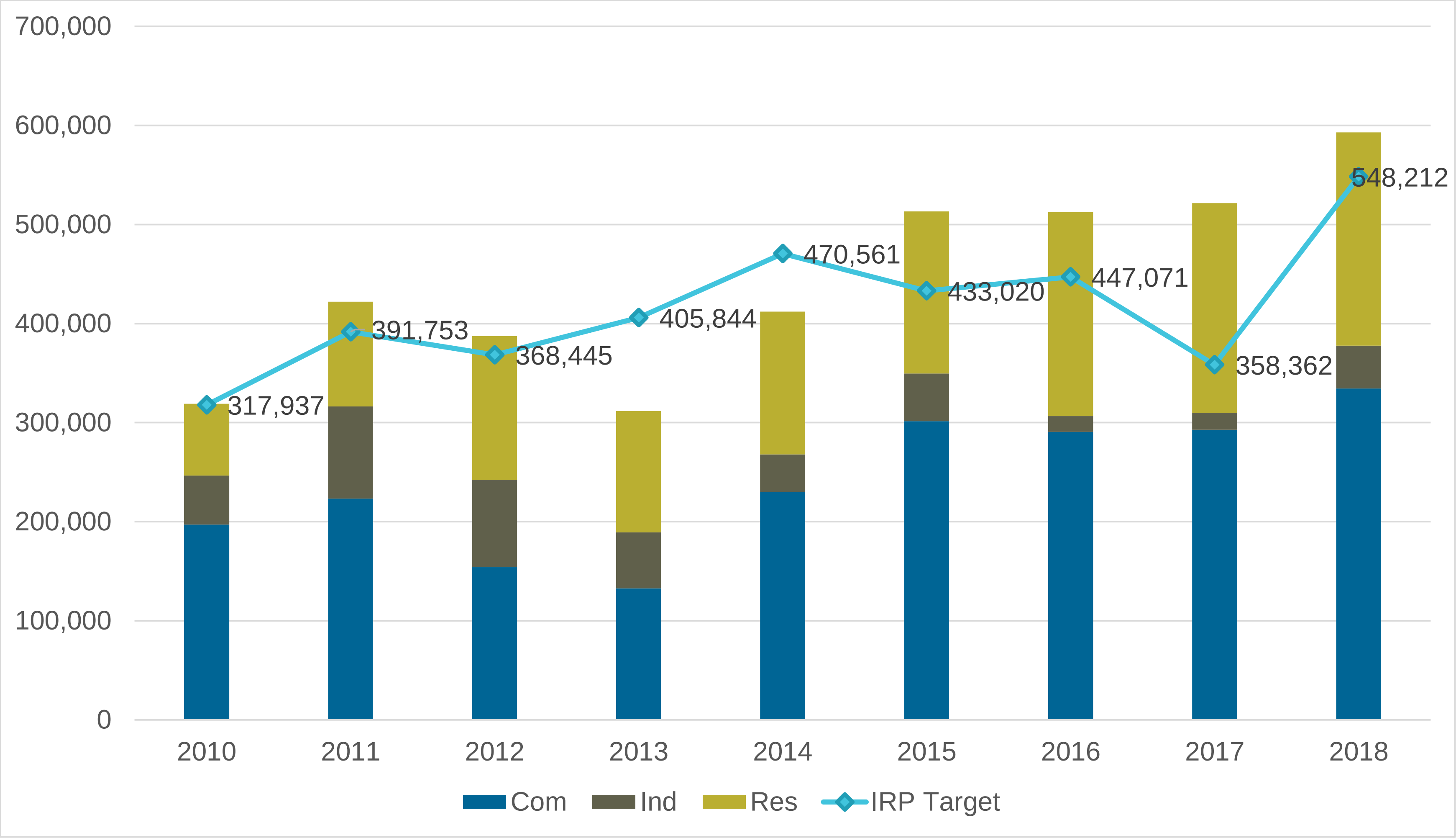
Supply Curve by TRC Ratio (20 year Cumulative Achievable Potential)



IRP Forecasts Compared to Actual Savings (Annual Gross Therms)

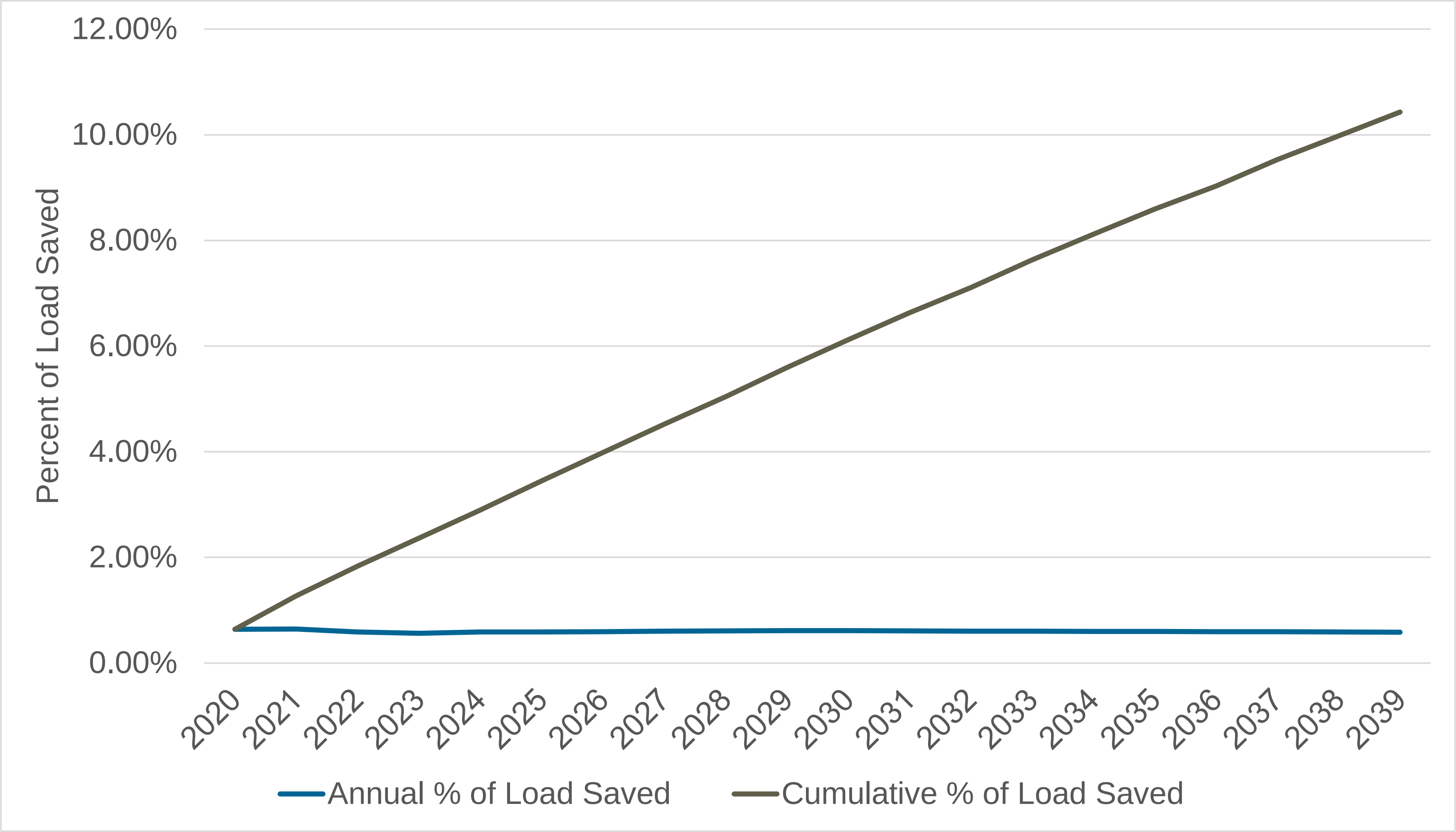


Historical Performance compared to IRP targets (Annual *Net* Therms)



From 2010-2018, Energy Trust has achieved 107% of IRP targets

Savings as a Percent of Load Forecast



Average Annual % of Load Saved = 0.60%

Scenario Runs

Scenarios Overview

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

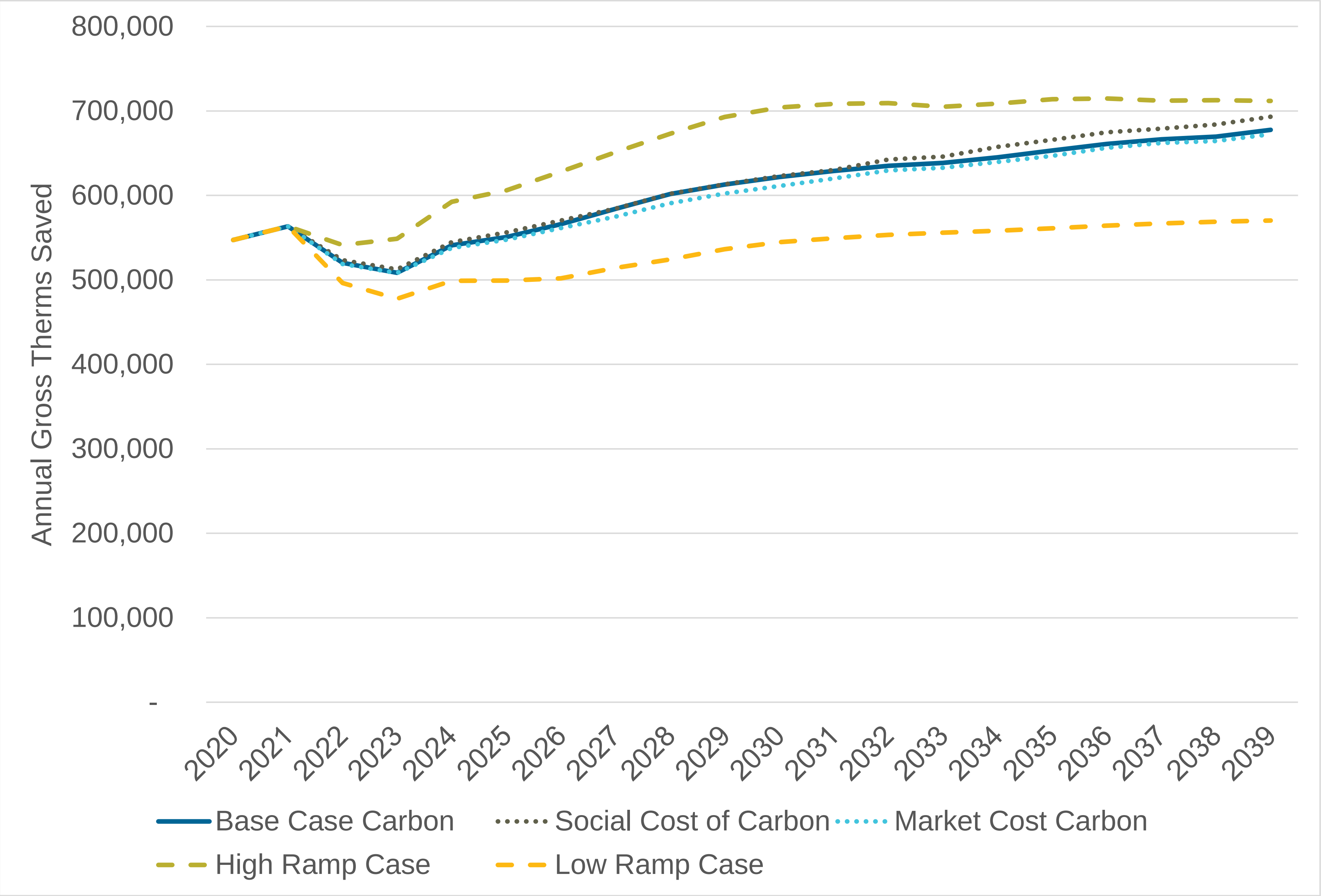
Carbon Scenarios Methodology

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

High/Low Ramp Scenarios Methodology

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

Scenario Analysis Results (Annual Therms)



Carbon Scenarios Discussion

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

High/Low Ramp Scenarios Discussion

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

Thank you

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Energy Trust of Oregon

Carbon Impacts

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Carbon Discussion

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

Base Case Carbon Forecast – Cap and Trade Market

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

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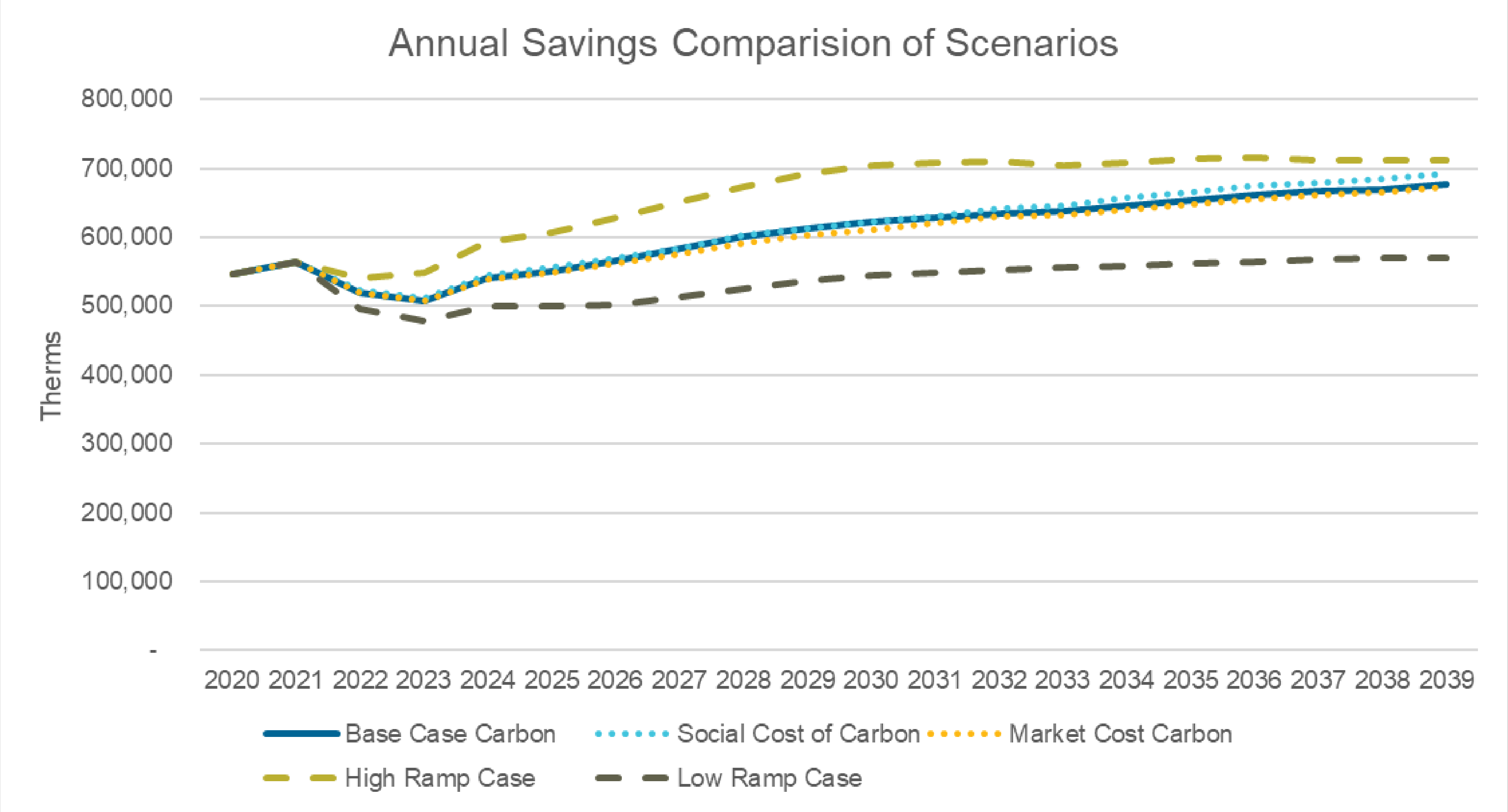
Alternative Carbon Forecasts

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

CPA Comparison: Scenarios vs Ramp Rate



SENDOUT® Optimization Modeling

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SENDOUT® Model

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

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SENDOUT® Model (Cont'd)

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

Modeling Transportation In SENDOUT® is a Balancing Act

- Start with a point in time look at each jurisdiction's resources
- Use the Nov19-Oct20 PGA portfolio
- Contracts –Receipt and Delivery Points
- We start with current transport contracts, using centralized receipts and approximately 67 delivery locations
- Rates - Current contractual, with CPI increase every 3 years
- Contractual vs. Operational
- Contractual can be overly restrictive
- Operational can be overly flexible
- Incorporating operational realities into our modeling can defer the need to acquire new resources.
- Gas Supply's job is to get gas from the supply basin to the pipeline citygate
- IRP focus is on the core
- Operations job is to take gas from the pipeline gate to our customers
- Operations focus is on the system, not just the core
- Limiting factor is receipt quantity –how much can you bring into the system?

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Modeling Challenges

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

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Supply Resource Optimization Process

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

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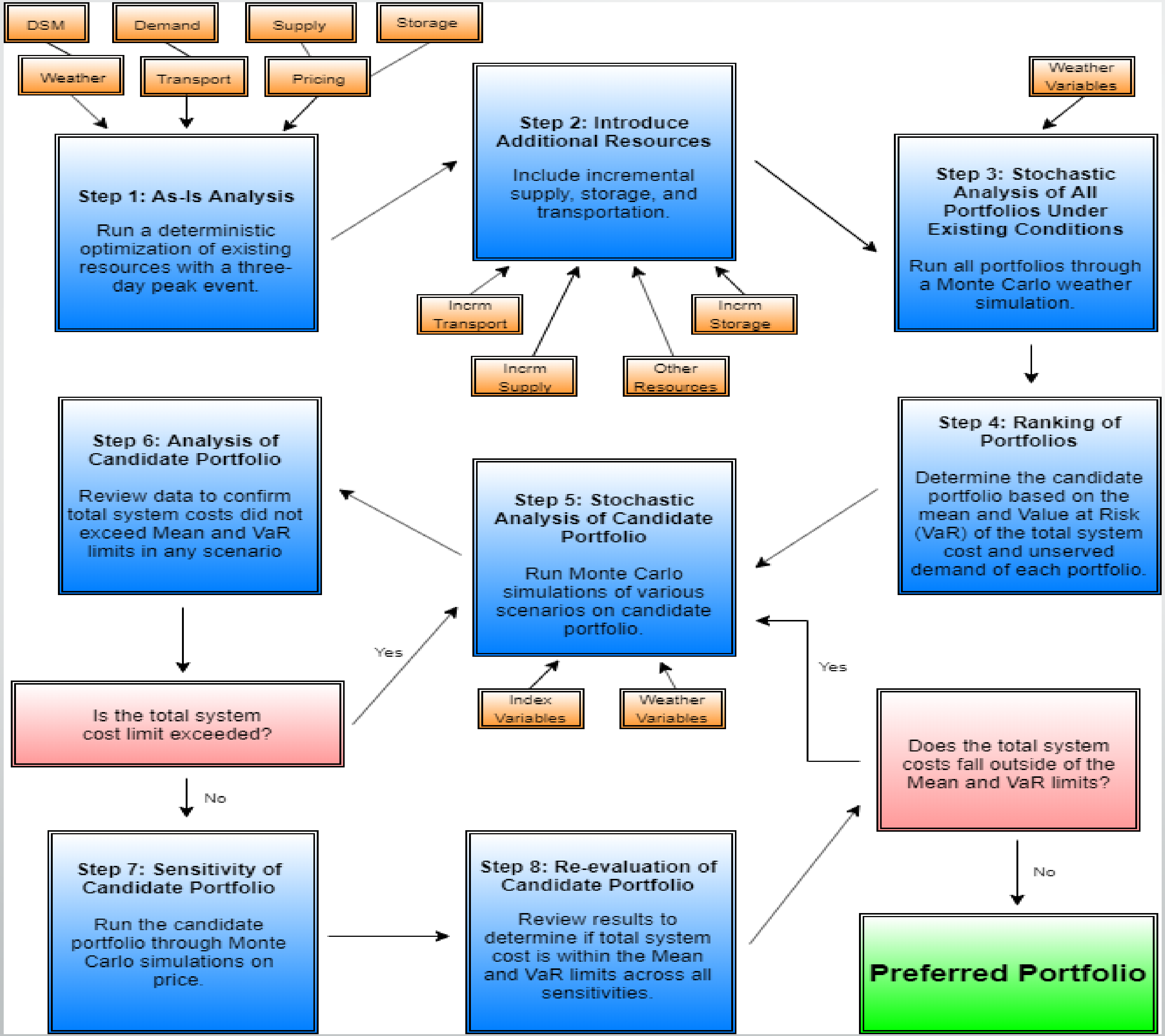
Supply Resource Optimization Process (Cont'd)

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

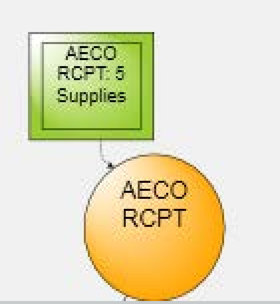

DSM
Demand
Supply
Storage
Weather
Transport
Pricing
Step 1: As-Is Analysis
Run a deterministic optimization of existing resources with a three-day peak event.
Step 2: Introduce Additional Resources
Include incremental supply, storage, and transportation.
Incrm Transport
Incrm Supply
Other Resources
Incrm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

Base Case Sendout Inputs

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

Supply

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



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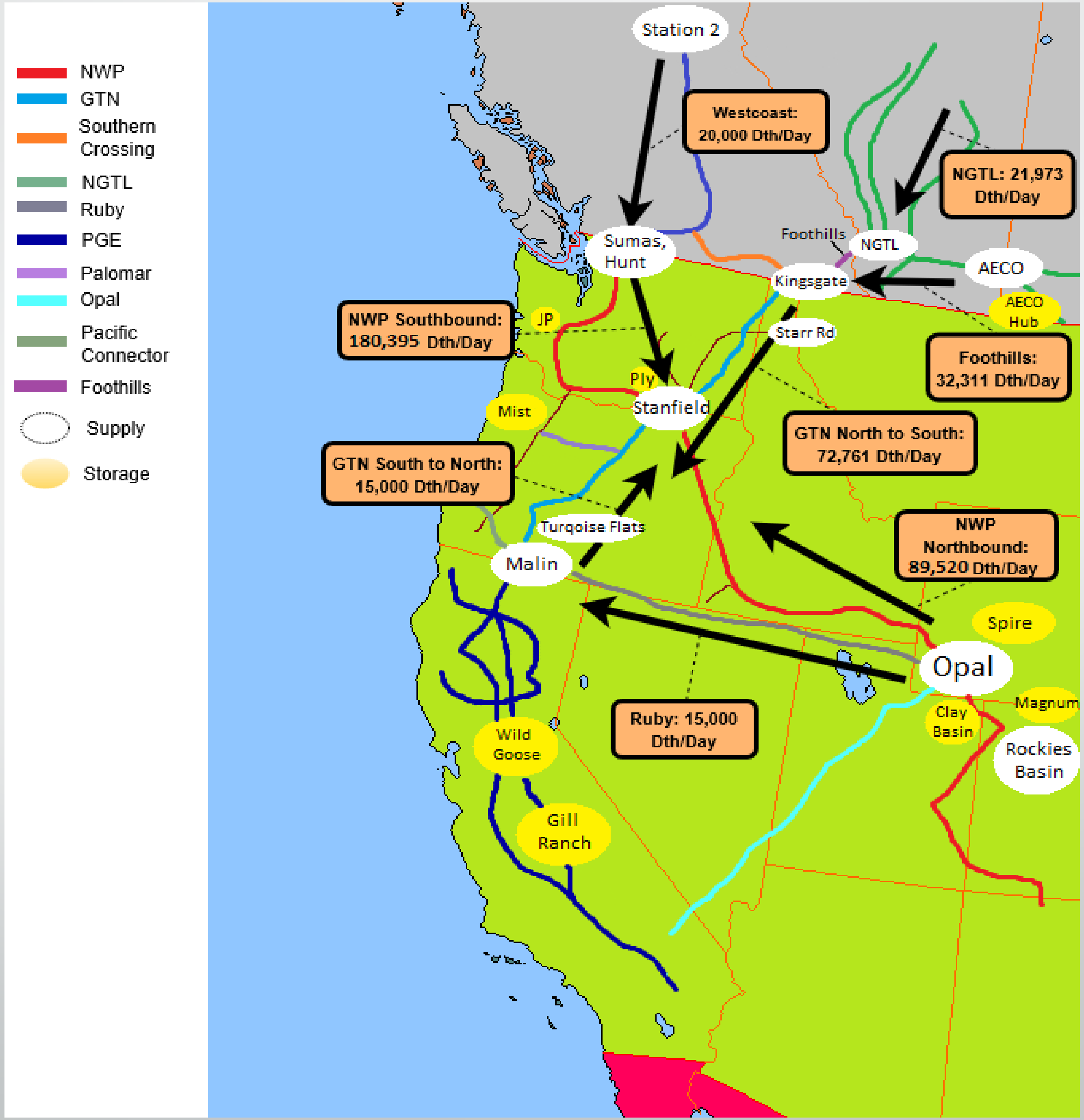
Supply



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Supply Base and Fixed

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

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Supply Example

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

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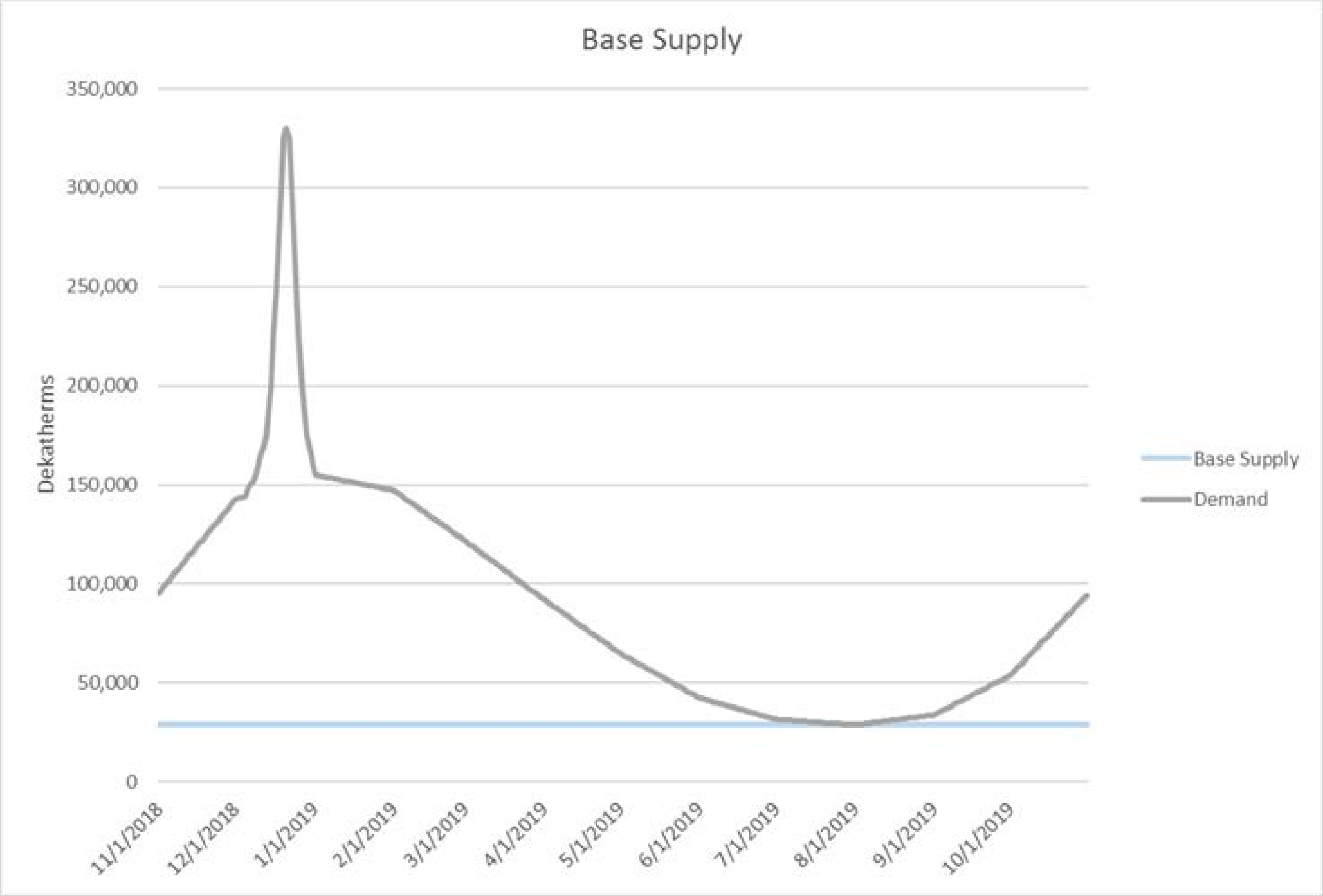
Base Supply (Cont'd)



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Winter base Supply

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

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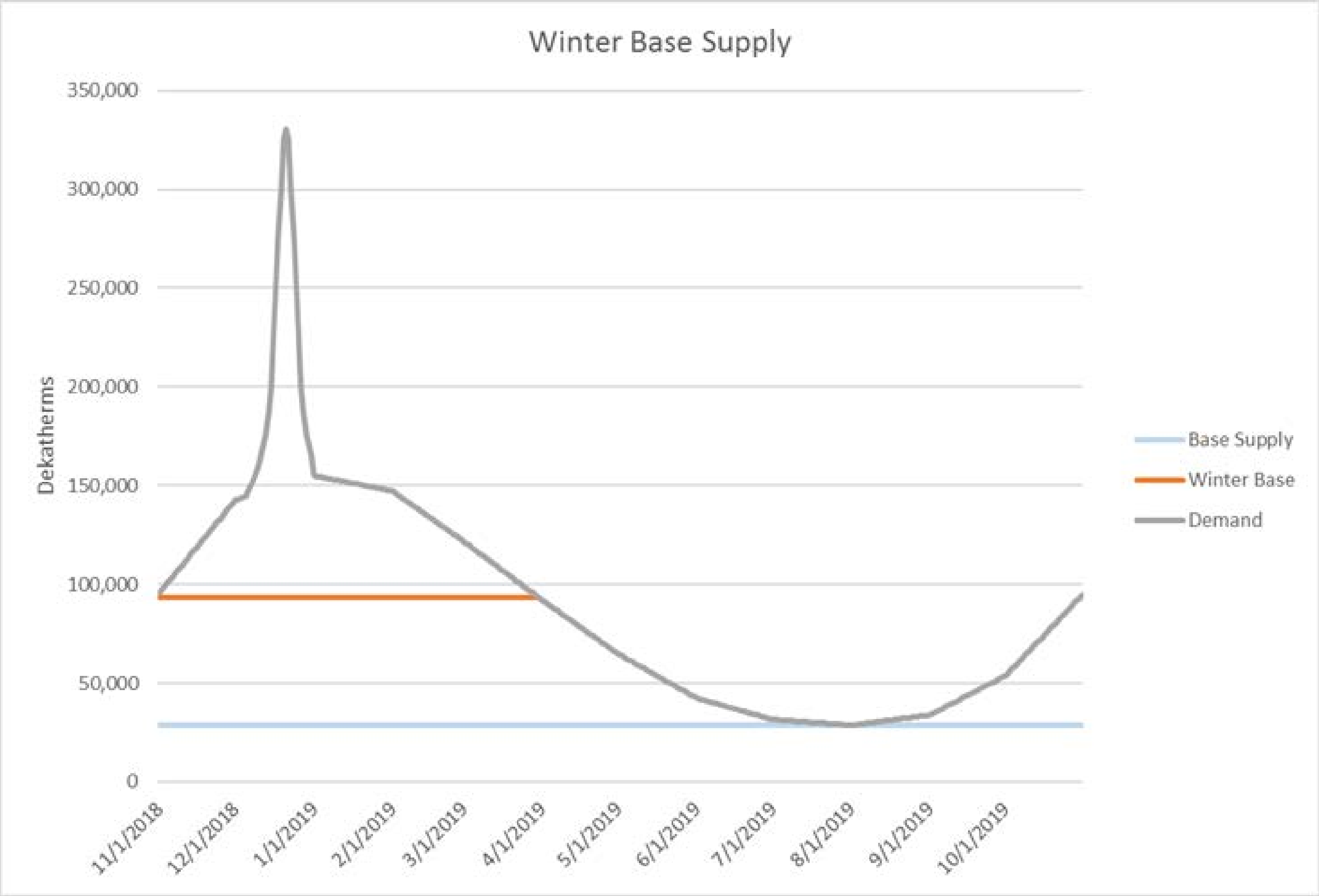
Winter Base Supply (Cont'd)



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Day Supply (Winter)

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

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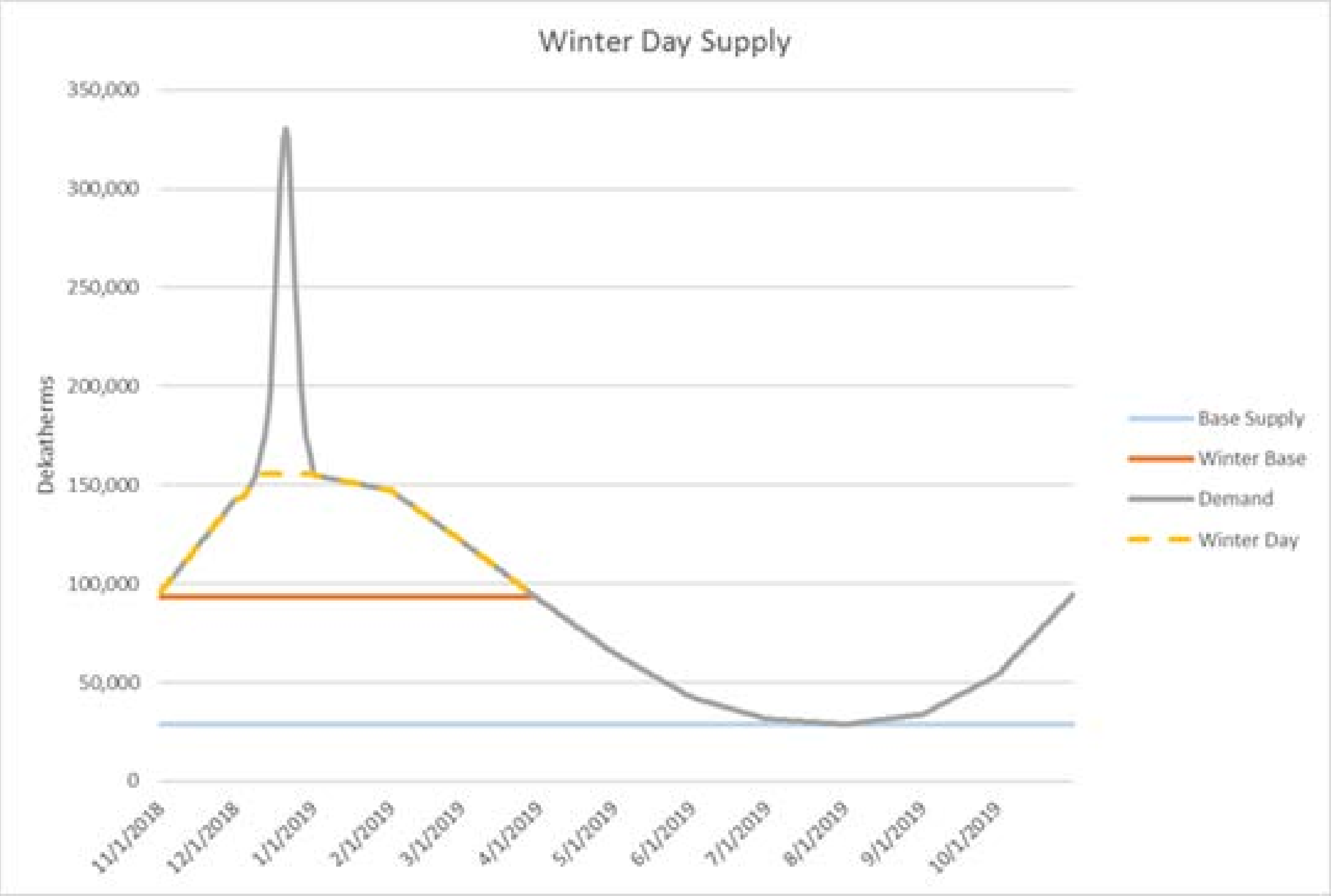
Winter Day Supply (Cont'd)



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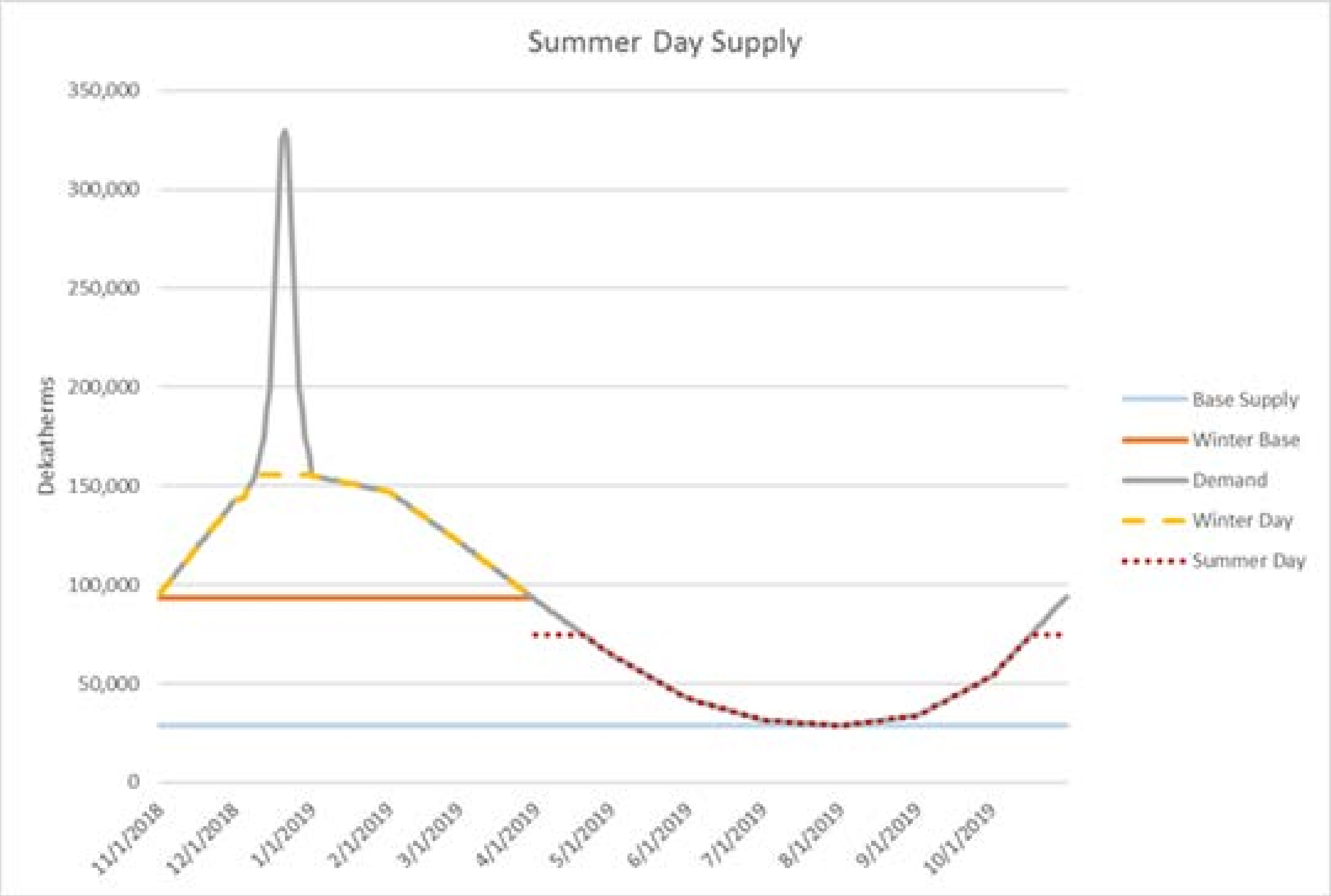
Day Supply (Summer)

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

Day Supply (Summer)



Peak Supply

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

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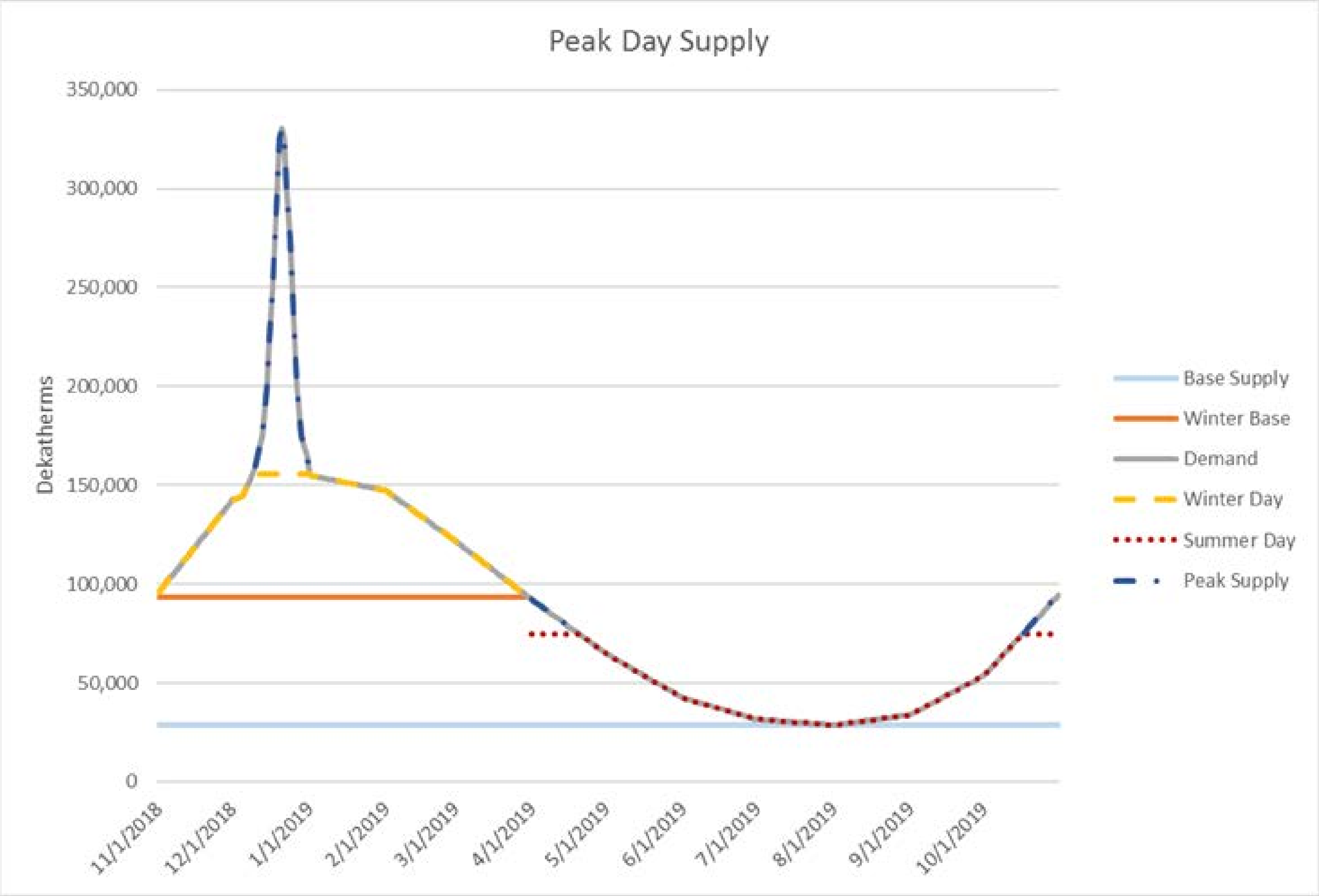
Total Supply



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Storage

- Cascade leases storage at 3 locations: Jackson Prairie (JP), Plymouth (Ply), and Mist.
- Cascade has 4 storage contracts with JP, 2 contracts with Plymouth, and 1 with Mist.
- Storage injections targets are set at 35% by the end of June, 80% by the end of August, and 100% by the end of September.
- These targets are set by our Gas Supply Oversight Committee.
- Cascade can withdrawal approximately 56,000 dth per day from JP, 78,000 dth per day from Plymouth, and 30,000 Dth per day from Mist for a total of approximately 164,000 dth per day.

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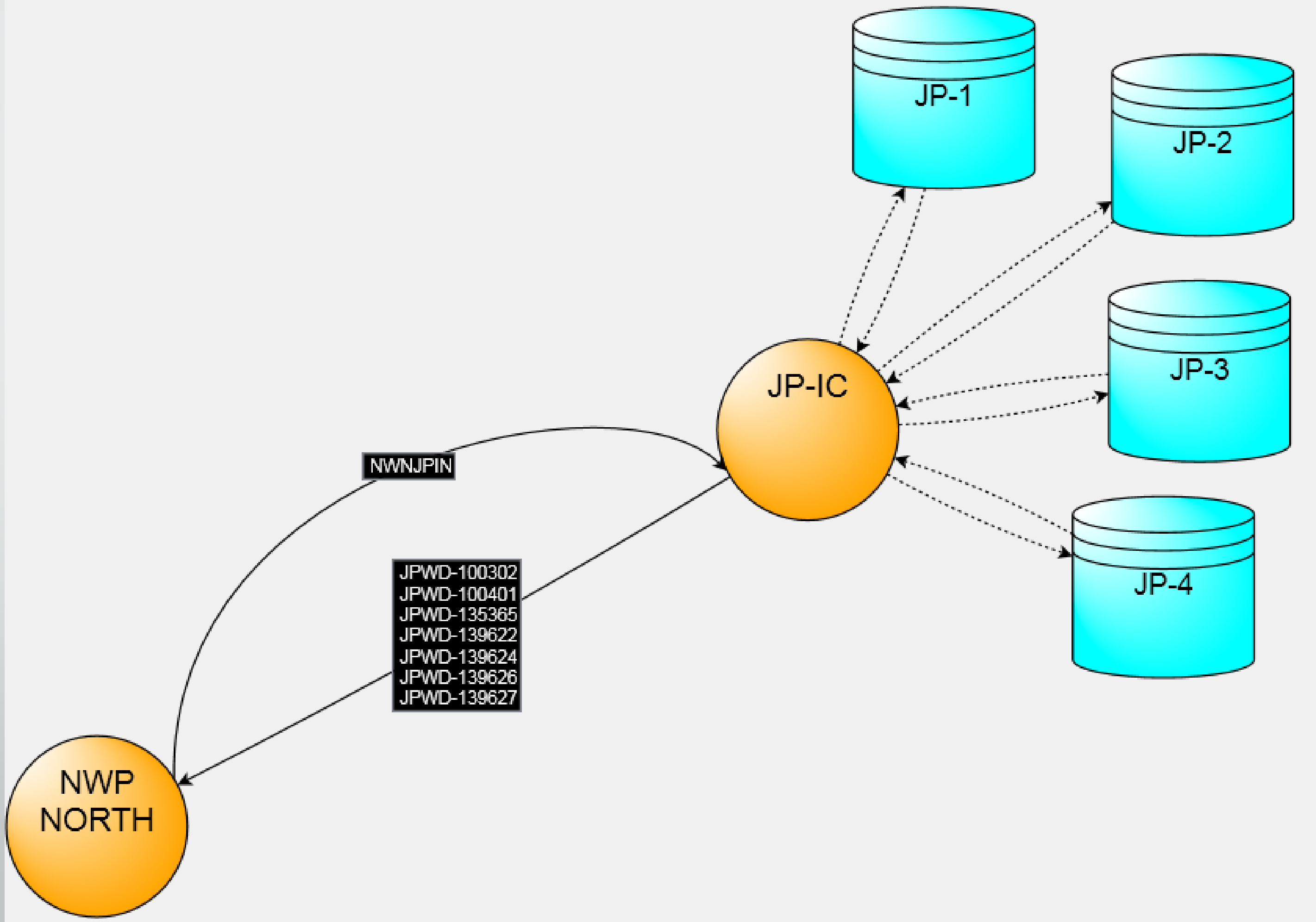
Storage Example



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Storage Example 2

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

Transportation

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

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Transportation (Cont'd)

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

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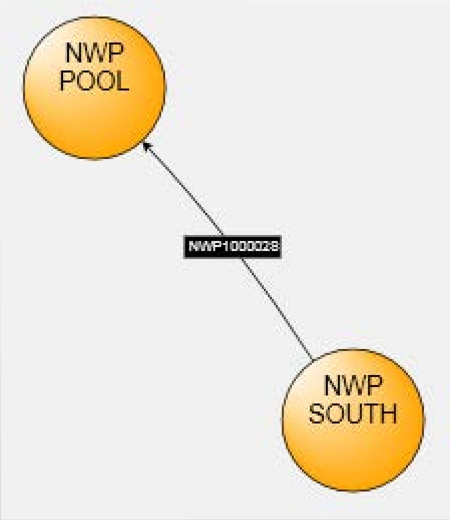
Transport Example



Transport Example

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

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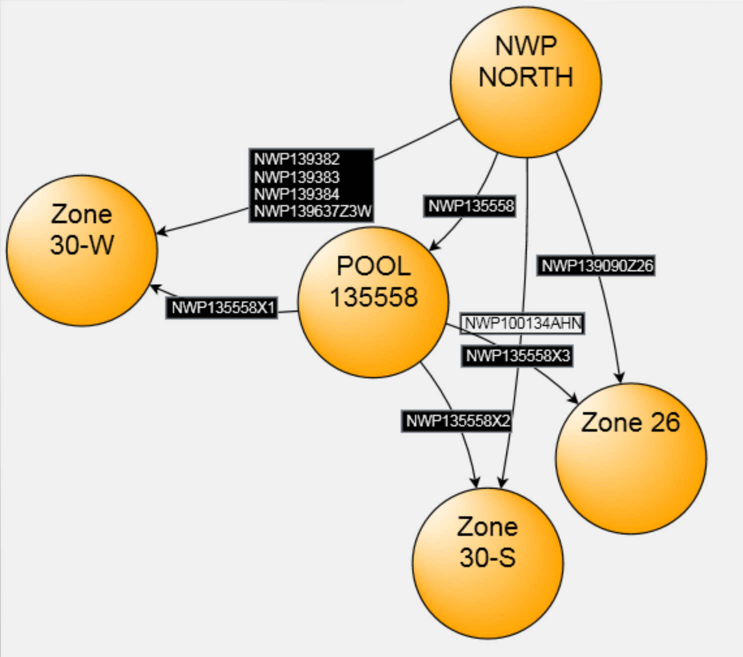
Delivery Rights vs Receipt Rights

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

Example of delivery right flexibility



All of the following must be true

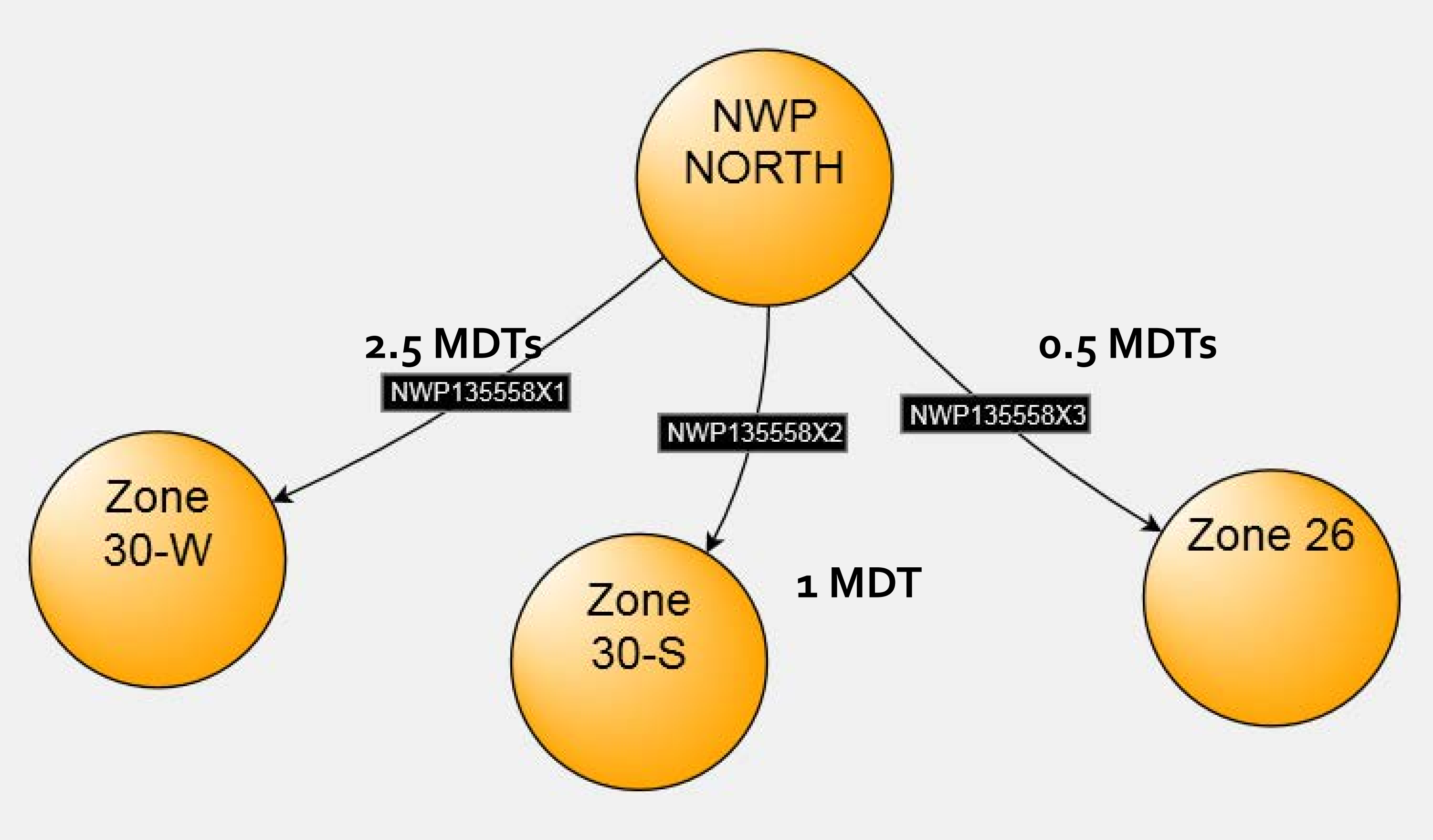
$$X1 \le 4\text{MDTs}$$

$$X2 \le 4\text{MDTs}$$

$$X3 \le 4MDTs$$

$$X1 + X2 + X3 \le 4MDTs$$

Example of delivery right inflexibility



Transport Constraints

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

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Transport Constraints Example

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

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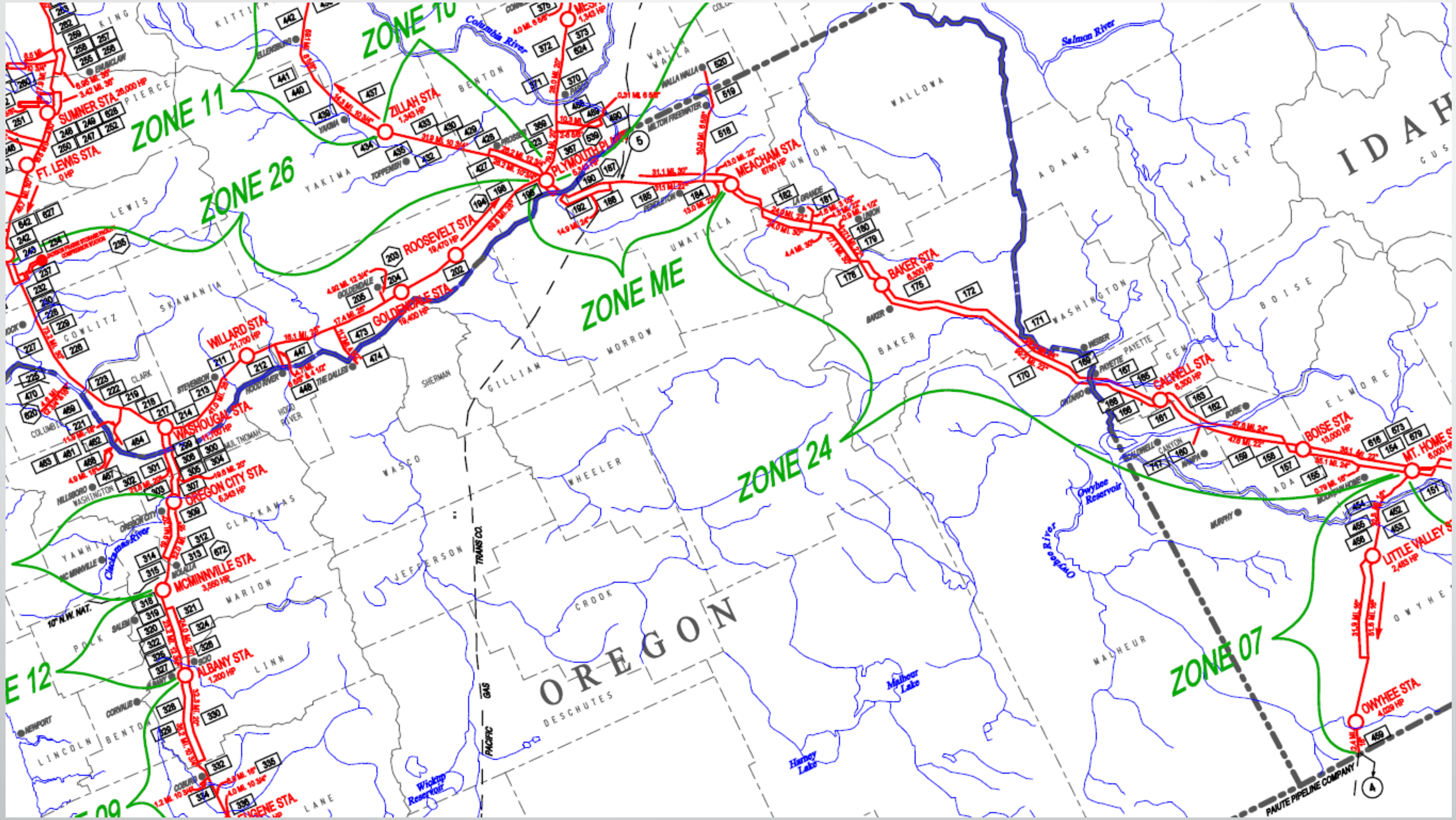
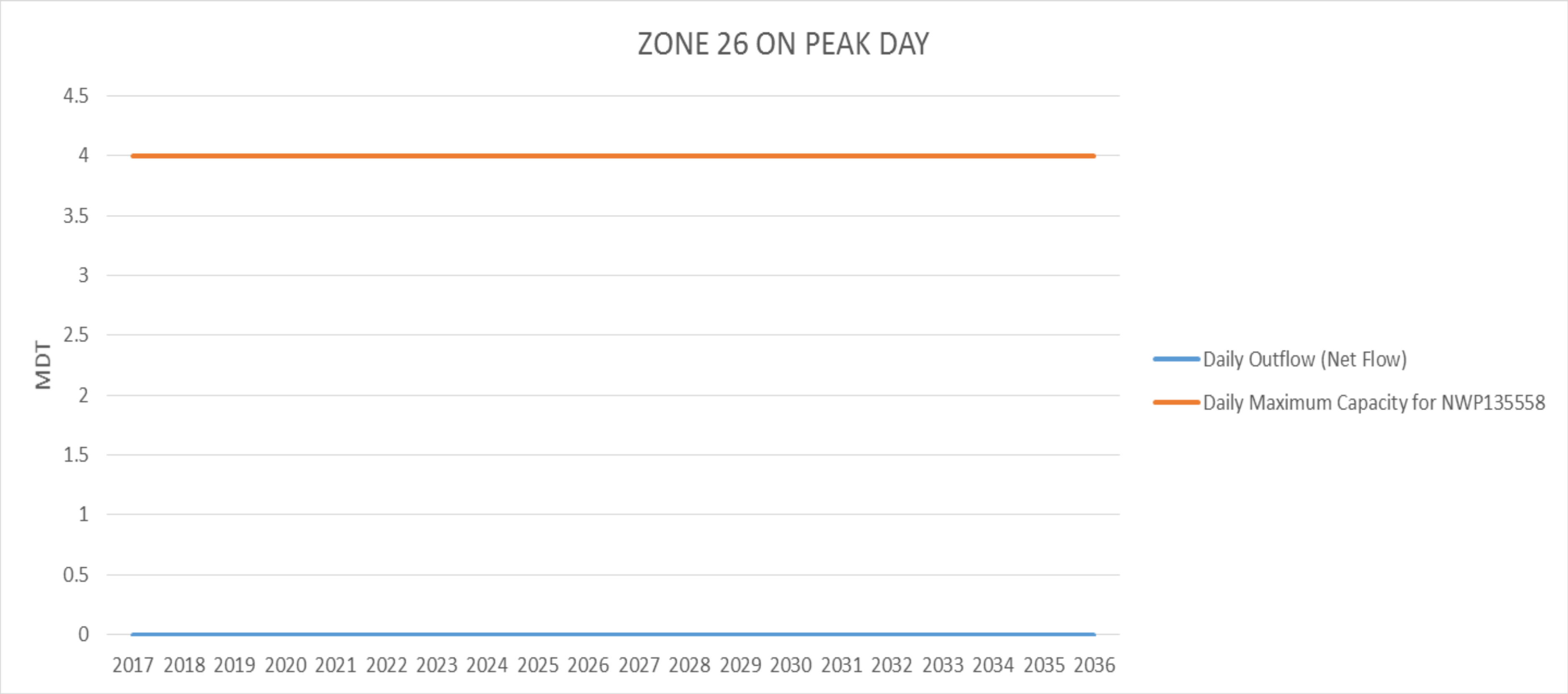
Location of Zones (Source: NWP)



Zone 26 on Peak Day for Transport 135558



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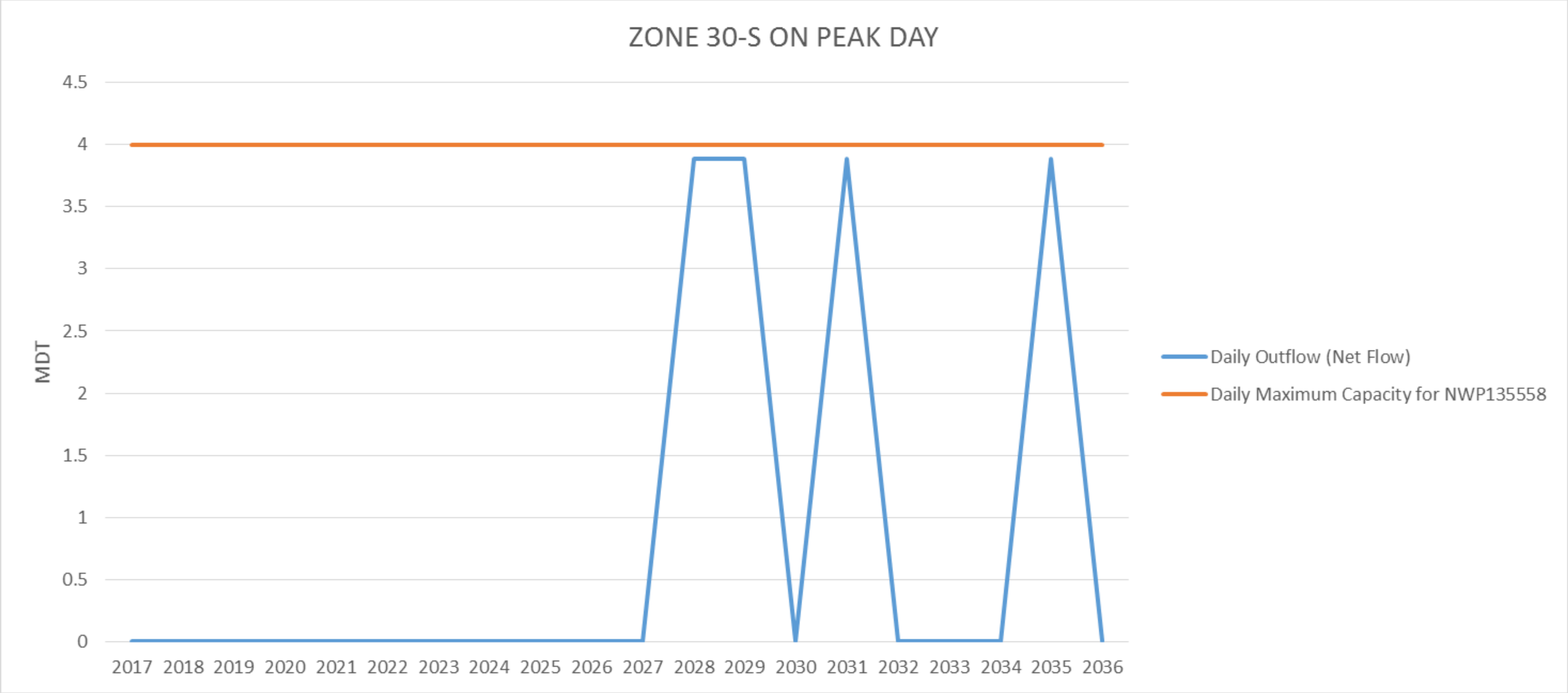
Zone 30-S on Peak Day for Transport 135558



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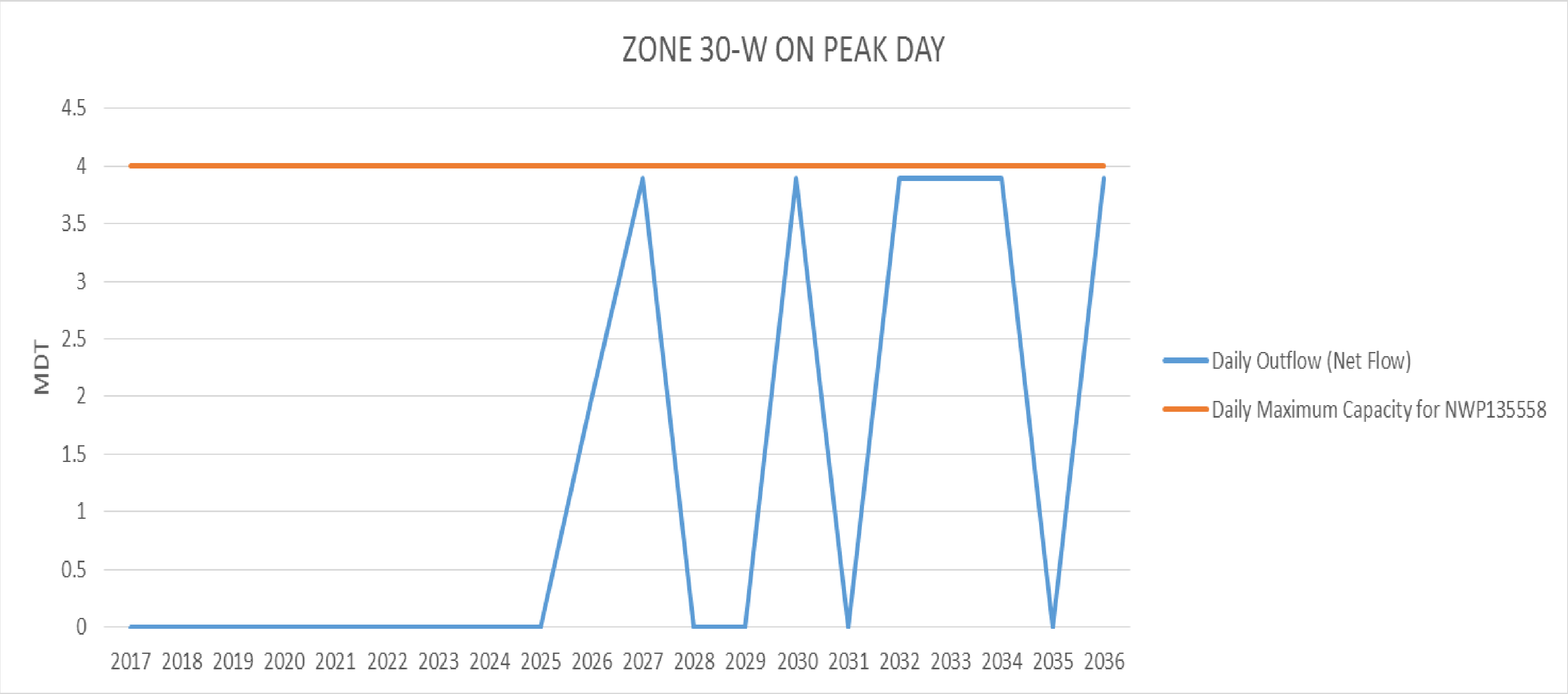
Zone 30-W on Peak Day for Transport 135558



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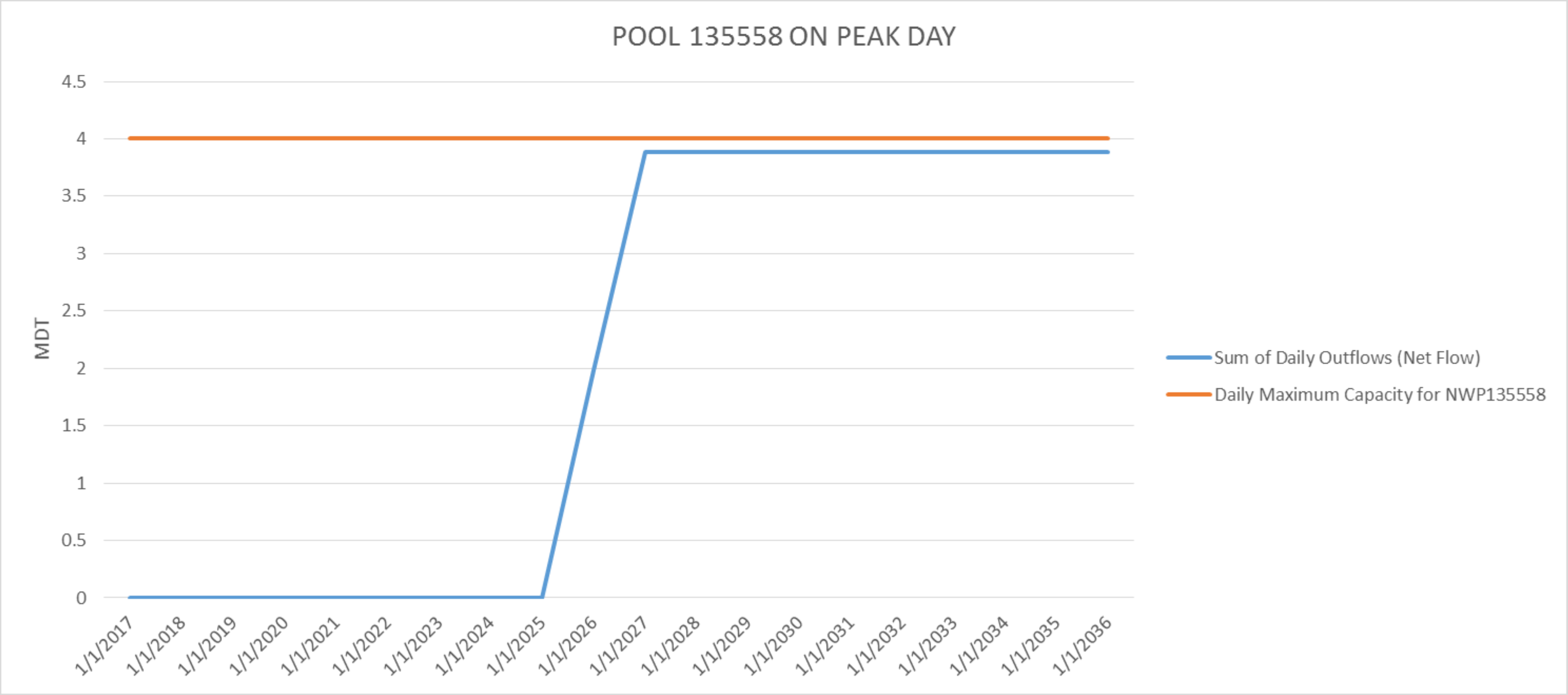
Transport Contract 135558 on Peak Day



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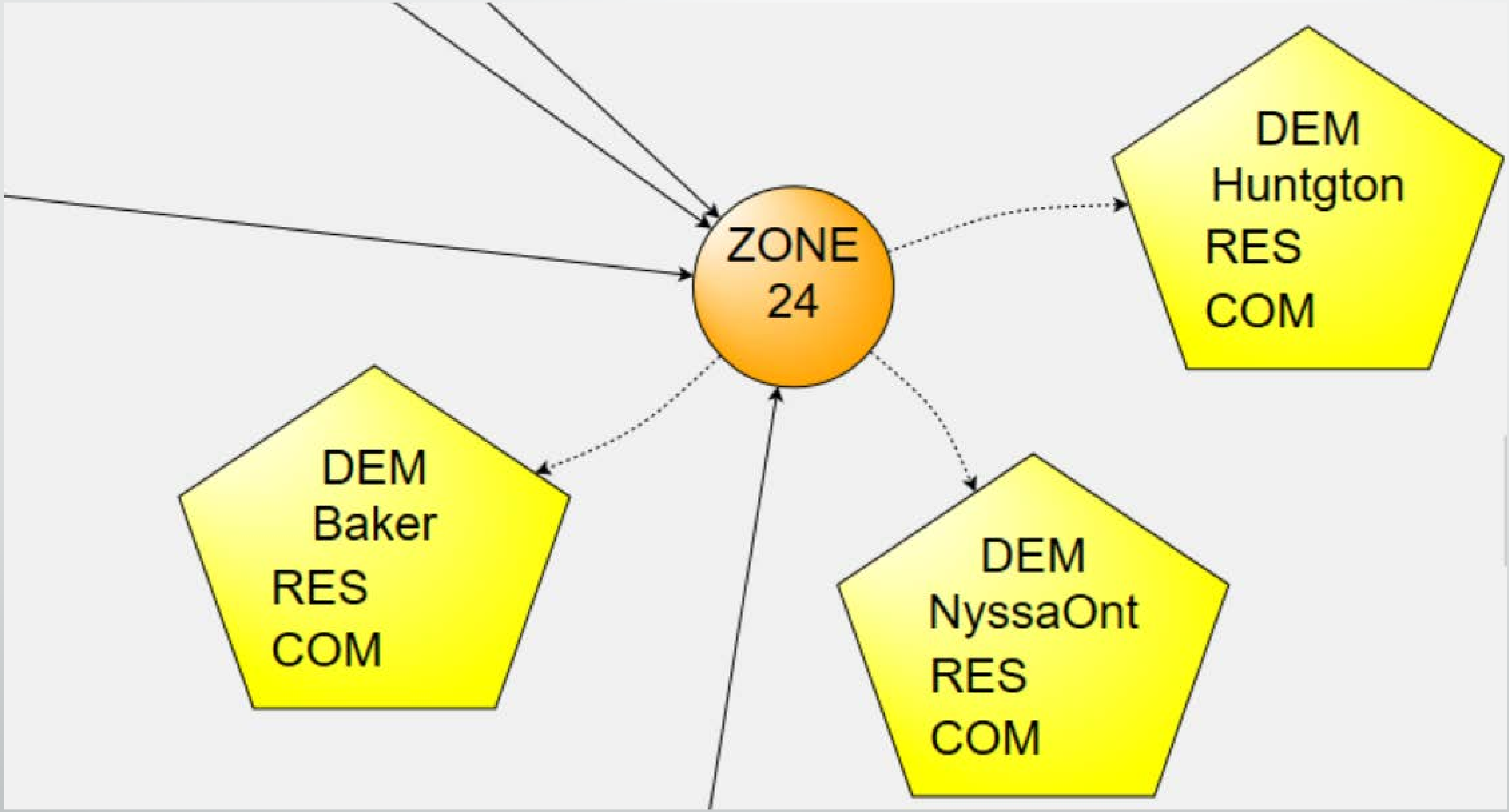
Demand Behind the Gate

- Cascade has strived over the last several years to enhance the IRP forecast and resource analysis to get to as granular a level as possible using the available data.
- Attempts to forecast demand behind the gate using existing forecasting methodology has been challenging.
- Customer billing data does not have daily meter reads for core customers making regression analysis on use per HDD per customer difficult.
- Some towns can be served by multiple pipelines and the mix can change over time.

Demand

- Demand is forecasted at the citygate level by rate schedule.
- For NWP, each citygate's demand is associated with the zone.
- For GTN, each citygate's demand is associated with it's respective citygate interconnect.
- Demand Inputs
  - Forecast type (Monthly amount or Regressions).
  - Monthly projected customers for 20 years.
  - Regression coefficients if using the Regression forecast type.
  - If using a monthly number, it is the 2020 demand for that month with a growth factor.

Demand Example



Demand Example 2

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

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Weather

- Weather inputs for SENDOUT include:
  - Monte Carlo
  - Historical
  - Normal
- Monte Carlo inputs include mean, standard deviation, max, minimum, and distribution.
- Historical data is used to build weather profiles for Monte Carlo.
- Normal weather is the daily average of the 30-year most recent history (1989-2019).

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Weather Example – Monte Carlo

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

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Preliminary Modeling Results

No DSM (Dth)

Demand Group	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Sunnyside	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	399	1,427	910
Yakima Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	197	2,870	-
Kennewick Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	240	3,726
Nyssa Ontario	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	947	792	1,084	997	1,133
Longview South Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	82	82	82
Bremerton Shelton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,603	528	4,939	4,302	4,774
Sumas Loop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,306	1,553	4,603
Bend Loop	-	1,154	2,769	-	-	-	-	-	-	-	-	-	-	542	2,158	3,773	4,290	7,005	8,620	10,236
Walla Walla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,464	2,524	2,690

DSM (Dth)

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

Served — Unserved — Unserved Covered by 3rd Party Citygate Supply

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2020 IRP Timeline

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

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Questions?

Cascade Natural Gas Corporation

2020 Integrated Resource Plan

Technical Advisory Group Meeting #4

Wednesday, Jan. 15th, 2020

Portland International Airport

Portland, OR

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