NW NATURAL 2018 INTEGRATED RESOURCE PLAN UPDATE

Technical Working Group

NW Natural

February 2, 2021

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” 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, 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.

Agenda

- Welcome
- Introduction
- Planning Environment
- Load Forecast Update
  - Heating Season Weather and Planning Standard
  - Customer Growth Forecast
  - Annual Load Forecast
  - Peak Load Forecast
- Capacity Resource Position and Mist Recall
- Avoided Costs
- Emissions Forecast
- Lunch 11:45-12:25
- Action Item Projects
  - Framing and Risk Assessment
  - Newport LNG Cold Box
  - North Coast Feeder Uprate
- Renewable Natural Gas (RNG)
  - RNG Policy Update
  - RNG Market Update
  - NW Natural RNG Resource Update
  - Hydrogen Update

Introduction and Planning Environment

Safety Moment - How to Properly Wear a Mask

FOLLOW THESE GUIDELINES TO PROPERLY WEAR YOUR FACE MASK

Wash your hands before and after touching the mask.

Touch only the bands or ties when putting on and taking off your mask.

Make sure the mask fits to cover your nose, mouth and chin. If you adjust the mask to cover those areas, wash your hands before and after.

Make sure you can breathe and talk comfortably through your mask.

Wash reusable masks after each use. If the mask is disposable, discard it when visibly soiled or damaged.

Dos and Don'ts of Mask Wearing

Cover mouth and nose

Not a chin strap

Not an ear decoration

Not a hat

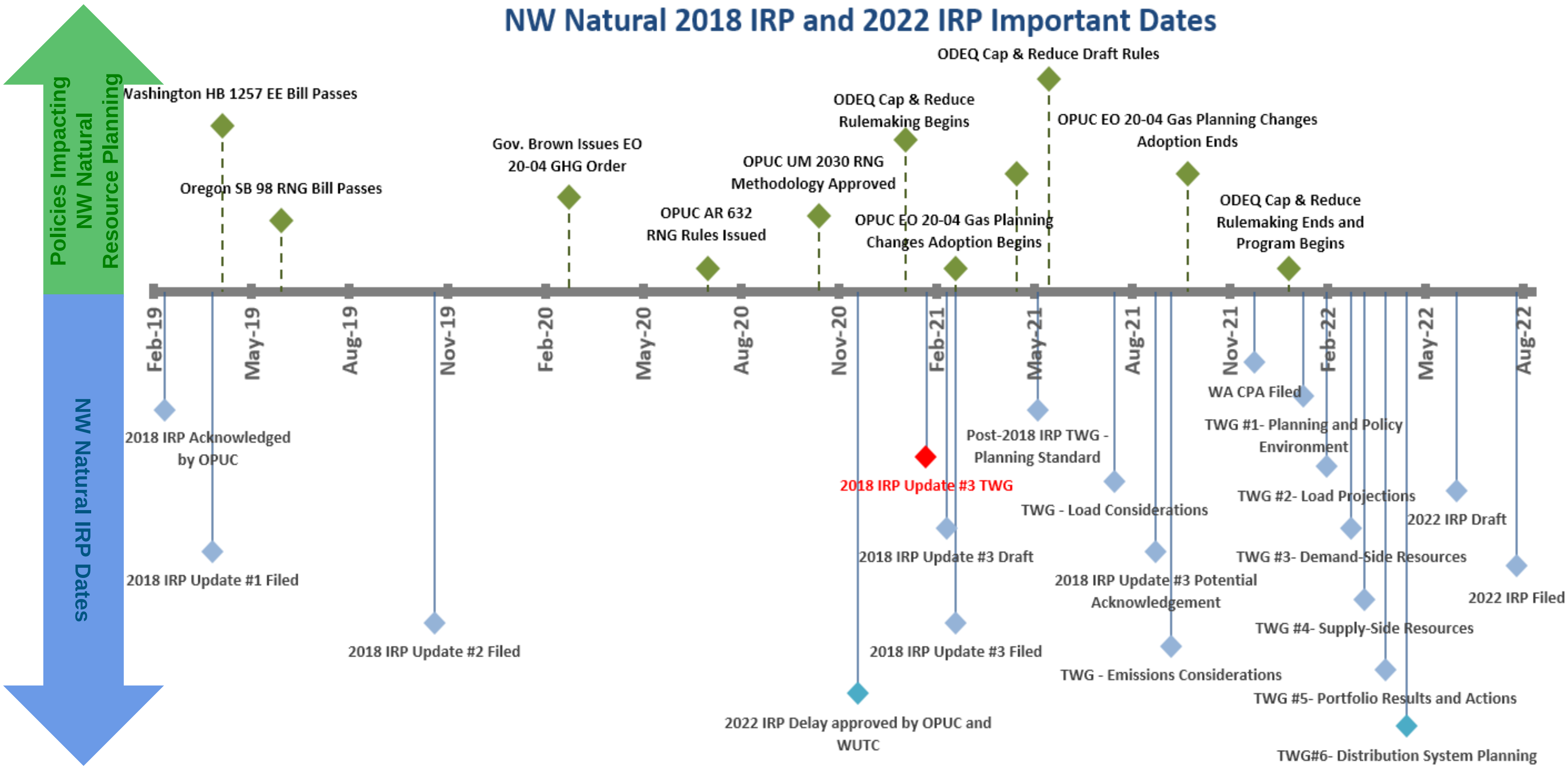
Overview – Who is NW Natural?

Quick Stats

- **Over 770,000 customer accounts**
  - 89% Oregon
  - 11% Washington
  - More than 140 communities
  - 18 counties
  - Serving roughly 2.5 million people
- **Over 14,000 miles of distribution and transmission mains and service lines**

NW Natural analysis, not for investment purposes.

Where have we been and where are we going?



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Update on Actions in 2018 IRP Action Plan

Action Description	Status
Recall Mist Storage Capacity for the 2020-21 and 2021-22 Gas Years	Updated load projections resulted in no Mist Recall being required for the 2020-21 gas year. Lower cost Citygate deliveries of 5,000Dth/Day are to be deployed for the 2021-22 gas year.
Use "all=in cost" RNG Evaluation Methodology to evaluate RNG resources	Item was not acknowledged, but transitioned to an investigation. Docket no. UM 2030 was started in 2019 and completed October 2020. The RNG evaluation methodology was amended and approved, and is now being used to evaluate RNG resources.
Complete Hood River Reinforcement Project	Construction started and the project was placed into service in September 2020 and included in rates.
Complete Happy Valley Reinforcement Project	Construction started and the project was placed into service in March, 2020 and included in rates.
Complete Sandy Feeder Reinforcement Project	Construction started and the project was placed into service in October, 2020 and included in rates.
Complete South Oregon City Reinforcement Project	Construction started and the project was placed into service in April, 2020 and included in rates.
Complete Kuebler Road (Salem) Reinforcement Project	The project is currently in the planning phase. It's yet to be determined what environmental permits, if any, will be required as final environmental studies are still to be performed. At this time the target is to start construction in the summer of 2021 and finish in Q4 of 2021.
Acquire Energy Efficiency savings via Energy Trust for Oregon for 2019 and 2020	Energy Trust acquired 97% of the 2019 goal on behalf of NW Natural customers. Final 2020 results are still pending.
Acquire Energy Efficiency savings via Energy Trust for Washington for 2019 and 2020	Energy Trust acquired 101% of the 2019 goal on behalf of NW Natural customers. Final 2020 results are still pending.

Aligning Short- and Long-term Needs with Policy Environment in Flux

- **Some policy uncertainty has been resolved since NW Natural filed its 2018 IRP (e.g. OR SB 98 and WA HB 1257 and their subsequent processes)**
- **Other policies, with potentially very large implications for long-term projections of load and resource options, are currently in flux but much is expected to be resolved over 2021**
  - This includes processes currently underway but unresolved from the issuance of Oregon Executive Order 20-04 on Climate Change by Governor Brown
    - The Oregon Department of Environmental Quality's Cap-and-Reduce program is currently in rulemaking and expected to be complete by the end of 2021
- **NW Natural anticipates it may need to implement substantial methodological changes to plan for compliance with the outcome of these rulemakings and processes, but are unsure what form this will need to take given the current uncertainty**
- **We have implemented a risk management plan to minimize reliability concerns to delay decisions that are sensitive to long-term load and resource availability until these processes complete**
  - This includes filing a delay to the Company's next IRP until July 2022 and seeking acknowledgement of urgent and low-regret decisions in an update to the 2018 IRP on March 1st
- **Projects NW Natural is seeking acknowledgement in this IRP Update are required based upon current need (i.e. are not dependent upon long-term projections) and pose meaningful near-term reliability risks**

What makes this update different?

- Due to delay, more time between this IRP and the next IRP than usual
- The update to be filed March 1, 2021 will include more assumption and result updates than NW Natural's typical IRP updates and include updated:
  - Gas and GHG prices
  - Load forecasts
  - Avoided Costs
  - Emissions Forecast
  - RNG and Hydrogen market and project information
- This update will seek acknowledgement from the OPUC on two projects:
  - Replacement of the Cold Box at the Newport LNG facility
  - A distribution system reinforcement project on Oregon's North Coast

Key Changes in 2018 IRP Update from 2018 IRP

	Methodology Change?	Updated with New Assumptions?	Updated with New Data?
Planning Horizon	✓	✓	✓
Conventional Gas Prices			✓
Expected Heating Season Planning Standard	✓	✓	✓
Peak Heating Season Planning Standard	✓	✓	✓
Peak Day Planning Standard			✓
Peak Hour Planning Standard			✓
Customer Count Forecasts			✓
Use Per Customer Forecasts			✓
Annual Energy Forecasts			✓
Peak Day Forecasts			✓
GHG Prices		✓	✓
GHG Policy Modeling Implementation			
Avoided Costs		✓	✓
Emissions Forecasts		✓	✓
Resource Selection Modeling			✓
Energy Efficiency Cost-Effectiveness Evaluation			✓
Gas Supply Resource Options		✓	✓
Stochastic Risk Analysis		✓	✓
Risk Adjusted Decision Criteria			✓
Distribution System Planning Criteria			

- **Planning horizon changed from 20 years to until 2050 to align better with policy environment**
- **The impact of climate change added to weather modeling of the heating season**
- **Greenhouse gas prices updated for policy (WA HB 1257) and prospective policy**
- **Impact of OR SB 98, OPUC AR 632, and OPUC UM 2030 included in RNG resource evaluation**
- **New data since last IRP incorporated into models for updated forecasts**

What is not changing in this update?

	Methodology Change?	Updated with New Assumptions?	Updated with New Data?
Planning Horizon	✓	✓	✓
Conventional Gas Prices			✓
Expected Heating Season Planning Standard	✓	✓	✓
Peak Heating Season Planning Standard	✓	✓	✓
Peak Day Planning Standard			✓
Peak Hour Planning Standard			✓
Customer Count Forecasts			✓
Use Per Customer Forecasts			✓
Annual Energy Forecasts			✓
Peak Day Forecasts			✓
GHG Prices		✓	✓
GHG Policy Modeling Implementation			
Avoided Costs		✓	✓
Emissions Forecasts		✓	✓
Resource Selection Modeling			✓
Energy Efficiency Cost-Effectiveness Evaluation			✓
Gas Supply Resource Options		✓	✓
Stochastic Risk Analysis		✓	✓
Risk Adjusted Decision Criteria			✓
Distribution System Planning Criteria			

- Methods and key assumptions to project load
- Methodologies employed to model environmental policy
- Implementation of environmental policies currently under consideration or in rulemaking
- Given the methodological updates that are not being made, NW Natural is not seeking acknowledgement of projects that are sensitive to uncertainty in environmental policy in this update

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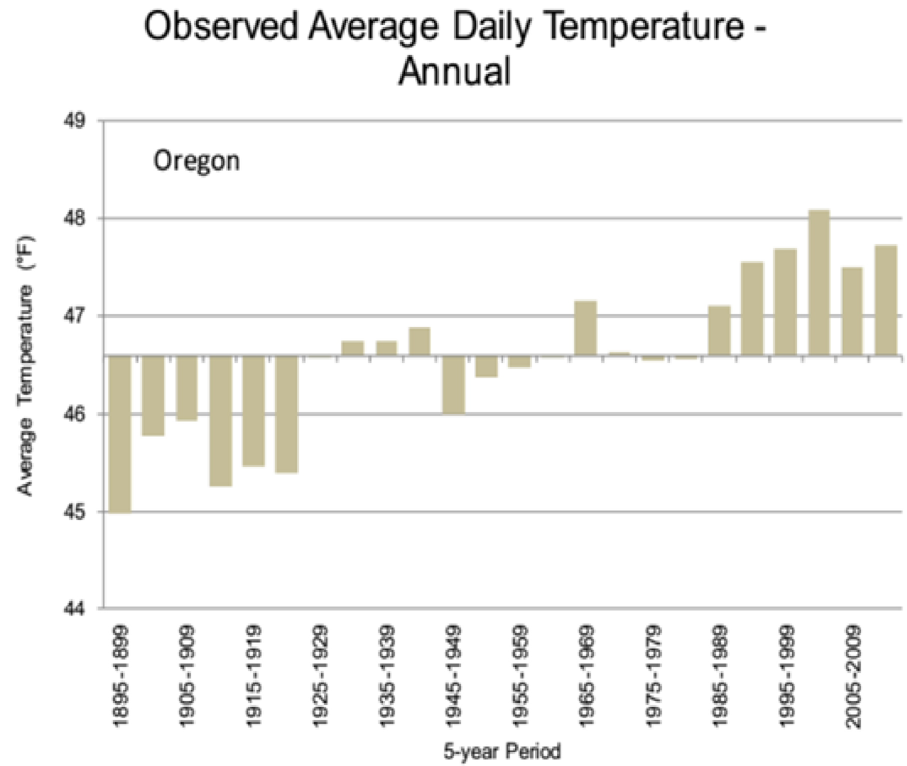
Heating Season Weather and Planning Standard

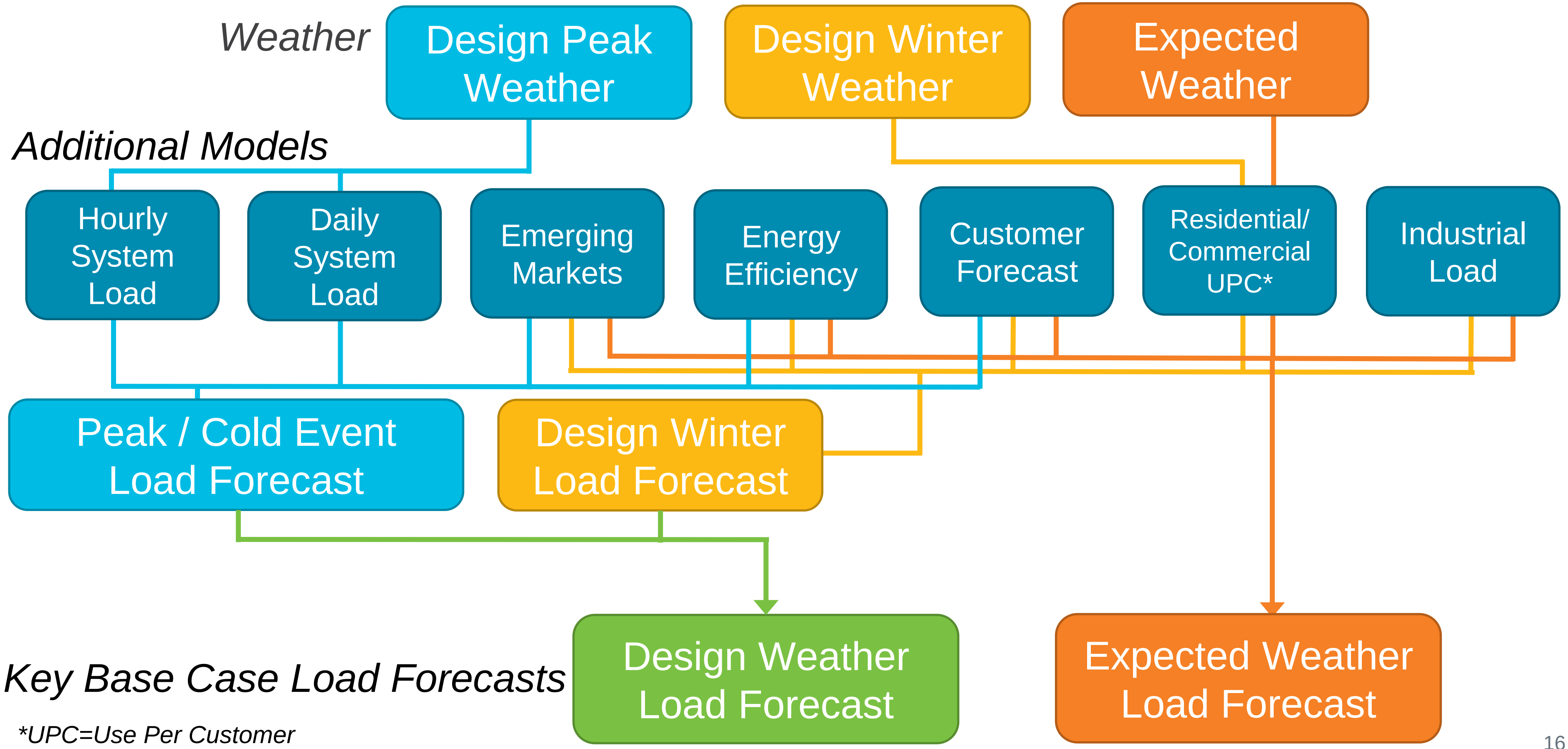
Why Incorporate the Impacts of Climate Change?

- **We believe climate change to be real and modeling it reflects the reality of weather trends to our business**
- **Great interest among stakeholders from the past TWGs**



Source: ODOE 2018 Biennial Energy Report - Chapter 2

Load Forecast Model Flow Chart



*UPC=Use Per Customer

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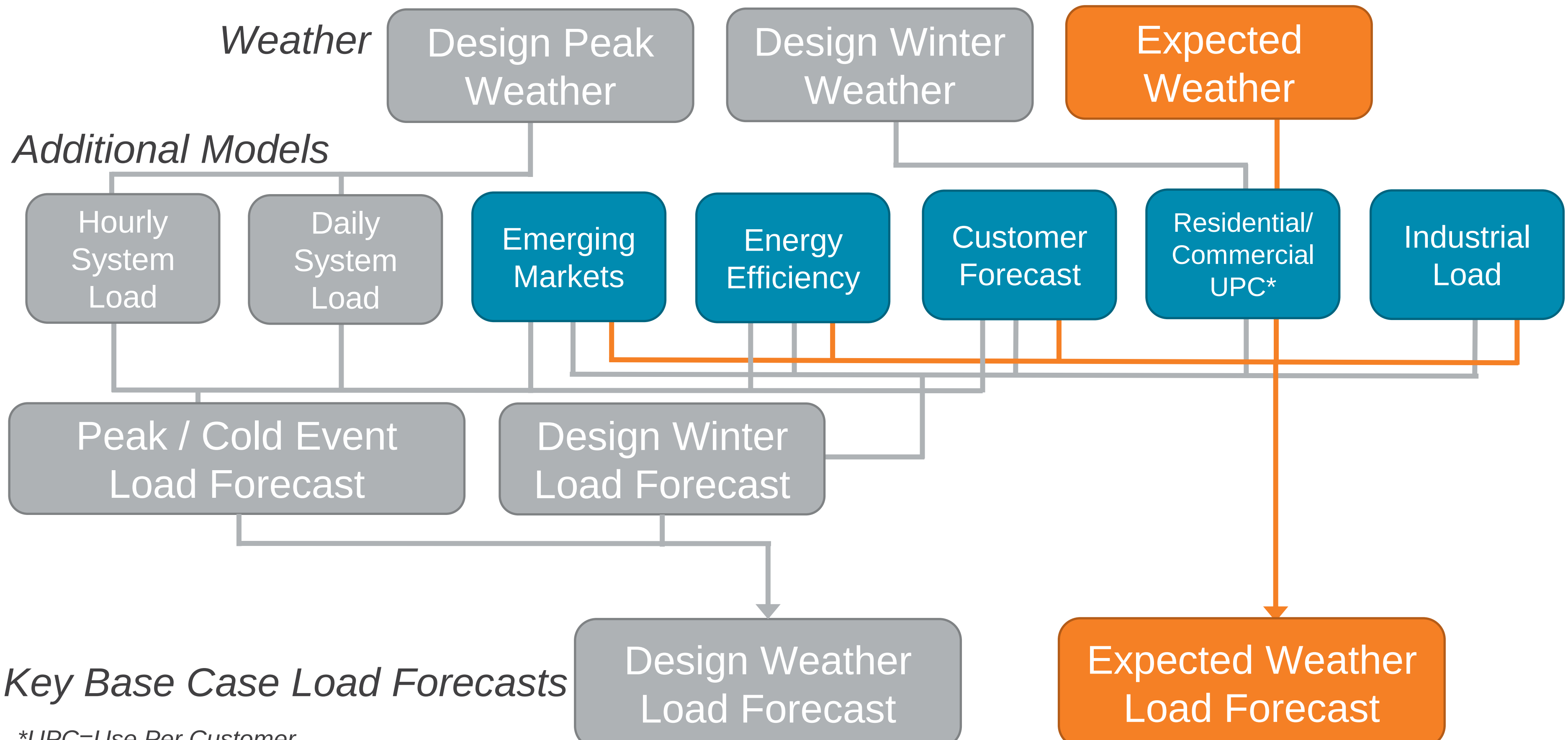
Expected Weather Load Forecast



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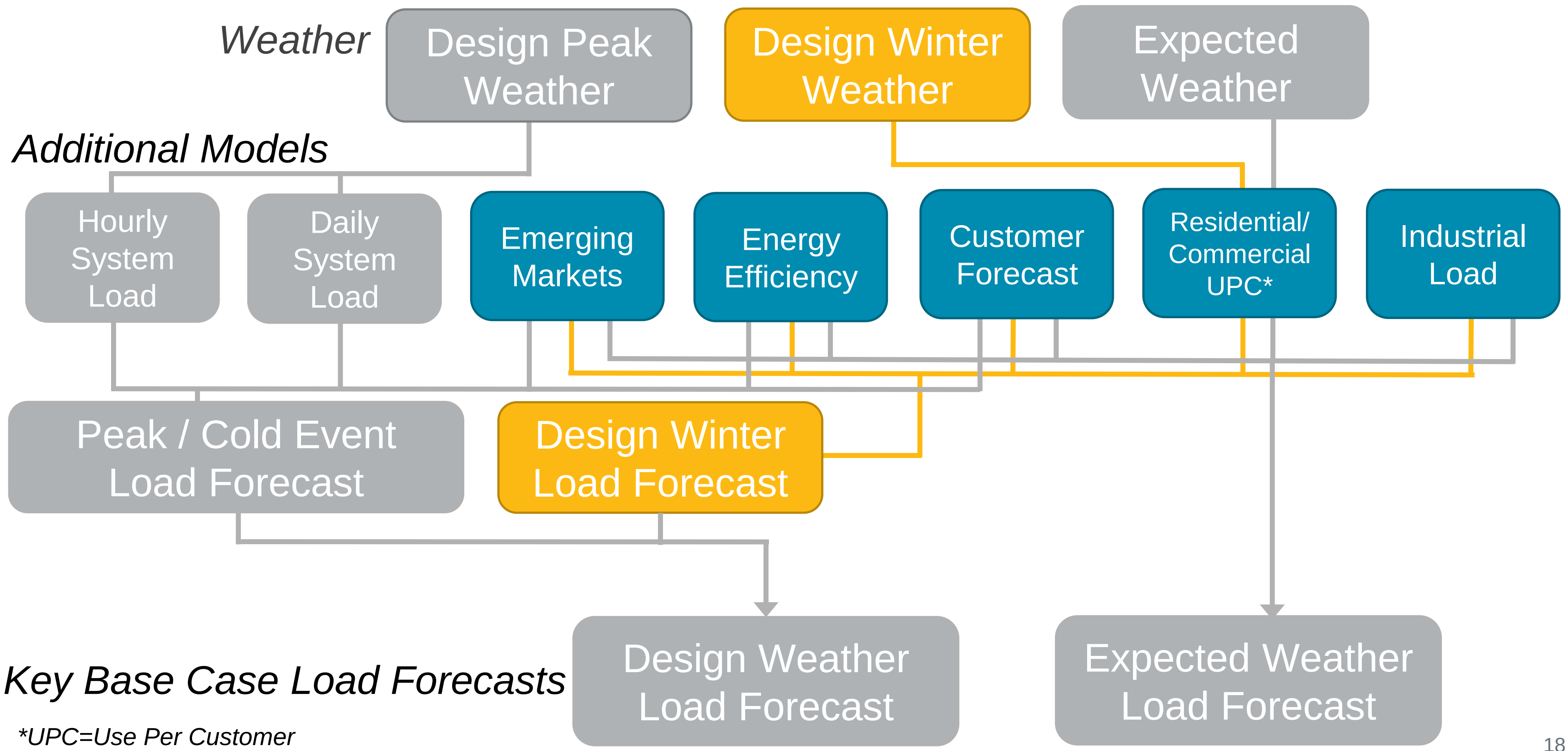
Design Winter Load Forecast



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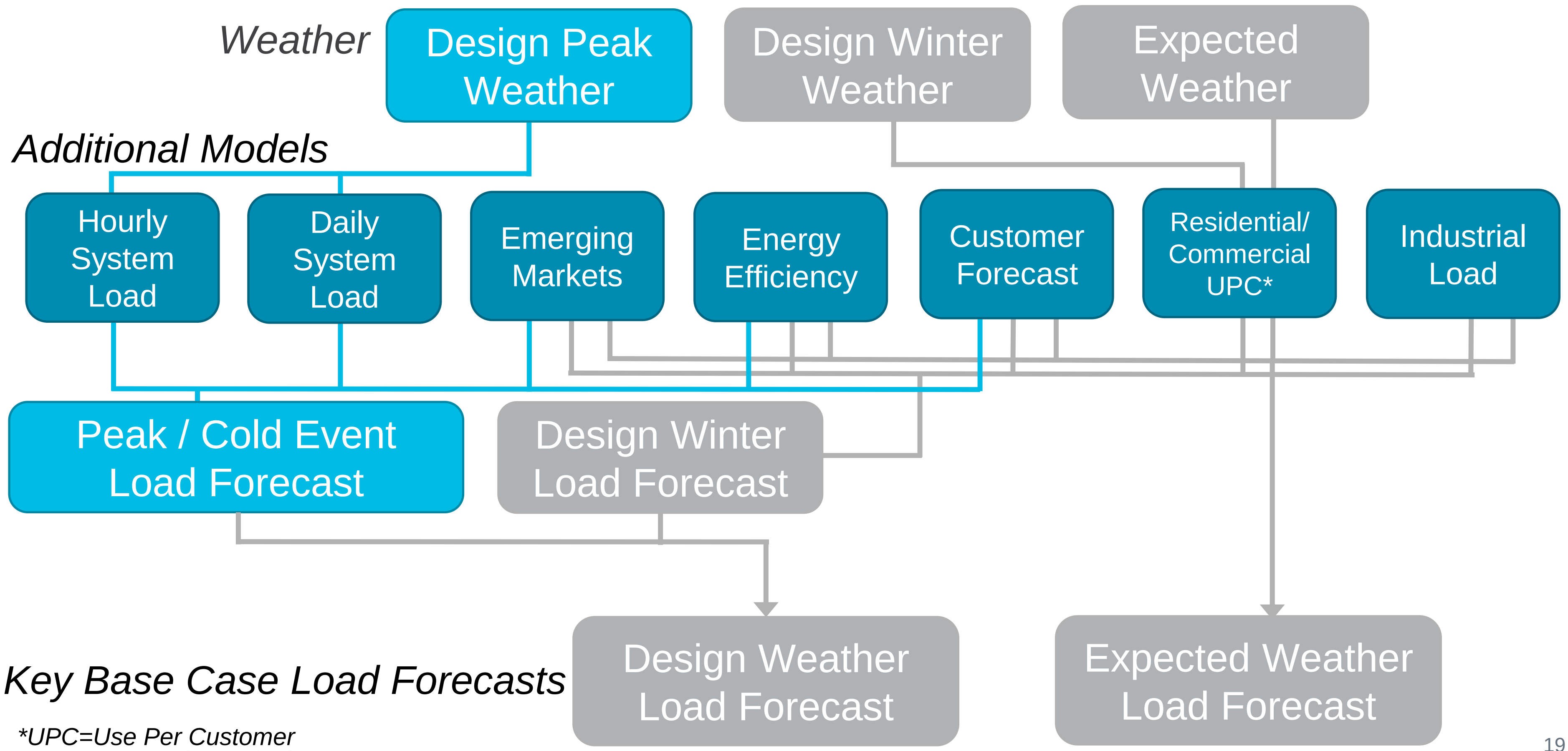
Design Peak and Cold Event Forecast



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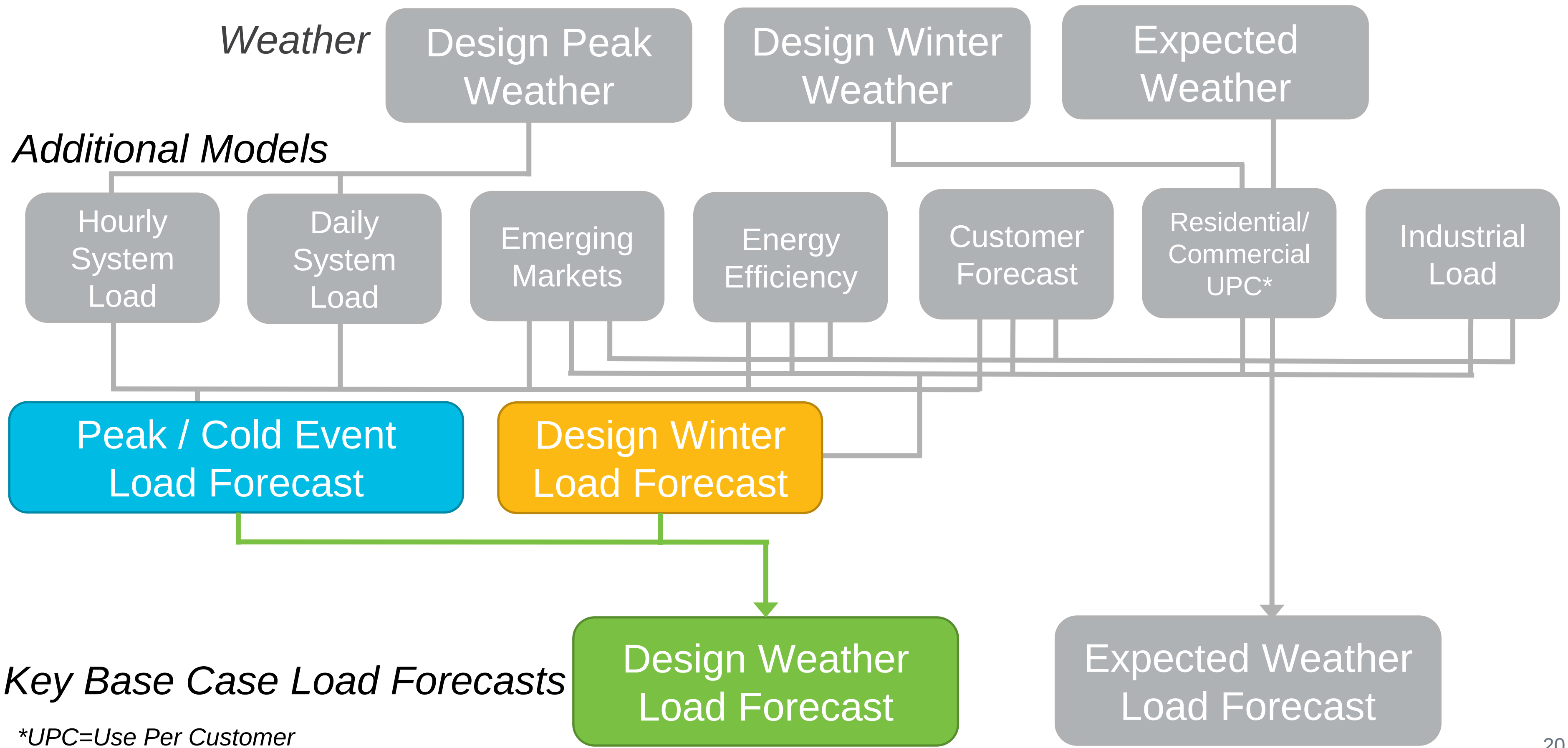
Design Weather Load Forecast



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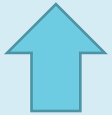
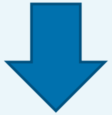
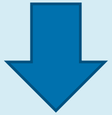
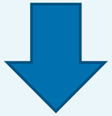
Where climate change trends enter the IRP?

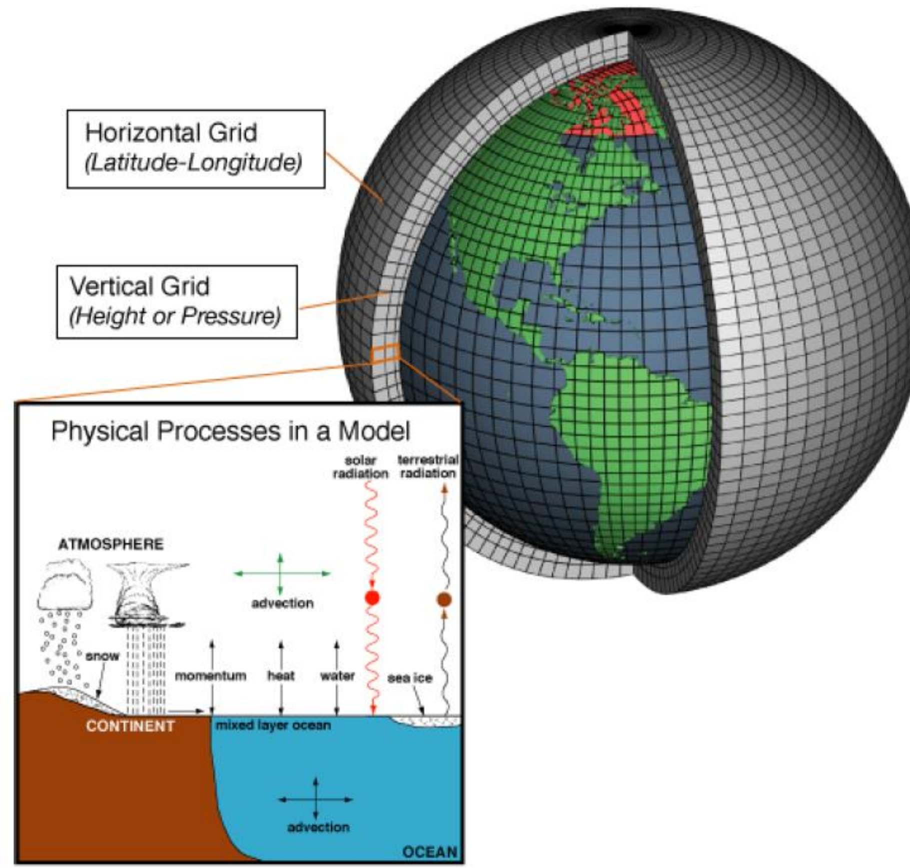
	Weather Pattern	Evidence of Climate Change	Old Method	New Method
Used for Cost Evaluation	Expected Weather	Yes; annual average temperatures are rising	Normal weather : 30 year average	Annual HDD informed by climate models, daily shape modeled from representative historical year
Used for Resource Planning	Design Winter Weather	Yes; on the whole winters are becoming warmer	90th percentile year selected based on cumulative winter HDDs (Nov-April) for the last 30 years	Daily winter weather (Nov-April) deviates from expected weather based on historical 90th percentile year based on cumulative winter HDDs
	Design Peak Weather	Uncertain; it is unclear how climate change is impacting extreme cold events in the near and long-term	Simulation based on historical coldest daily temperatures	Simulation based on historical coldest daily temperatures

How will climate change impact resource planning?

Forecast	Description	Ceteris Paribus (All Else Equal) Impact Direction
Temperature	Average annual temperatures are rising	
Heating Degree Days	Cumulative heating degree days are declining	
Annual Load	Annual load requirements will be less due to less space heating requirement	
Emissions	Lower load requirements will lead to less emissions	

Data Source: Climate models

- Coupled Model Intercomparison Project Phase 5 (CMIP5)
- Recommended climate models by the Intergovernmental Panel on Climate Change (IPCC)
- Down scaling provided by Earth System Grid Federation (ESGF) through the Lawrence Livermore National Lab
- Does not provide data about extreme temperatures (i.e., peak conditions)



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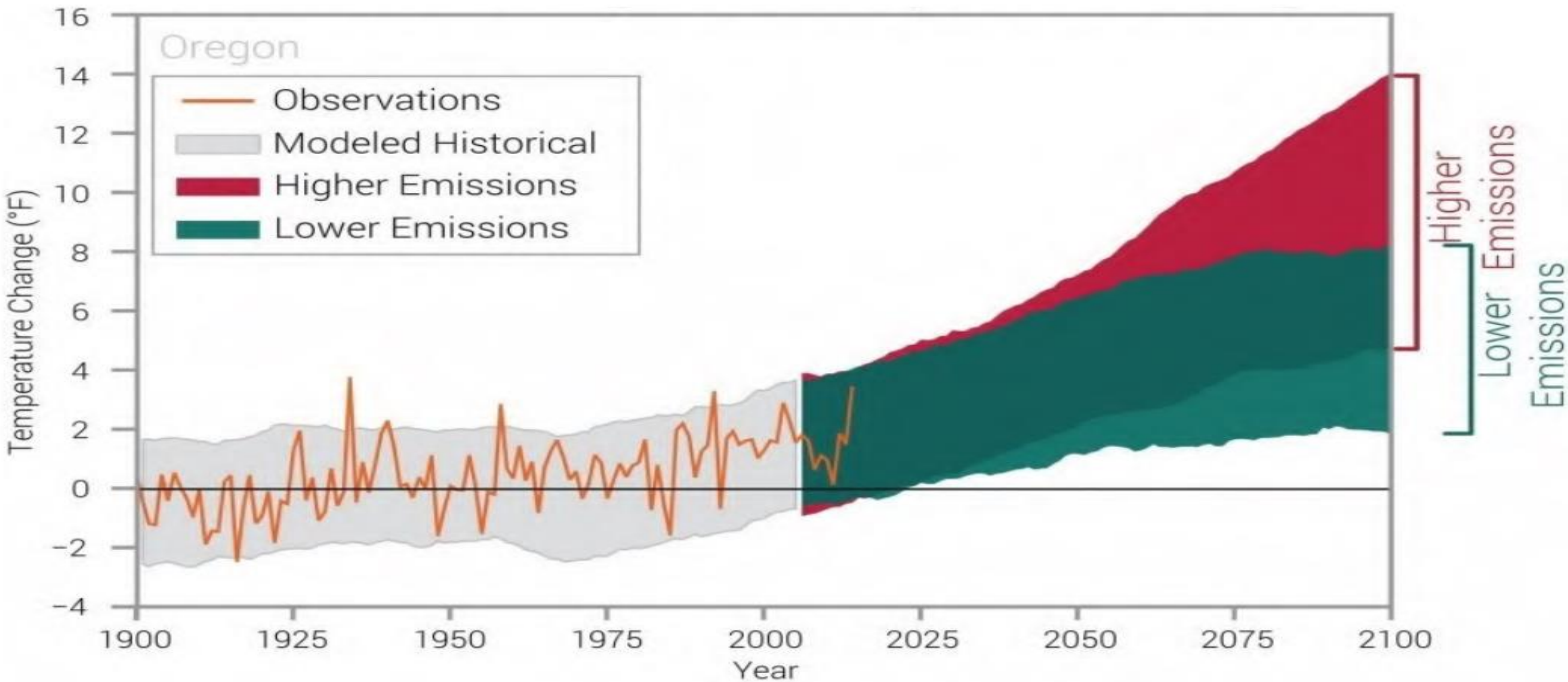
Data Source

1. **Projections from 2020-2050 from 5 models with Representative Carbon Pathway scenario 8.5 obtained from *https://pcmdi.llnl.gov/mips/cmip5/***
2. **The building blocks of GCM are made up of at least two of the following components i.e. earths atmosphere, ocean, land surface, land ice and sea ice**
   - ccsm4.6
   - cnrm-cm5.1
   - gfdl-cm3.1
   - hadgem2-cc.1
   - miroc5.1
3. **Projections downscaled to 9 location around our service territory**

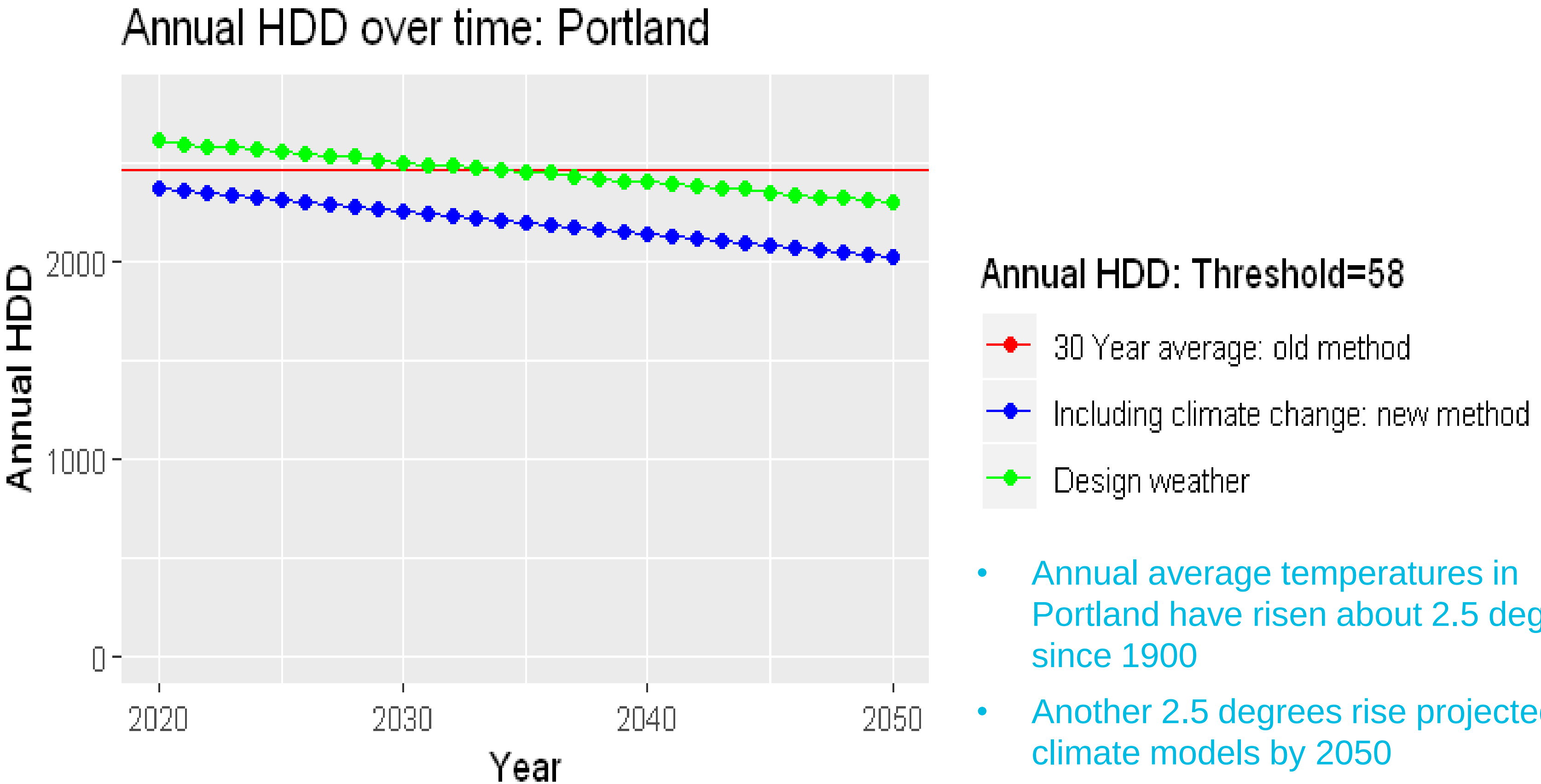
Annual temperature change:

Observed and projected annual average temperature change in Oregon 1895-2100



Source: ODOE 2018 Biennial Energy Report - Chapter 2

Annual HDD Portland



- Annual average temperatures in Portland have risen about 2.5 degrees since 1900
- Another 2.5 degrees rise projected by climate models by 2050

Generating Expected Weather

- **Find a representative year: We selected 2012 after looking at annual HDDs**
- **Adjust the temperature of 2012 so that the HDDs of representative year match to those of projections from 2020-2050**
- **This gave daily expected weather (i.e., temperature) for each year starting from 2020 to 2050**
  - This weather is akin to normal weather used in past IRPs, however; the term “normal weather” typically implies a historical average
  - Since we are using climate models to forecast weather that deviates from historical averages, NW Natural is using the term “expected weather”

Generating Design Winter Weather

- **Find 90th percentile winter over the last 30 years based on cumulative winter HDDs (November-April)**
  - 90th percentile winter weather year: 2000
- **Calculate difference between 90th percentile winter daily temperatures and 30 year average**
- **Adjust winter days in expected weather by this difference**
- **This gave daily design winter weather (i.e., temperature) for each year starting from 2020 to 2050**
  - Forecasted load using design winter weather is combined with forecasted load for a peak cold event to create the design weather load forecast used for resource planning

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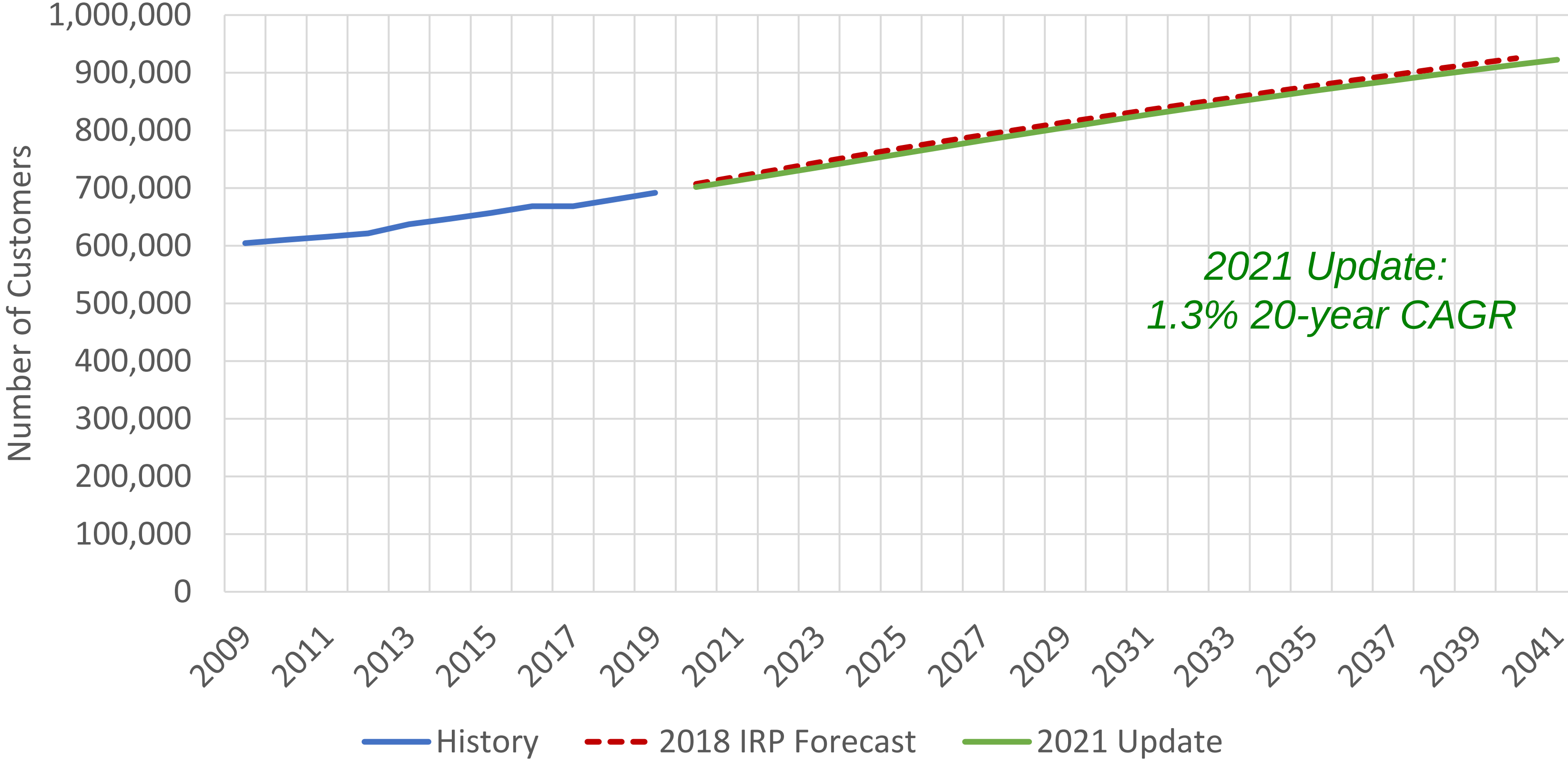
Customer Growth Forecast

Customer Count Forecasts

Key Takeaways

- Update using 2018 IRP forecasting models
- New data since 2018, short-term forecasts
- Minor adjustments to regression specifications according to variable significance, performance
- Residential 20-year CAGR: 1.3%
- Commercial 20-year CAGR: 0.9%

Residential Customer Count



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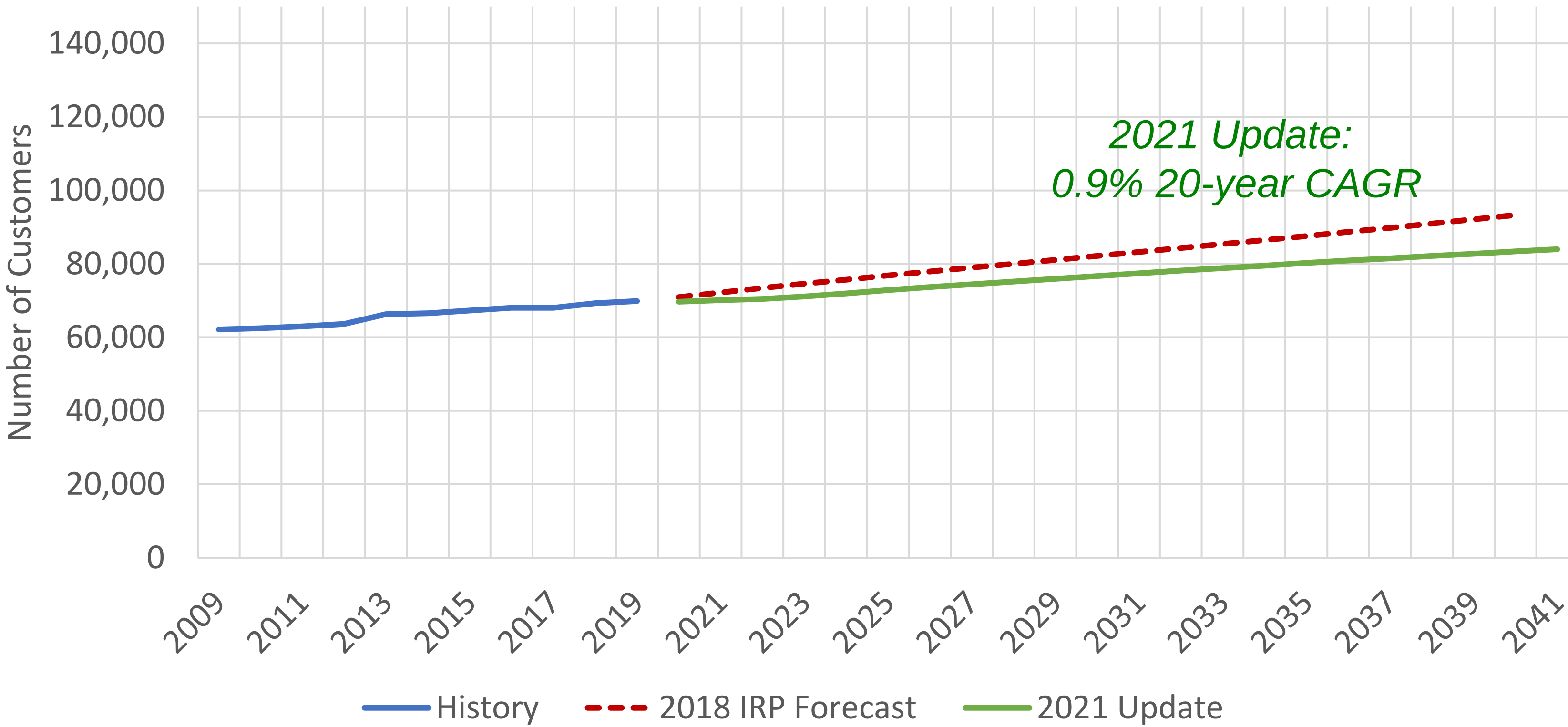
Commercial Customer Count



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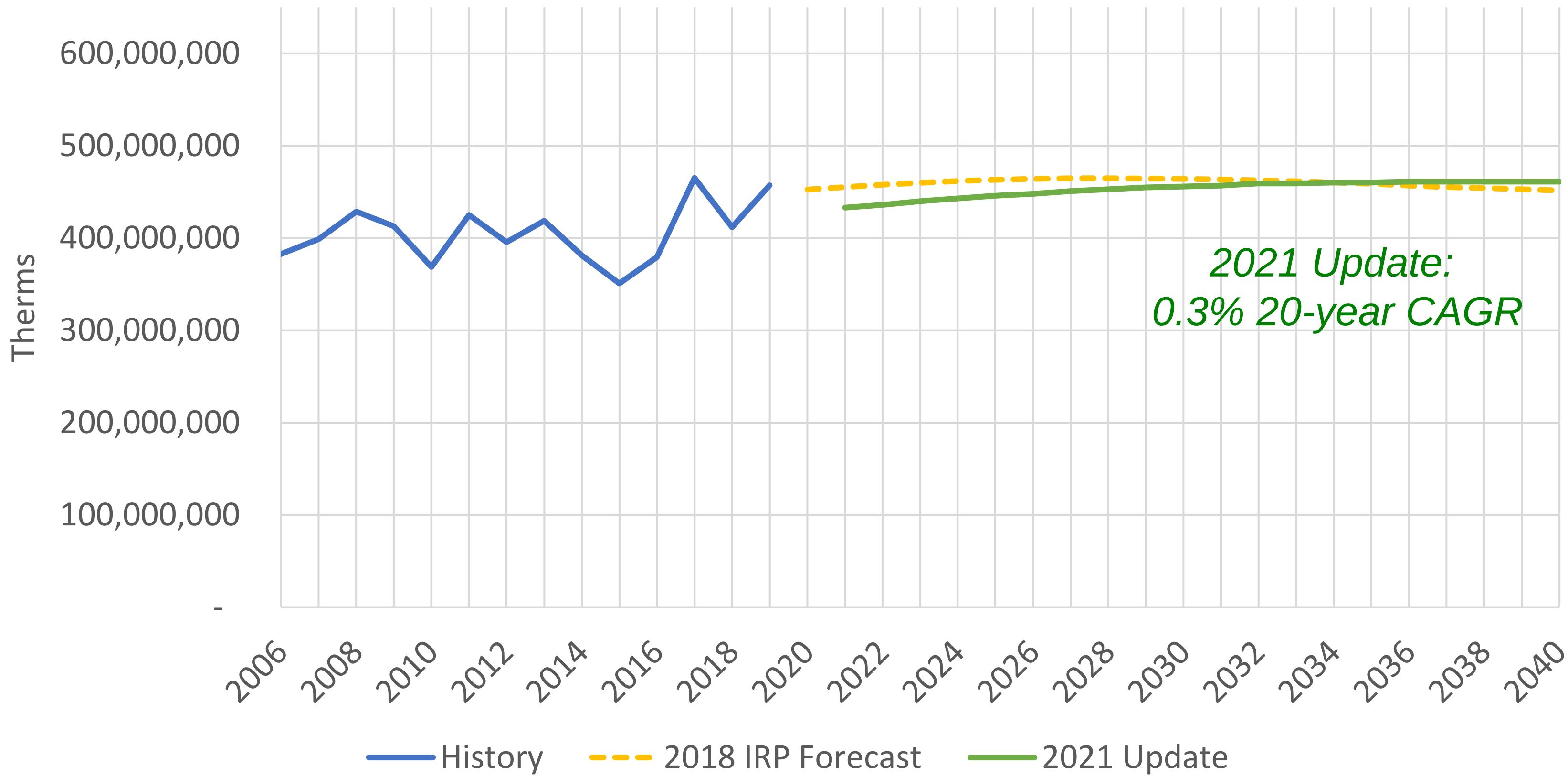
Annual Load Forecast

Res/Com Annual Load Forecasts

Key Takeaways

- Update using 2018 IRP forecasting models
- New data since 2018, EE forecast from Energy Trust
- Using expected weather that includes modeled climate change
- Residential 20-year CAGR: 0.3%
- Commercial 20-year CAGR: 0.7%

Expected Annual Load - Residential



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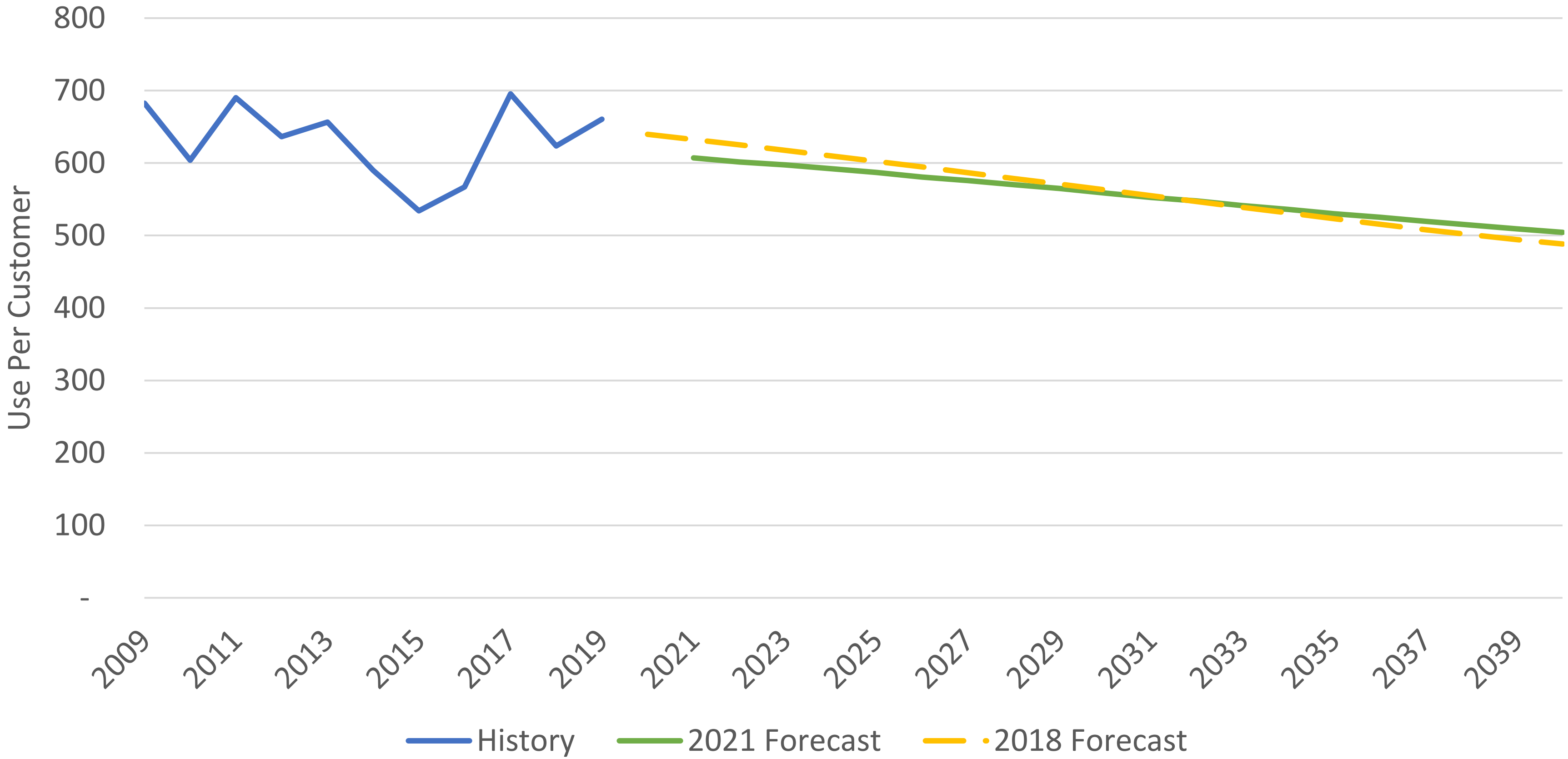
Residential Use Per Customer



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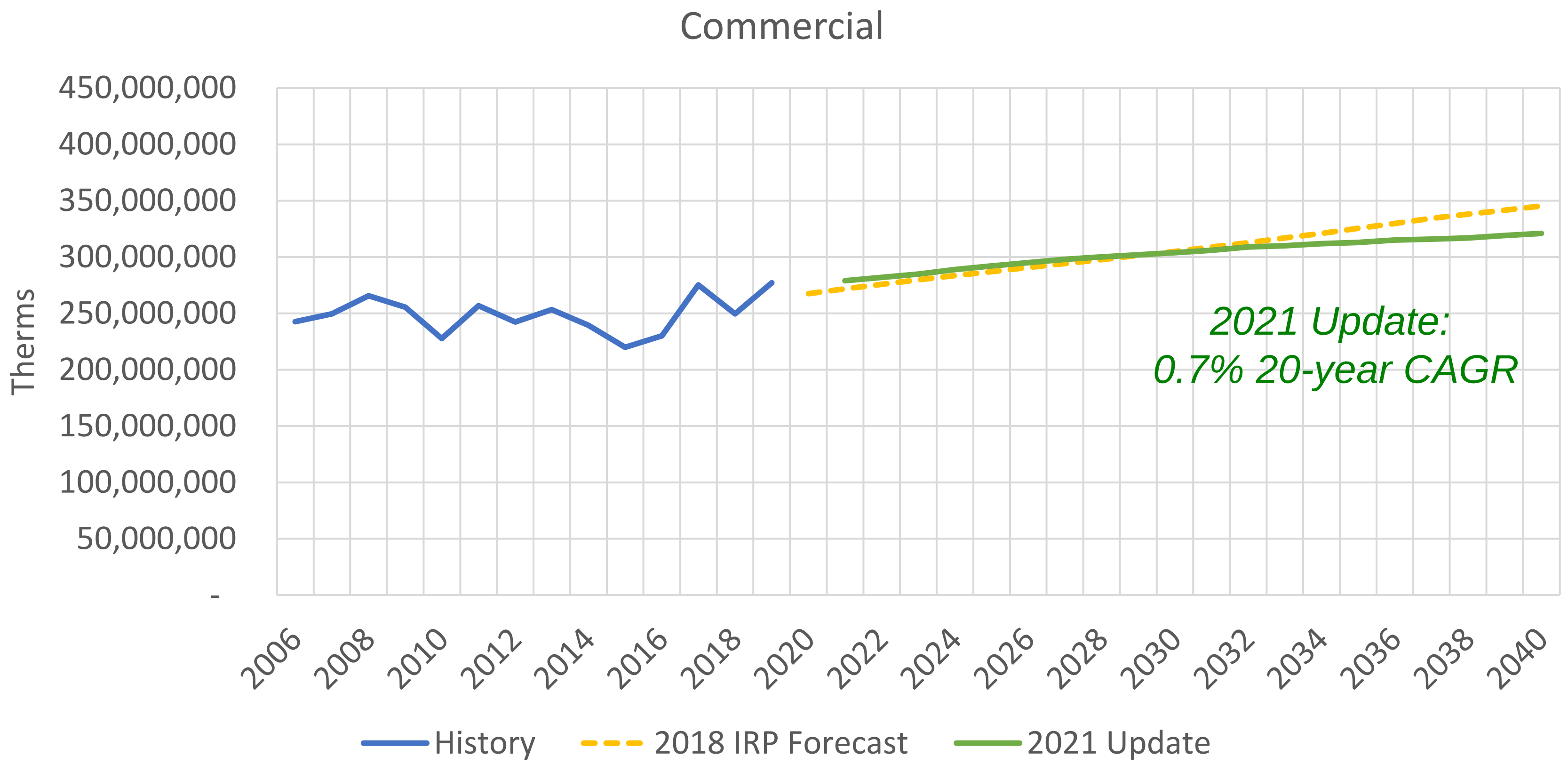
Expected Annual Load - Commercial



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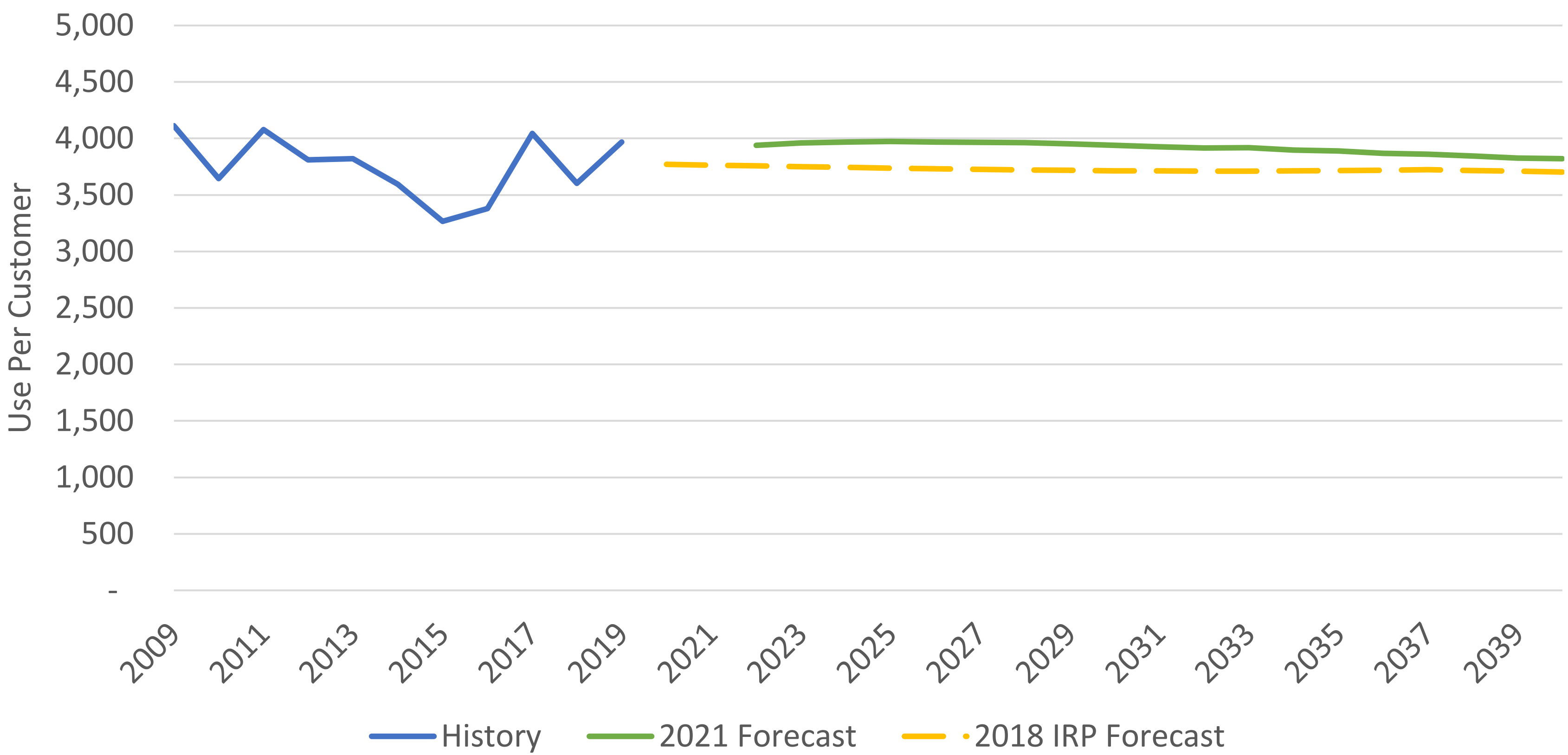
Commercial Use Per Customer



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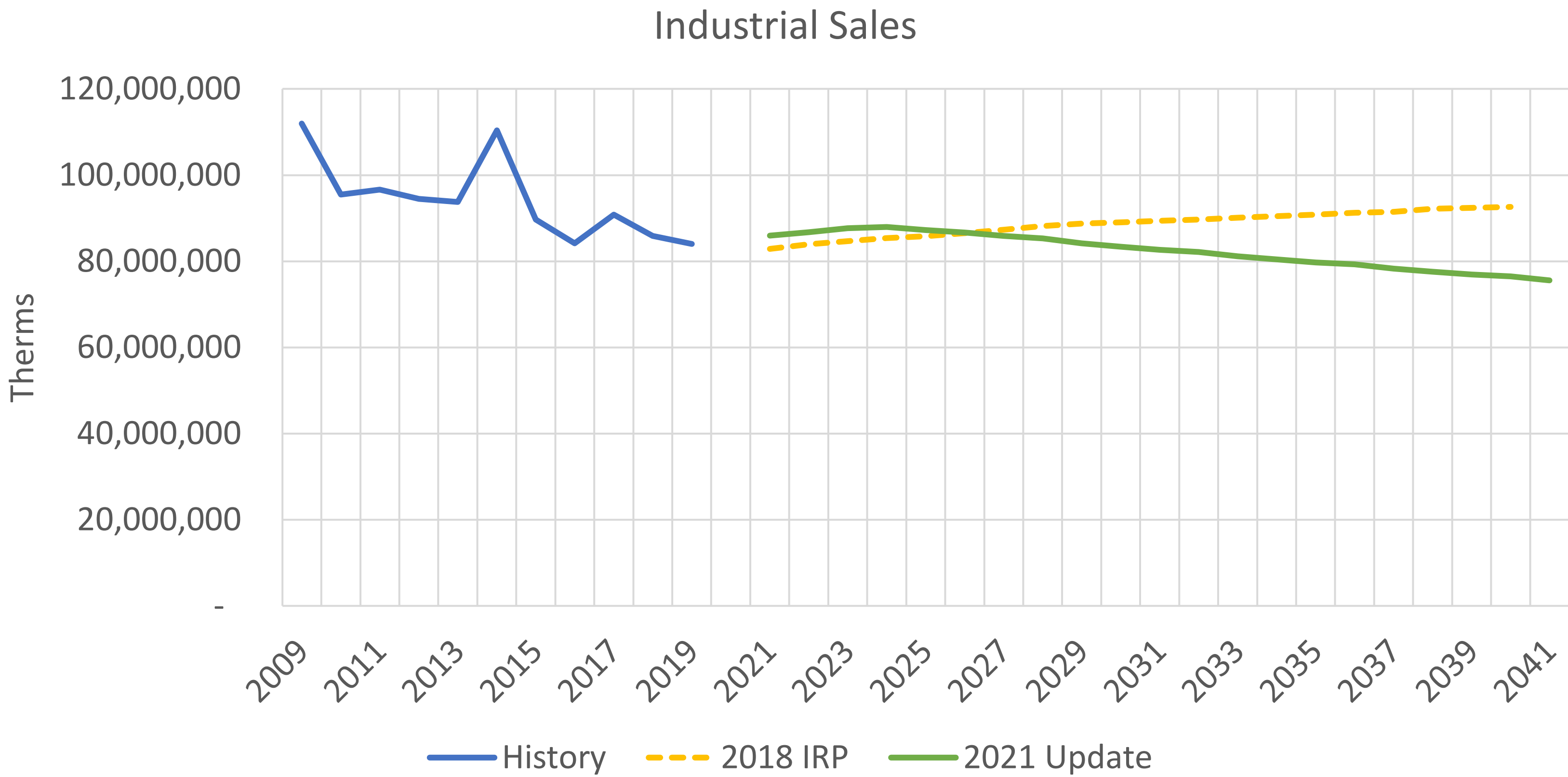
Industrial/Transport Load Forecasts

Key Takeaways

- Update using 2018 IRP forecasting models
- New data since 2018, short-term forecast
- Minor adjustment to regression specification: alternate driver variable
- Residential 20-year CAGR: 0.3%
- Commercial 20-year CAGR: 0.7%

Expected Annual Load - Industrial Sales



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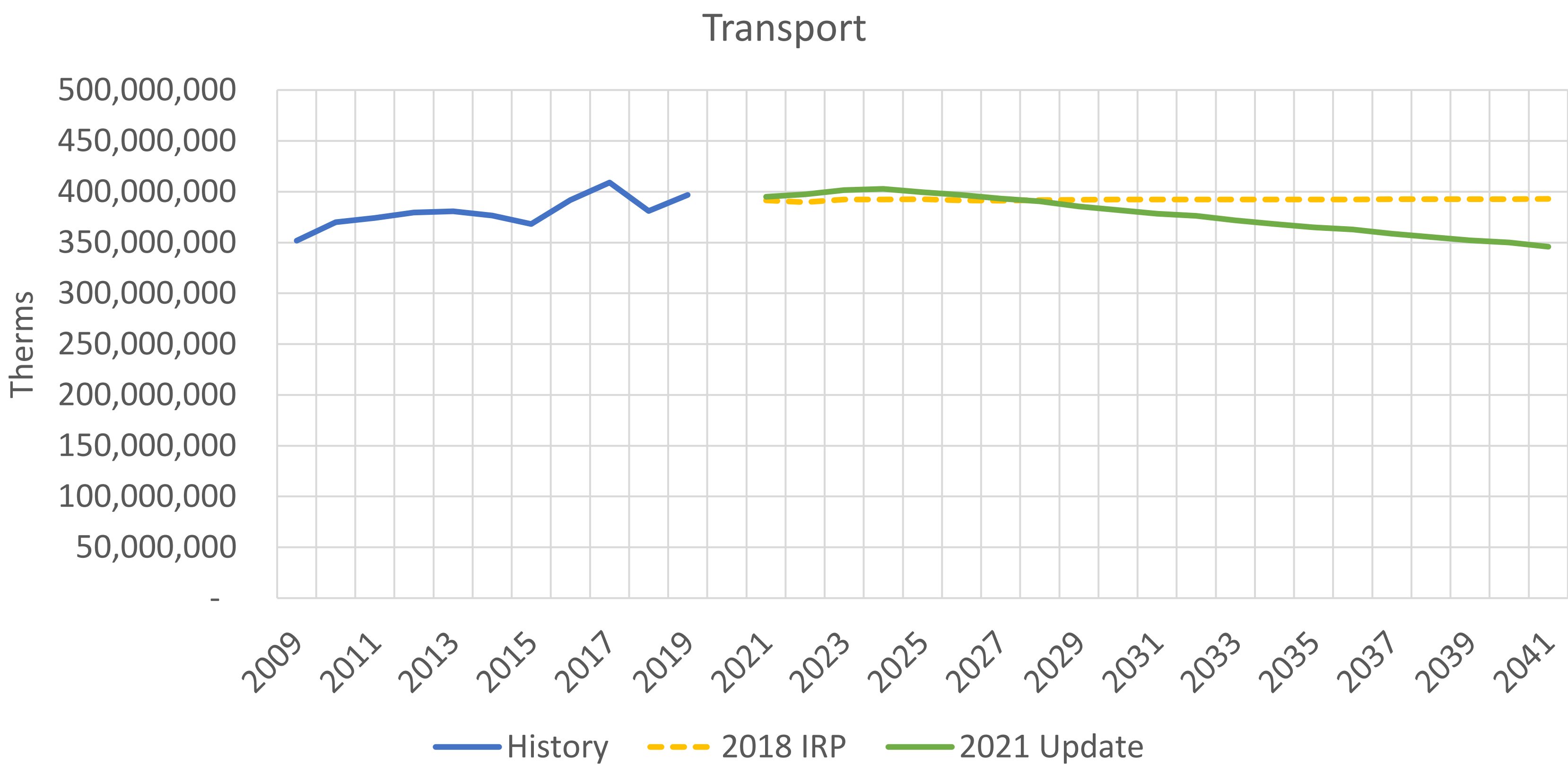
Expected Annual Load - Transport



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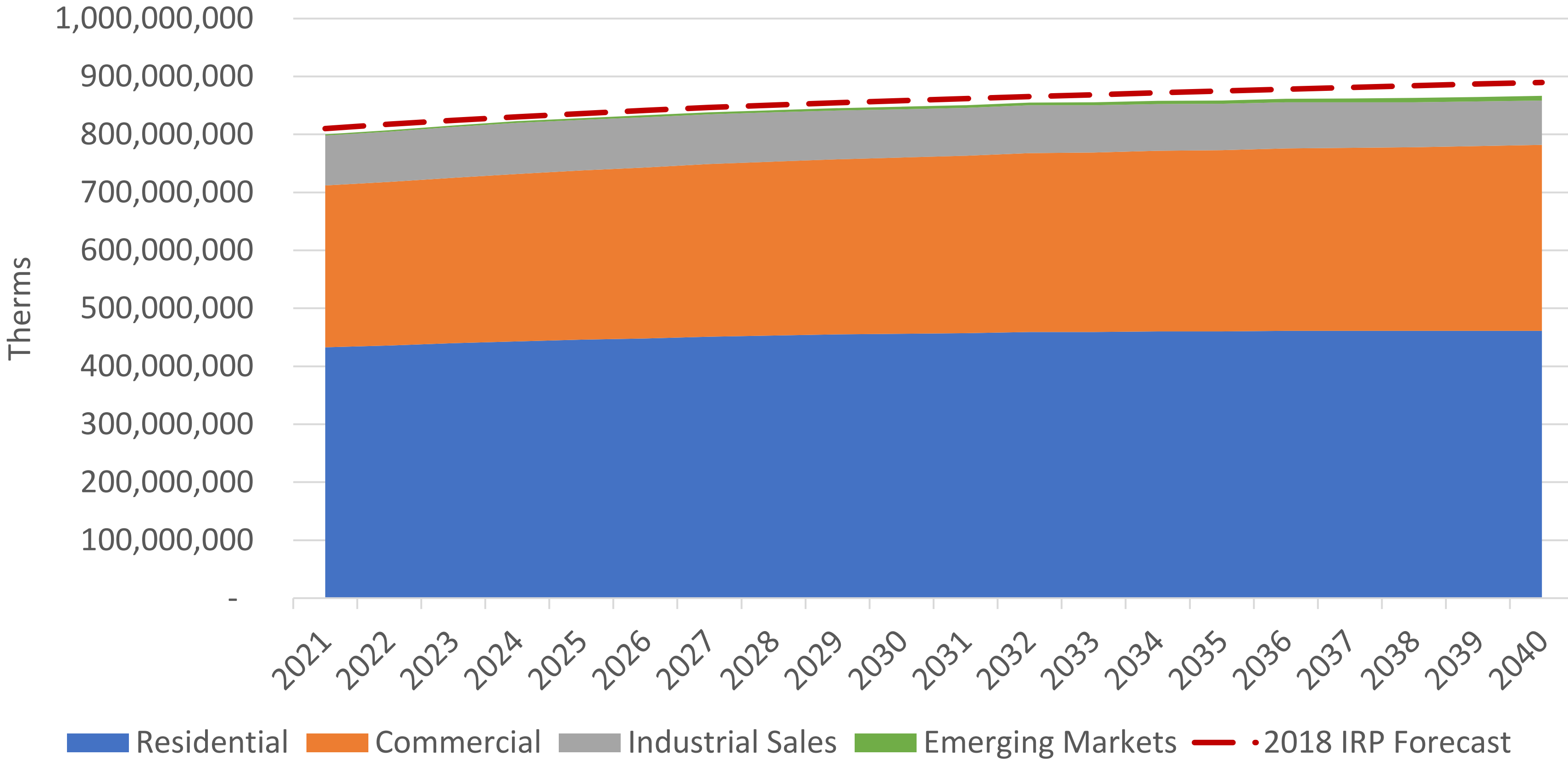
Expected Annual Forecast - Sales



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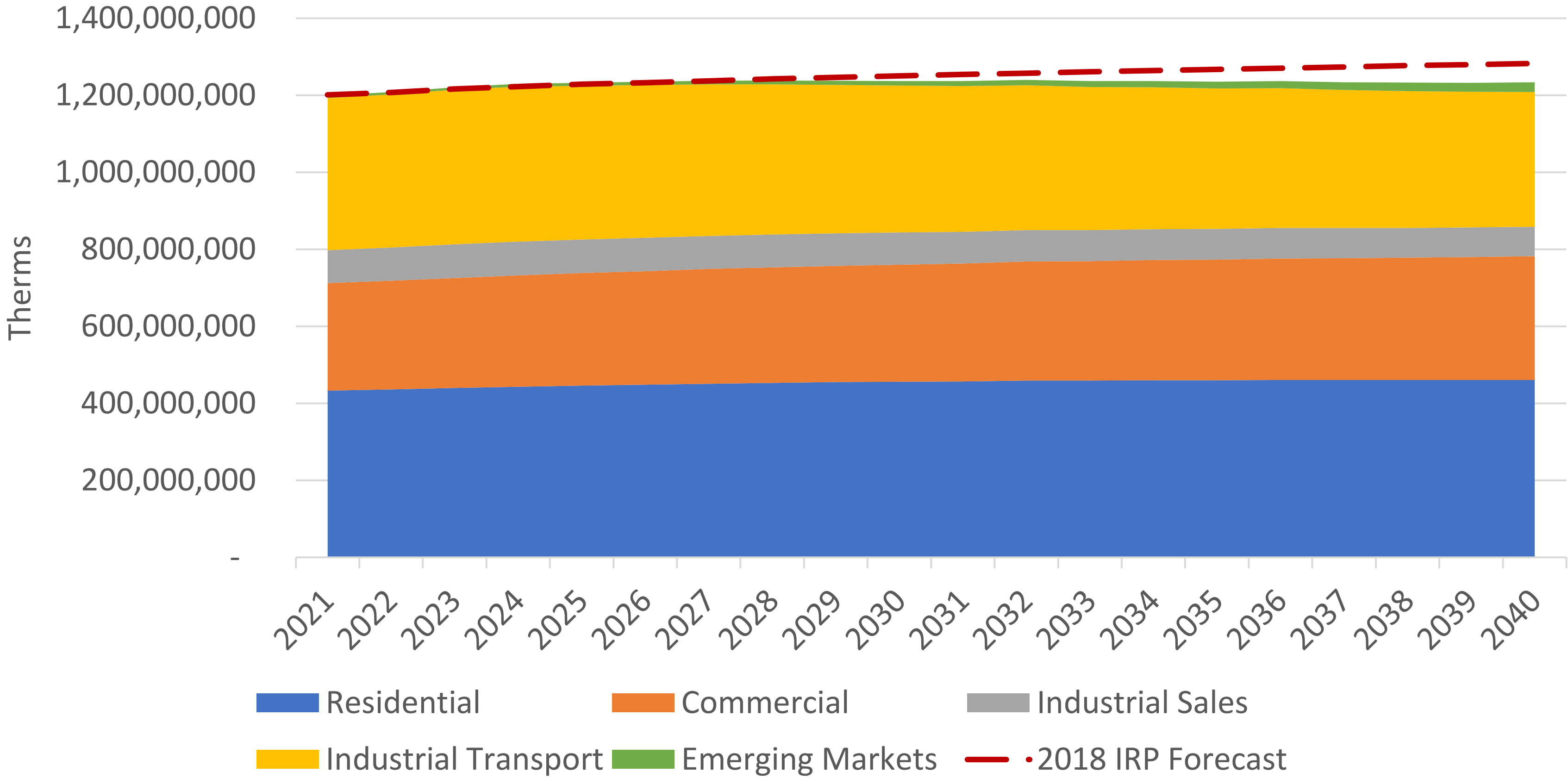
Expected Annual Forecast - Throughput



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Peak Load Forecast

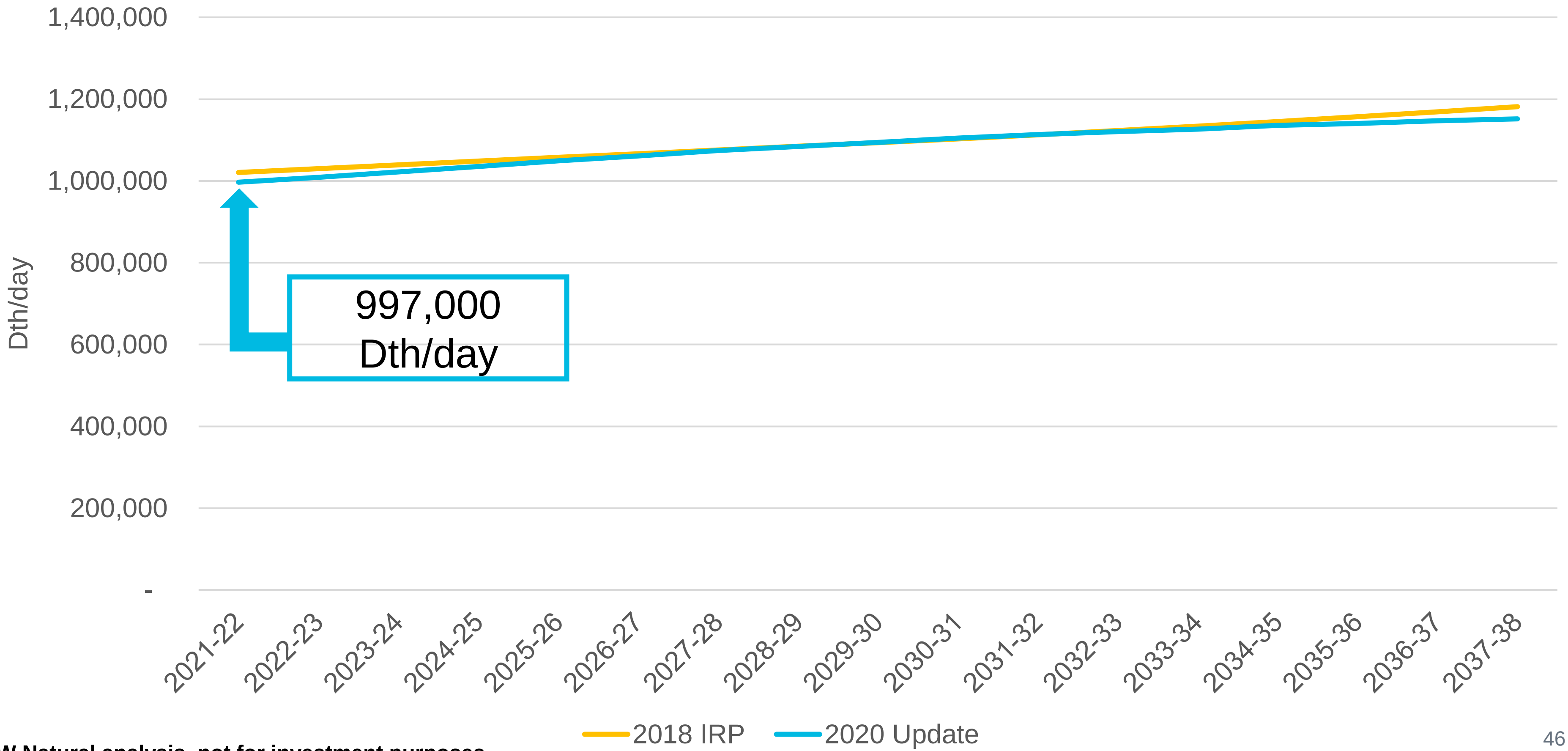
Peak Day Planning Standard

Assuming no resource outages, we plan our supply capacity resources to meet the highest daily firm sales demand with 99% certainty in a given winter.

Steps (see 2018 IRP for more details)

1. Use historical data to estimate relationship between daily firm sales and driver variables
2. Use historical data to simulate the coldest temperature day and other demand drivers
3. Predict firm sales load based on simulated data, customer count forecast, and time trend impacts
4. Find the 99^{th} percentile firm sales load for each year planning horizon
5. Adjust for peak impacts not captured by historical data for emerging markets and energy efficiency

Peak Day Firm Sales Forecast



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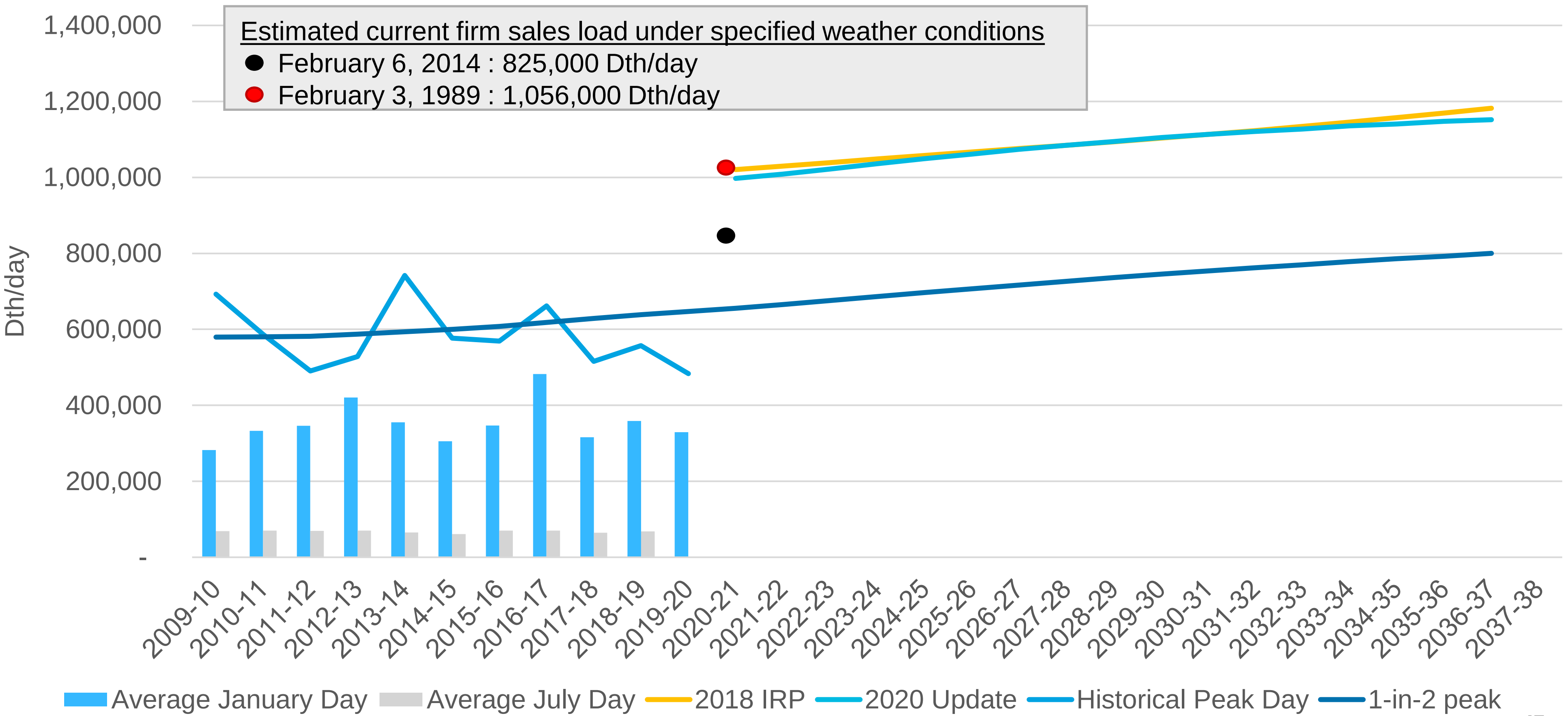
Peak Day Firm Sales Forecast



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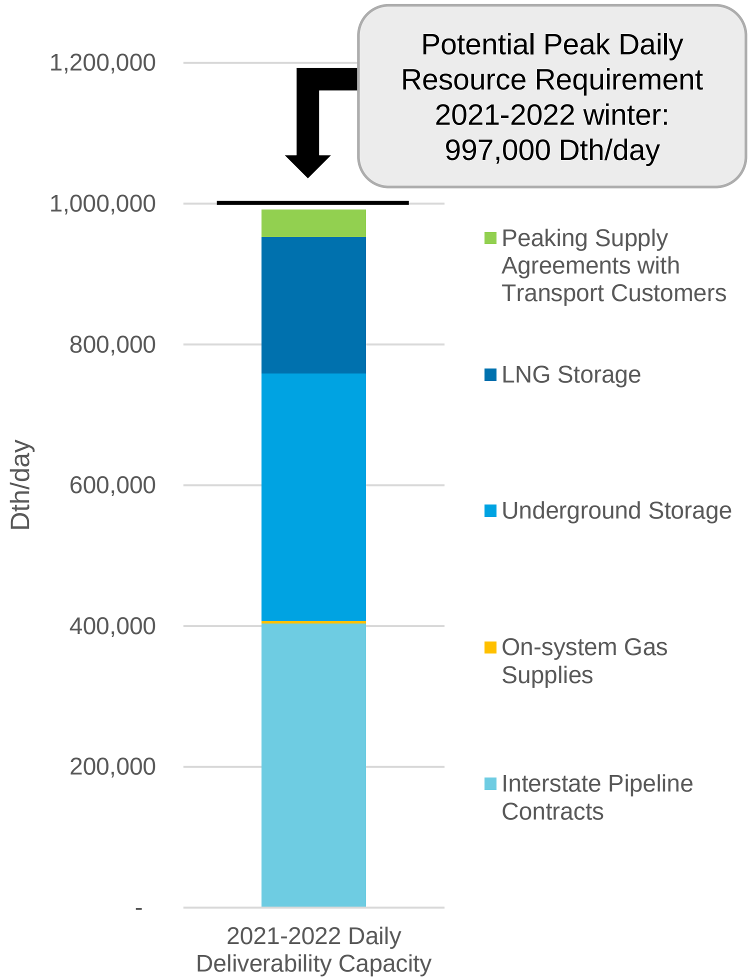
Capacity Resource Position Mist Recall

Near-term Firm Sales Supply Capacity Resource Requirements



Resource Stack

- **992,000 Dth/day of deliverability available for the 2021-2022 winter**
- **Consistent with 2020 PGA filing**

Updates from 2018 IRP

- **Updated heat content of LNG facilities**
- **Inclusion of on-system injections of brown gas from RNG interconnects**
- **Segmented capacity fully available through 2024-2025 winter**

Resource Requirement

- **5,000 Dth/day of deliverability to meet potential peak day resource requirement (0.5% of total resource need)**

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Near-term Resource Options

Mist Recall

- **Transferring Mist storage assets from interstate storage to utility customers**
- **Assets are transferred at a depreciated cost of the assets**
- **Lead time for Mist Recall is 12 months from the start of the winter when it is needed (e.g., decision to Recall Mist for 2021-2022 winter occurs in the fall of 2020)**
- **Mist Recall is a great benefit to customers due to the small lead time and as it can be recalled as needed in small incremental 'chunks'**
- **Recalls are rounded to the nearest 5,000 Dth/day of deliverability**
- **Shown to be least cost least risk firm resource in past IRPs**

Citygate Deliveries

- **Contracts for gas supplies delivered directly to NW Natural's service territory by the supplier utilizing their own NWP transportation service**
- **Deliveries are negotiated for a small window (e.g., 5 days) that can be exercised by NW Natural if required**
- **Costs include:**
  - Reservation charge (fixed cost)
  - Commodity cost, if exercised, typically indexed to a specified spot price
- **Not relied upon as a long term firm resource as these deals are typically negotiated for a single winter**
- **Less lead time is needed than Mist Recall, however; if used in lieu of Mist Recall same amount of lead time is needed**

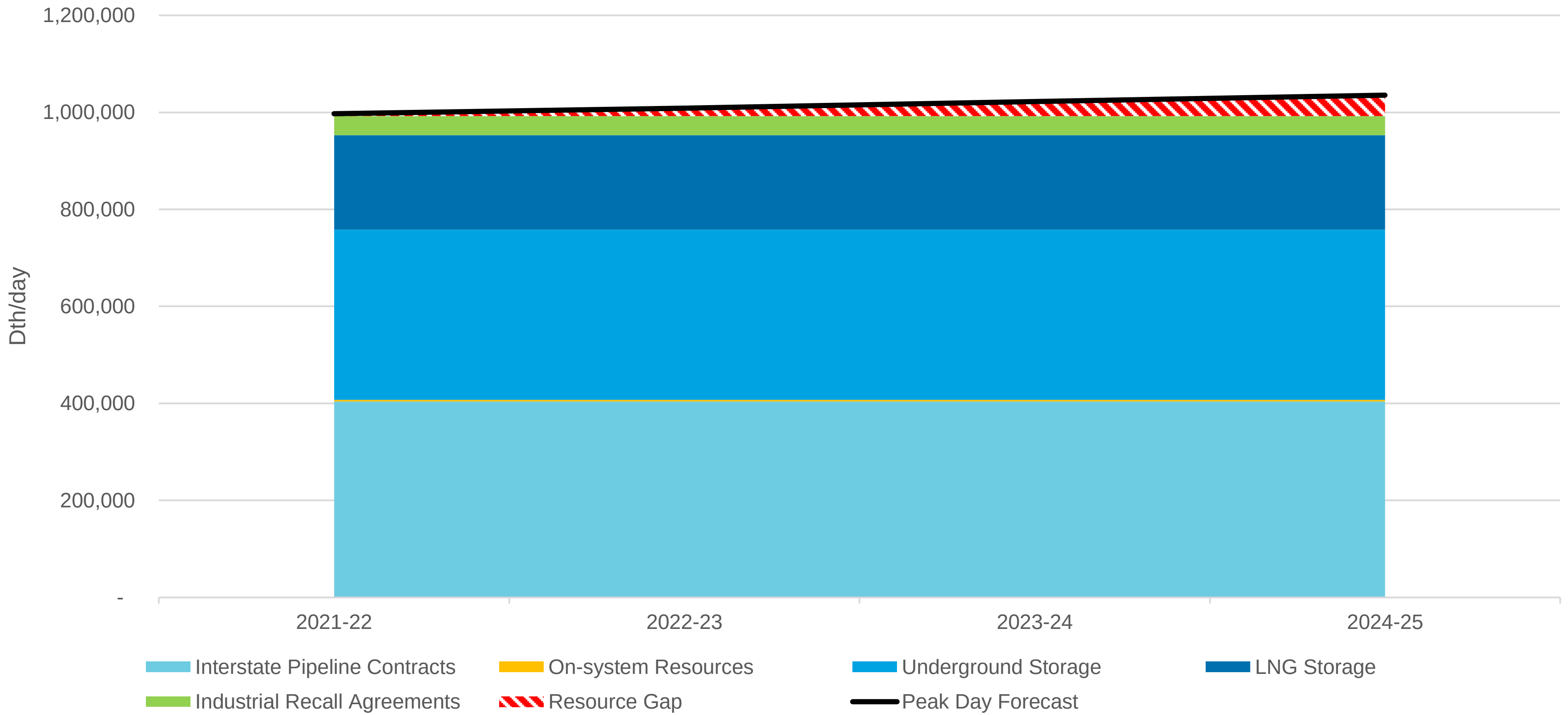
2021-2022 Winter

- **Updated peak day forecast and updated resource stack shows a resource requirement for 5,000 Dth/day of deliverability**
- **NW Natural negotiated a Citygate delivery for the 2021-2022 winter:**
  - 5,000 Dth/day
  - Delivery at NWN Citygate
  - NW Natural's call option (i.e. there is no cost to customers unless the option is exercised)
  - Commodity costs would be indexed to a specified spot price, if exercised
- **Trade-offs for using Citygate deliveries instead of Mist Recall**

Benefits	Costs/Risks
• Cheap supply capacity costs (i.e., cheap reservation charge compared to Mist Recall costs)	• Limited number of days available • Potential high gas costs, if exercised

- **Citygate delivery chosen to fill the resource gap for 2021-2022**
  - Using NW Natural's risk-adjusted resource evaluation the Citygate deal was determined to be the best combination of cost and risk for customers
  - The probability the option will need to be exercised during 2021-22 is estimated to be less than 1%

Near-term winters (2-4 years) Firm Sales Capacity Requirements



NW Natural analysis, not for investment purposes.

Near-term Resource Options

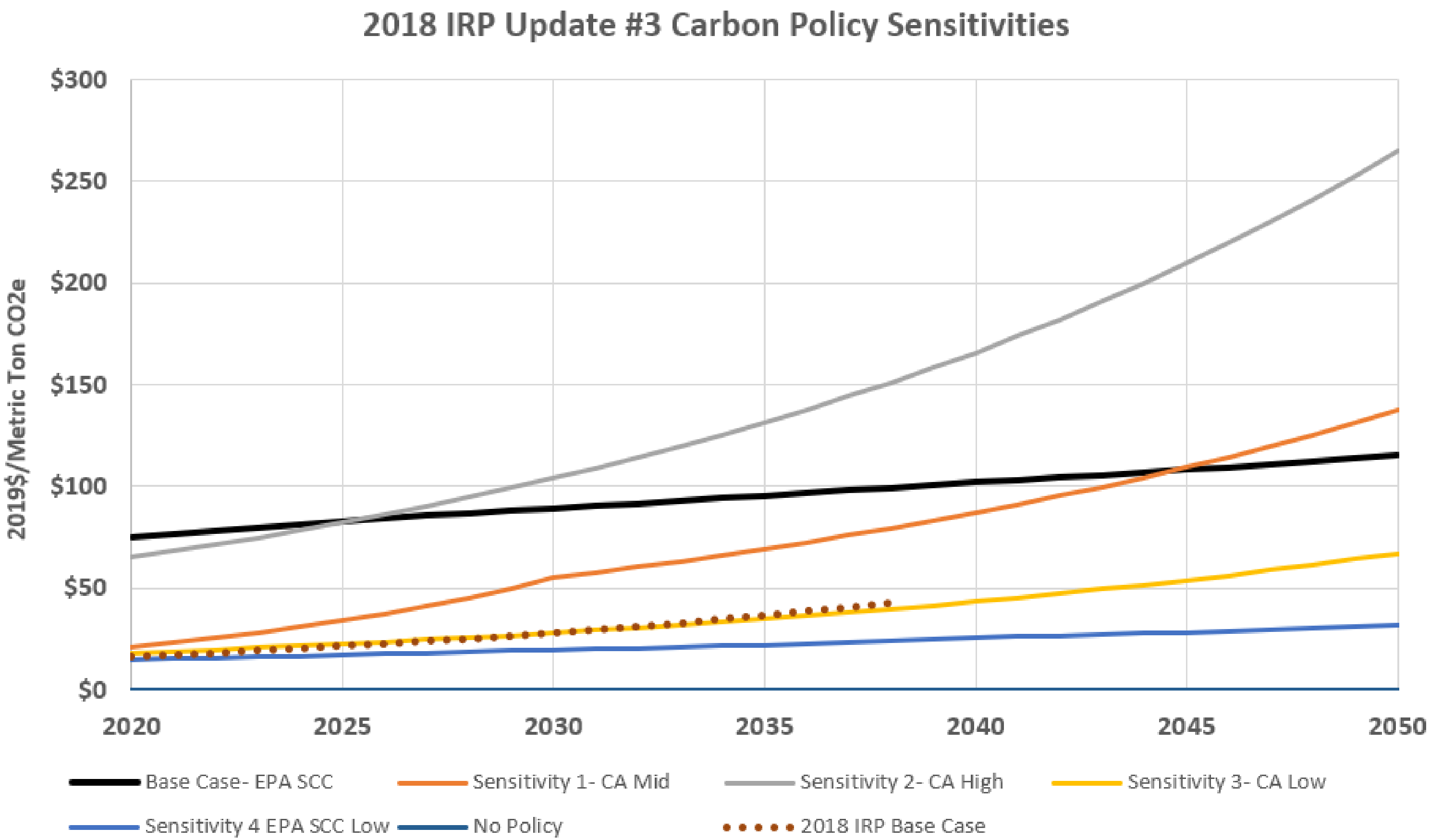
- **Mist Recall, Citygate Deals, or a combination of both**

Gas Year	Current Forecast of Firm Sales Supply Capacity Resource Requirements (rounded to 5,000 Dth/day)	Resource
2021-22	5,000	Citygate deal for 5,000 Dth/day
2022-23	15,000	TBD, Fall of 2021
2023-24	30,000	TBD, Fall of 2022
2024-25	45,000	TBD, Fall of 2023

- **NW Natural's firm sales peak day forecast and input assumptions for the resource stack daily deliverability (e.g., heat content of LNG facilities) are updated the summer prior to the decision in the fall and can change the resource requirement**

Avoided Costs

Carbon Pricing Update

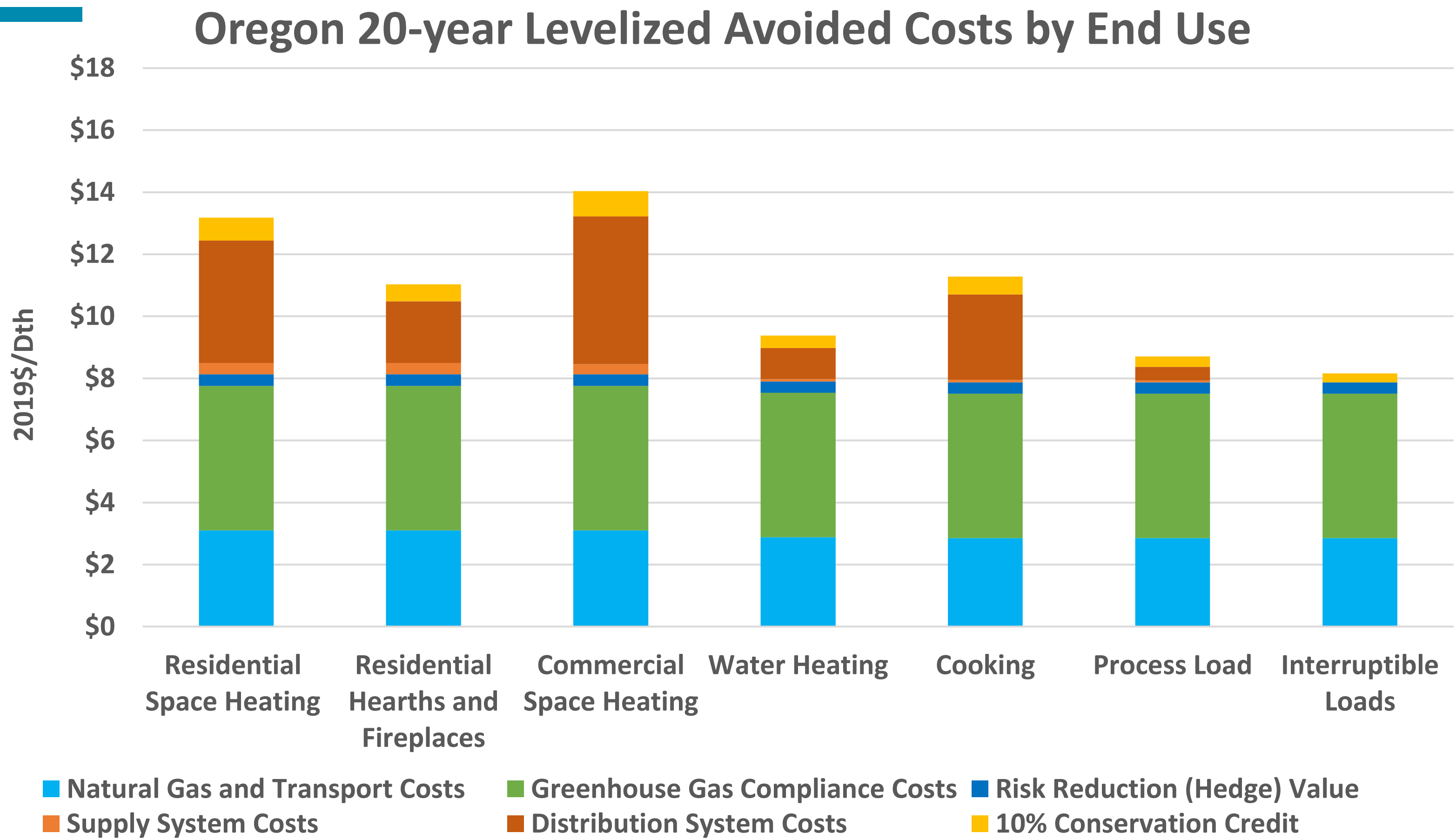


NW Natural analysis, not for investment purposes.

Avoided Costs Summary

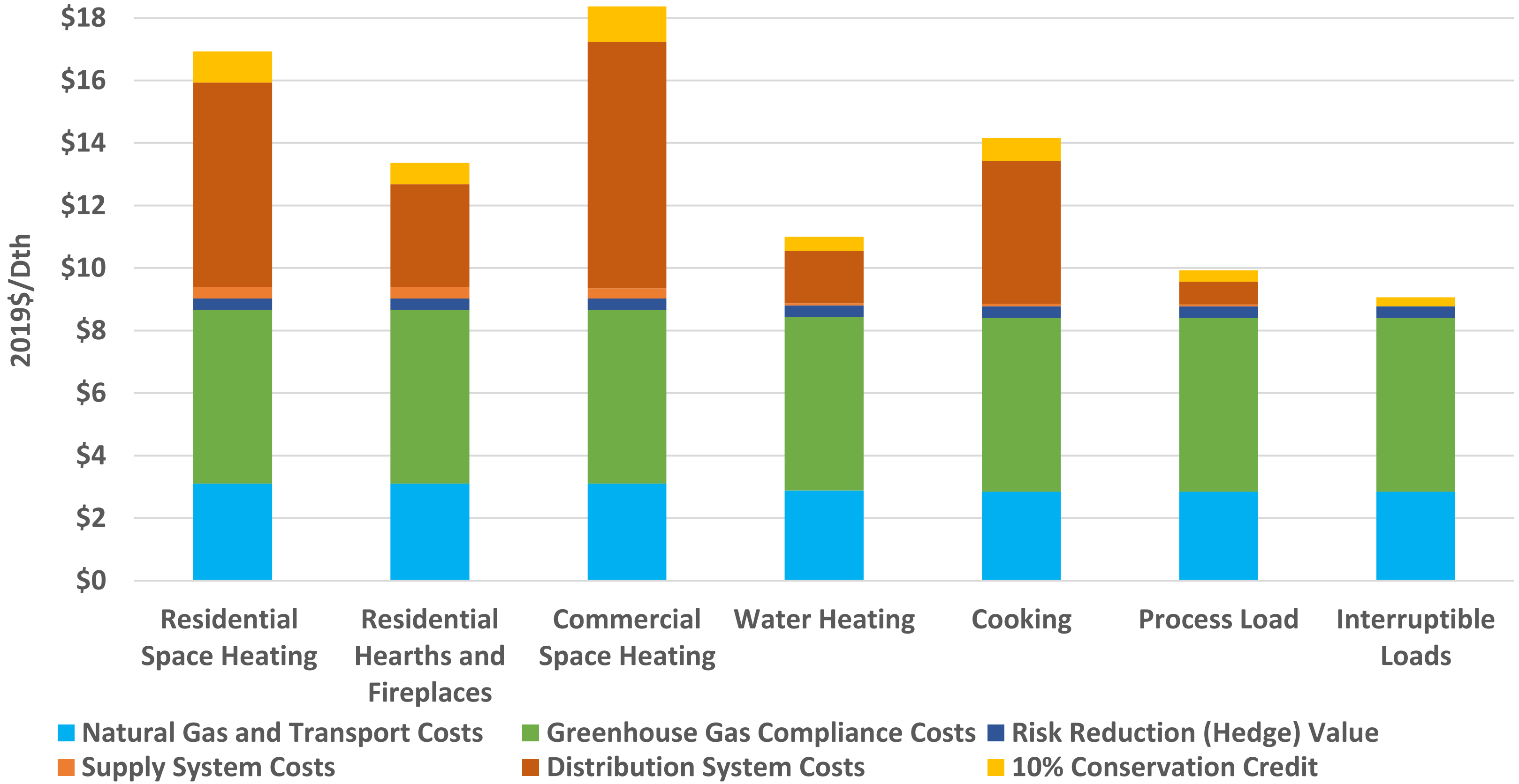
- The are numerous applications of avoided costs
  - Avoided cost methodologies discussed as part of the 2018 IRP and UM 2030 are now being put into practice for renewable natural gas
- Avoided costs vary by end use, with the end uses that contribute most to peak having the highest avoided costs
  - Levelized avoided costs over the next 20 years vary from between about $9/Dth for industrial process load to more than $18/Dth for Commercial space heating
- Avoided costs are higher than in previous IRPs due primarily to 2 factors:
  1. Greenhouse Gas Cost Projections: This update to avoided costs includes the social cost of carbon in the base case (implementing proposed action from OPUC related to EO 20-04 in Oregon and HB 1257 implementation in Washington)
  2. Updated and more granular distribution system capacity costs estimates

Oregon Avoided Costs

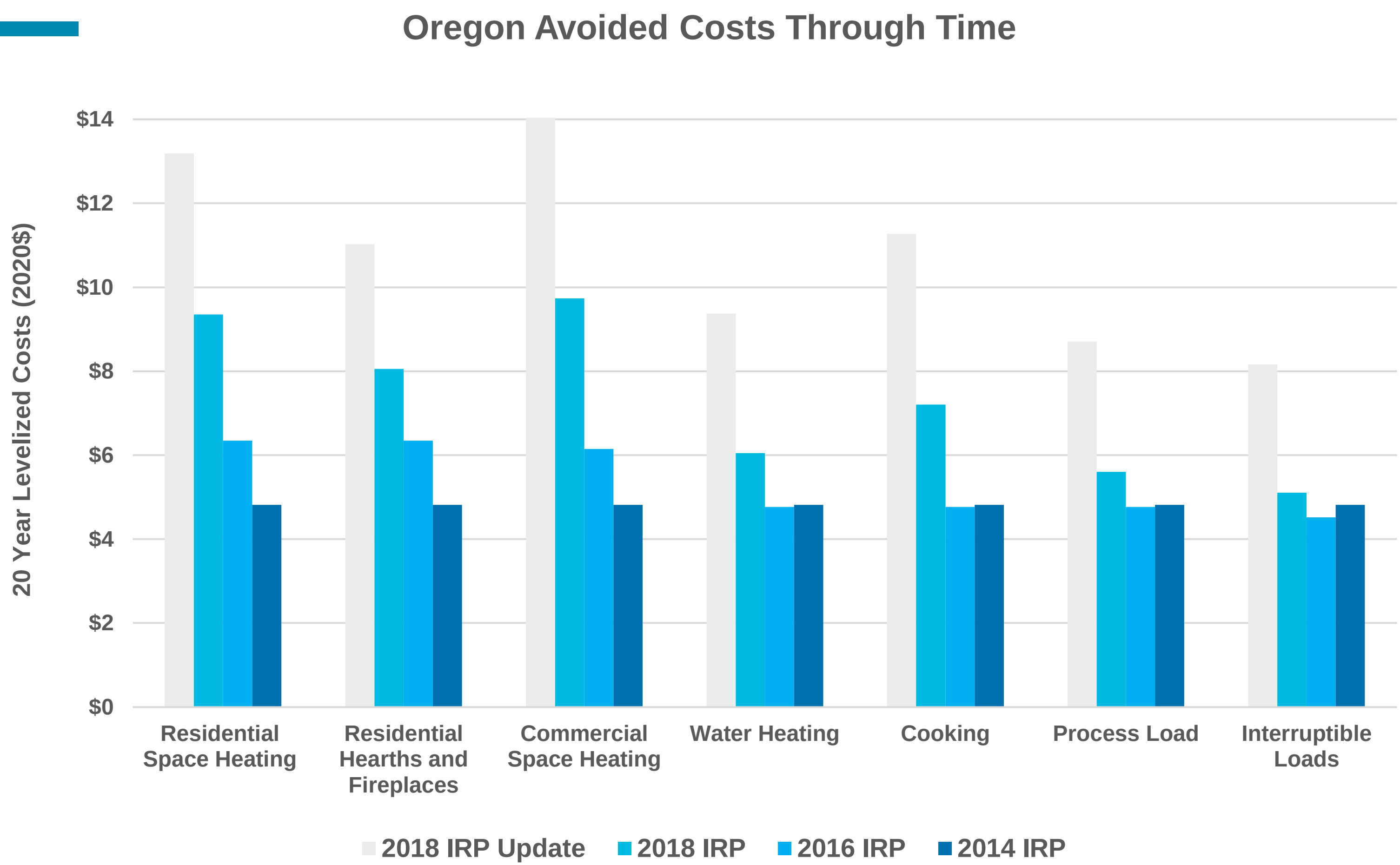


NW Natural analysis, not for investment purposes.

Washington Avoided Costs



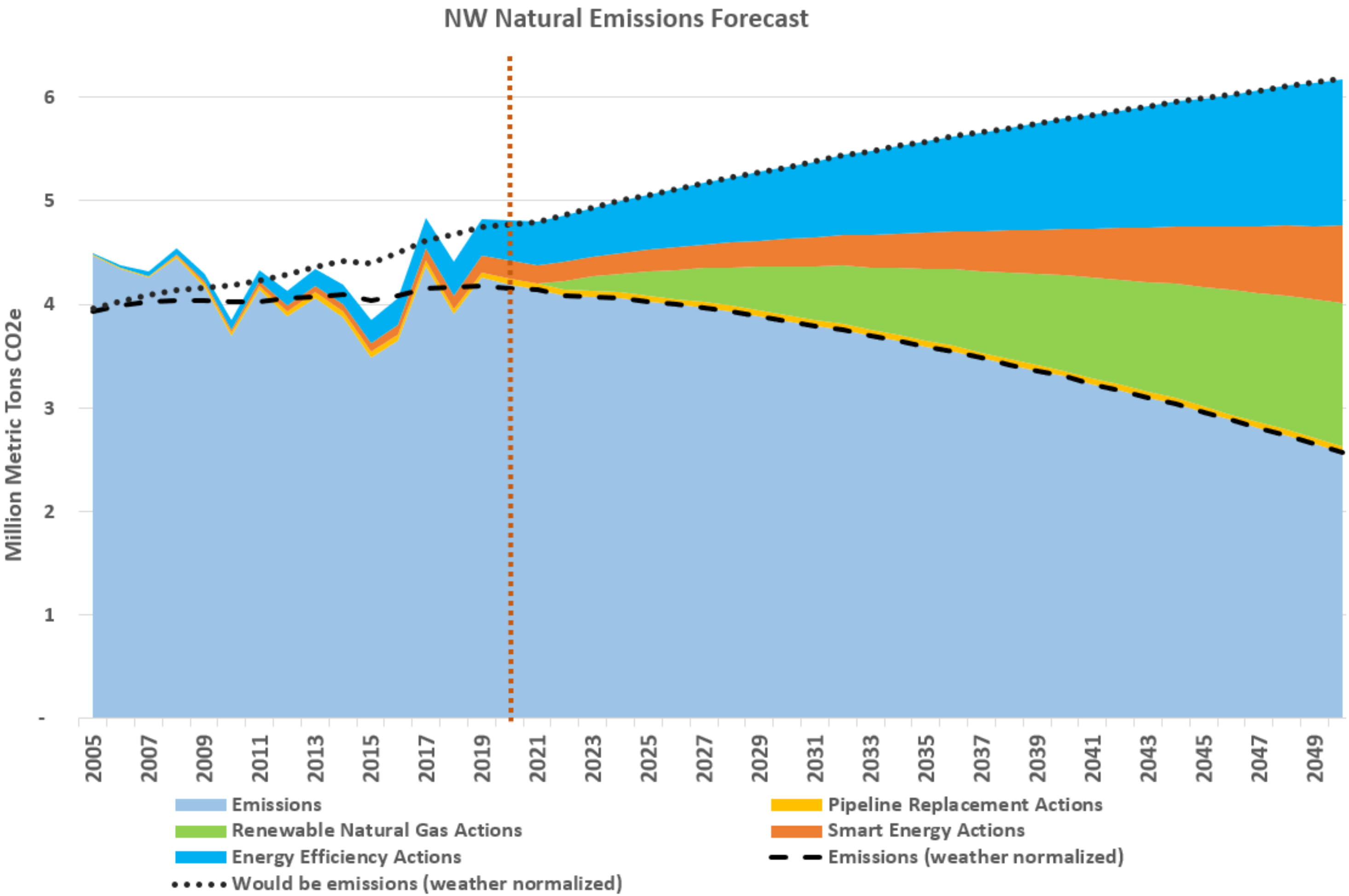
Avoided Costs Evolution



NW Natural analysis, not for investment purposes.

Emissions Forecast

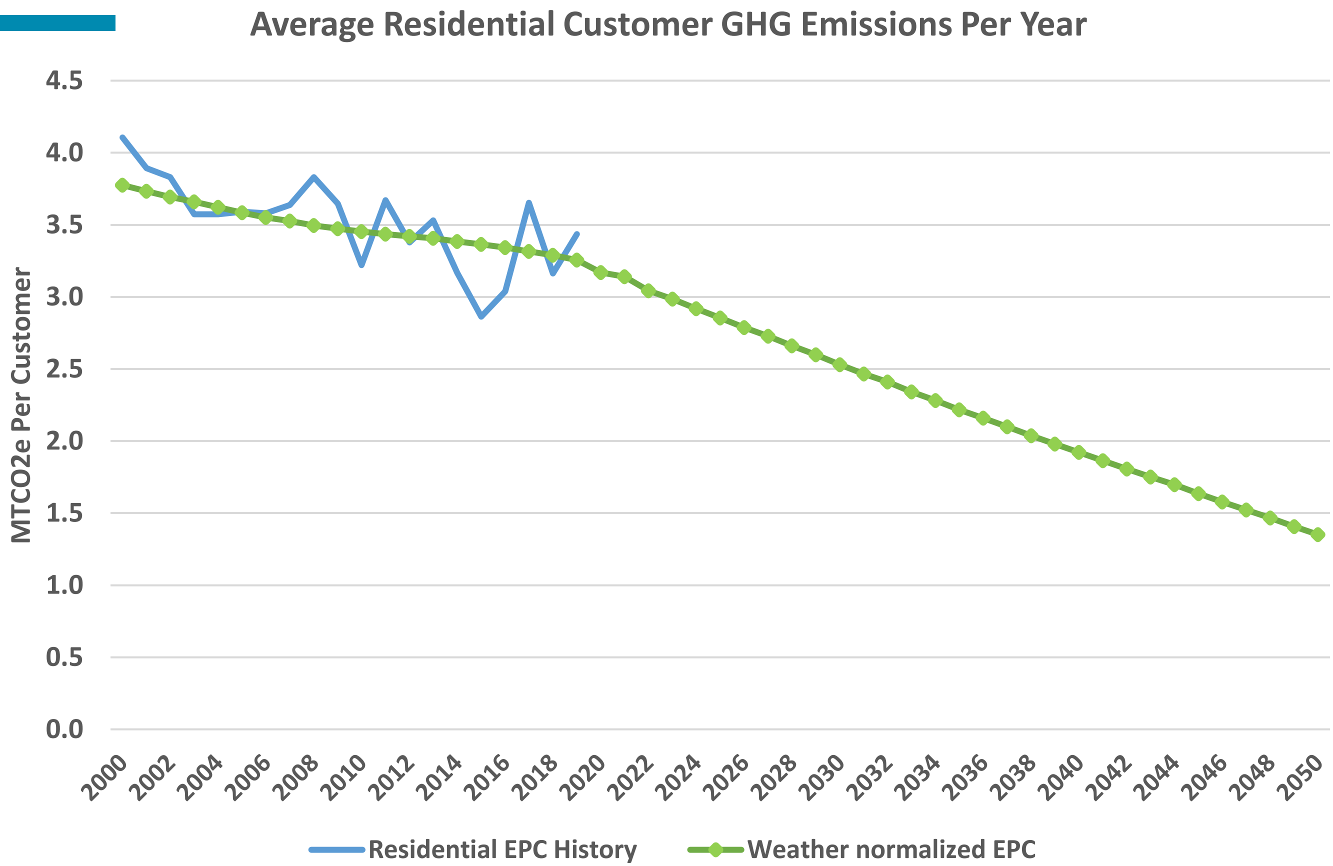
Emissions Forecast Under Current Policy



- Emissions from sales customers shown
- Actual emissions will always be "noisy" due to weather variation from year to year
  - Emissions are higher than normal weather expectation in years with colder than typical heating seasons (and lower for milder than typical heating seasons)
- Includes expected impact of OR SB 98 and WA CETA
- Does not include expected impact of ODEQ's cap-and-reduce program, other EO 20-04 related initiatives, or prospective legislation being considered in the 2021 session

NW Natural analysis, not for investment purposes.

Emissions per Customer Decline



- Includes impact of energy efficiency, RNG and the Smart Energy carbon offset program
- Residential Smart Energy program Savings allocated equally to all customers

NW Natural analysis, not for investment purposes.

Lunch

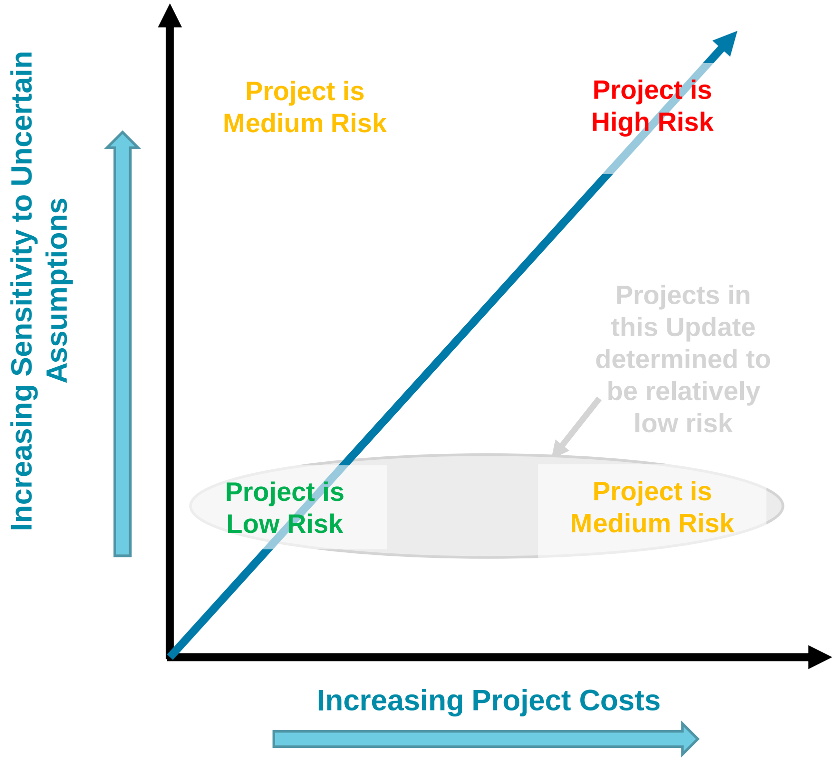
Action Item Projects

Why are we seeking acknowledgement of these projects now?

- **The current uncertainty in the policy environment makes decisions on projects that are dependent upon long-term load projections and/or resource options as the least-cost option riskier decisions to make**
- **Projects that rely on a current need and are the least-cost solution across the possible range of future outcomes are much lower risk projects**
- **NW Natural is seeking acknowledgement of projects in this update that:**
  1. are needed in the short-term to maintain reliability to meet current loads; and

  3. are the least-cost option regardless of what long-term load materializes; and

  3. not relatively high cost projects



Expected 2018 IRP Update #3 Action Plan

Action Item no. 1:

Replace the Cold Box at the Newport LNG facility for a targeted in service date of 2025 at a estimated cost of $20.5 million to $26.7 million

Action Item no. 2:

Proceed with Uprating the North Coast Feeder to be in service for the 2022-2023 heating season at an estimated cost of $7 million to $14 million

Newport Cold Box

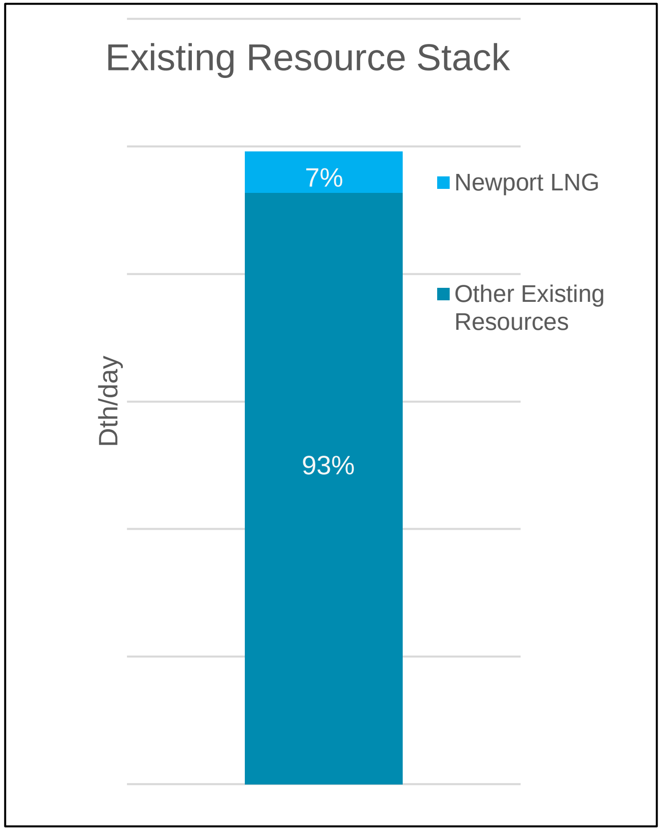
Newport LNG

NW Natural analysis, not for investment purposes.

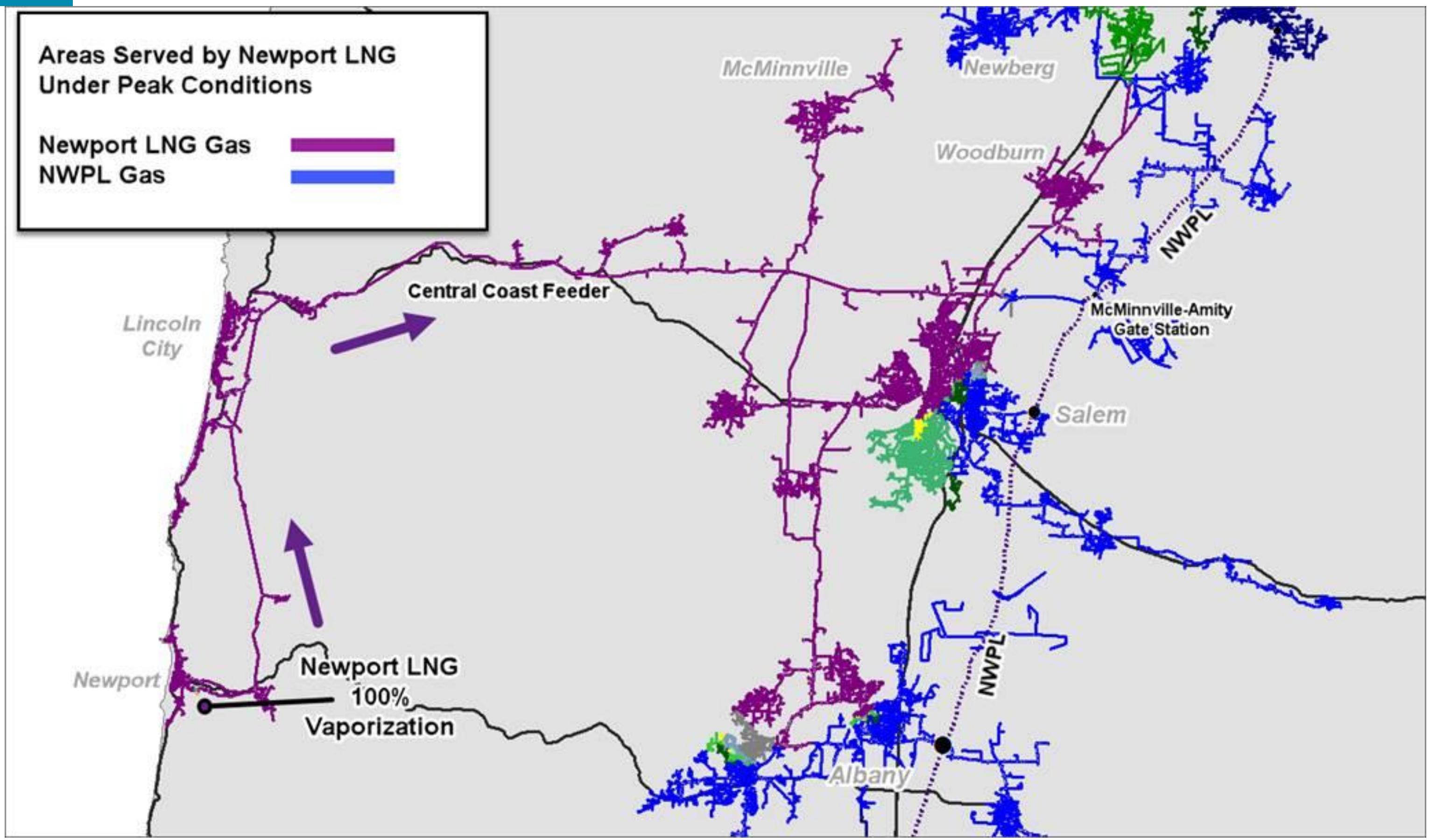
Newport LNG

- **Built in 1977**
- **1,000,000 Mcf capacity storage tank**
- **LNG Production 5,800 Mcf/day**
- **Vaporization capacity of 100,000 Mcf/day**
- **Current takeaway capacity of approximately 60,000 Mcf/day** (65,000 Dth/day*)
- **Roughly 7% of our current daily deliverability capability**
- **Strategically located to provide distribution system benefits**

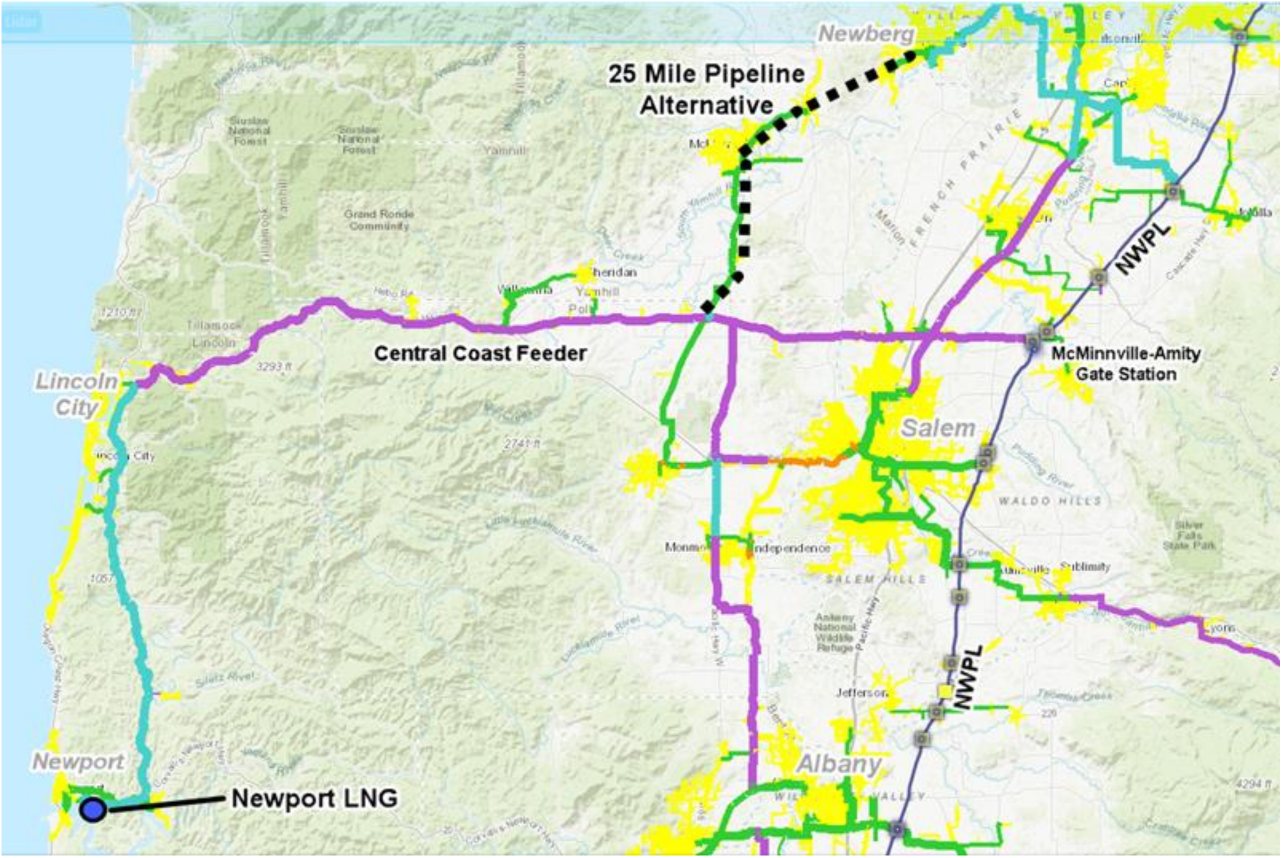
*Dth/day can vary based the heat content of the stored gas



Newport LNG – Serves Multiple Functions



Newport LNG Alternative Considered



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Newport LNG - History

- **Refurbishment of facility discussed beginning in 2012**
- **LC 60 – 2014 IRP included plans to refurbish the facility**
- **Alternatives examined:**
  - Refurbishment with cost estimate of $25 million, construction over three years
  - Alt A – Contract for additional pipeline capacity – estimated $19.3 million annually
  - Alt B – Construction of 25 mile high-pressure transmission facility plus Mist recall – estimated construction of $54 million plus annual O&M $0.2 million / year

Refurbishment showed a net savings of $28 million versus Alt B

- **OPUC Order No 15-064 acknowledged moving forward with the Newport refurbishment**

Newport LNG - Refurbishment Challenges

- **Cold Box design part of pre-treatment project**
  - Priority of project focused on pre-treatment refurbishment activities, however Cold Box identified for repair/cleaning or replacement based on further analysis
- **Cost estimates in 2014 IRP lower than actual costs**
- **Decision made to attempt to clean Cold Box as opposed to replacement**
  - Less costly
  - Increase lifespan
- **Further work with the consultant determined cleaning Cold Box was not feasible**
- **Other refurbishment activities completed consistent with the monetary ask in the 2014 IRP**
- **Additional estimate included in 2018 IRP was lower than actual costs ($4.8 million)**
  - Multiple reasons – seismic issues
  - Gas quality

Newport LNG – Refurbishment-Today

- **Cold Box needs to be replaced – cleaning is not an option**
  - Without an operational Cold Box, Newport LNG cannot liquify natural gas and would not be available as a source of gas supply
- **Current Design and Cost Estimate for Cold Box - more detailed, more certain.**
  - Replace cold box - $17.6 million
- **Alternative examined is 25-mile pipeline as in 2014 IRP with update Cost Estimate based on recent similar pipeline cost estimates.**
  - Cost estimates for pipeline - $170.8 million

Newport LNG – Original Estimate vs. Current Approach

- **Original estimate was based on high-level review by Engineering contractor - typical estimating methodology at the time. Focus of original effort was Pretreatment System.**
- **Since this original estimate, NW Natural has improved estimating approach to perform a Preliminary Design and Cost Estimate Study to support the project review process.**
- **Study identified several contributing factors that were not well understood during the original estimate, including:**
  - Siting location, foundation requirements, equipment design, piping, demolition, construction, and project contracting options.

2019-2020 Engineering Cold Box Study

$800K Project Budget **1 Year Effort**

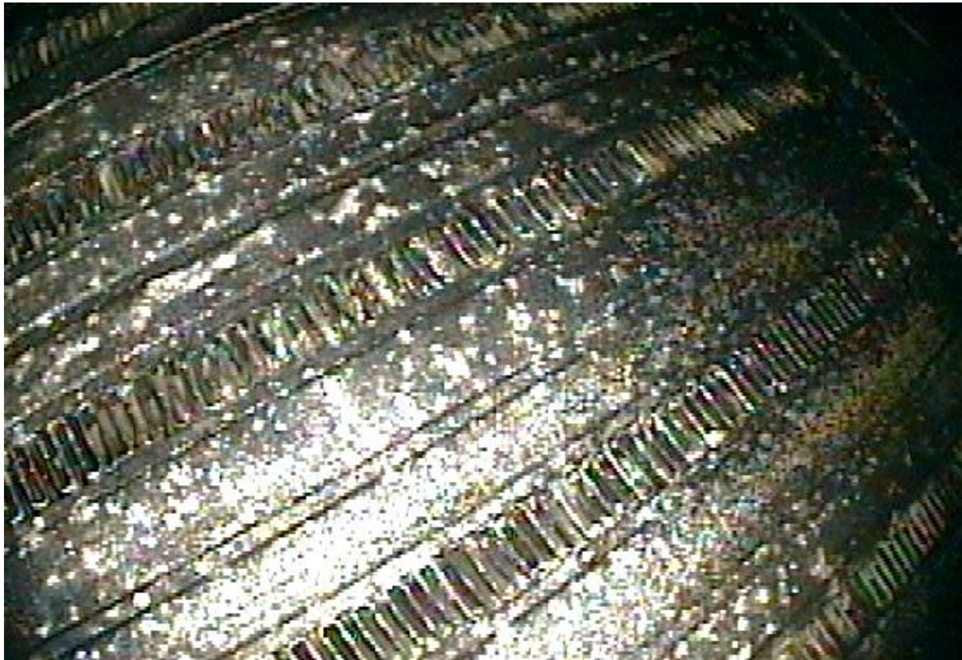
Engineering Team

- Sanborn Head - Cost Estimating and Author of Study
- Status Engineering - Process Engineering
- Harris Group - Detailed Engineering
- Geo Engineers - Geotechnical Study

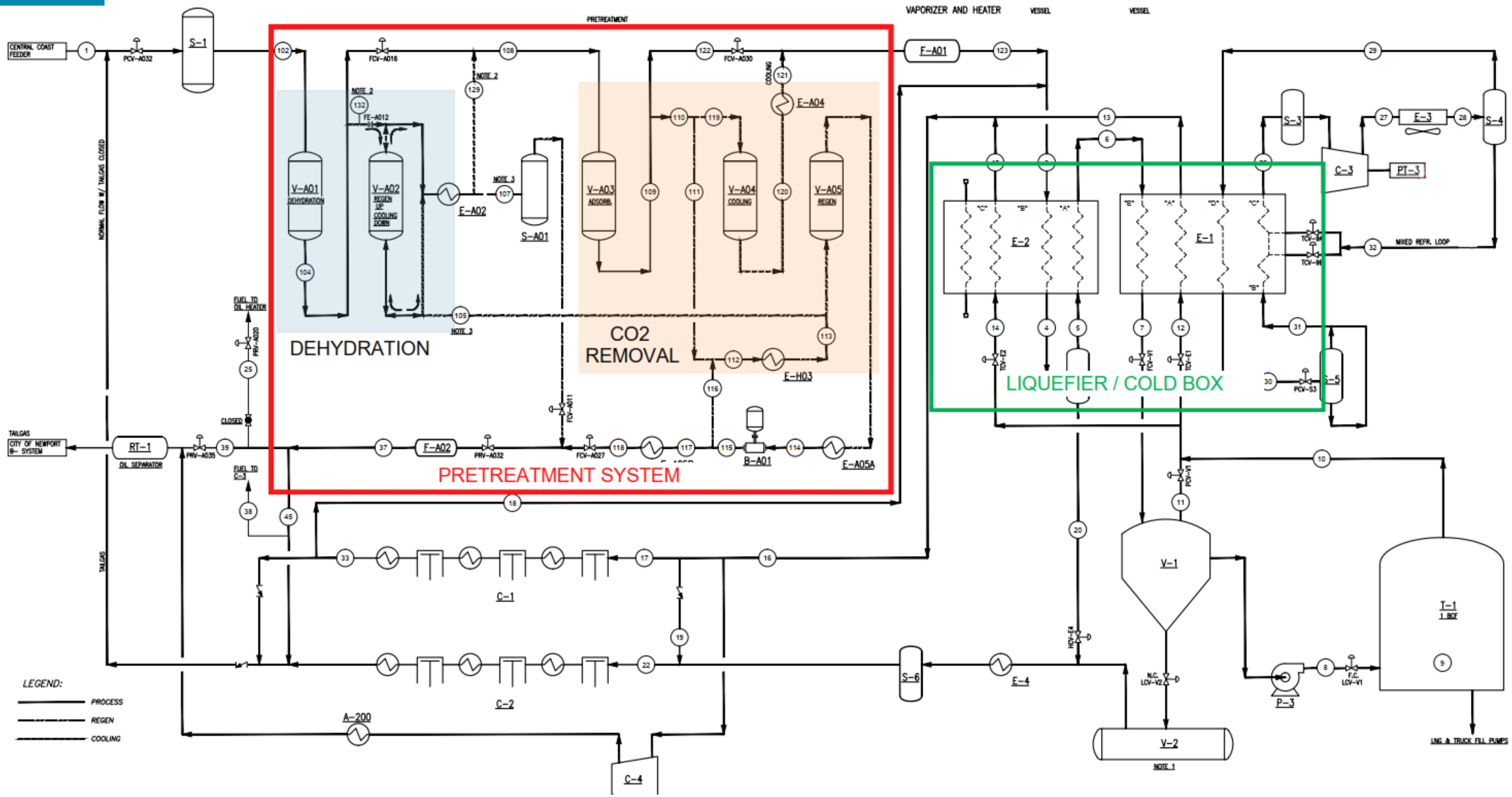
Cold Box Replacement Requirement

- Original Equipment, typically 30 year life
- Designed for different gas quality
- Pressure required to operate 3x+ design
- Frequent shut downs, every 1-2 weeks
- Contaminated passes
- Cleaning efforts canceled due to risk
- Not repairable if it fails

	Component	Original Design	Actual Range Last 15 yrs	Notes
C1	Methane	94%	97-89%	
C2	Ethane	2.82%	2 - 7%	Increasing
C3	Propane	0.80%	0.5 - 2%	
I-C4	I-Butane	0.11%	0.08 - 0.25%	Increasing
N-C4	N-Butane	0.15%	0.1 - 0.3	Increasing
C5	I-Pentane	0.06%	0.095%	
C6+	Hexane	0%	0.04%	



Process Engineering Existing System



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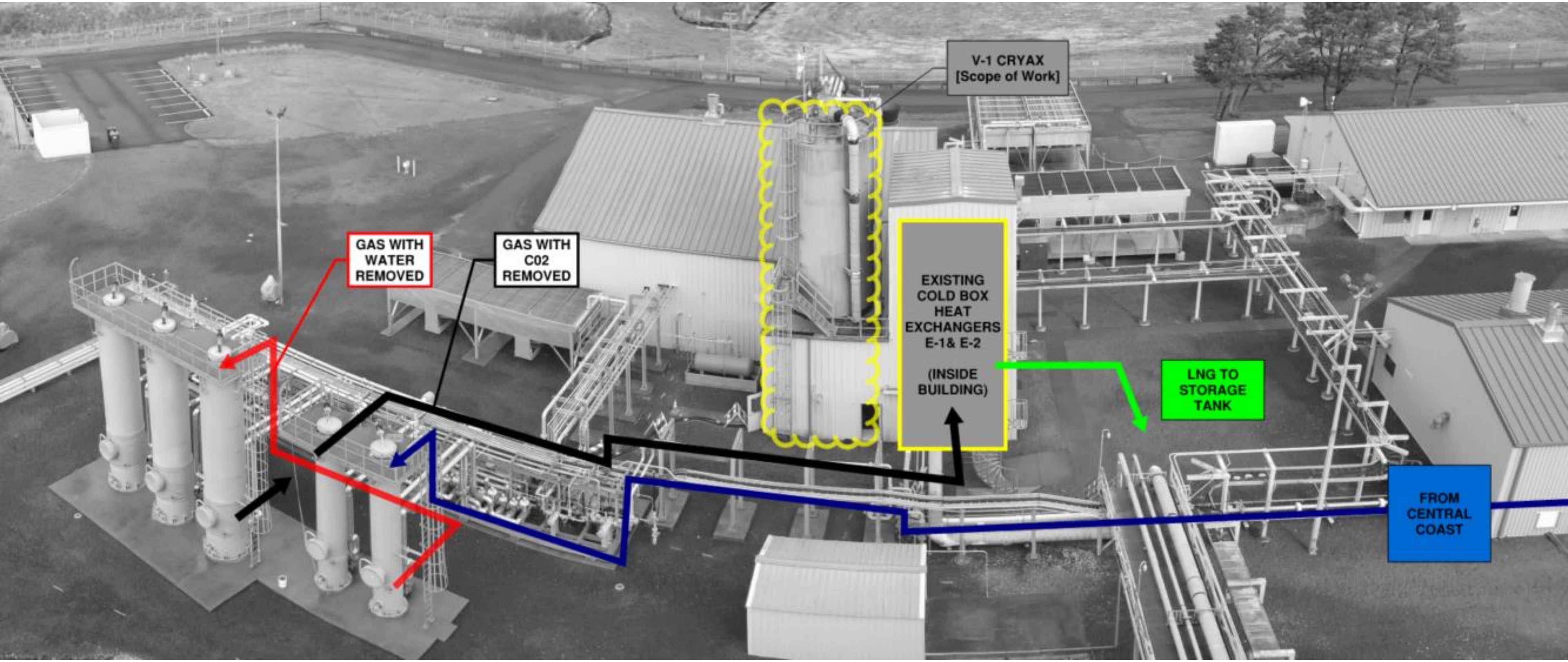
How it Works



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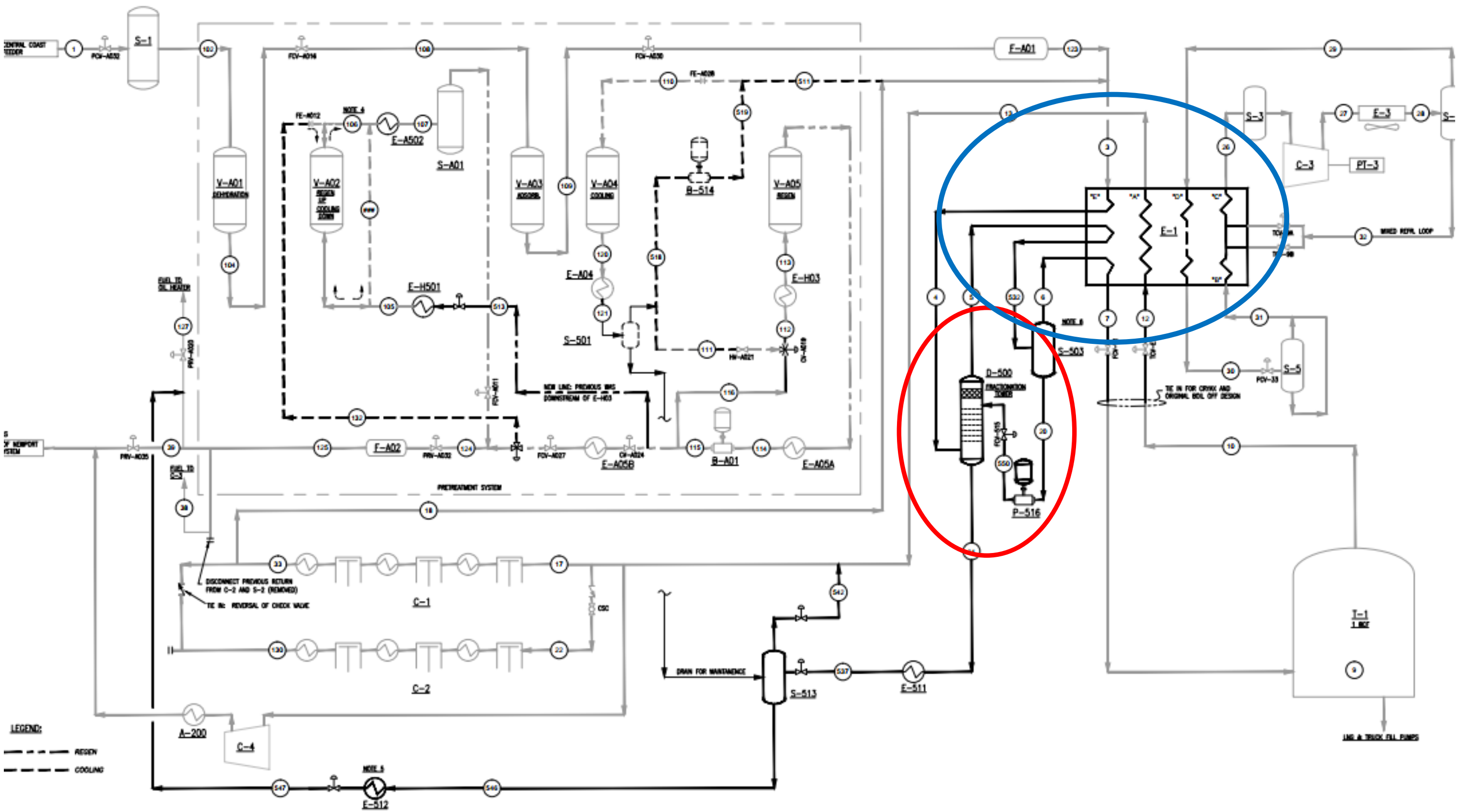
Process Engineering Conceptual Design



NW Natural analysis, not for investment purposes.

Construction Plan

NW Natural analysis, not for investment purposes.

Layout Photo

NW Natural analysis, not for investment purposes.

Cost Estimate

Cold Box vendor provided estimate for major equipment

Contractor review of approach and estimate

10% design effort to support estimate details

PROJECT COMPONENTS	ESTIMATE OVERVIEW		
COLD BOX REPLACEMENT			
			% of Scope Cost
ENGINEERING AND OVERHEAD	$ 3,276,764	$ 4,275,793	19%
MAJOR EQUIPMENT	$ 3,533,000	$ 4,384,600	20%
DEMOLITION	$ 410,300	$ 594,935	2%
CIVIL/SITE CONSTRUCTION	$ 808,450	$ 1,166,853	5%
STRUCTURAL CONSTRUCTION	$ 1,129,600	$ 1,348,780	6%
MECHANICAL CONSTRUCTION	$ 2,249,070	$ 2,953,791	13%
ELECTRICAL CONSTRUCTION	$ 506,595	$ 734,563	3%
INSTRUMENTATION/CONTROL	$ 1,155,125	$ 1,490,819	7%
STARTUP AND COMMISSIONING	$ 245,000	$ 318,500	1%
TRAINING	$ 55,000	$ 71,500	0%
FREIGHT	$ 200,534	$ 260,694	1%
	Base Price	*With Contingency*	**30%**
PROJECT TOTAL	***$ 13,569,438***	***$ 17,600,827***	

Newport LNG Project – Cost of Service

Installation Costs

Installation Cost	
Cold Box Replacement	$17.6M
Alternative Pipeline	$170.8M

Cost of Service Comparisons

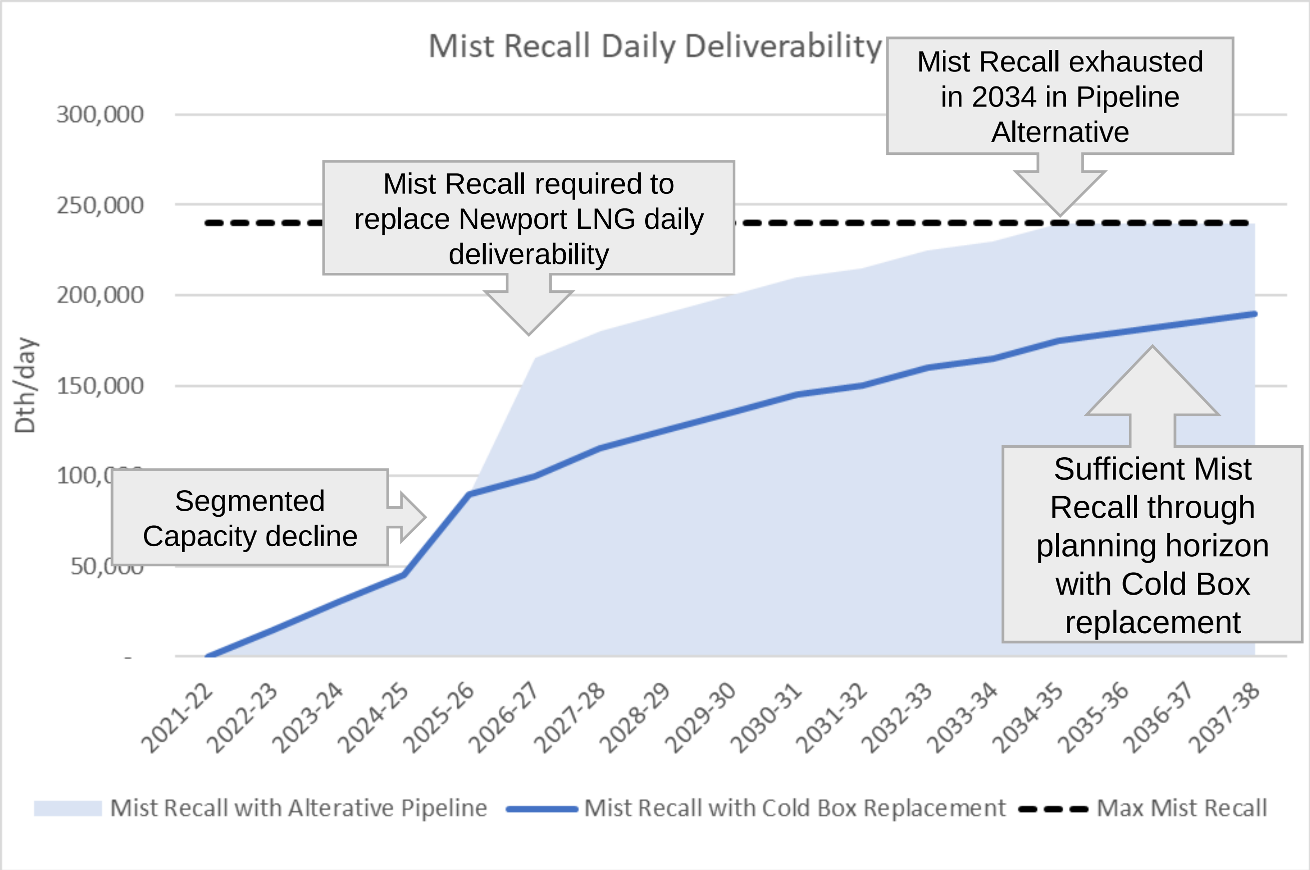
	40-Year PVRR	Levelized Annual Revenue Requirement
Cold Box Replacement	$26.7 M	$1.46 M
Alternative Pipeline	$248.31 M	$13.56 M
Delta	$221.61 M	$12.1 M

NW Natural analysis, not for investment purposes.

Newport LNG Project – Portfolio Impacts for Mist Recall

Assumptions for Alternative Pipeline Portfolio

- **Pipeline Alternative comes online summer of 2026**
- **Mist Recall is exhausted in 2034**
- **For this analysis, once Mist Recall is exhausted no additional resources are acquired**
  - This is a conservative approach for portfolio with the pipeline alternative
  - Additional resources acquisitions would only add costs to the portfolio analysis



*Max Mist Recall can vary based on heat content of stored gas

Newport LNG Project – Portfolio Costs

Portfolio PVRR (2021-2050)

	Fixed Storage Costs	Fixed Pipeline Costs	Supply Variable Costs	Other Variable Costs	Total Portfolio Costs
Cold Box Replacement	$63 M	$1,162 M	$10,548 M	$69 M	$11,841 M
Alternative Pipeline	≥$58 M	≥$1,312 M	$10,542 M	$70 M	≥$11,986 M
Delta	-$5 M	$150 M	-$2 M	$1 M	≥$145 M

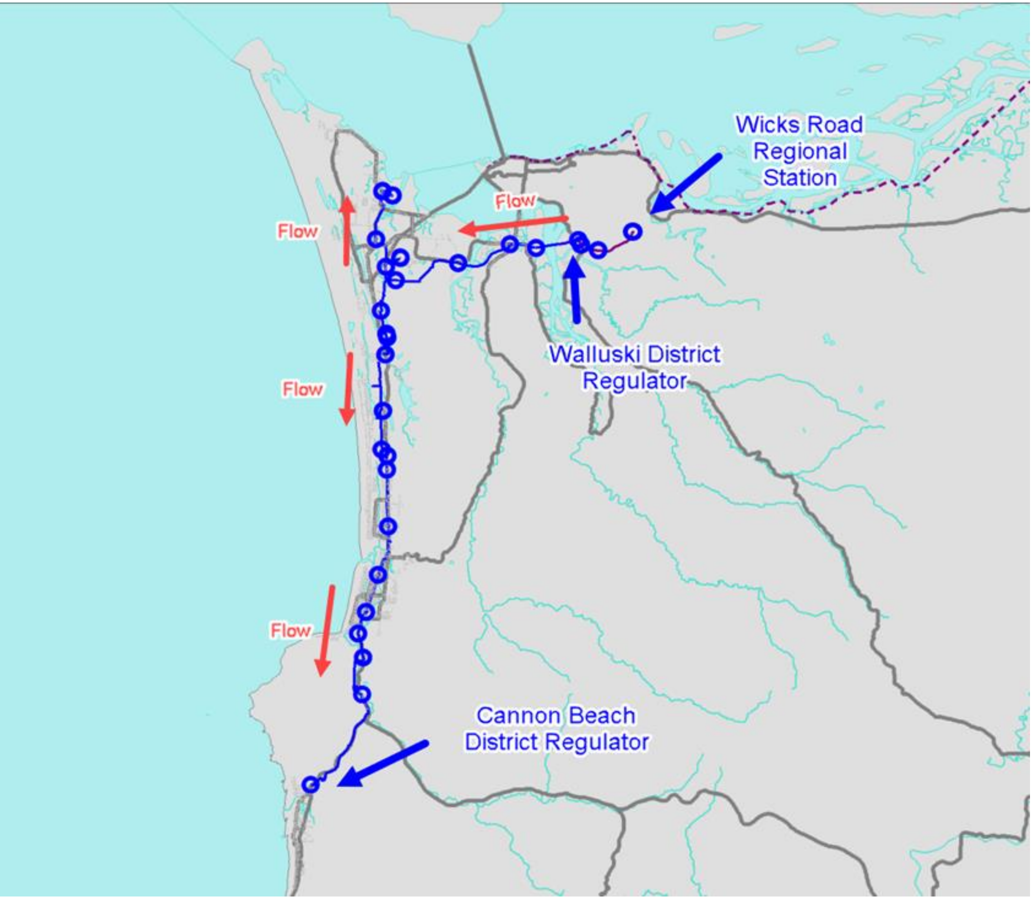
Notes:
1) Fixed storage costs include the cost of the cold box (or lack thereof), fixed costs for Mist Recall and fixed cost for Jackson Prairie.
2) The only difference in fixed pipeline costs are the costs of the alternative pipeline.
3) Supply variable costs reflect the difference in optimized gas purchases due to differences in storage capacity of Mist Recall. Supply variable costs include a carbon adder.
4) Other variable costs include fuel and variable costs associated with the different gas purchases, storage injections, and optimization of storage capacity.
5) Differences in summed totals are attributed to rounding errors.

North Coast Feeder

Overview of Project Development Process

- Monitor pressures in system and record results
- Verify equipment settings and functionality
- Model system based on experienced demands, recorded pressures, and equipment settings
- Develop and model System Reinforcement solution
- Develop cost estimate for proposed Project
- Consider alternatives to System Reinforcement Project

North Coast Feeder



- Sole source of gas supply for our customers in the Astoria area.
- Walluski District Regulator feeds gas to customers in Warrenton, Seaside, and Cannon Beach.

NW Natural analysis, not for investment purposes.

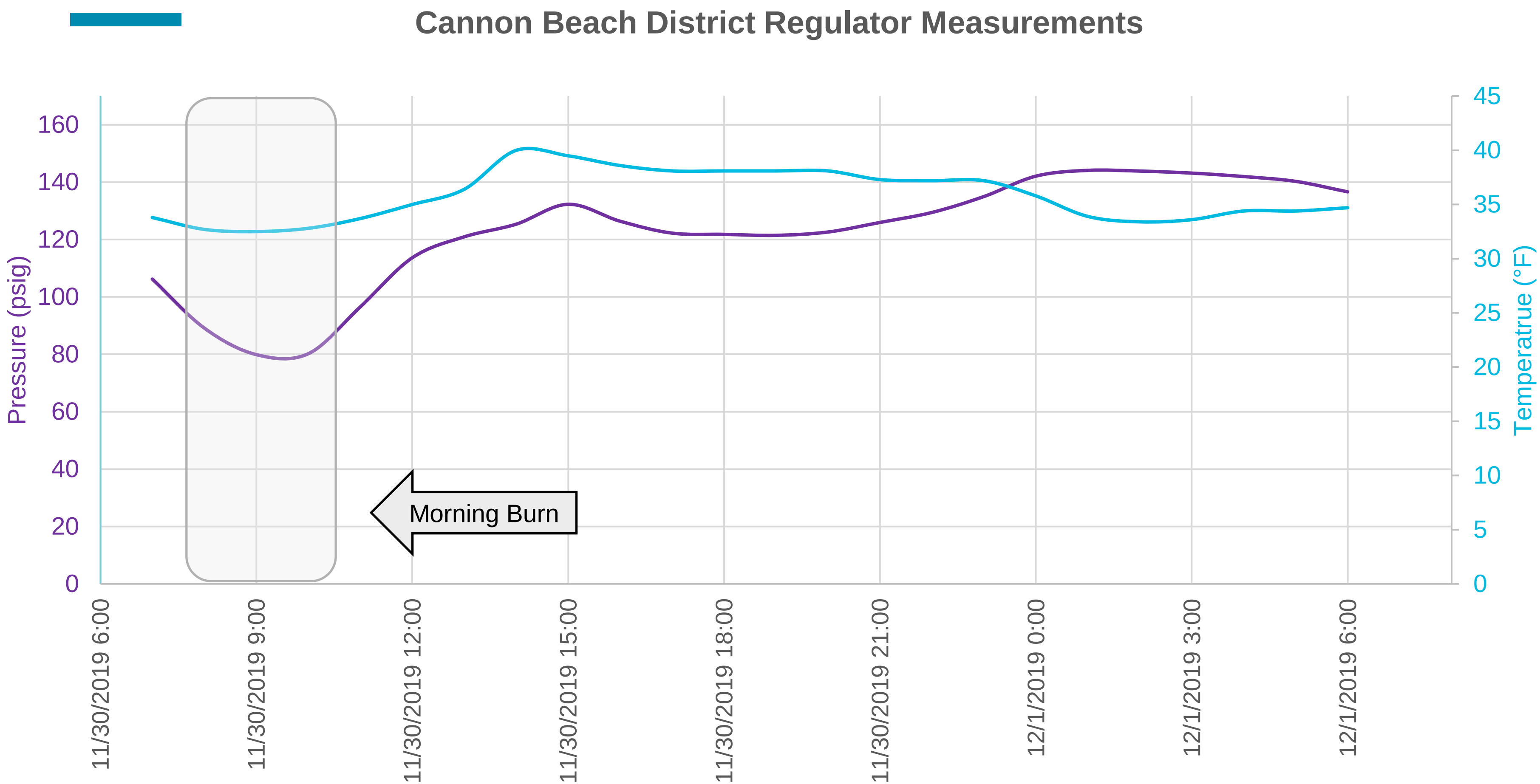
North Coast Feeder

- In 2018, Synergi modeling results indicated that the North Coast high pressure system has low pressures at the inlet of the Cannon Beach district regulator.
- The Cannon Beach district regulator is fed from a single 175 MAOP high pressure line by the Walluski district regulator from the north.
- The low pressures found in the hydraulic model triggered a request to site an EPPR (Electronic Portable Pressure Recorder) at the inlet of the Cannon Beach district regulator during the 19/20 heating season to monitor pressures.

North Coast Feeder

- **The EPPR was set at the inlet of Cannon Beach in November 2019.**
- **During the month of November, retrieved data indicated that the inlet pressure dropped below 80 psig when the Walluski district regulator was set at 162 psig.**
  - The findings of the EPPR data supported the pressure losses identified in the model because the pressure dropped by 50.7%.
  - The EPPR case temperature during this event revealed that Cannon Beach experienced a 29 heating degree day (36°F).
- **Historically, the North Coast sees daily temperatures well below 32°F and even has experienced daily average temperatures below 20°F.**
- **The graph on the next slide illustrates the pressure sagging below 80 psig on 11/30/2019 at around 9:00 AM as temperature dipped to about 32°F.**

North Coast Feeder



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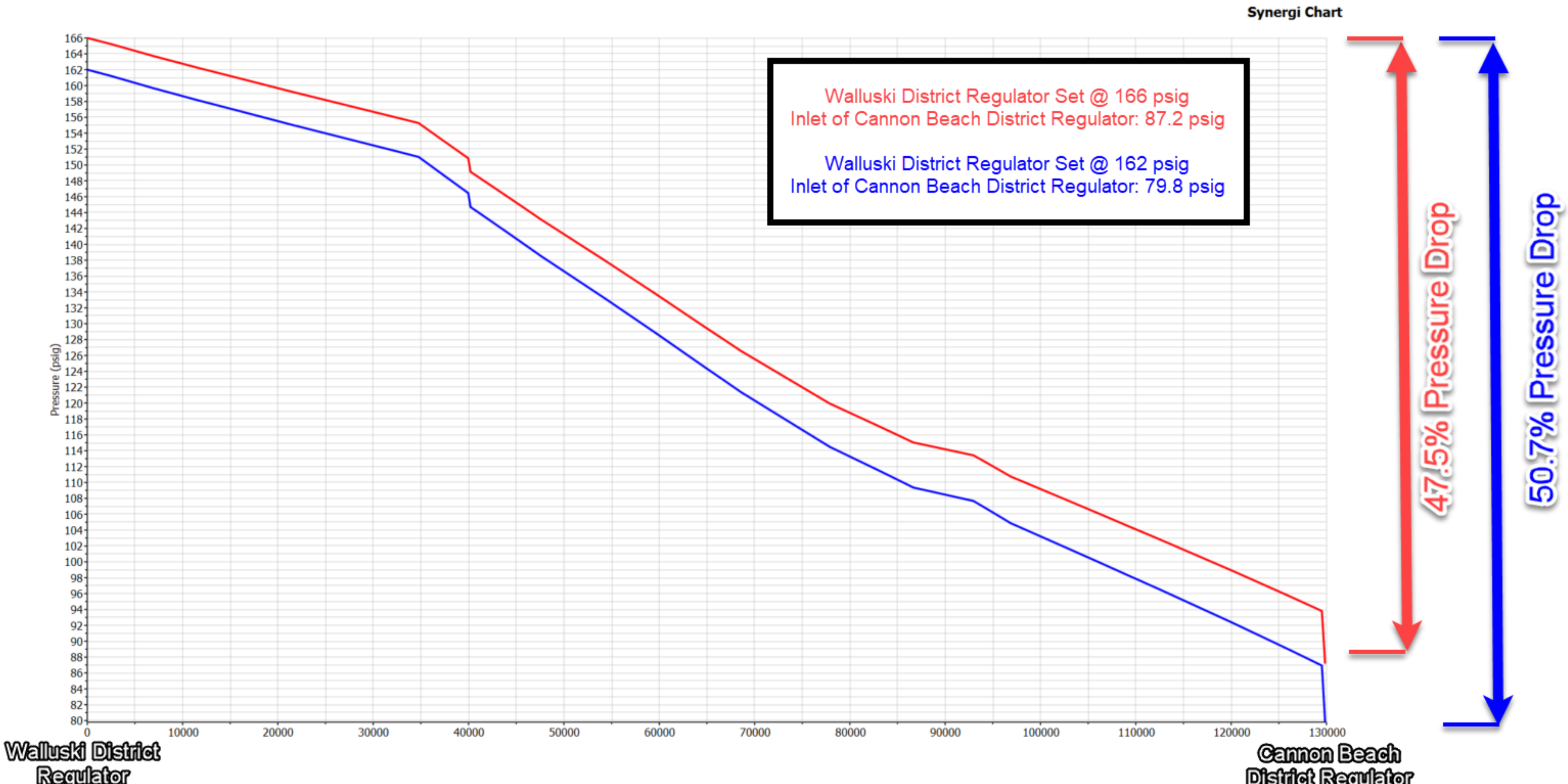
North Coast Feeder

- **The low pressures recorded on the EPPR resulted in a request to increase the setpoint of the Walluski district regulator from 162 psig to 166 psig (the highest setpoint possible) in December 2019.**
- **A model was developed to evaluate what the Cannon Beach district regulator inlet pressure would be during the 11/30/2019 event with the Walluski district regulator set at 166 psig instead of 162 psig.**
  - The results of the model show that the inlet of the Cannon Beach district regulator would be approximately 87 psig with the same demand. This means that with the Walluski Regulator set at 166 psig, we would have recorded a pressure drop of 47.5%, which exceeds the 40% pressure drop criteria.
  - The next slide illustrates the pressure profiles for the demands found on 11/30/2019 with the Walluski district regulator set points at 162 psig and 166 psig.

North Coast Feeder

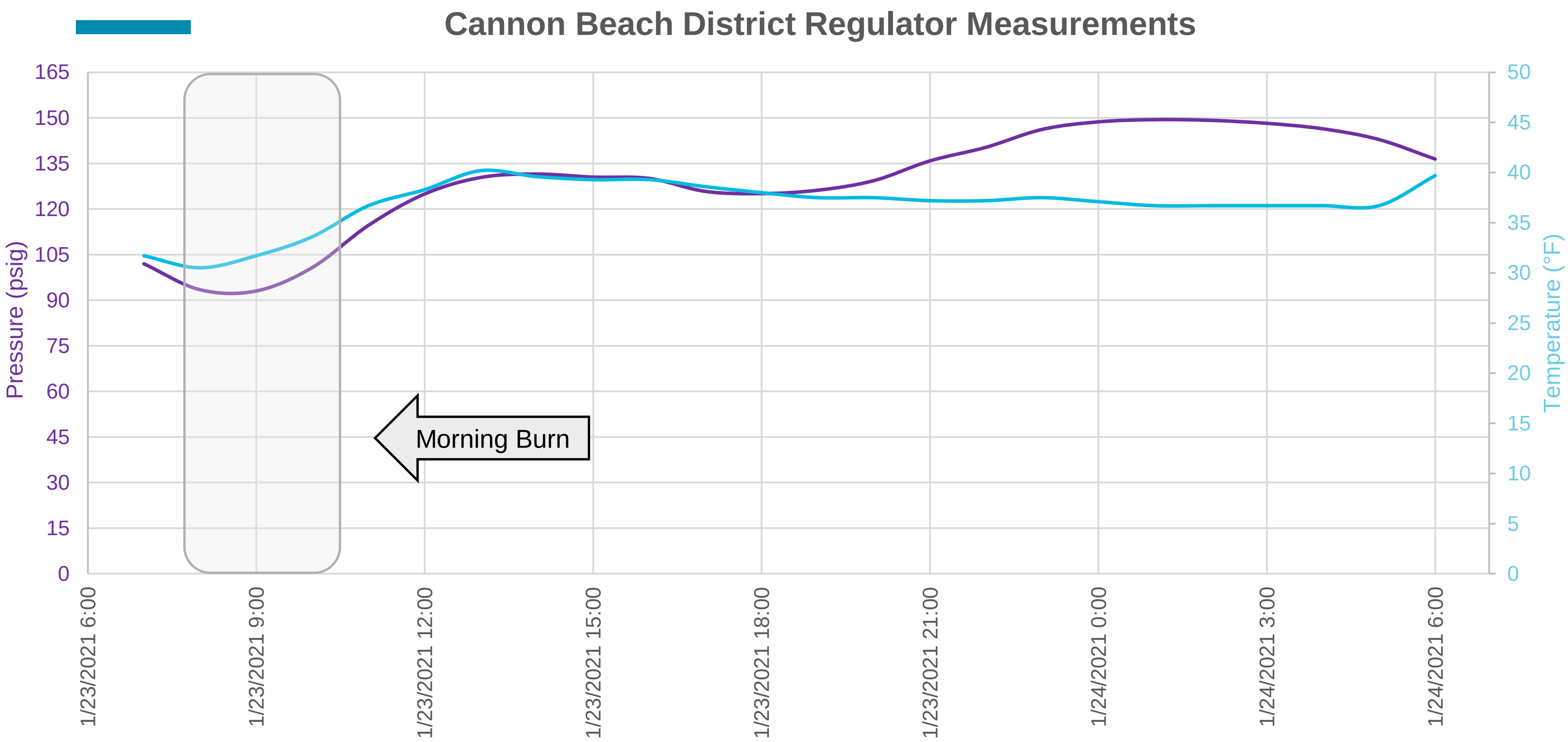


NW Natural analysis, not for investment purposes.

North Coast Feeder

- **Recent developments confirm Synergi modeling results.**
- **On January 25, 2021, a dataset was extracted from an EPPR sited at the Cannon Beach District Regulator which includes a 40% pressure drop violation.**
- **The low pressure measurement appeared on January 23, 2021.**
  - The EPPR recorded a measurement of 93.1 psig at the inlet of the Cannon Beach District Regulator.
  - The low pressure reading occurred while the Walluski District Regulator was set to 165 psig.
  - 93.1 psig indicates that the North Coast Transmission Feeder experienced a 43.6% pressure drop.
  - EPPR case temperatures during the day indicates a 28 heating degree day (37°F).

North Coast Feeder



NW Natural analysis, not for investment purposes.

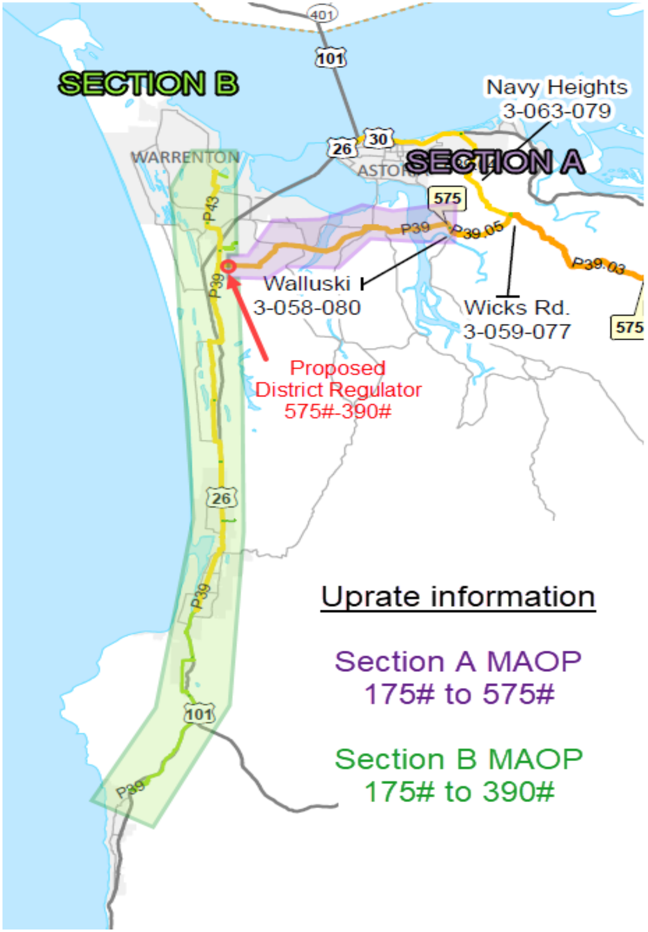
North Coast Feeder

- **The recommended improvement consists of uprating the North Coast Transmission Feeder west of the Walluski District Regulator.**
- **The proposed uprate is broken into two sections, Section A and Section B.**
- **Section A consists of uprating the 8”(W) high pressure main between Walluski District Regulator to Rodney Acres Rd from a MAOP 175 psig to 575 psig.**
  - After the uprate, Section A will be classified as transmission because it will be operating above 20% SMYS due the planned uprate. Because the MAOP east of Walluski is already at 575 psig, the Walluski District Regulator is no longer required to control pressure and will be abandoned.

North Coast Feeder

- **Section B consists of uprating the high pressure system west of where the 8"(W) terminates from a MAOP 175 psig to 390 psig.**
  - Section B will still be classified as High-Pressure distribution because the MAOP is below the definition of transmission.

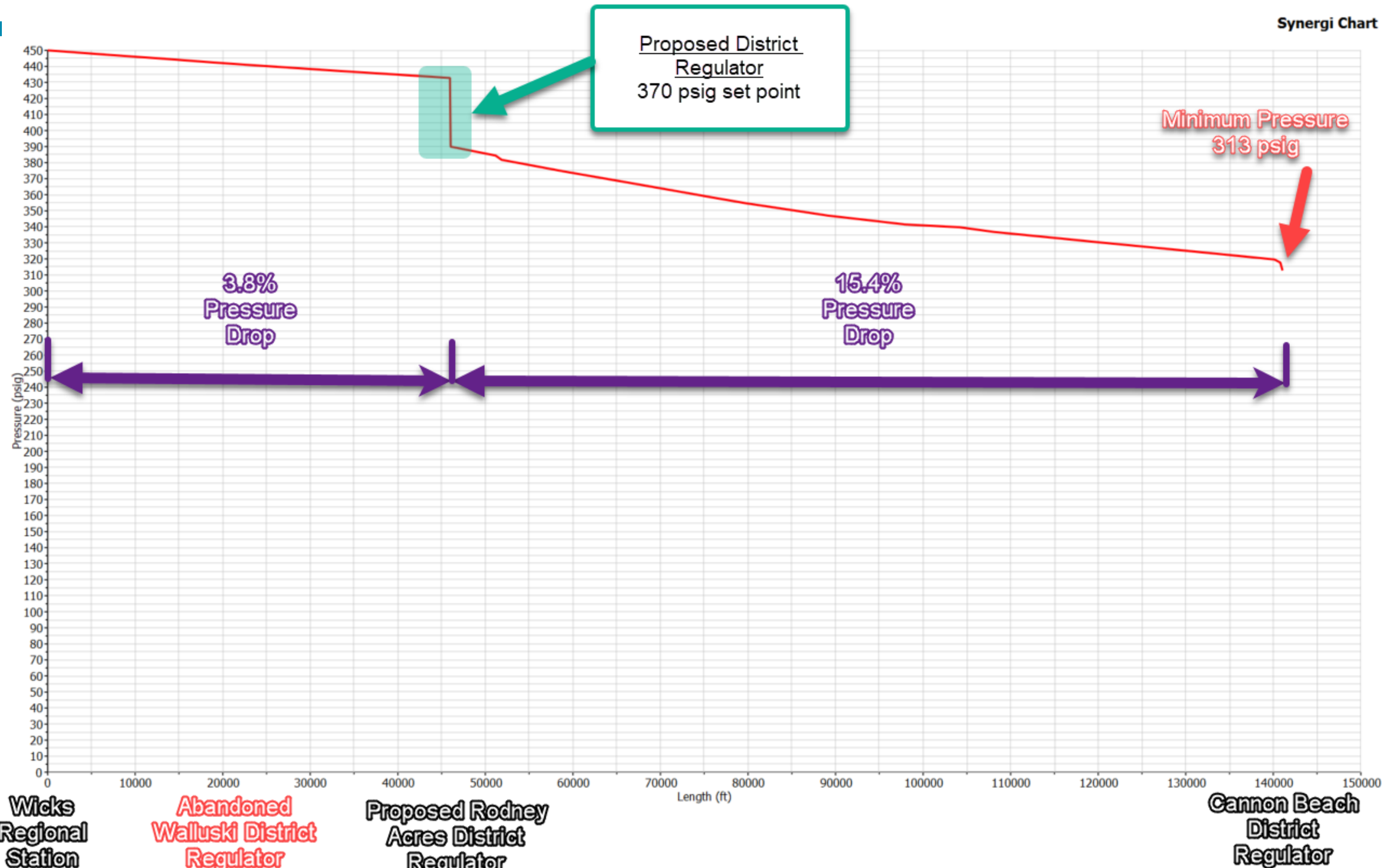
- **This figure provides a general overview of the uprating.**



North Coast Feeder

- **Peak Hourly Modeling after the improvement.**
  - Although section A was uprated to an MAOP of 575 psig, during an extreme weather event we would expect lower pressures than the normal operating pressure because of higher demands.
  - Taking peak usage into consideration, the model pressure was set to 450 psig at the Wicks Road regional station.
  - The peak model results conclude that the inlet of Cannon Beach will see pressures of 313 psig during a peak day with the uprate.
  - The modeling reinforces that the uprate adequately serves existing demands and should satisfy potential growth on the North Coast for the foreseeable future.

North Coast Feeder



NW Natural analysis, not for investment purposes.

North Coast Feeder

- **Summary of the scope of work and preliminary cost estimate for the North Coast Feeder Uprate project for inclusion in the proposed 2021 IRP Update:**
- **Note: All piping and regulators with insufficient test documentation must be retested or replaced before pressure uprate can occur.**
  - 11 service regulator inlet piping replacement or full replacement
  - 13 district regulator inlet piping replacement or full replacement
  - 1 new pressure regulating station at Rodney Acres Rd.
  - 1 new pigging launcher and receiver station
  - Material sampling and recording along 7 miles (1 sample per mile)
  - 2 short sections of 4” and 2” pipe to be retested or fully replaced.
- **The preliminary total project cost estimate for the above scope of work for the North Coast Feeder Uprate is between $2,900,000 and $5,800,000 without COH.**

Alternative Analyses

Targeted Interruptible Schedule Agreements

- Estimated technically potential load savings from large firm industrial loads in the affected area switching to interruptible service
- Insufficient technical potential available
- With firm industrial loads curtailed in the model, Synergi Gas results demonstrate that the 175 MAOP system will continue to experience a greater than 40% pressure drop during peak hourly conditions

Alternative Analyses

Satellite LNG Facility

- Estimated cost to site LNG facility to serve affected area
- Cost significantly higher than pipeline uprate

North Coast Feeder

- **Alternative Analyses Complete**
  - Satellite LNG not cost effective
  - Targeted interruptible schedule agreements insufficient

	40-year PVRR
Feeder Uprate	$7.1M - $14.1M
Satellite LNG Alternative	$37.1M
Targeted Interruptible Schedule Agreements	N/A (insufficient)

Renewable Natural Gas (RNG)

RNG Policy Update

Big Changes in RNG Policy Since 2018

- No official Renewable Natural Gas policy impacting LDCs in Oregon and Washington existed when NW Natural developed its 2018 IRP
- Major policies related to LDC RNG procurement have been established over the last couple of years
  - Oregon Senate Bill 98 Passed in 2019
    - AR 632 Rulemaking and UM 2030 investigation completed in 2020
  - Washington HB 1257 passed in 2019

OPUC Docket No. AR 632 – Update

- SB 98 – 2019 bill set voluntary renewable natural gas targets

Years	Volumes (RNG Share of Sales Load)
2020-2024	5%
2025-2029	10%
2030-2034	15%
2035-2039	20%
2040-2044	25%
2045-2049	30%

- AR 632 – OPUC Rulemaking docket to implement SB 98
- New rules adopted as Section 150 in the OARs
- Similar to OR Renewable Portfolio Standards
- Cost guardrails – up to five-percent of annual revenue requirement

OPUC Docket No. AR 632 – Rules

- Renewable Thermal Certificates (RTC) used for compliance
- RFP requirements included
  - Qualified investments – production facilities upstream of conditioning equipment, pipeline interconnection or gas cleaning
- Annual compliance report required
- Renewable Natural Gas Resource Planning (IRPs)
  - Must "include information relevant to the RNG market, prices, technology, and availability"
  - Opportunities, challenges and strategy to meet RNG targets
  - Cost-effectiveness calculation (see also Appendix H)

OPUC Docket No. UM 2030 - Update

- NW Natural's 2018 IRP included Appendix H – Renewable Gas Supply Resource Evaluation Methodology
- At the 8/27/2019 Public Meeting Staff presented a memo recommending opening of an investigation into:

  "determining the cost-effectiveness of Renewable Natural Gas (RNG) resources for NW"
- The Commission concurred, opening Docket No. UM 2030
- Phase 1
  - Workshop held December 13, 2019
  - Revised Appendix H filed January 10, 2020
- Phase 2 – Actual project
  - Workpapers filed June 1, 2020
  - Workshop held June 16, 2020

OPUC Docket No. UM 2030 - Update

- Staff recommended approval of proposed RNG evaluation methodology
- Commission concurred in OPUC Order No. 20-403 (10/26/2020)
- Methodology compares RNG to conventional gas on "all-in" costs where:

All-in costs = Cost of gas + GHG Emissions costs - Avoided infrastructure costs

- Update Schedule of methodology components:

Inputs and Forecasts	Frequency of Update	Additional Explanation
Resource Under Evaluation	Most Current Estimate	For example, if an RNG project requires any capital costs, the most current estimate of those costs will be run through the cost-of-service model and used for the evaluation.
Gas Prices (Deterministic and Stochastic)	Twice a year	Our third-party consultant provides long term gas price forecasts twice each year in August and February.
Peak Day & Annual Load Forecast	Once a year	These forecasts are updated spring/summer to include data from the most recent heating season.
GHG Compliance Cost Expectations (Deterministic and Stochastic)	Once a year	The GHG compliance cost assumptions will be updated each year after the legislation sessions in each state or when legislation is signed into law. *
Design, Normal, and Stochastic Weather	Each IRP	Resources are planned based on design weather, but are evaluated on cost using normal and stochastic weather.
Gas Supply Capacity Costs (Deterministic and Stochastic)	Each IRP	For the 2018 IRP base case this included the cost of Mist Recall, a pipeline uprate and a local pipeline expansion.
Distribution System Capacity Costs	Each IRP	NW Natural will calculate and present the avoided distribution avoided costs through the IRP process.

NW Natural analysis, not for investment purposes.

Washington HB 1257

- Washington law passed April 18, 2019
- Section 12 – Development of RNG resources should be encouraged
- Section 13 – Renewable gas programs discussed – 5% cost cap included
- Section 14 – Requires volunteer RNG programs

RNG Market Environment

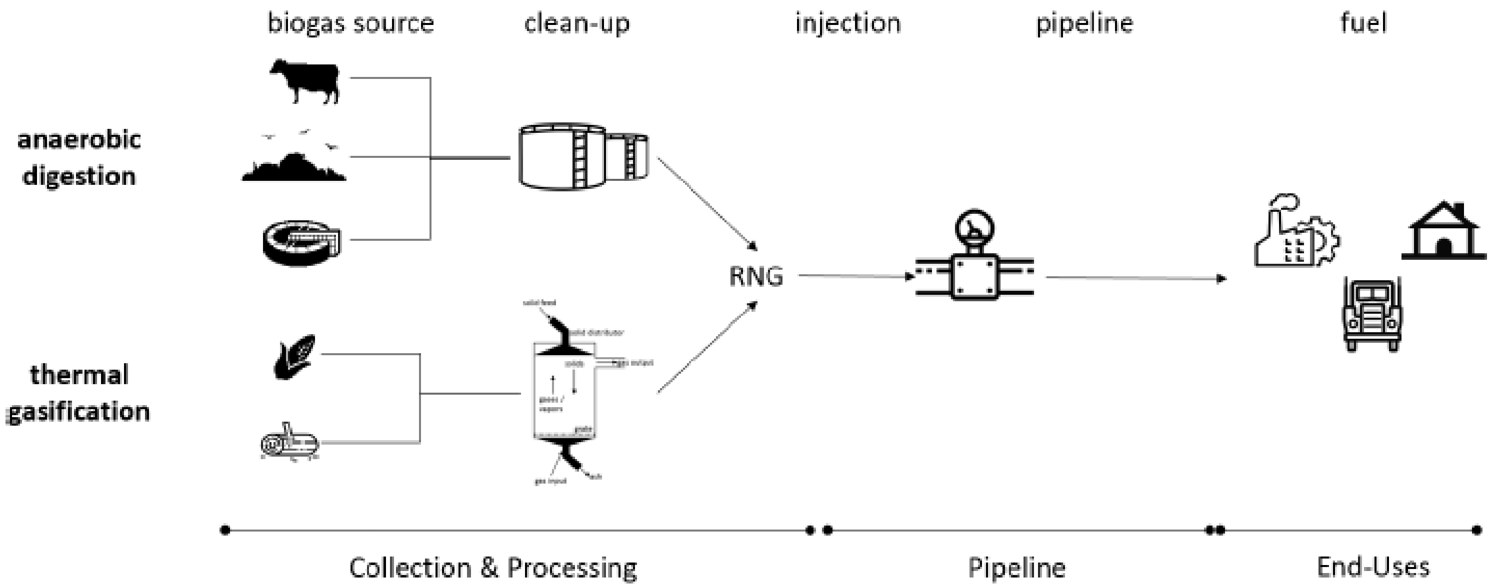
Federal RINs and California LCFS

Two main programs driving RNG market

- **LCFS and RFS drive the RNG market pricing**
- **California Low Carbon Fuel Standard (LCFS)**
  - Program enables fuel providers to monetize the greenhouse gas (GHG) reductions attributable to the fuel
    - Focus is on the carbon intensity (CI) of the project
  - Oregon has a similar Clean Fuels Program but it's not as lucrative
- **Federal Renewable Fuel Standard (RFS)**
  - Monetizes the volumetric unit of the renewable fuel
    - Type of Renewable Identification Number (RIN) varies by feedstock
- **Both programs include more fuels than just RNG**

RNG Production

RNG is produced over a series of steps: collection of a feedstock, delivery to a processing facility for biomass-to-gas conversion, gas conditioning, compression, and injection into the pipeline.



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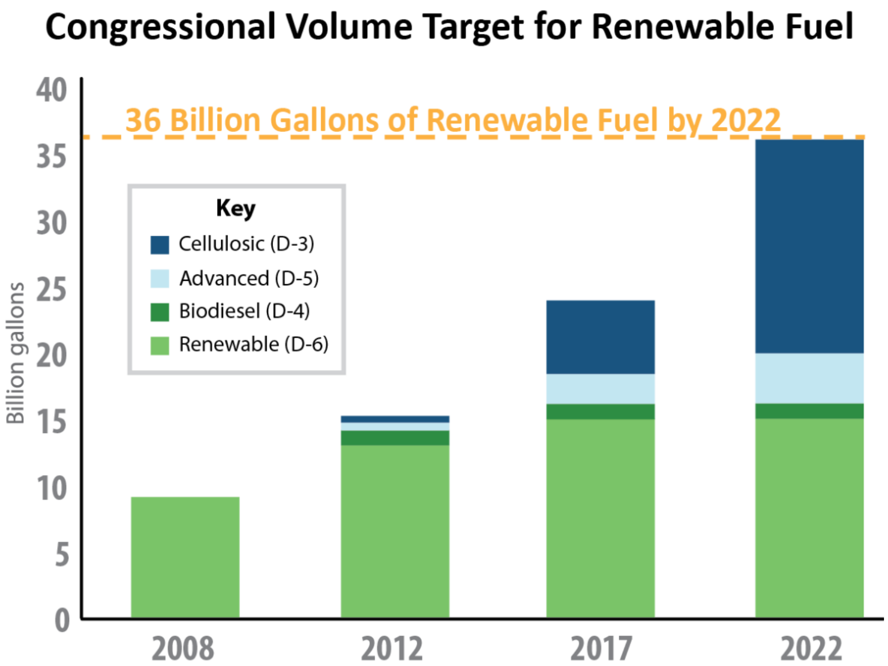
RFS

- **The RFS mandates biofuel volumes to be blended into transportation fuel**
  - Renewable volume obligations (RVOs) set annually by EPA
- **It is expected that the program will continue after 2022**
- **Program was developed as part of the Energy Policy Act (EPAct) of 2005 and revised/updated by the Energy Independence and Security Act (EISA) in 2007**



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RFS - RINs

RINs are the currency of the RFS program

- 1 Dth of RNG earns 11.727 D3 RINs (an ethanol gallon equivalent of fuel)
- Obligated parties meet compliance by submitting a quantity of RINs equivalent to their RVOs for each of the four standards

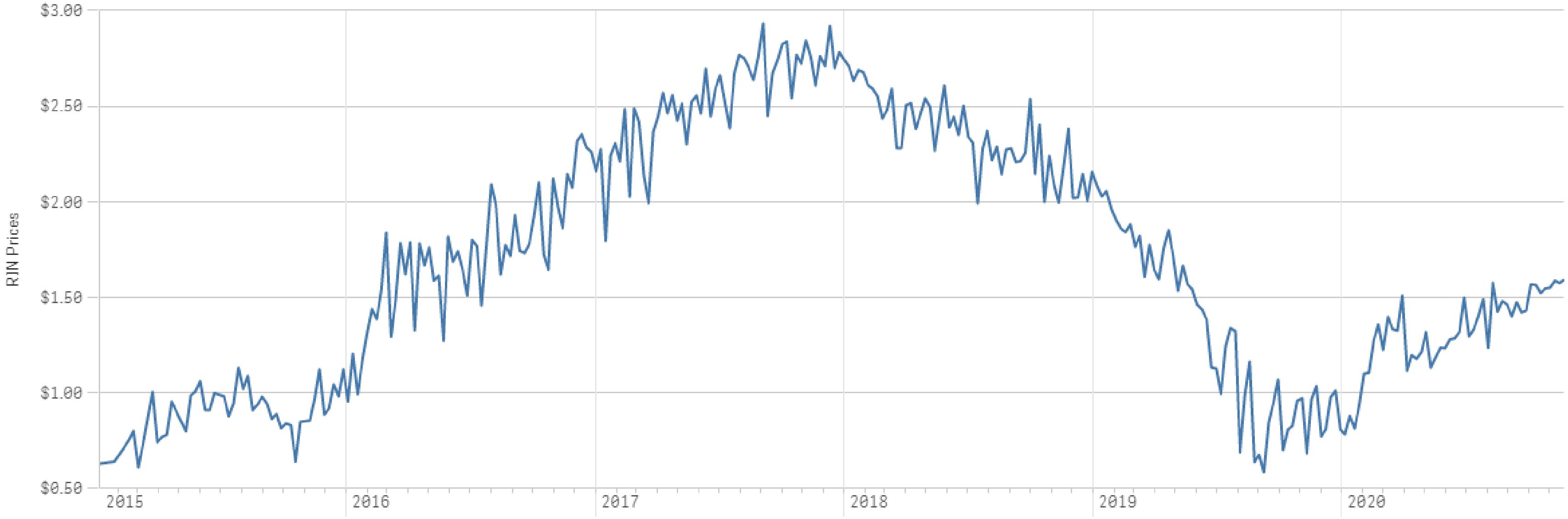
RIN Type	Description / Biofuel	Min GHG Reductions (threshold)	RFS Qualifying Categories
D3	Cellulosic Biofuel	≥60% GHG savings	**Cellulosic**, Advanced or Renewable
D4	Biomass-Based Diesel	≥50% GHG savings	Biomass-Based Diesel, Advanced or Renewable Diesel
D5	Advanced Biofuel	≥50% GHG savings	Advanced or Renewable
D6	Renewable Fuel	≥20% GHG savings	Renewable (Corn-Based Ethanol)
D7	Cellulosic Diesel	≥60% GHG savings	Cellulosic or Advanced, Biomass-Based Diesel, or Renewable

Historical Weekly D3 RIN Pricing

Since one Dth of RNG earns 11.727 D3 RINs, historical prices would value RNG anywhere from about $7 to $34 within the RFS

Gas focused on this D3 RIN market is what NW Natural is competing with for RNG

Most all landfill gas would be priced in the D3 RIN market



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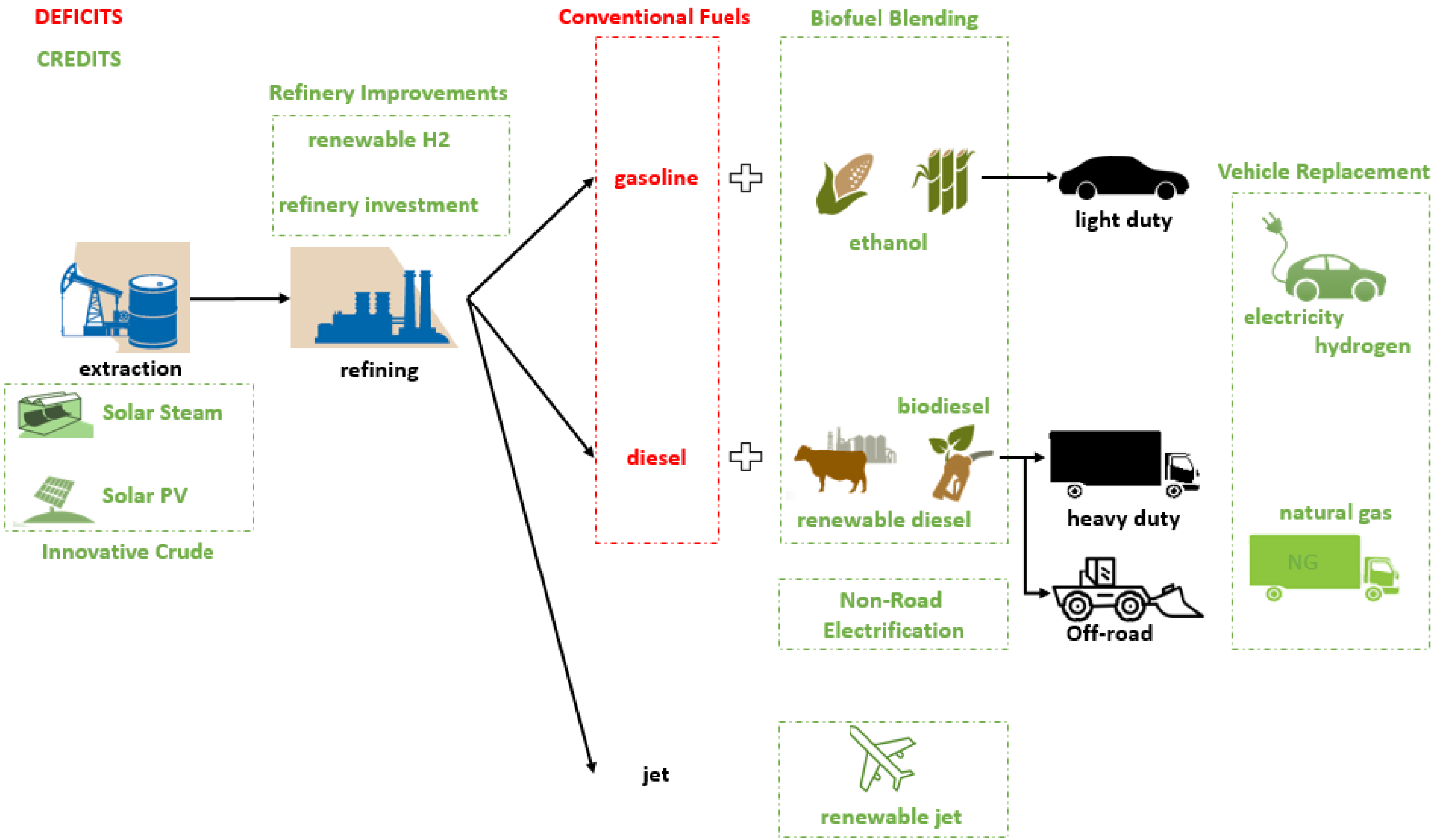
LCFS

- California transportation fuel program which began in 2011
- Requires a 7.5 percent reduction in transportation fuel carbon intensity by 2020 and a 20 percent reduction by 2030
- Carbon intensity (CI) is measured in grams of carbon dioxide equivalents (gCO2e) per unit energy (megajoules, MJ) of fuel and is quantified on a lifecycle or well-to-wheels basis
- LCFS credit = 1 metric ton of CO_2 emissions reductions
- Operates on a system of deficits and credits

LCFS Operates on a system of deficits and credits



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LCFS – Obligated Parties

Obligated parties

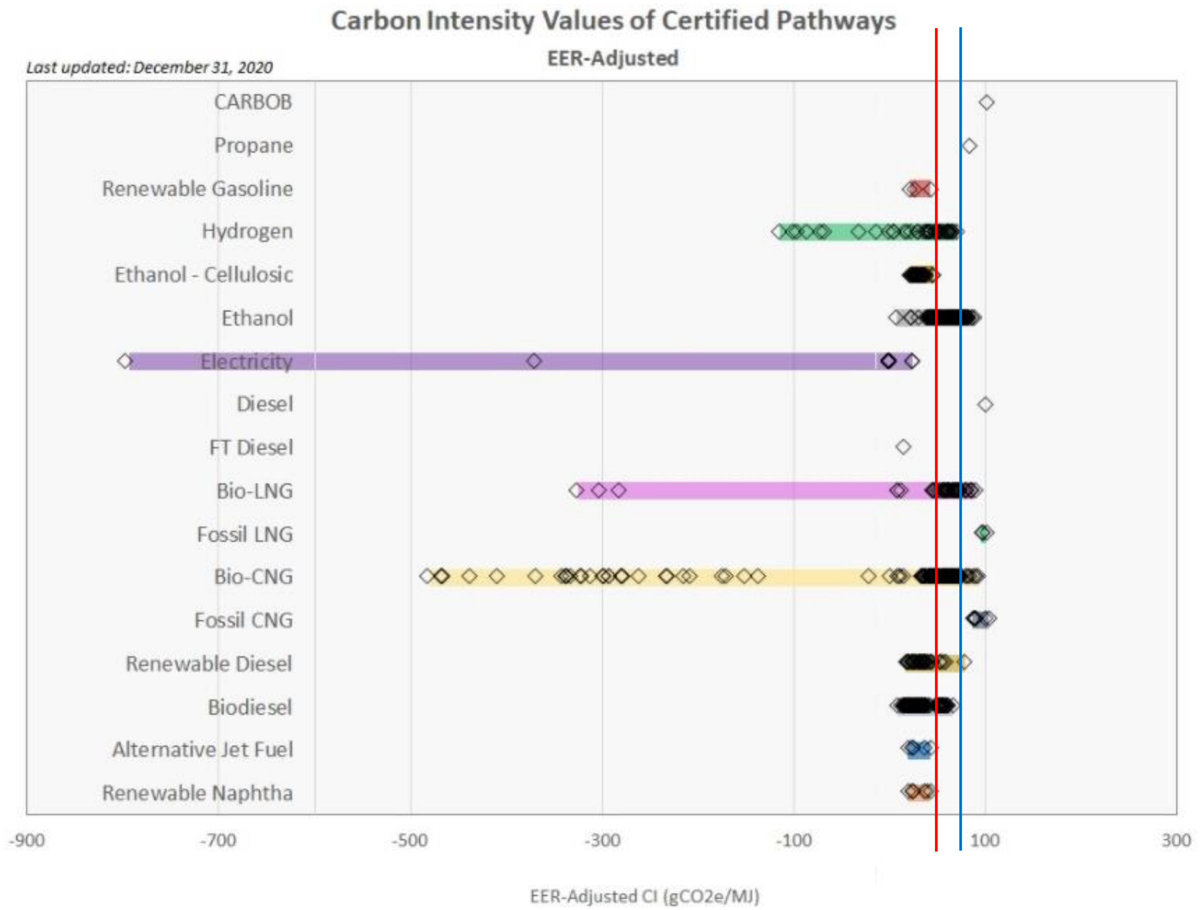
- More than 90% of the ***deficits*** are generated by seven companies based on ICF estimates, as shown in the table below

*Note that Shell recently completed its sale of its Martinez Refinery and related logistics assets to PBF, meaning that PBF's estimate share of obligations is now closer to 14%, further consolidating more than 90% of LCFS exposure to just six regulated parties

Obligated Party	Est. Share of Obligation
Marathon	28%
Chevron	24%
Valero	11%
Phillips 66	11%
Shell*	9%
BP	5%
PBF*	5%

LCFS – CI

- **Gas/diesel has a CI of about 100 gCO_2e/MJ**
- **With a 7.5% bogey, projects need to beat ~92 gCO_2e/MJ**
- **At 20% projects will need to beat ~80 gCO_2e/MJ**
- **The lower the project score the higher the LCFS credit generation**
- Dairy is generally the lowest ranging from -100 to -400
- Landfill gas scores ~10 to 40
- Biodiesel scores ~50
- Corn ethanol scores ~70



Source: https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities

Credit Pricing

LCFS credit prices are expected to stay high for the foreseeable future and trade at or around the price cap of $200/ton

Anecdotally at a credit price of $200/ton

- RNG from landfills (with a CI score of 40 g/MJ) ~ $9/Dth
- RNG from dairy manure digesters (CI score of -250 g/MJ) ~ $70/Dth

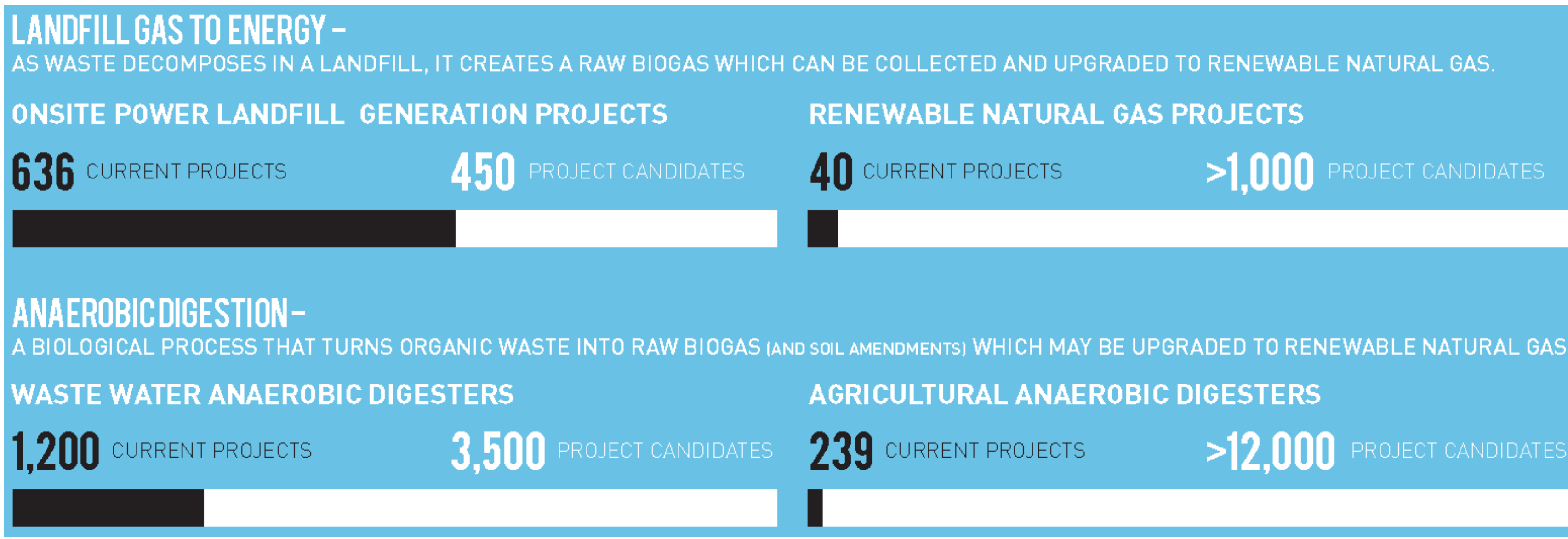
California LCFS combined with Federal RINs

- A dairy project selling into both credit markets could provide value ~$100/Dth

Market for NW Natural

- A landfill gas project that may only have RINs has historically priced between $7 and $34 per Dth
- NW Natural can provide a stable offtake for a D3 RIN type project and steer the cost into the mid/low teens

Current US Resources



Source: https://www.rngcoalition.com/infographic

130 OPERATIONAL/ONLINE (U.S. - 119, CANADA - 11)

35 UNDER CONSTRUCTION (U.S. - 34, CANADA - 1)

74 IN SUBSTANTIAL DEVELOPMENT (U.S. - 63, CANADA - 11)

Most recent numbers show 157 RNG facilities now operating, 76 under construction and 79 projects in planning

RNG Activities

On-system connections, offtake agreements, development projects

RNG in Oregon

- **SB 98 is now in place for RNG procurement**
  - Automatic Adjustment Clause (AAC) filed in December and expected to be used for development projects when applicable (ADV 1215)
- **Developing voluntary RNG tariff**
- **SB 844 is another possible mechanism for certain projects**
  - Voluntary emission reduction program incentivizing LDCs to invest in projects that reduce emissions and provide benefits to customers

SB 98 Rulemaking Summary

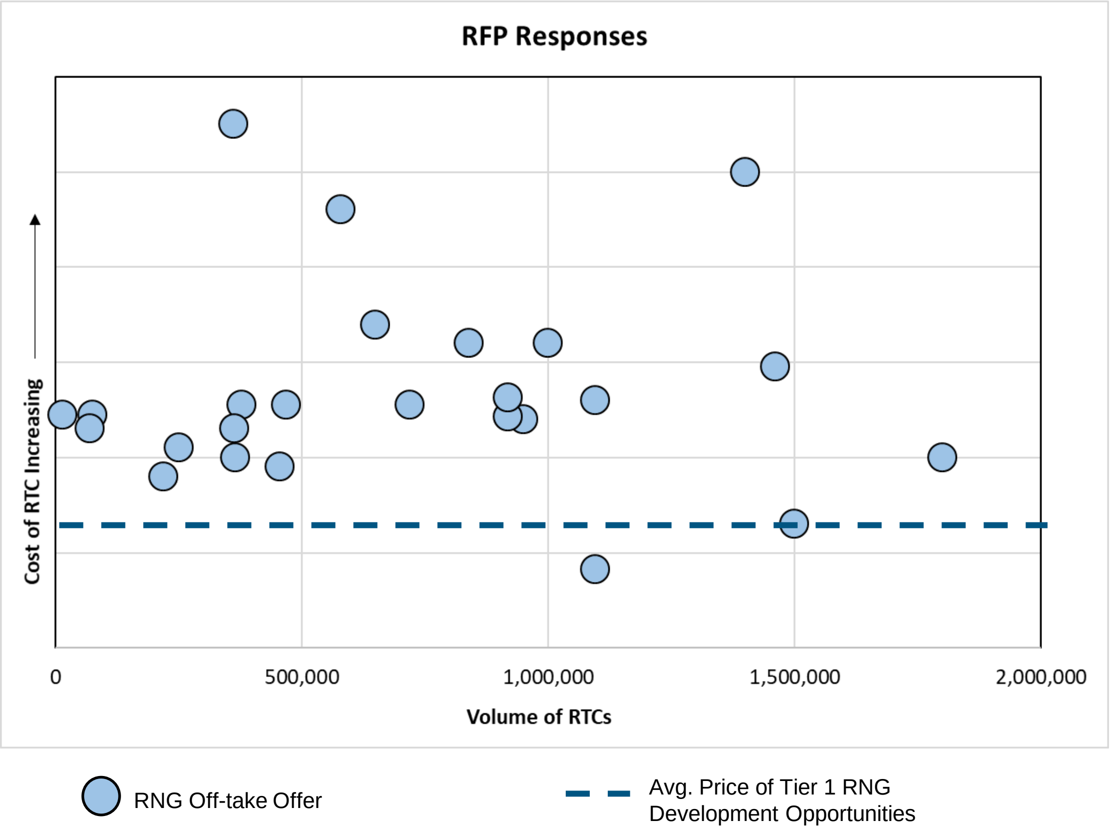
- **Final rules adopted in July 2020**
- **NW Natural's approach under the rules:**
  - Can procure RNG from any location
  - Gas purchases: recovered through PGA
  - Capital investment: recovered through rate case or AAC
  - No current prioritization of one feedstock over another
  - RNG is "delivered" and reported via a transaction for the Renewable Thermal Credit (RTC), the natural gas equivalent of a Renewable Energy Credit (REC)
  - Use M-RETS (similar to WREGIS) to track the chain of custody of an RTC

On-System RNG Interconnect Updates

- **Expecting to begin flowing RNG on our system in early 2021**
  - Customers not acquiring renewable credits for the first on-system projects
  - Paying standard on-system price for 'brown gas'

Project	Current Status/Update	Expected Injection Date
City of Portland	Construction underway	Q3 2021
Eugene-Springfield	Construction underway	Q2 2021
Shell New Energies (Junction City)	Construction underway	Within the next few months

Results of RNG Procurement RFP



RFP due diligence continues for RNG off-take contracts

- 25 responses received; however, a number of them don't work under SB 98
- Primarily off-system opportunities
- Wide range of prices and volumes

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Development Opportunities

- **Finding a variety of investment structures offered through developers**
- **Development opportunities generally expected to provide RNG at a lower cost to customers**
- **First project part of partnership with Tyson Fresh Meats**
  - Proceeding with first of various RNG sites at Tyson food processing plants
- **Working on various additional development opportunities**
  - Many are landfills and food waste projects with no real dairy opportunities at this point

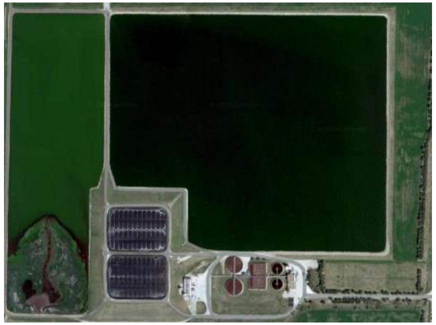
RNG Diligence

- **The market isn't liquid and we are working with the opportunities available in the current market**
  - With the offtake RFP and market research, we have seen a good number of project opportunities
- **Optimizing portfolio within SB 98 cap**
  - First cap is 5% of revenue requirement through 2024
  - Will be able to execute on a number of projects within this cap
  - Expecting to achieve greater than 5% of gas volumes within cap
- **Tyson Lexington Project delivers RTCs at a low cost when compared to other opportunities**
- **Comparing incremental cost across projects**

Tyson: Lexington, Nebraska Site

Tyson Fresh Meats Lexington:

- Beef packaging
- In operation since 1990
- Invested additional $47 million in facility in 2016
- Employs 2,700 people



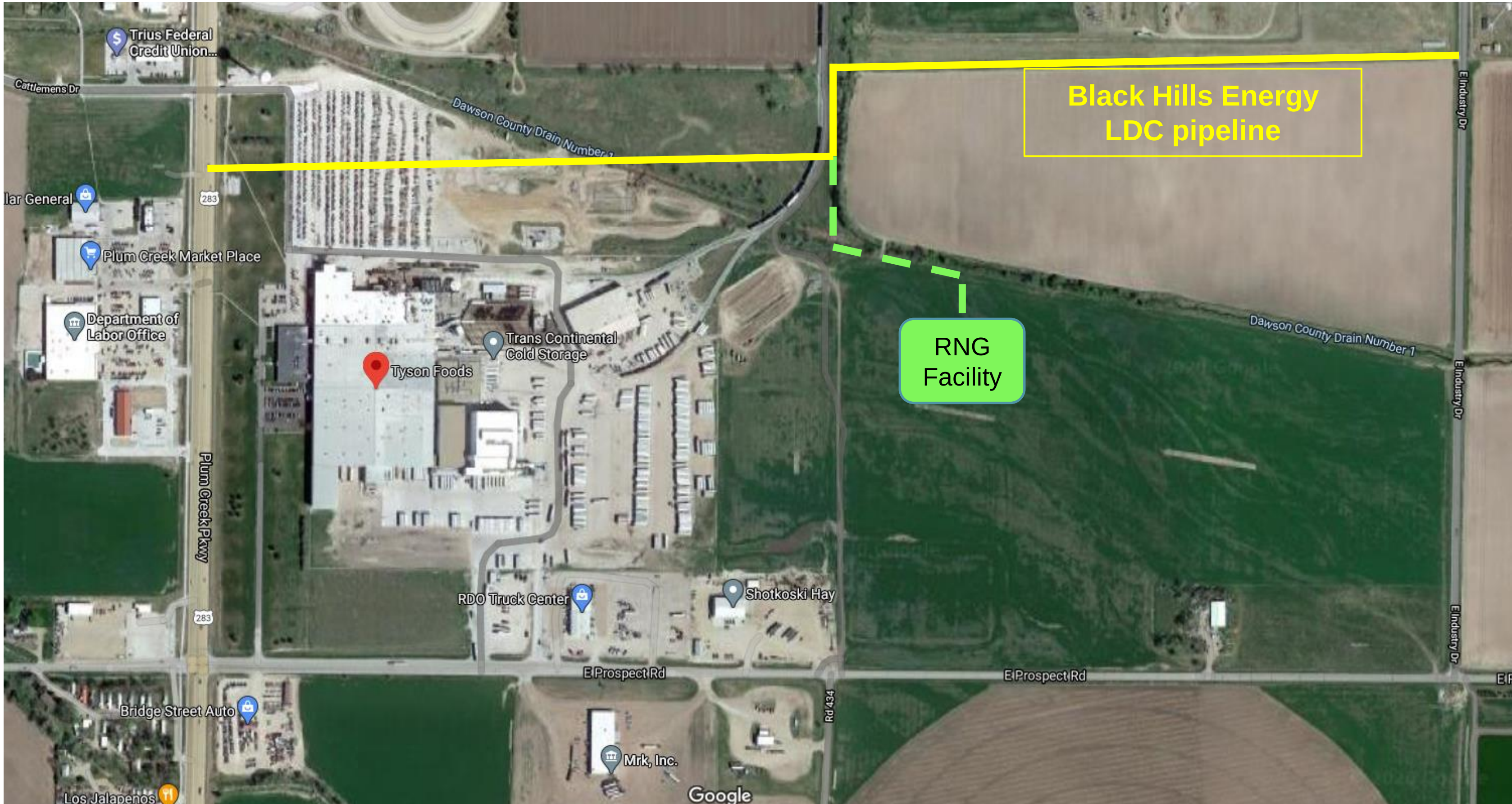
Covering of Existing Lagoons:

- Separate project undertaken by Tyson and BioCarbN

NW Natural RNG Project:

- Invest in Pentair membrane cleaning and conditioning technology
- Invest in interconnection to Black Hills Energy (local LDC)

Tyson: Lexington, Nebraska Site



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Hydrogen

Destination Zero:

The pathway to our vision of carbon neutral

A decarbonized network:

- Deep energy efficiency
- Renewable natural gas
- Renewable hydrogen
- Blended and dedicated hydrogen systems

Renewable Natural Gas
Dedicated Hydrogen
Waste CO2
Renewable Electricity

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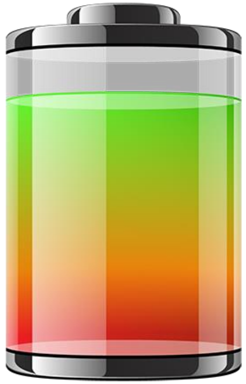
Role of Hydrogen and Power to Gas

- **Hydrogen enables deeper coupling of the gas and electric grids – critical for decarbonization**
  - Long-term energy storage for low water/wind/solar weeks, months, or years
  - Store and monetize curtailed renewables
  - Ancillary grid benefits
  - Alleviates transmission congestion
- **Lowers costs for all customers by avoiding new transmission, generation, and storage build-outs**
- **Provides unlimited low-carbon molecules to help decarbonize the natural gas grid**
- **Enables resilience planning – more energy options**
- **Lowest cost of electric seasonal storage (by far)**

Power to Gas Grid Benefits



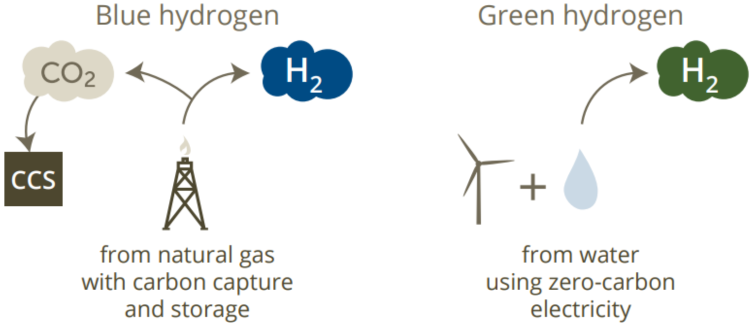
- **Access to seasonal renewable energy storage**
  - Curtailed energy
  - Hydro
  - 20 million Dth in NW Natural system alone (~equivalent to 6 million MWh)
- **Use existing thermal generation assets**

- **Millisecond response time**
  - Demand response
  - Voltage and frequency stabilization
  - Avoid operating reserve costs
- **Alleviate transmission congestion**

Role of Hydrogen

- **Solution for difficult sectors (industry, aviation, transportation, etc.)**
- **Multiple pathways**
  - Blended hydrogen
    - Blue hydrogen
    - Green hydrogen – electrolysis
    - Ammonia
  - Methanated hydrogen

Source: Airbus



Source: Pembina Institute

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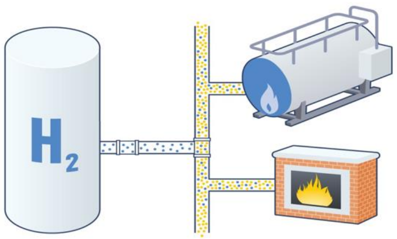
Stages of Hydrogen & Power to Gas

○ Long-term: Direct hydrogen blending

- Lowest cost gas
- Enables distributed production
- Requires preparation
  - System and appliance compatibility
  - Training
  - Energy delivery capacity



○ What NWN is doing today

- Blend testing at Sherwood
- Collaborating with other gas utilities and labs
- Member of Hyready consortium

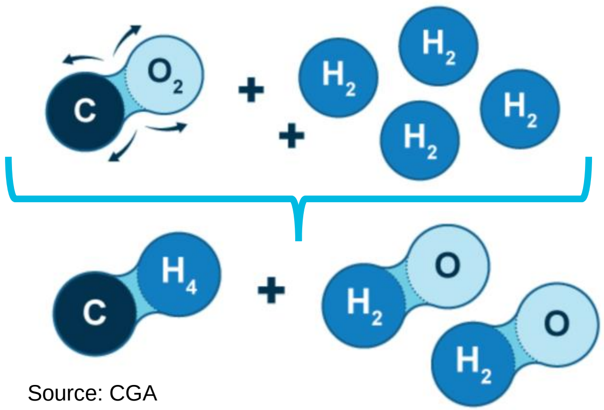
Stages of Hydrogen & Power to Gas

○ Short-Term: Methanation

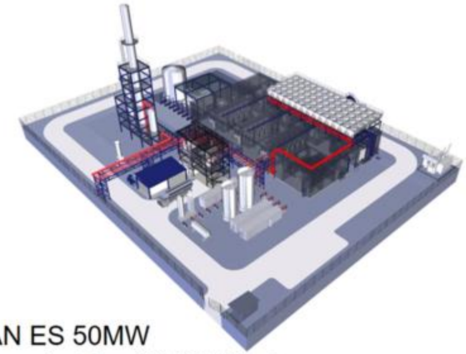
- Enables large projects now
- Economies of scale create competitive costs of gas
- No blend limitations
- Compatible with existing infrastructure
- Can be repurposed for pure hydrogen

○ What NWN is doing today

- Eugene pilot project
- Investigating partnerships for larger projects



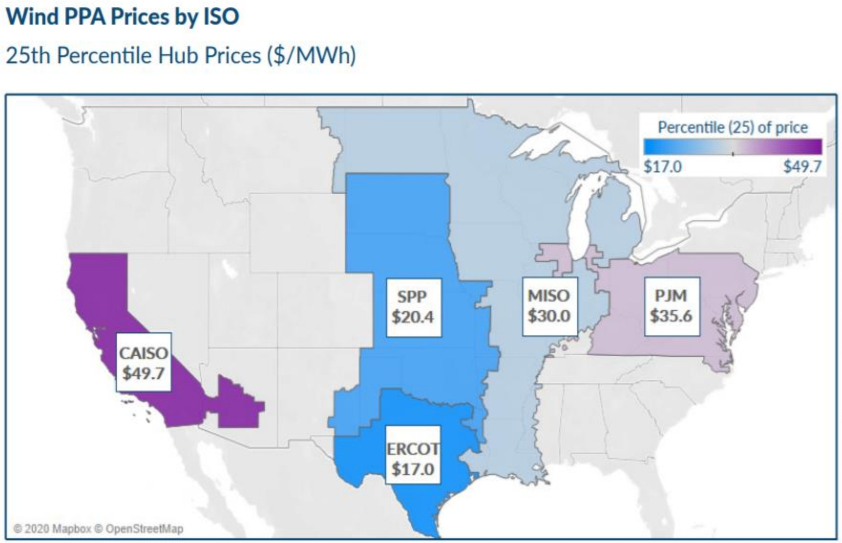
Source: CGA



MAN ES 50MW
Power-to-Gas (SNG) Plant

Location Aspects of Power to Gas

- On system electrolyzers can provide additional benefits
  - Reduce gas transmission capacity costs
  - Local grid benefits
- Cost of electricity is critical
- How do we structure rates to reflect benefits to the region?



Source: Level10 Energy

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Eugene Power to Gas Pilot (2-10MW)

- **Partnership**
  - EWEB
  - Bonneville Environmental Foundation
  - NW Natural
  - Local industry
- **Project uses excess low-carbon from local industry and renewable electricity to produce low-carbon methane for:**
  - Current needs of natural gas customers
  - Future needs (can be assigned as storage)
- **Demonstrates the viability of the technology before scaling up**
- **Potential source of hydrogen for vehicle fueling**
- **Large enough to learn from, small enough to avoid excess costs**
- **Can be repurposed for pure hydrogen blending in the future to increase CO2 emissions reductions and decrease cost of energy**

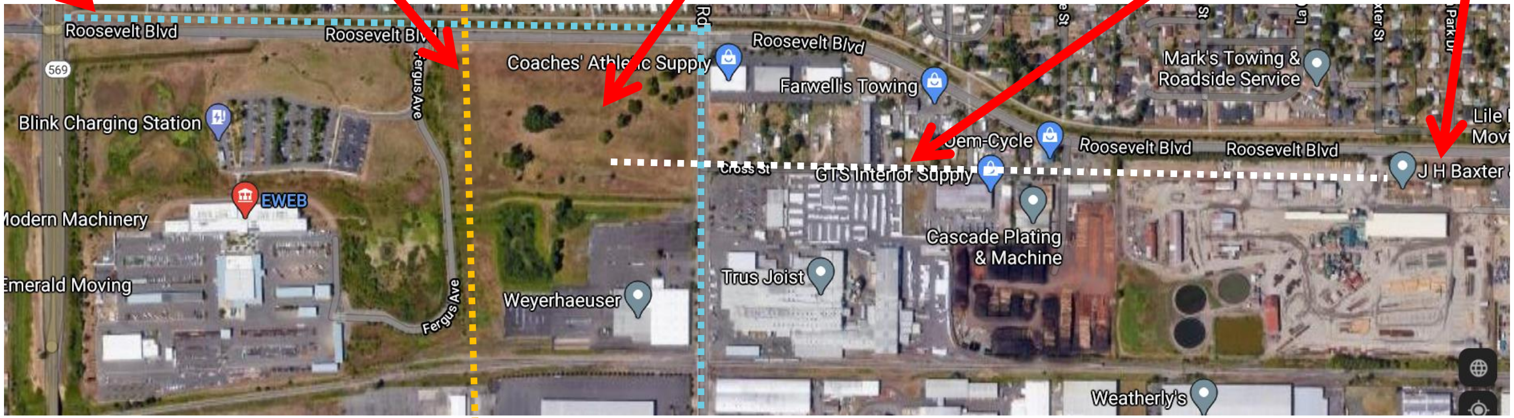
Eugene Pilot Proposed Location

Source: Bioenergy International

CO_2 emissions from natural gas combustion gathered and piped from industry

NW Natural gas line

BPA transmission line



Source: Google Maps

NW Natural analysis, not for investment purposes.

Hydrogen and Power to Gas is Growing

- Planned 5MW hydrogen at Douglas PUD (vehicle use) for 2021
- Largest electrolyzer to-date in North America is 20MW (Quebec, industrial gas use)
- ATCO and Enbridge have blending projects at 2% and 5% respectively this year
- California gas utilities have filed for three blending projects
- Over 40 PtG plants in various stages of planning and construction world-wide
- Germany has announced 5GW of production capacity by 2030, and 10GW by 2040
- Planned global investment is 3.2-8.2GW by 2030