NW Natural Load Considerations for the 2022 IRP Technical Working Group

Load Considerations TWG

September 29, 2021

NW Natural®

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

- Procedures and Introductions
- Today's Technical Working Group: Load Considerations in the Current Planning Environment
- Understanding Customer Energy Usage and Emissions
- Previous IRP Base Case Using Historical Trend Models
- Considerations Looking Forward
- End-use Load Forecasting Process
- Key Inputs to Modeling
- Discussion

Take 2 Minutes for Safety: Hydration & Injury Prevention

A fully hydrated body is about 50-65% water. Losing just 1% of your body's water content to sweat can put you at risk for injury- especially in hot or humid weather.

- **Cartilage Wear**
  Water & electrolytes are essential for delivering nutrients that help cartilage repair itself when injured.

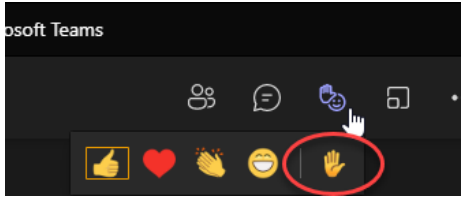
- **Muscle Function**
  Dehydration decreases muscle elasticity which increases injury potential.

- **Spinal Discs**
  The nucleus of each spinal disc is about 70% water (in adults). Hydration is essential for maintaining spinal disc strength and pliability.

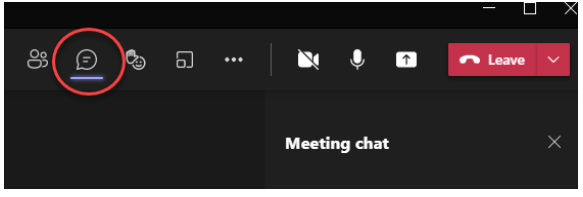
TWG Procedures for Participation

Stakeholder engagement is critical to holding effective Technical Working Groups (TWGs). NW Natural appreciates active stakeholder participation.

- Please **mute** your microphones during the presentation, except when commenting and or asking a question
  - All participants are muted upon entry into the meeting
- Cameras are optional and up to each participant to use
  - All participant cameras are set to off upon entry into the meeting
- Add a comment or question at any time using the “raised hand” or the chat box
  - A member of the NW Natural IRP team will monitor raised hands and the chat box

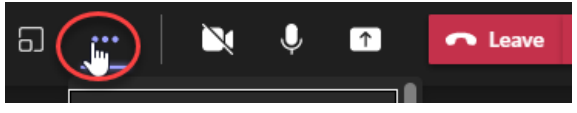


Raised hand function is found in the reactions



Chat box will open when you click on the conversation bubble

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

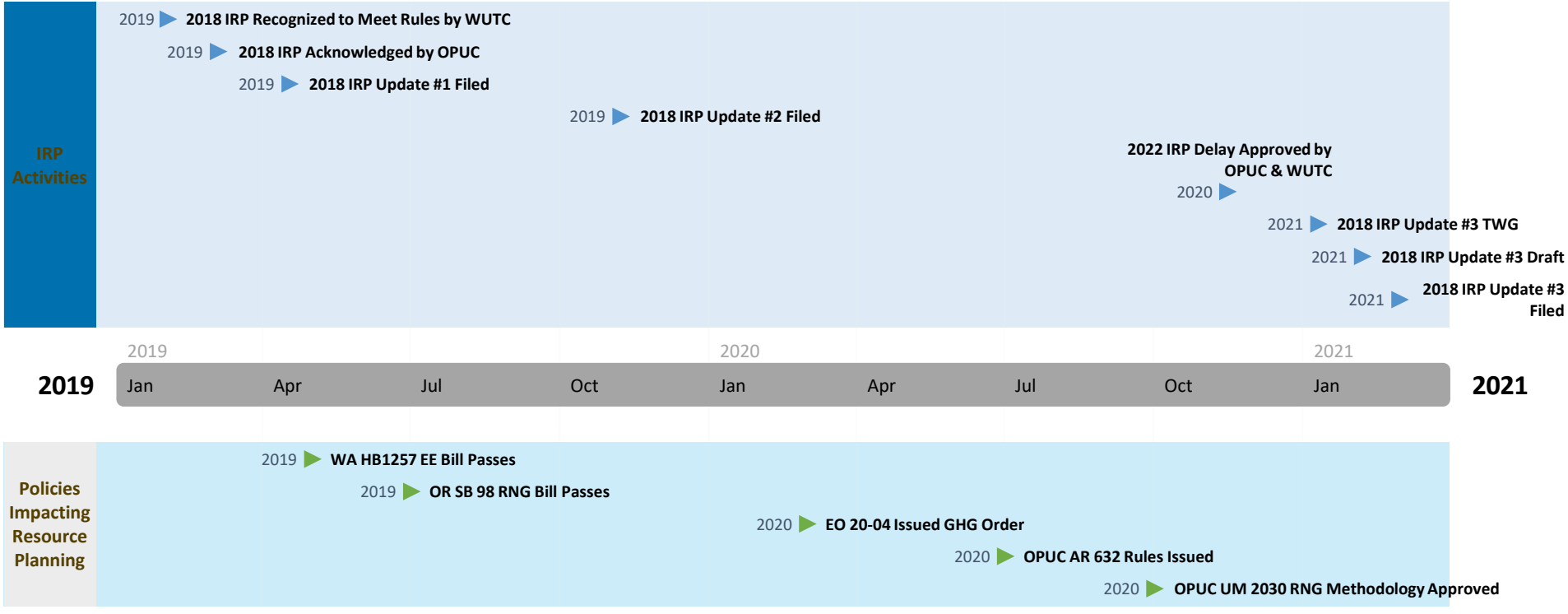


Click the ellipses, then chose “turn on live captions”

Community & Equity Advisory Group

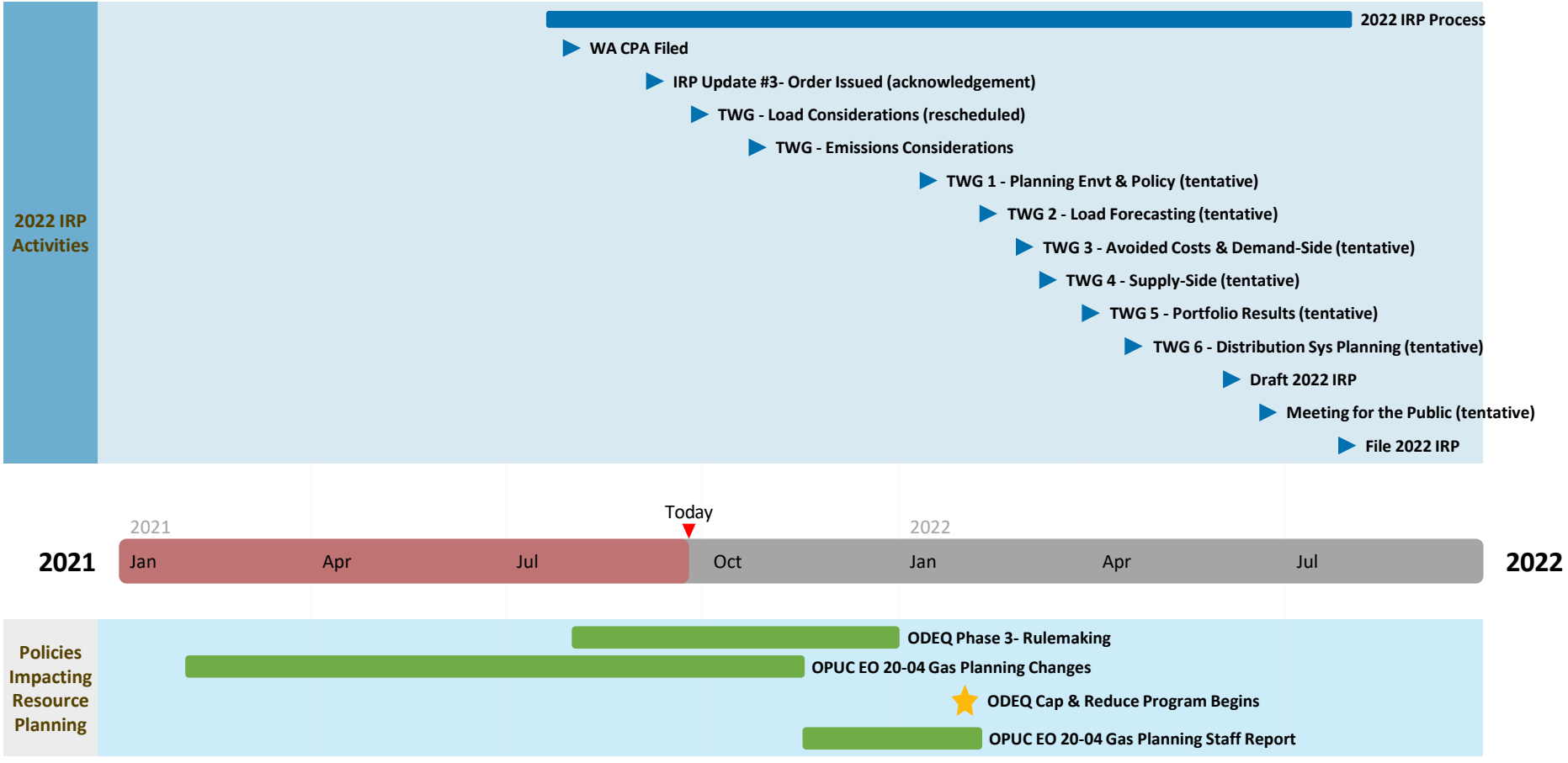
- NW Natural has a long history of community involvement throughout its service territory & has a commitment to diversity, equity, and inclusion.
- Increasing attention to the impacts of energy system planning on historically underrepresented and underserved communities in regional discourse and policy
  - Demonstrated by recent climate-related policies in Oregon and Washington
  - This heightened focus mirrors NW Natural's commitment to improving energy equity and easing the energy burden for its most vulnerable customers.
- The Company is working to formulate a Community & Equity Advisory Group (CEAG) to advise on system planning processes, & other key company programs and initiatives.

IRP Activities Since Filing 2018 IRP



Prepared for IRP Working Group - Not to be used for investment purposes.

2022 IRP Timeline



Today's Technical Working Group: Load Considerations in the Current Planning Environment

Changes in the Policy Landscape – Oregon

- **SB 98 – Established voluntary portfolio standard targets for renewable natural gas (RNG)**
- **On March 10, 2020, Governor Kate Brown signed Executive order 20-04 which directs Oregon's Department of Environmental Quality (ODEQ) to take actions to reduce Oregon's GHG emissions and develop a cap and reduce program**
- **ODEQ actions** [Link] **:**
  - Developed draft rules for Oregon's Climate Protection Plan (CPP)
  - Held 6 Rulemaking Advisory Committee Meetings (RACs)
  - Complete draft rules released 8/5/2021
  - Public hearings September 22, 2021, and September 30, 2021

Changes in the Policy Landscape – Washington

- **The 2018 Amendments to the WA residential codes went into effect on February 1, 2021**
- **Technical Advisory Groups are currently meeting for the commercial code cycle**
- **SB 5126 – Cap and Invest bill** [Link]
- **HB 1257 – Clean Buildings bill** [Link]
  - Voluntary renewable natural gas tariff
  - Conservation potential assessment (CPA) and two-year energy efficiency plan

Changes in the Policy Landscape – Jurisdictional and Local Governments

- Several local jurisdictions and local governments in the Pacific Northwest are developing climate action plans
- Some are considering placing a moratoria on new natural gas hook-ups
- At the same time, some jurisdictions are implementing an anti-moratoria of new natural gas hook-ups
- Local surcharges and carbon taxes are also being considered

Implications for the IRP

- **Resource planning requires us to be able to adapt long-term load forecasting techniques and tools to account for these changes in the policy landscape**
- **IRP is policy agnostic and not policy advocacy**
  - The IRP process evaluates the planning environment as it currently stands and how this environment will likely change over the planning horizon
  - Resources are evaluated for costs and risks, and planned to reliably and safely serve customers
- **We do have the tools for addressing changes in the policy landscape**
  - These tools were utilized in load forecasting different scenarios presented in the 2018 IRP
  - We will likely need to rely upon these tools for the base case load forecast for the 2022 IRP

Today's Technical Working Group

- As part of the extension for the IRP, NW Natural agreed to hold a couple of TWGs with stakeholders to discuss:
  1) load considerations
  2) emissions considerations
- Today we will be focusing on load considerations and discussing with Stakeholders the methodology and tools we have for load forecasting
- The TWG on emissions considerations will be held 10/26/21 and we waiting on having final rules for ODEQ's Climate Protection Plan

Today's Primary Goals and Objectives

Load Considerations

- **Share with Stakeholders the tools NW Natural uses and implements to forecast load**
  - Including a discussion about what we have done in previous IRPs and IRP updates
- **Show how these tools are flexible enough to implement changes to historical trends that aren't present in currently available data**
- **Discuss hurdles and challenges to forecasting load due to fundamental shifts in policy**
- **Given these tools for load forecasting, we would like Stakeholder feedback on:**
  - Additional tools we could implement/incorporate
  - Suggestions on load forecasting scenarios

Understanding Customer Energy Usage and Emissions

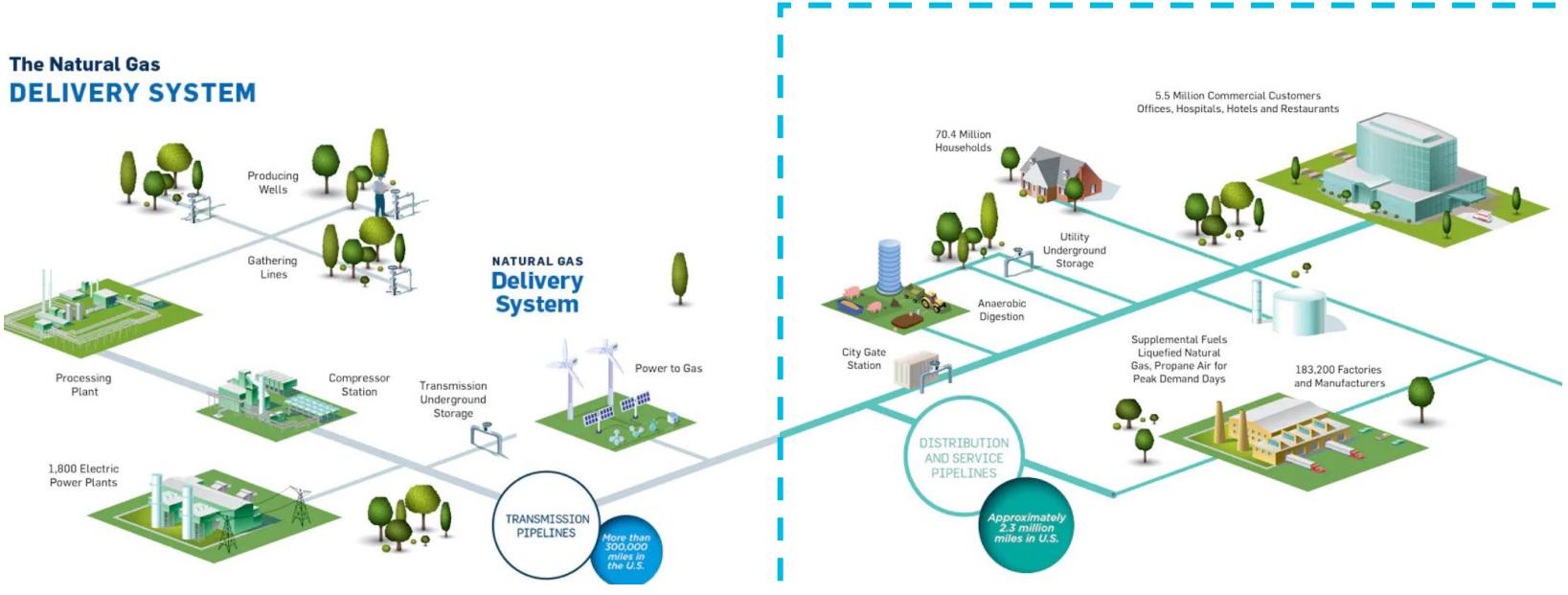
NW Natural Overview

- 160-year-old Oregon company
- Serve over 2 Million Oregonians and more than 200,000 in Southwest Washington
- Deliver natural gas safely and affordably to businesses and homes

Supply Chain

NW Natural®

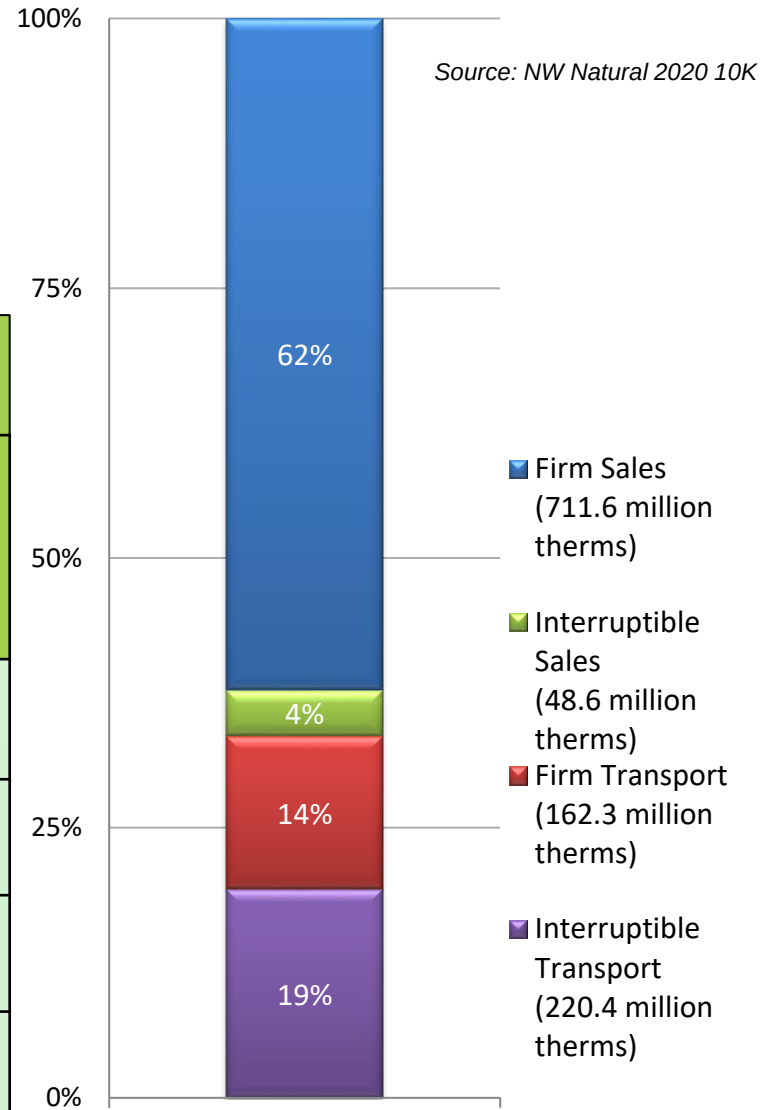
Local Distribution Company (LDC)



Source: Adapted from American Gas Association

Customers Type: Sales vs Transport

Customer Type	System Capacity Resource Planning		Distribution System Planning
	Design Winter & Expected Weather Forecast	Peak Day Forecast	Peak Hour Forecast
Firm Sales	✓	✓	✓
Interruptible Sales	✓		
Firm Transport			✓
Interruptible Transport			

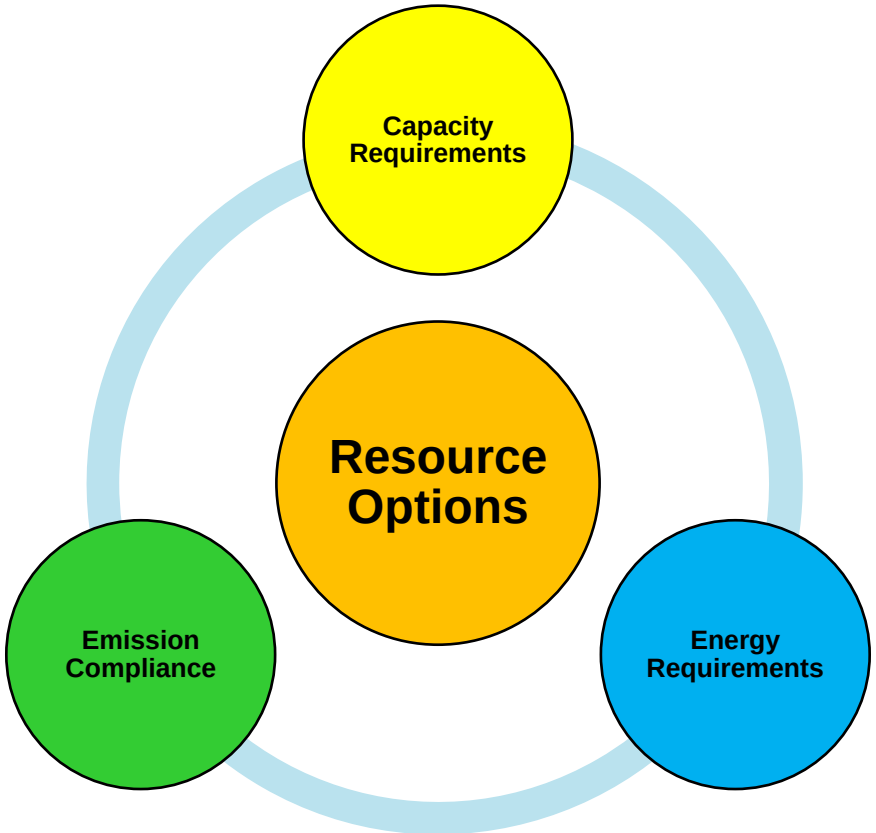


Percentage of YE Volume 2020 by Service Type

System Capacity Resources Options

Supply-side Options
- Basin Gas Purchases
- Off-System RNG
- On-System RNG
- Power-to-Gas
- Underground Storage
- LNG Storage
- Pipeline Capacity

Demand-side Options
- Energy Efficiency
- Demand Response

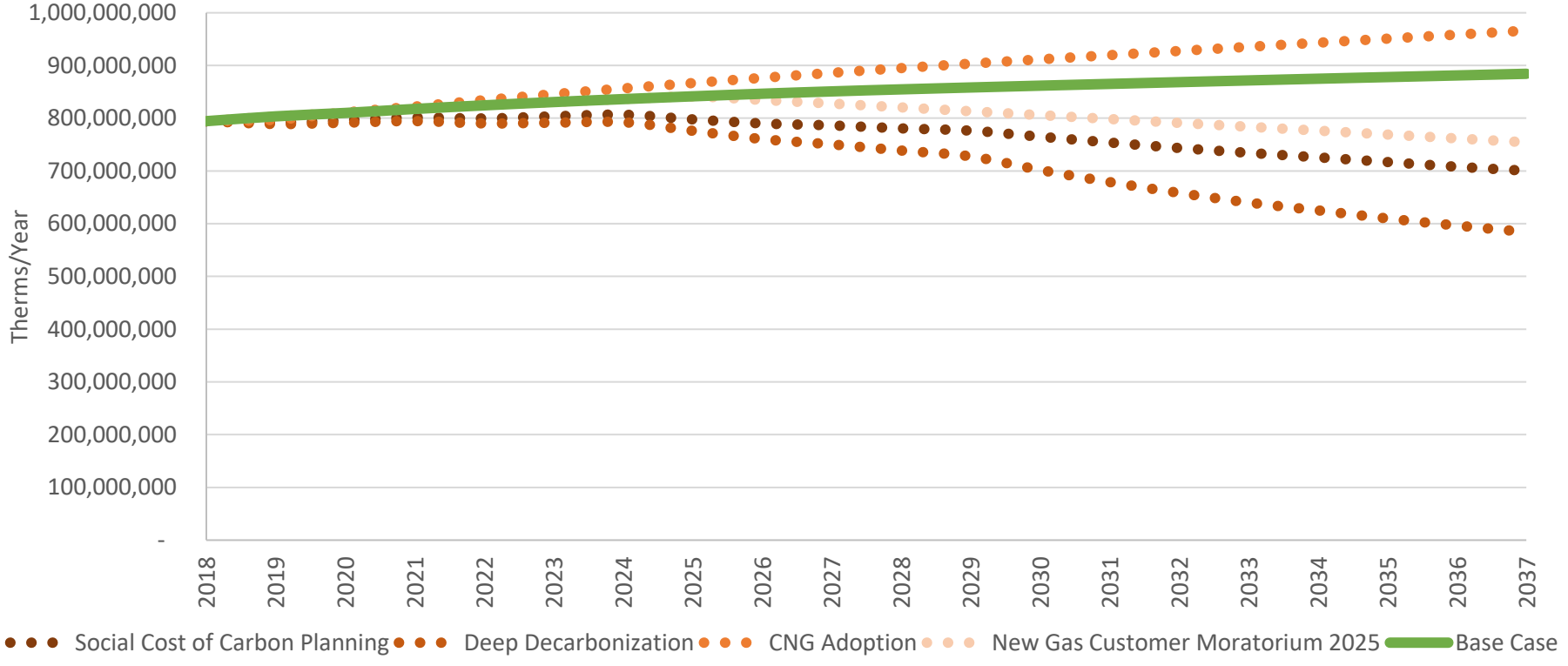


Distribution System Planning Options

Distribution System Planning Alternatives (not all options are possible or applicable in all situations)				Option Currently Considered for Cost-Effectiveness Evaluation
Supply-Side Alternatives		Pipeline Related Capacity Options	Loop existing pipeline	✓
			Replace existing pipeline	✓
			Install pipeline from different source location into area	✓
			Uprate existing pipeline infrastructure	✓
			Add or upgrade regulator to serve area of weakness	✓
			Gate station upgrades	✓
			Add compression to increase capacity of existing pipelines	✓
	Non-Pipeline Solutions	Distributed Energy Resources (DER)	Mobile/fixed geographically targeted CNG storage	✓
			Mobile/fixed geographically targeted LNG storage	✓
			On-system gas supply (e.g. renewable natural gas, H2)	✓
			Geographically targeted underground storage	✓
Demand-Side Alternatives		Demand Response	Interruptible schedules (DR by rate design)	✓
			Geographically targeted interruptibility agreements	✓
			Geographically targeted demand response (GeoDR)	
		Energy Efficiency	Peak hour savings from normal statewide EE programs	✓
			Geographically targeted energy efficiency (GeoTEE)	

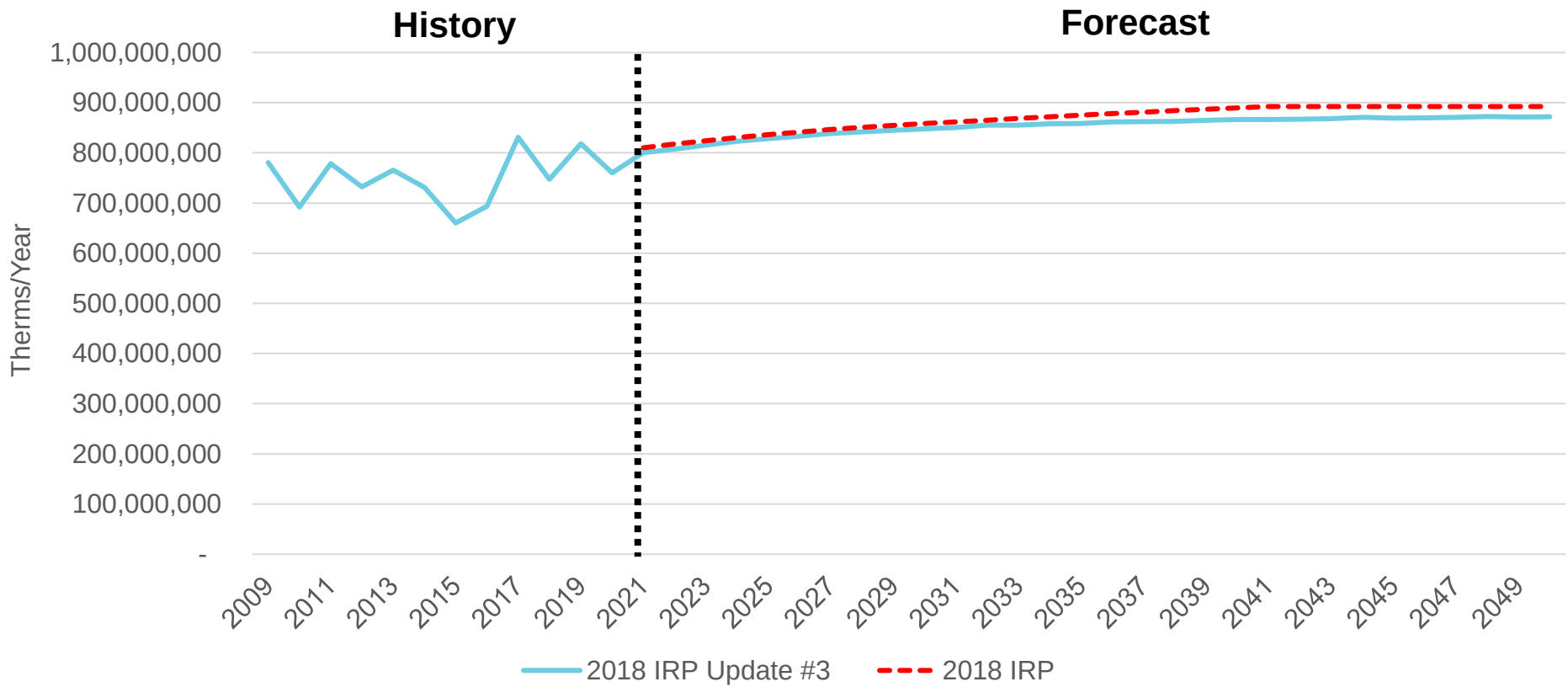
Sales Load Forecasts

(2018 IRP Sensitivities)



Expected Weather Annual Sales Load Forecast

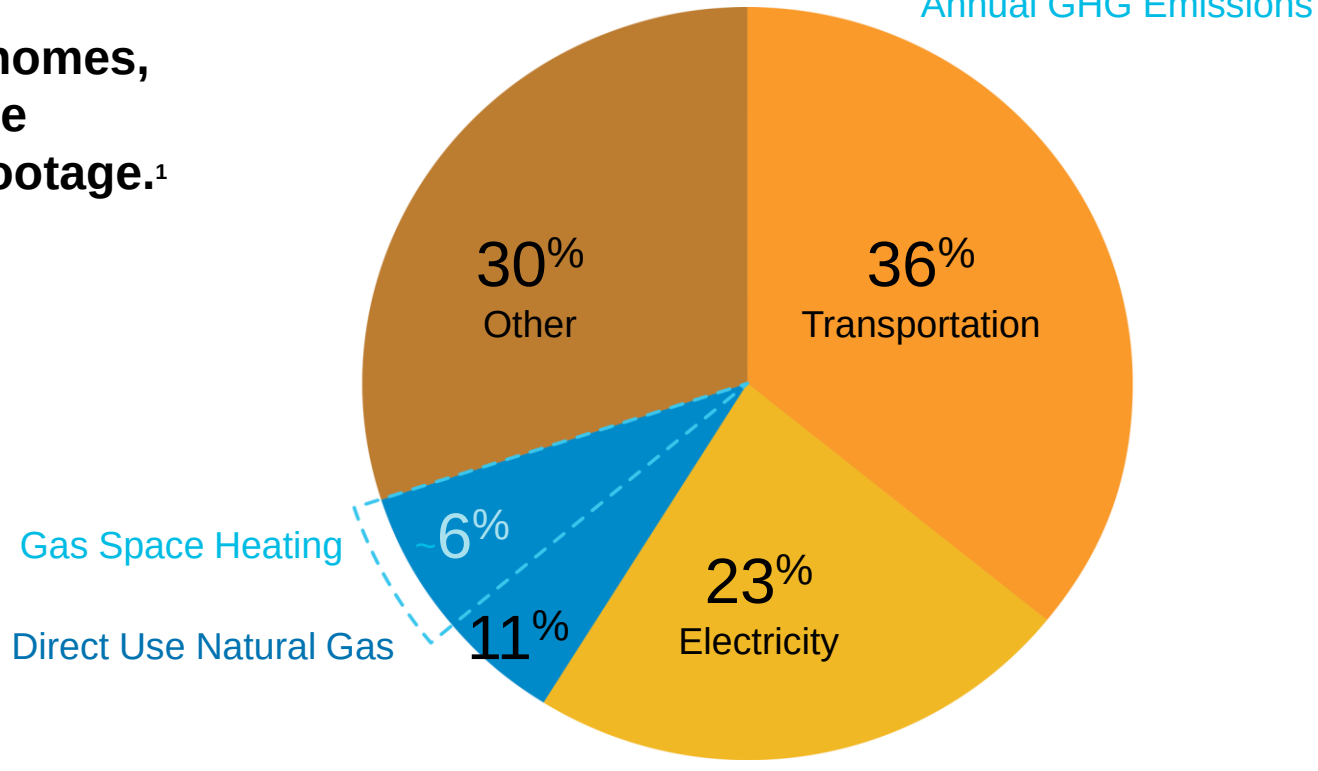
(2018 IRP Update #3*)



*2018 IRP Update #3 incorporated increased average annual temperatures due to climate change

Regional Emissions

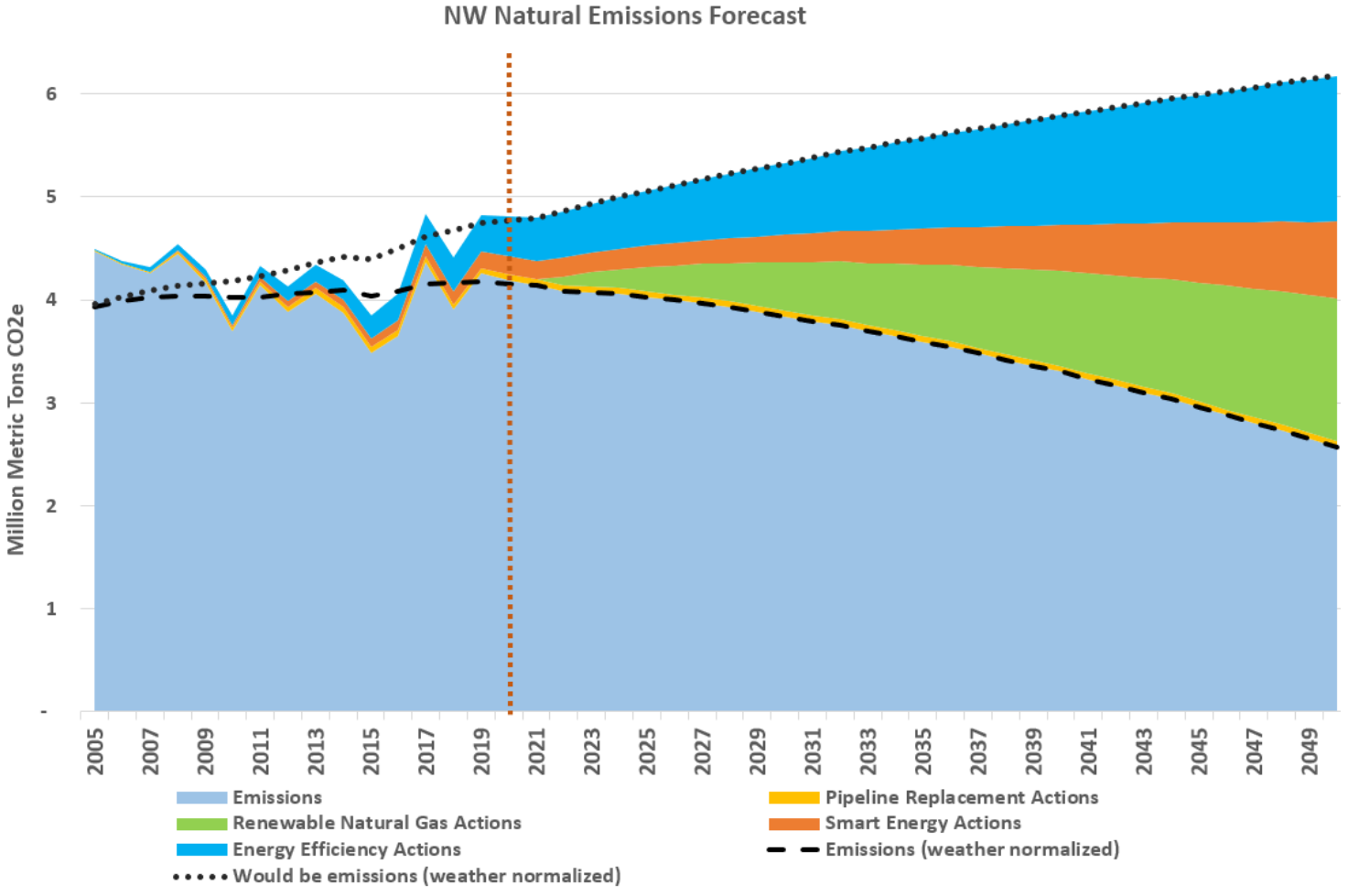
Gas serves 56% of homes, but nearly 70% of the residential square footage.[1]



Sources:
[1] 2016-2017 NEEA Residential Building Stock Assessment
Chart: GHG emissions inventories published by the Oregon, Montana, and Idaho DEQ & Washington Department of Ecology

Emissions Forecast Under Current Policy

(2018 IRP Update #3)

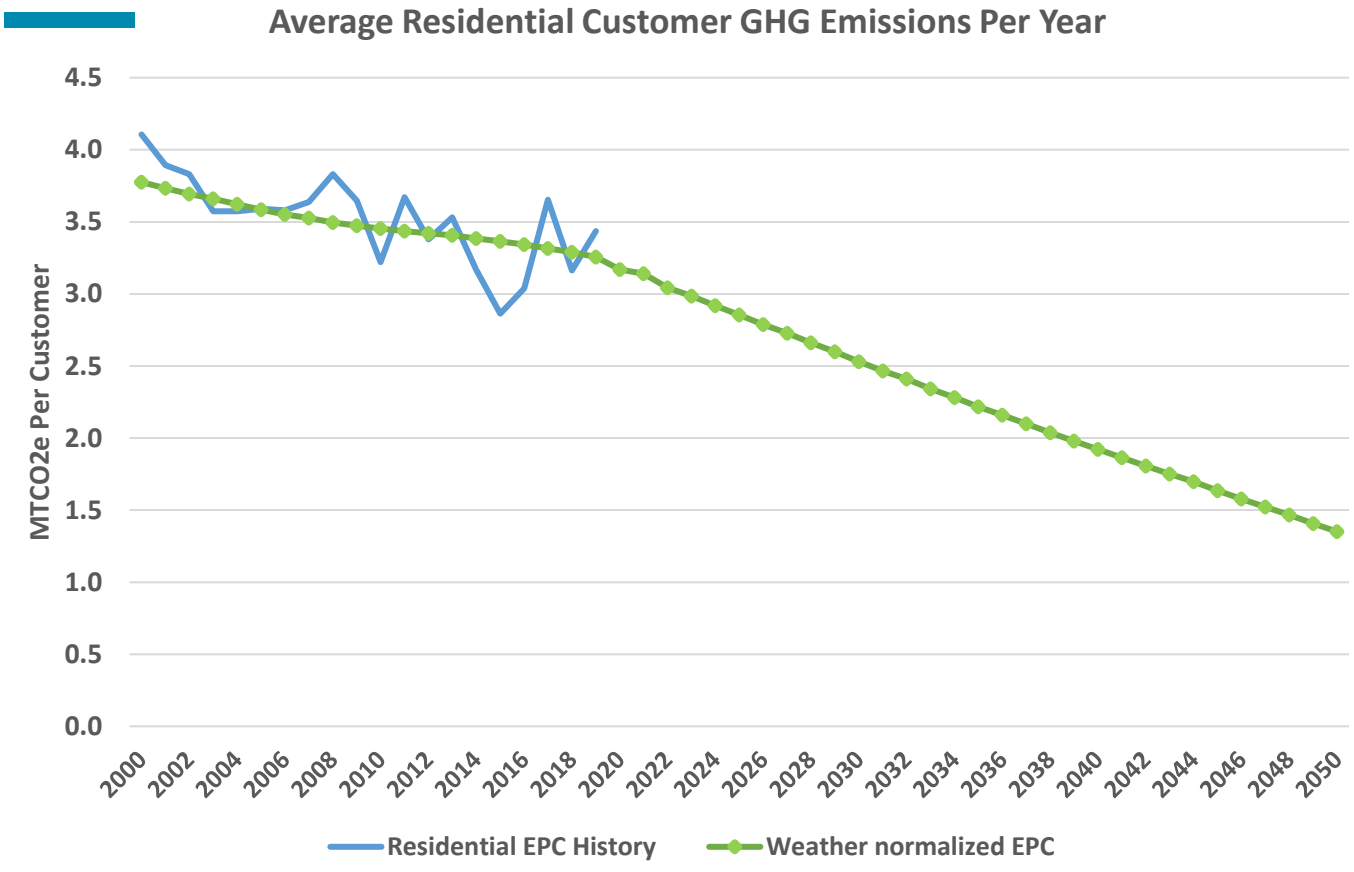


- Emissions from sales customers shown
- Actual emissions will always be "noisy" due to weather variation from year to year
  - Emissions are higher than normal weather expectation in years with colder than typical heating seasons (and lower for milder than typical heating seasons)
- Includes expected impact of OR SB 98
- Does not include expected impact of ODEQ's cap-and-reduce program, other EO 20-04 related initiatives, or WA SB 5126 (Cap and Trade)

Prepared for IRP Working Group - Not to be used for investment purposes.

Emissions per Customer Decline

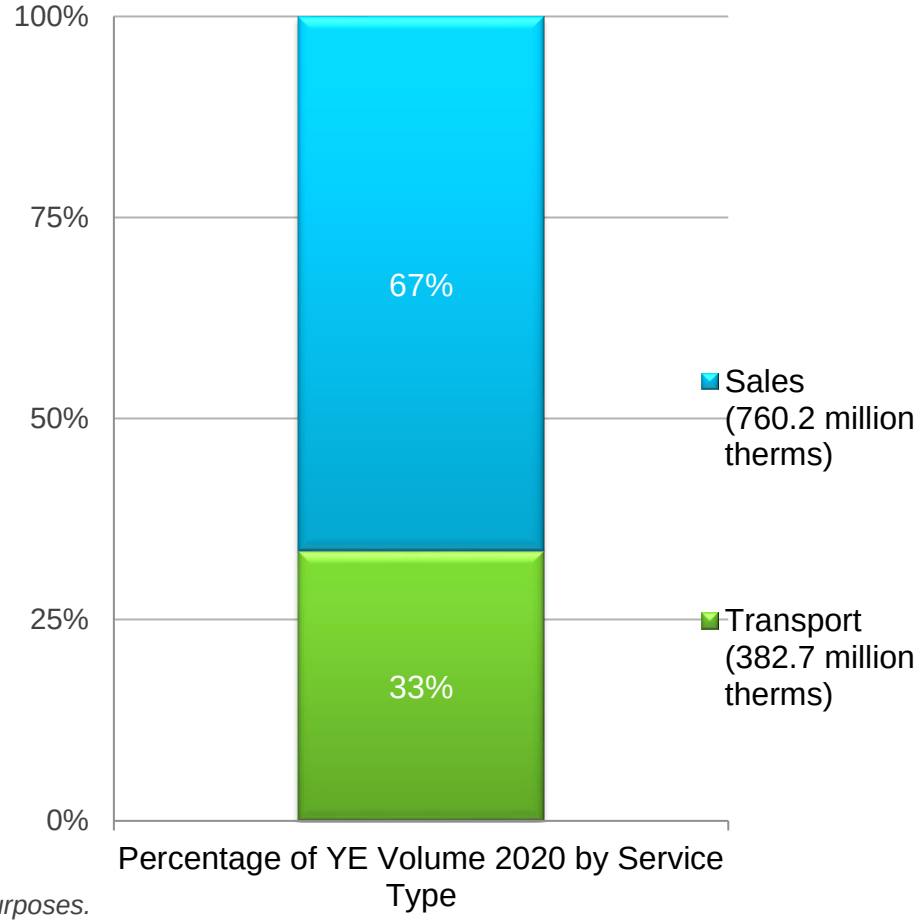
(2018 IRP Update #3)



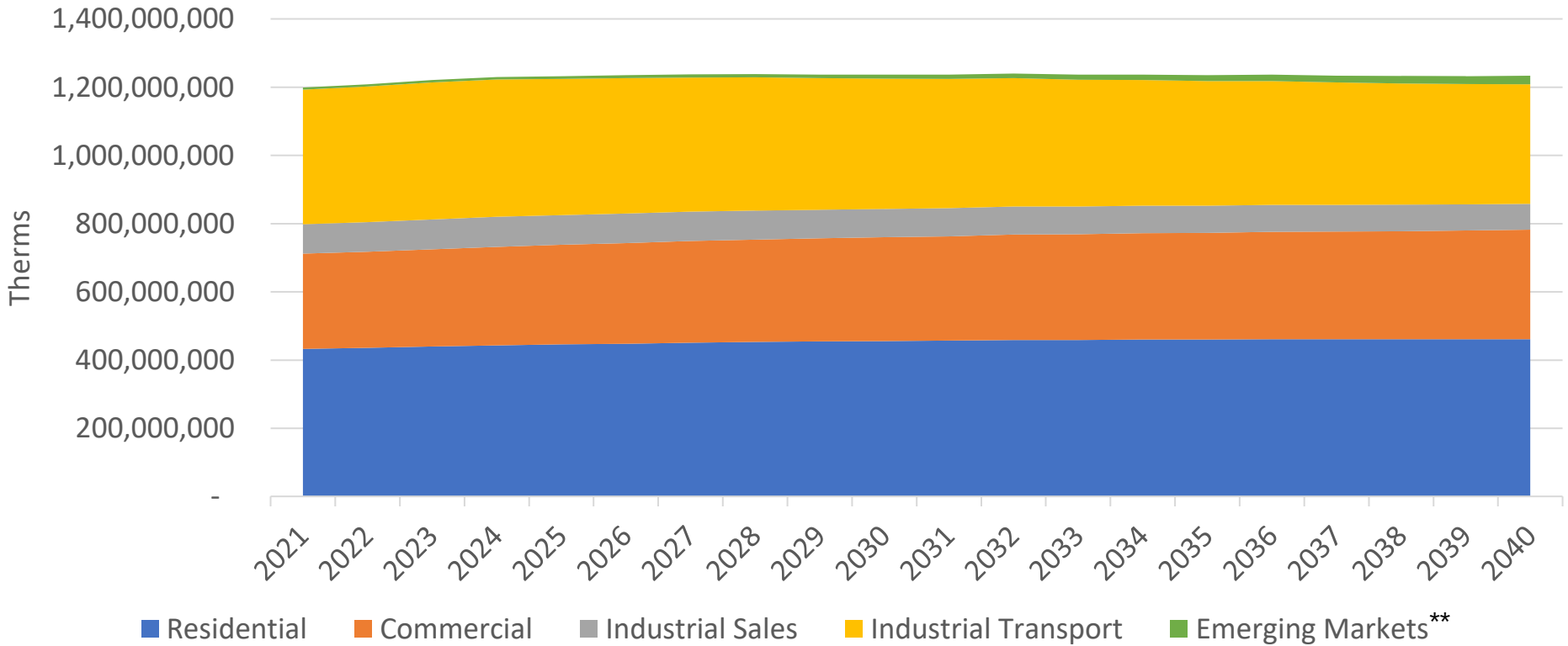
- Includes impact of energy efficiency, RNG and the Smart Energy carbon offset program
- Residential Smart Energy program Savings allocated equally to all customers

OR CPP will Likely Require NW Natural to Cover Transportation Customers

- Emissions forecast shown in the 2018 IRP and the 2018 IRP update #3 only included emissions from **sales** customers
- Direction from ODEQ RAC Meetings suggests that NW Natural will be responsible for emissions from transportation customers
- Transportation customers are responsible for purchasing and bringing their natural gas to NW Natural's system
- Transportation customers make up about 1/3 of natural gas deliveries to customers
- Most transportation loads are large industrial customers, which use gas as an input in their production

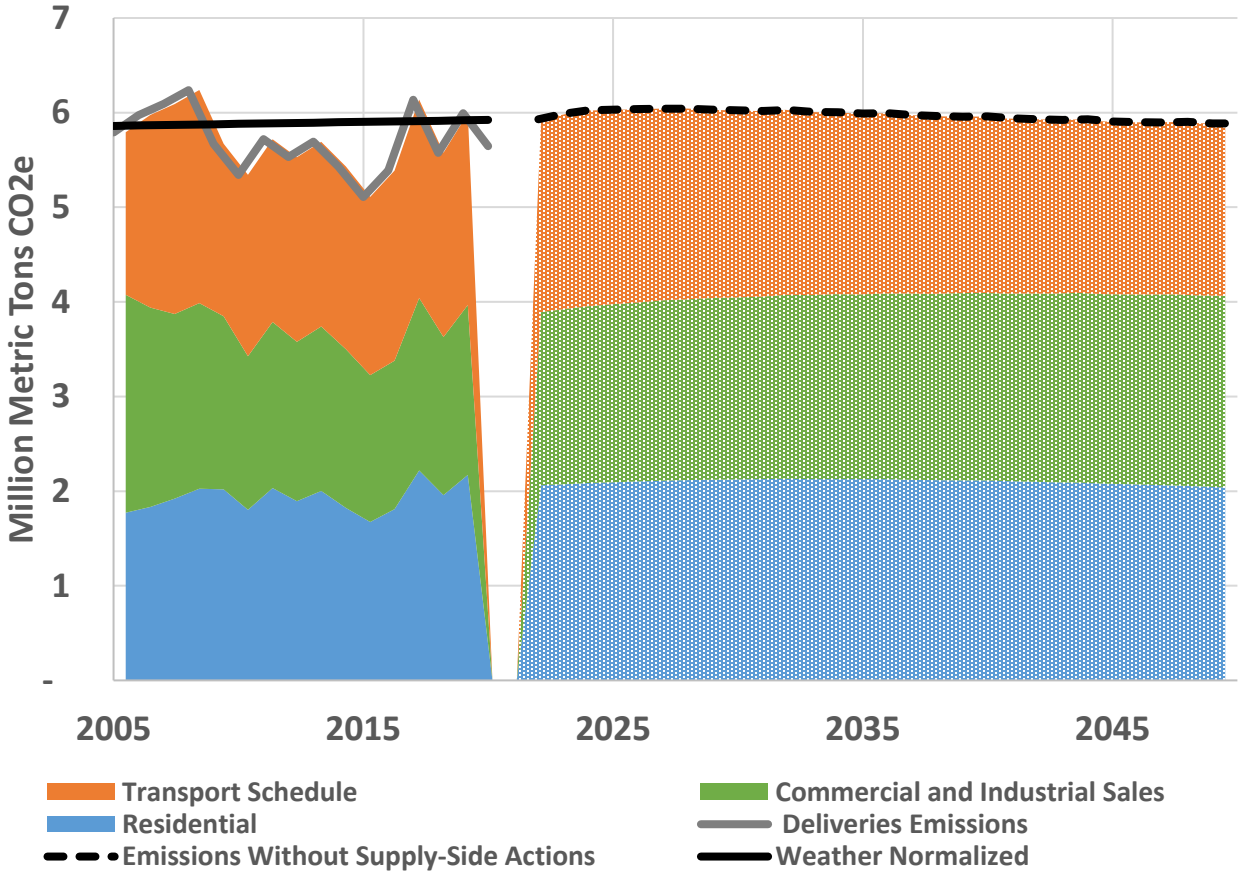


Expected Weather Annual Forecast – Throughput
(2018 IRP Update #3*)



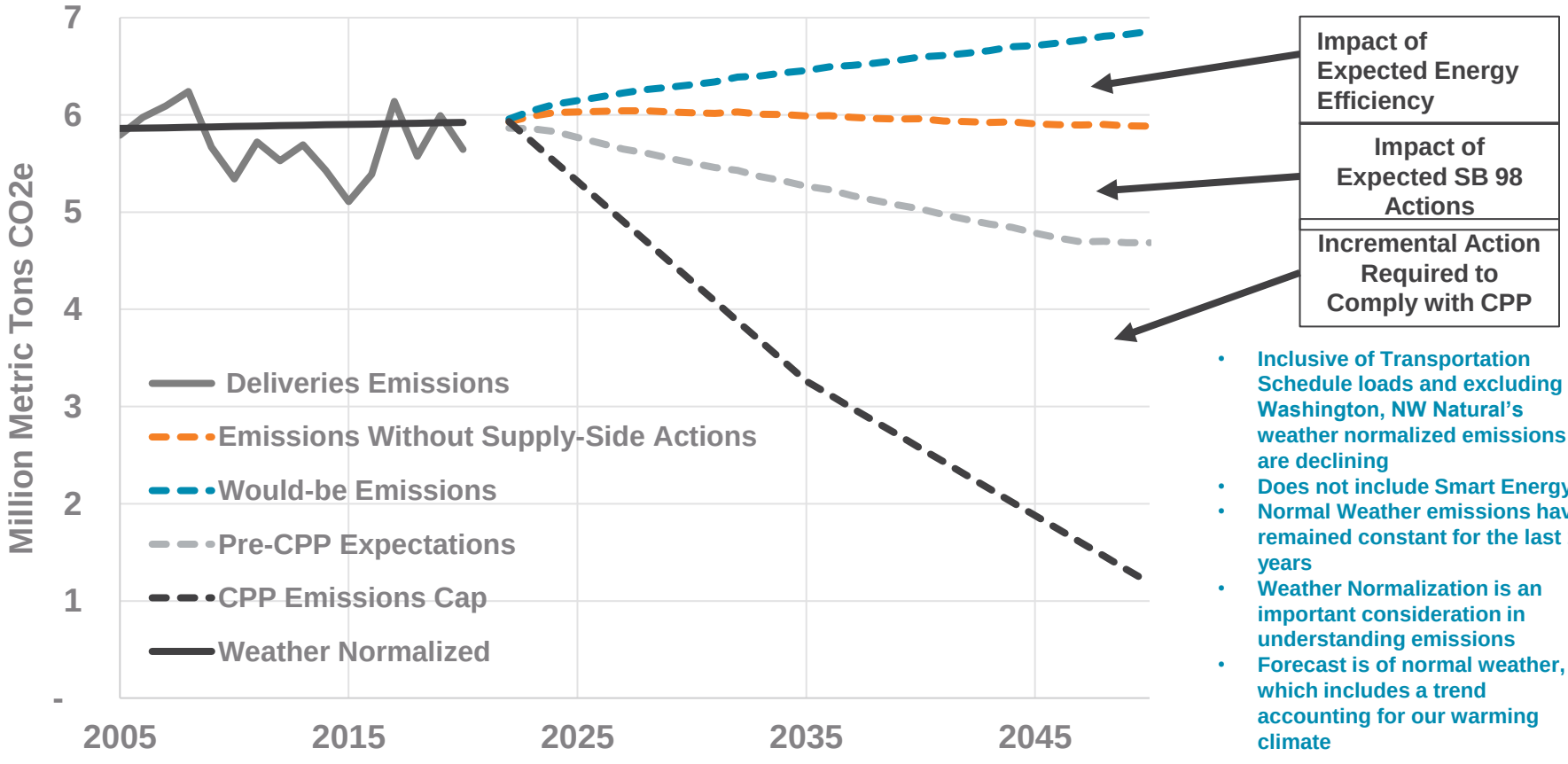
*2018 IRP Update #3 incorporated increased average annual temperatures due to climate change
**Emerging markets includes forecasted load from compressed natural gas vehicles

Emission Forecast With Transport



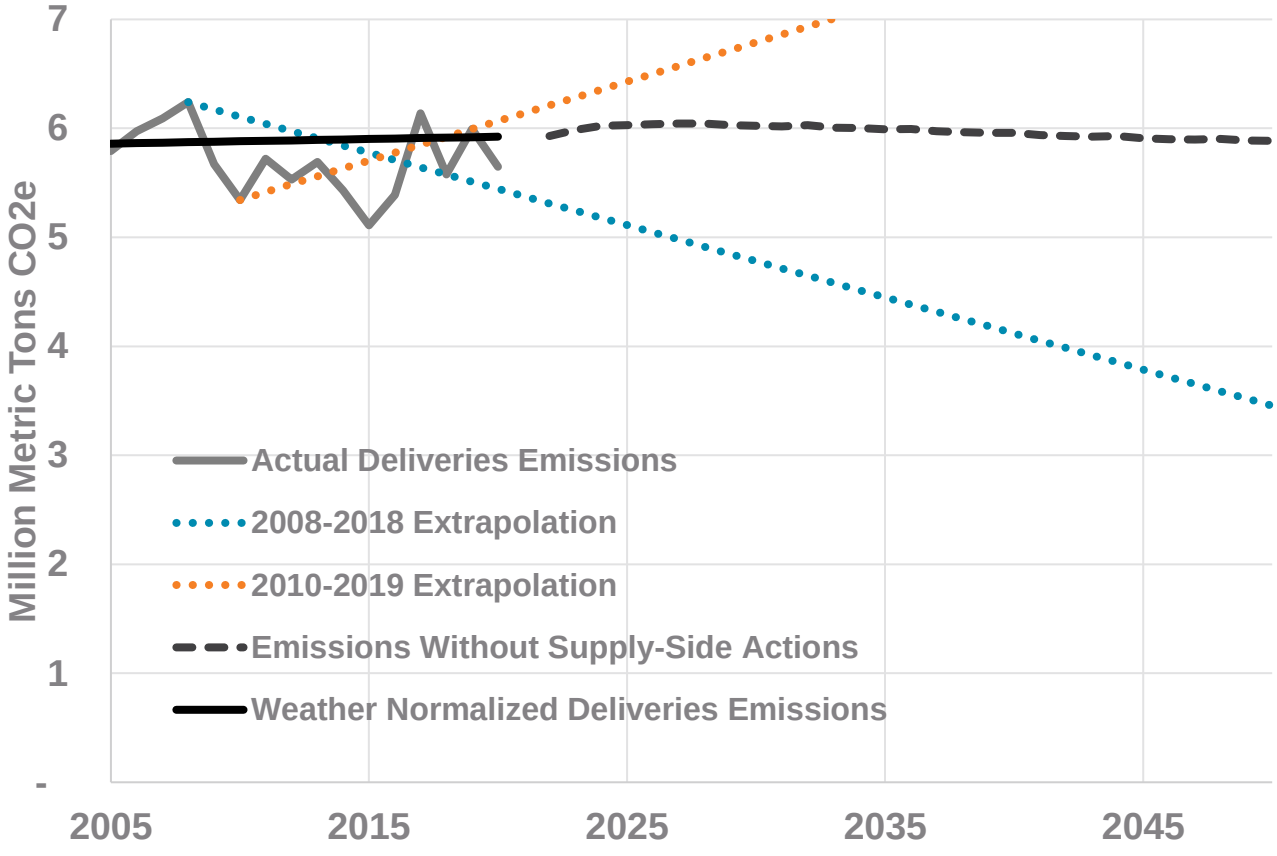
- Includes gas delivered – but not sold – by NW Natural (i.e., gas delivered on Transportation Service Schedules)
- Shows emissions as if all load was served by conventional natural gas (i.e., does not show expected decrease in emissions due to RNG and other supply-side actions)

NW Natural's CPP Compliance Needs



- Inclusive of Transportation Schedule loads and excluding Washington, NW Natural's weather normalized emissions are declining
- Does not include Smart Energy
- Normal Weather emissions have remained constant for the last 15 years
- Weather Normalization is an important consideration in understanding emissions
- Forecast is of normal weather, which includes a trend accounting for our warming climate

Weather Normalizing Matters



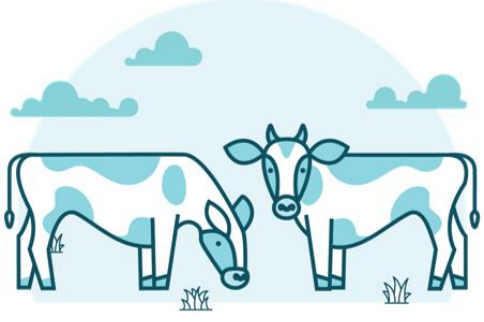
- Past usage and emissions are “noisy,” and will be in the future
- Differences in weather from year to year drive this volatility
- Forecasts are shown for normal weather
- Extrapolations of non-normal weatherized data can be misleading
- NW Natural models weather that adjusts for climate change

Three Primary Pathways to Continue to Reduce Emissions

1) Energy conservation – providing the same energy services with less
   Building shell improvement; installing more efficient equipment; process improvements

2) Lowering the carbon intensity of the product we deliver
   Renewable natural gas; power-to-gas

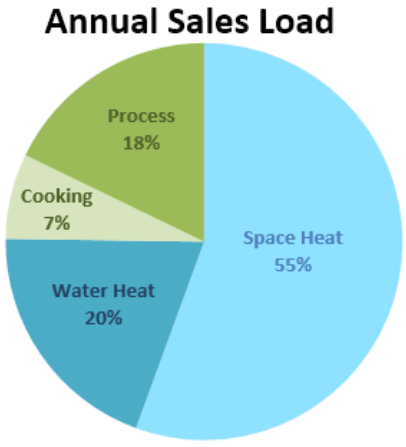
3) Offset conventional natural gas emissions
   Purchase emissions offsets; community climate investments

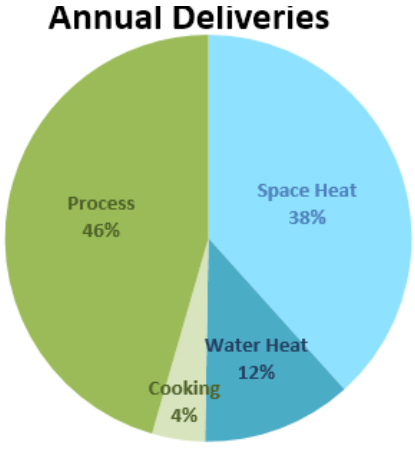


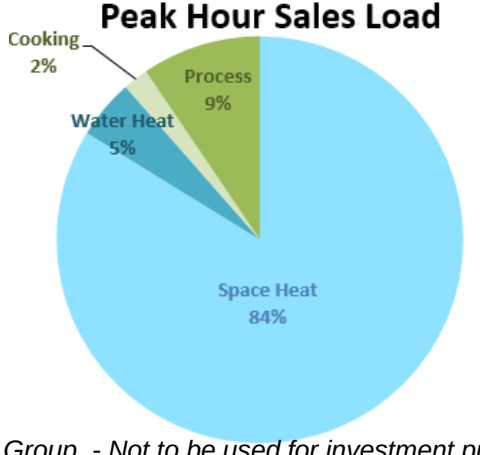
Context for Today's focus of NW Natural's Load Forecast

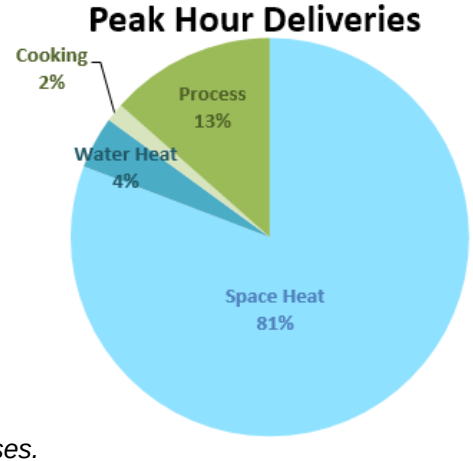
- **Our next TWG will focus on modeling emissions compliance under a cap and reduce policy in Oregon and a cap and invest policy in Washington**
  - Previous IRPs used expected emissions compliance costs over the planning horizon and demand-side and supply-side resources are evaluated
  - Now emissions will be a binding constraint where demand-side and supply-side resources are evaluated for less cost least risk for complying with the constraint
- **Today's TWG will focus specifically on considerations for load and the tools we have to develop a load forecast and scenarios for planning resources over the planning horizon**

How is natural gas used?

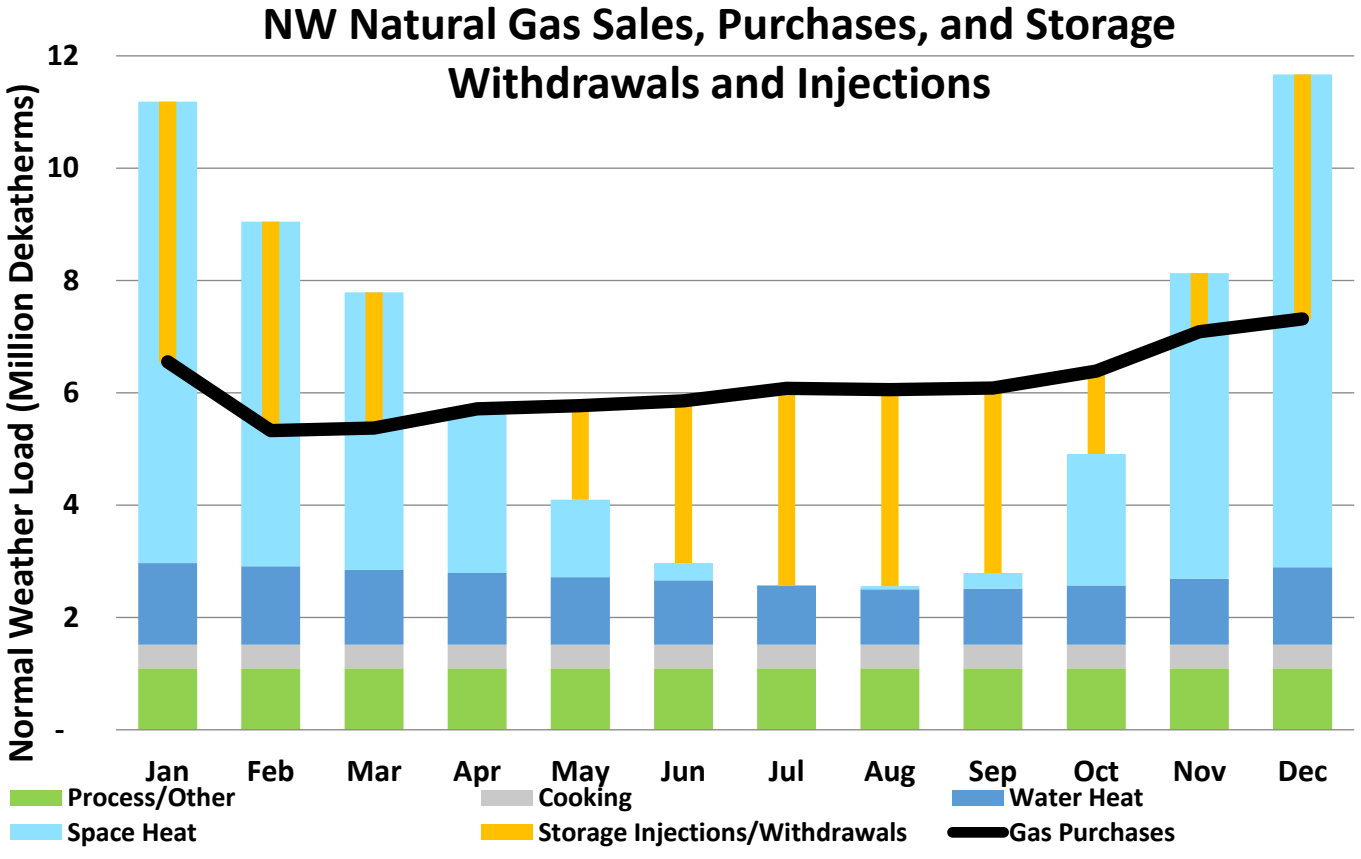








Seasonal Load Breakdown by End Use- 2018 IRP



- Load is highly seasonal
- Seasonality needs are cost-effectively met with existing energy storage
- Peak load is roughly 3 times the average load throughout the year
- Does not include transportation schedule load

Break
(5 minutes)

Previous IRP Base Case Using Historical Trend Models

Recent IRP Update #3 Summary

		20-year Compound Annual Growth Rate	
		2018 IRP Update #3	2018 IRP
Residential Sales	Customer Count	1.30%	1.35%
	Expected Annual Load Forecast	0.3%	0.0%
Commercial Sales	Customer Count	0.9%	1.38%
	Expected Annual Load Forecast	0.7%	1.3%
Industrial Sales and Transport	Expected Annual Load Forecast	-.64%	-.1%
Total Sales	Expected Annual Load Forecast	0.4%	0.6%
Peak Day Firms Sales	Load Forecast	0.83%	0.91%

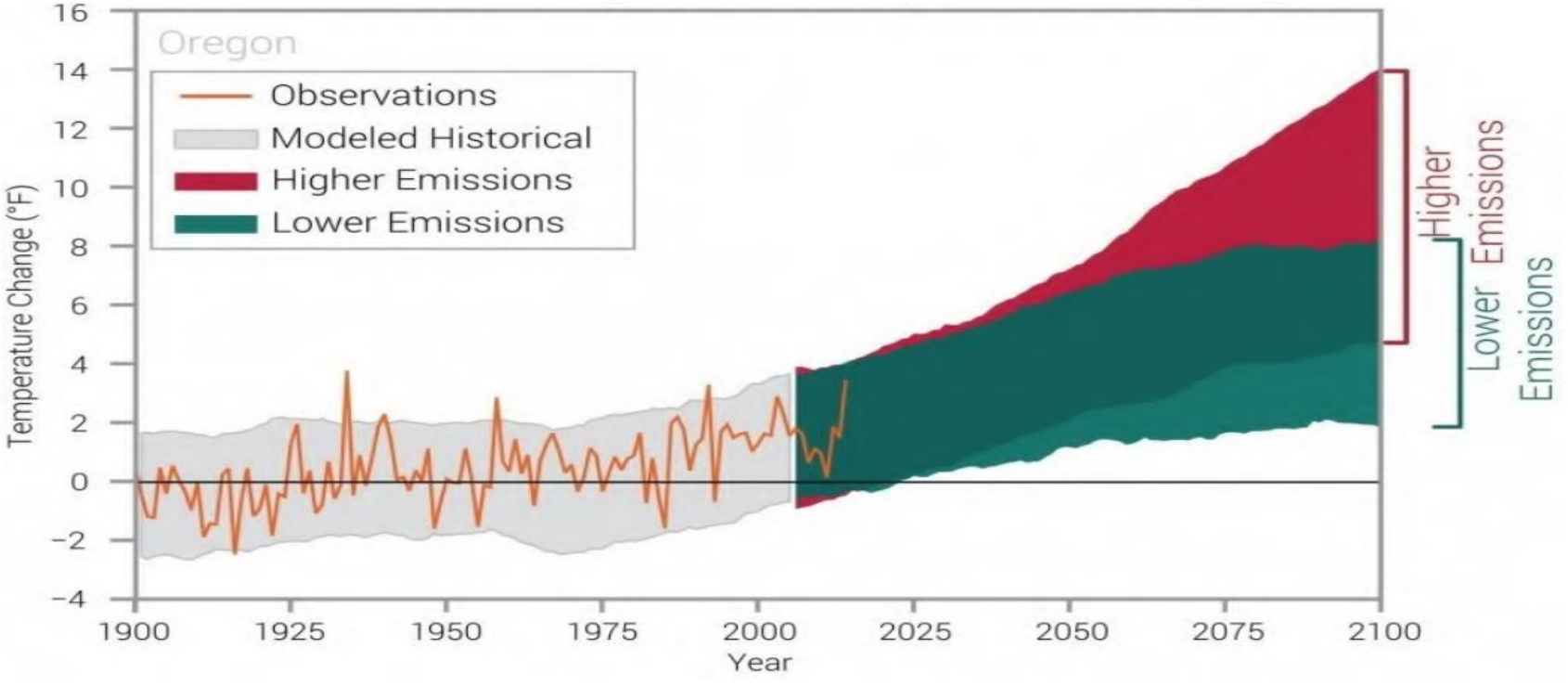
Load Forecasting Base Case Models 2018 IRP and IRP update

- Weather
- Customer Count Forecast
- Residential UPC Model
- Commercial UPC Model
- Energy Efficiency Forecast
- Industrial Load Forecast
- Daily System Load Model
- Hourly System Load Model

Load Forecast Model Flow Chart: – Starting with Weather

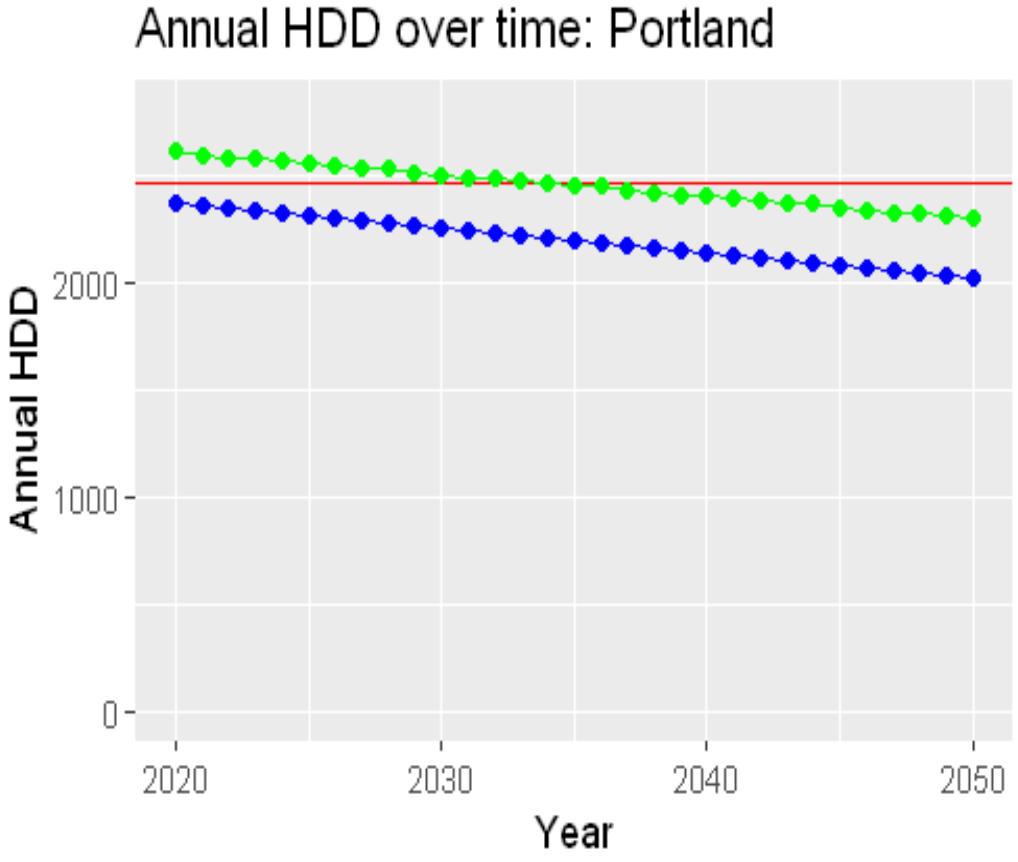
Annual temperature change:

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



Source: ODOE 2018 Biennial Energy Report - Chapter 2

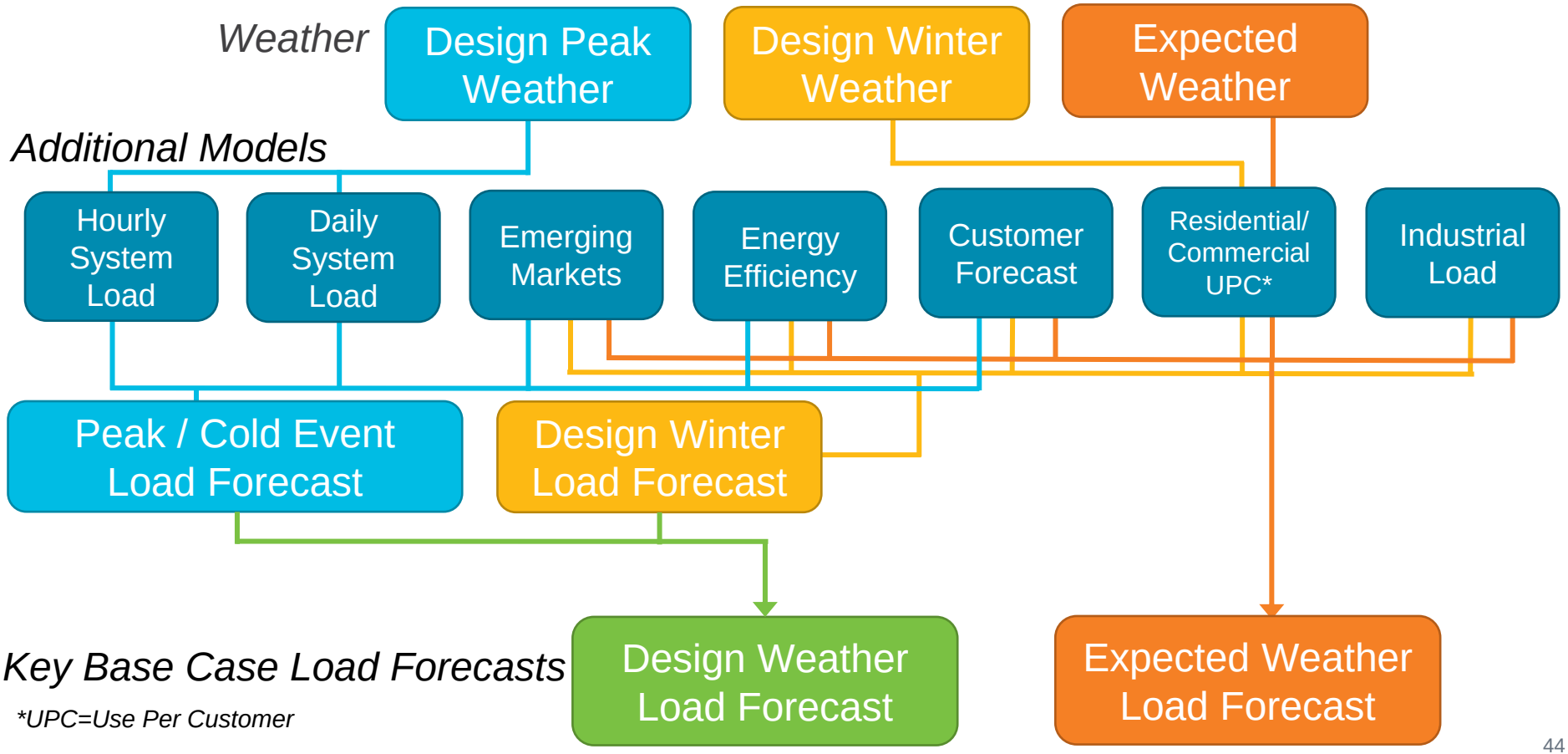
Annual HDD Portland



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

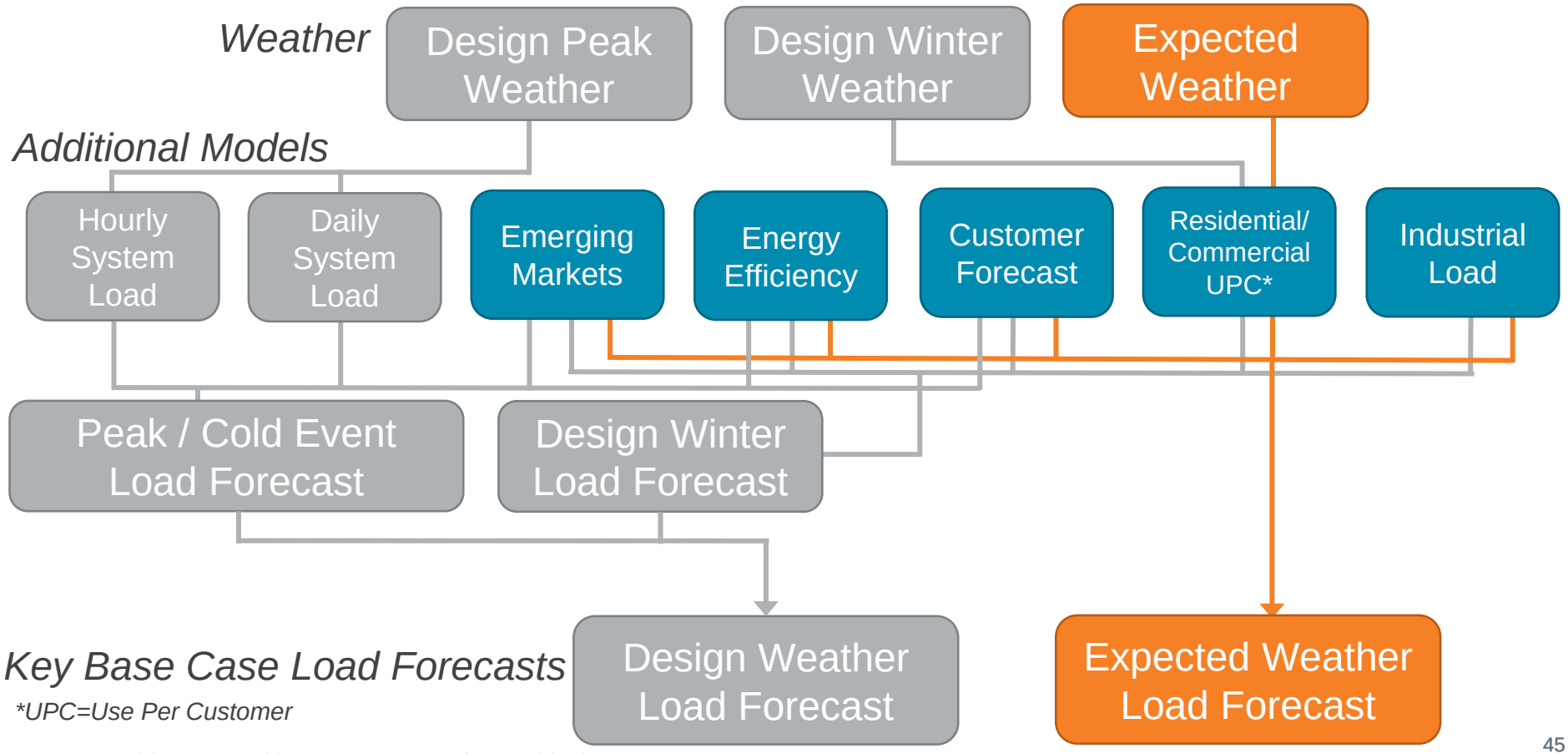
Load Forecast Model Flow Chart

Load Forecast Model Flow Chart



*UPC=Use Per Customer

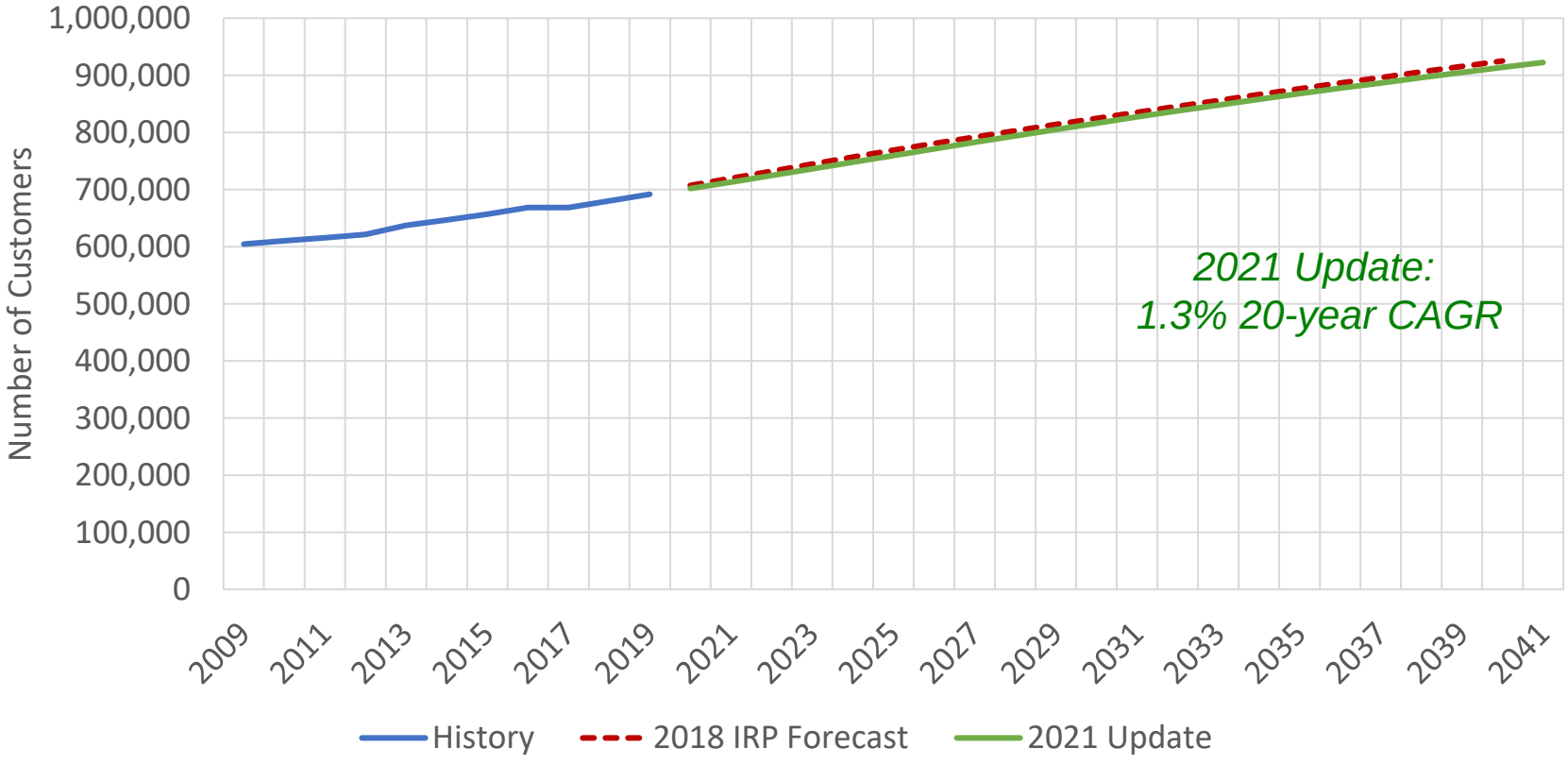
Expected Weather Load Forecast



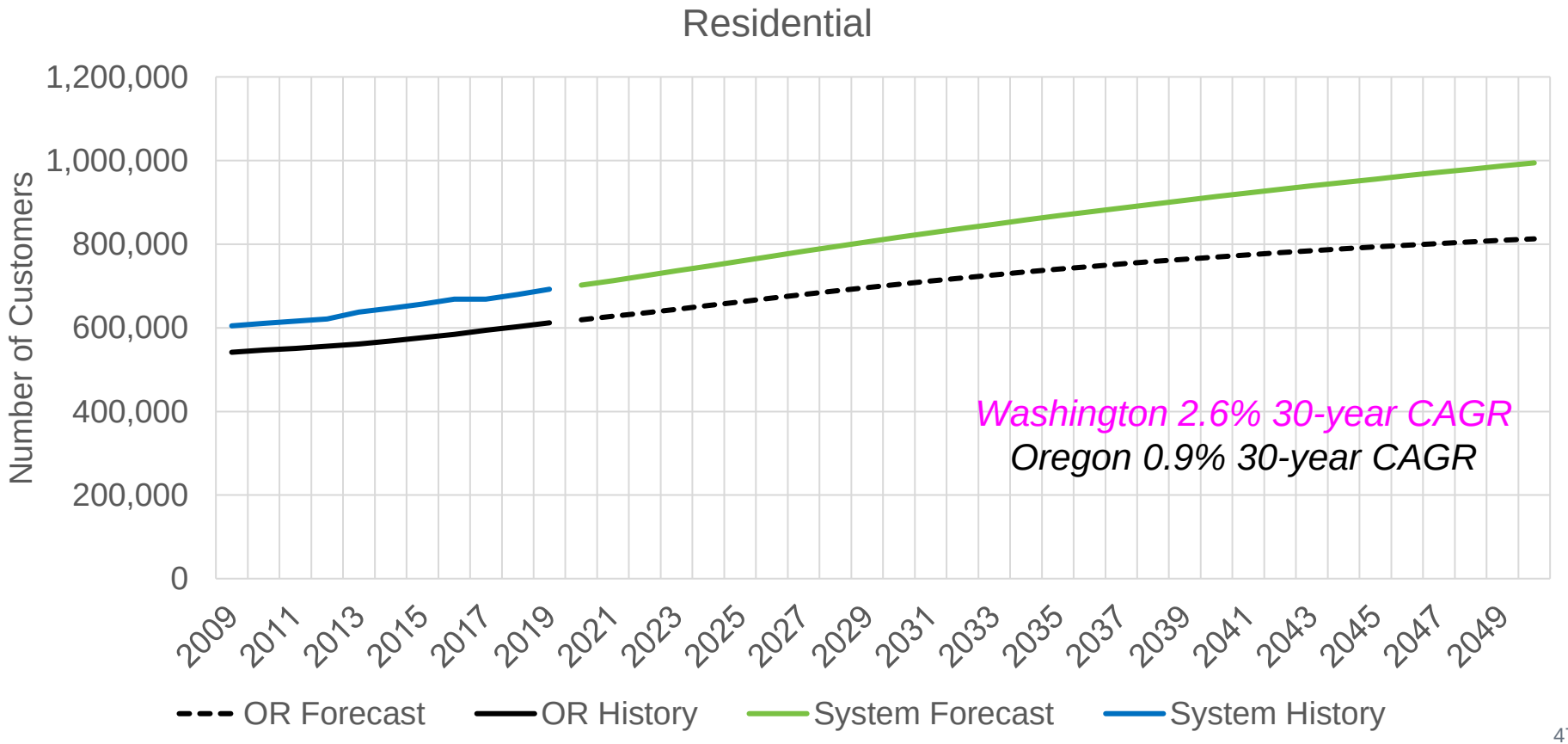
*UPC=Use Per Customer

Residential Customer Count

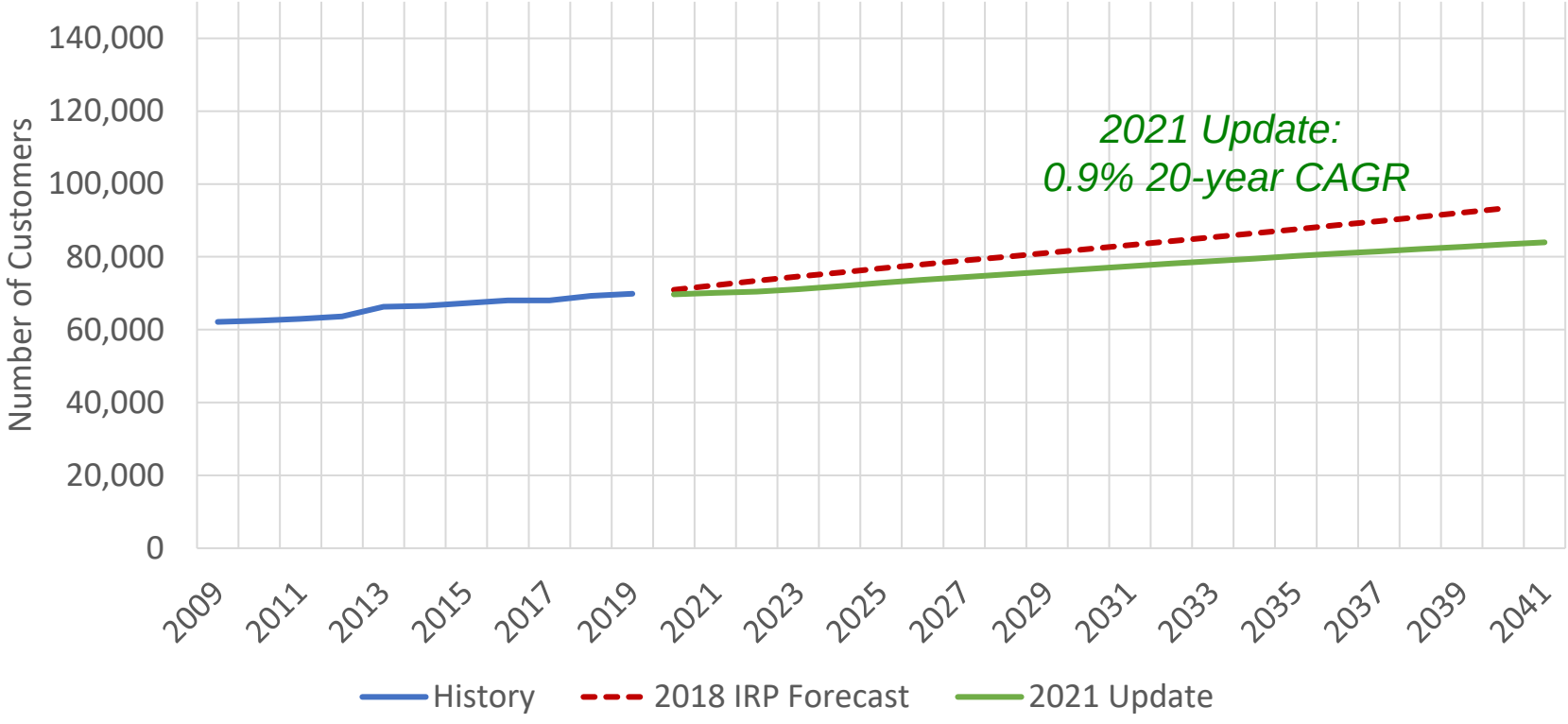
(2018 IRP Update #3)



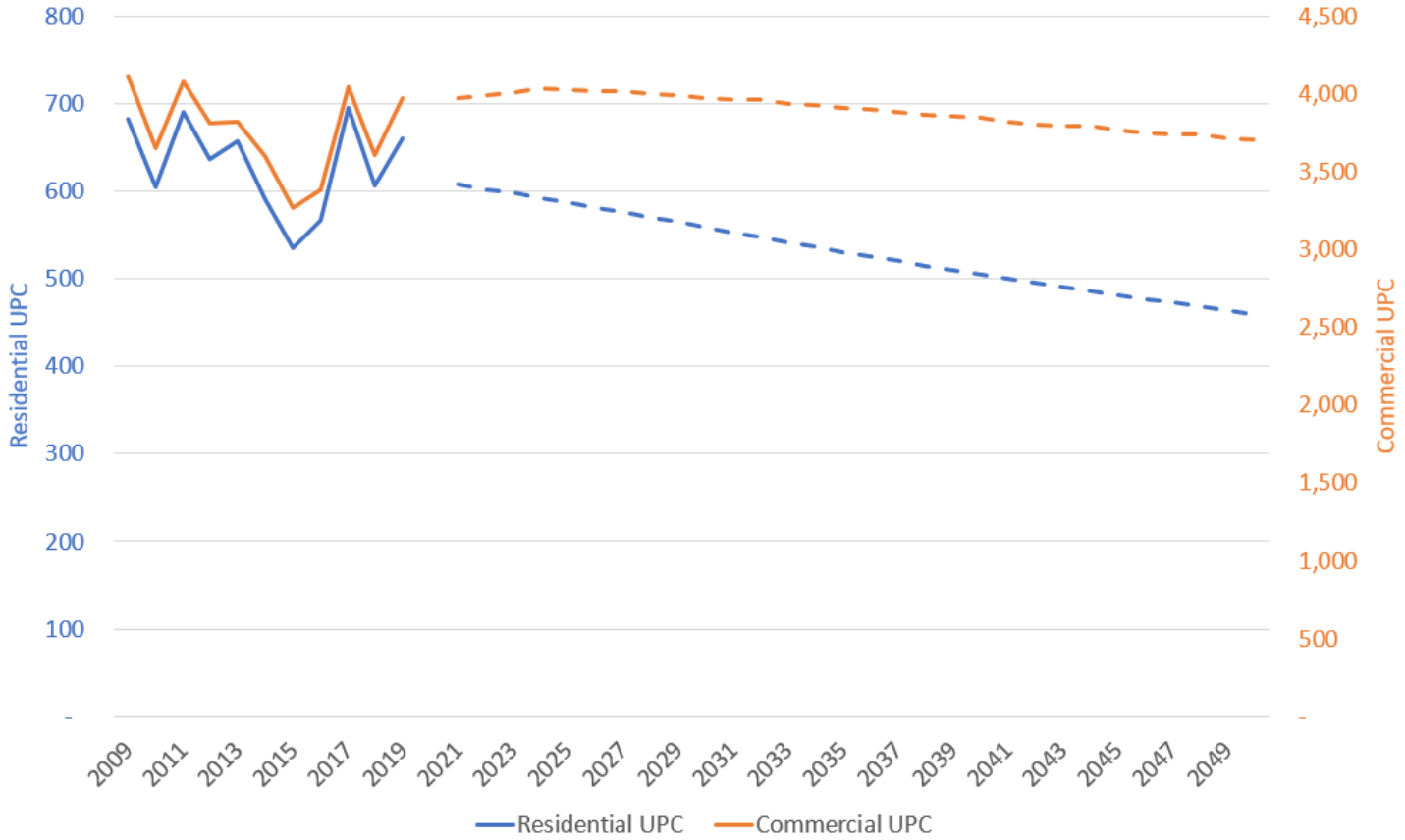
Residential Customer Count by State
(2018 IRP Update #3)



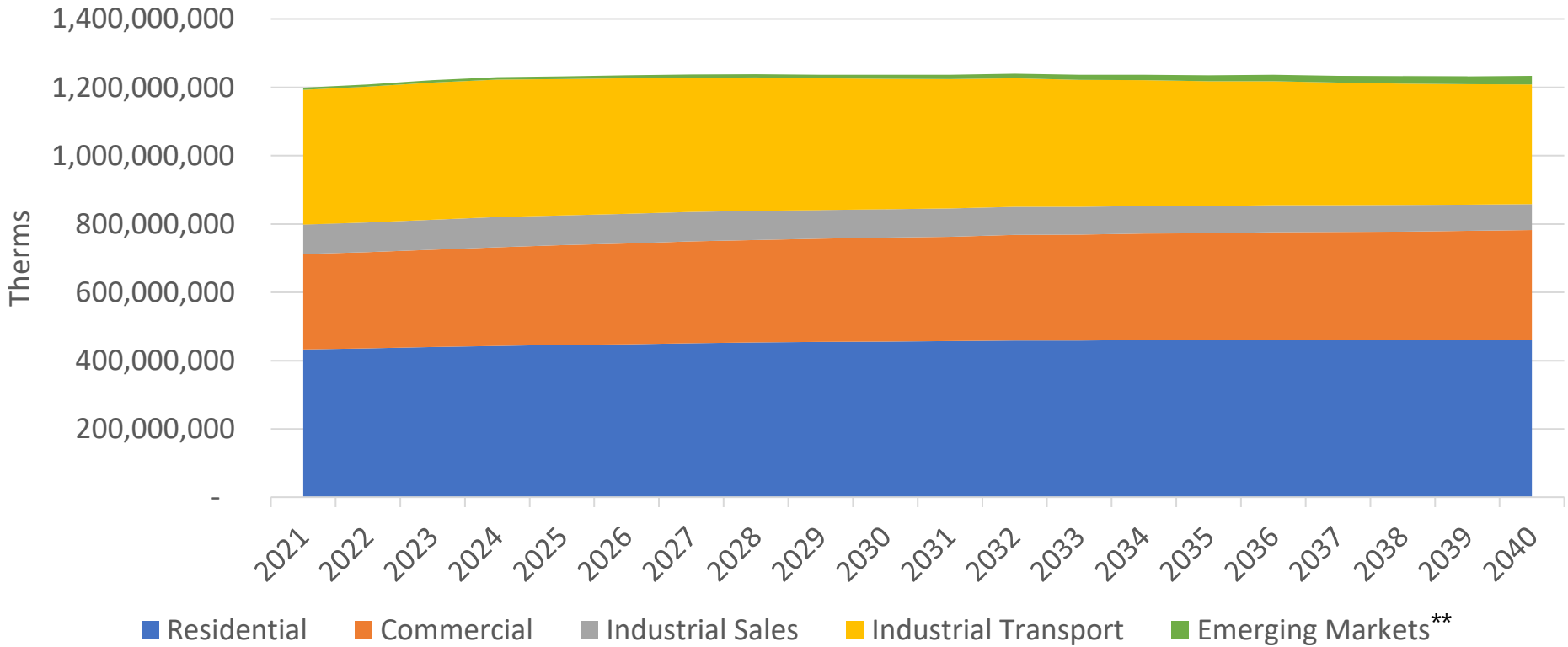
Commercial Customer Count
(2018 IRP Update #3)



Use Per Customer

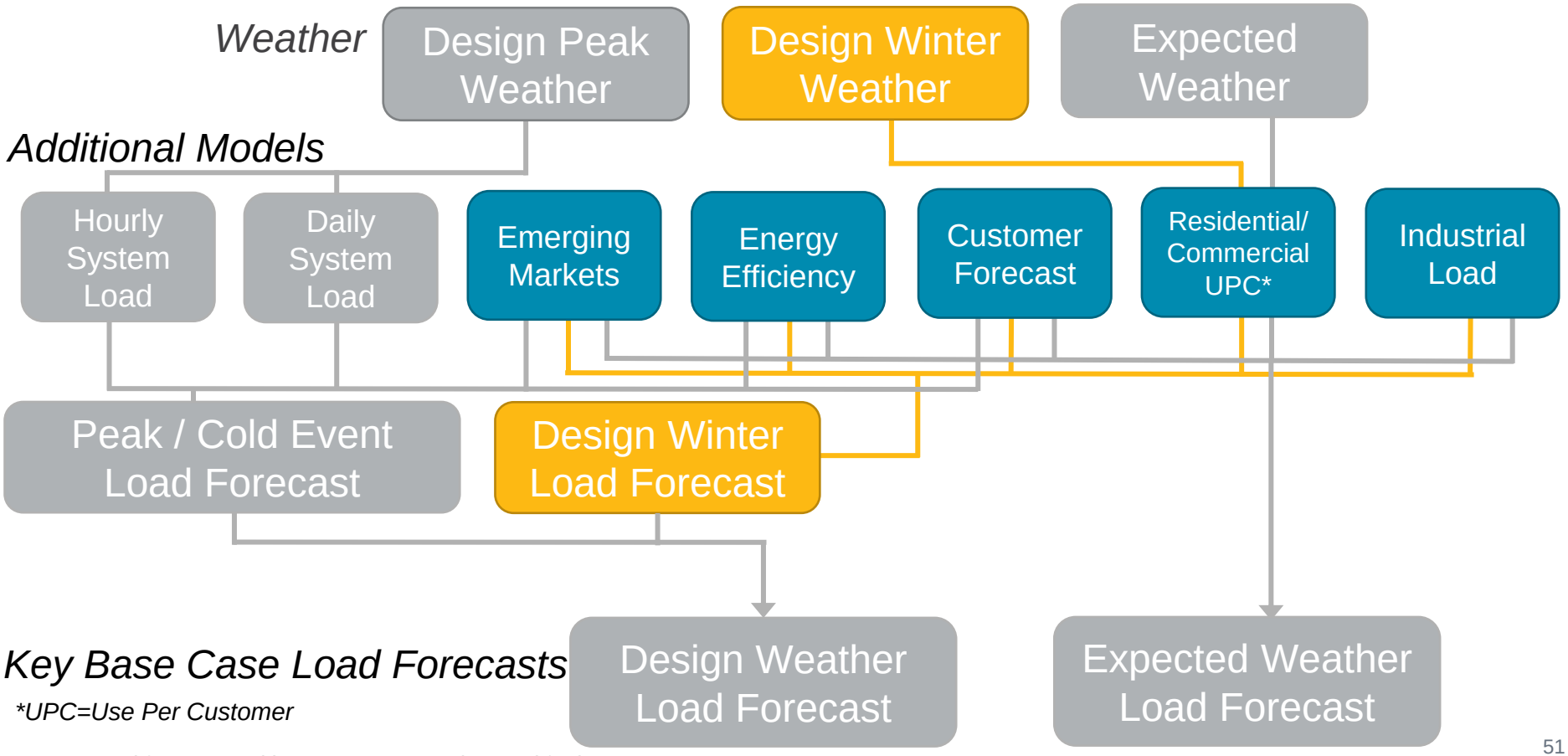


Expected Weather Annual Forecast – Throughput
(2018 IRP Update #3*)



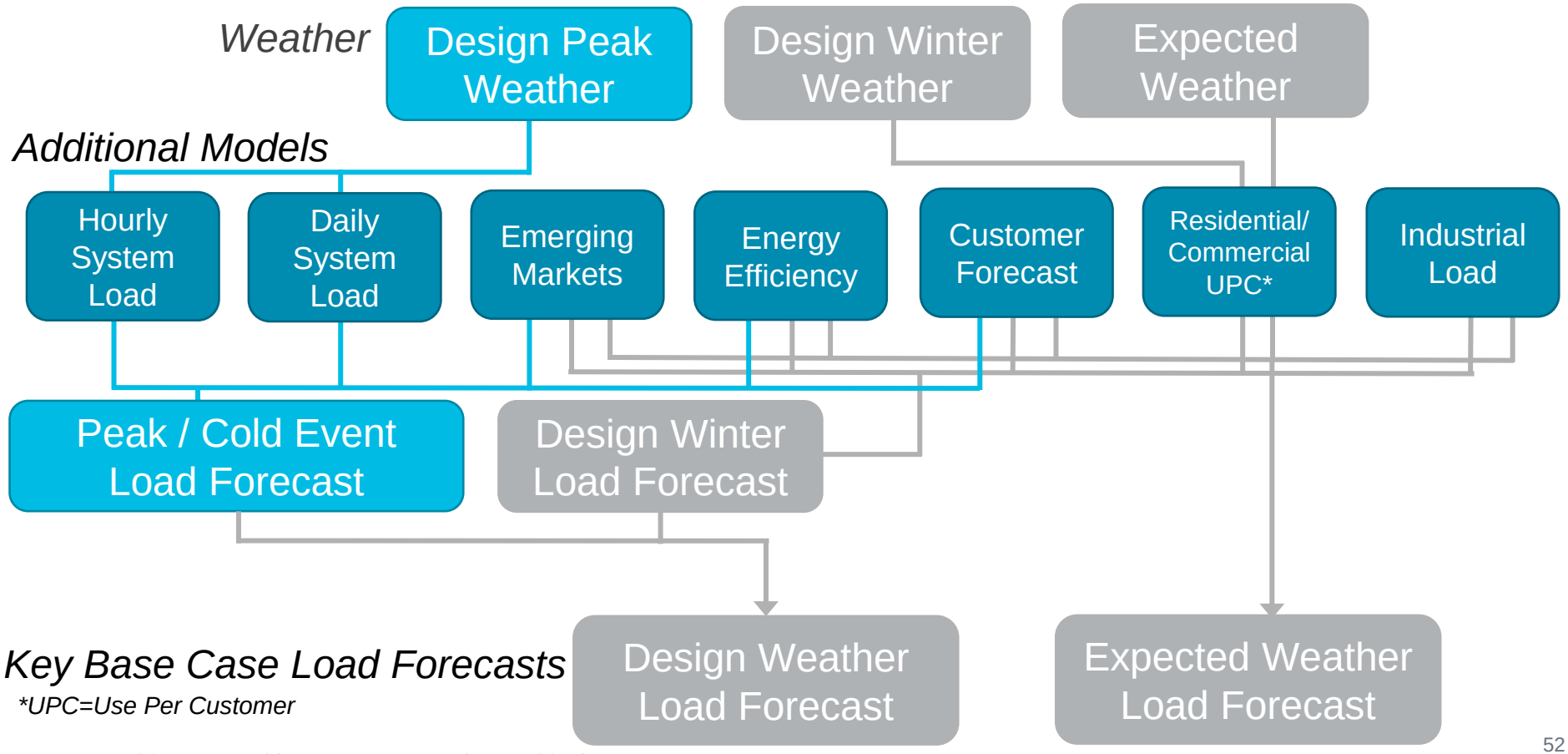
*2018 IRP Update #3 incorporated increased average annual temperatures due to climate change
**Emerging markets includes forecasted load from compressed natural gas vehicles

Design Winter Load Forecast



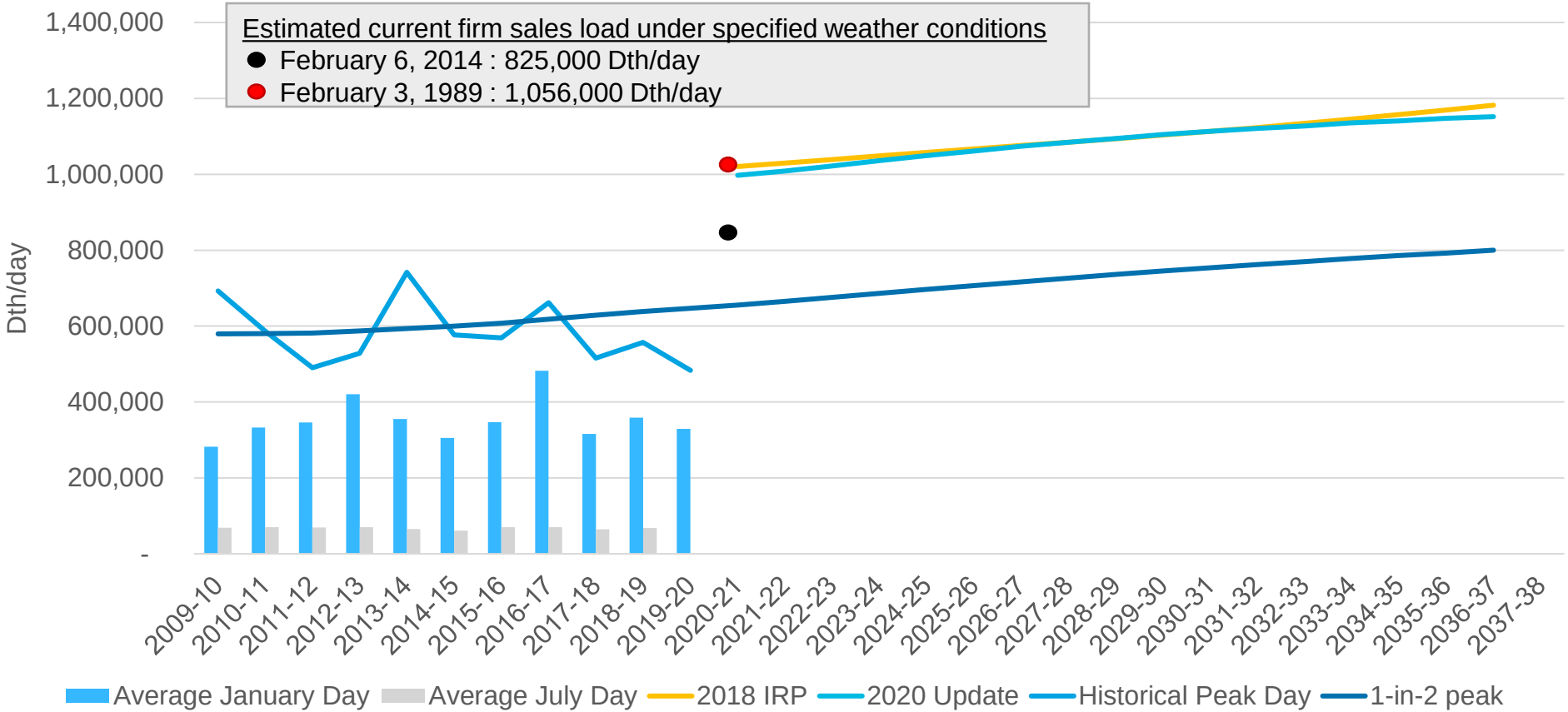
*UPC=Use Per Customer

Design Peak and Cold Event Forecast



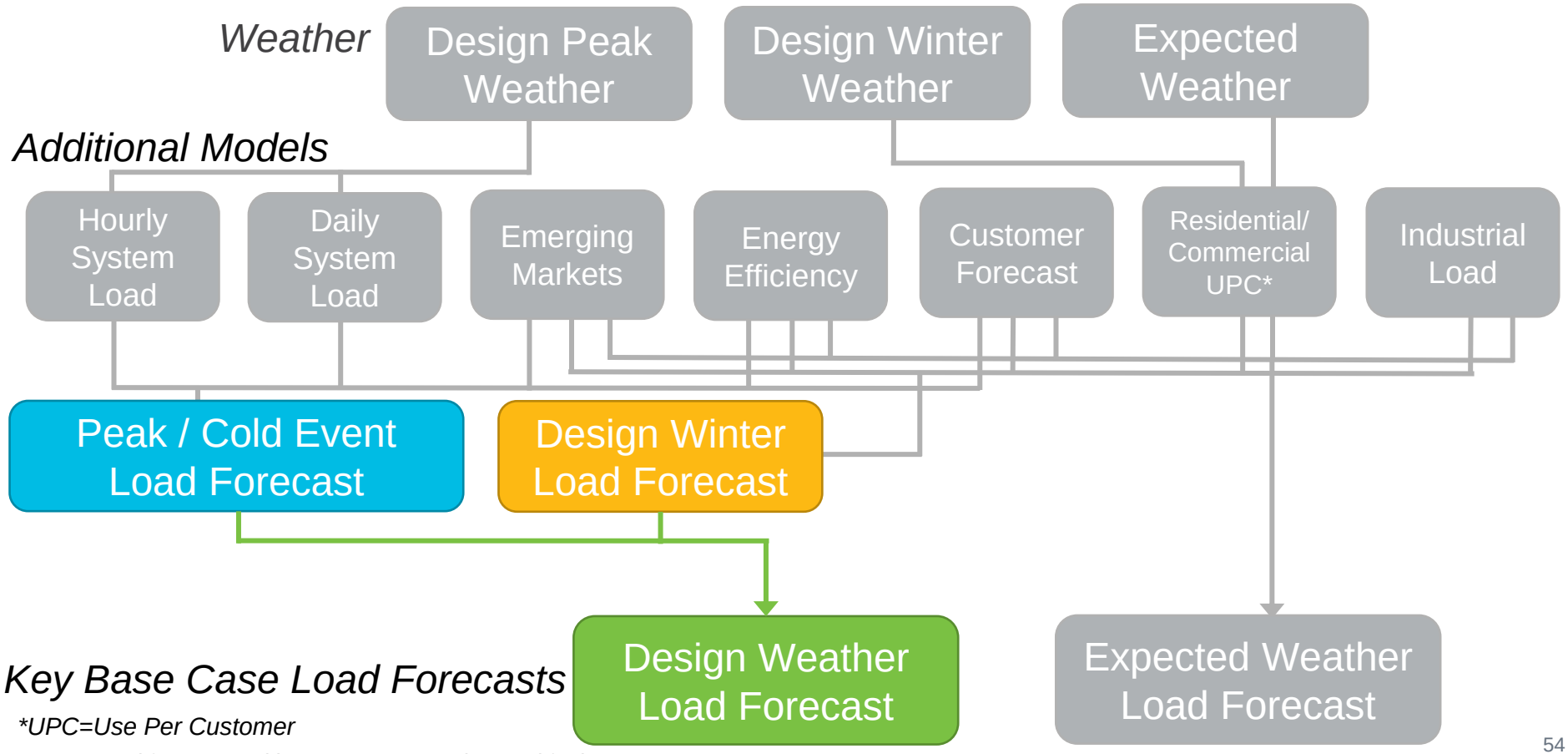
*UPC=Use Per Customer

Peak Day Firm Sales Forecast
(2018 IRP Update #3)



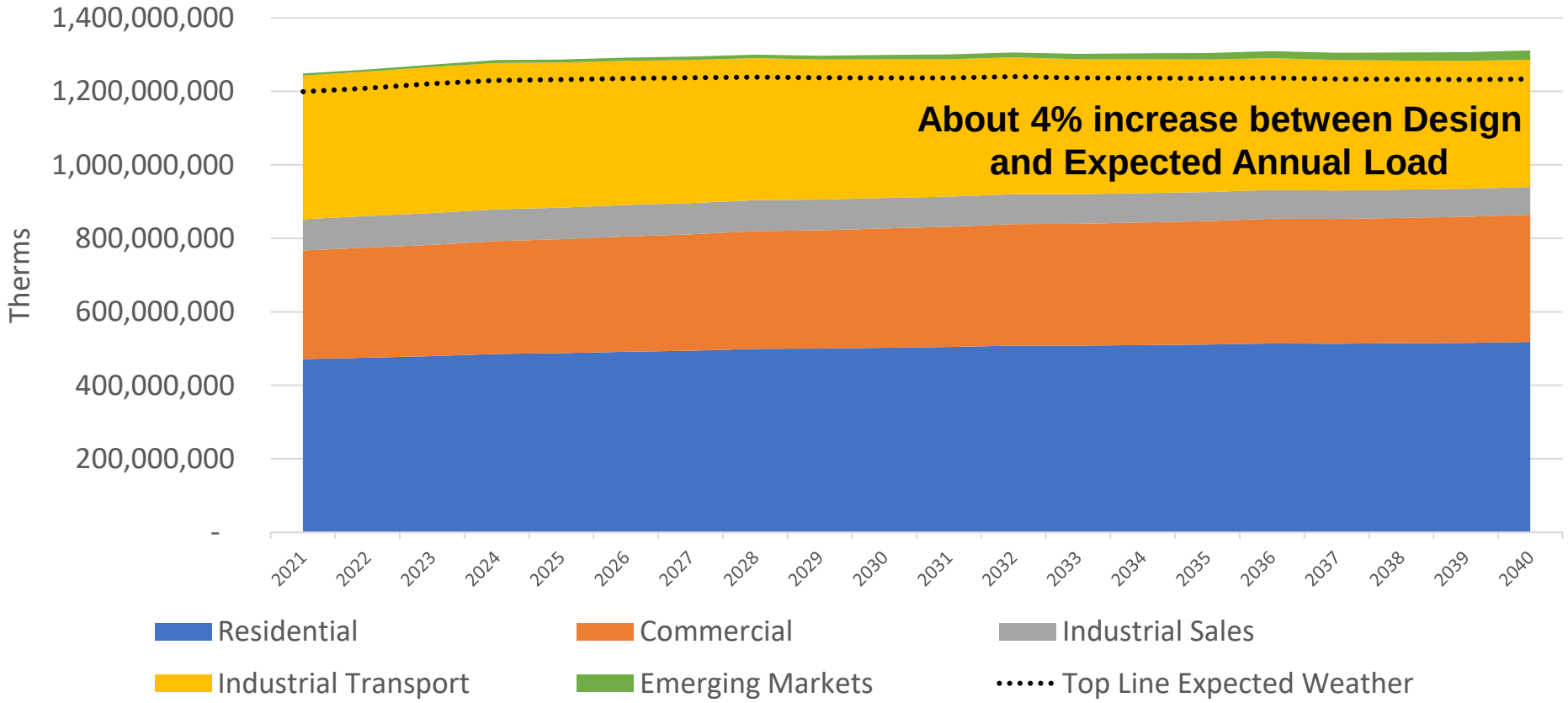
Prepared for IRP Working Group - Not to be used for investment purposes.

Design Weather Load Forecast



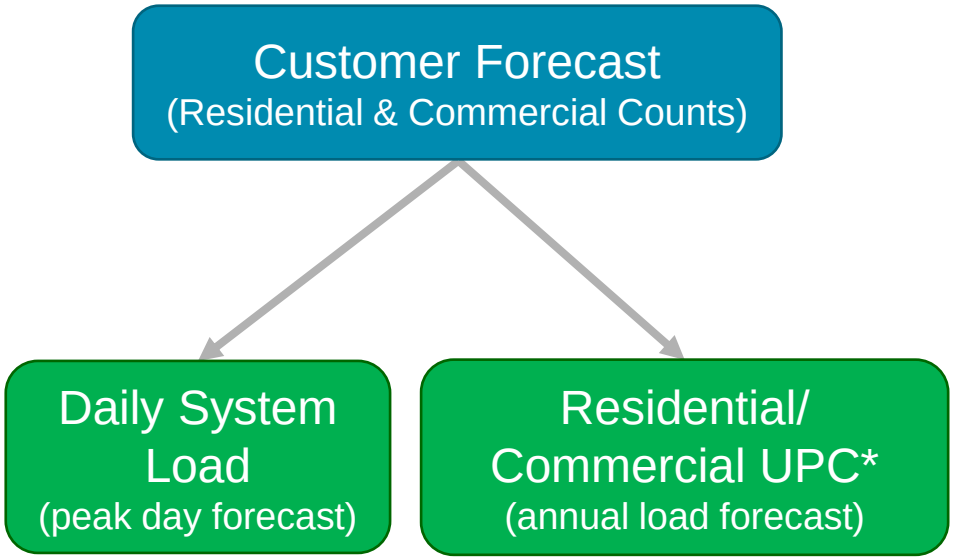
*UPC=Use Per Customer

Design Weather Annual Forecast – Throughput
(2018 IRP Update #3)



Considerations Looking Forward

Historical Trend Models



Load forecasting starts with the customer count forecast

The customer count forecast feeds into both the peak-day load forecast and the annual load forecast

1) Previous statistical models for customer count forecasts project forward historical trends in customer additions (new construction and conversions)

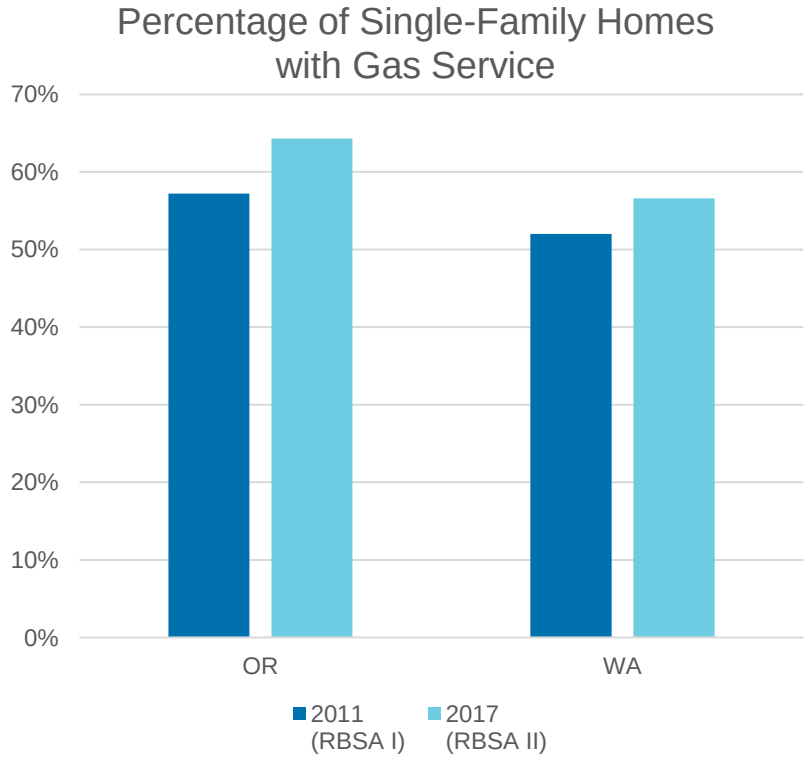
2) Previous statistical models for peak and annual load forecasts project forward a continuation of end-use equipment penetration based on historical trends

**UPC=Use Per Customer*

Historical Trends Could Shift

- **Given changes in the policy environment historical trends may change:**
  - **Customer growth**
    - Customer additions from new construction
    - Rate of conversions (i.e., existing residential homes and commercial businesses switching to natural gas from alternative fuel sources)
  - **End-use equipment penetration**
    - Trends in customer usage of natural gas for space heating, water heating, cooking, etc..
    - Addition of new technologies (e.g., gas-fired heat pumps)
  - **Equipment efficiency being installed**
    - Trends in the average efficiency of the end-use equipment stock across customers
    - Building-shell improvements
    - Efficiency gains in industrial processes
- **Using stock roll-over forecasting tools, we can incorporate adjustments to the statistical models to account for these shifts in the overall usage profile**
- **To do this, it is important to understand where customer additions, end-use equipment and equipment efficiency currently exist**

Homes with Gas Service

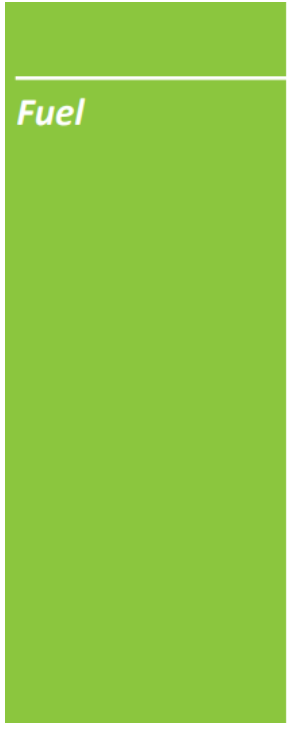


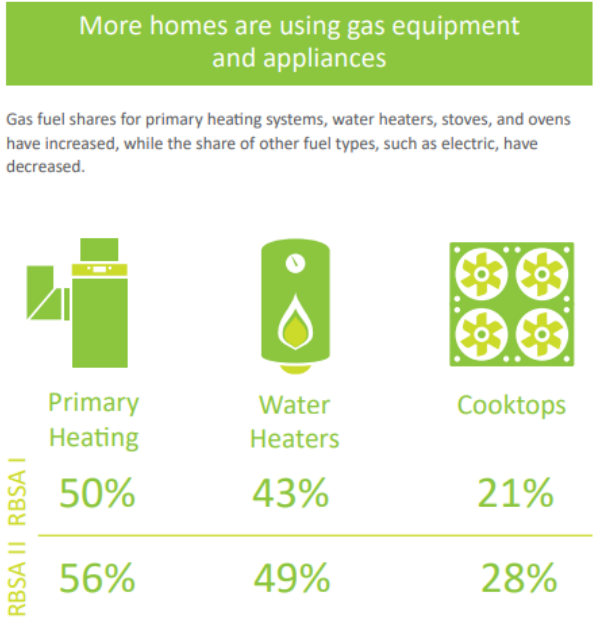
- NEEA's survey is region-wide and includes areas where natural gas service is not available
- For areas we serve, our market share for single-family new construction is about 75%
- The percentage of multi-family new construction with gas service is much smaller, but has increased over the last few years
- Next RBSA will be in available in 2023

Source: NEEA RBSA - Single-Family Homes Report 2011; 2016-2017

Single-Family Residential End-use Penetration

- Historical trends have shown an overall increase in gas equipment in single-family homes
- Primary space heating accounts for the majority, about 55% of NW Natural's annual sales load
- Water heaters account for about 10% of the annual sales load
- Cooktops account for a small portion, about 7% of annual sales load





Source: NEEA RBSA - Single-Family Homes Report 2016-2017

Multi-Family Space Heating Penetration

- Natural gas makes up much less of the space heating needs for multi-family
- Historical trends have shown an increase in natural gas furnaces for multi-family

Distribution of Primary Heating Systems

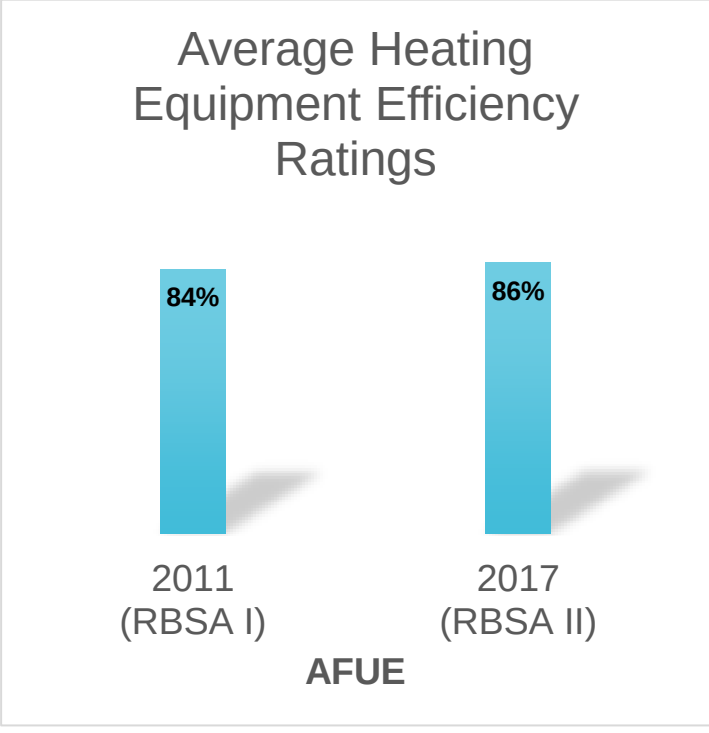
The primary heating table characterizes the heating systems of buildings whether they rely on a central system, such as a boiler, or on unit-level equipment, such as baseboard heaters.

	Electric	Natural Gas	Wood
Central Boiler	0%	1%	0%
Central Furnace	0%	0%	0%
Air Source Heat Pump	2%	0%	0%
Boiler	0%	0%	0%
Electric Baseboard and Wall Heaters	58%	0%	0%
Furnace	4%▲	8%▲	0%
Mini-Split Heat Pump	3%	0%	0%
Other Zonal Heat	21%	0%	0%
Package Terminal Heat Pump	0%	0%	0%
Stove/Fireplace	0%	2%	1%

Units characterized above as Other Zonal Heat were counted as electric baseboard heating in RBSA I.

Source: NEEA RBSA II - Multi-Family Homes Report 2016-2017

Space Heating Efficiency

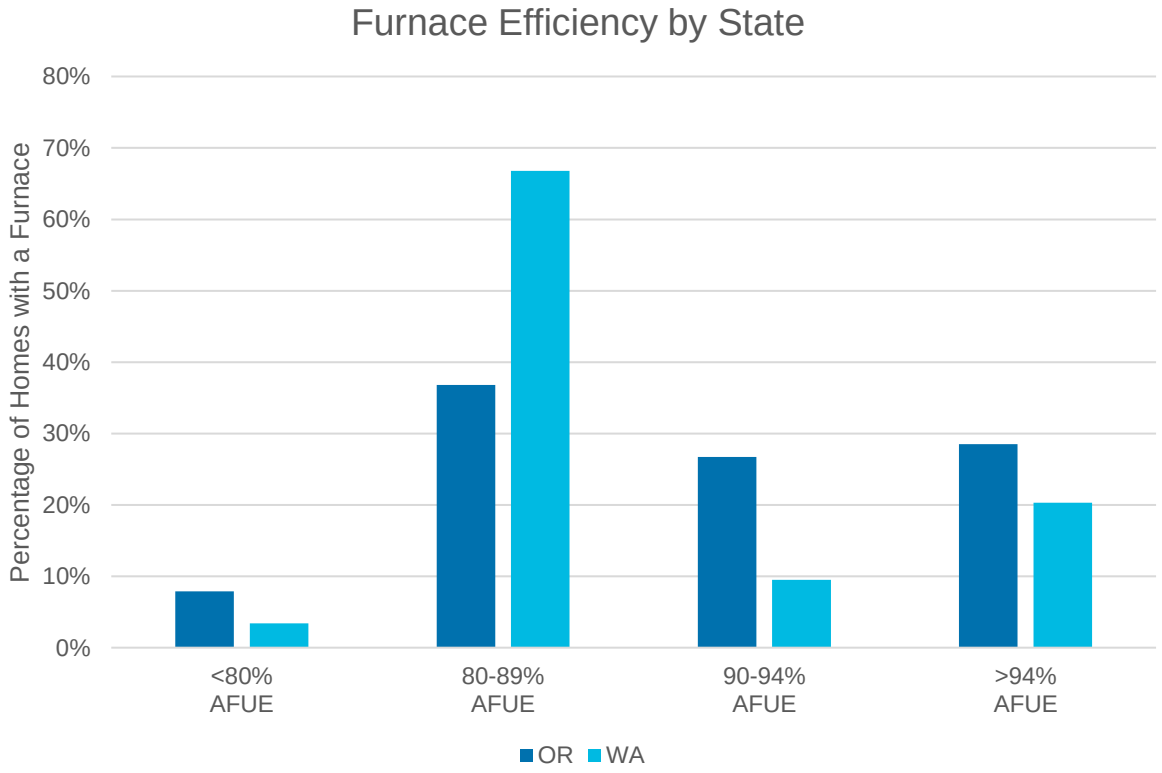


- Space heating equipment efficiency has increased over time
- The average stock efficiency increases as customers install more efficient equipment over time, either due to market transformation and/or changes in codes and standards
- Average furnace AFUE (Annual Fuel Utilization Efficiency) in the Pacific NW is about 86% as of RBSA II

Source: NEEA RBSA - Single-Family Homes Report 2016-2017

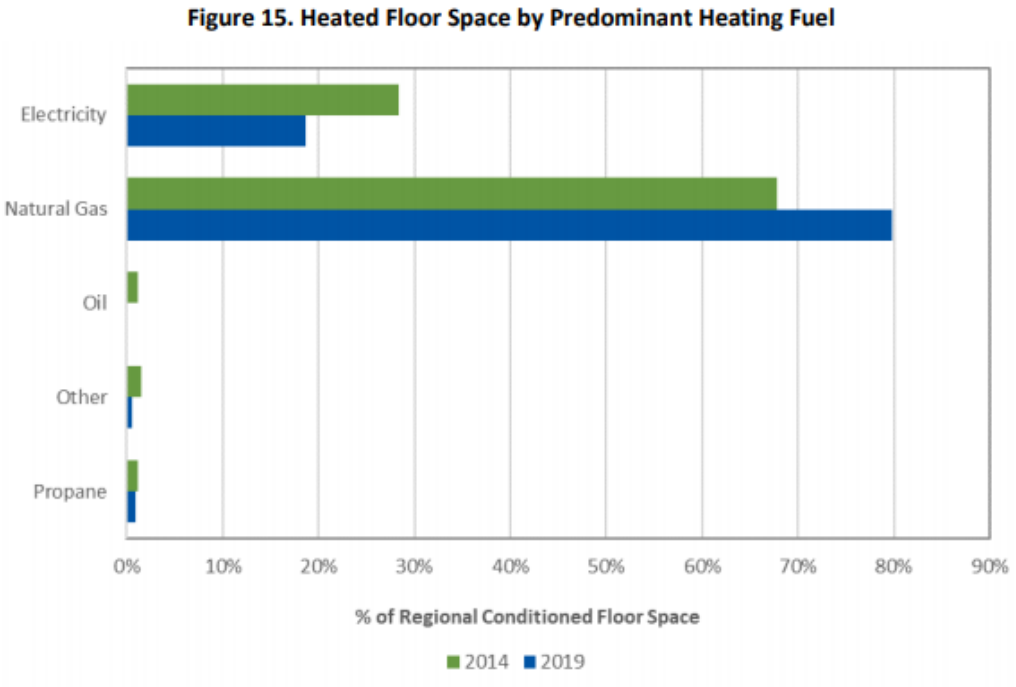
Space Heating Efficiency by State

- Furnace efficiencies vary greatly across customers
- As these furnaces are replaced, there is a lot of opportunity for energy efficiency gains through more efficient space heating
- Gas-fired heat pumps will further increase space heating efficiency as they enter the market (up to 140% efficient)



Source: NEEA RBSA - Single-Family Homes Report 2016-2017

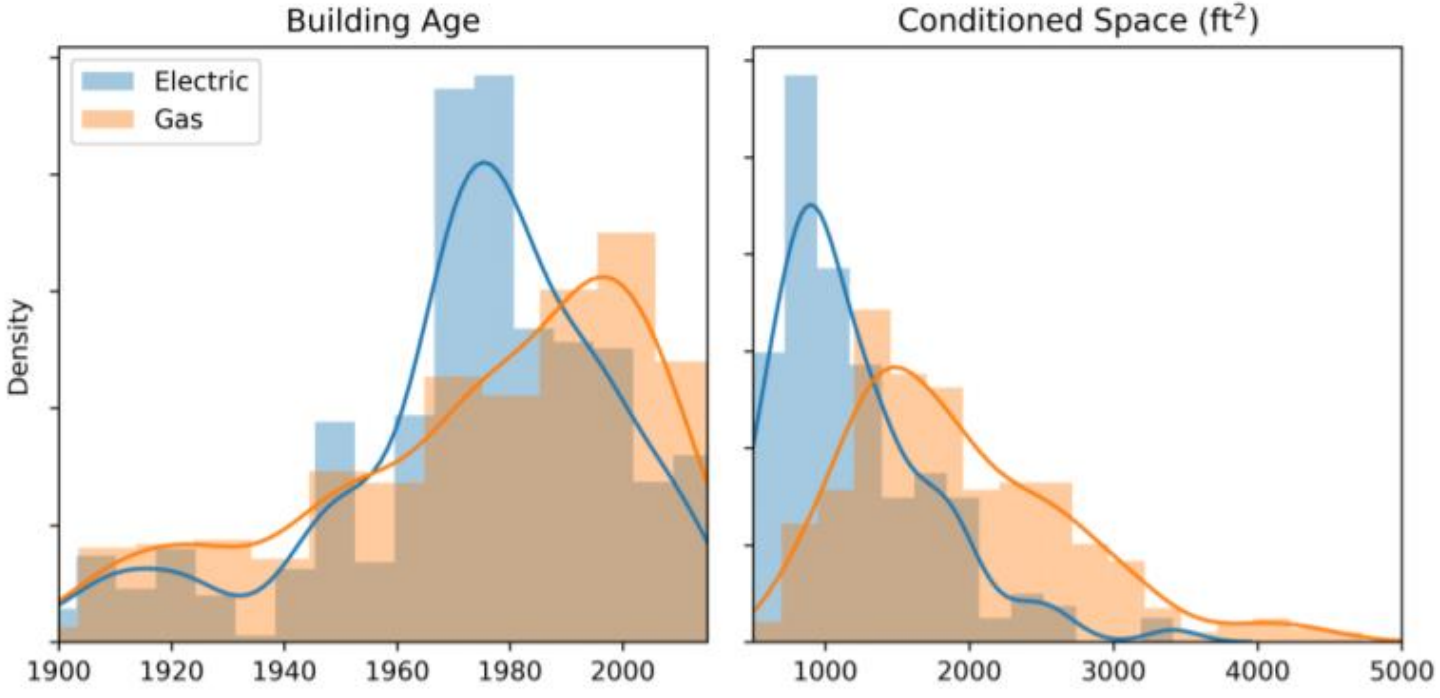
Commercial Space Heating



- There is a significant increase in the commercial business space heated by natural gas since the previous CBSA in 2014
- Most of this change is due to a new sample design for the CBSA, which sampled more retail business and less office space
- However, both the 2014 and 2019 CBSA indicate that the current commercial building stock relies mostly on natural gas as the primary space heating fuel

Source: NEEA CBSA – Commercial Building Stock Assessment 4 (2019) Final Report; Figure 15

Space Heating Needs Served by Direct Use

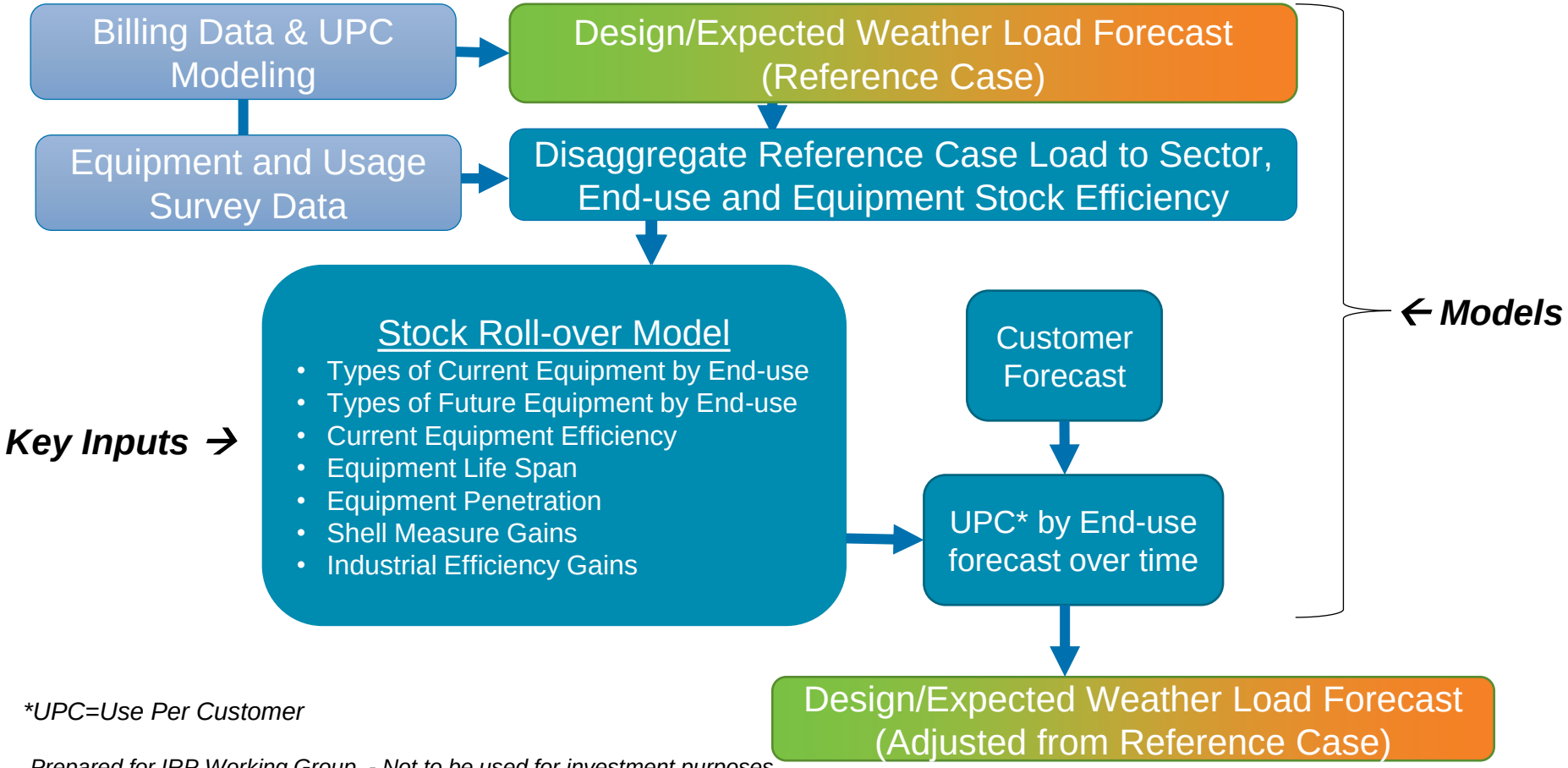


End-use Load Forecasting Process

End-use Forecasting Methodology

- **Adjustments always begin with the reference case (i.e., statistically driven models)**
  - This reference case will represent a forecast based on historical trend models
- **Changes in customer additions can be reflected through adjustments on segments of the customer count forecast**
  - New construction, conversions, residential, commercial
- **Changes in equipment penetration can be reflected through NW Natural's stock roll-over model**
  - The stock roll-over model relies on a forecast of historical trends
  - Start with reference case, customer count forecast, and existing end-use equipment efficiency within the building stock
  - Uses assumptions of equipment replacement and calculates the impacts on load from the penetration of various equipment types and equipment efficiencies
  - End-use load forecasting is necessarily assumption driven

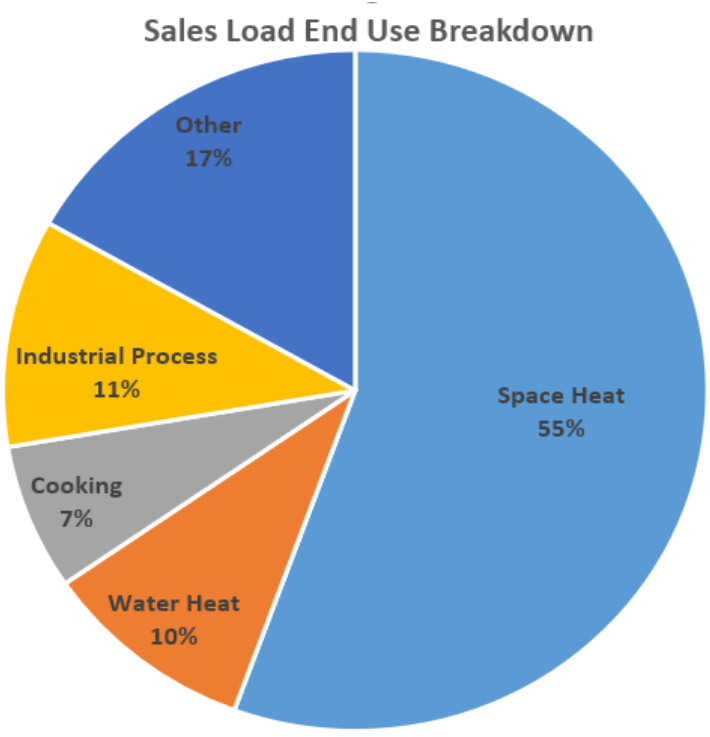
End-use Forecasting Flow Diagram



*UPC=Use Per Customer

Sales by End-use

- Roughly 2/3 of gas delivered is to sales customers
- Space heating drives sales load, accounting for more than half of sales load
- The average efficiency of the installed equipment within the building stock is a major determinant of the load within each end-use category
- The average efficiency is determined by the make up of the equipment in the building stock
- Newly installed equipment, typically replaced when old equipment dies or installed for new customers, changes the average efficiency over time



Space Heating Equipment Example	Relative Efficiencies
Furnace Stock Efficiency (2019)	87.4%
High Efficiency Furnace Install	95%
Gas-fired Heat Pump	140%
Dual Fuel System	TBD

End-Use Load Disaggregation- Residential Example

End Use	Time Period	All Customer Annual Average Usage	Annual Average Usage by Customers who Have Space or Water Heating	All Customer Average Peak Share of Annual Usage
Primary Space Heating	Normal Weather Annual Usage	494	565	0.768719
	Peak Day	7.26	8.31	0.011311
	Peak Hour	0.356	0.407	0.000554
Water Heating	Normal Weather Annual Usage	117	176	0.181856
	Peak Day	0.38	0.57	0.000592
	Peak Hour	0.025	0.038	0.000039
Other Load	Normal Weather Annual Usage	32	N/A	0.049425
	Peak Day	0.410	N/A	0.000639
	Peak Hour	0.021	N/A	0.000032
Total	Normal Weather Annual Usage	642	N/A	1.000000
	Peak Day	8.05	N/A	0.012541
	Peak Hour	0.401	N/A	0.000625

Share of NW Natural customers who use natural gas as the primary fuel:

	Primary Space Heating	Water Heating
NW Natural	**87.4%**	**66.3%**

Stock Rollover – Residential Space Heating Example

	Burnout Replacement	New Construction	Total Installs	Average Install Efficiency	Stock Efficiency
2005	17,506	13,946	31,452	88%	
2006	18,055	13,711	31,766	88%	
2007	18,490	10,876	29,366	88%	
2008	18,780	7,262	26,043	90%	
2009	18,941	4,018	22,959	90%	
2010	19,113	4,286	23,399	90%	
2011	19,264	3,792	23,057	90%	
2012	19,436	4,303	23,739	92%	
2013	18,284	4,919	23,202	92%	
2014	20,904	6,232	27,137	92%	
2015	21,534	6,579	28,112	92%	
2016	22,062	7,029	29,091	92%	
2017	24,358	8,486	32,844	92%	
2018	24,034	7,673	31,706	92%	
2019	24,193	7,970	32,163	92%	
2020	28,334	6,650	34,984	93%	87%

- **With the estimated equipment installs in a given year and the end-use disaggregation the impact of assuming a change in install efficiencies/ technologies can be incorporated into the load forecast**
- **Questions like the following can be answered- what would be the impact on load if 25% of installations going forward were natural gas-powered heat pumps?**

Stock Roll-over Model

Start with standard use per customer regression analysis

- Forecasts are based on past observations
- Residential and commercial customer counts are an input to the model
- Disaggregate the use per customer total to end-use

Anticipation that history may not be the best predictor of future use

- Executive Order
- New technologies
- New codes and standards

End-use load forecasting can modify econometric forecasts for expectations around:

- Efficiency and penetration of end-use equipment for sales customers
- Codes and Standards implemented (building shell improvements)
- Improvements in industrial process efficiency

Levers in the Stock Roll-over Model for Reference Case Adjustment

Current Stock Roll-over Model Levers

Equipment Penetration and Efficiency

Residential

- Space Heating
- Water Heating

Commercial

- Space Heating
- Water Heating

Shell Improvement

Incremental Industrial Load Efficiency

- Stock-rollover model will forecast load based on the equipment life and efficiency
- Equipment Penetration and Shell improvement will impact the use per residential and commercial customer
- Incremental industrial energy efficiency will impact the whole industrial sector

Gas Heat Pumps – GHPs

Performance: Exceeding 100% Efficiency

Demonstration Highlights:

Residential

Water Heater (>1.20 UEF)

- **54% energy savings**[1]

Space and Water Heating/"Combi" (>140% AFUE)

- **45% energy savings**, including operation at -30ºF w/o backup heat[2]

Commercial

Hot Water/Boiler (>130% TE)

- **53% therm savings** (hot water) *and* 14% kwh savings w/A/C[3]

Internal combustion engine driven VRF (>1.50 $COP_{heating}$ >1.40 $COP_{cooling}$)

- Successful operation in both warm and cold climates[4]

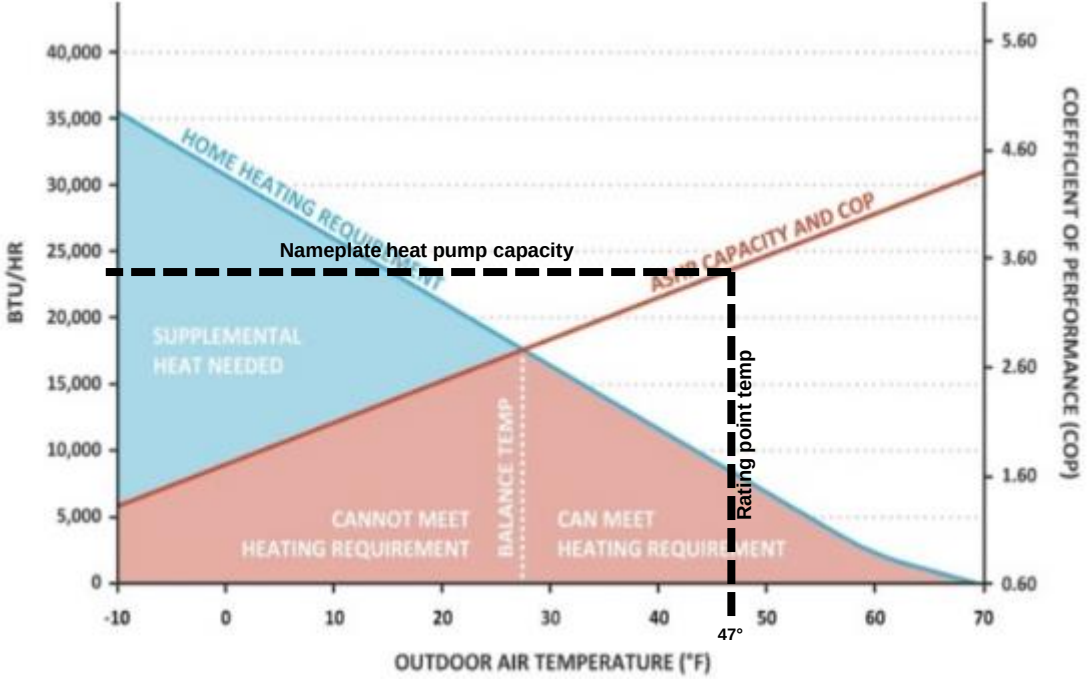
Rooftop Unit (>1.30 $COP_{heating}$ @ 47ºF)

- Cold-climate testing indicates only 5% capacity reduction at 5ºF[4]

For more information: 1) Glanville, P.et al. (2020) Integrated Gas-fired Heat Pump Water Heaters for Homes: Results of Field Demonstrations and System Modeling, ASHRAE Transactions; Vol. 126 325-332.; 2) Glanville, P. et al. (2019) Demonstration and Simulation of Gas Heat Pump-Driven Residential Combination Space and Water Heating System Performance, ASHRAE Transactions; Vol. 125 264-272.; 3) Glanville, P. Innovative Applications of Thermal Heat Pumps in Multifamily Buildings and Restaurants, Presented at the ACEEE 2020 Hot Water Forum.; 4) GTI & Brio, Gas Heat Pump Technology and Market Roadmap, 2019.

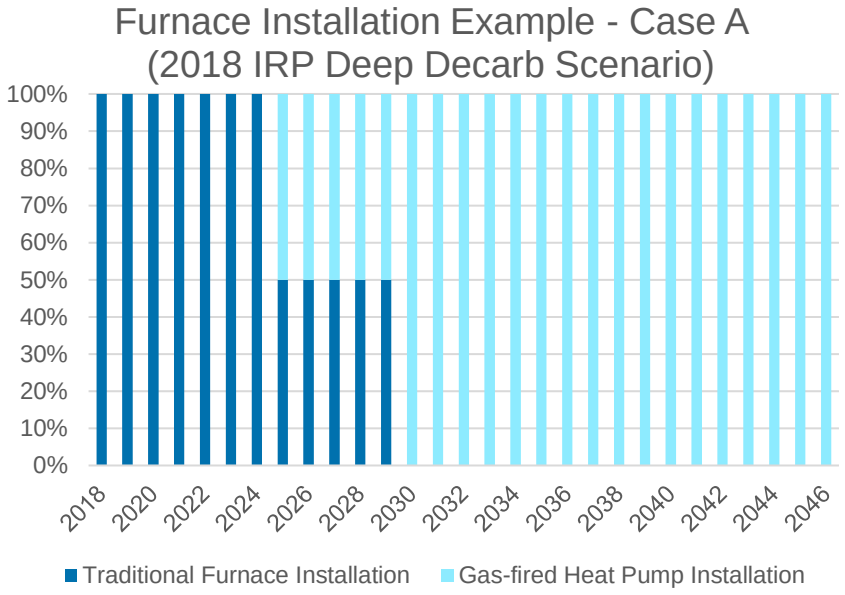
Dual-Fuel Heat Pumps-

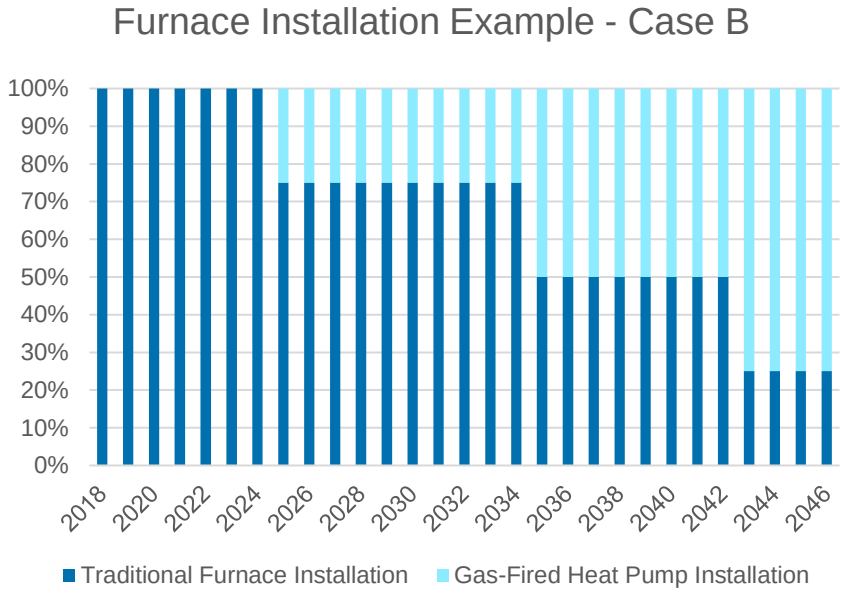
Electric heat pump with direct use natural gas backup furnace for peak periods



- Electric heat pumps are efficient, but efficiencies decline as temperature decreases
- To maximize annual efficiency and maintain comfort, electric heat pumps almost always have a backup system for cold temperatures – particularly ducted systems which are dominant in single-family homes
- An electric resistance furnace is the most common cold weather backup if a gas furnace is not used
- A system with electric resistance backup is inefficient during cold periods, which contributes large peaks to utility loads and is expensive for customers

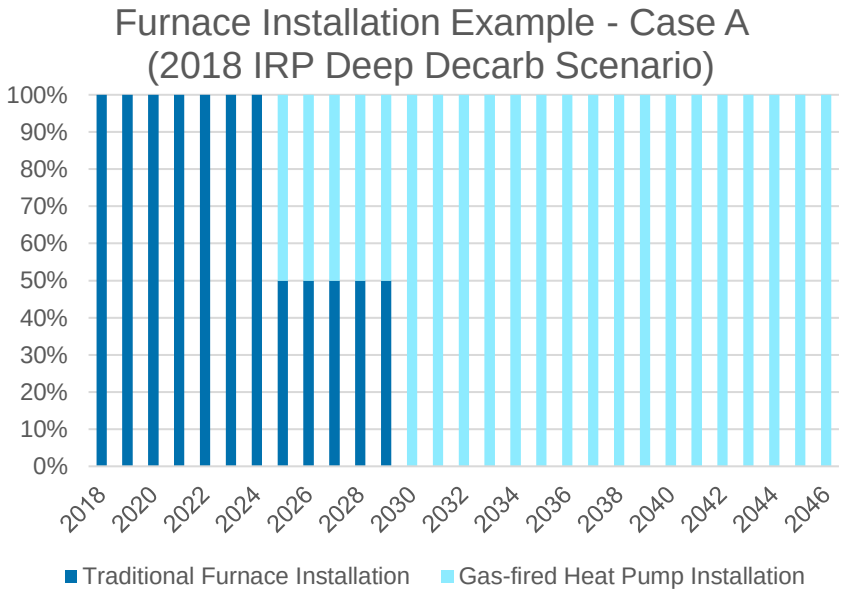
Space Heating Mix – Examples

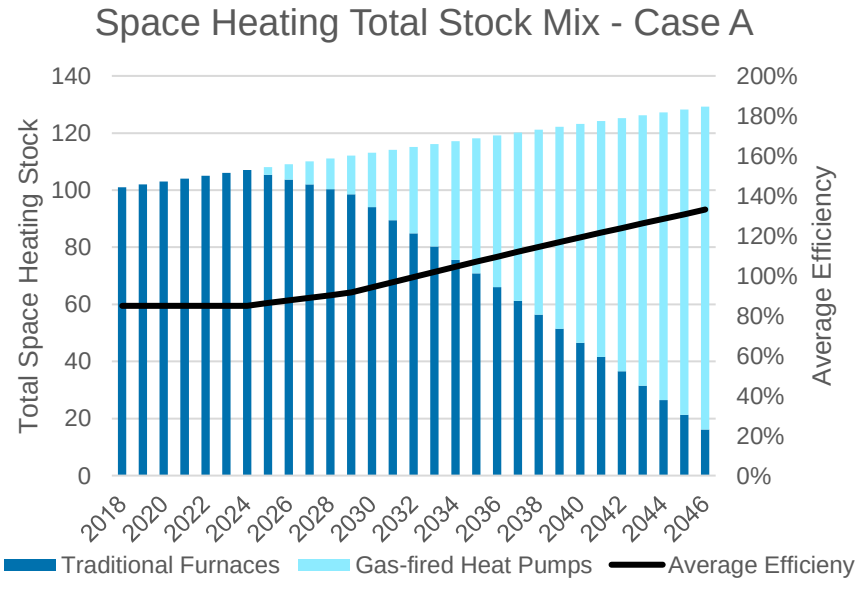




- Graphs are showing a potential percentage mix of newly installed equipment
- This includes both new construction **and** replacement on burnout installation of space-heating equipment
- Less gas delivered in Case A due to increased efficiency of new installations as compared to Case B

Space Heating Mix – Examples





- As the new equipment is installed, the total stock mix and average efficiency of equipment providing energy services within the building stock changes slowly over time
- This type of change in equipment efficiency is not being captured by our statistical models
- End-use load forecasting methodology starts with the reference case, but can account for shifts in emerging technology and equipment penetration

Lunch Break
(back at 12:30pm)

Key Inputs to Modeling

Important Concepts

- **End-use load forecasting still relies on previous models to develop the reference case and implements a stock roll-over model to obtain estimated use per customer by sector and end-use**
- **The stock roll-over model is the tool to adjust the reference case to reflect shifts from historical trends**
  - For a given sector and end-use, the reference case can become the forecast (either for the base case or a scenario) if no shifts from historical trends are expected
  - The stock roll-over model gives us the flexibility to incorporate potential shifts caused by fundamental changes in policy
- **While being a more flexible tool to make adjustments to the reference case, the stock roll-over requires assumptions regarding key inputs**
  - Adoption rates of new or more equipment
  - Equipment life span
  - Assumptions about improvement in building shells and/or industrial process efficiency gains
- **The IRP process, engagement with stakeholders, input from subject matter experts, and data analytics will help guide these key assumptions to develop load forecasts**

Key Assumptions from 2018 IRP Scenarios

		Base Case Demand Sensitivities			Statistical Load Sensitivities		Environmental Policy Sensitivities			
		1	2	3	4	5	6	7	8	9
		Base Case - No New Regional Pipeline	New Regional Pipeline in 2025 - Fully Subscribed	New Regional Pipeline in 2025 - Excess Capacity	High Customer Growth	Low Customer Growth	Use Social Cost of Carbon in Resource Planning	Deep Decarbonization	CNG Adoption in Medium- and Heavy-Duty Transportation	New Direct Use Gas Customer Moratorium in 2025
Demand-Side Assumptions	Customer Growth	Expected (Statistical Trend Continuation)			High 90% Confidence Interval	Low 90% Confidence Interval	Expected (Statistical Trend Continuation)		Expected Res and High Comm and Ind CNG	No new direct use customers allowed after 2025
	Space Heat Equipment	Expected (Trend Continuation Plus Adjustment for Energy Trust Energy Efficiency Savings Projection)			Expected (Trend Continuation Plus Adjustment for Energy Trust Energy Efficiency Savings Projection)		Newly installed units [illegible] Powered Heat Pumps in 2025 and 50% in 2030	Newly installed units [illegible]% Natural Gas [illegible]ed Heat Pumps in 2025 and 100% GHP in 2030	Trend Continuation Plus EE Savings Projection	Trend Continuation Plus EE Savings Projection for Existing Customers
	Water Heating Equipment						New units 25% Nat Gas Heat Pump WH in 2025 and 50% GHPWH in 2030	[illegible] units 50% Nat Gas Heat Pump WH in 2025 and 100% GHPWH in 2030	Trend Continuation Plus Adjustment for Energy Trust Energy Efficiency Savings Projection	
	Industrial Load Efficiency						25% Increase in Industrial Efficiency	50% Increase in Industrial Use Efficiency	Trend Continuation	
	Building Shell Improvement	Shell Related Savings in Energy Trust Energy Efficiency Savings Projection			Shell Related Savings in Energy Trust Energy Efficiency Savings Projection		High CO2 Price Sensitivity Energy Efficiency Savings	Aggressive Shell Savings	Shell Related Savings in Energy Trust Energy Efficiency Savings Projection	
Supply-Side Assumptions	Regional Interstate Pipeline Expansion	No new regional interstate pipeline in Planning Horizon	Regional Pipeline Project in 2025 - Fully Subscribed	Regional Pipeline Project in 2025 - Excess Capacity	No new regional interstate pipeline in Planning Horizon		No new regional interstate pipeline in Planning Horizon			
	Renewable Natural Gas	Base Case Assumptions			Base Case Assumptions		Base Case Assumptions	Policy, Market, and Costs Attractive for Direct Use RNG	Continuation of Federal Transportation RNG Policy	Base Case Assumptions
	Power-to-Gas Hydrogen							Policy, Market, and Costs Attractive for PtG	Base Case Assumptions	
	Carbon Pricing						Social Cost of Carbon	High Sensitivity		

Key Inputs

Stock-roll over model

Key Demand-side Inputs Needed for End-use Load Forecasting

		2018 IRP Base Case Assumptions	2022 IRP Base Case Assumption	Growth Scenarios	Environmental Policy Scenarios
Demand-Side Assumptions	Customer Growth	Expected (Statistical Trend Continuation)	TBD		
	Space Heat Equipment	Expected (Trend Continuation Plus Adjustment for Energy Trust Energy Efficiency Savings Projection)			
	Water Heating Equipment				
	Industrial Load Efficiency				
	Building Shell Improvement	Shell Related Savings in Energy Trust Energy Efficiency Savings Projection			

Preview for next time: Emission Considerations

		Base Case Demand Sensitivities			Statistical Load Sensitivities		Environmental Policy Sensitivities			
		1	2	3	4	5	6	7	8	9
		Base Case - No New Regional Pipeline	New Regional Pipeline in 2025 - Fully Subscribed	New Regional Pipeline in 2025 - Excess Capacity	High Customer Growth	Low Customer Growth	Use Social Cost of Carbon in Resource Planning	Deep Decarbonization	CNG Adoption in Medium- and Heavy-Duty Transportation	New Direct Use Gas Customer Moratorium in 2025
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	Water Heating Equipment						New units 25% Nat Gas Heat Pump WH in 2025 and 50% GHPWH in 2030	New units 50% Nat Gas Heat Pump WH in 2025 and 100% GHPWH in 2030	Trend Continuation Plus Adjustment for Energy Trust Energy Efficiency Savings Projection	
	Industrial Load Efficiency						25% Increase in Industrial Efficiency	50% Increase in Industrial Use Efficiency	Trend Continuation	
	Building Shell Improvement	Shell Related Savings in Energy Trust Energy Efficiency Savings Projection			Shell Related Savings in Energy Trust Energy Efficiency Savings Projection		High CO2 Price Sensitivity Energy Efficiency Savings	Aggressive Shell Savings	Shell Related Savings in Energy Trust Energy Efficiency Savings Projection	
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	Renewable Natural Gas	Base Case Assumptions			Base Case Assumptions		Base Case Assumptions	Policy, Market, and Costs Attractive for Direct Use RNG	Continuation of Federal Transportation RNG Policy	Base Case Assumptions
	Power-to-Gas Hydrogen							Policy, Market, and Costs Attractive for PtG	Base Case Assumptions	
	Carbon Pricing						Cost of Carbon Compliance			

Key Inputs

Carbon Compliance will need to be modeled as a constraint and not a cost

Discussion

Questions/Feedback

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