Load Forecast for the 2022 IRP- Technical Working Group

TWG #2- Load Forecast
February 11, 2022

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Forward Looking Statement

This and other presentations made by NW Natural from time to time, may contain forward-looking statements within the meaning of the U.S. Private Securities Litigation Reform Act of 1995. Forward-looking statements can be identified by words such as “anticipates,” “intends,” “plans,” “seeks,” “believes,” “estimates,” “expects” 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.

Today's Agenda

1. **Procedures and Introductions**
2. **Background and Framing**
   - TWG 1 Recap
   - Load Forecasting Context
   - Weather Models
3. **Reference Case Load Forecast**
   - Peak Day Forecast
   - Annual Load Forecast
     - Customer Count
     - Use Per Customer
     - Energy Efficiency
     - Final Reference Case Forecast by Sector
4. **Accounting for Uncertainty**
   - Load Scenarios
   - Stochastic Simulations

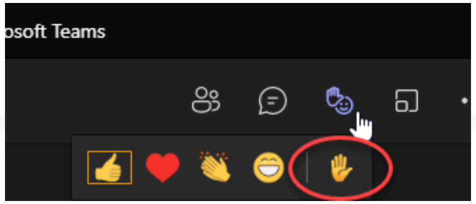
Procedures for Participation

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

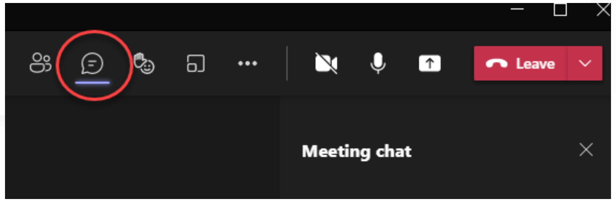
- Cameras are optional and up to each participant to use
- All participant cameras are set to off upon entry into the meeting

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

Raised hand function is found in the reactions

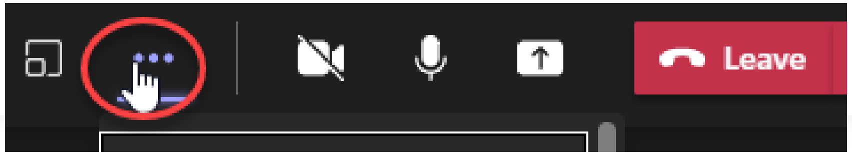


Chat box will open when you click on the conversation bubble



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

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



Take 2 Minutes for Safety:

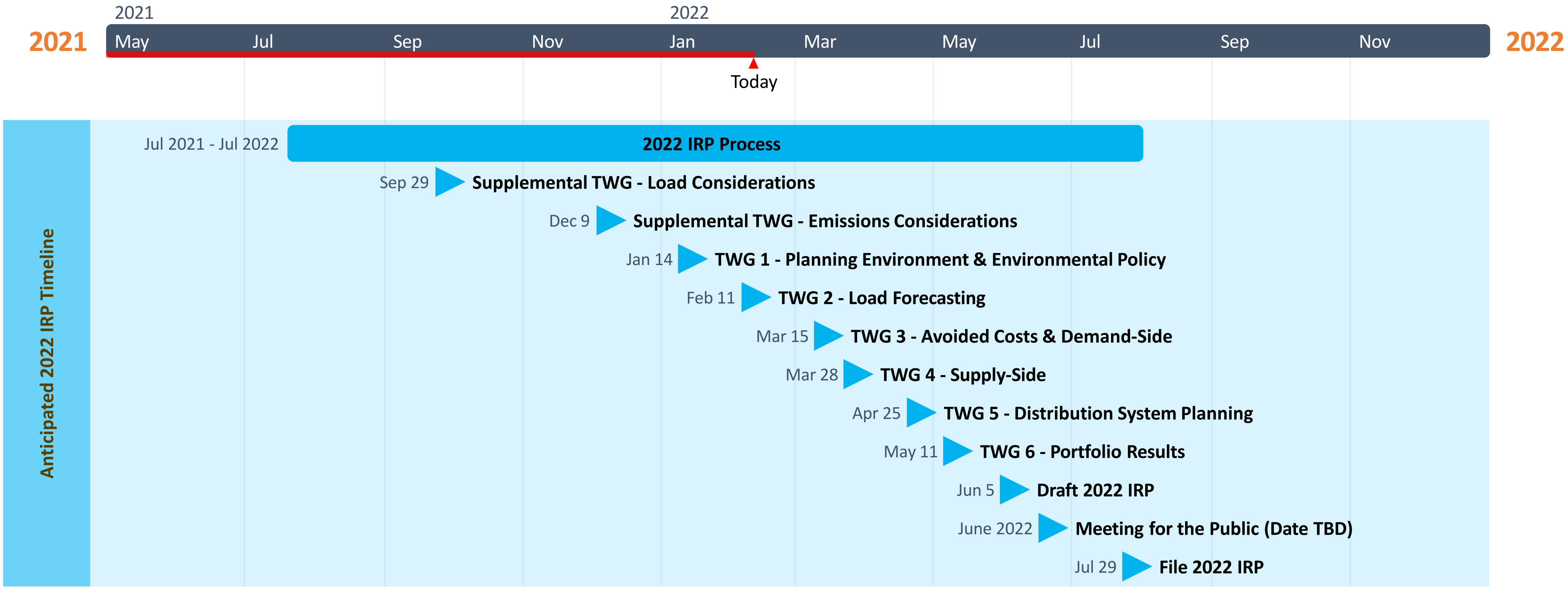
Working Safely in Cold Weather

Know	Know the wind chill temperature and expected weather conditions before venturing outdoors for work or extended periods of time (more than 15 minutes).
Dress	Dress properly • Wear layers, insulated gloves & boots, and cover your head. • Have extra layers & rain/waterproof gear at hand; Moisture can increase heat loss from the body.
Communicate	Communicate your intended location & route to others before leaving
Recognize/Act	Know how to recognize the symptoms of cold stress & where services are located (vehicle to warm up inside of; indoor heated space; medical services). Be sure to monitor your physical condition for signs of cold exposure

Cold weather can expose those outdoors to cold stress, frostbite, and hypothermia.

Preparation is the key to cold weather safety!

2022 IRP Anticipated Timeline



IRP Process, Objectives, and Evolution

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

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

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

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

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

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

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

Overview of Previous TWG

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

NW Natural 101: Introduction to NW Natural's IRP

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

Planning Environment & Scenario Discussion

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

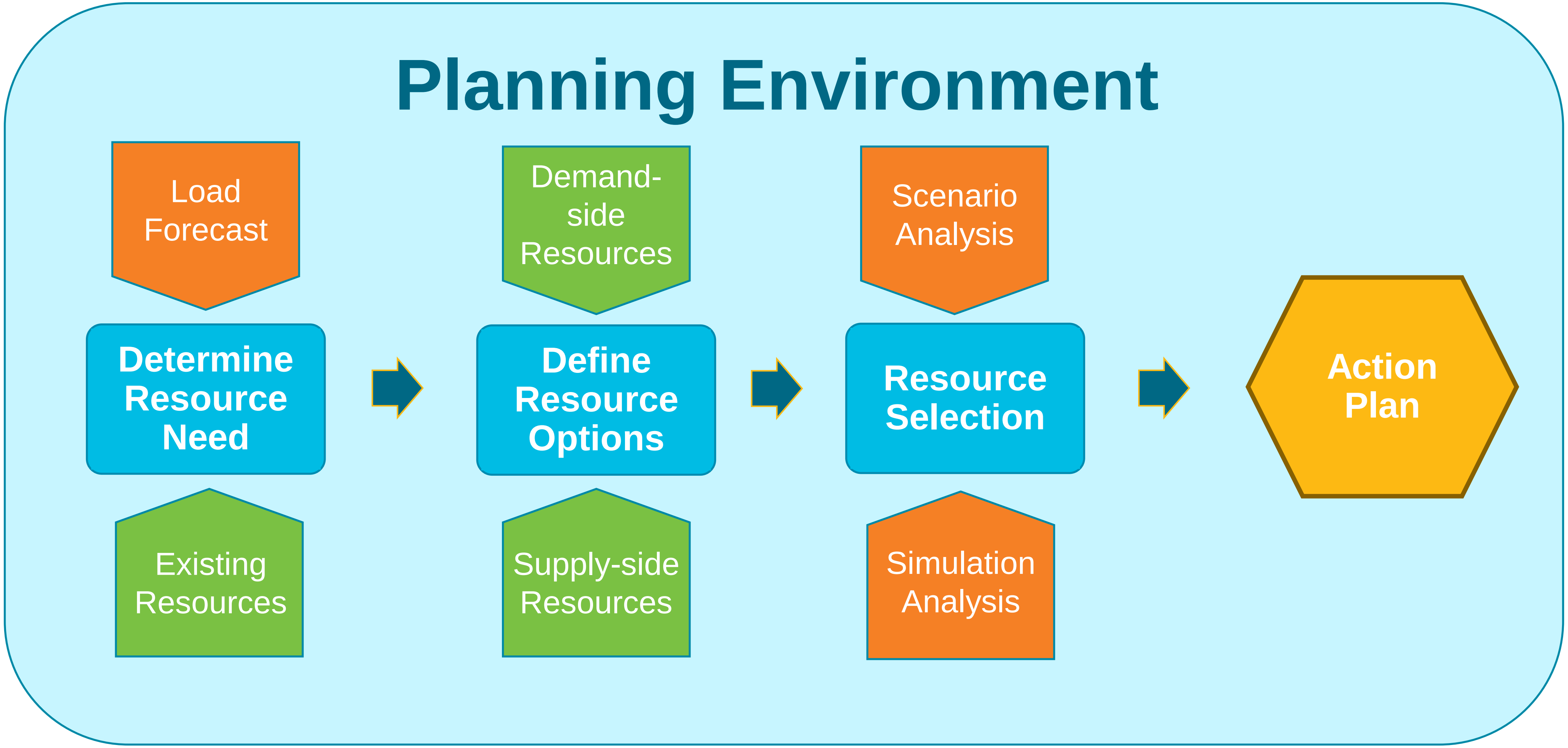
Scenario Analysis Feedback*

	2022 IRP Proposed Scenarios- Summary Version	1 Base Case - Compliance with OR-CPP and SB 98 and WA-CCA	2 Carbon Neutral by 2050	3 New Direct Use Gas Customer Moratorium in 2025	4 Building Electrification	5 RNG and H2 Production Tax Credit	6 Limited RNG Availability	7 Supply-Focused Decarbonization	8 Deep Decarbonization Study-Based
Demand-Side	Customer Growth	Current Expectations		No New Customers After 2025		Current Expectations			
	Space and Water Heating Equipment	Moderate gas powered heat pump and hybrid heating adoption		High electrification of existing residential and small commercial load	Full electrification of existing residential and small commercial load by 2050	Moderate gas heat pump and hybrid heating adoption		No gas powered heat pumps and low levels of hybrid heating	Increasing gas heat pump and hybrid heating adoption
	Industrial Load Efficiency	Moderate increase	High increase	Moderate increase				Limited increase	Moderate w/ electrification
	Building Shell Improvement	Energy Trust projection	Energy Trust high sensitivity projection	Ajusted Energy Trust projection		Energy Trust projection			100% by 2030
Supply-Side	Renewable Natural Gas	Moderate availability and cost assumption	Moderately-high availability and moderate cost assumption	Moderate availability and cost		Moderate availability and low cost to customers	Low availability and moderately high cost	Moderate availability and cost assumption	Moderate availability and high (stale) cost assumption
	Hydrogen	Moderate blending and dedicated system deployment allowed; moderate cost assumption							Moderate blending allowed; high (stale) cost
OR- Community Climate Investements		Costs and limits defined in CPP rule							
WA- Allowances & Offsets		TBD- Pending Rule Development							

***Orange text indicates assumptions that received stakeholder feedback and adjustments are under consideration**

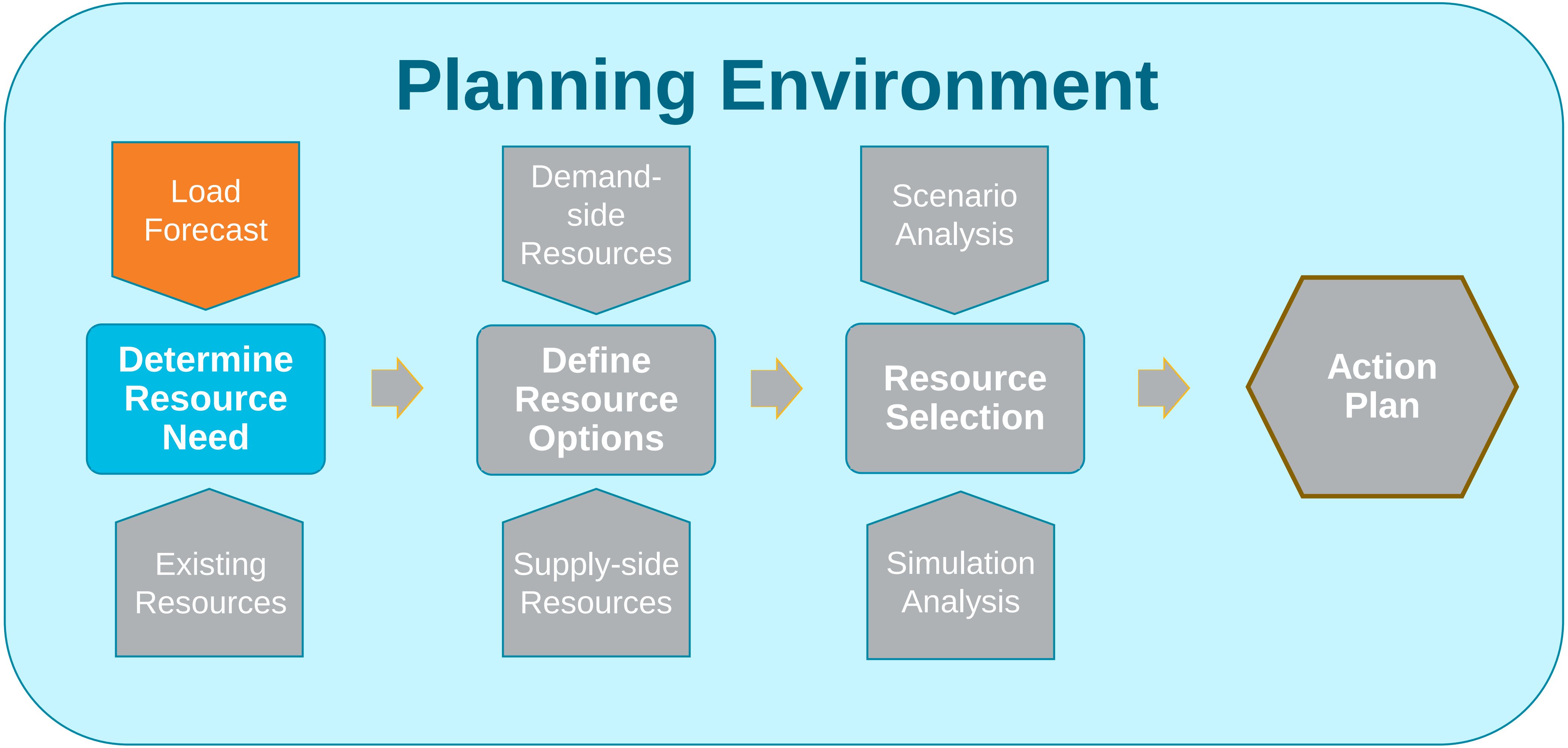
Framing for the 2022 IRP Load Forecast

IRP Process



Green = Resources   Orange = Tools

IRP Process



Green = Resources   Orange = Tools

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

Load Forecasting Framework

- In the past, IRP load forecasts have relied on statistical regression models to project forward historical trends based on historical customer data
  - Our statistical models embed the historical trends for many important demand drivers, for example; customer growth, energy consumption preferences, broad economic impacts, state immigration patterns, customer mix, end-use equipment mix, etc., etc. (*not an exhaustive list*)
- For previous IRPs, these historical trend models have been <u>necessary</u> and <u>sufficient</u> for IRP analysis
  - Typically, these historical trend models established the “base case” or expected load forecast
  - Scenarios and simulated analysis were used understand the impacts of potential futures that deviated from the expected trends

Load Forecasting Framework

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- Statistical models are very useful to understand the trajectory for energy demand based on previous experience and expectations
- For this IRP, statistical forecasting models analyzing historic data are <u>necessary</u>, but not <u>sufficient</u> to represent a "base case" as we have done in previous IRPs
  - For this IRP we will be calling the forecasts generated by statistical models using historical data as the "**reference case**"
  - The reference case provides a *business as usual* or continuation of historical trends and is the starting point to develop load scenarios and simulations to account for uncertainty

Load Forecasting Framework

- The tools needed to make the appropriate adjustments to the reference case and construct an expected load forecast are not new for NW Natural
- Scenarios in the 2018 IRP focused on two important trends that impact our load forecast (Table 7.7 in the 2018 IRP)
  1) <u>Customer Growth</u>
     - Scenarios: 4 (high customer growth), 5 (low customer growth), and 9 (customer moratorium)
  2) <u>Equipment penetration</u> and over-all efficiency for energy services by end-use equipment
     - Scenarios: 6 (social cost of carbon in resource planning), and 7 (Deep Decarbonization)
     - End-use refers to the application of energy services (e.g., space heating, water heating, etc.)
     - We implement a stock roll-over model to analyze how changes in equipment and efficiency impact the load
- Adjustments to the customer growth and end-use equipment through the stock roll-over model can be made to reflect future expectations

Goals and Purpose of Load Forecasting

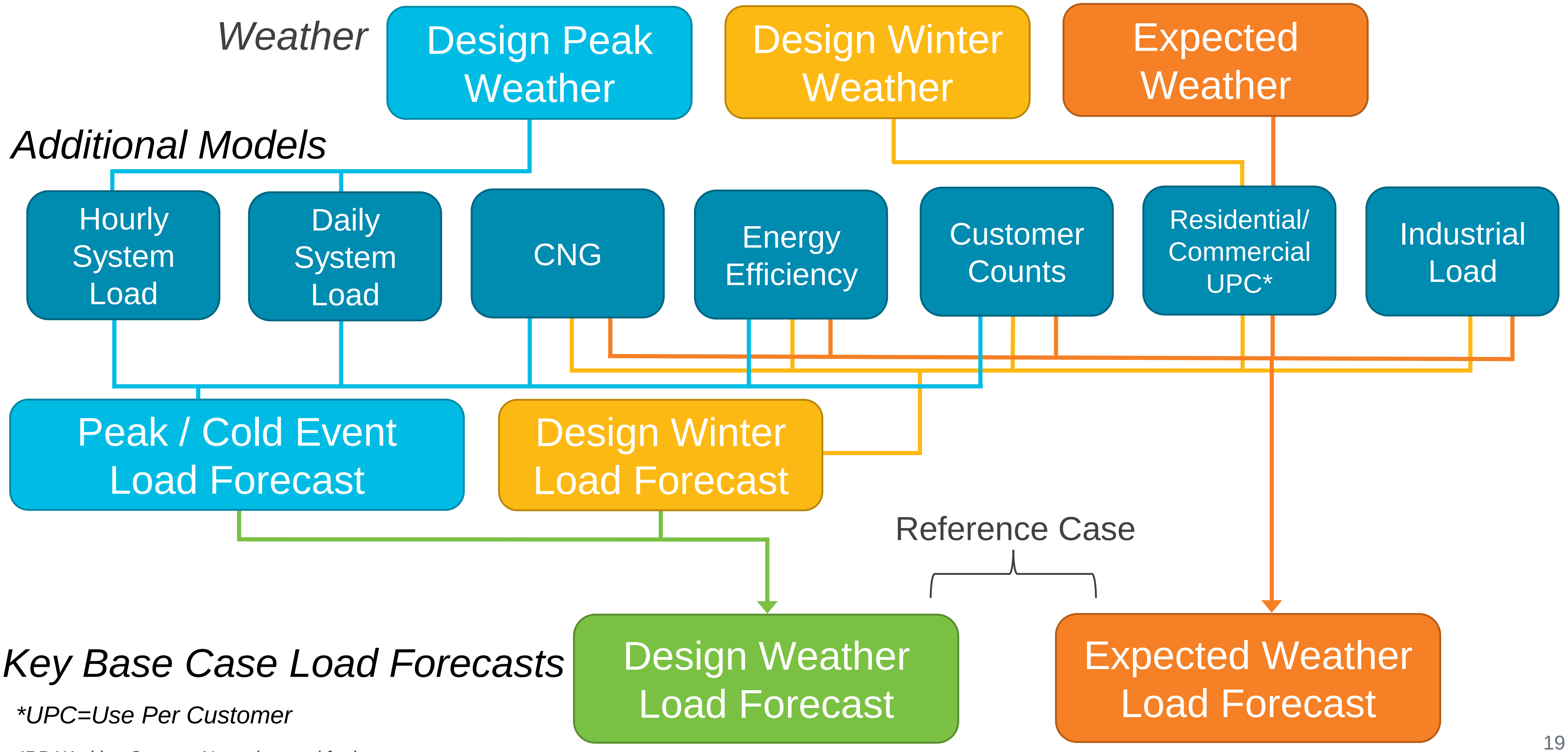
- The goal of load forecasting is to obtain a reasonable prediction of customer demand for energy services
  - Energy services can be met by both demand-side and supply-side resources
- The purpose is to determine the resource requirement based on the forecasted demand
- Resource requirements will need to satisfy three criteria
  - Annual/seasonal demand (energy requirement)
  - Peak demand (capacity requirement)
  - Emissions savings demand (compliance requirement)

Goals and Purpose of Load Forecasting

- One thing that is certain about load forecasting is that it will not be 100% accurate
- Using the best information available to get as close to the bullseye as we can, while keeping modeling process manageable
  - We are always looking to improve our modeling, but must balance model complexity with accuracy and precision
- This requires forecasting at the right level of granularity (e.g., customer segment, sector, state, load center) and allocating where appropriate

Load Forecasting Flow Diagram

Load Forecast Model Flow Chart



**UPC=Use Per Customer*

Load Forecast Model Flow Chart

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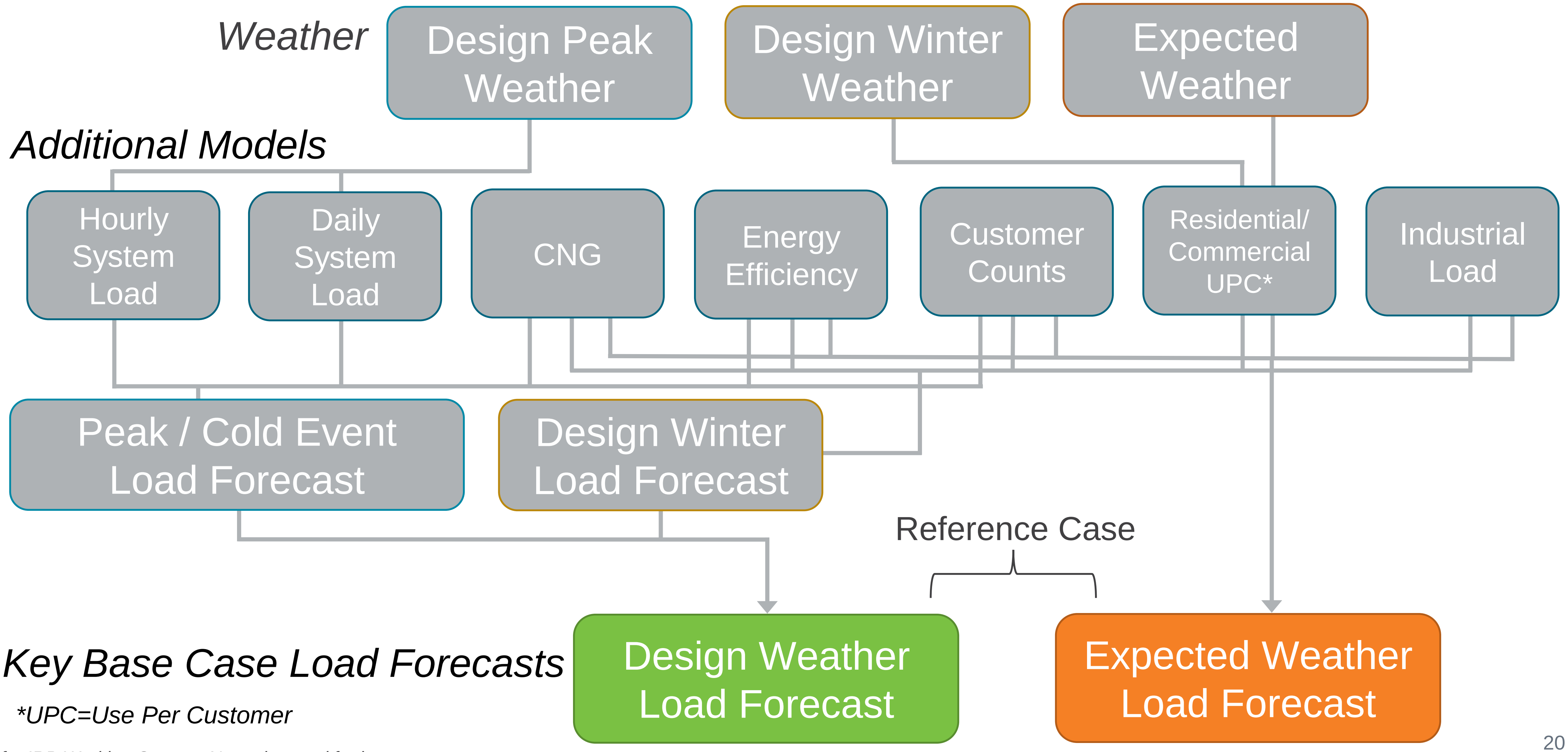

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End-use Forecasting Diagram

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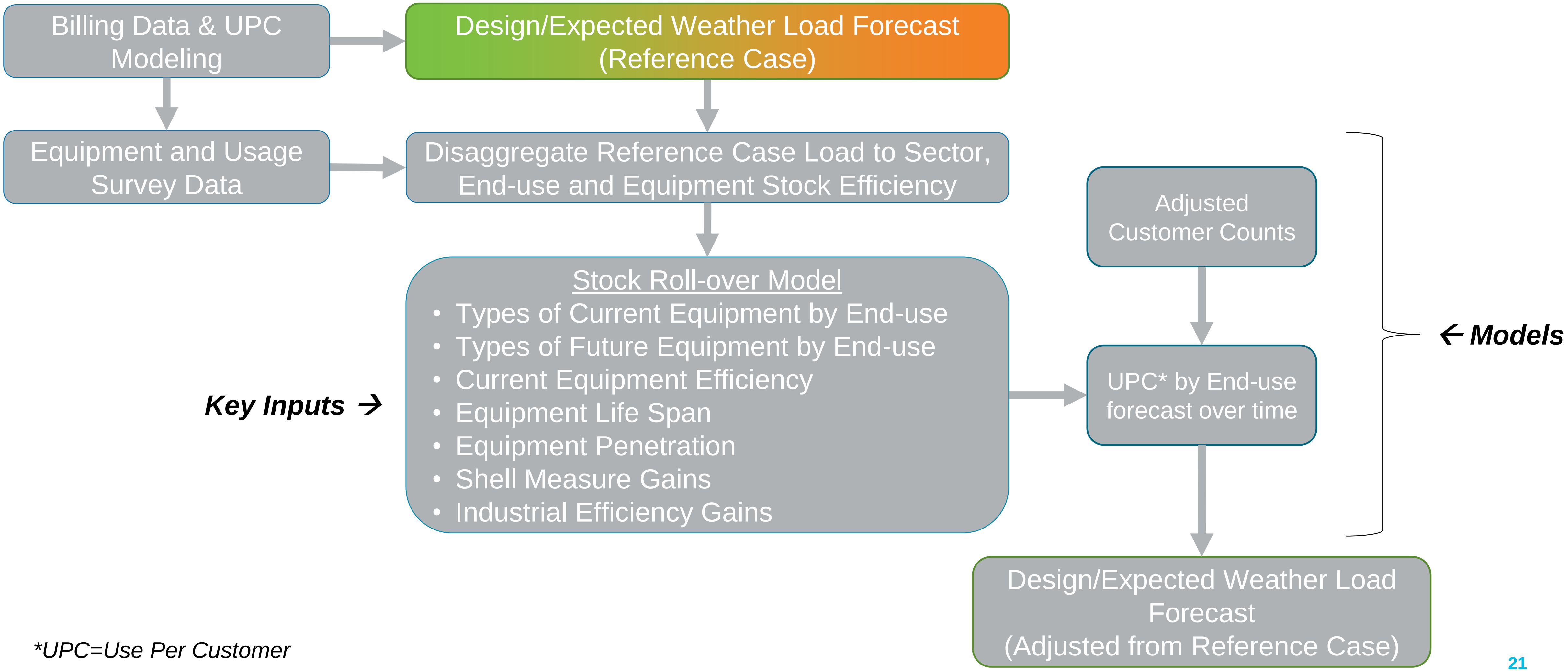

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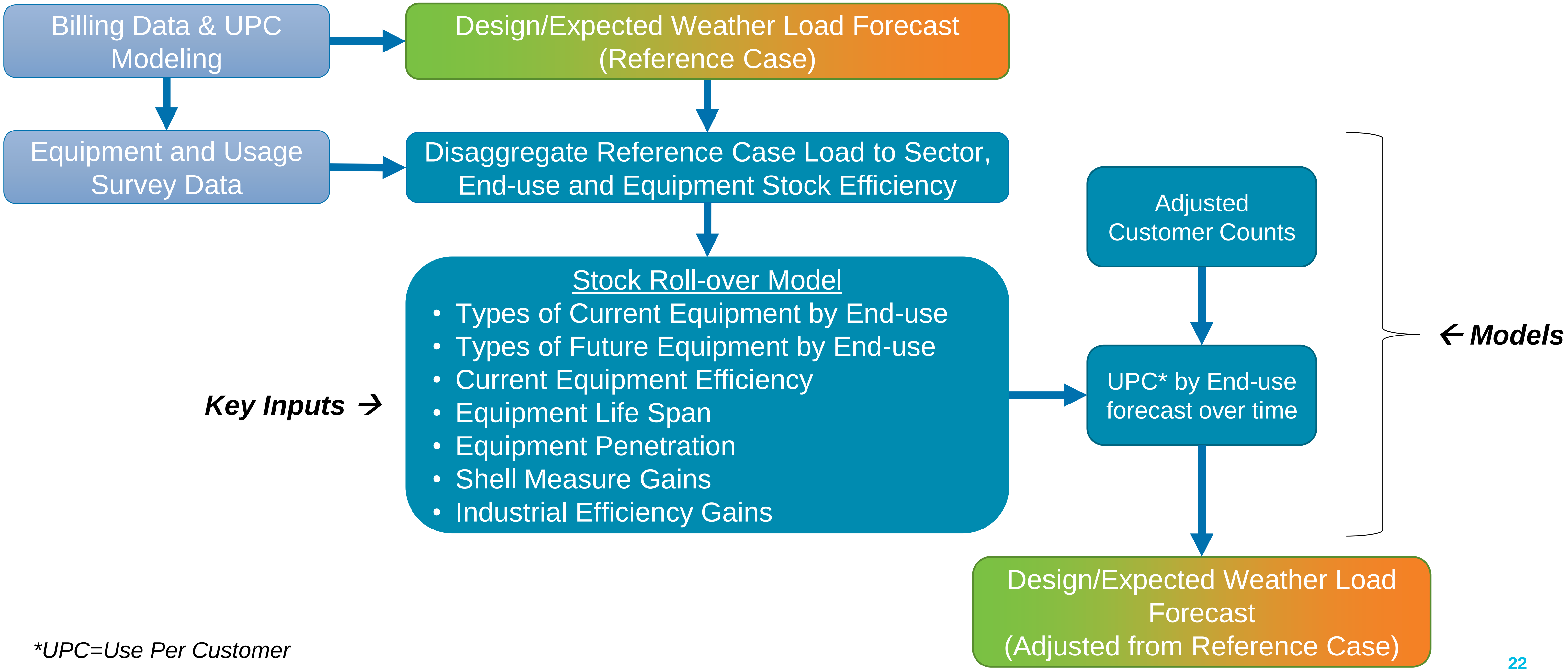
Load Scenarios End-use Forecasting Diagram



*UPC=Use Per Customer

One Big Caveat for Everything Presented Today

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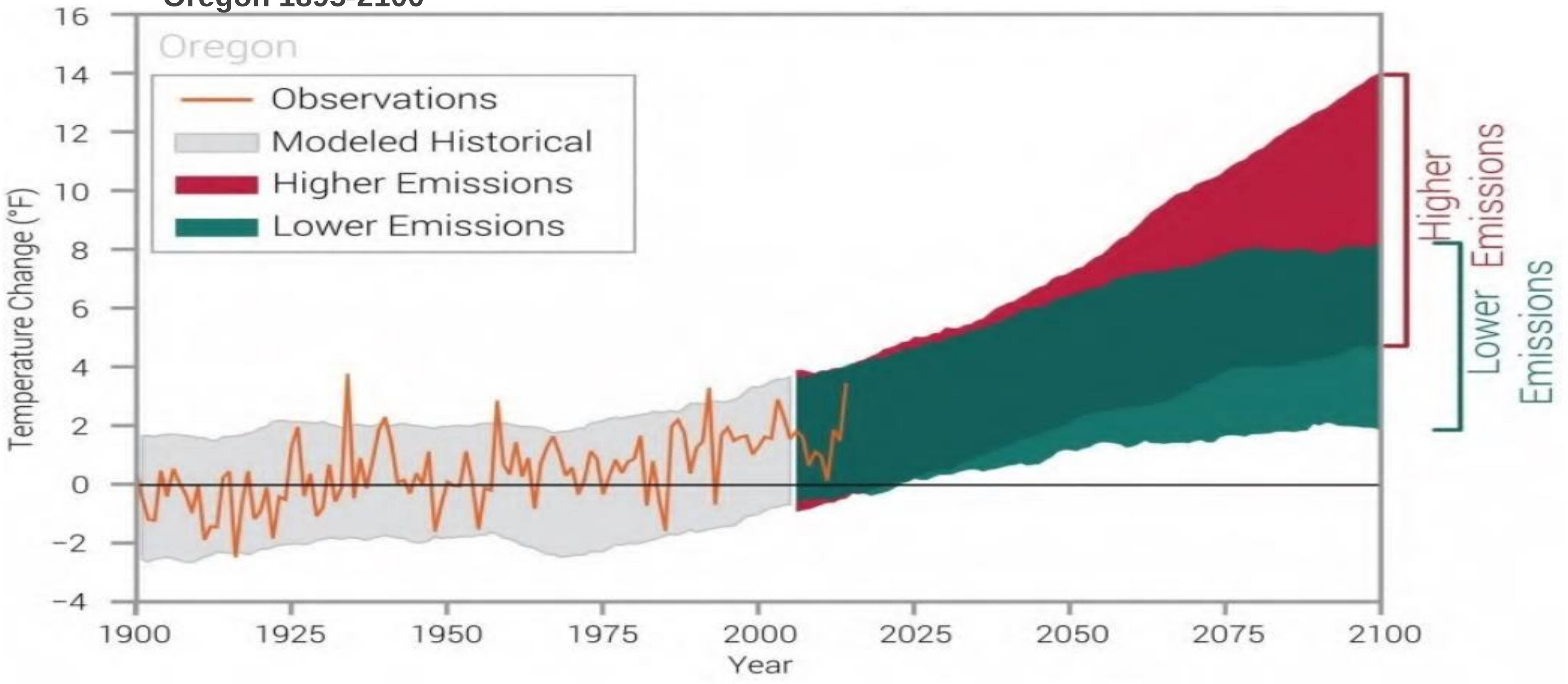
Energy Efficiency

- We are still working with Energy Trust and AEG to develop the energy efficiency forecast, a.k.a. conservation potential assessment (CPA) for Oregon
- The 2022 IRP will also be using the Washington CPA completed by AEG in August of 2021
- Today we will present load forecasts, which incorporate a previous energy efficiency forecast
- We will update these load forecasts for the 2022 IRP to include the updated energy for both Washington and Oregon

Weather Models and Forecast

Annual Temperature Change

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



Source: ODOE 2018 Biennial Energy Report - Chapter 2

Weather Models

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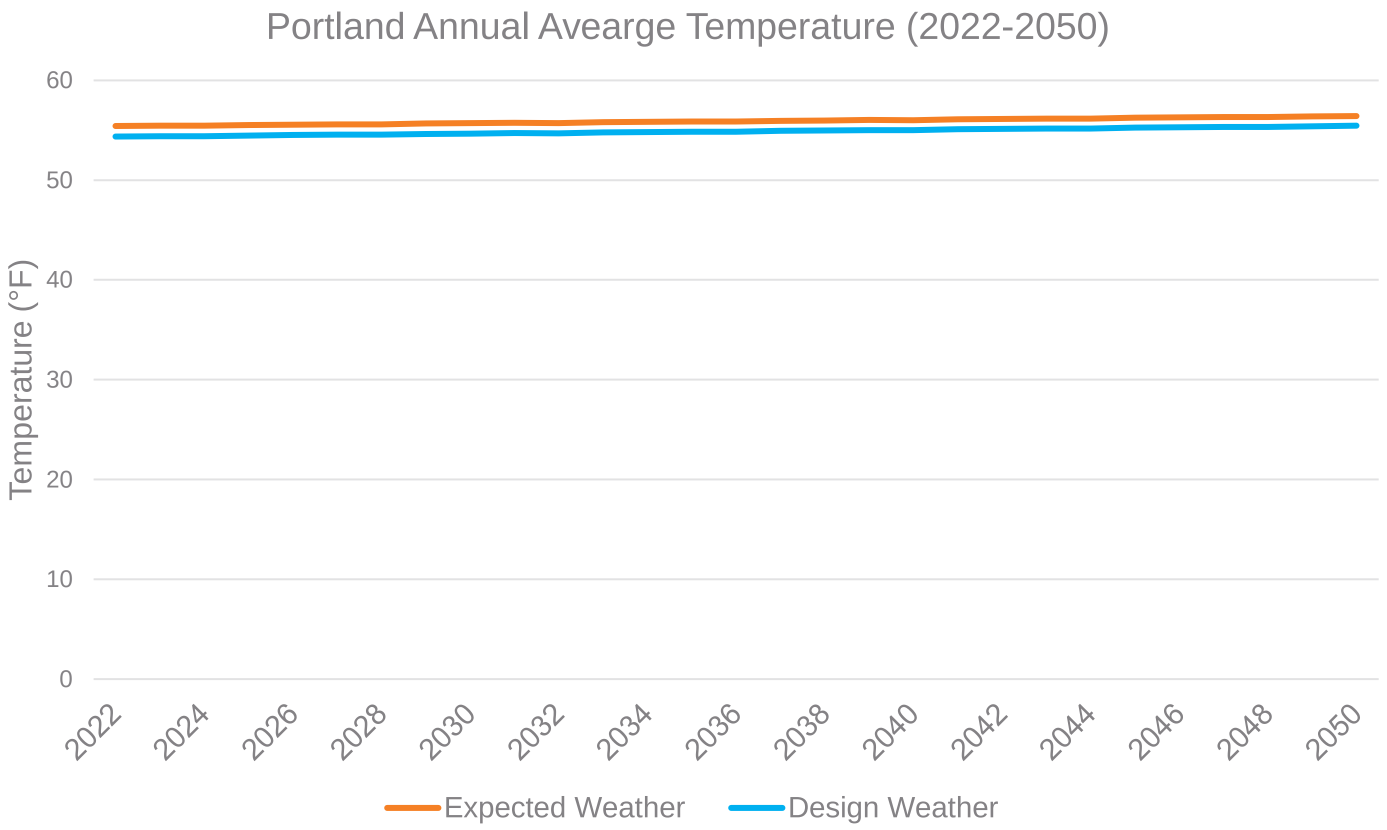
Weather

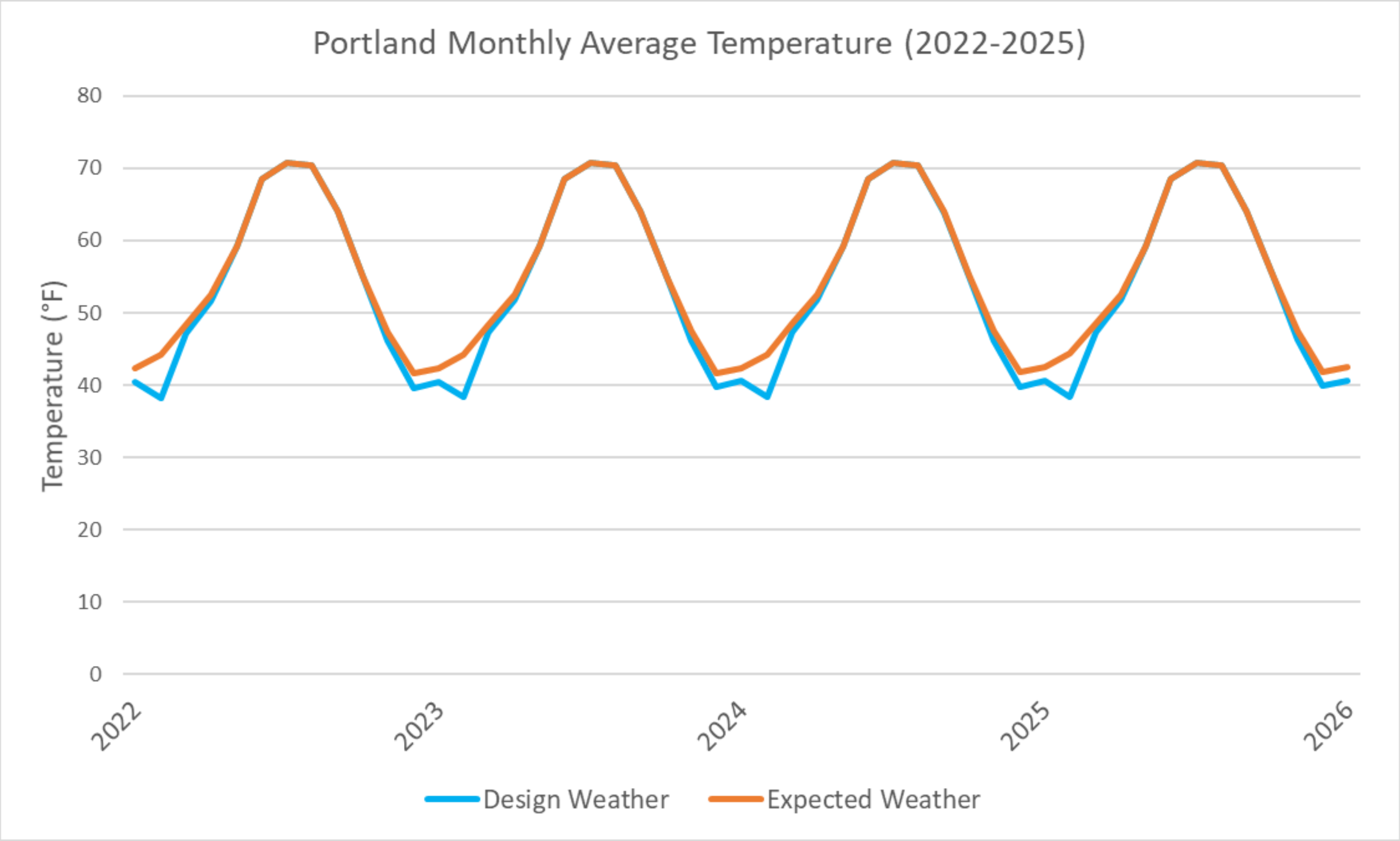
Design Peak Weather	Design Winter Weather	Expected Weather

- Annual HDDs incorporate a climate change trend based on climate models from the Intergovernmental Panel on Climate Change (IPCC)
- Our weather models create daily temperatures for 9 different locations throughout out our service territory
- For each location, monthly HDDs are shaped based on the 30-year average percentage of HDD that fall within that month
- Daily temperatures within a month are shaped based on a corresponding representative historical month for each location
  - Using a representative daily shape creates daily volatility in temperatures, which is important for resource planning
- While annual HDDs are declining into the future, the same temperature shape is applied to each forecast year
- Expected and design winter weather are an input to the use per customer (UPC) model for residential and commercial customers
- Design *peak* weather is forecasted as a simulation for the peak day forecast

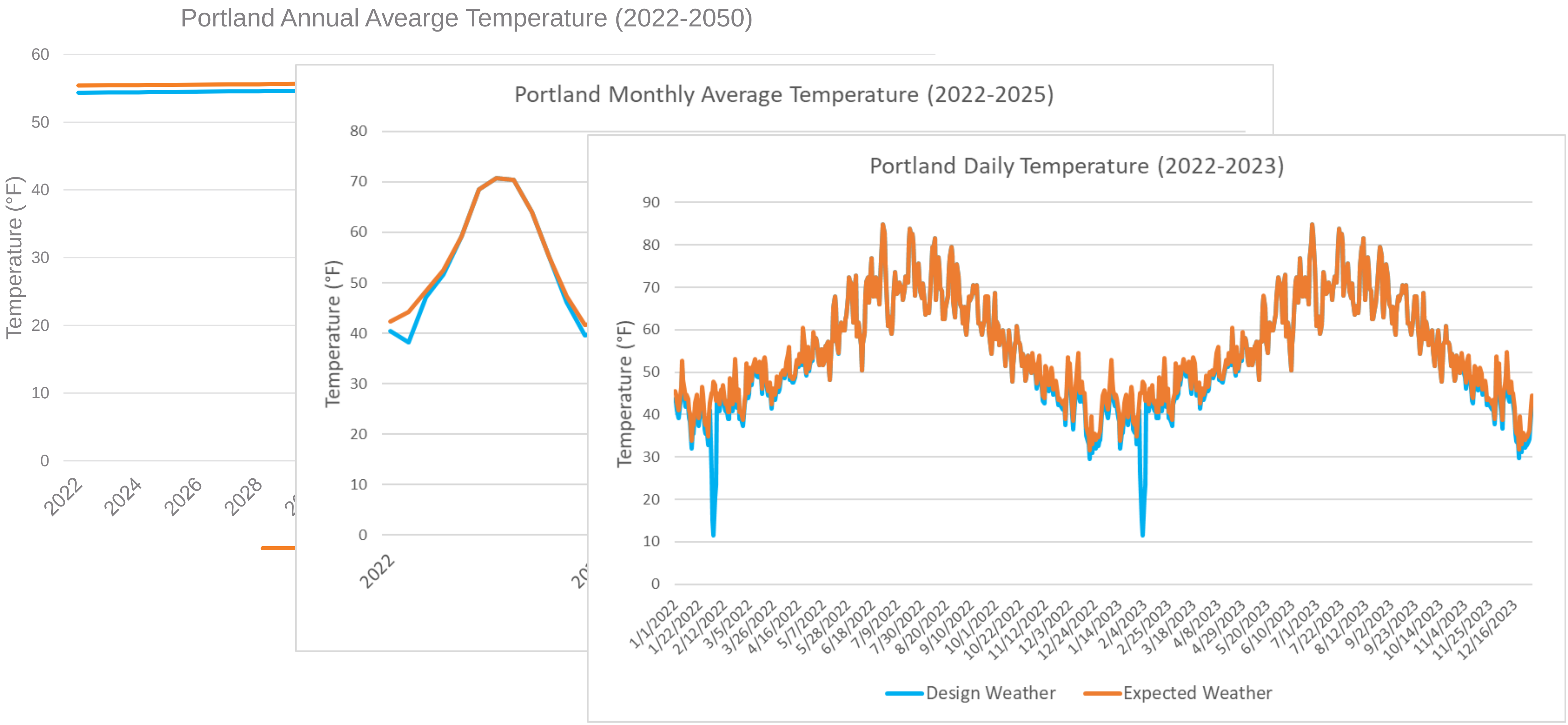
Portland Example



Portland Example



Portland Example



What does Climate Change mean for NW Natural?

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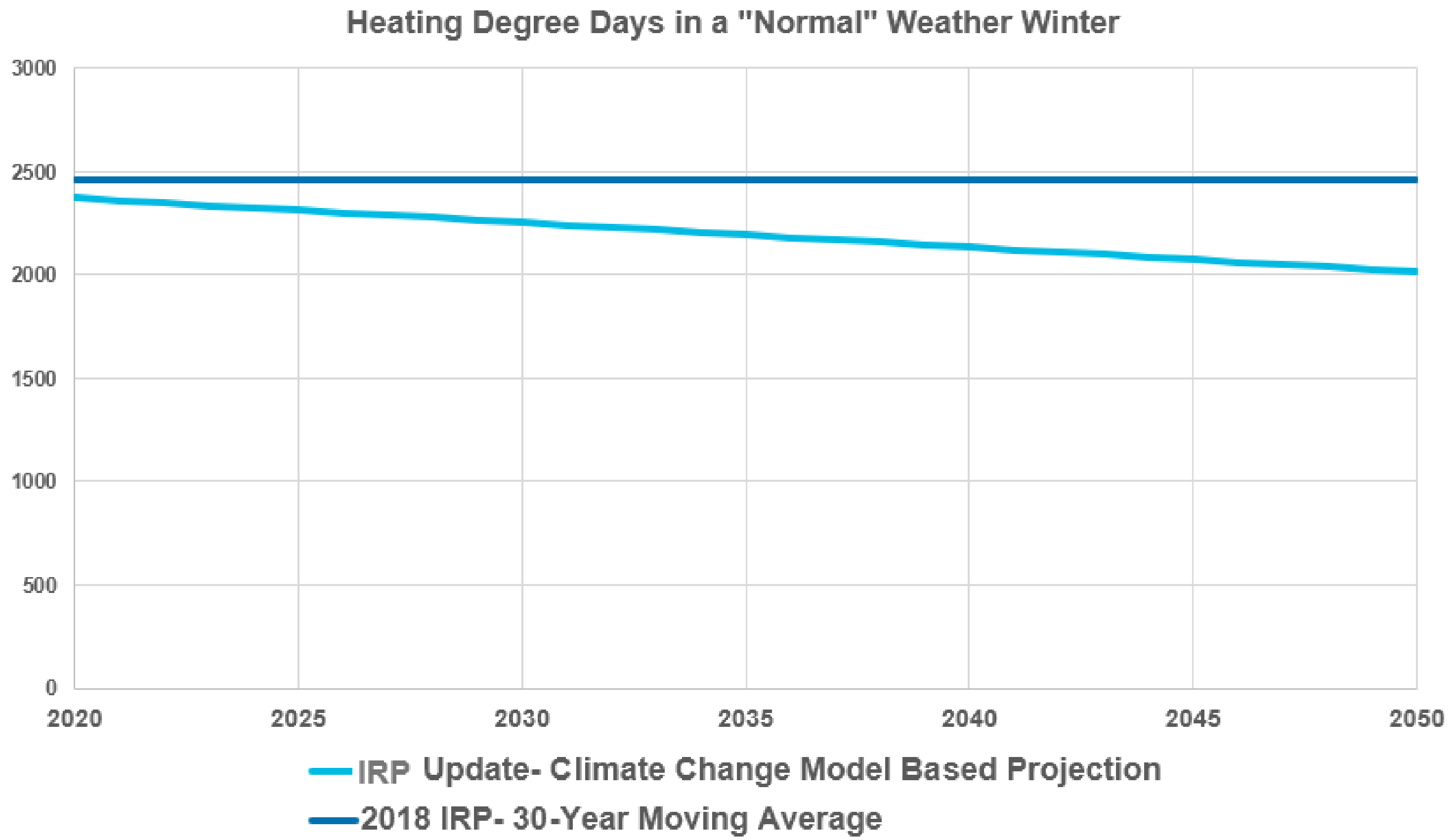
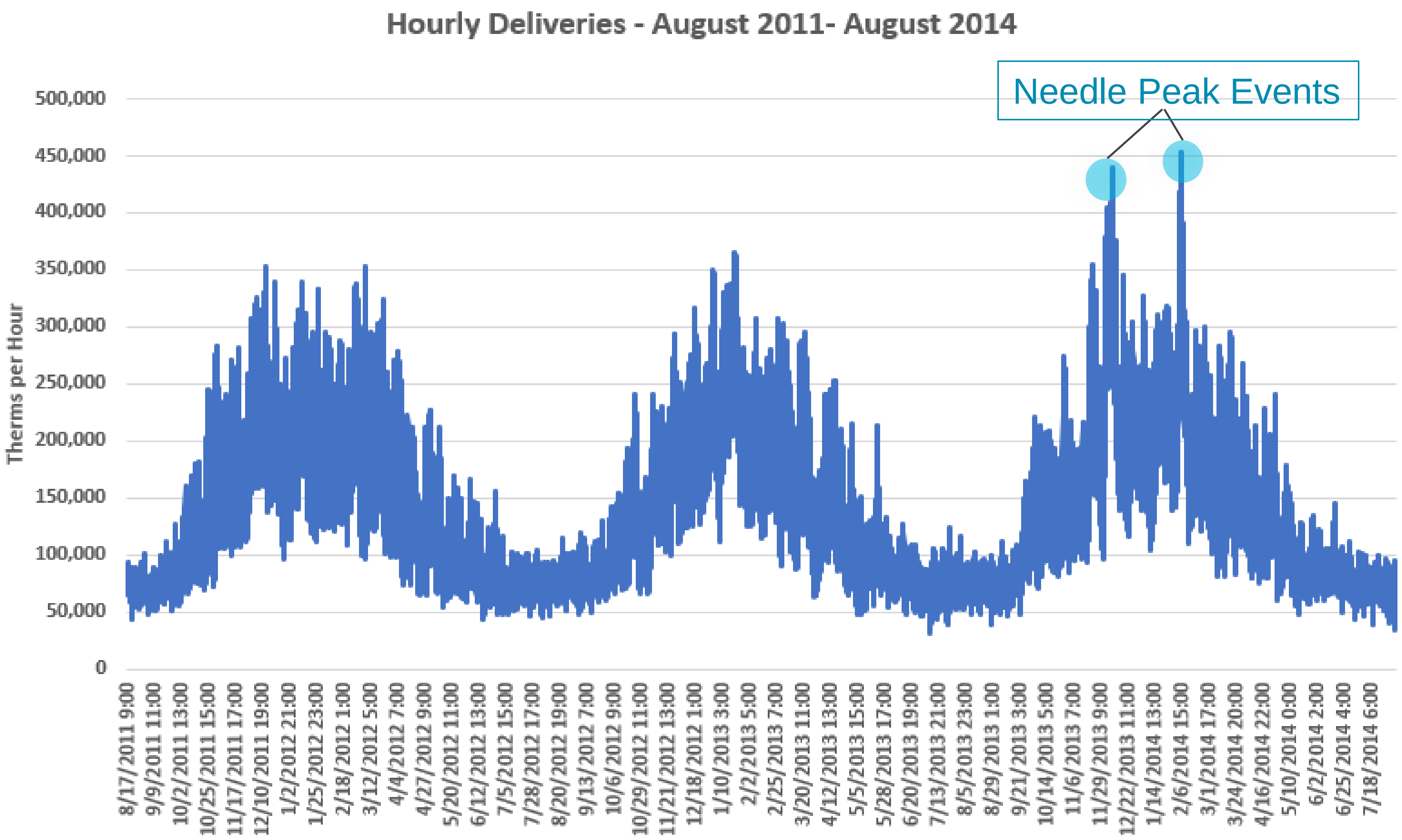
Heating Degree Day (HDD) = maximum(0,58-Temperature)



- While there is no indication that cold events are becoming less severe, there is clear evidence heating seasons are getting milder
- Implementing a similar approach to the NWPCC, NW Natural now incorporates leading climate change models into weather forecasting
- Results in 3% reduction in HDDs in 2020 and 18% in 2050

The Peak Day Forecast – Reference Case

What is a "Needle Peak"?



- Extreme weather causes energy usage spikes that drive building heating or cooling needs
- These spikes, or peak events, result in much higher usage than all other times
- The more of a utility's load that is heating or cooling the "peakier" the load
- More than half of the energy NW Natural delivers is for space heating, so our load is very "peaky"
- Planning peak events occur far less frequently than each winter

Weather Models – Design Peak Weather

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Weather

Design Peak Weather	Design Winter Weather	Expected Weather

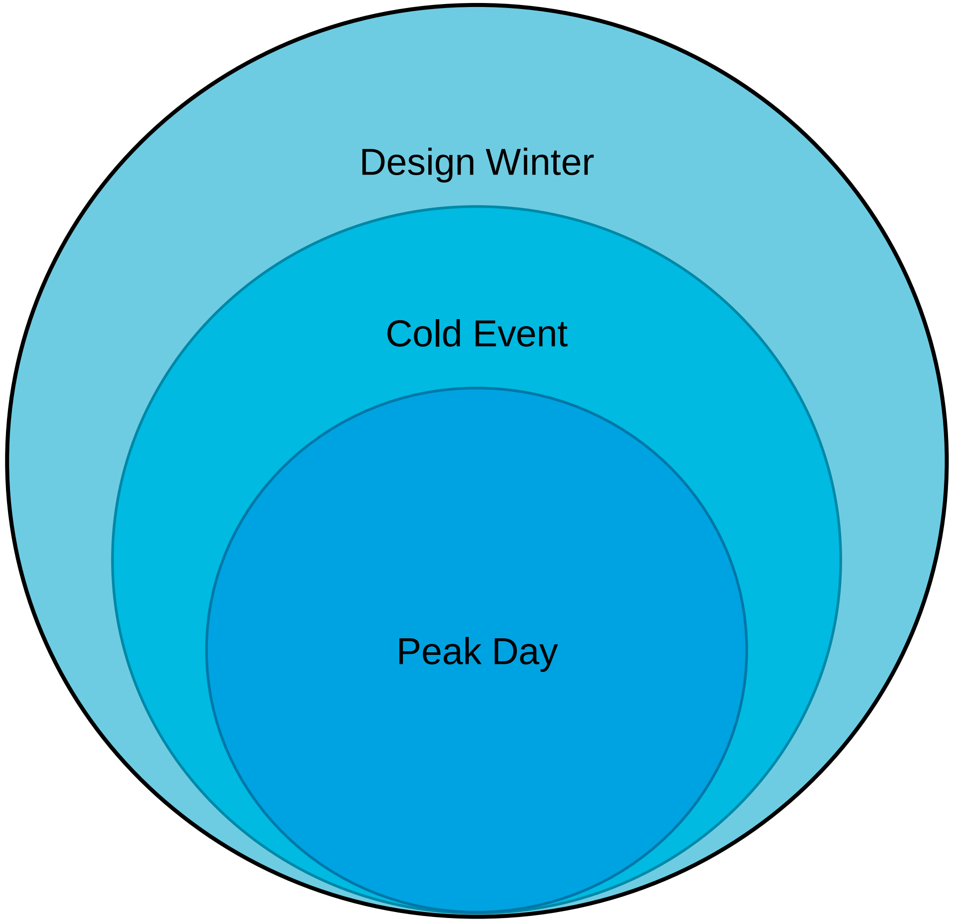
- Design Peak
  - *Peak day* weather drives the capacity requirement for each winter in NW Natural's IRP
    - Uses a Monte Carlo simulation of conditions that drive the highest demand day in a heating season
    - Simulated from historical data and includes more than just temperature
    - Peak day conditions have a 1% likelihood of occurring going into any forecasted winter
  - A cold event, also is incorporated into design peak weather
    - Includes two cold days both prior and post the peak day
    - Base on regression analysis using historical data of the two days prior and post the coldest day of the year
  - This cold event is modeled as February 1st – 5th, with the peak day modeled as February 3rd
    - Historically, we have experienced our coldest day of the year as early as the month of November
    - We model the peak day late in the winter to ensure our storage resources are adequate to meet a late winter peak event
    - The 5-day cold event is inserted into the design winter weather = design weather

Why Do IRPs Focus on Peak Planning?

- The most likely time for customers to lose service due to resource constraints occurs at the same time when it is the most dangerous time for customers to lose service
- Firm sales customers depend on the gas utility to provide reliable gas service to heat their homes and businesses
- Unexpected lack of heat during an extreme cold snap can be very dangerous for customers
- Natural gas LDC planning standards are typically strict due to the high stakes and consequences of outages which would occur during cold events if resources become constrained

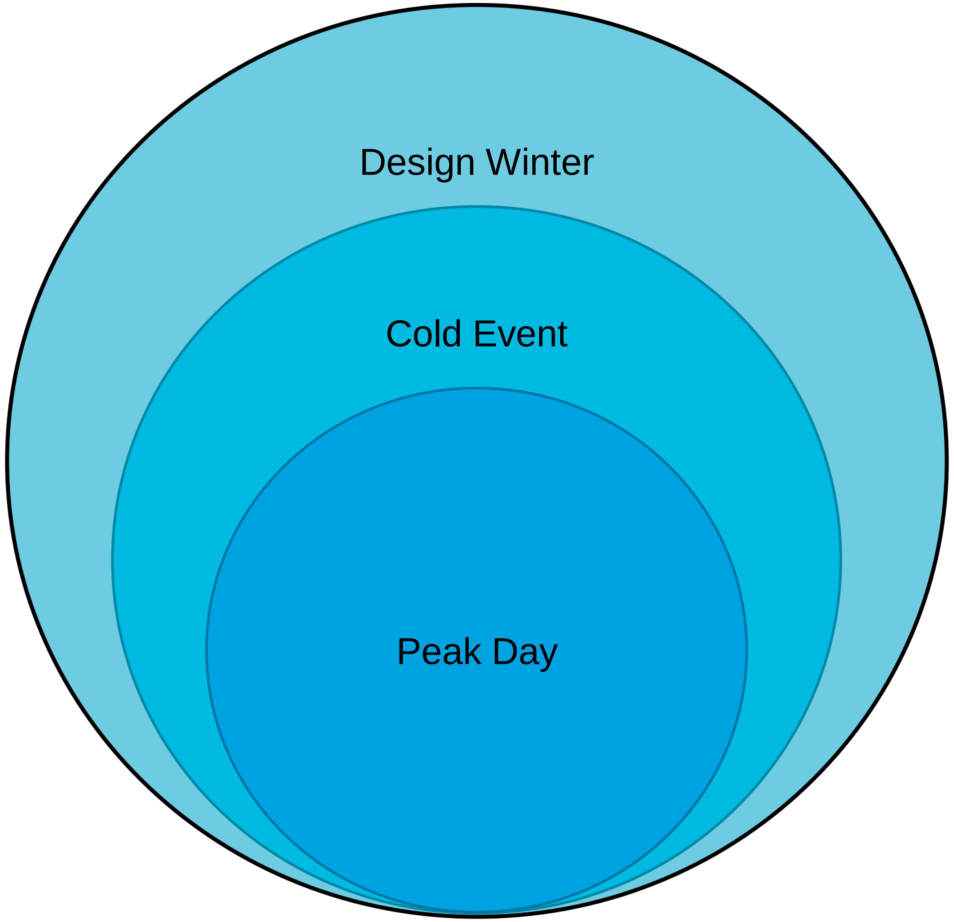
Peak Day Gas Supply Planning

- Required by OR IRP Guidelines
  - Guideline 1(b).2 - At a minimum, utilities should address the following sources of risk and uncertainty: Natural gas utilities: demand (**peak**, swing and base load), commodity supply and price, transportation availability and price, and cost to comply with any regulation of greenhouse gas emissions.
  - Guideline 4(d) - At a minimum, utilities should address the following sources of risk and uncertainty: Natural gas utilities: demand (**peak**, swing and base load), commodity supply and price, transportation availability and price, and cost to comply with any regulation of greenhouse gas emissions.
  - Guideline 4(f) - Analysis of measures the utility intends to take to **provide reliable service**, including cost-risk tradeoffs.
  - Guideline 11 - Natural gas utilities should analyze, on an integrated basis, gas supply, transportation, and storage, along with demand-side resources, to **reliably meet peak**, swing, and base-load system requirements. Electric and natural gas utility plans should demonstrate that the utility's chosen portfolio achieves its stated reliability, cost and risk objectives.
- Required by WA IRP Guidelines
  - WAC 480-90-238(2)(b) - LRC analysis considers demand side uncertainties.



Peak Day Gas Supply Planning

- NW Natural plans its system capacity resources for gas supply planning to meet peak day demand and peak hour demand for planning its distribution system (TWG #5)
- We focus on the day for system capacity resources and gas supply planning because natural gas contracts and pipeline contract are specified in MMBtu/day
- Unlike the electric grid, the gas system has enough slack (packing/drafting) to nominate gas purchases and shipping at a daily level
- Plan supply capacity resources to serve the highest firm sales demand day going into each gas year with 99% certainty assuming all resources are available (i.e. no forced outages)
- We presented a deep dive our planning standard during a TWG on June 3, 2021 and attached that presentation to meeting invite
  - Same Peak Day model presented at this TWG is used for 2022 IRP



Customer Types and Resource Planning

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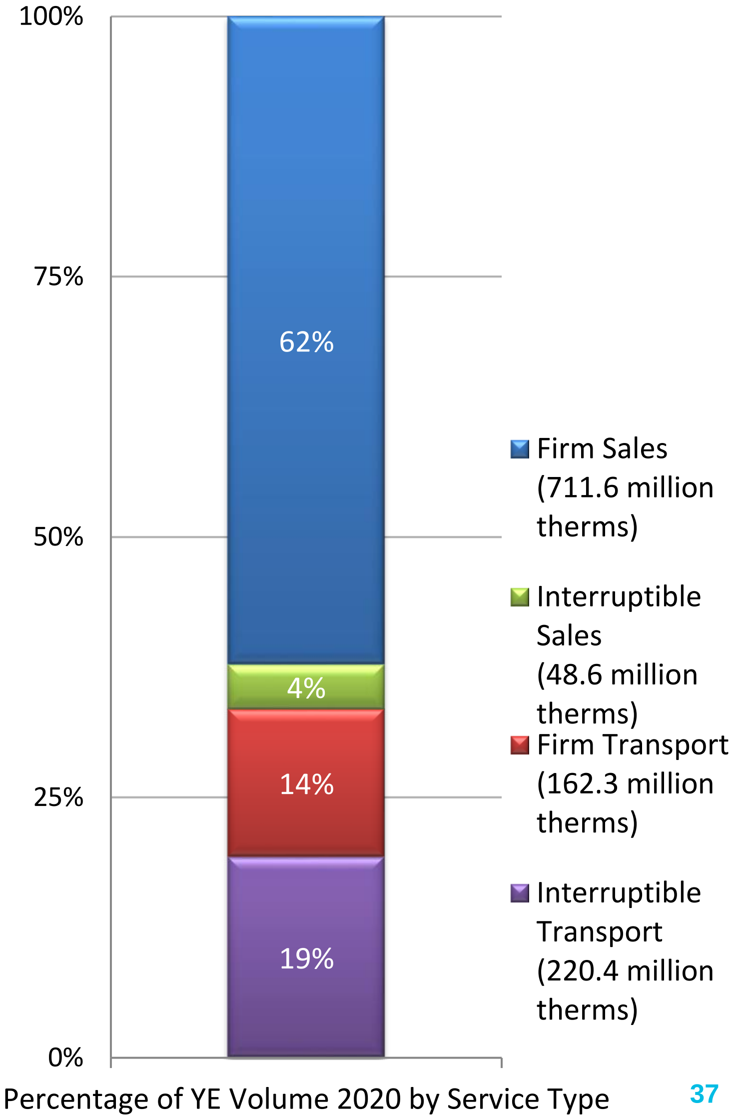
	System Capacity Resource Planning			Distribution System Planning
Customer Category	**Design Winter Weather Energy Requirements**	**Peak Day Capacity Requirements**	**Emission Compliance**	**Peak Hour Capacity Requirements**
Firm Sales	✓	✓	✓	✓
Interruptible Sales	✓		✓	
Firm Transport			✓	✓
Interruptible Transport			✓	



Demand Response Preview

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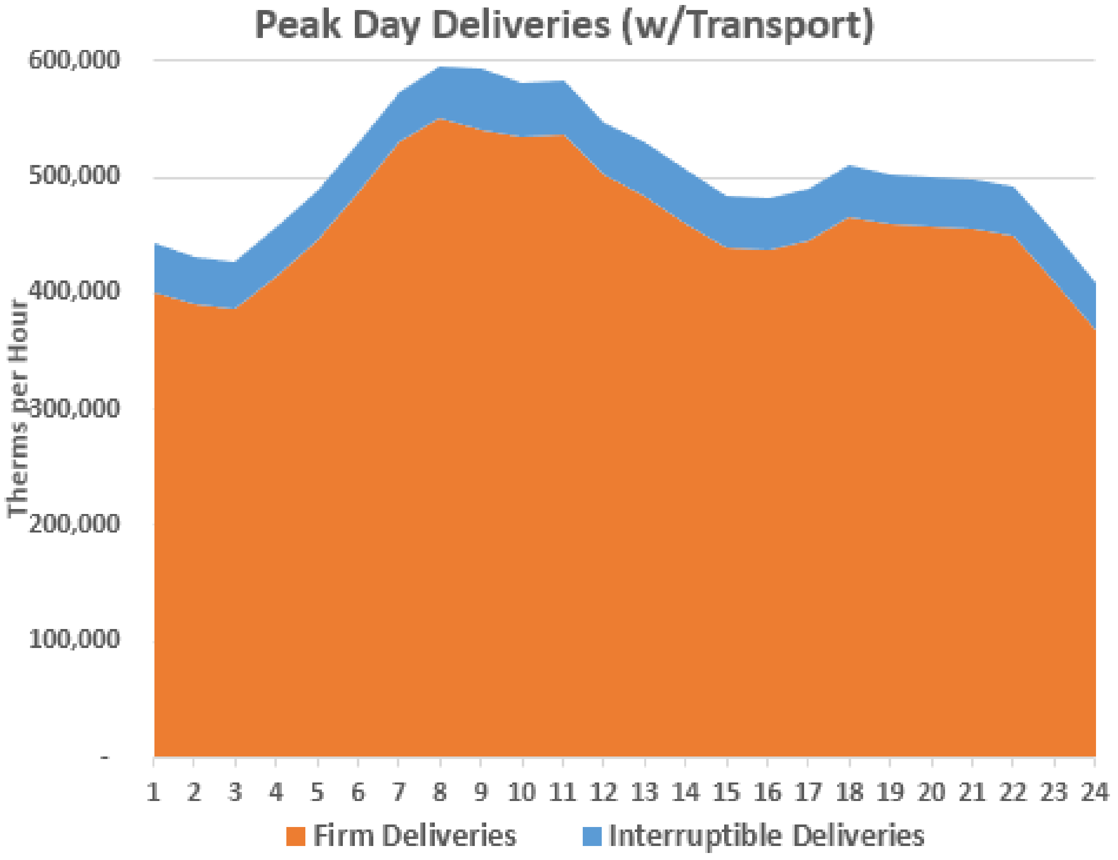
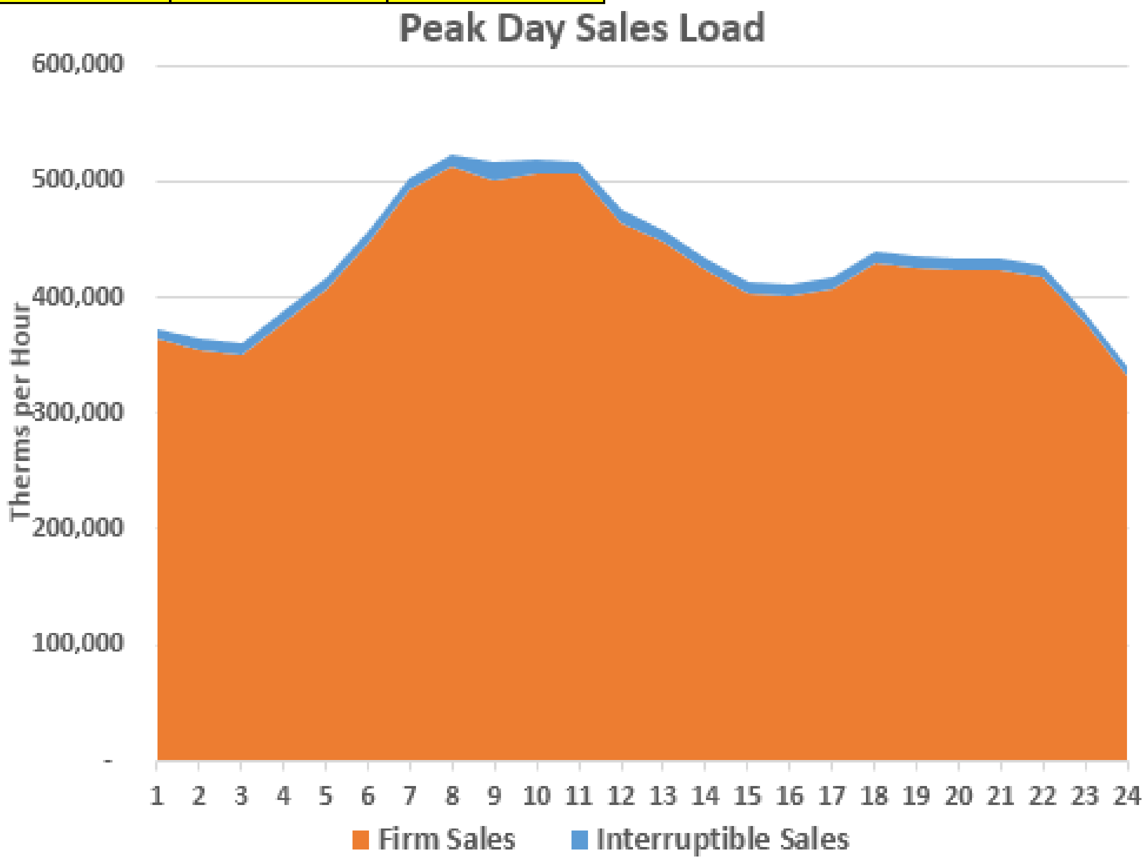
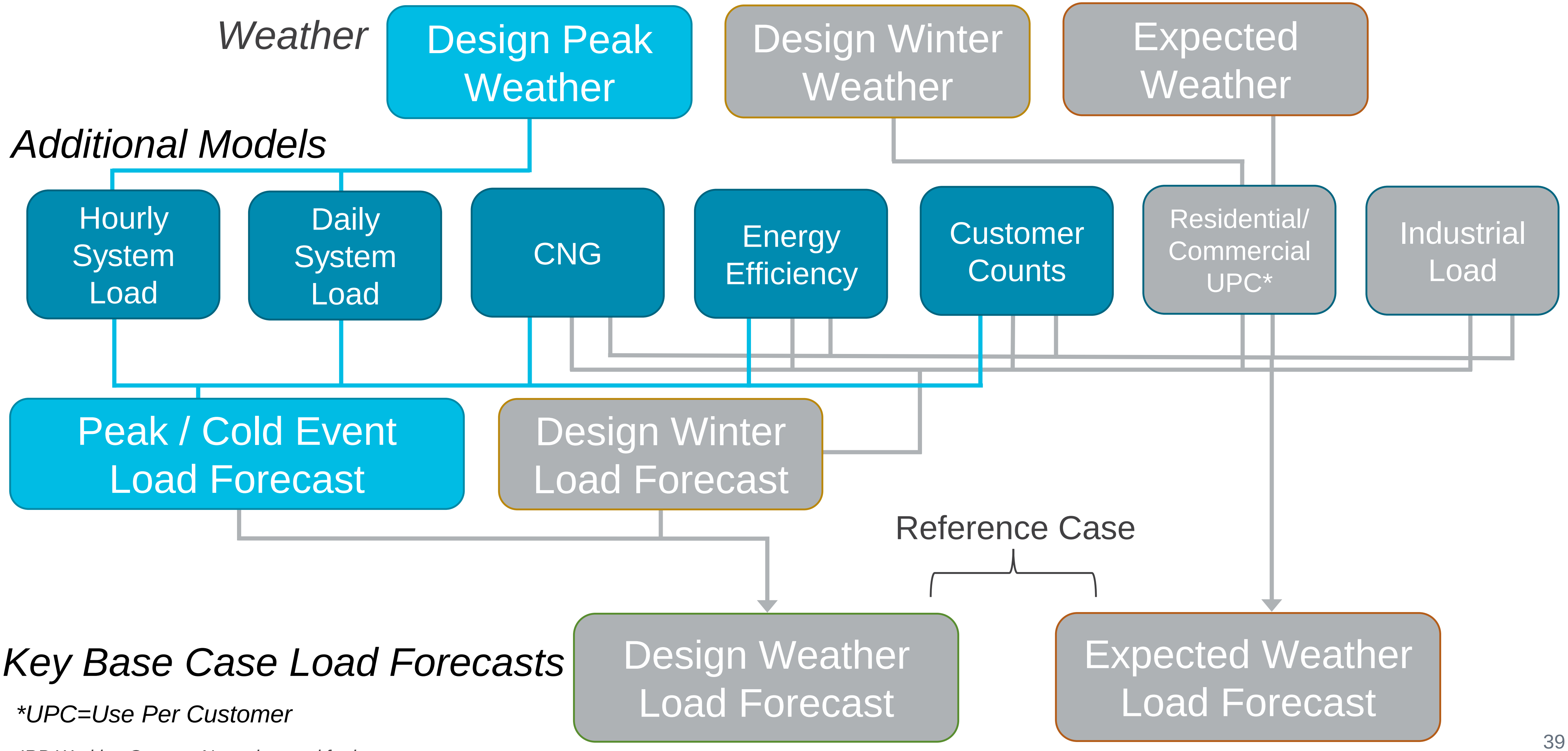
Current NW Natural Demand Response via Interruptible Schedules				
		1-in-2 Peak	1-in-10 Peak	1-in-30 Peak
Interruptible Share of Throughput	Peak Hour	10.7%	9.9%	8.8%
	Peak Day	11.3%	10.4%	8.7%
Interruptible Share of Sales	Peak Hour	3.4%	3.4%	2.9%
	Peak Day	3.1%	2.9%	2.4%





Peak Forecast



*UPC=Use Per Customer

NW Natural Metering

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Billing Meters vs SCADA Metering

Billing Meters

- Records usage for every customer as they use gas
- Extremely accurate; batch sets of meters are tested regularly for accuracy
- Meters are read on billing cycles (roughly once a month) and time stamped for each read
- Provides monthly usage data for each customer
- Large transport and interruptible customers have more complex metering that records their usage hourly

Supervisory control and data acquisition (SCADA)

- Records gas flowing from the interstate pipeline onto NW Natural's System
- Also, records gas flowing in and out of storage
- Used by gas control to monitor our system on a day-to-day basis
- Generally, very accurate; but meters can record faulty data from time to time
- Used to view system or regional demand at a very granular time scale (e.g., hourly)

NW Natural Metering

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Billing Meters vs SCADA Metering

SCADA data is used for daily system load model

Supervisory control and data acquisition (SCADA)

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Daily System Load Model

Linear Regression	Coef.	Robust Std. Err.	t	P>|t|
Temperature	17,530.49	6,743.85	2.6	0.009
Previous Day Temperature	-8,800.16	301.73	-29.17	0.000
Solar Radiation	-13.42	2.42	-5.55	0.000
Wind Speed	5,497.50	657.94	8.36	0.000
Snow Depth	-26,923.99	5,393.96	-4.99	0.000
Customer Count	2.80	0.47	5.97	0.000
Friday Indicator	-32,051.75	7,212.22	-4.44	0.000
Saturday Indicator	-46,305.20	7,239.25	-6.4	0.000
Sunday Indicator	-43,988.44	6,721.36	-6.54	0.000
Holiday Indicator	-26,013.29	3,629.11	-7.17	0.000
Time Trend	-17,466.71	4,458.50	-3.92	0.000
Bull Run River Temperature	-1,535.16	127.82	-12.01	0.000
Temperature * Previous Day Temperature	141.54	6.53	21.67	0.000
Temperature * Solar Radiation	0.16	0.05	3.04	0.002
Temperature * Wind Speed	-47.92	15.38	-3.12	0.002
Temperature * Snow Depth	697.40	177.77	3.92	0.000
Temperature * Customer Count	-0.05	0.01	-5.16	0.000
Temperature * Friday Indicator	499.65	158.31	3.16	0.002
Temperature * Saturday Indicator	579.50	163.26	3.55	0.000
Temperature * Sunday Indicator	674.01	151.08	4.46	0.000
Temperature * Time Trend	398.48	99.99	3.99	0.000
Constant	-590,018.30	299,682.00	-1.97	0.049

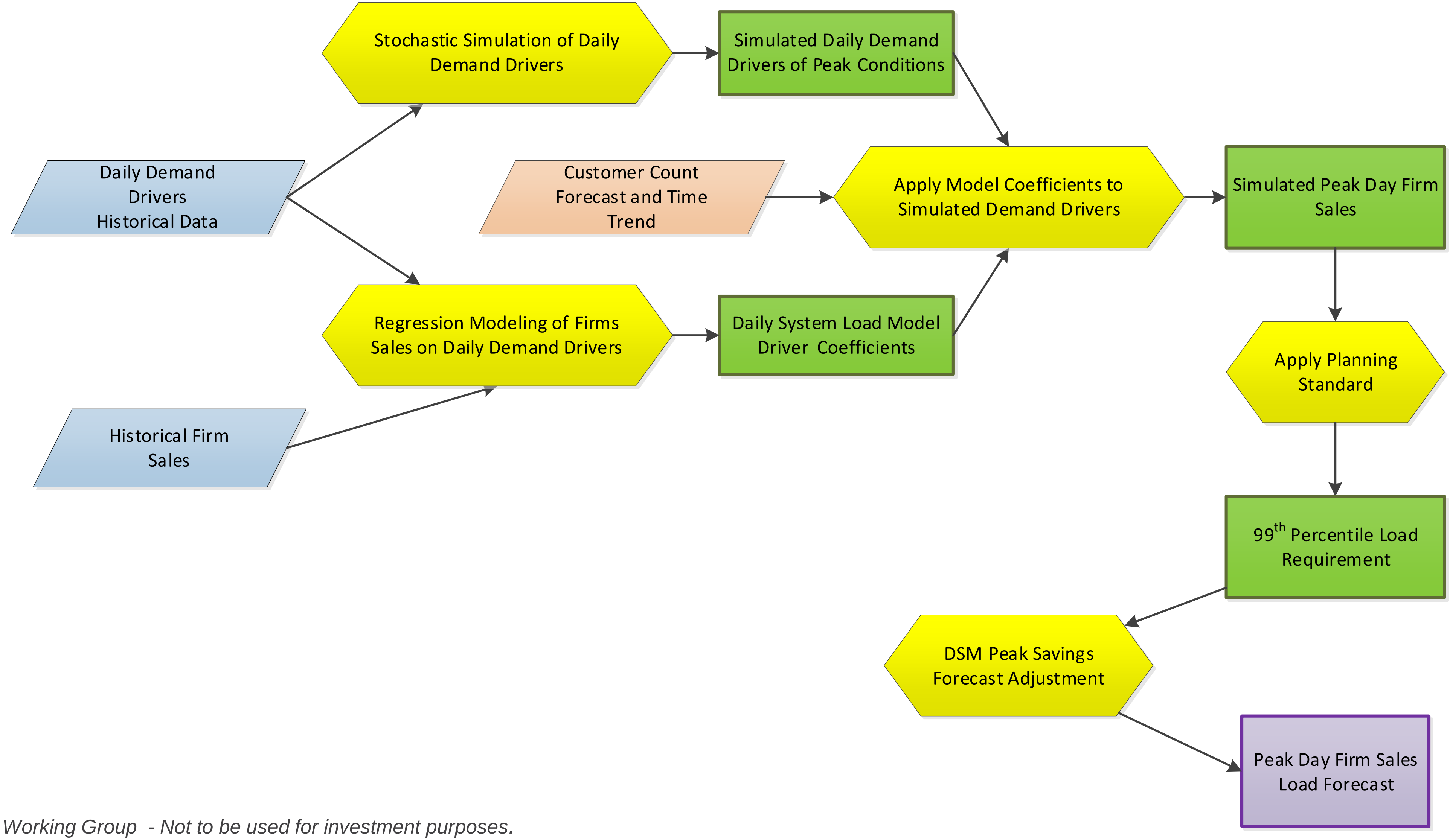
Note that coefficients cannot be interpreted individually.

Marginal Effect of Temperature For the Average January Weekday†	
Temperature	-13,964

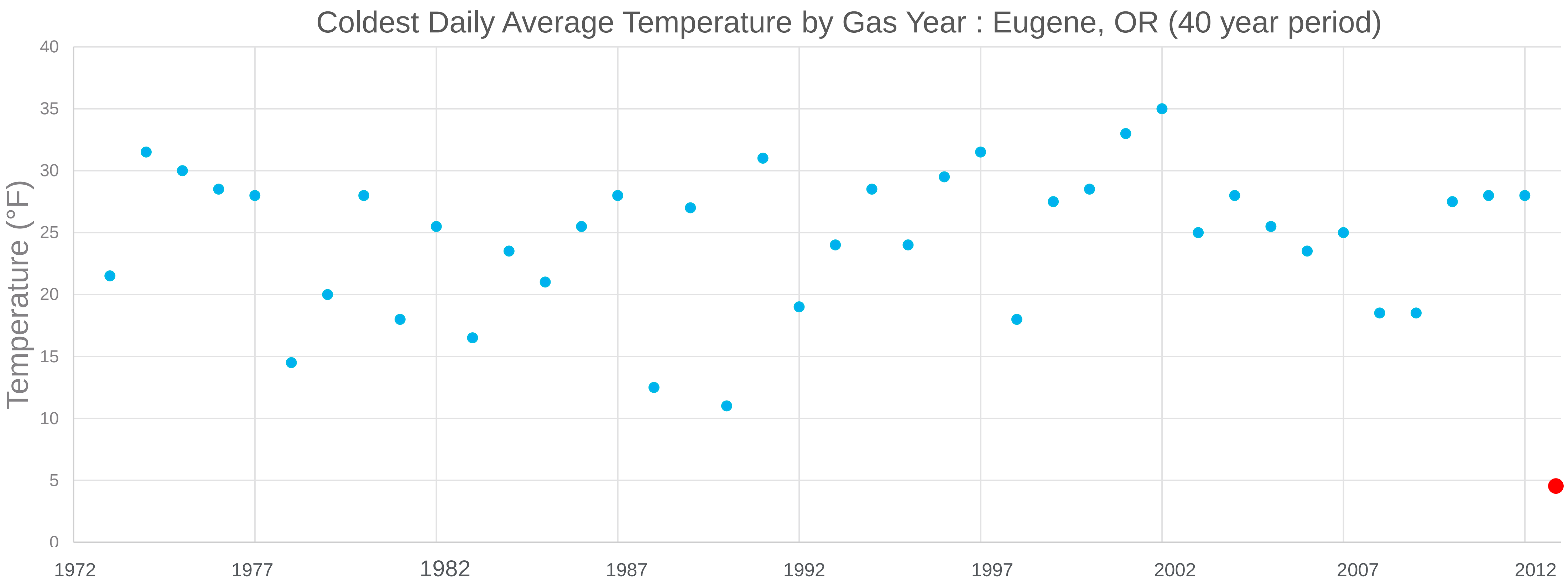
† Previous Day Temp = 41.3; Solar Radiation = 1,281; Wind Speed = 7.1; River Temp = 40.2; Time = 12; Cust (YE 2020 Com+Res) = 773,388

Marginal Effect	Evaluated at 25°F	Evaluated at 45°F
Previous-Day Temperature	-5,262	-2,431
Wind Speed	4,300	3,341
Solar Radiation	-9.5	-6.36
Customer Count	1.446	0.360
Saturday Indicator	-27,138	-20,228

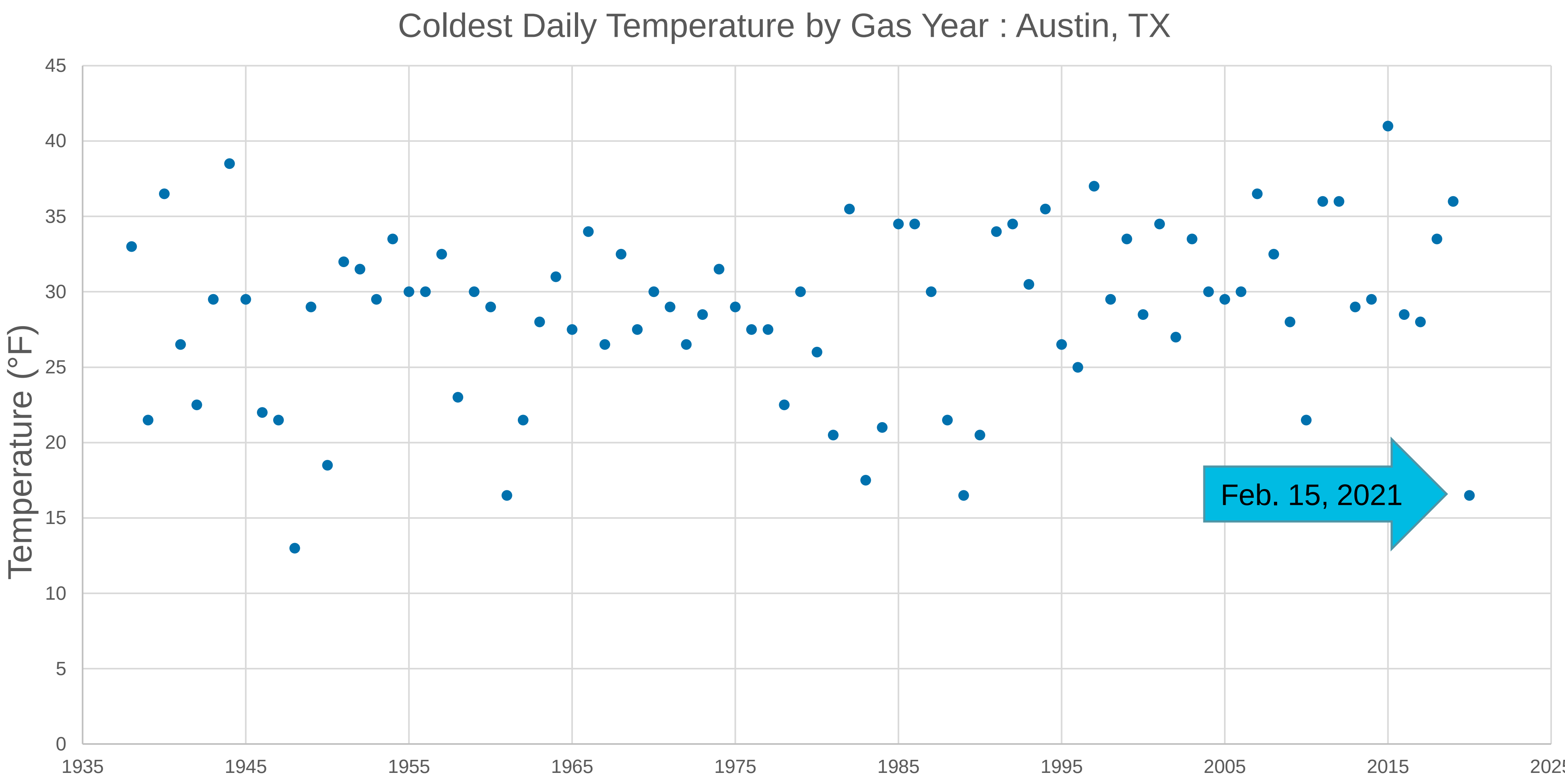
Peak Day Forecast Flow Diagram



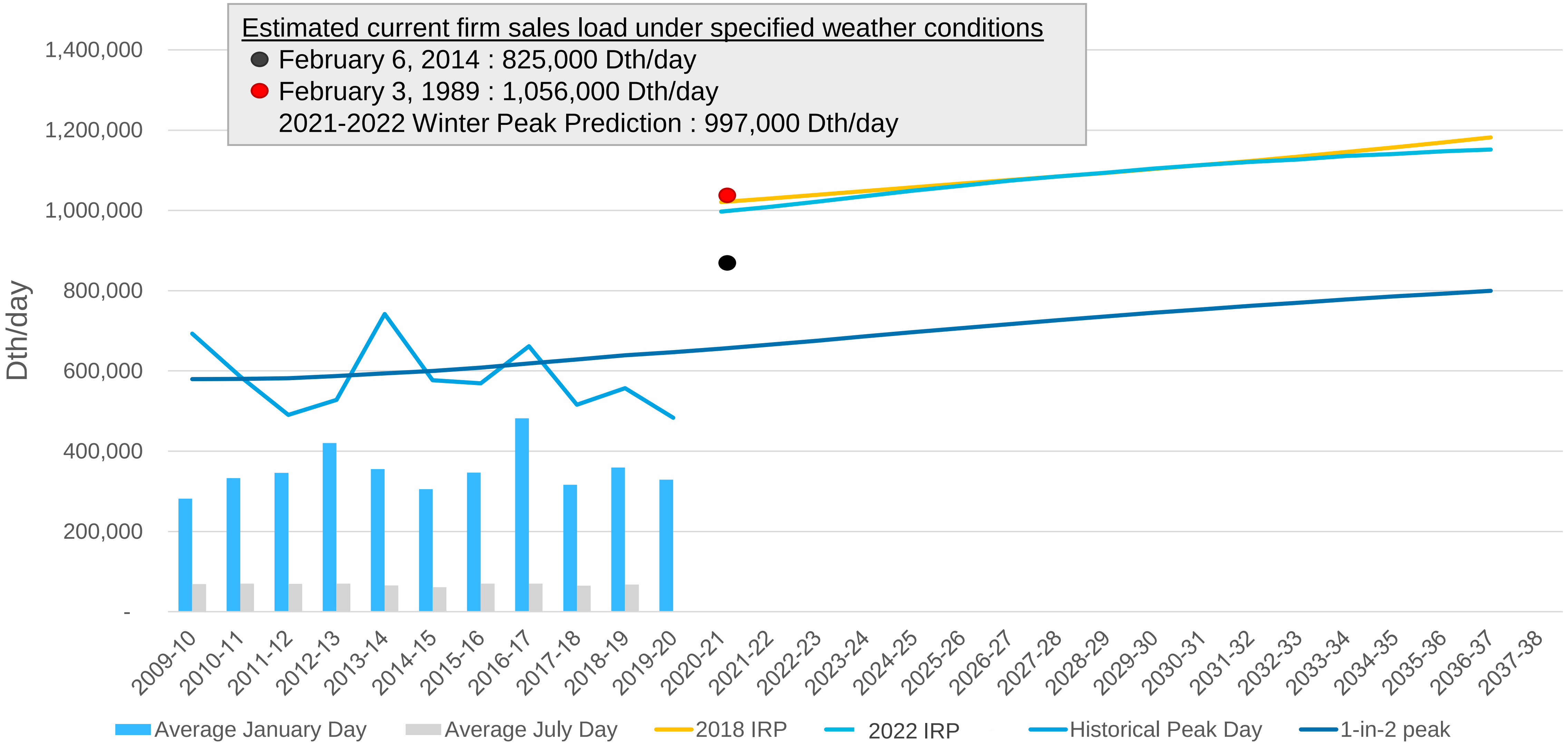
Eugene weather



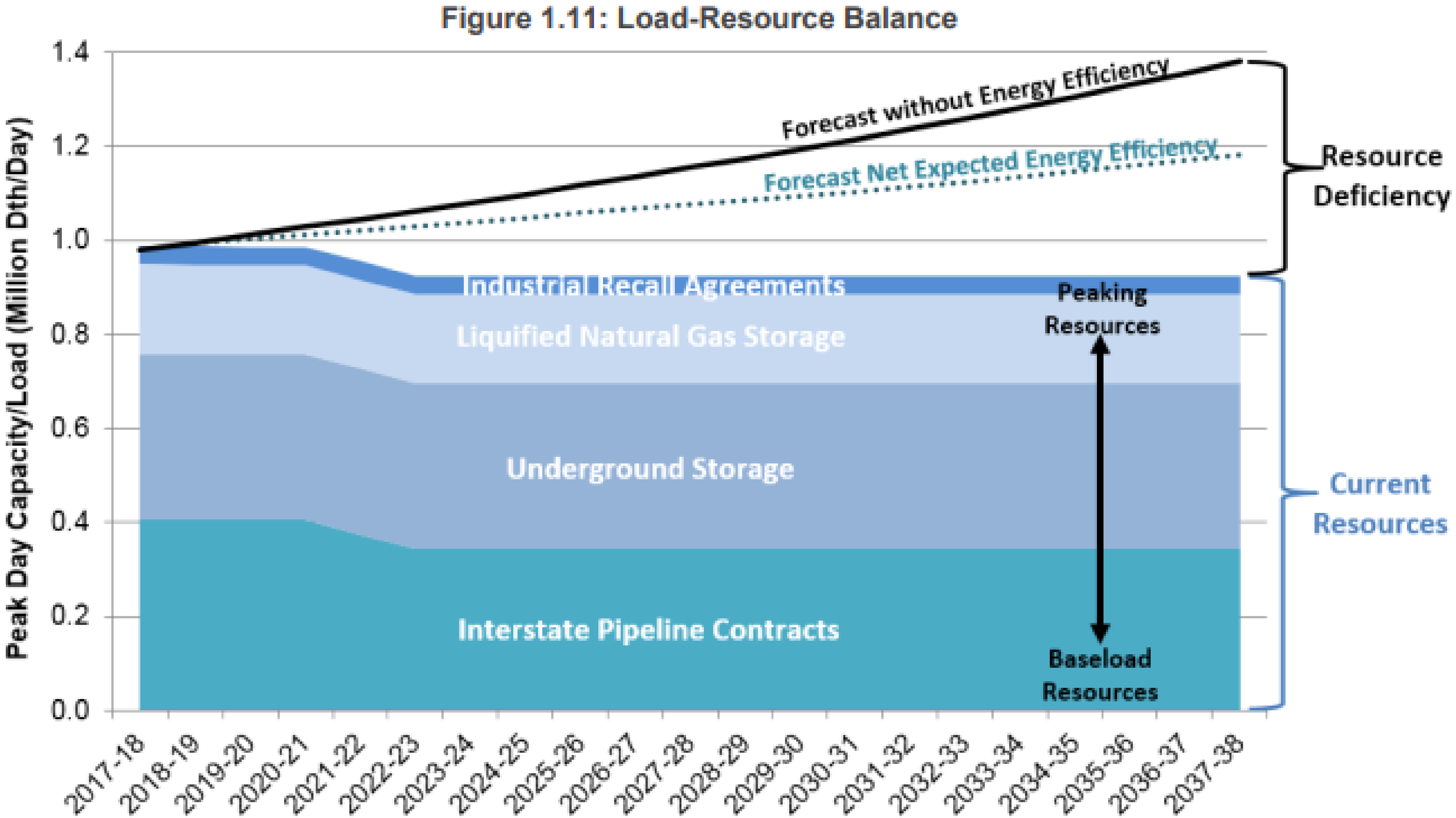
Recent Events in Texas



Peak Day Firm Sales Forecast



Peak Load-Resource Balance



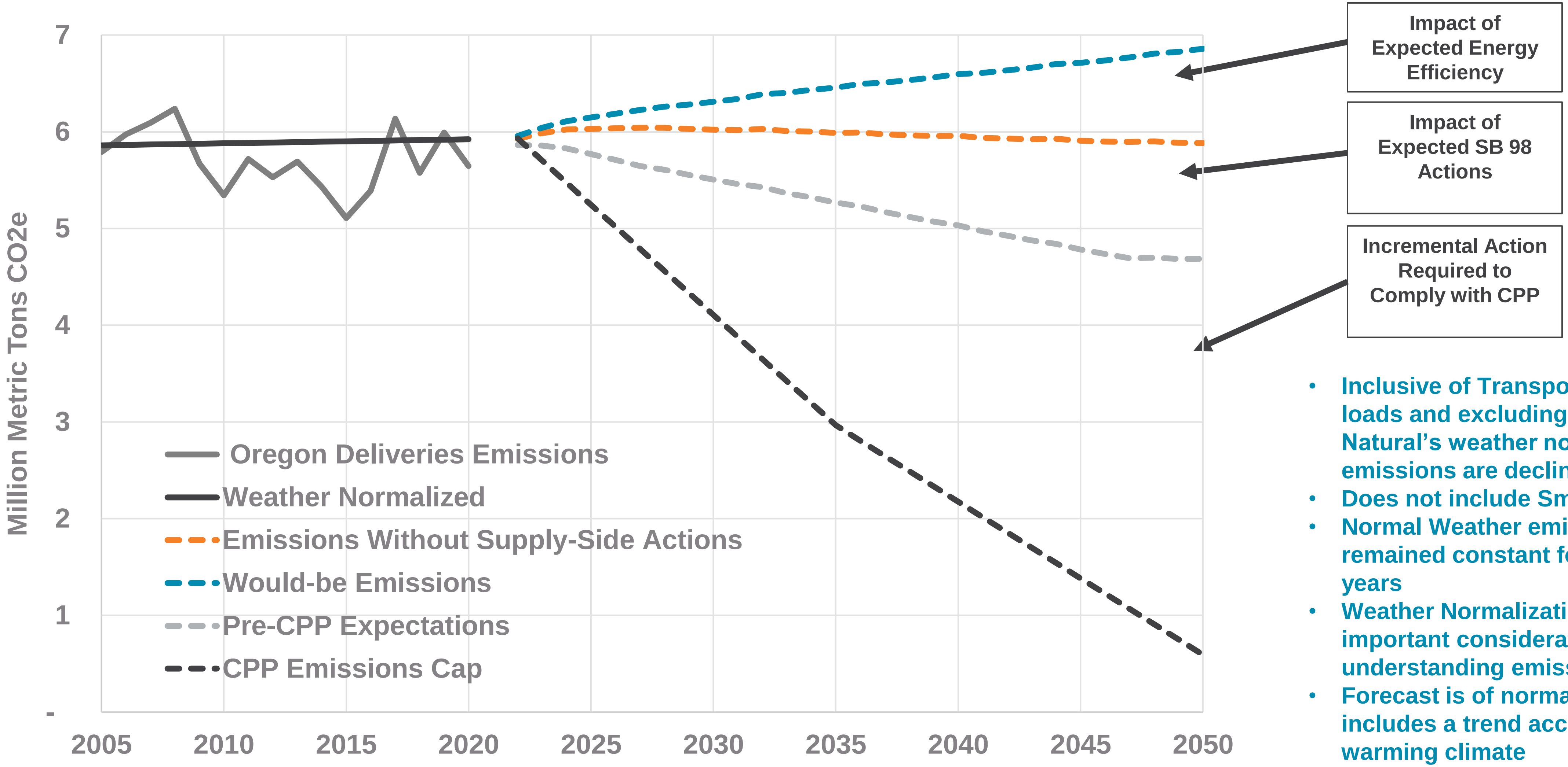
***2018 IRP Peak-Load Resource Balance shown, 2022 IRP Peak Load Resource Balance to be finalized over next TWGs**

Reference Case Load Forecast

Environmental Policy Context

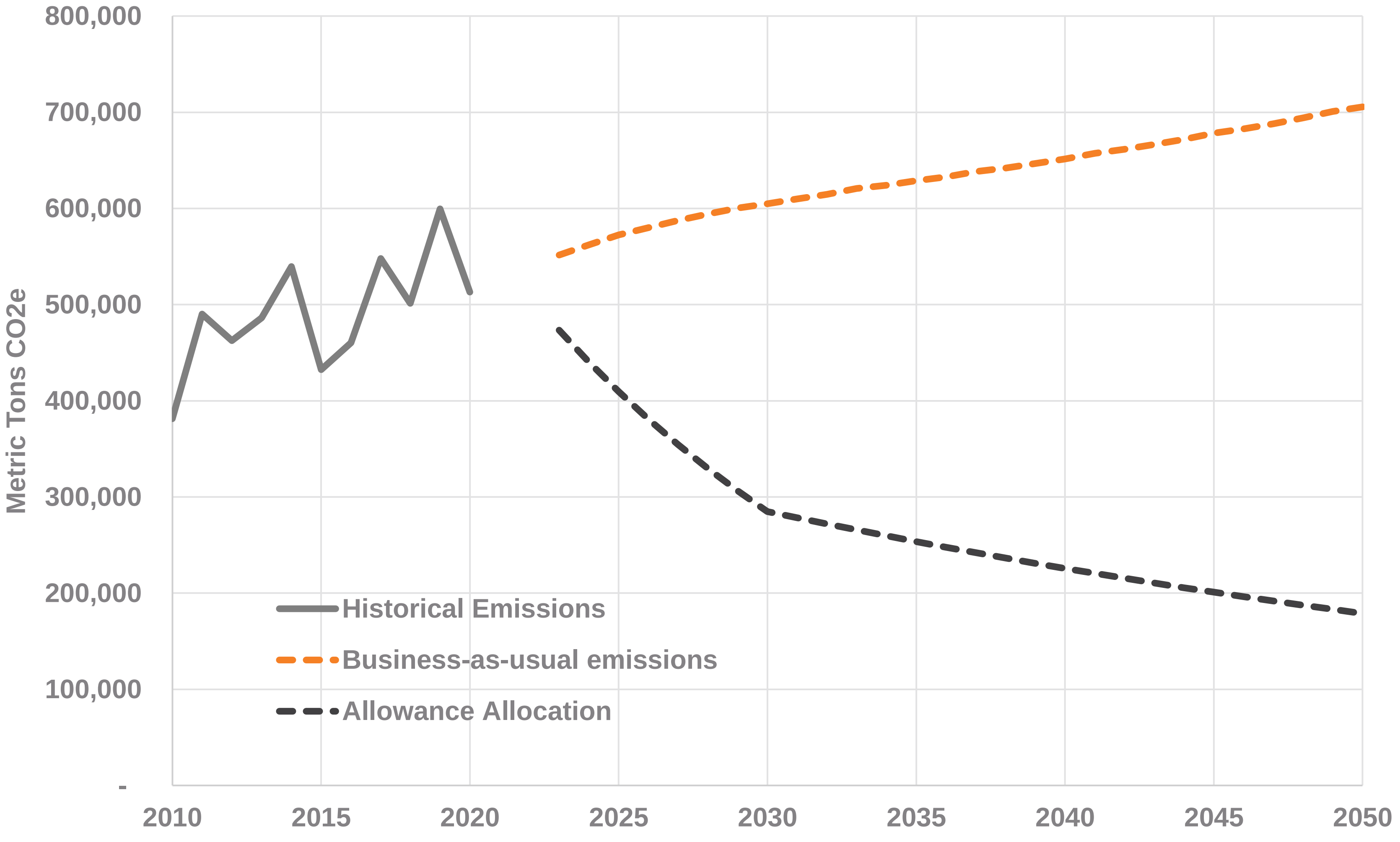
NW Natural’s Oregon Compliance Outlook

NW Natural®



- 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

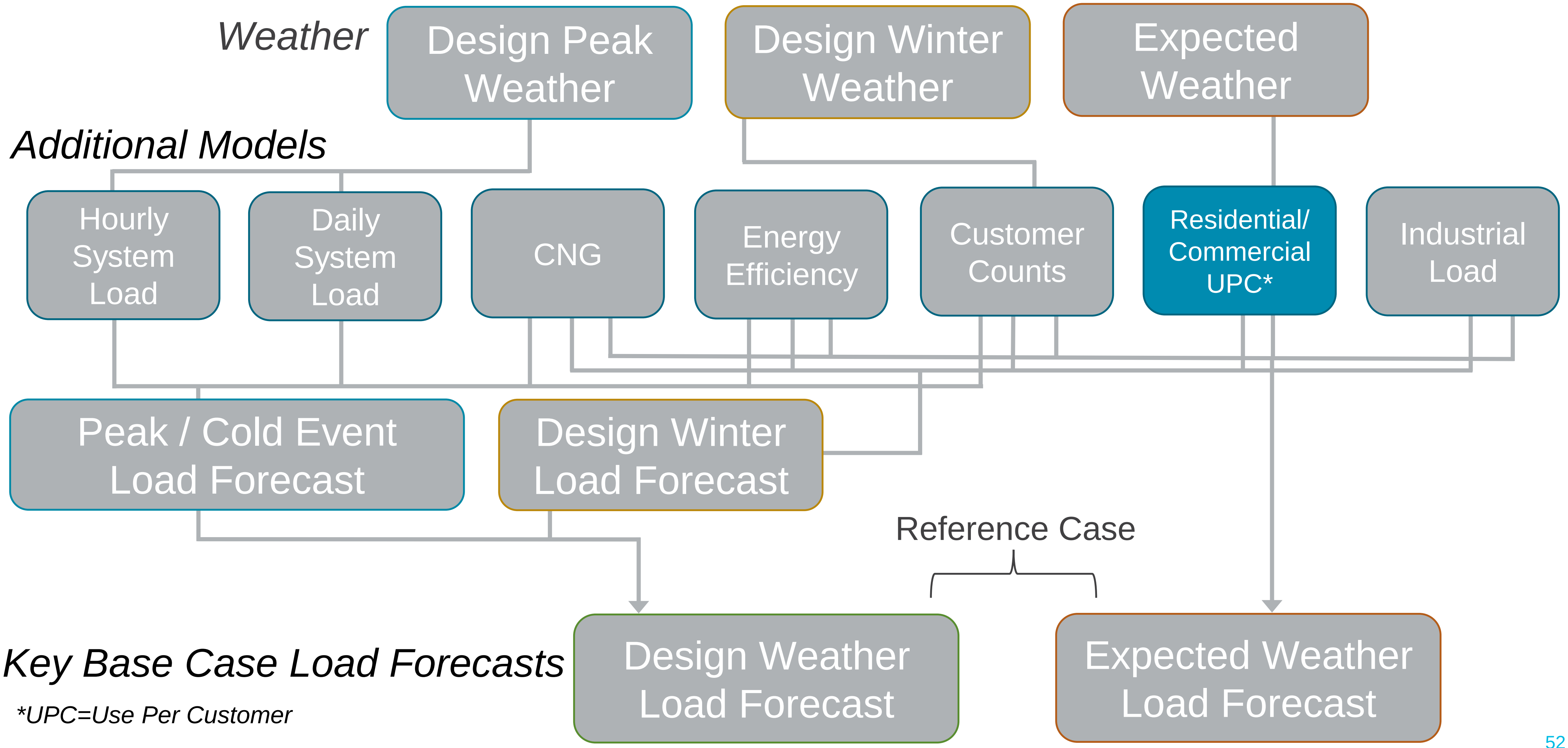
NW Natural's Washington CCA Compliance Outlook



- **Represents NW Natural's understanding of draft CCA rules as of 1/10/2022**
- **Inclusive of Transportation Schedule loads and excluding NW Natural's Oregon Service Territory**
- **Weather Normalization is an important consideration in understanding emissions**
- **Forecast is of normal weather, which includes a trend accounting for our warming climate**

Reference Case Load Forecast
Use Per Customer (UPC) Model

Load Forecast Model Flow Chart



*UPC=Use Per Customer

NW Natural Metering

NW Natural®

Billing Meters vs SCADA Metering

Billing Meters

- Records usage for every customer as they use gas
- Extremely accurate; batch sets of meters are tested regularly for accuracy
- Meters are read on billing cycles (roughly once a month) and time stamped for each read
- Provides monthly usage data for each customer
- Large transport and interruptible customers have more complex metering that records their usage hourly

Supervisory control and data acquisition (SCADA)

- Records gas flowing from the interstate pipeline onto NW Natural's System
- Also, records gas flowing in and out of storage
- Used by gas control to monitor our system on a day-to-day basis
- Generally, very accurate; but meters can record faulty data from time to time
- Used to view system or regional demand at a very granular time scale (e.g., hourly)

NW Natural Metering

NW Natural®

Billing Meters vs SCADA Metering

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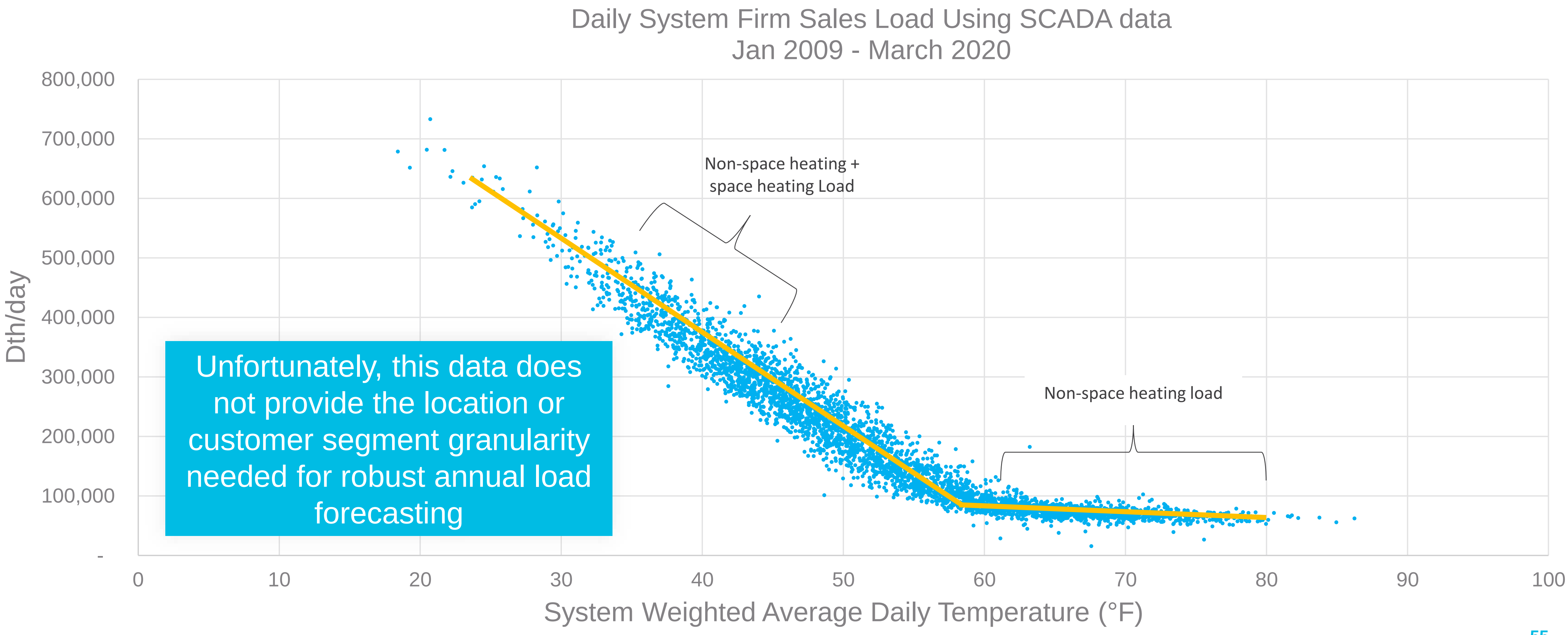
- Extremely accurate; batch sets of meters are tested regularly for accuracy
- Meters are read on billing cycles (roughly once a month) and time stamped for each read
- Provides monthly usage data for each customer
- Large transport and interruptible customers have more complex metering that records their usage hourly

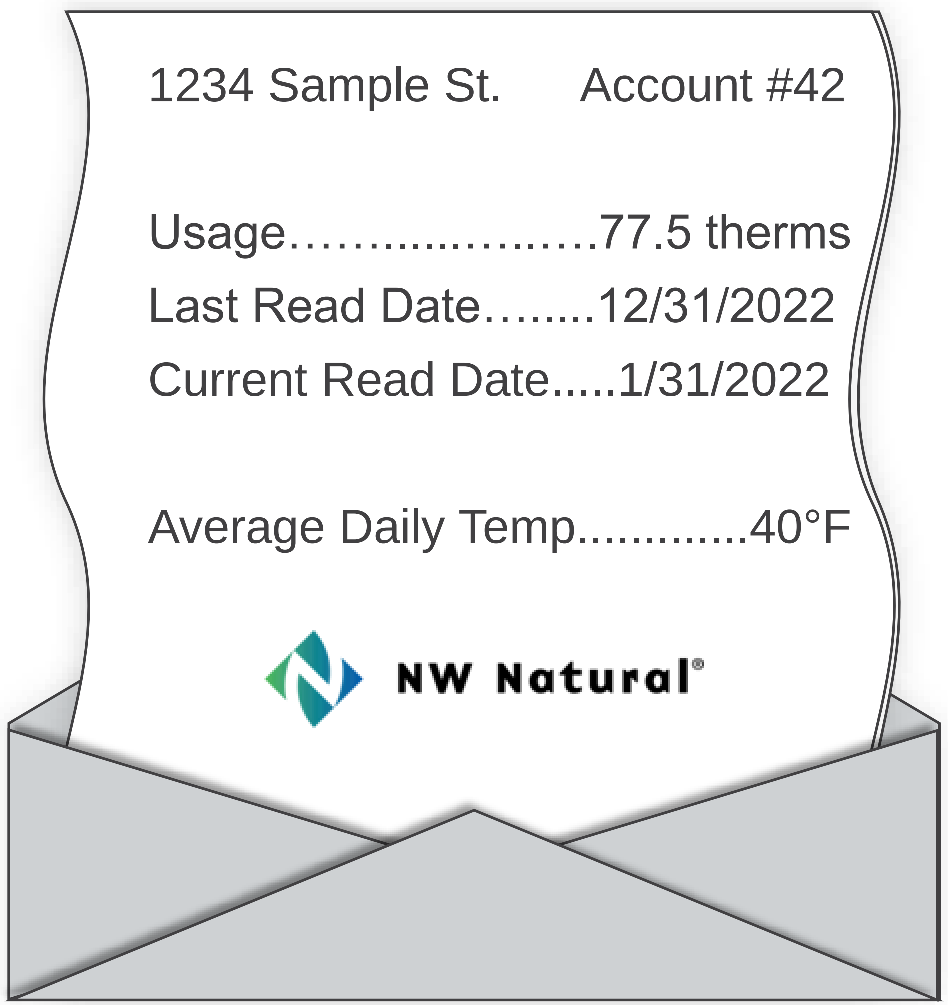
Billing data is used for UPC model

What does NW Natural's System Load look like as a Function of Temperature?



Unfortunately, this data does not provide the location or customer segment granularity needed for robust annual load forecasting

Transforming Billing Data to Use Per Day and Associate a Daily Temperature



Number of days = 31; Usage = 77.5 therms

Use Per Day = 2.5; Daily Temperature 40°F

- This bill equals one record in the UPC regression
- The UPC model is using billing data since 2009
- Number of records used for the UPC regression model is about ≈ 100 Million records

  [700,000 customers *12 months*12 years]

Sign into your NW Natural Account to view your average therms per day!

NW Natural®

Date Range

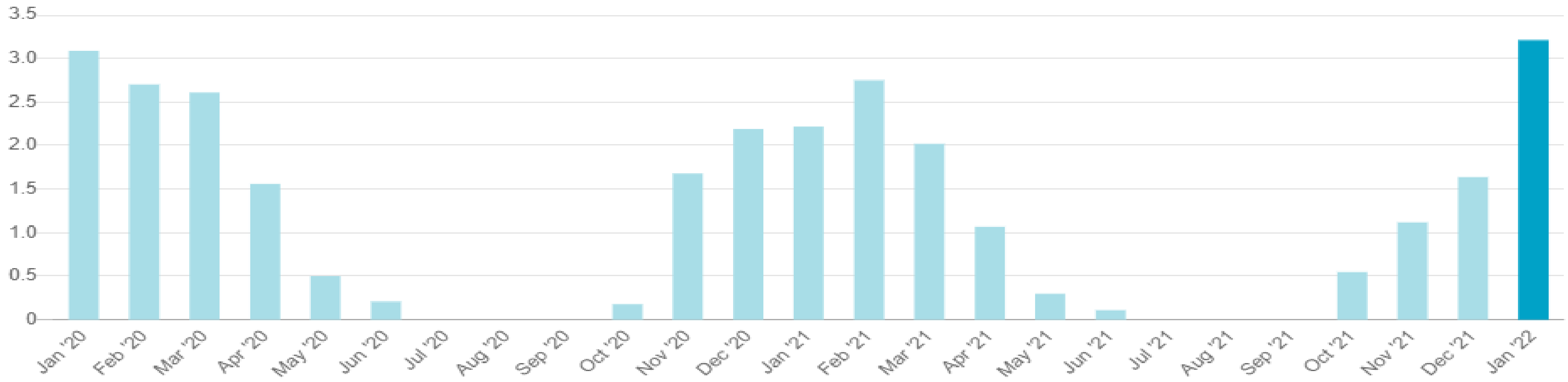
You can view up to 3 years of your previous usage history.

From: 12/21/2019

To: 1/21/2022

Submit

Average Therms Per Day



UPC Model

The UPC model uses billing data and regression analysis to make daily estimates of daily usage per customer (therms/customer/day) as a function of the daily temperature

- Regressions are run for 7 different customer segments

Residential
Existing
Conversions
Single Family New Construction
Multi Family New Construction

Commercial
Existing
Conversions
New Construction

NOTE: Commercial customers on rate schedules 31/32/41/42 are excluded from the UPC modeling and estimated similarly to the industrial customers

- Residential/commercial existing customer estimates are done for 9 different locations (matched to the same weather stations); residential/commercial new construction and conversions are estimated at the state level

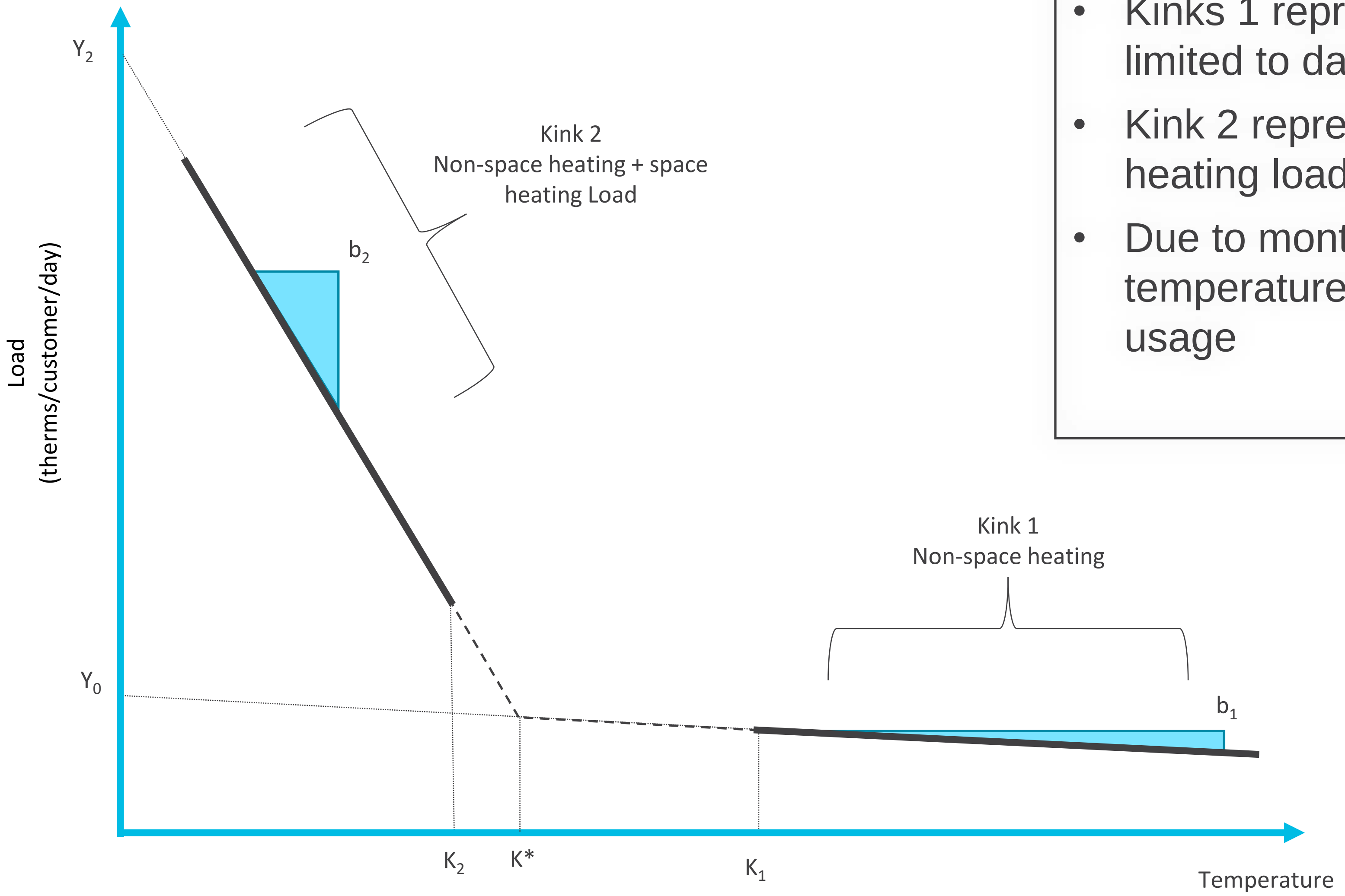
Existing – Bills from all current customers

Albany	Astoria	Coos Bay
Eugene	Lincoln City	Portland
Salem	The Dalles	Vancouver

Conversions/New Construction – Bills from new construction/conversions since 2018
Oregon
Washington

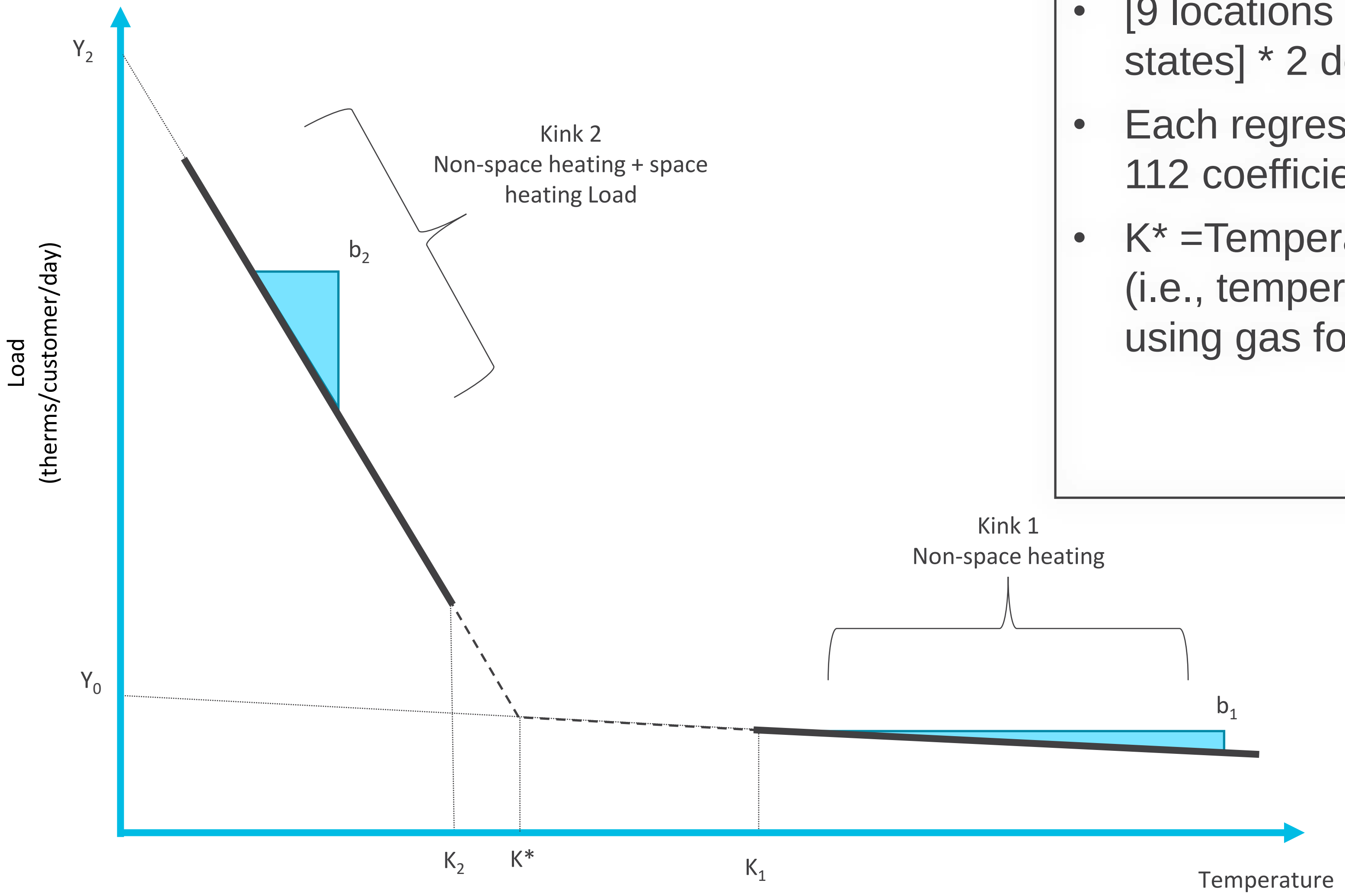
- 2 demand segments
  - Non-heating load at warmer temperature
  - Heating load plus non-heating load at cold temperatures
  - The cut point temperature for when heating load starts for the average customer varies by location and customer segment

Regression Model and Coefficients



- Kinks 1 represents non-space heating load and is limited to data with temperatures above K_1
- Kink 2 represents space heating plus non-space heating load and is limited to temperatures below K_2
- Due to monthly averaging including bills with temperatures between K_1 and K_2 will over-estimate usage

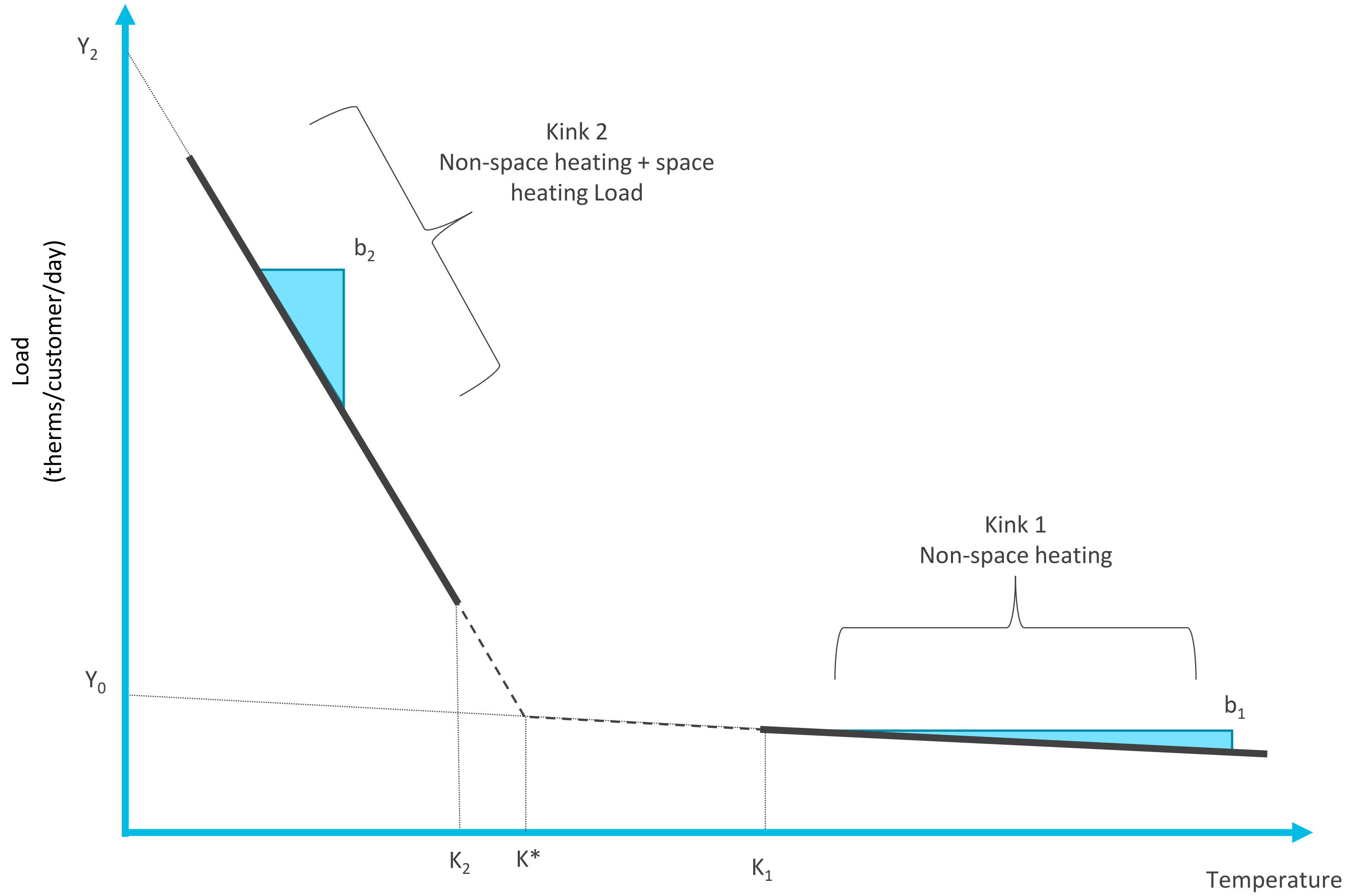
Regression Model and Coefficients



- [9 locations * 2 types of existing + 5 types of new * 2 states] * 2 demand kinks = 56 regressions
- Each regression has a slope (b) and an intercept (Y) = 112 coefficients
- K* =Temperature where Kink 1 and Kink 2 intersect (i.e., temperature where the average customer starts using gas for heating requirements)

$$K^* = \frac{Y_1 - Y_2}{b_2 - b_1}$$

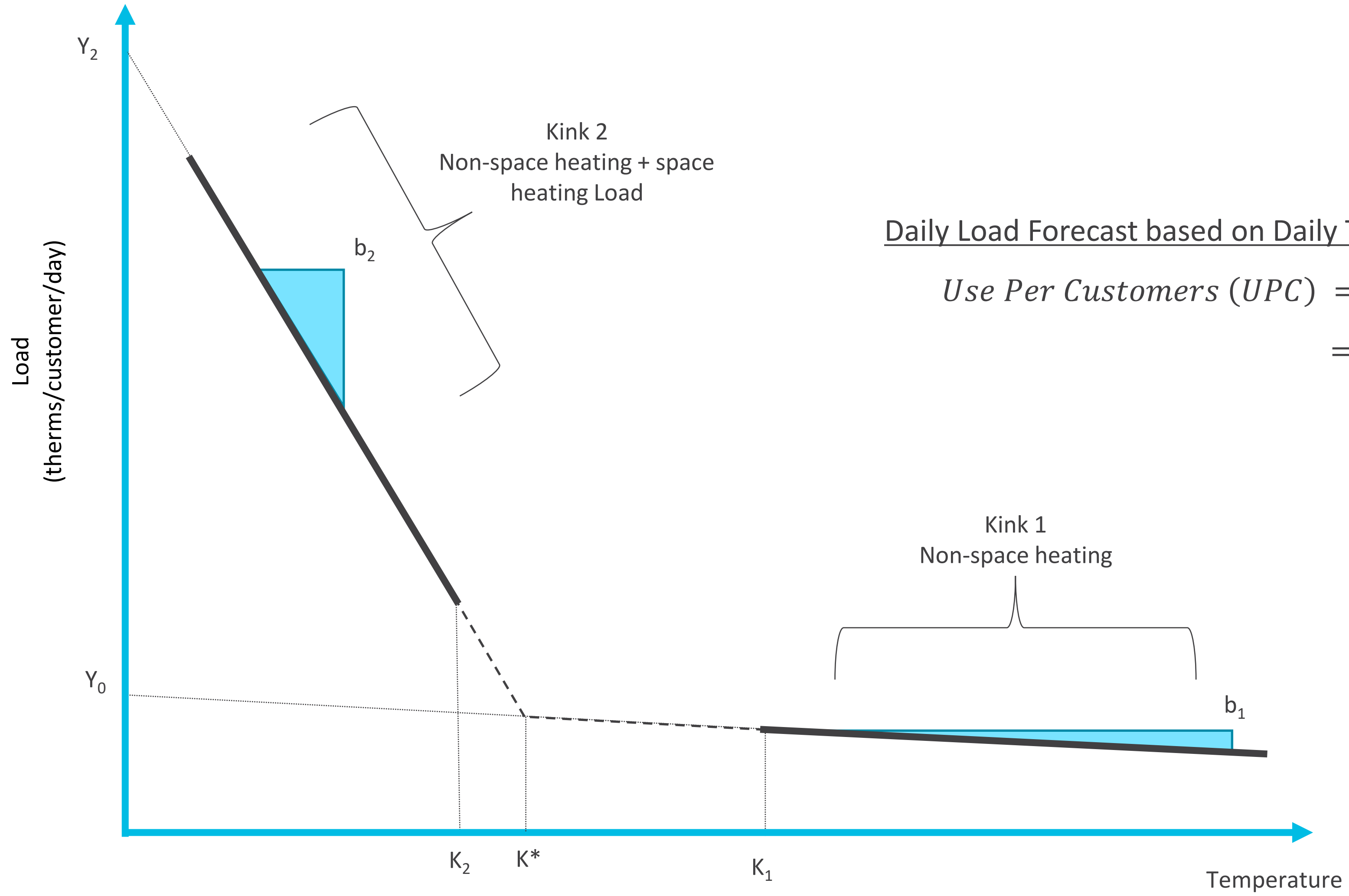
Regression Model and Coefficients



service state	district code	segment	Y1	b1	Y2	b2
OR	ALB	com_exist	6.67	-0.06	34.88	-0.55
OR	AST	com_exist	3.81	0.00	28.33	-0.44
OR	COOS	com_exist	4.25	0.00	49.62	-0.76
OR	DALO	com_exist	6.31	-0.05	33.47	-0.52
WA	DALW	com_exist	6.31	-0.05	33.47	-0.52
OR	EUG	com_exist	9.26	-0.09	41.67	-0.67
OR	LC	com_exist	5.31	0.00	32.63	-0.51
OR	POR	com_exist	8.35	-0.08	43.95	-0.70
OR	SAL	com_exist	6.27	-0.05	41.08	-0.67
WA	VAN	com_exist	8.75	-0.08	40.70	-0.64
OR	ALB	res_exist	1.23	-0.01	9.16	-0.15
OR	AST	res_exist	2.21	-0.03	9.54	-0.16
OR	COOS	res_exist	0.37	0.00	9.66	-0.16
OR	DALO	res_exist	1.32	-0.01	7.13	-0.11
WA	DALW	res_exist	1.32	-0.01	7.13	-0.11
OR	EUG	res_exist	1.06	-0.01	8.67	-0.14
OR	LC	res_exist	2.74	-0.04	9.12	-0.15
OR	POR	res_exist	1.80	-0.02	10.25	-0.16
OR	SAL	res_exist	1.06	-0.01	9.93	-0.16
WA	VAN	res_exist	1.69	-0.02	10.24	-0.16
OR		com_nc	4.63	0.00	63.76	-0.89
OR		com_conv	3.20	0.00	40.31	-0.60
WA		com_nc	3.74	0.00	43.12	-0.60
WA		com_conv	3.94	0.00	56.97	-1.04
OR		res_sfnc	1.87	-0.02	8.22	-0.13
OR		res_mfnc	0.41	0.00	2.37	-0.04
OR		res_conv	0.88	-0.01	7.00	-0.11
WA		res_conv	0.27	0.00	7.74	-0.12
WA		res_sfnc	0.25	0.00	8.49	-0.14
WA		res_mfnc	0.16	0.00	2.87	-0.05

Regression Model and Coefficients

service state	district code	segment	Y1	b1	Y2	b2
OR	ALB	com_exist	6.67	-0.06	34.88	-0.55
OR	AST	com_exist	3.81	0.00	28.33	-0.44
OR	COOS	com_exist	4.25	0.00	49.62	-0.76
OR	DALO	com_exist	6.31	-0.05	33.47	-0.52
WA	DALW	com_exist	6.31	-0.05	33.47	-0.52
OR	EUG	com_exist	9.26	-0.09	41.67	-0.67
OR	LC	com_exist	5.31	0.00	32.63	-0.51
OR	POR	com_exist	8.35	-0.08	43.95	-0.70
OR	POR	res_exist	1.80	-0.02	10.25	-0.16
OR	SAL	res_exist	1.06	-0.01	9.93	-0.16
WA	VAN	res_exist	1.69	-0.02	10.24	-0.16
OR		com_nc	4.63	0.00	63.76	-0.89
OR		com_conv	3.20	0.00	40.31	-0.60
WA		com_nc	3.74	0.00	43.12	-0.60
WA		com_conv	3.94	0.00	56.97	-1.04
OR		res_sfnc	1.87	-0.02	8.22	-0.13
OR		res_mfnc	0.41	0.00	2.37	-0.04
OR		res_conv	0.88	-0.01	7.00	-0.11
WA		res_conv	0.27	0.00	7.74	-0.12
WA		res_sfnc	0.25	0.00	8.49	-0.14
WA		res_mfnc	0.16	0.00	2.87	-0.05

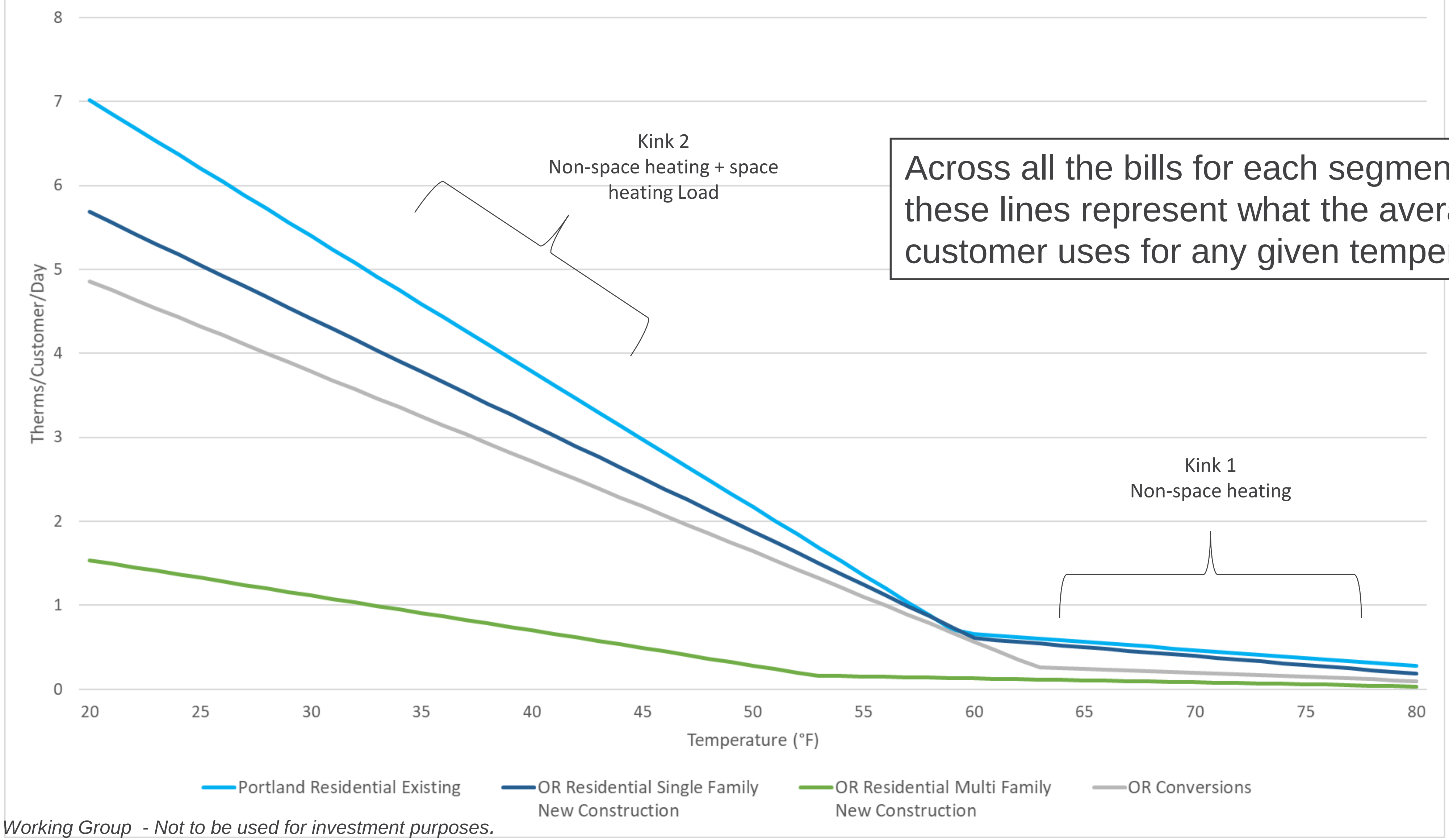


Daily Load Forecast based on Daily Temperature (T)

$$Use\ Per\ Customers\ (UPC) = Y_2 + b_2 * (T) \qquad if\ kink\ 2: T < K^*$$

$$= Y_1 + b_1 * (T) \qquad if\ kink\ 1: T \geq K^*$$

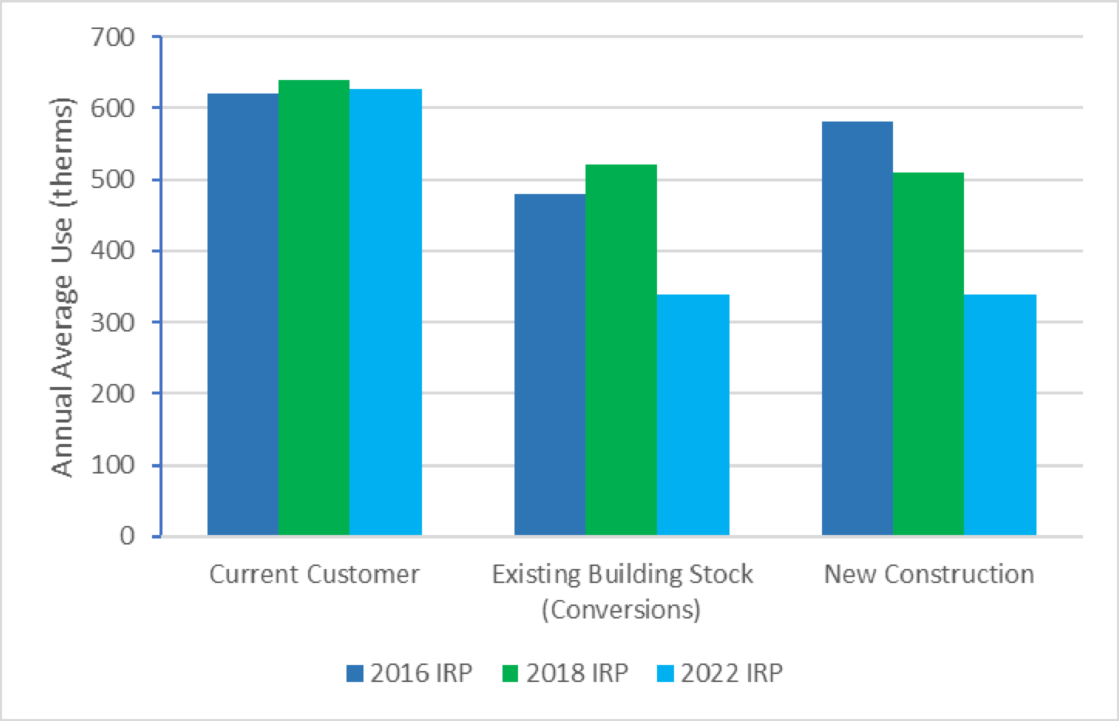
Portland Residential UPC Example



Across all the bills for each segment these lines represent what the average customer uses for any given temperature

Existing vs New Construction vs Conversion

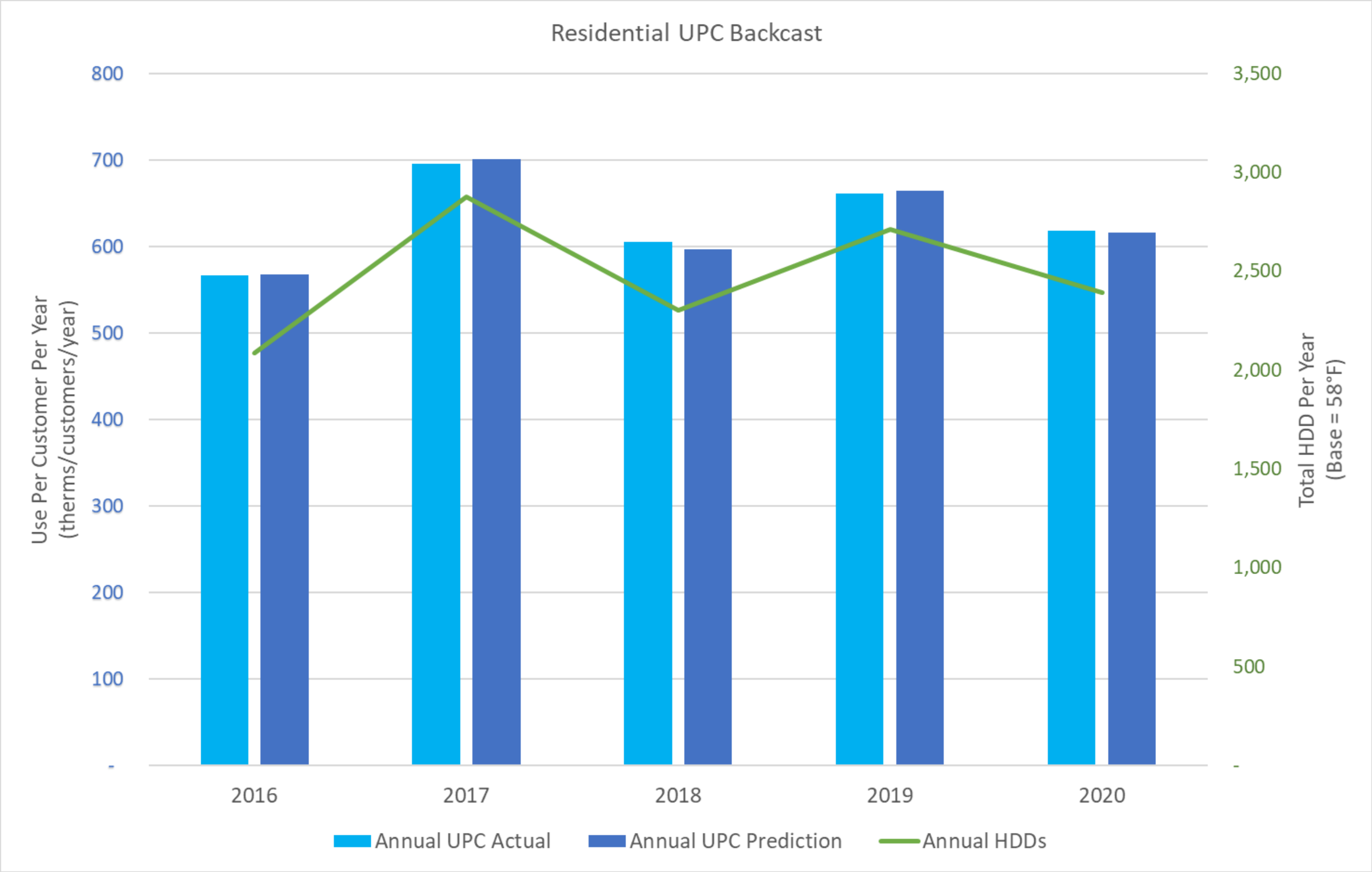
Residential



Commercial

Note: Conversions and New Construction estimates are based on billing data since 2018

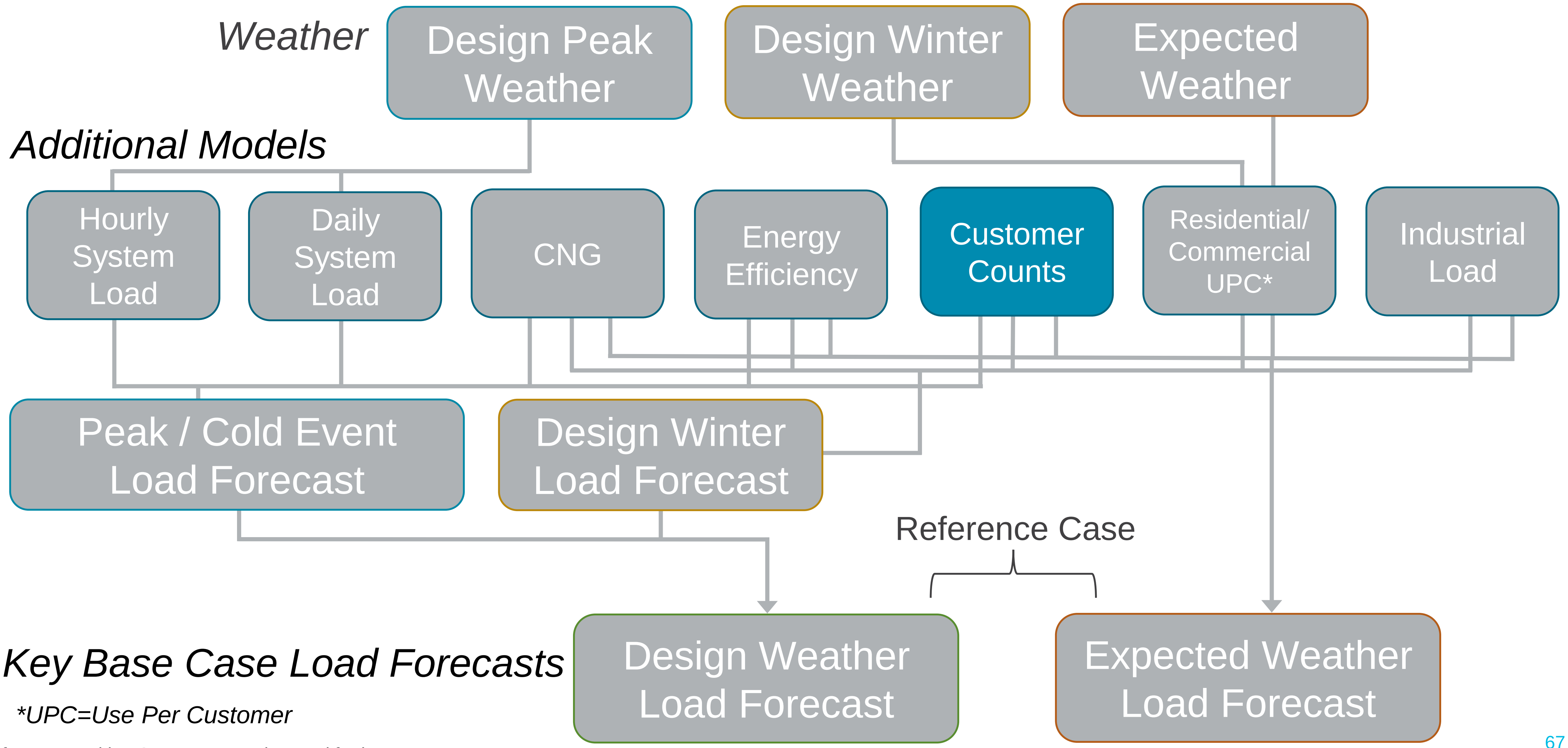
How well does the model forecast?



Reference Case Load Forecast
Customer Count Forecast

Customer Count Forecast

NW Natural®



IRP Customer Count Process

NW Natural®

Near-term Customer Count Forecast

NW Natural's Business Analytics' Short-term Meter Set Forecast by State

Commercial New Construction
Commercial Conversions
Residential Single Family New Construction
Residential Multi Family New Construction
Residential Conversions
Commercial and Residential Losses

+

Existing Customer Base by State

OR Existing
WA Existing

=

Near-term Customer Count Forecast (4 Years)

State Level Sub-segment Forecasts
(2 x 7 = 14 series)

Long-term Customer Count Forecast

Annual State-level Econometric Forecasts through 2050

OR & WA x Res/Com
(2 x 2 = 4 series)

Combine with Near-term Forecast

Allocate State-level Econometric Forecast to Sub-segment allocation

State Level Sub-segment Forecasts
(2 x 7 = 14 series)

Combine with Historical Growth by Area

Allocate to Load Center

Load Center Level Sub-segment Forecasts
(10 x 7= 70 series)

Historical Monthly Growth and Daily Linear Interpolation

Daily Customer Count by Segment by Load Center

General Notes about the Customer Count Forecast

- Same specifications as in 2018 IRP Update #3
  - Regress customer growth on historical data and project forward based on Oregon Economic Administration (OEA) forecasts
- Tested and corrected for nonstationarity / autoregressivity
- First 3 years are taken from BA meter set forecast, “blended” into econometric forecasts in year 4
- OEA provides RHS variable forecasts; extended through 2050 using long-term Census/PRC population projections
- Large commercial customers are included in the commercial customer count forecast
  - Rate schedules = '31CSF’, '32CSF’, 'C41SF’, 'C42SF’
  - However; load for these customers is forecasted separately with the Industrial Forecast and counts of these customers subtracted out for the UPC model

Econometric RHS Variables and Models

NW Natural®

Dependent Variable	Independent variable
OR Residential Customer Growth	Change in housing stock (OR housing Starts)
WA Residential Customer Growth	Change in housing stock (US housing Starts)
OR Commercial Customer Growth	Population growth (OR population)
WA Commercial Customer Growth	Local economic activity (Total employment growth in OR)

Econometric RHS Variables and Models

NW Natural®

Residential:

$$\Delta OR\ customer\ growth_t = \alpha + b_1 \frac{(\Delta OR\ starts_t + \Delta OR\ starts_{t-1})}{2} \quad (1)$$

$$\Delta WA\ customer\ growth_t = \alpha + b_1 \frac{(\Delta \ln(US\ starts_t) + \Delta \ln(US\ starts_{t-1}))}{2} \quad (2)$$

Commercial:

$$\Delta OR\ customer\ growth_t = \alpha + b_1 \frac{(\Delta \ln(OR\ pop_t) + \Delta \ln(OR\ pop_{t-1}) + \Delta \ln(OR\ pop_{t-2}))}{3} \quad (3)$$

$$\Delta WA\ customer\ growth_t = \alpha + b_1 \frac{(\Delta \ln(OR\ emp_t) + \Delta \ln(OR\ emp_{t-1}) + \Delta \ln(OR\ emp_{t-2}))}{3} \quad (4)$$

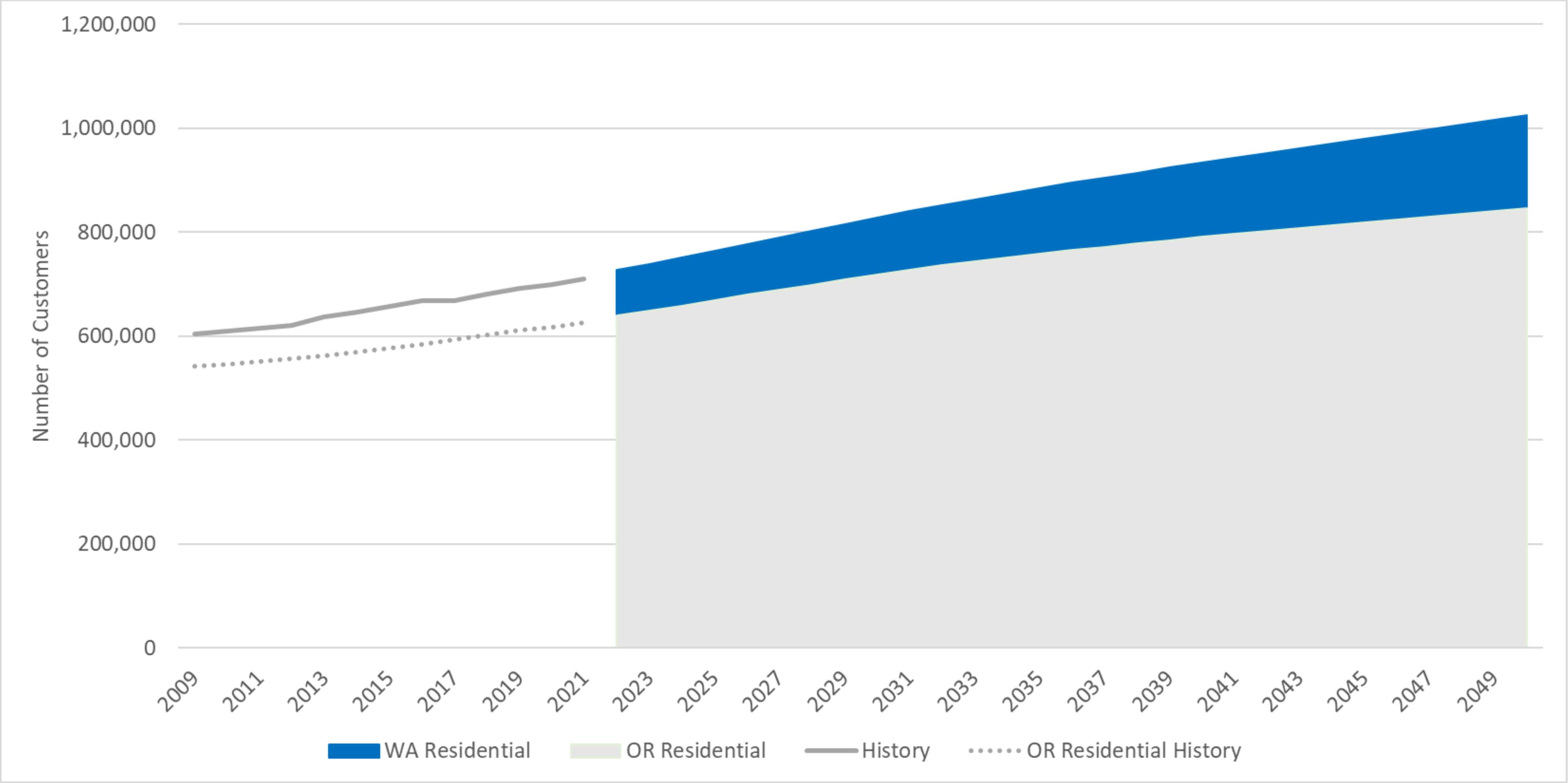
Equation #	α	b_1
1 – OR Residential	-158	405**
2 – WA Residential	37	1,768**
3 – OR Commercial	29	64,625*
4 – WA Commercial	158**	1.3*

* p-value < 5%

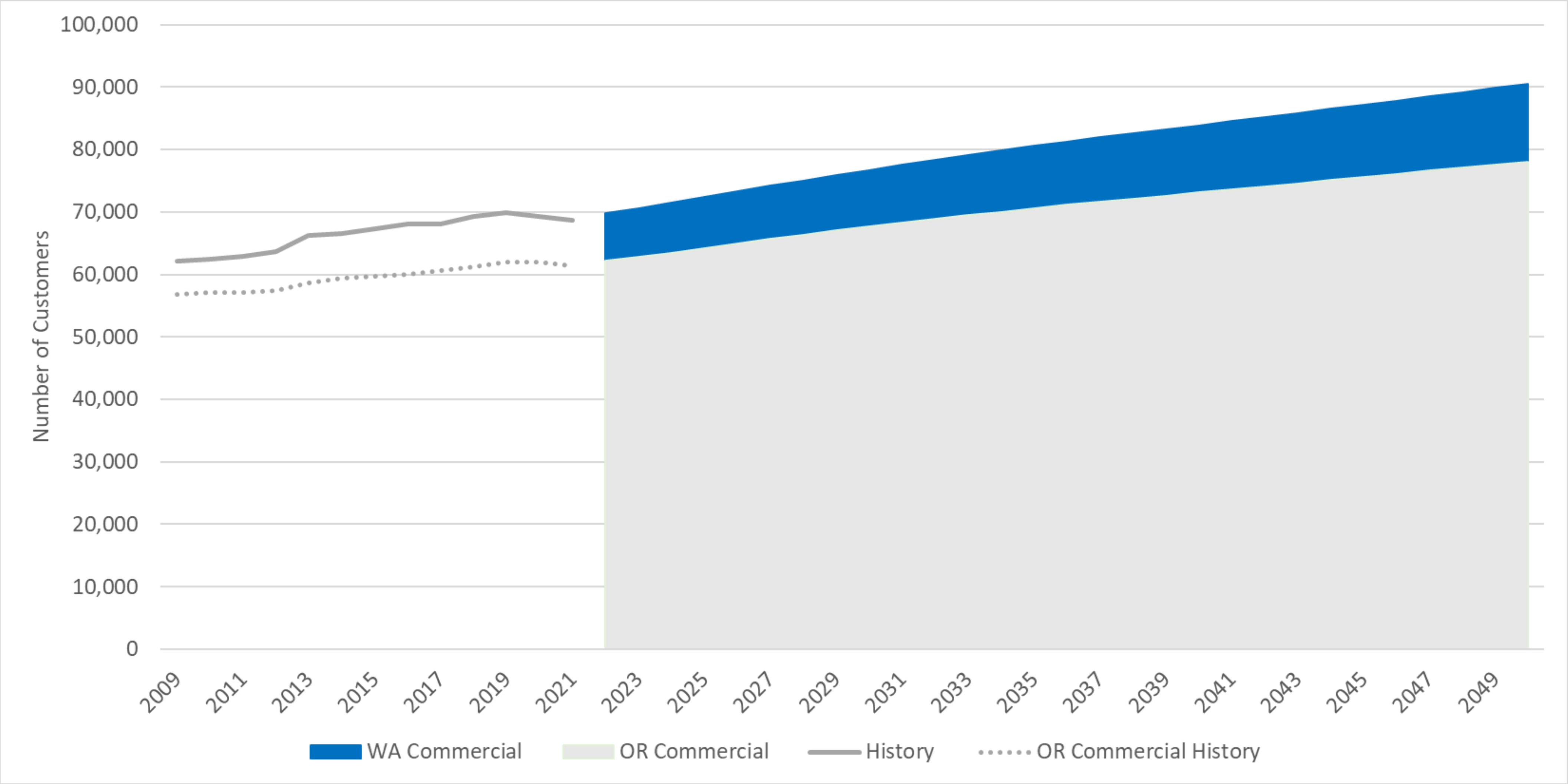
** p-value < 1%

Note: Coefficients are not comparable across equations due to different right hand side variables and specifications

Residential Customer Count –Reference Case



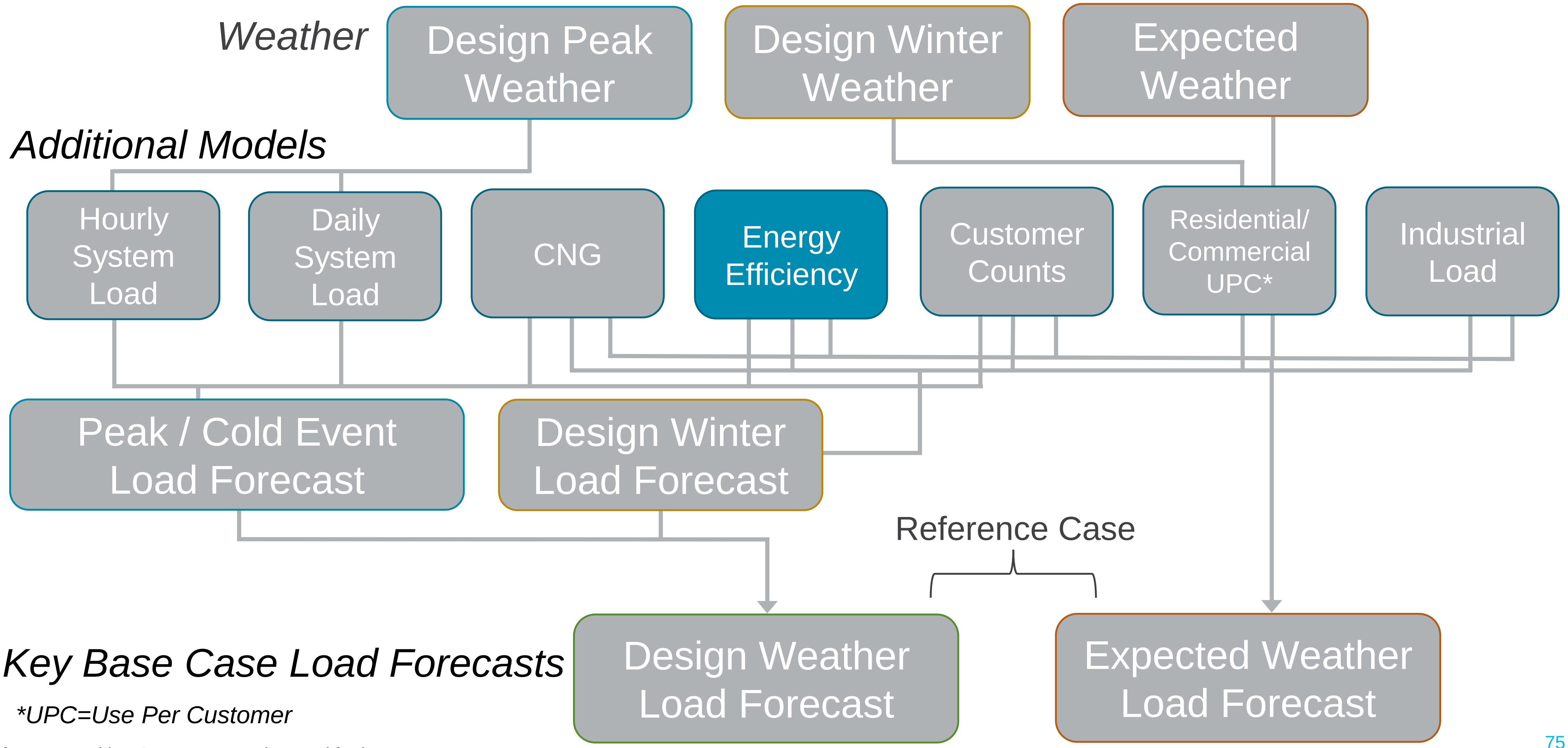
Commercial Customer Count – Reference Case



Reference Case Load Forecast

Accounting for Energy Efficiency

Energy Efficiency Forecast



*UPC=Use Per Customer

Energy Trust of Oregon

NW Natural partners with the Energy Trust of Oregon to deliver energy efficiency programs and measure to NW Natural customers

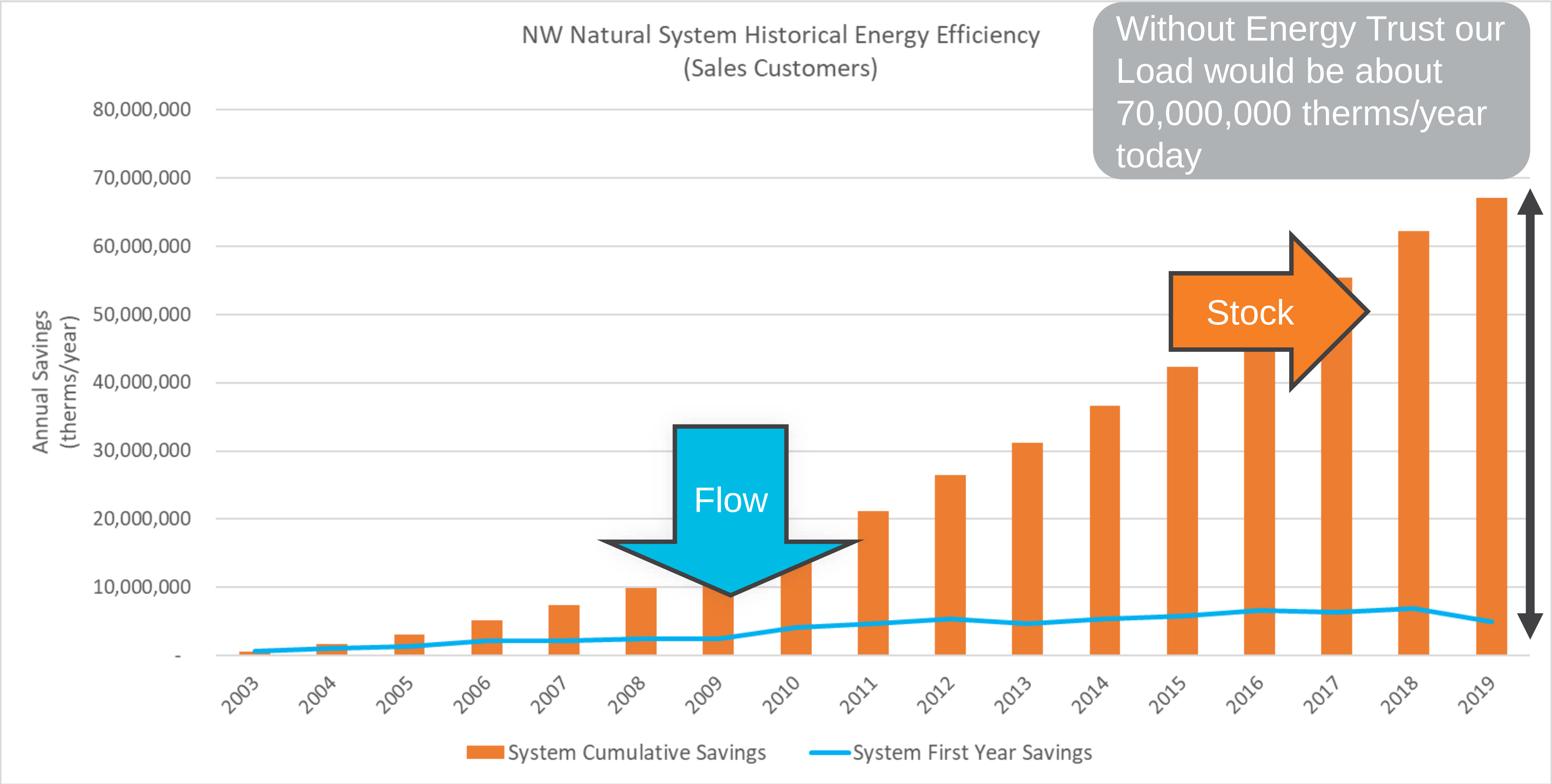
Program Offerings for Oregon	Program Offerings for Washington

• Residential
  • New Homes
  • Existing Homes
• Commercial
  • New Buildings
  • Existing Buildings
• Industrial and Agriculture
	• Residential
	  • New Homes
	  • Existing Homes
	• Commercial
	  • New Buildings
	  • Existing Buildings

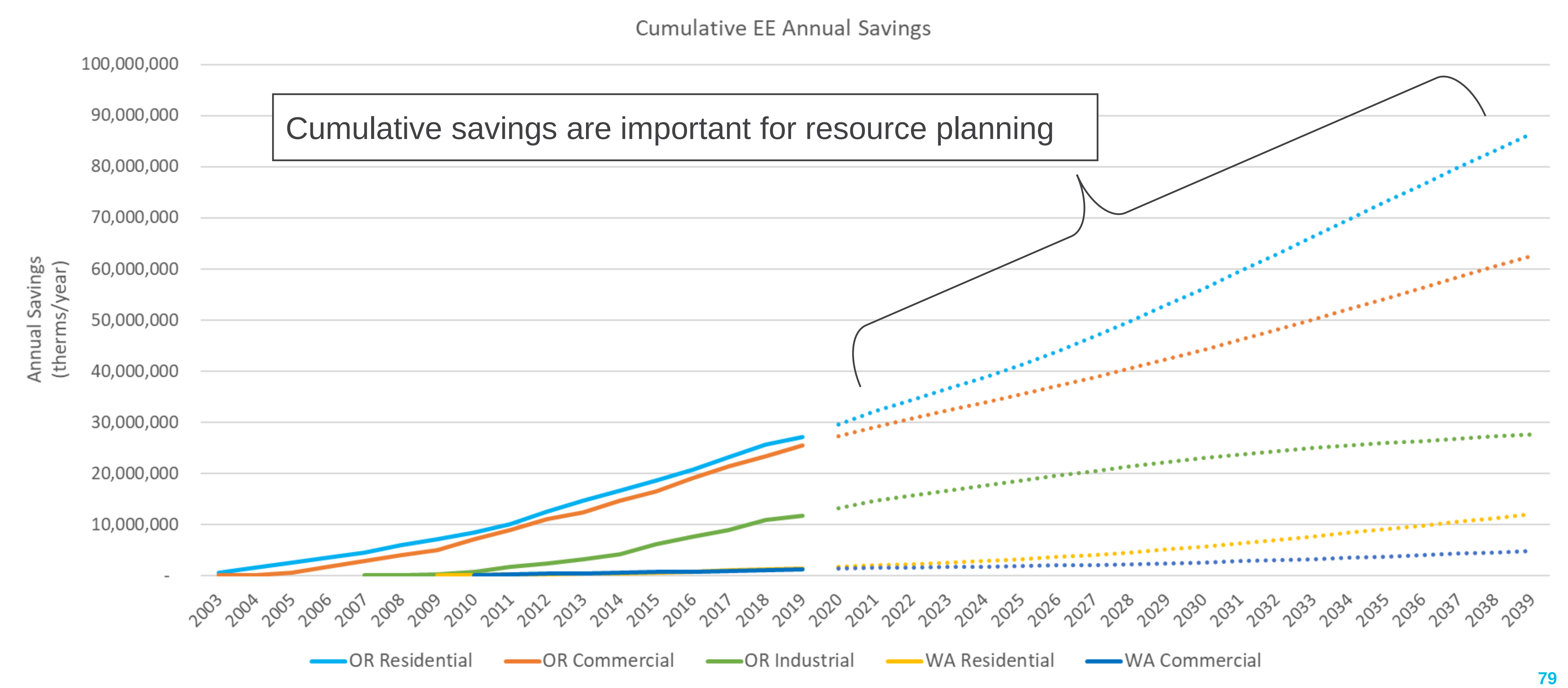
Conservation Potential Assessments (CPAs) / EE Forecast

- Energy Trust of Oregon is currently working with NW Natural on the energy efficiency forecast for sales customers in Oregon
  - The timing for developing the OR CPA was dependent on CPP rulemaking and we are all working hard to complete this work for the 2022 IRP
- Legislation in WA (HB 1257) required a CPA for WA be conducted early last year to inform biennial EE targets starting in 2022
  - Applied Economics Group (AEG) conducted a CPA for NW Natural WA sales customers
- The methodology and the forecasts for these CPAs will be presented at a later TWG
- The forecast shown today is a previous forecast provided by the Energy Trust in preparation for NW Natural's 2020 IRP (prior to our extension request for the IRP)
- The slides presented today demonstrate how the energy efficiency forecast is incorporated into NW Natural's load forecast and should are a place holder for value to be updated
- We will update the reference case load forecast with the updated CPAs for the 2022 IRP

First Year Savings vs Cumulative Savings



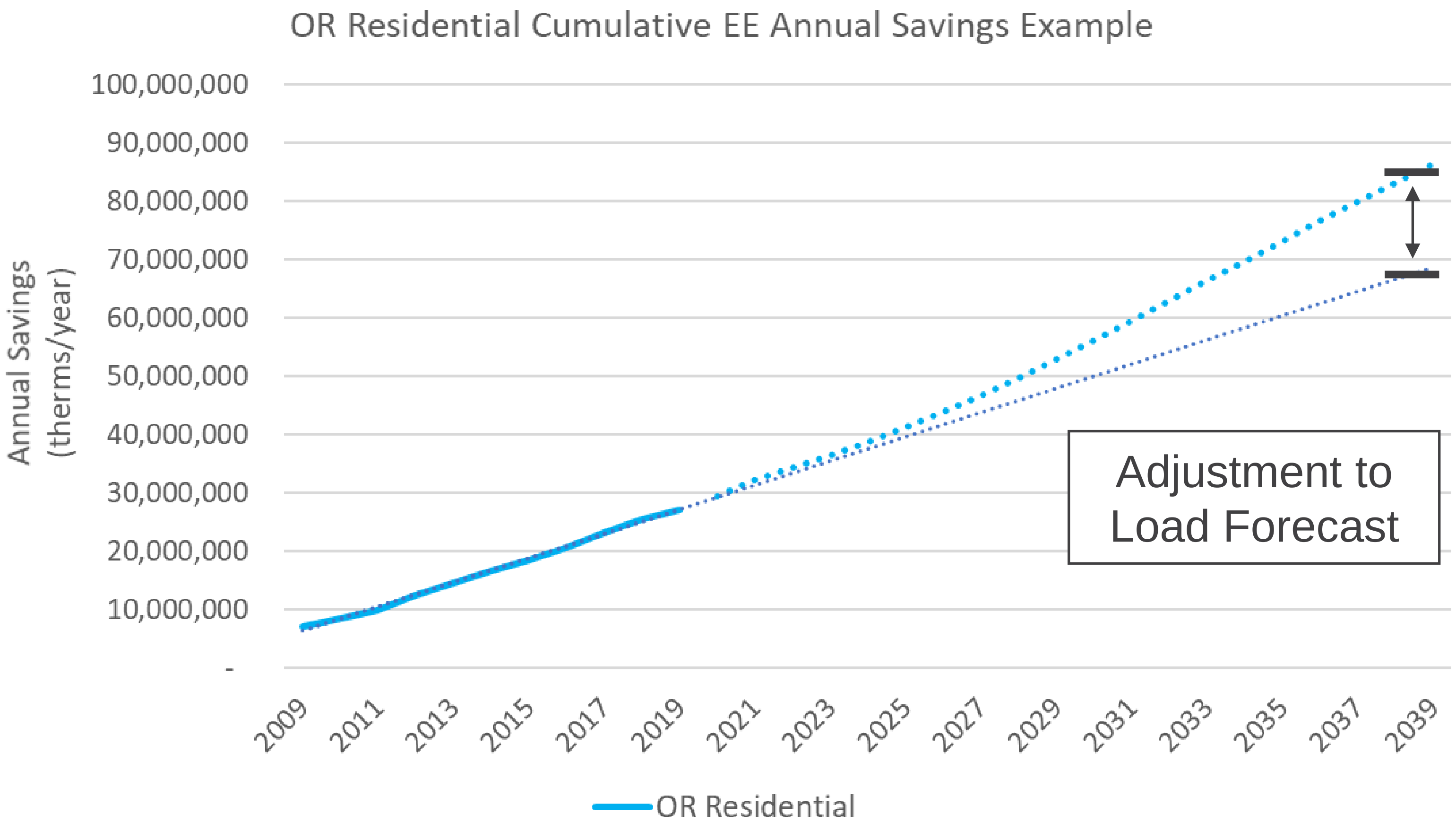
Cumulative Savings By Sector



Adjusting NW Natural's Load Forecast

NW Natural®

- Historical customer usage data used for UPC modeling contains the energy efficiency trends
- To account for this, we estimate a trend for EE based on historical data and adjust the load forecast by the difference between the trend and the EE forecast
- Adjustment is calculated by state and sector for each forecast year and allocated to load center and daily load based on a daily load to total annual load ratio
- Similar adjustment is made for the peak day forecast at the system level for peak day savings



Reference Case Load Forecast

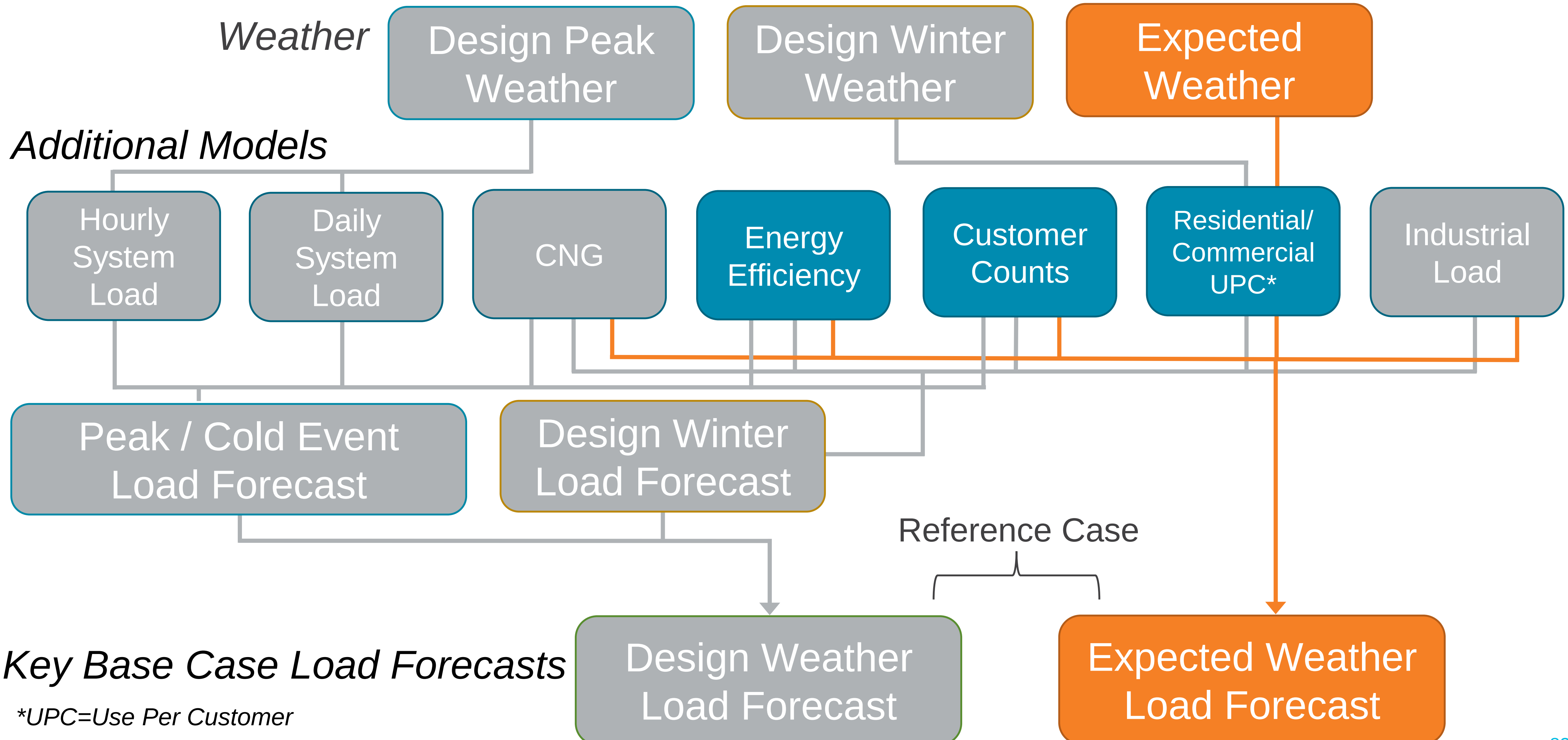
Residential and Commercial
Expected Weather Forecast

Weather Models – Expected Weather

Weather | Design Peak Weather | Design Winter Weather | Expected Weather

- Expected Weather
  - Akin to normal weather used in previous IRP's; we make the distinction for "Expected Weather" which incorporates climate change trends, whereas the term "normal weather" typically means a historical average (e.g., 30 year historical)
  - We know that actual daily, monthly, and annual temperatures will be *noisy* (i.e., random) as we move into the future
  - Our expected weather forecast represents what we expect to see on average for any given forecast year

Residential and Commercial Expected Weather Load Forecast



Adding it all up!

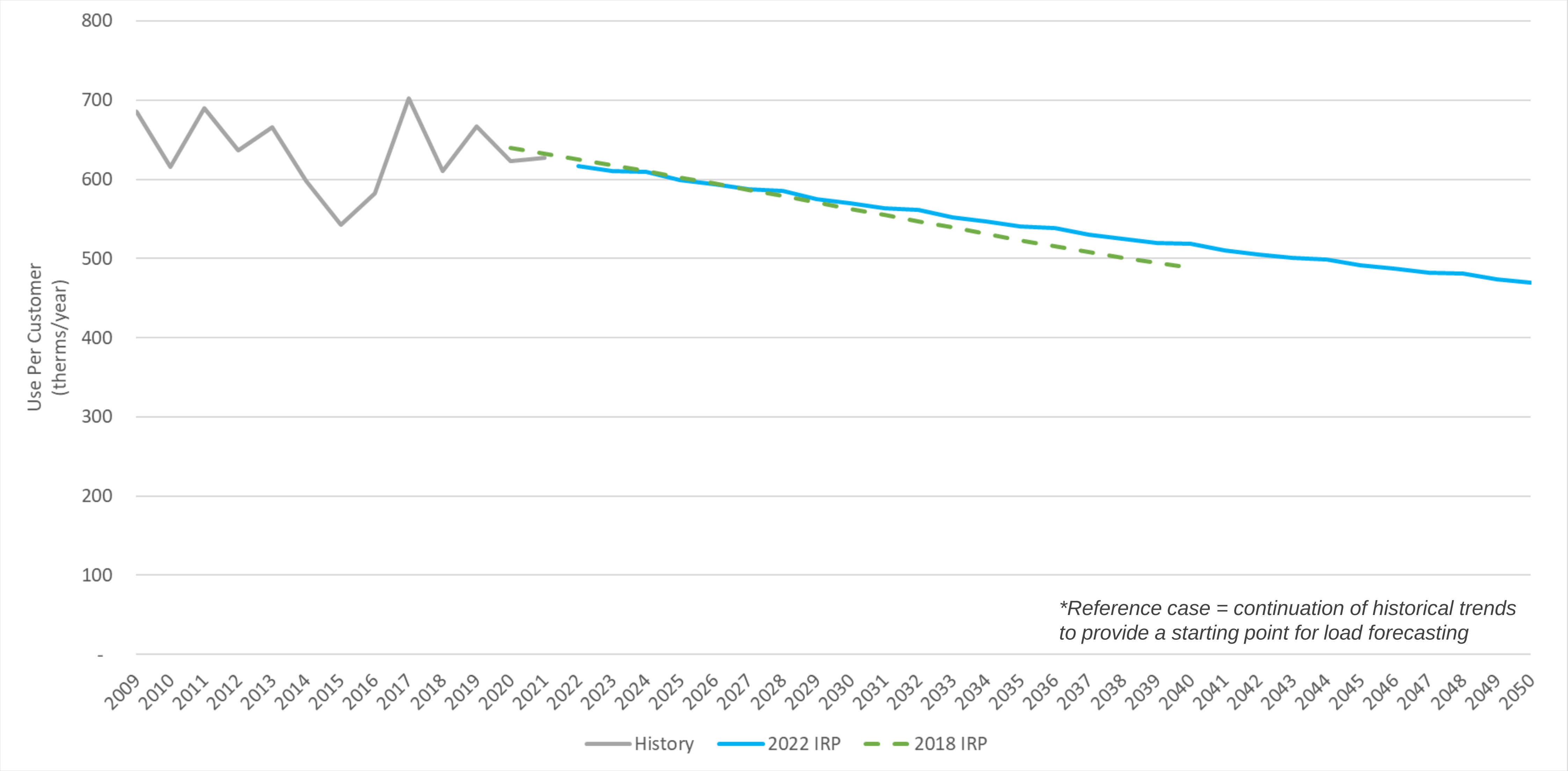
$$\textit{Total Residential Daily Load} = \sum_i \sum_j f\left(UPC_{i,j} \middle| Daily\ Temp_i\right) * \ Customer\ Count_{i,j} + EE\ Residential\ Adjustment_i$$

$$\textit{Total Small Commercial Daily Load} = \sum_i \sum_k f\left(UPC_{i,k} \middle| Daily\ Temp_i\right) * \ Customer\ Count_{i,k} + EE\ Commercial\ Adjustment_i$$

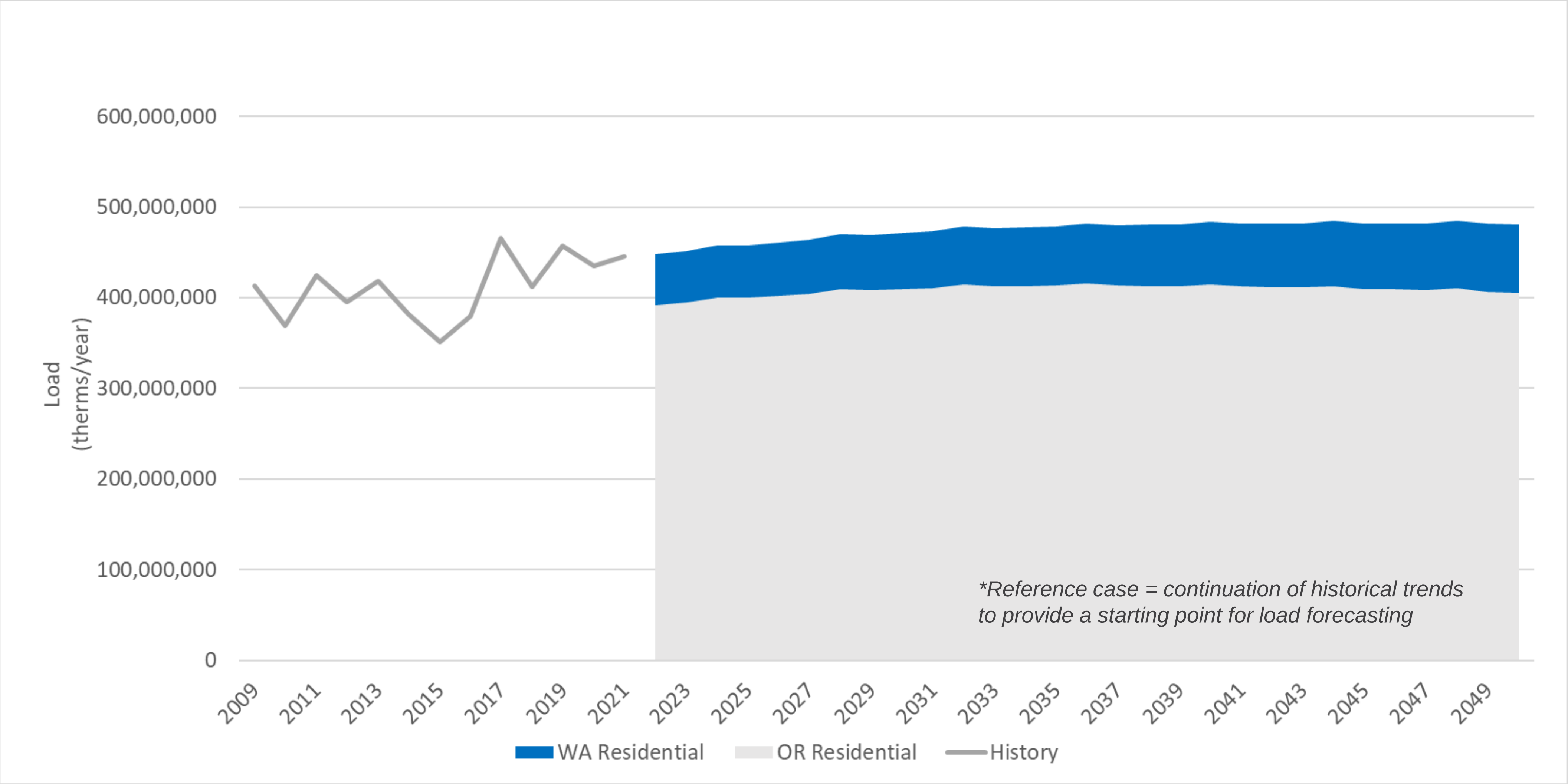
$i \in$	$j \in$	$k \in$
Astoria, Albany, Coos Bay, Dalles WA, Dalles OR, Eugene, Lincoln City, Portland, Salem, Vancouver	*Residential Existing, Residential Conversions, Residential Single-Family New Construction Residential Multi-Family New Construction*	*Commercial Existing, Commercial Conversions, Commercial New Construction*

Notes: UPC coefficients for new construction and conversions are estimated by state but assigned to the appropriate load centers; Dalles OR and Dalles WA in the model have the same weather but are allocated different customers counts to account for customers in the different states. Small commercial is distinguished here since large commercial is estimate separately.

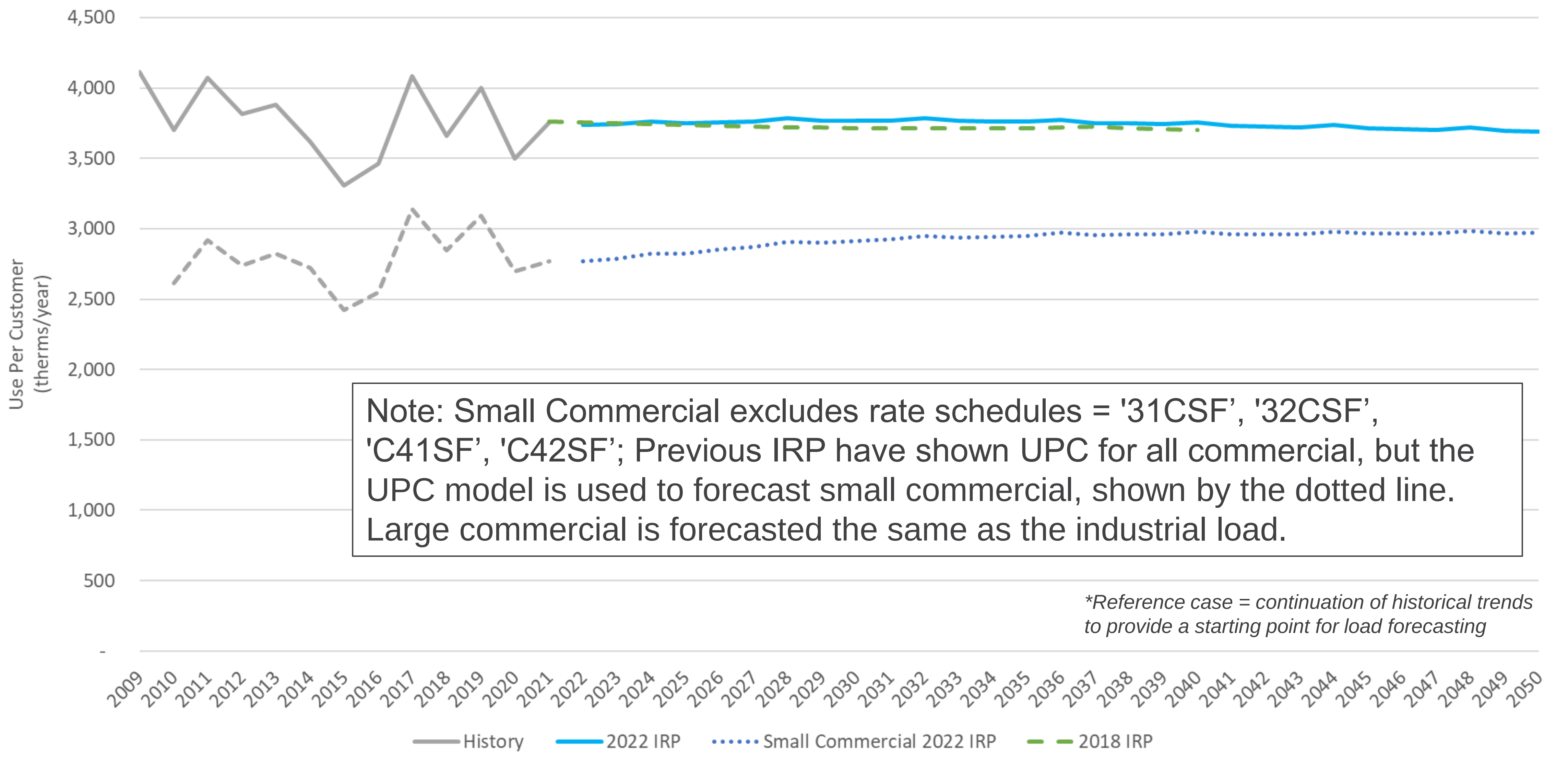
Residential Use Per Customer – Reference Case



Residential Load – Reference Case



Commercial Use Per Customer – Reference Case

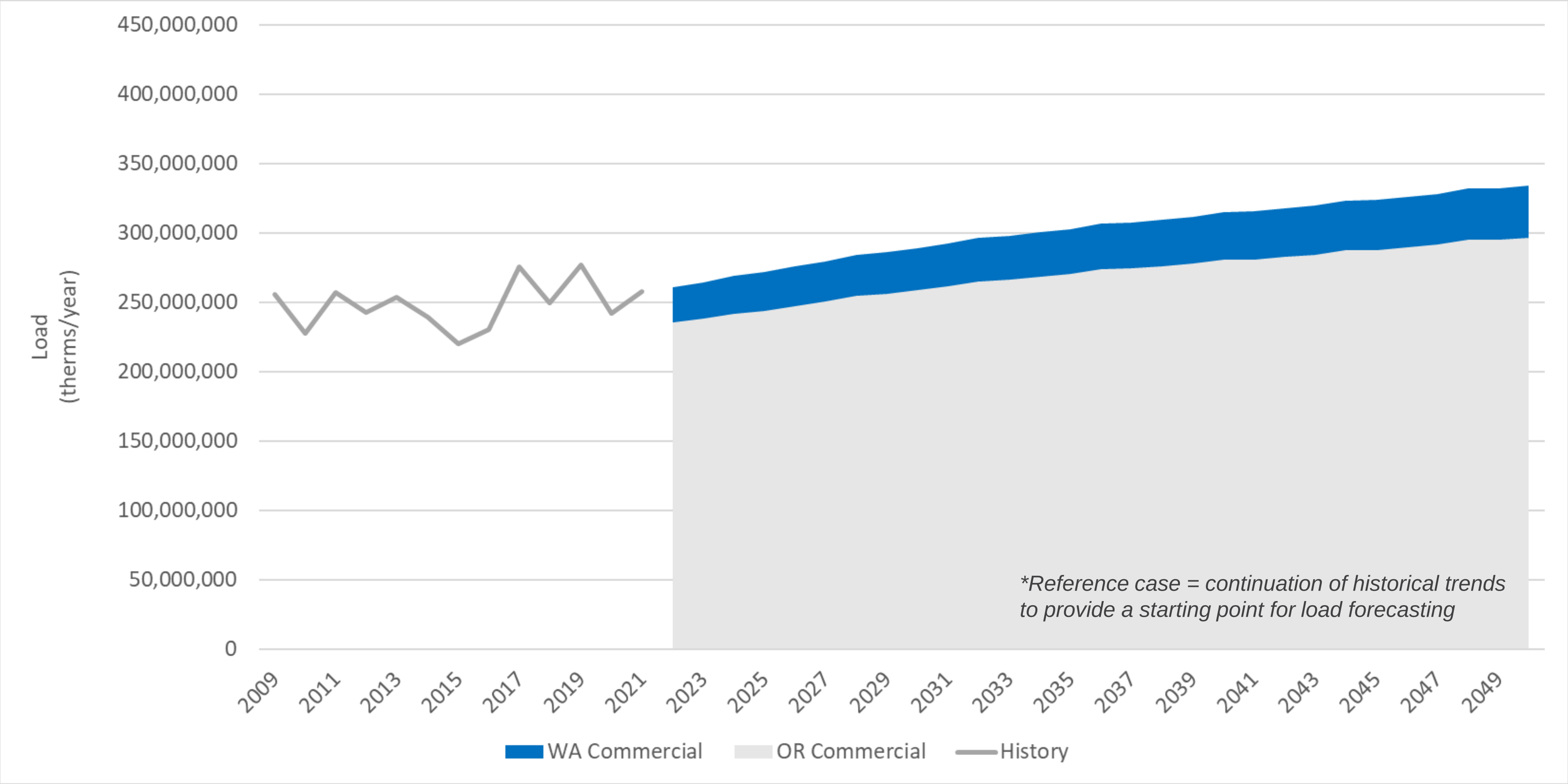


Note: Small Commercial excludes rate schedules = '31CSF', '32CSF', 'C41SF', 'C42SF'; Previous IRP have shown UPC for all commercial, but the UPC model is used to forecast small commercial, shown by the dotted line. Large commercial is forecasted the same as the industrial load.

**Reference case = continuation of historical trends to provide a starting point for load forecasting*

Commercial Load Forecast – Reference Case

NW Natural®

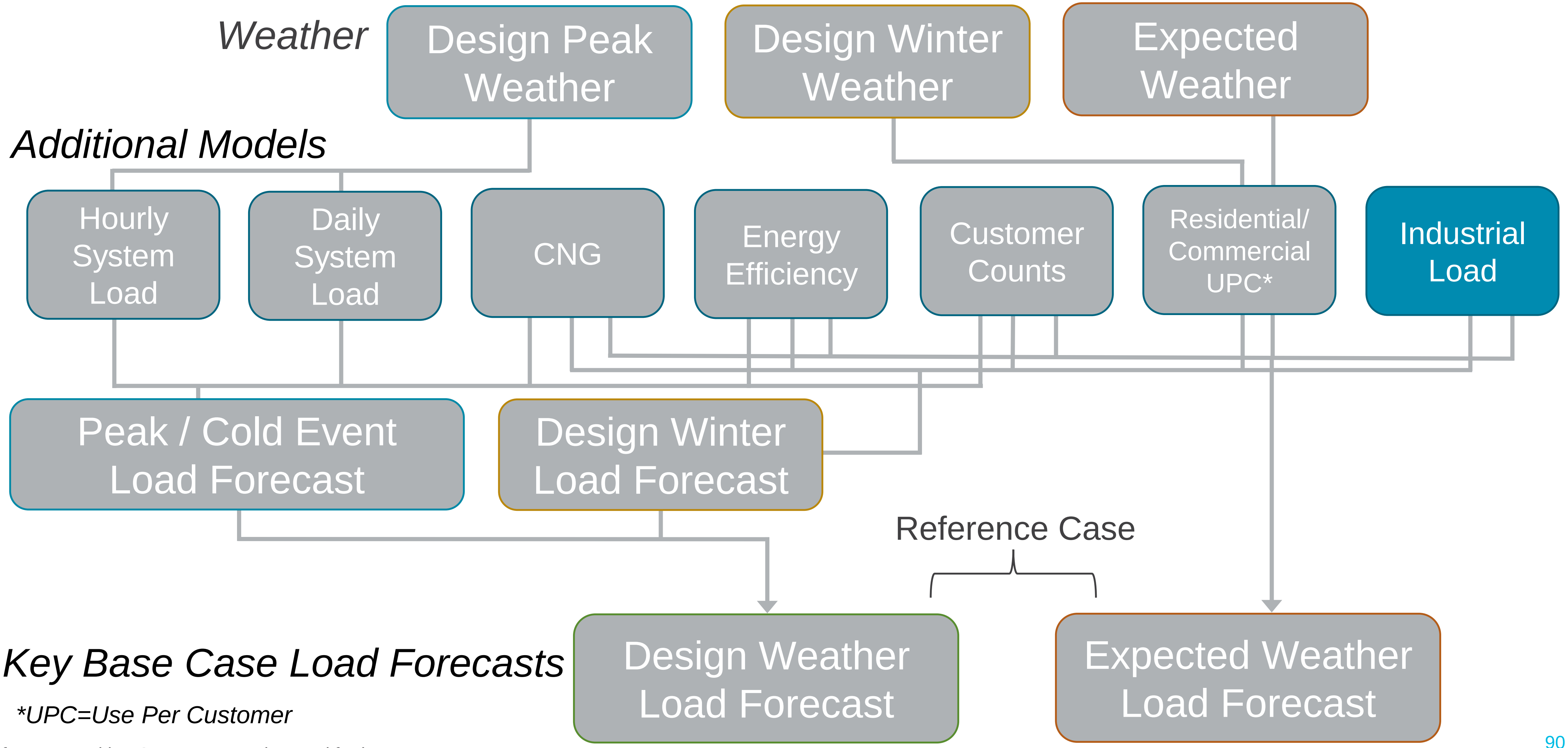


Reference Case Load Forecast

Industrial, Large Commercial and CNG Load Forecast

Industrial Load Forecast

NW Natural®



*UPC=Use Per Customer

IRP Industrial Load Forecast Process

NW Natural®

Near-term Industrial Forecast

NW Natural's SME Short-term Monthly Industrial Load Forecast by Type and Load Center

Firm Sales
Interruptible Sales
Firm Transportation
Interruptible Transportation

=

Near-term Monthly Industrial Load Forecast (2 Years)

Type by Load Center
(4 x 10 = 40 series)

Long-term Industrial Forecast

Annual System Econometric Forecasts through 2050

Total NW Natural Industrial Load

→ Combine with Near-term Forecast

Allocate to Month, Customer Type, And Load Center

Type by Load Center
(4 x 10 = 40 series)

→ Convert monthly load to daily

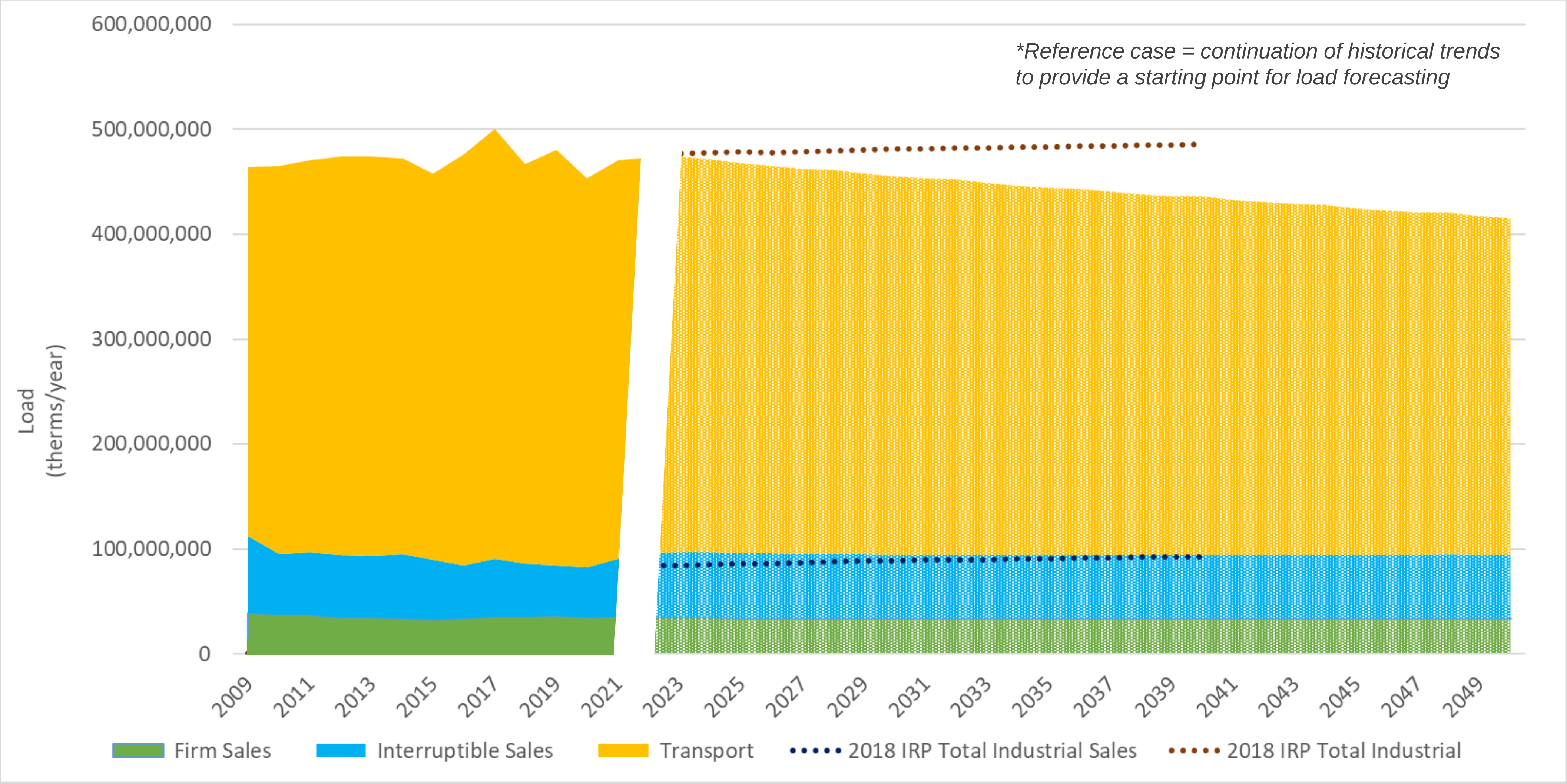
Daily Industrial Load by Customer Type and Load Center

General Notes about the Industrial Forecast

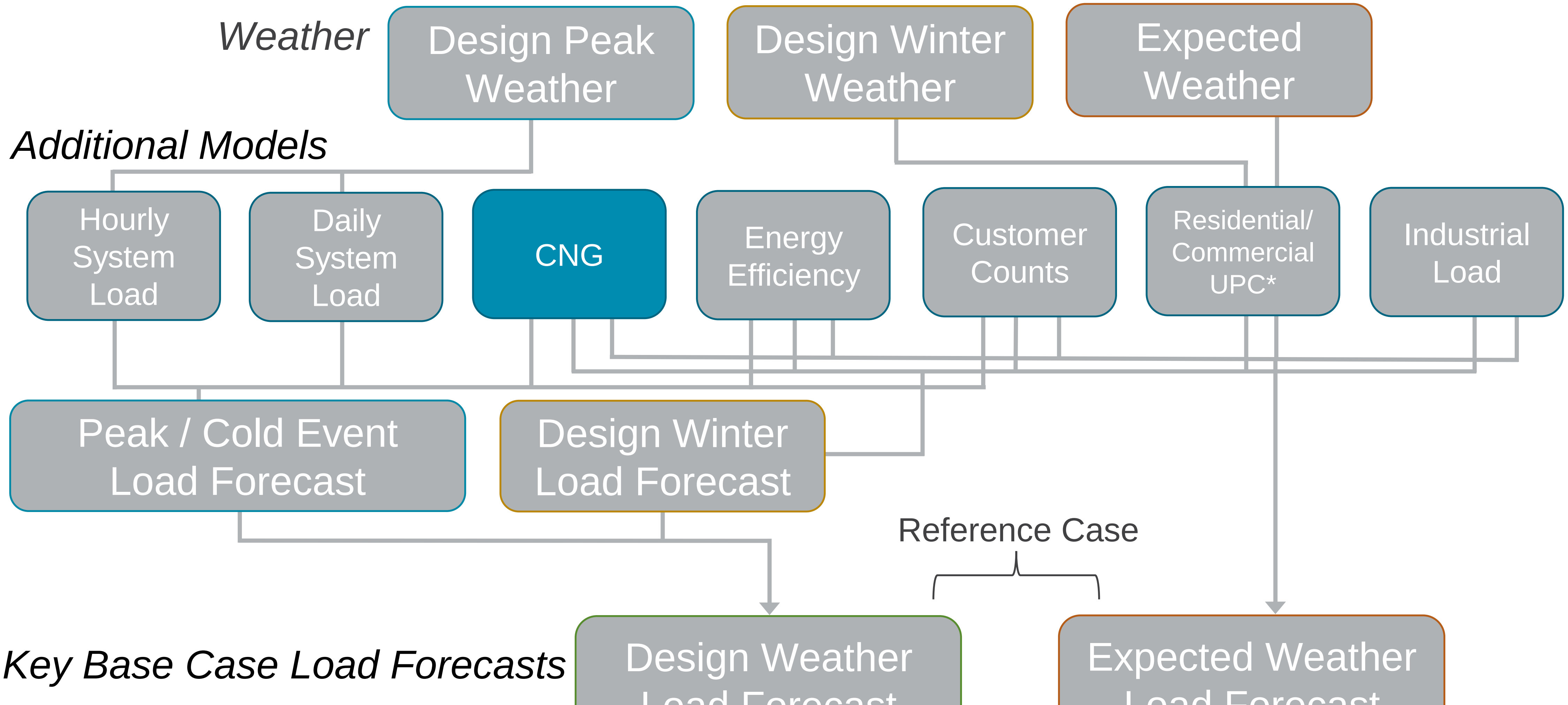
- Same specifications as in 2018 IRP Update #3
  - Regress on historical data and project forward based on Oregon Economic Administration (OEA) forecasts
- First 2 years of the forecast are taken from internal NW Natural SME and growth rates from the econometric model are applied from 2024 – 2050
- OEA provides RHS variable forecasts; extended through 2050 using compound annual growth rate (CAGR) of the last 5 years of OEA's forecast
- Industrial load growth rates are applied to previous 3-year average large commercial load for large commercial load forecast
  - Rate schedules = '31CSF', '32CSF', 'C41SF', 'C42SF'

Dependent Variable	Independent variable
Annual Industrial Load	Index for US industrial output (Forecast of driver variable provided by OEA)

Industrial Load Forecast – Reference Case



CNG Market Load Forecast

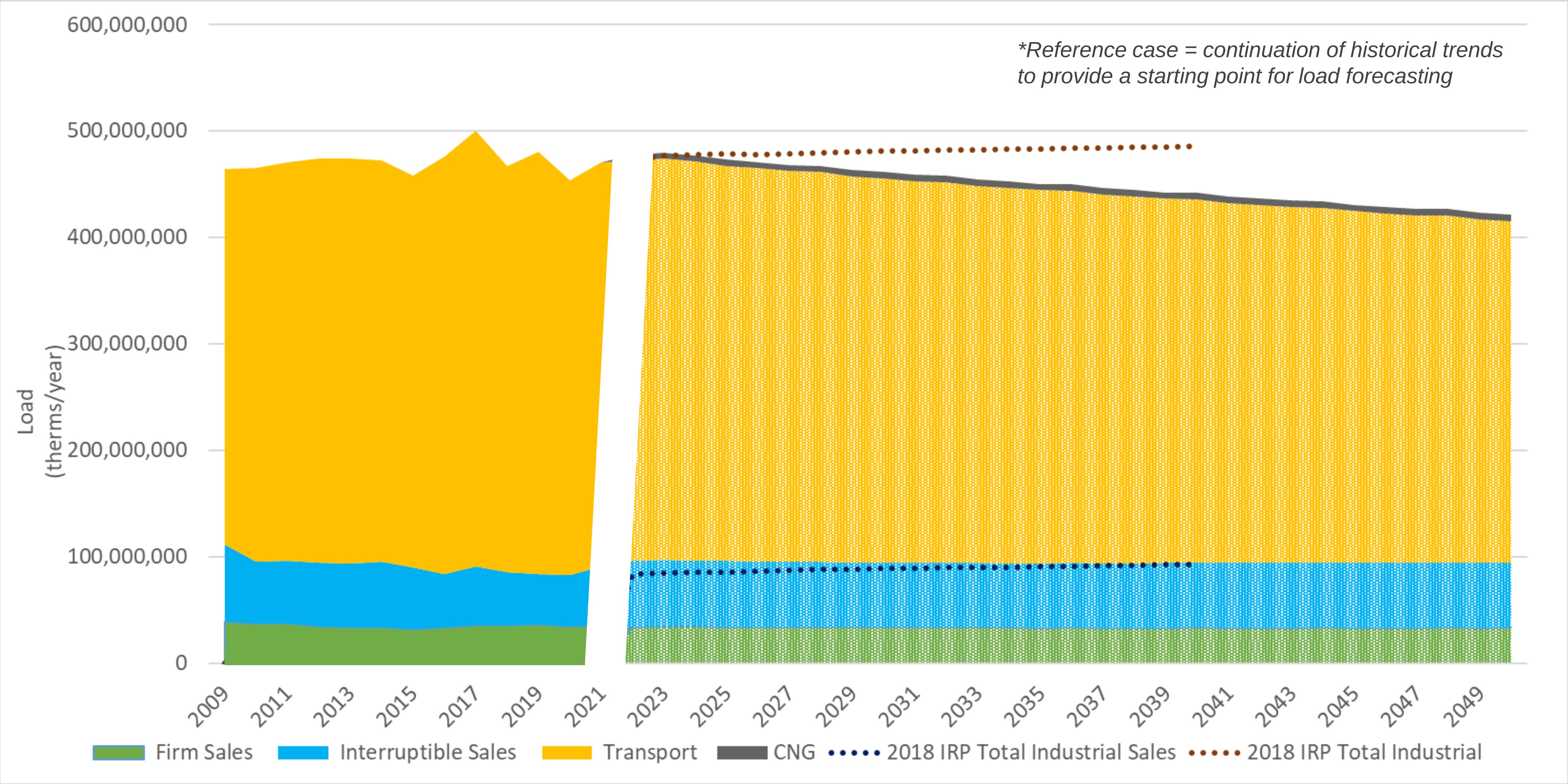


**UPC=Use Per Customer*

CNG Market Forecast

- Compressed Natural Gas (CNG) is used for natural gas vehicle fleets
- Previously called emerging market forecast in prior IRPs, but since it only contains load from CNG, we've changed the label it to be more explicit
- The CNG forecast used for emerging markets is developed by a NW Natural SME
- Very tiny portion of NW Natural's over all load

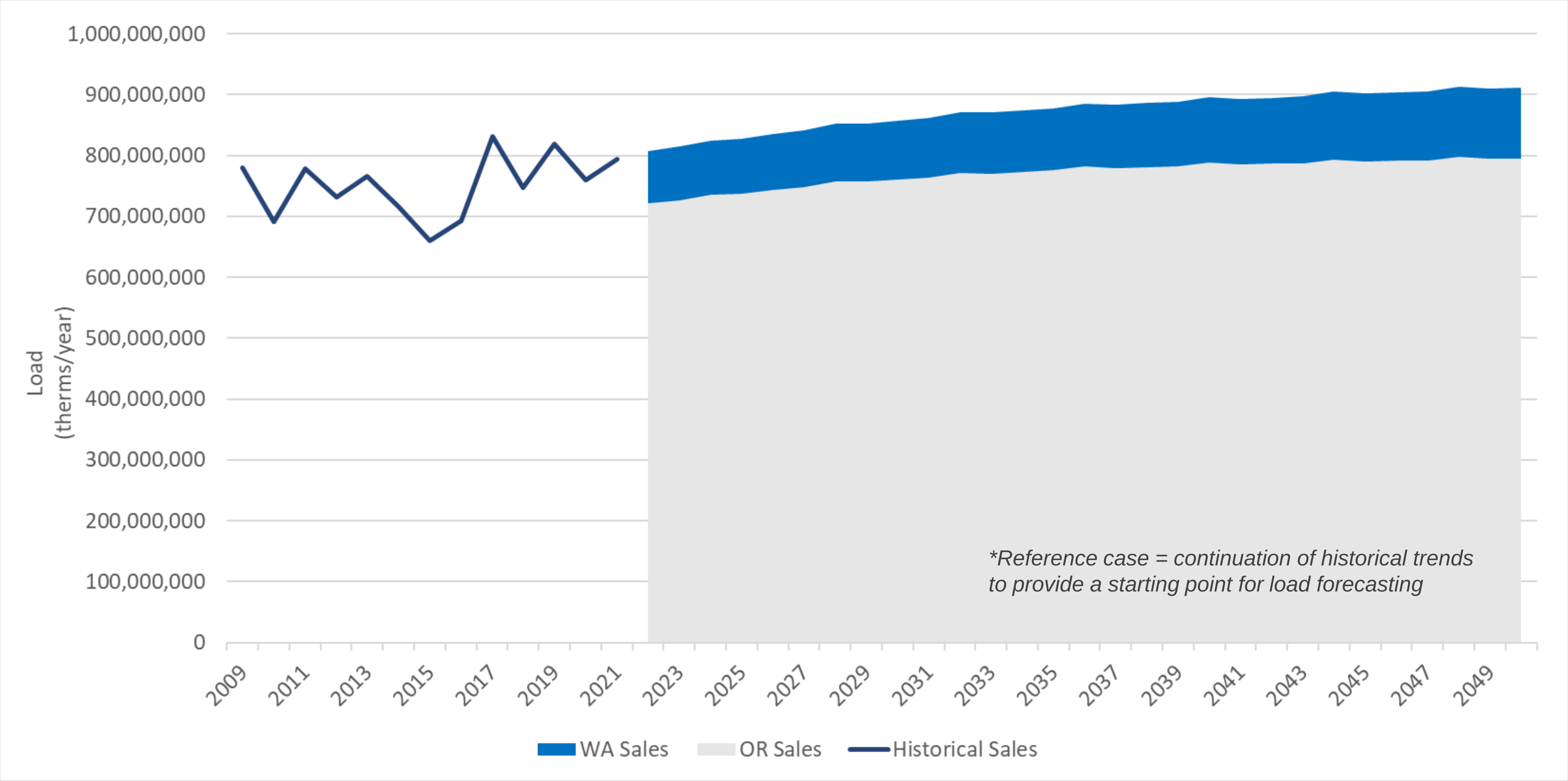
Industrial and CNG Load Forecast – Reference Case



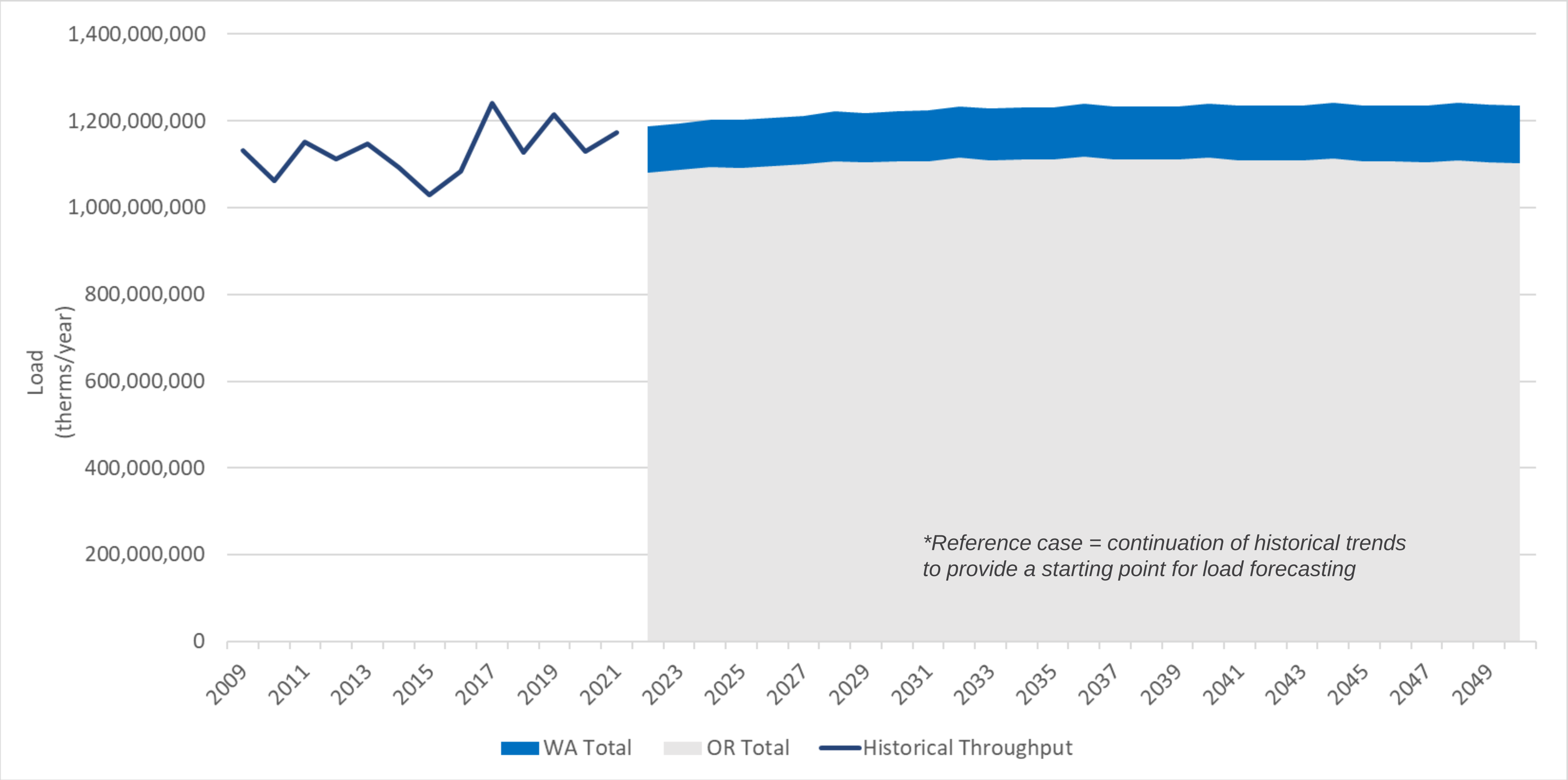
Reference Case Load Forecast

Total System Expected Weather Forecast

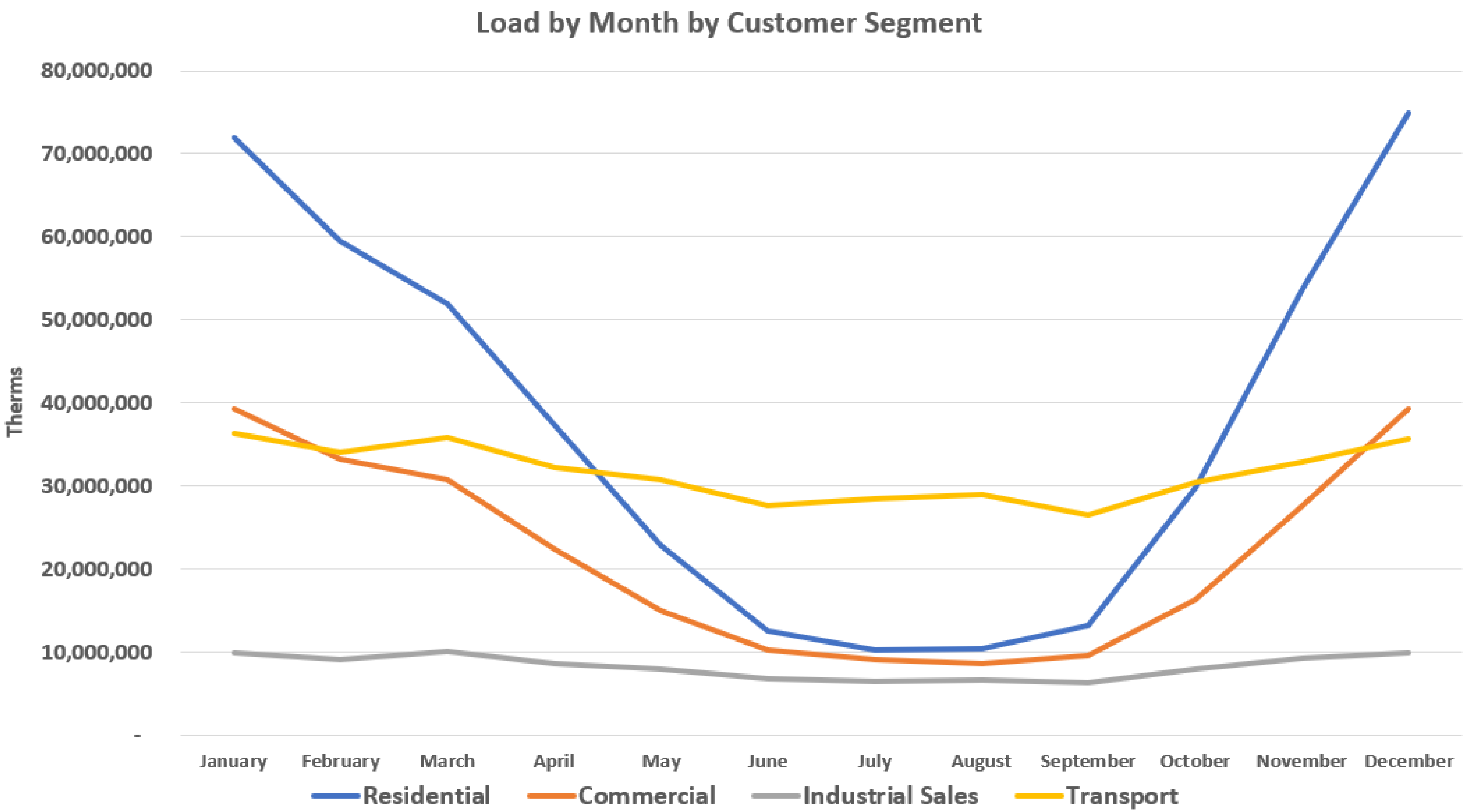
Expected Total System Sales Load – Reference Case



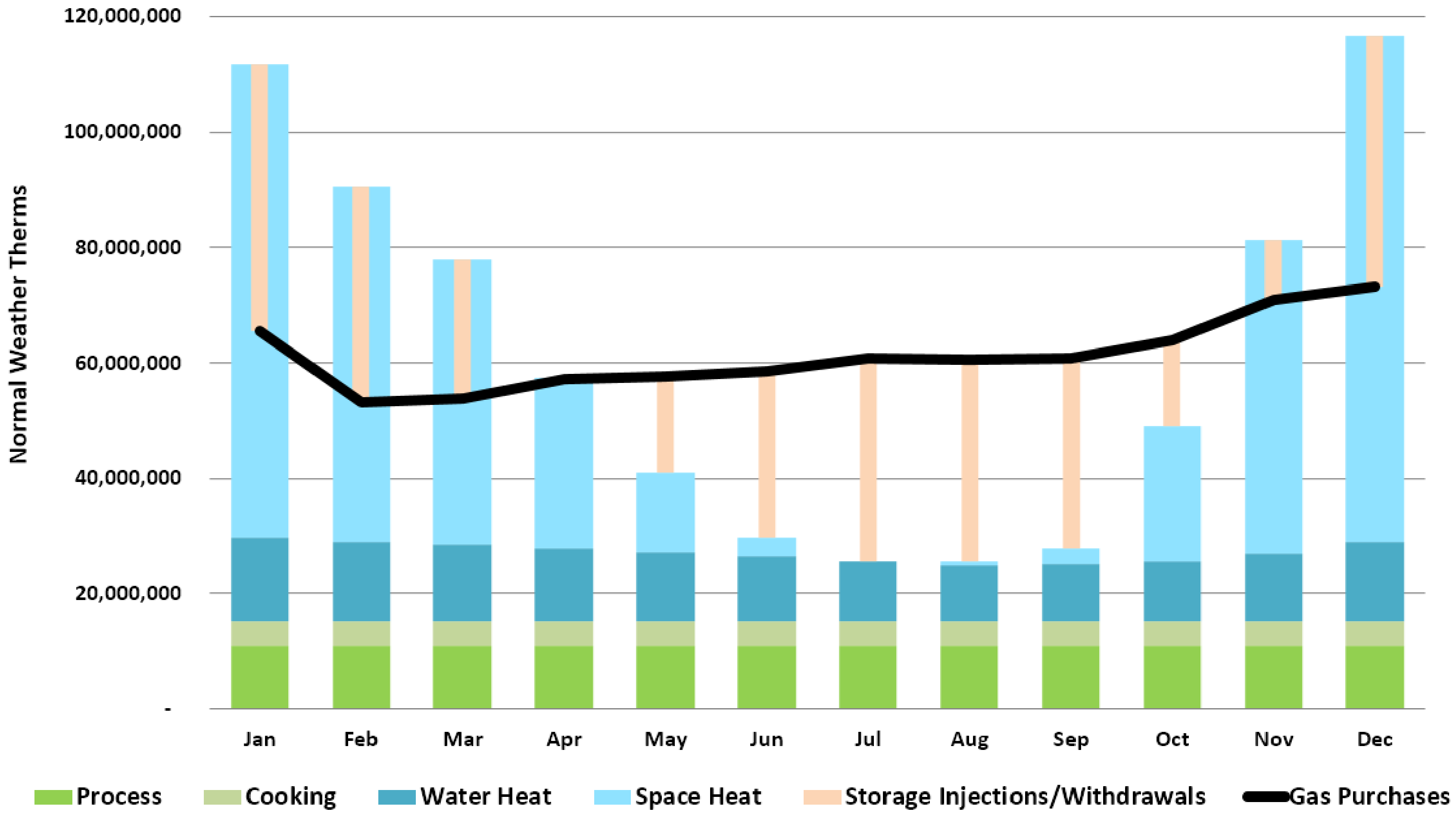
Expected Total System Throughput – Reference Case



Load Seasonality by Customer Type



Energy storage is critical to meeting seasonal demand



Source: NW Natural 2018 IRP, Figure 1.8: NW Natural Monthly Sales Load by End Use. Includes both firm and interruptible customers

Reference Case Load Forecast

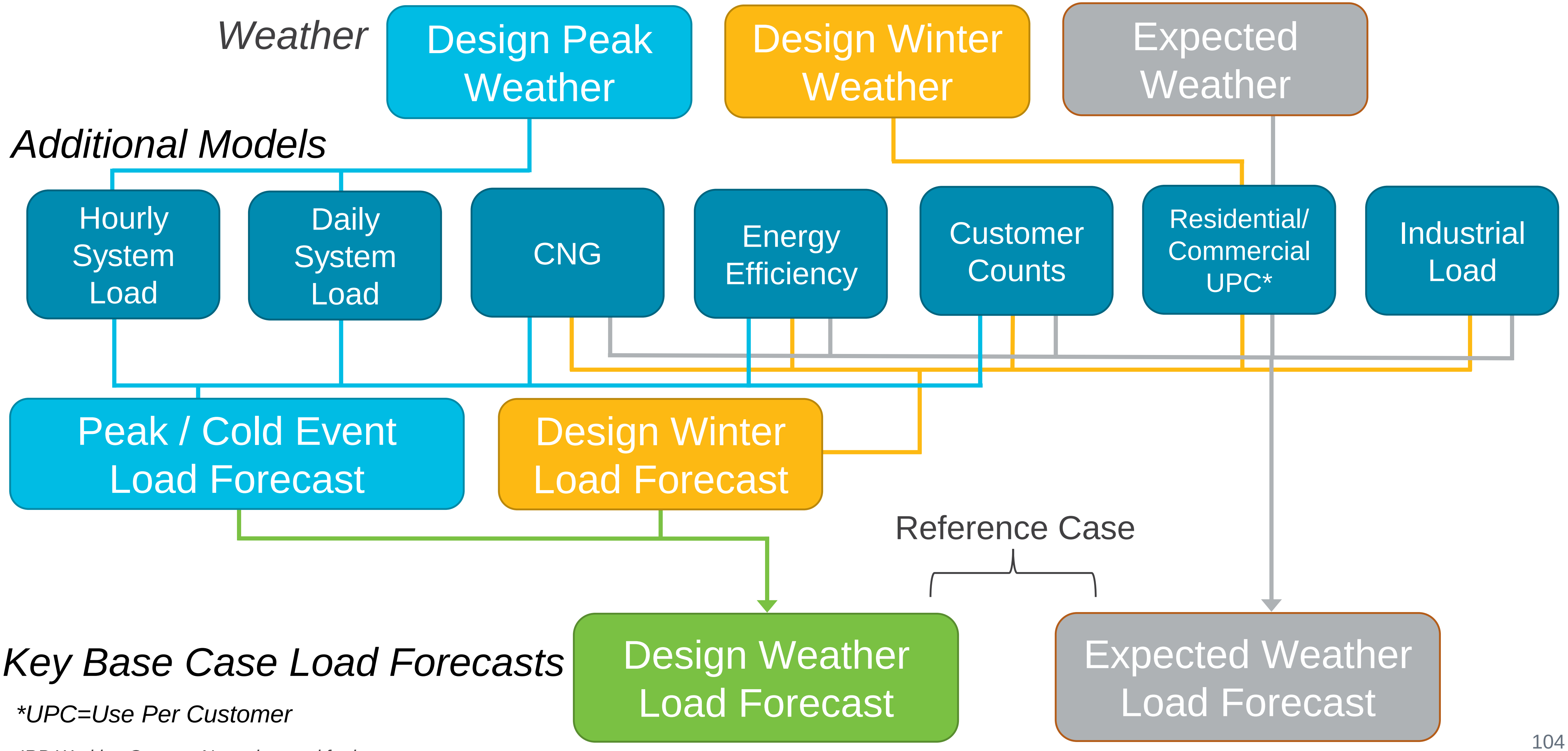
Design Weather Forecast

Weather Models – Design Winter

Weather | Design Peak Weather | Design Winter Weather | Expected Weather

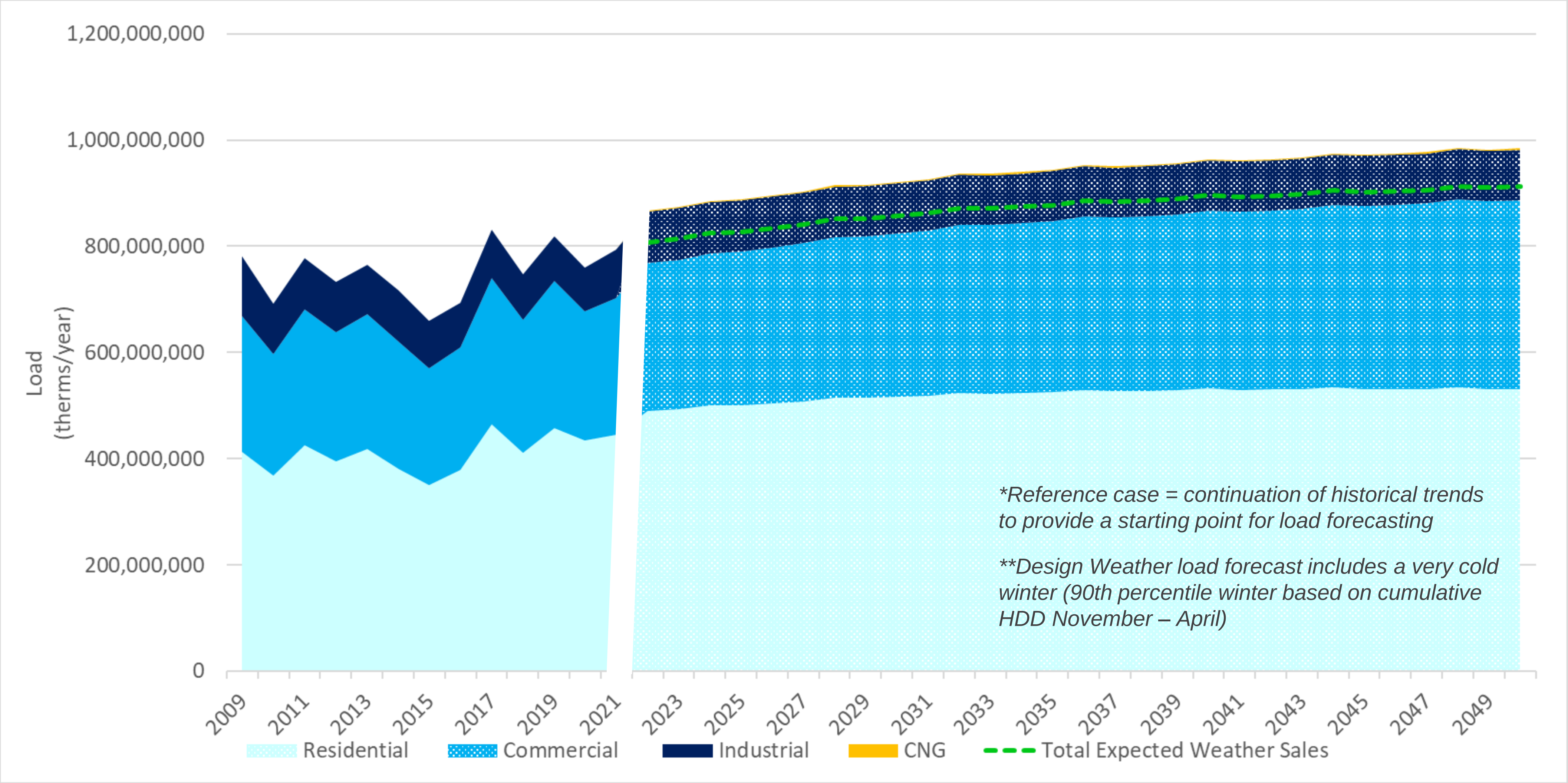
- Design Winter
  - We plan our resources for a colder than expected winter (November – April)
  - This ensures that we have the right level of resources needed to serve energy throughout a very cold winter in any given forecast year
  - Monthly HDDs for the design winter weather are adjusted from the expected weather forecast based on the 90th percentile of cumulative winter HDDs (Nov-April) of the last 30 years of data for each location
  - Because the design winter weather is an adjustment from the expected weather forecast, the climate change trends in HDDs are also incorporated into the design winter

Design Weather Forecast

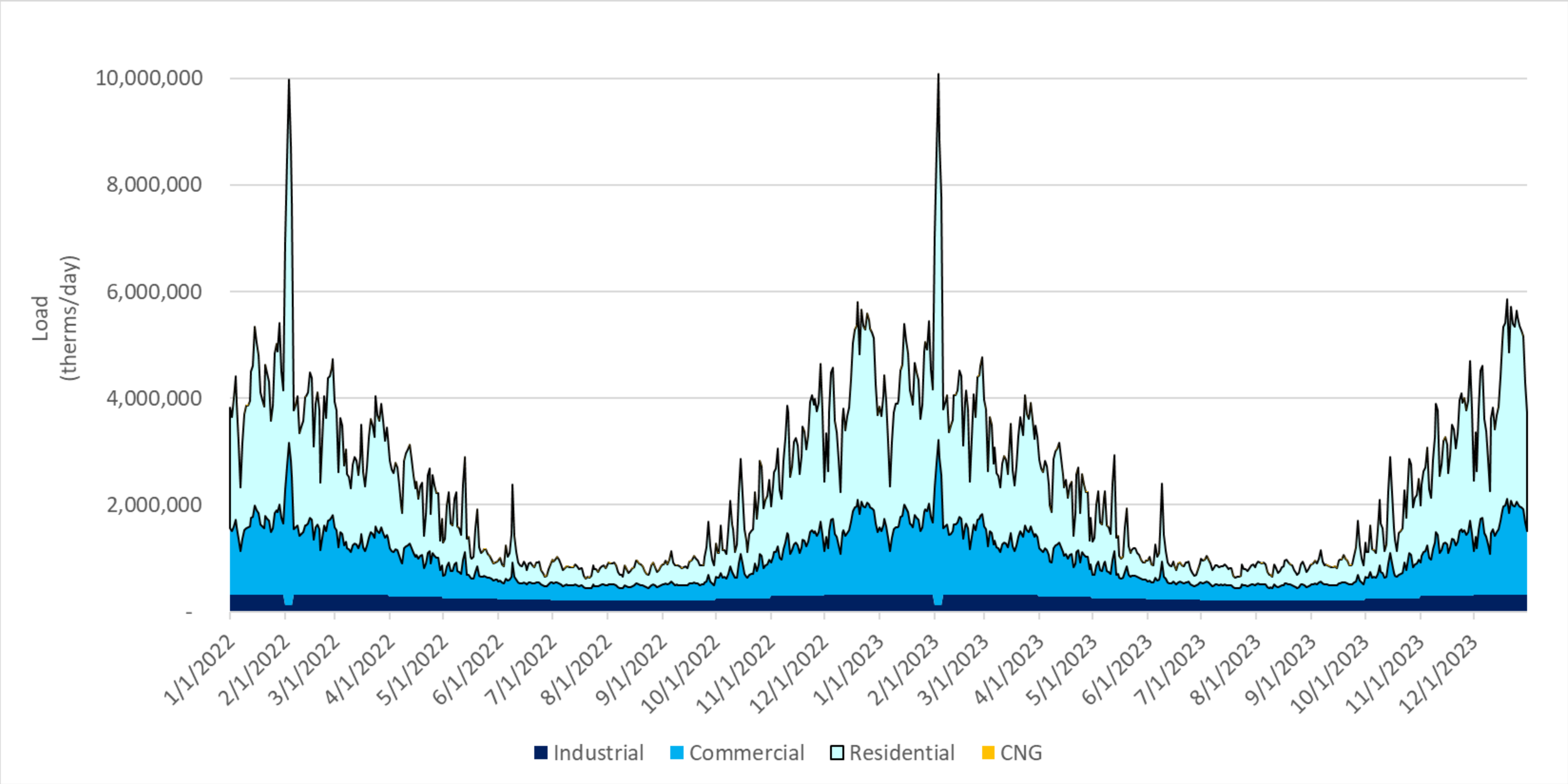


*UPC=Use Per Customer

Design Weather Sales Load Forecast – Reference Case



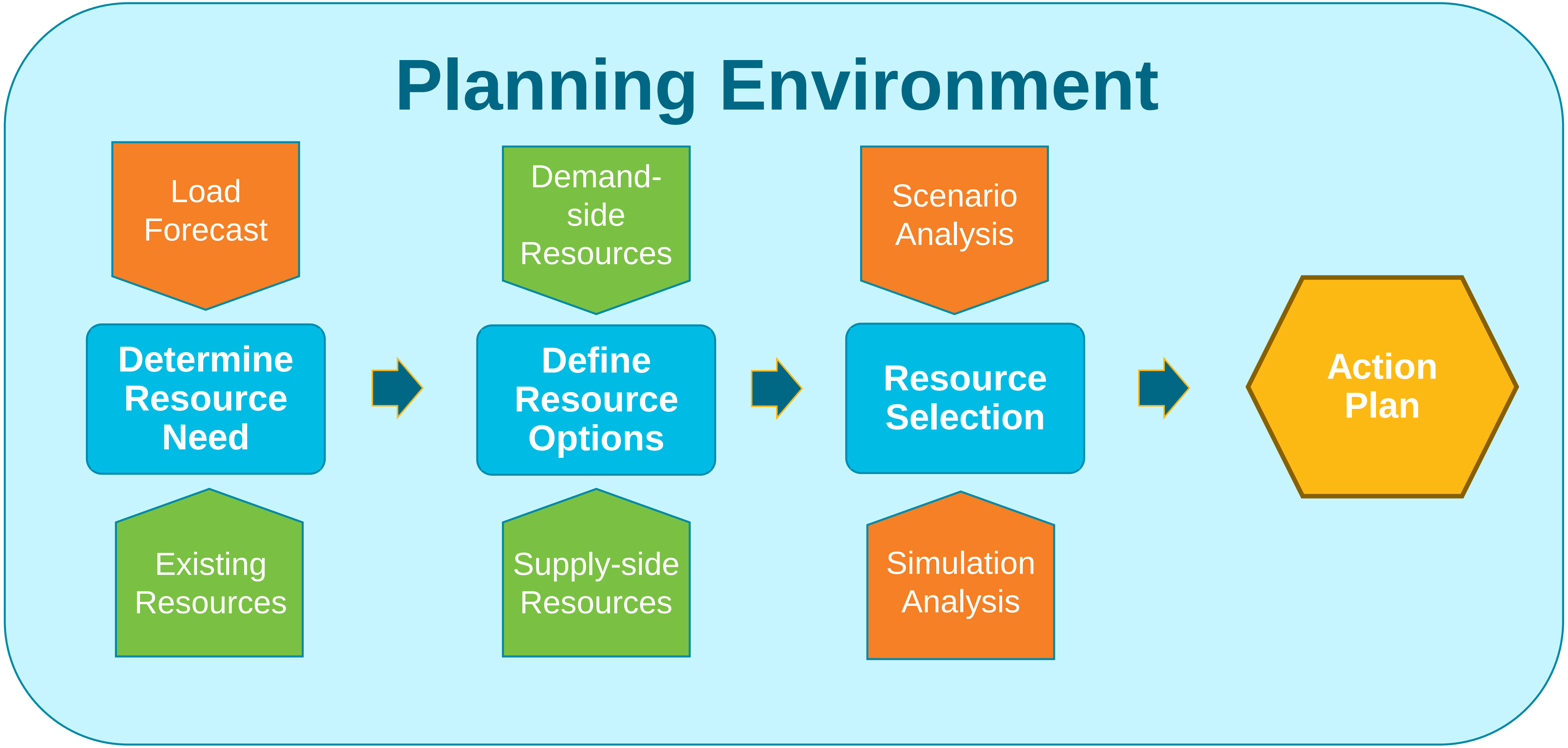
Design Weather Sales Load Forecast – Reference Case



Accounting for Uncertainty

Scenario and Stochastic Load Forecasts

IRP Process



Green = Resources   Orange = Tools

Uncertainty in Load Forecasting

Long-term Uncertainties

- The economy
  - Population growth
  - Industry types
- Housing and building types
- Fuel choice
- Environmental policy
- Technological change
  - Equipment
- Climate change
- Codes and standards
- Energy markets

Short-term Uncertainties

- The economy
  - Economic conditions (e.g. COVID and supply-chain disruptions)
- Weather
- Energy markets

Risk Analysis:
Scenario & Simulation Analysis

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NW relies upon scenario analysis and stochastic simulation analysis to assess risk

Both types or risk analysis are aimed at arriving at robust resource decisions that represent the best combination of cost and risk

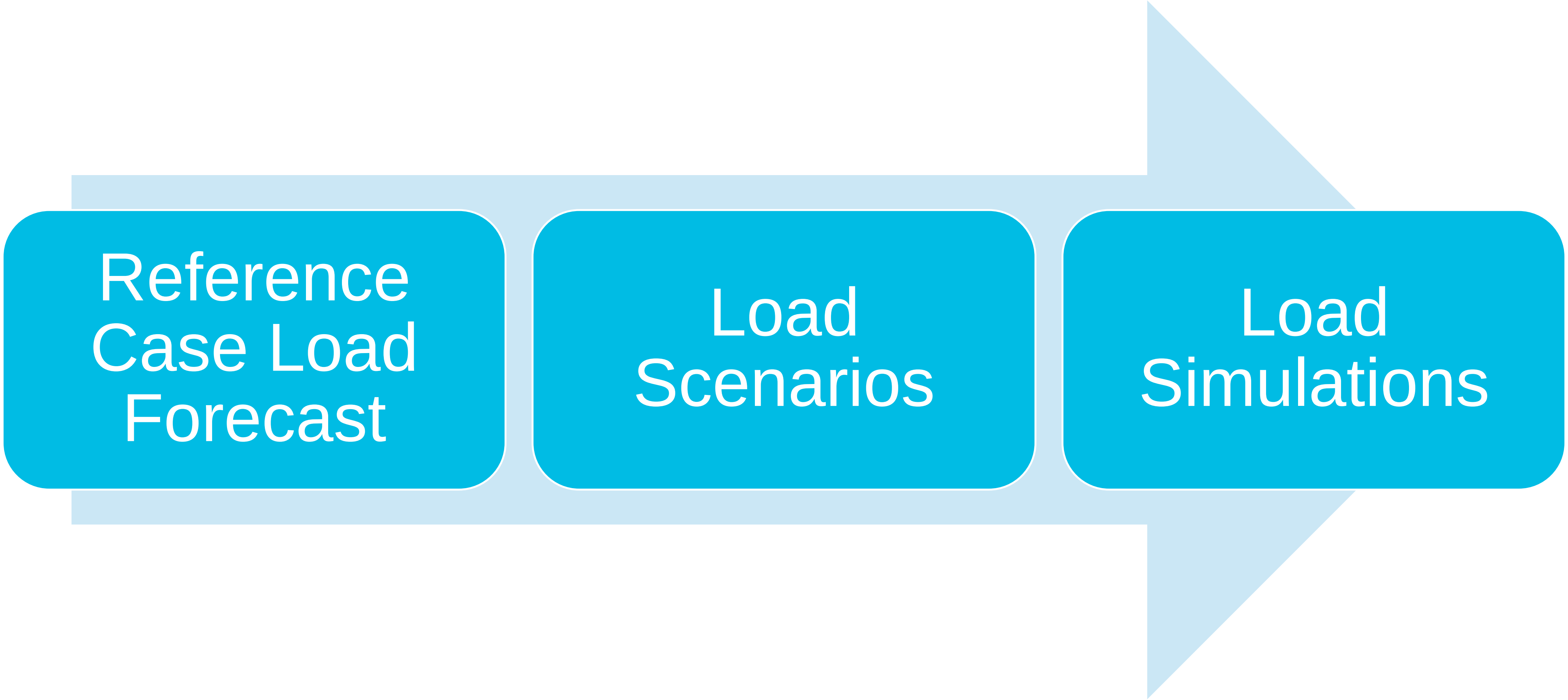
Scenario Analysis

- Helpful to understand key risks and how changes in key assumptions would impact resource decisions

Stochastic Simulation

- Leveraging scenario analysis and data to define stochastic inputs and stress test decisions

Getting from Reference Case Forecast to Load Simulations



Scenario Analysis Feedback*

	2022 IRP Proposed Scenarios- Summary Version	1	2	3	4	5	6	7	8
		Base Case - Compliance with OR-CPP and SB 98 and WA-CCA	Carbon Neutral by 2050	New Direct Use Gas Customer Moratorium in 2025	Building Electrification	RNG and H2 Production Tax Credit	Limited RNG Availability	Supply-Focused Decarbonization	Deep Decarbonization Study-Based
Demand-Side	Customer Growth	Current Expectations		No New Customers After 2025		Current Expectations			
Demand-Side	Space and Water Heating Equipment	Moderate gas powered heat pump and hybrid heating adoption		High electrification of existing residential and small commercial load	Full electrification of existing residential and small commercial load by 2050	Moderate gas heat pump and hybrid heating adoption		No gas powered heat pumps and low levels of hybrid heating	Increasing gas heat pump and hybrid heating adoption
Demand-Side	Industrial Load Efficiency	Moderate increase	High increase	Moderate increase				Limited increase	Moderate w/ electrification
Demand-Side	Building Shell Improvement	Energy Trust projection	Energy Trust high sensitivity projection	Ajusted Energy Trust projection		Energy Trust projection			100% by 2030
Supply-Side	Renewable Natural Gas	Moderate availability and cost assumption	Moderately-high availability and moderate cost assumption	Moderate availability and cost		Moderate availability and low cost to customers	Low availability and moderately high cost	Moderate availability and cost assumption	Moderate availability and high (stale) cost assumption
Supply-Side	Hydrogen	Moderate blending and dedicated system deployment allowed; moderate cost assumption							Moderate blending allowed; high (stale) cost
	OR- Community Climate Investements	Costs and limits defined in CPP rule							
	WA- Allowances & Offsets	TBD- Pending Rule Development							

***Orange text indicates assumptions that received stakeholder feedback and adjustments are under consideration**

Load Scenarios End-use Forecasting Diagram

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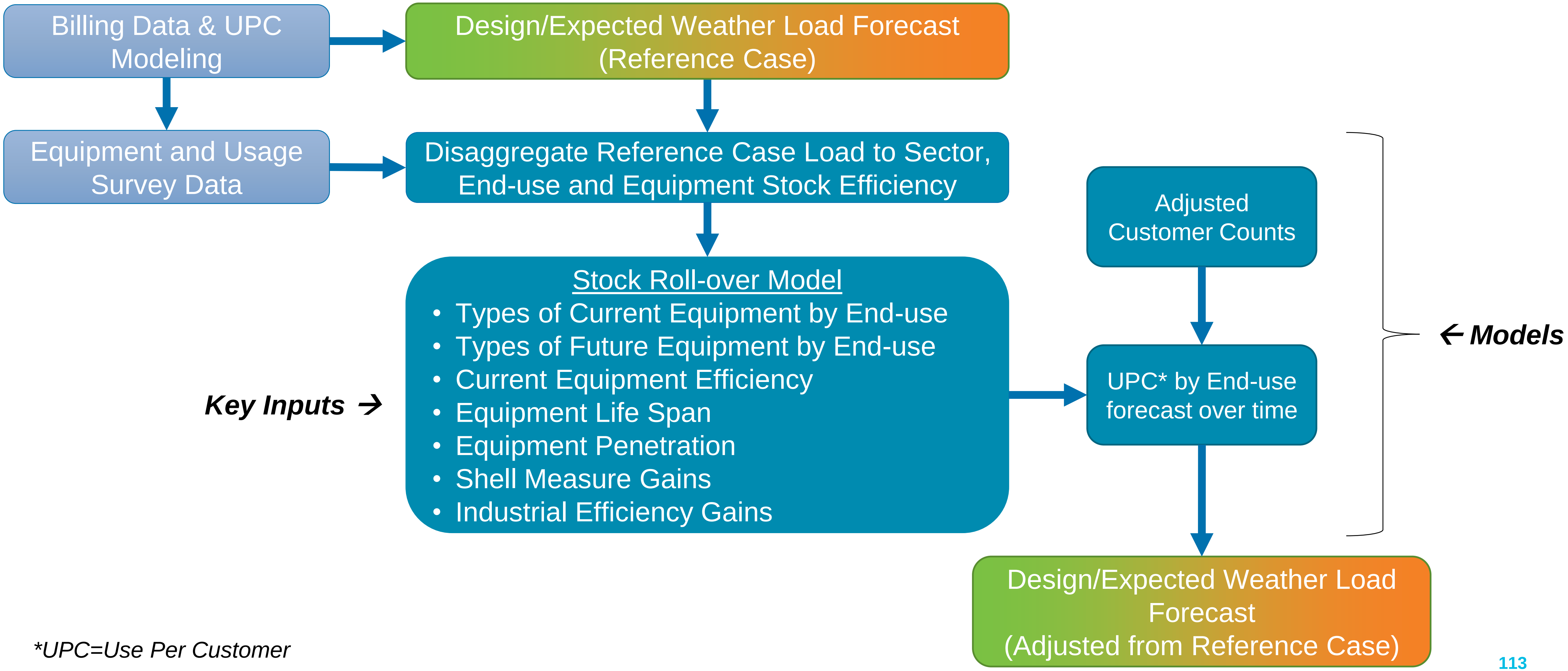


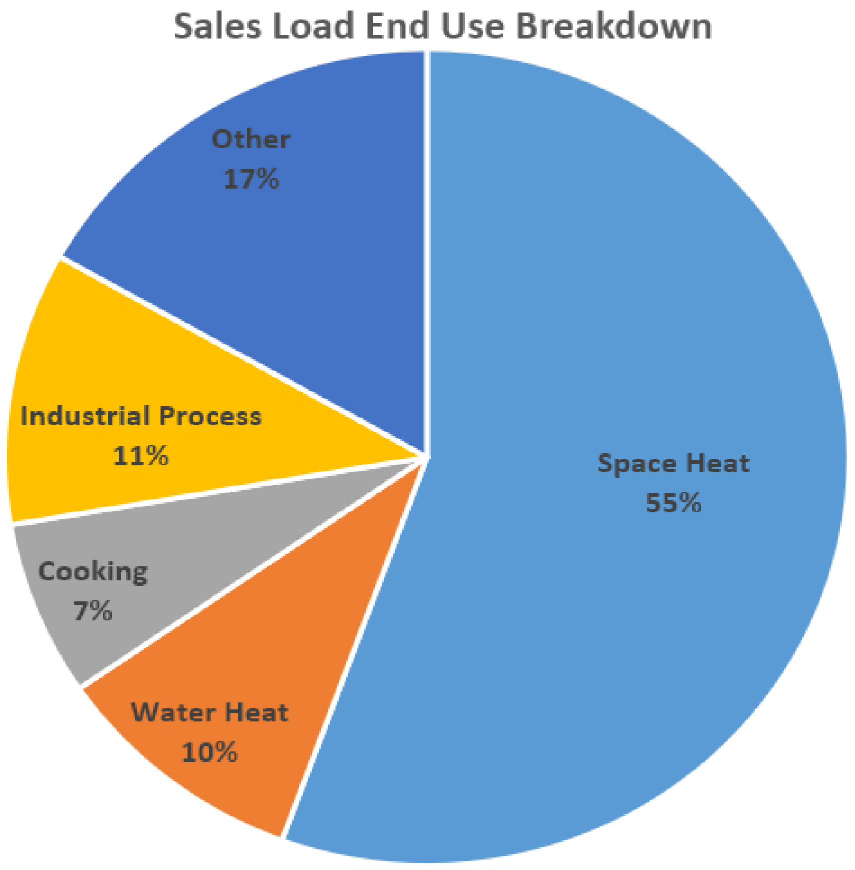
*UPC=Use Per Customer

End-Use Forecasting Context

- 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 model 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

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	89%
High Efficiency Furnace Install	95%
Gas-fired Heat Pump	140%
Dual Fuel System	90% when used

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

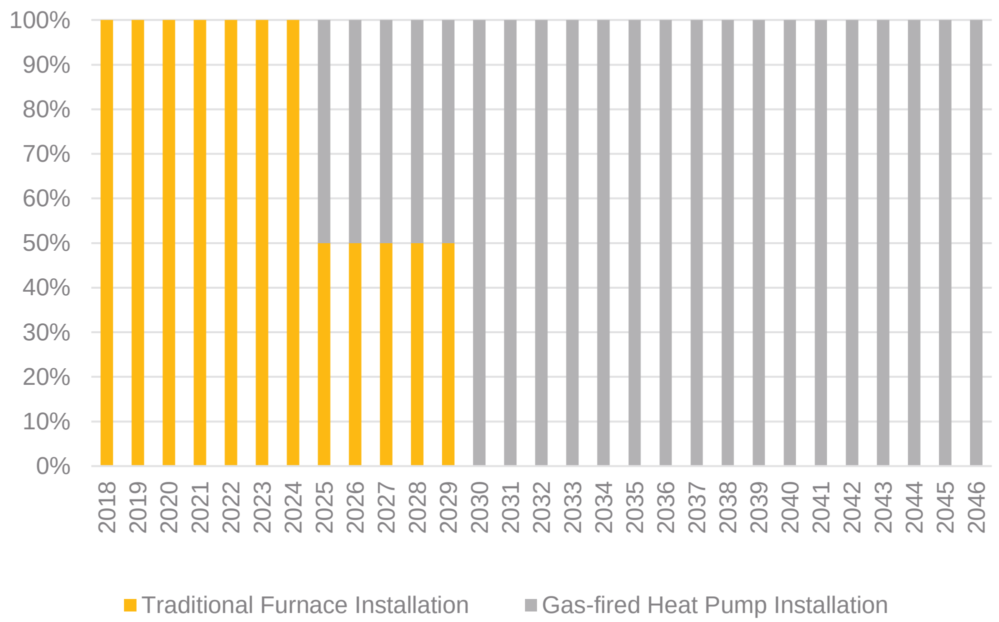
End use load forecasting requires determining:

1. **What share of NW Natural customers use natural gas for the end use?**
2. **What is the average efficiency of the equipment used for the end use?**

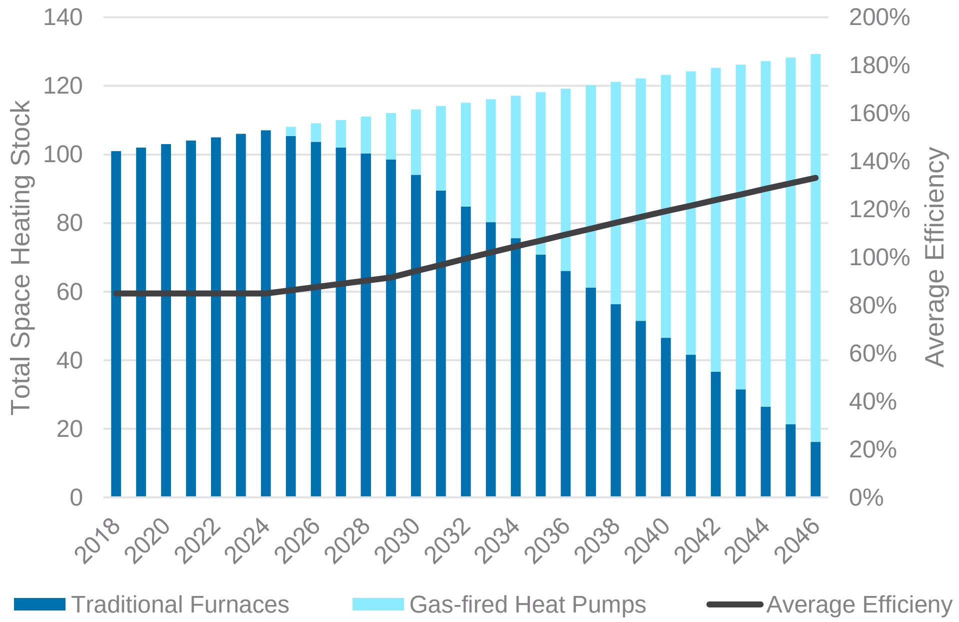
	Space Heating	Water Heating
Share of Customers gas is primary source:	87%	65%
Average efficiency of equipment for end use:	89%	73%

Stock Turnover Model – Space Heat Example

Breakdown of Units Installed by Year



Impact on Equipment Penetration



- As the new equipment is installed, the total stock mix and average efficiency of equipment providing energy services within the building stock changes over time
- Changes in efficiency different from historical trends are largely not accounted for in our reference case
- End-use load forecasting methodology starts with the reference case, but can account for shifts in trends due to things like emerging technologies and the policy environment

Draft* Residential Load by Scenario

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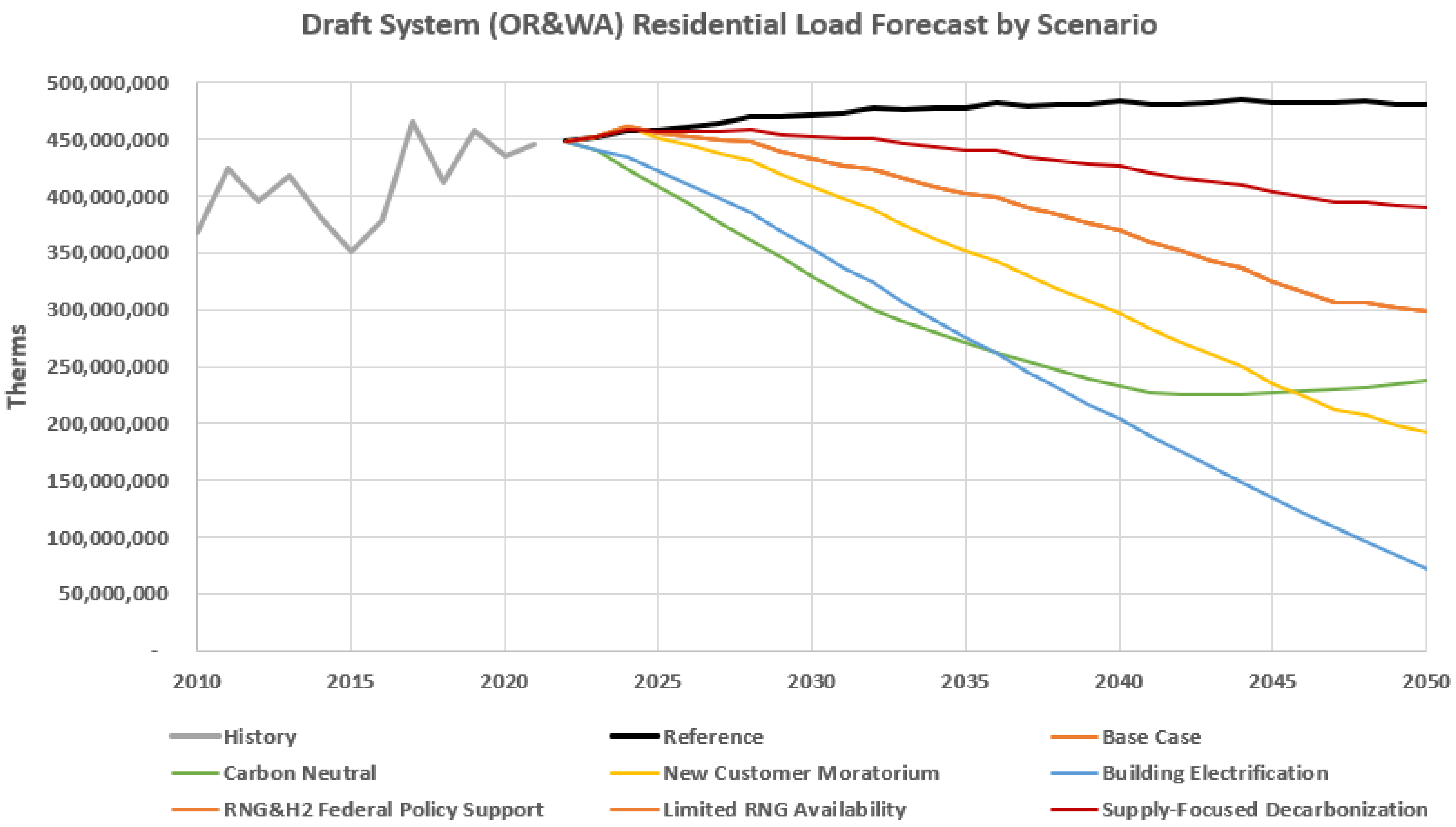
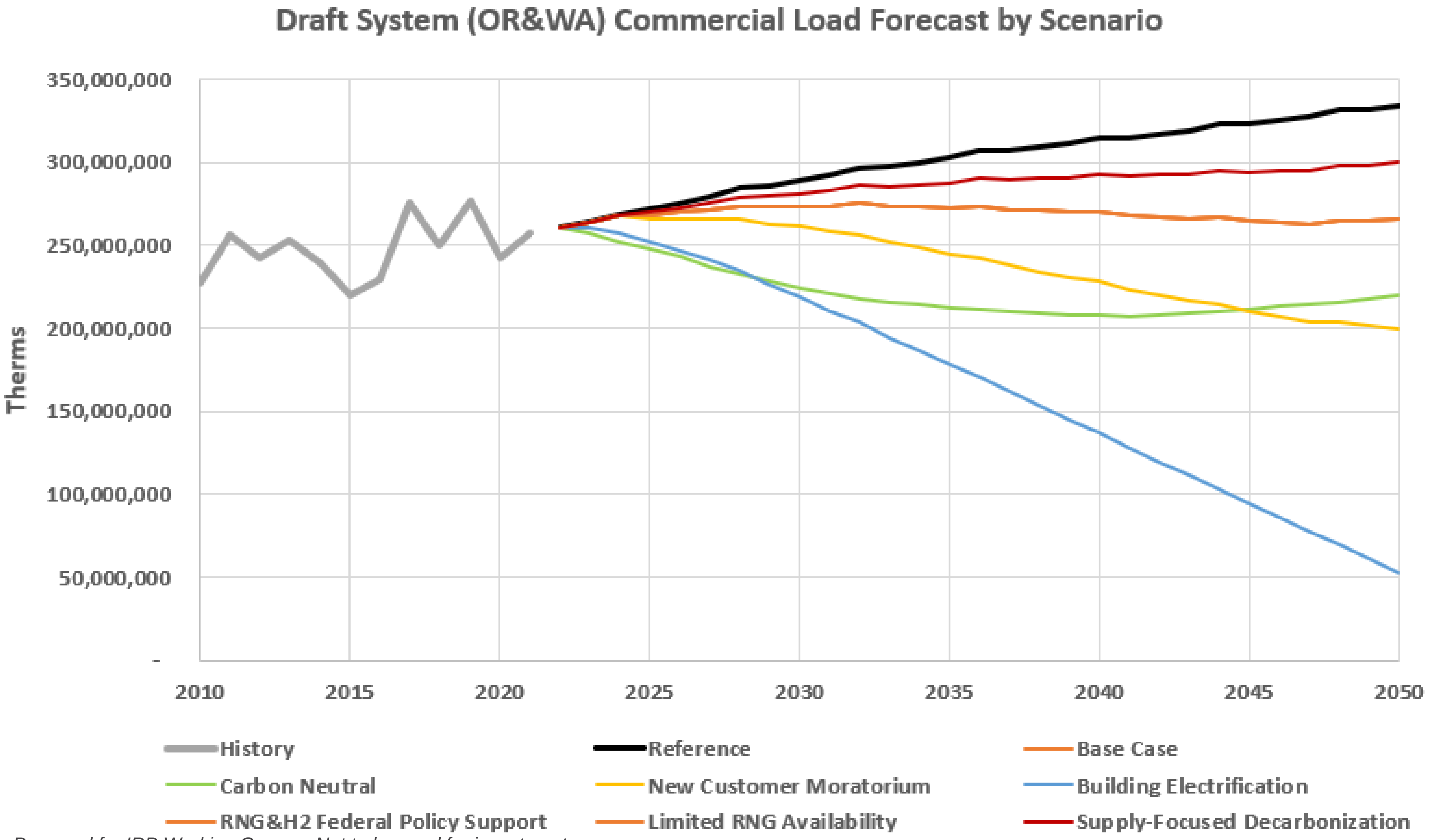


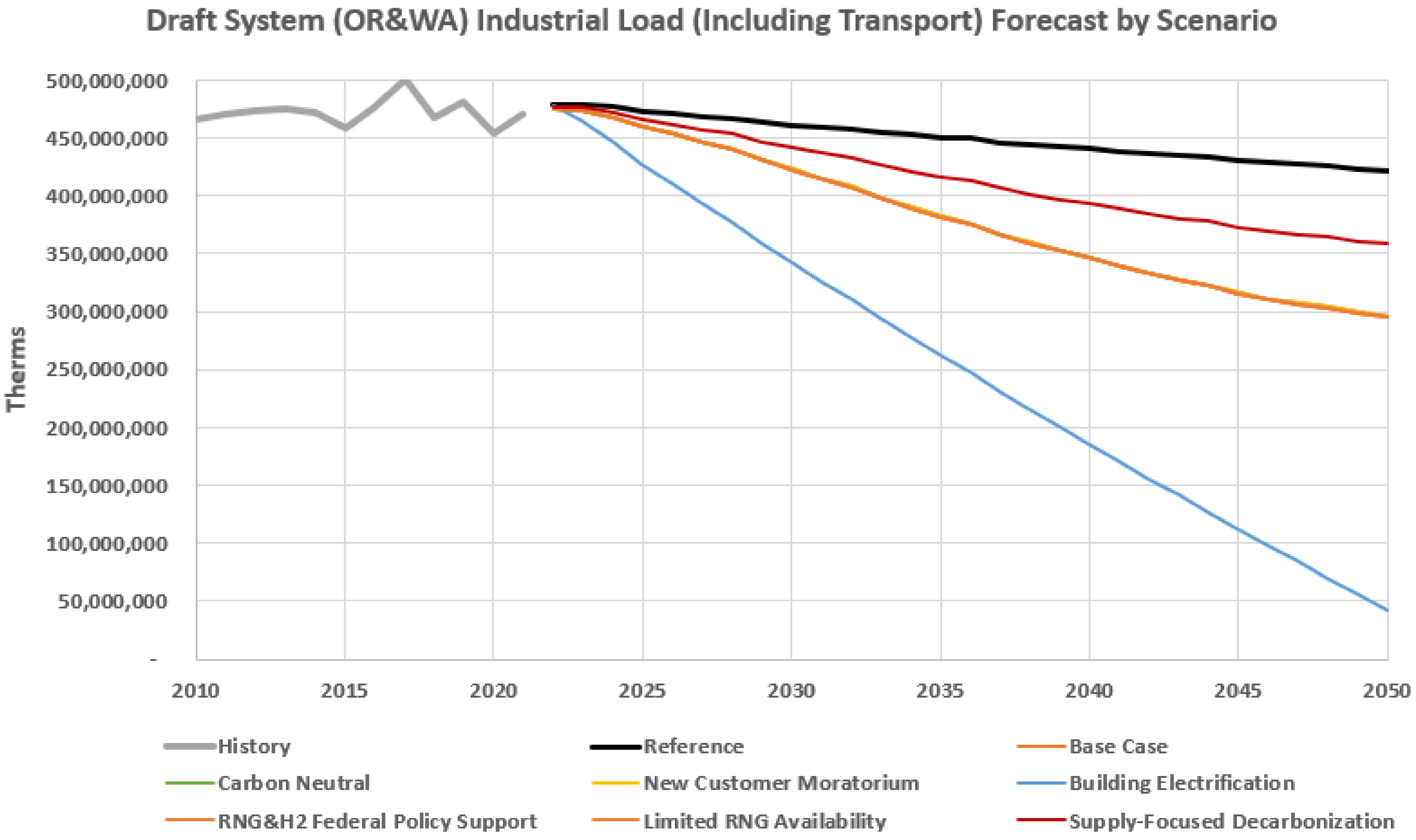
*Draft to indicate general range of loads to be considered. Final assumptions for load scenarios still being developed from stakeholder feedback

Draft* Commercial Load by Scenario



*Draft to indicate general range of loads to be considered. Final assumptions for load scenarios still being developed from stakeholder feedback

Draft* Industrial Load by Scenario



*Draft to indicate general range of loads to be considered. Final assumptions for load scenarios still being developed from stakeholder feedback

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

Draft* Total Loads by Scenario

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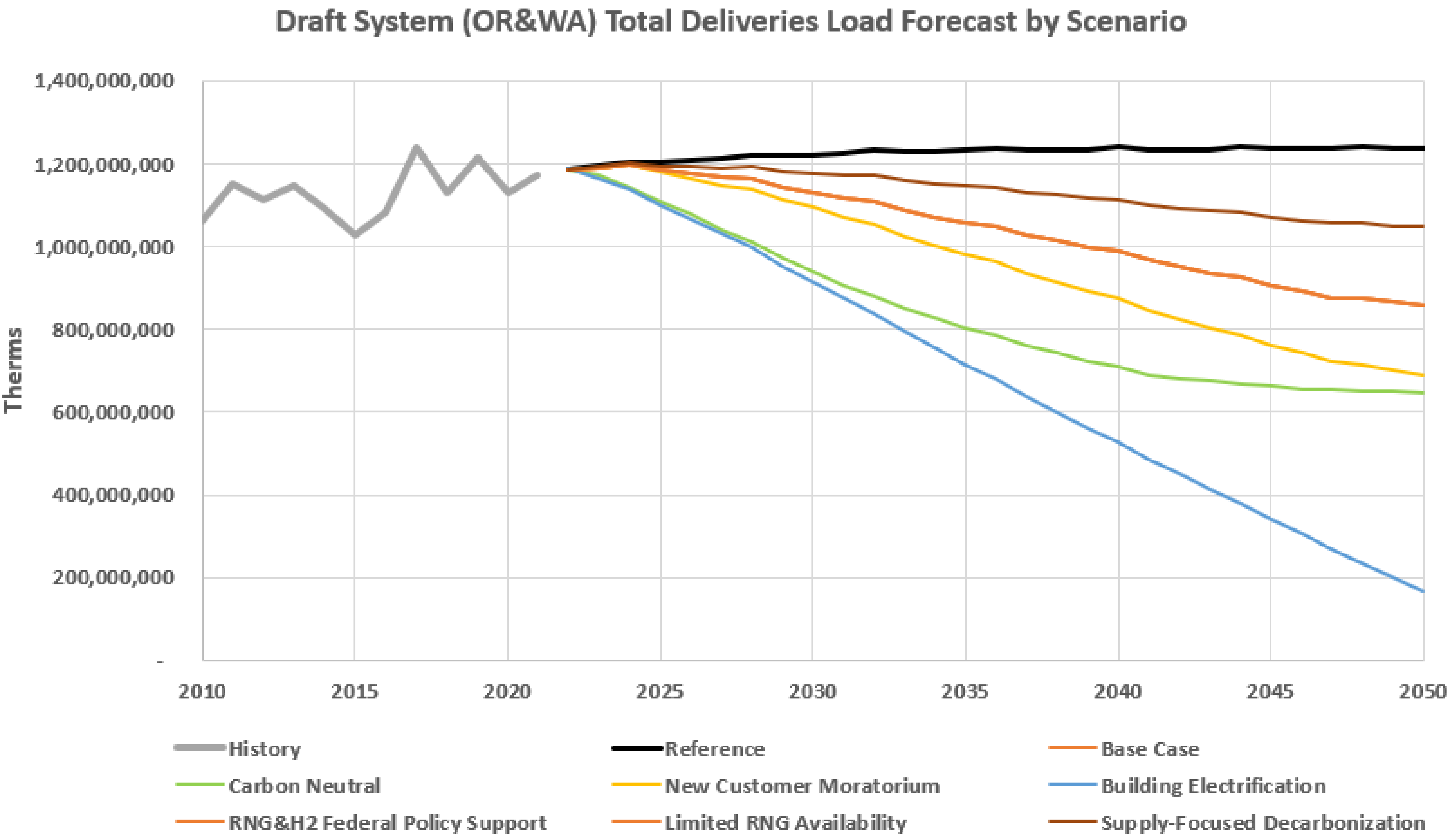


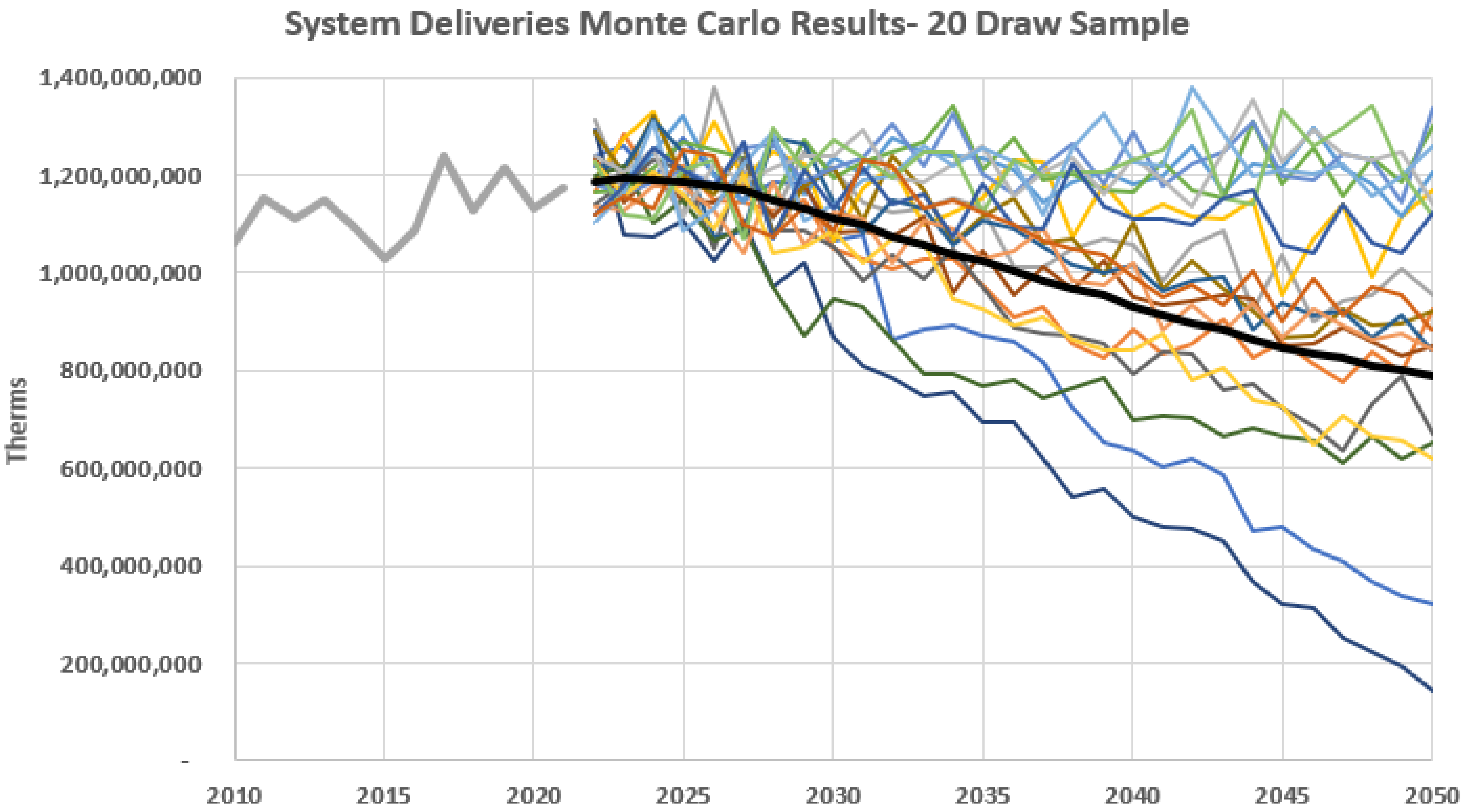
*Draft to indicate general range of loads to be considered. Final assumptions for load scenarios still being developed from stakeholder feedback

Stochastic Monte Carlo Load Simulation

NW Natural®

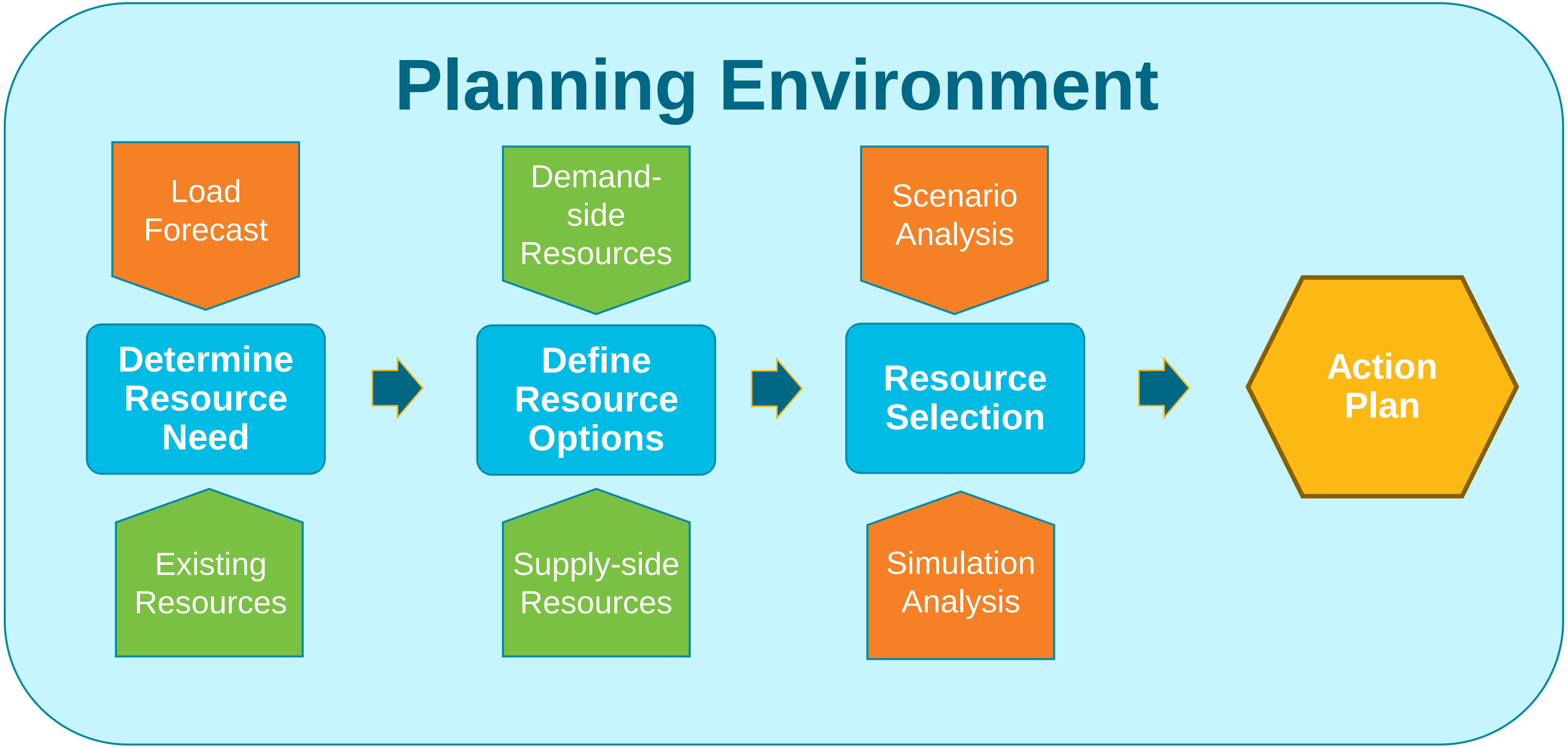
- Long-term variance in load determined by load scenarios
  - Current assumptions
    - Path deviation for a load scenario can start any year between 2022 and 2028
    - All scenarios equally likely
- Short-term variance in load determined by weather and economic uncertainties
  - Current assumptions
    - Standard deviation in annual heating degree days from weather modeling combined with economic deviation
    - Economic deviation from history of non-weather

Load Simulations for Optimization



*Draft to indicate general range of loads to be considered and show how each forecast draw will deviate in the short-term around a long-term trend. Final assumptions for load scenarios still being developed from stakeholder feedback.

IRP Process



Green = Resources   Orange = Tools

Questions/Feedback

Strategic Planning | Integrated Resource Planning Team

irp@nwnatural.com

We value your feedback today and are asking for feedback on our load forecasting by March 4th, 2022