Load Forecast for the 2025 IRP- Technical Working Group

TWG #4
Load Forecast
December 17, 2024

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.

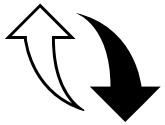
All forward-looking statements made in this presentation and all subsequent forward-looking statements, whether written or oral and whether made by or on behalf of the Company, are expressly qualified by these cautionary statements. Any forward-looking statement speaks only as of the date on which such 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.

Today's Agenda

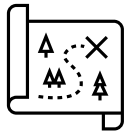
- Logistics
- Recap of previous Technical Working Group (TWG)
- Objectives for today
- Framing for the 2025 IRP Load Forecast
- Break
- Reference Case Load Forecast
  - Customer Count Forecast
  - Residential & Small Commercial
  - Industrial & Large Commercial
  - Total System
  - Peak Day

Facilitator Requests

Engage constructively and courteously towards all participants



Take space and make space



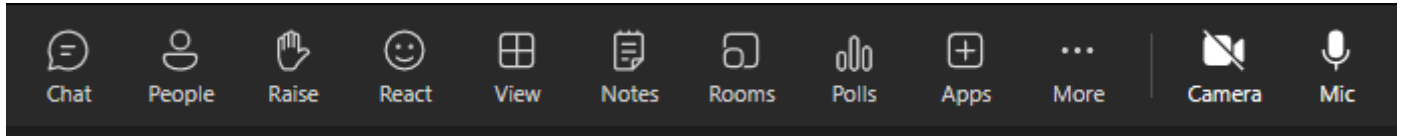
Respect the role of the facilitator to guide the group process

Avoid use of acronyms and help each other understand

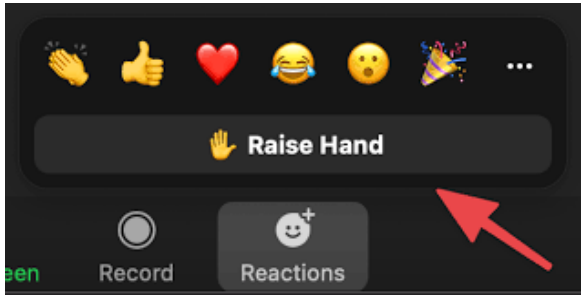
Aim to focus on the meeting topic

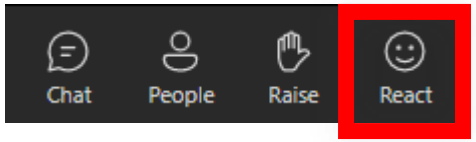
How to Interact in a Teams Meeting

- Participant Controls are at the top or bottom of your screen

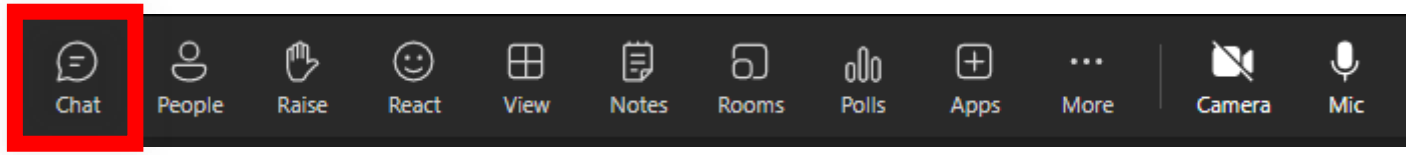


- Ask a question or comment at any time using the “raised hand”





- You may also use the chat box



A member of the IRP team will monitor the chat, and participant list for raised hands during the meeting.

Meeting Best Practices – virtual spaces

To maintain an engaged and productive space, please:

Mute your mic unless asking a question and/or providing comment

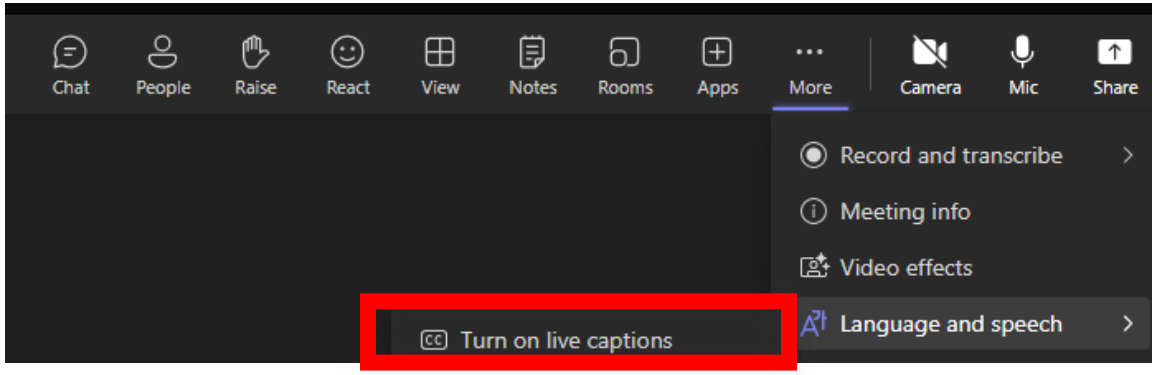
Turn your camera on when speaking (if you are comfortable and your bandwidth allows)

Limit side conversations in the chat

Make efforts to adhere to the meeting schedule

Teams Meeting – Accessibility Functions

- Live Captions - real-time auto-generated text of what is said in a meeting. They appear a few lines at a time for a user who has turned them on, and aren't saved



- Reducing Distractions and Customizing Views:
  - Microsoft Teams has a variety of features to support different learning styles, please find reference material for:
    - Turn on live captions during meetings
    - Customize your meeting view
    - Change background effects in Teams meetings
    - Reduce background noise in Teams meetings
    - 5 tips for using Teams when you're deaf or hard of hearing
- Meeting Recordings:
  - NW Natural will record IRP virtual meetings and will post them to the NW Natural website on the resource planning webpage

Two Minutes for Safety: Winter Weather

Driving Safely

- Avoid using cruise control in wintry conditions
- Steer in the direction of a skid, so when your wheels regain traction, you don't have to overcorrect to stay in your lane
- Accelerate and decelerate slowly
- Increase following distance to 8 to 10 seconds
- If possible, don't stop when going uphill

Walking Safely

- Choose the right shoe. Shoes and boots need to fit properly and have soles with good traction.
- Leave early. Falls are more likely to happen when you're in a rush.
- Walk like a penguin. Take short steps and walk as flat-footed as possible on icy or slippery ground.
- Keep your hands free. You'll need them to help you balance.
- Remove snow and ice from walkways frequently. Don't wait for it to melt.
- Keep the lights on.
- Advocate for your safety. If the entrances or sidewalks do not look safe, speak up and let someone know.

Recap Nov. 21 TWG ▷ ▶ Today's objectives

- Answered clarifying questions about the scenarios
- Collected feedback on the range of scenarios
- Learned about the climate science used in scenario modeling
- Addressed questions about:
  - How assumptions and effects of the electric power sector modeling affect other scenarios
  - How climate change information is affecting heating requirements used in forecasts
  - Understanding temperature degree days

- Gain a shared understanding of customer counts for IRP
- Gain a shared understanding of load forecasting for reference case
- Address clarifying questions and collect feedback on load forecasting information

Current Technical Working Group Schedule

TWG No.	Date	Type & Purpose of Engagement
TWG#1	Oct 22, 2024	Planning Environment
TWG#2	Nov 1, 2024	Scenarios
TWG#3	Nov 21, 2024	Scenarios Cont. and Climate
TWG#4	Dec 17, 2024	Load Forecast
TWG#5	Jan 21, 2025	Avoided Costs & Demand-Side Resource
TWG#6	Jan 28, 2025	Supply-Side & Compliance Resources
TWG#7	Apr 1, 2025	TBA
TWG#8	Apr 8, 2025	Distribution System Planning
TWG#9	Apr 29, 2025	Resource Optimization Planning Model
TWG#10	May 6, 2025	Portfolio Results and Action Plan
File Draft	Jun 13, 2025	Comments due by July 7th
File 2025 IRP	**Aug 2, 2025**	**Beginning of formal process**

- All TWGs will be facilitated and virtual
- Dates and topics are tentative and subject to change
- Please refer to website for most up to date information: IRP Website
- Feedback form direct link: Feedback Form
- Email us at IRP@nwnatural.com

Other Public Engagement Opportunities

Public Engagement Opportunity & Topic	Date	Type & Purpose of Engagement
Energy Resource (IRP) Fair #1:	November 16, 2024	**In-Person Only. Opportunity to learn and engage on IRPs and Energy Services & Programs. Event to be held in collaboration with community partners.** ***Parkrose High School from 11:00am to 2:00pm***
Public Engagement Webinar #1:	February 4, 2025	**Opportunity to learn and engage on an IRP and key topics previously presented and related to resource planning and utility energy services.**
Energy Resource (IRP) Fair #2:	May 10, 2025	**In-Person Only. Opportunity to learn about IRPs and Energy Services & Programs & Proposed Action Plan and engage. Event to be held in collaboration with community partners.**
Public Engagement Webinar #2:	May 12, 2025	**Opportunity to learn and engage on an IRP and key topics previously presented and related to resource planning and utility energy services.**

- Please check our dedicated IRP website for the most current information:

  IRP Website

Framing the 2025 IRP Load Forecast

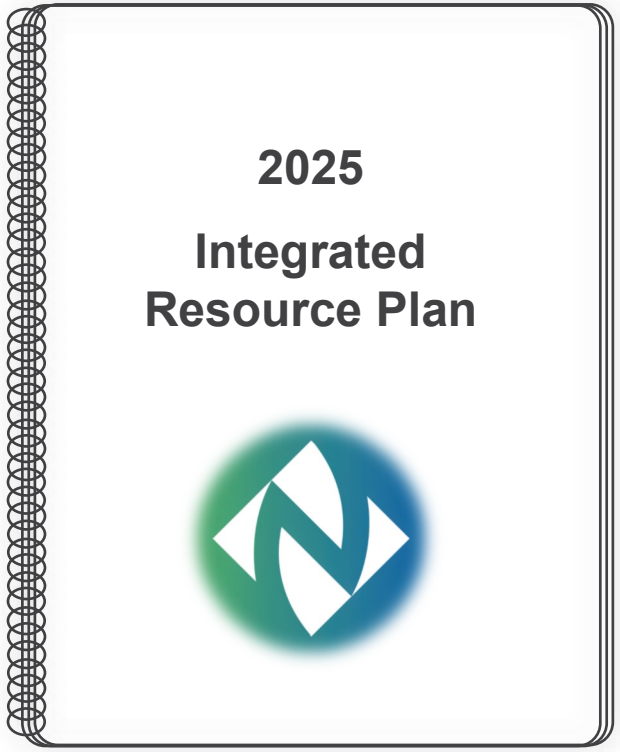
IRP Process

Purpose of Load Forecasting

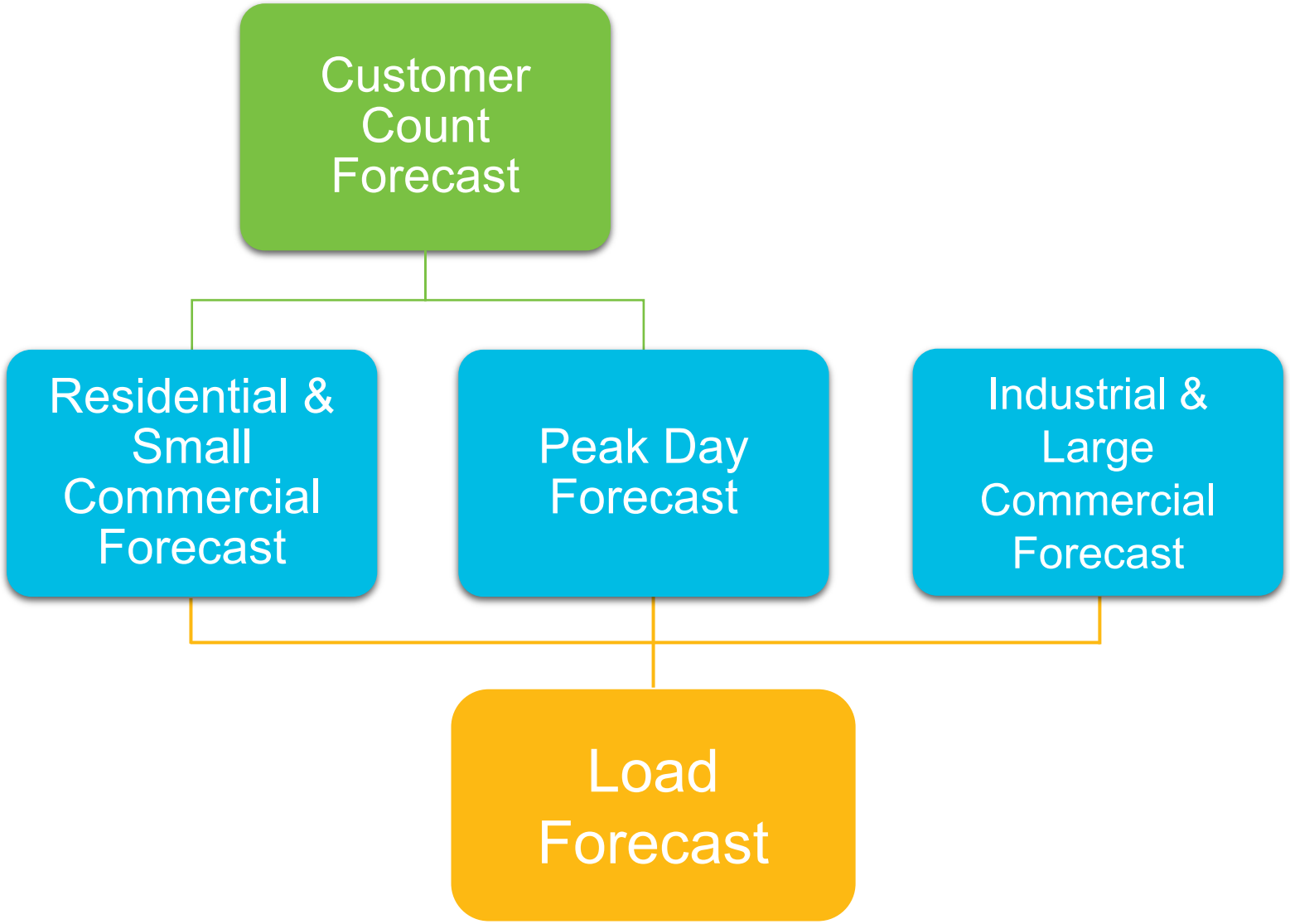
- "When forecasting, all models are wrong, but some models are useful"
  - We use the most recent information available to derive usage/demand estimates
  - Model complexity is balanced with accuracy and precision
  - Modeling customer usage requires forecasting at the right level of granularity
- Load forecasts establish the resource requirements that will need to satisfy three criteria
  - Annual/seasonal demand (energy requirement)
  - Peak demand (capacity requirement)
  - Emissions savings demand (compliance requirement)

Load Forecasting Framework

- The IRP load forecasts rely on statistical regression models to correlate usage with demand drivers
  - Customer growth/customer mix/state in-migration
  - Energy consumption preferences
  - Broad economic impacts
- The **reference case** reflects how current policies are impacting customer additions/subtractions and customer usage
- **Scenarios** are used to model potential future states of the world which deviate from the reference case to establish the bounds of future demand profiles

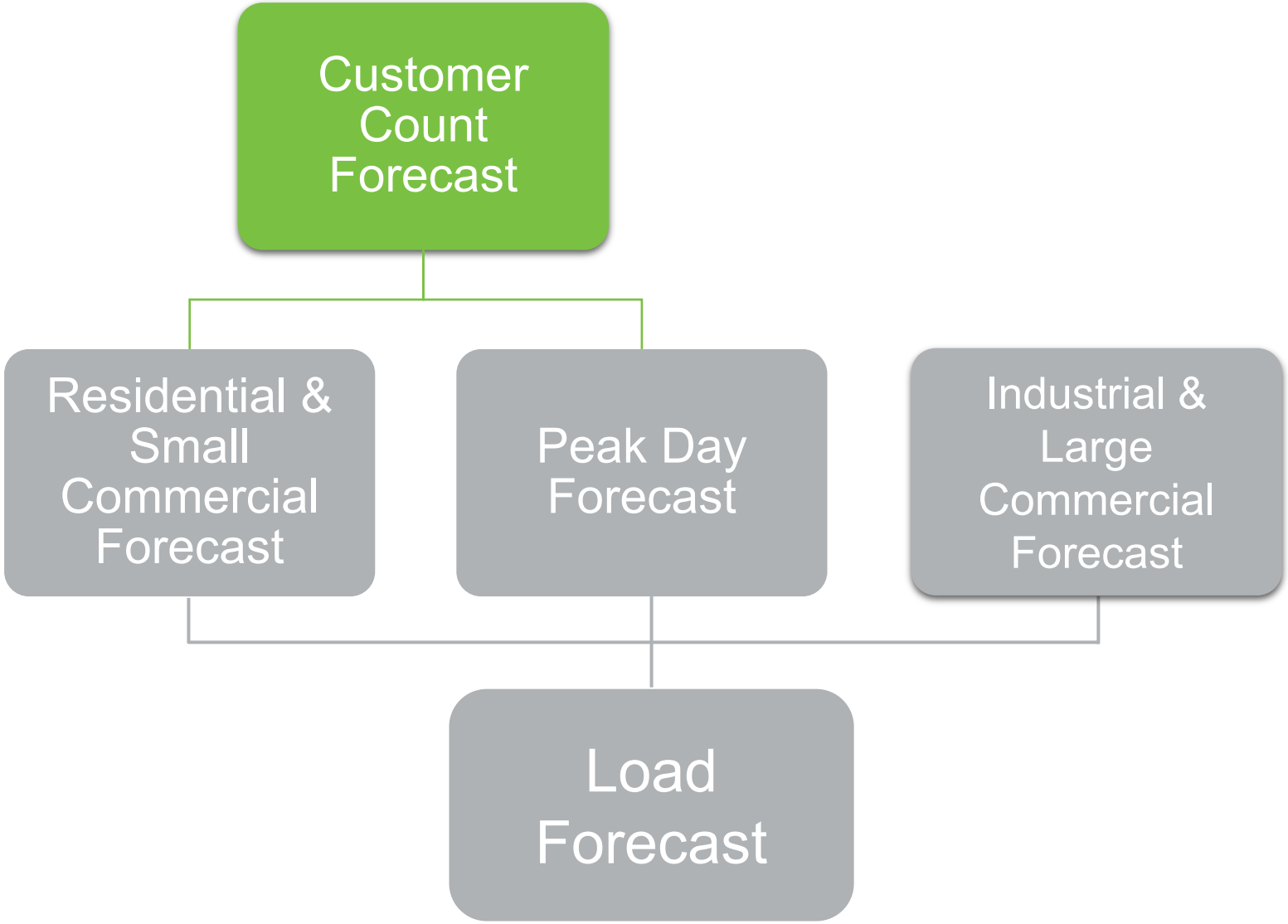


Load Forecast Flow Diagram



Reference Case Load Forecast
Customer Count Forecast

Load Forecast Flow Diagram



IRP Customer Count Process

Near-term Customer Count Forecast

NW Natural's SME Short-term Meter Set Forecast by State + Existing Customer Base by State = Near-term Customer Count Forecast (3 Years)

Long-term Customer Count Forecast

Notes and Model Changes for Customer Count Forecast

- ARIMA models with customer count regressed on historical data and projected forward with forecasts of variables from Oregon Office of Economic Analysis (OEA).
- For Oregon residential and Washington commercial models first two years of forecast come from Subject Matter Expert (SME) meter set forecast with year 3 a blend of meter set forecast and econometric forecast, after which econometric forecast used.
- For Washington residential and Oregon commercial all three years of meter set forecast incorporated into model as forward-looking time series with no blend of the two forecasts, and econometric forecast starting in year 4.
- Washington residential and commercial models use shorter time series data for modeling.
- Large commercial customers are included in the commercial customer count forecast, but load for these customers forecasted separately in the Industrial Forecast.

Independent Variables Used in Customer Count Forecast Models

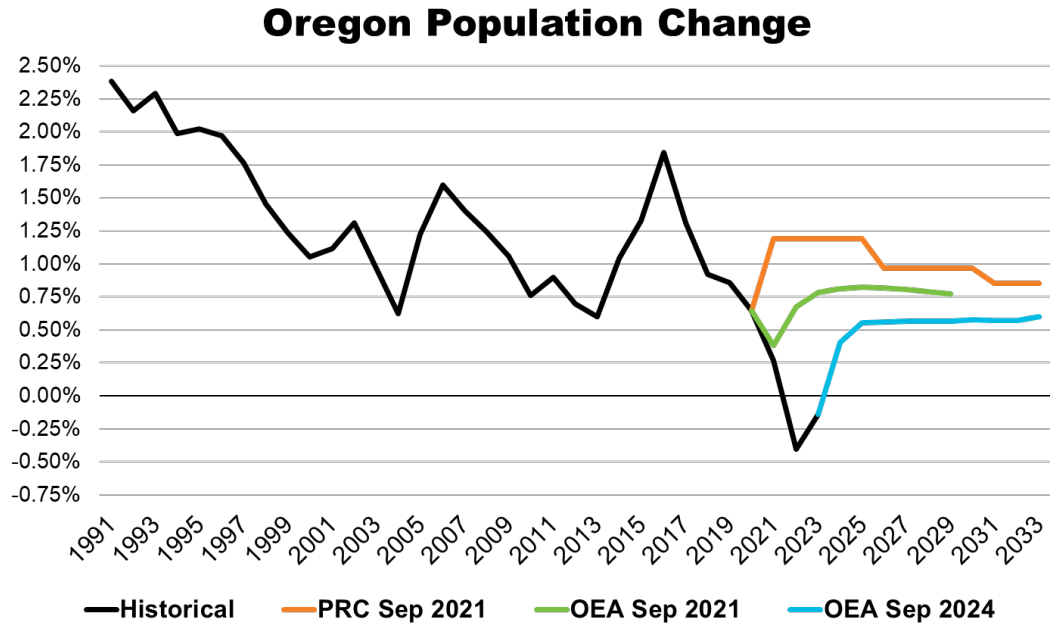
Model	Oregon	Washington
Residential	Oregon Housing Starts	Oregon Housing Starts
Commercial	Oregon Population	Oregon Total Nonfarm Employment

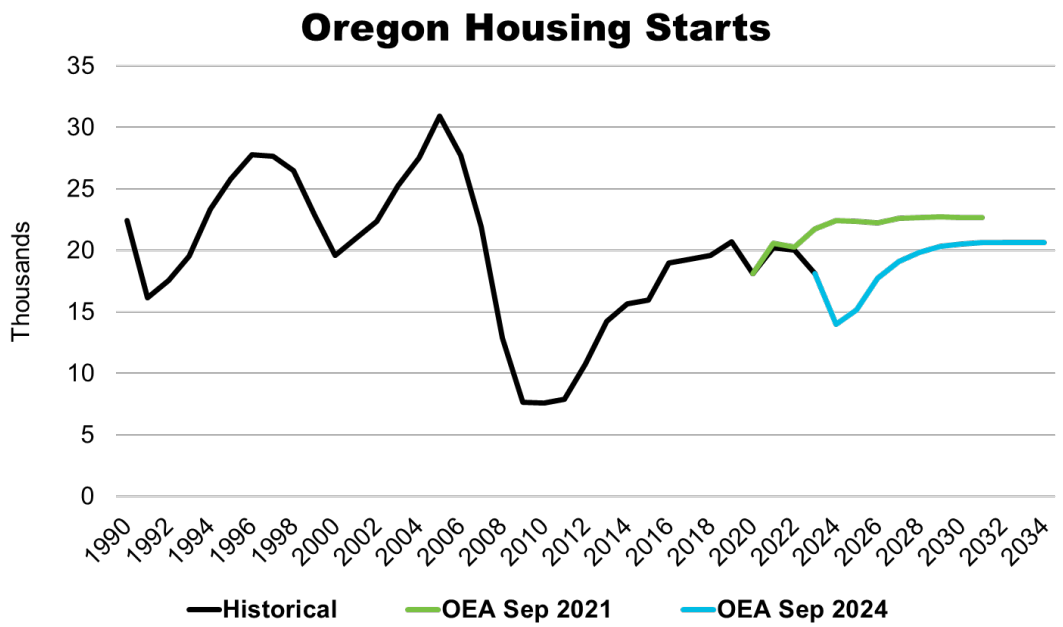
**Oregon Office of Economic Analysis source for all independent variables time series data and forecasts*

Macroeconomic Drivers of Change in Customer Count Forecast

1. **Population**
   - Population trends and forecasts for Oregon have significantly changed since COVID-19.
   - Oregon, once a fast-growing state, now a laggard with population decline and lower growth in long-run forecast from OEA.
2. **Housing Starts**
   - Population key independent variable in regression, so less population, less housing starts.
   - Housing starts forecast also lower from OEA.
3. **Employment**
   - Less population also means less employment growth.
   - Employment forecast also lower from OEA.

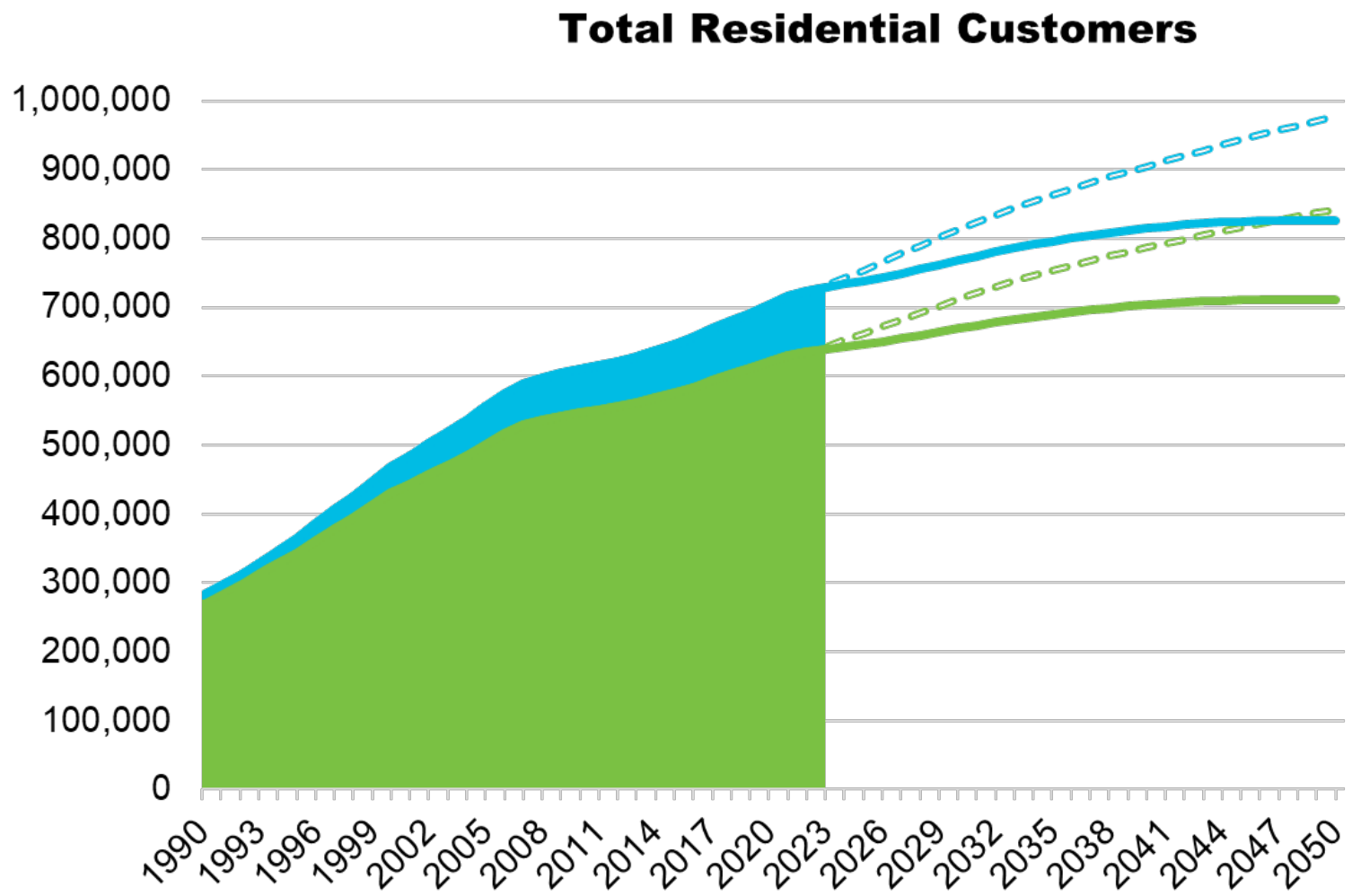
Less Population & Housing Starts Growth





- Oregon has seen significant changes in growth since the 2022 IRP that have an impact on the company's ability to add new customers.
- Population growth expectations have changed from 1.03% at the time of the 2022 IRP to 0.55% for the 2025 IRP – a nearly 50% reduction in expected population growth.
- Housing starts, which we also use for customer count forecast models, are also expected to be lower over the planning horizon, as population change is the primary variable used in the housing starts model.

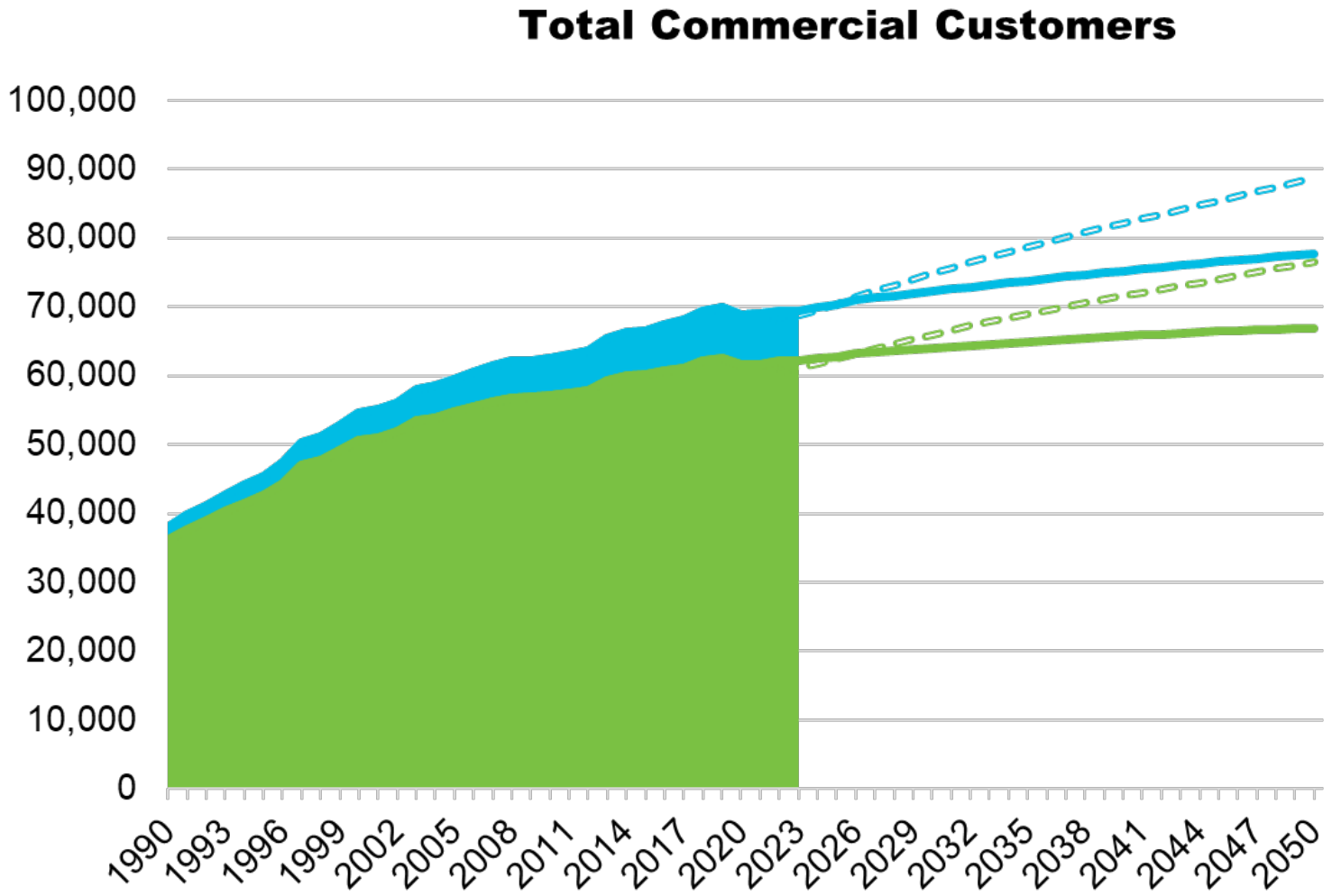
Residential Customers – Reference Case



	CAGR
WA 2022 IRP	1.56%
OR 2022 IRP	1.0%
WA 2025 IRP	**0.93%**
OR 2025 IRP	**0.39%**

2022 IRP Total:	1.01%
2025 IRP Total:	**0.46%**

Commercial Customers – Reference Case



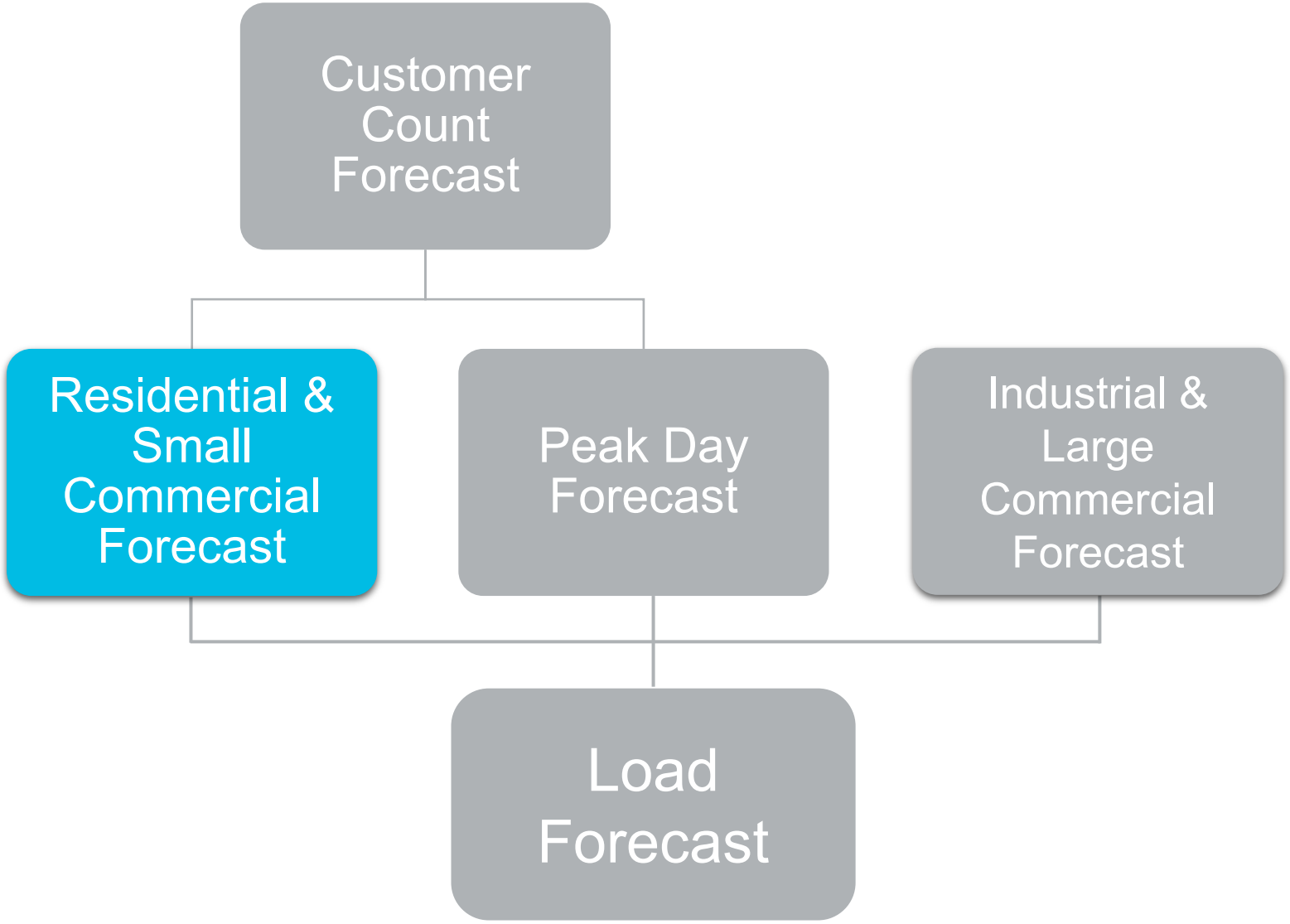
	CAGR
WA 2022 IRP	1.78%
WA 2025 IRP	**1.5%**
OR 2022 IRP	0.74%
OR 2025 IRP	**0.27%**

2022 IRP Total:	0.87%
2025 IRP Total:	**0.42%**

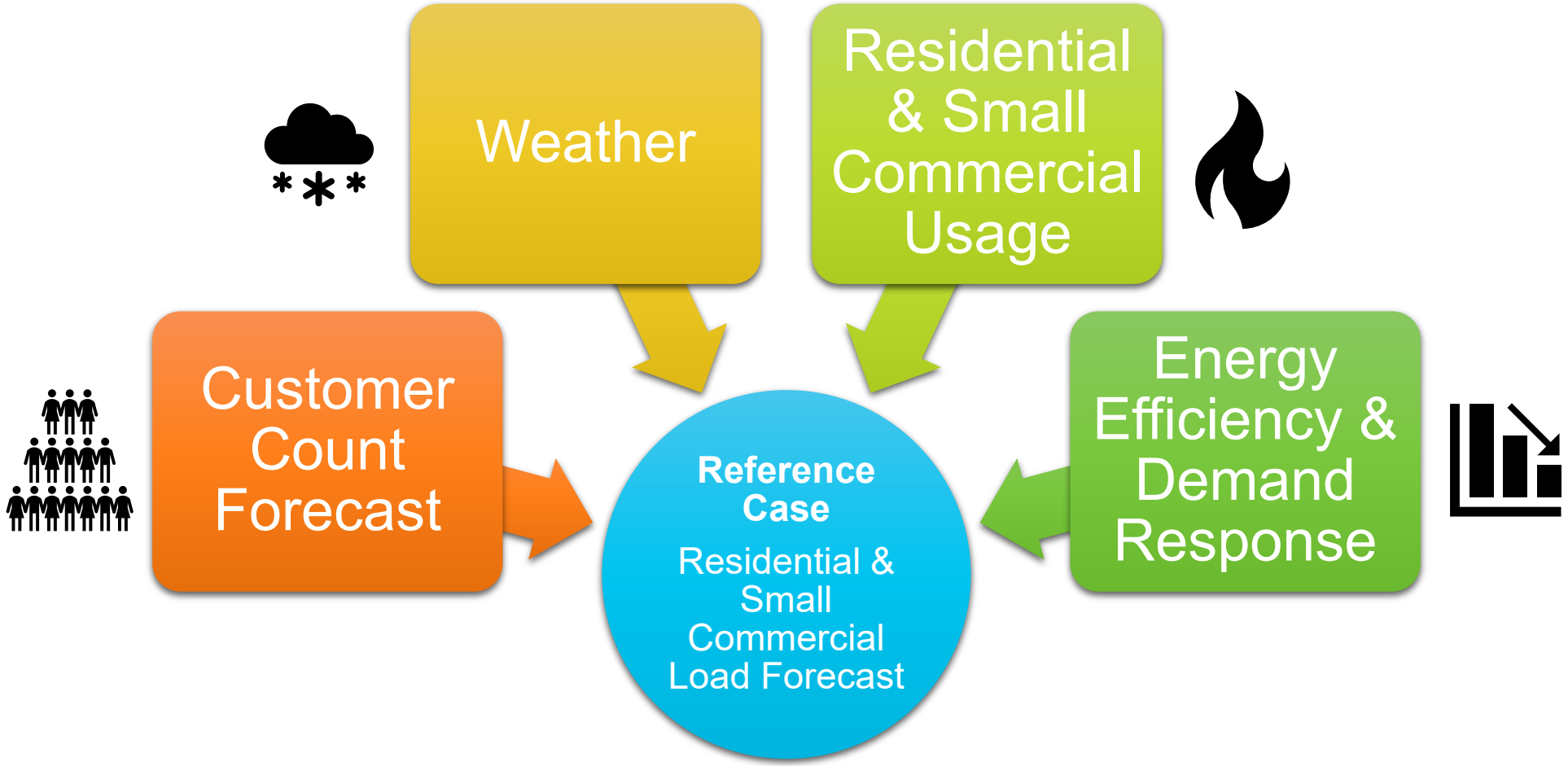
Break

Reference Case Load Forecast: Residential & Small Commercial

Load Forecast Flow Diagram



Residential & Small Commercial Flow Diagram



Estimating Usage

- Meters record usage, for each customer, as they utilize natural gas
  - Extremely accurate – batch sets of meters are tested regularly for accuracy
  - Meters are only read on billing cycles (roughly, 1x per month)
  - Thus, monthly usage data for each customer is available, but no daily usage (or higher granularity) data exists
- The billing data is used in the **Use per Customer (UPC)** model to derive daily estimates of usage for our various customers segments in each load center
- New meters do have the ability to record more granular daily usage, but only a subset of customers currently have these types of meters

Estimating Usage

- Over our 12 load centers, we estimate the UPC (therms/customer/day) as a function of temperature
  - This occurs across two rates classes which comprise seven distinct market segments
  - Total of 84 UPC estimates

Load Centers

Albany, Astoria, Coos Bay, Eugene, Lincoln City, Portland Central, Portland West, Portland East, Salem, The Dalles (OR)

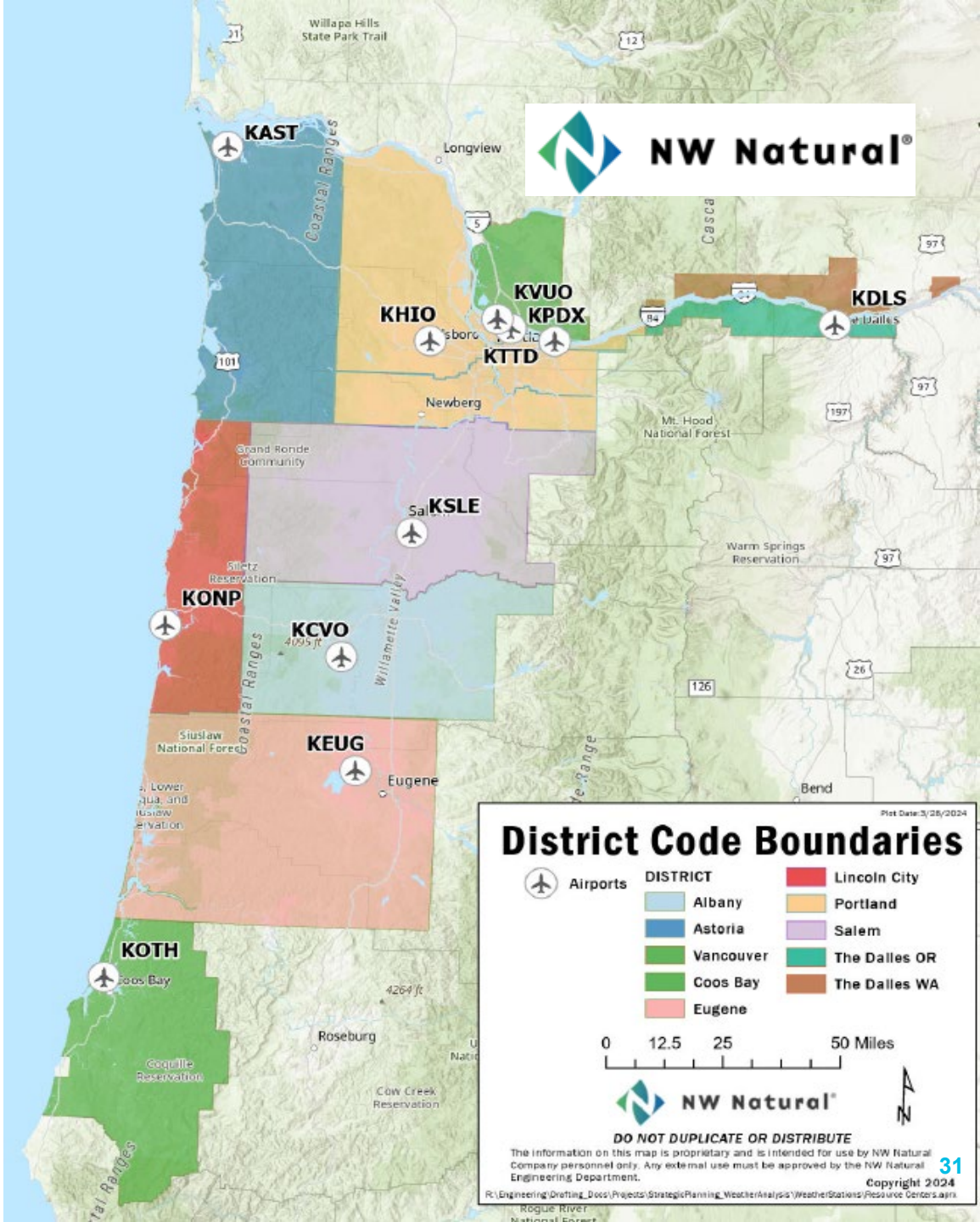
The Dalles (WA), Vancouver

Residential

Existing
Conversions
Single Family New Construction
Multifamily New Construction

Small Commercial

Existing
Conversions
New Construction

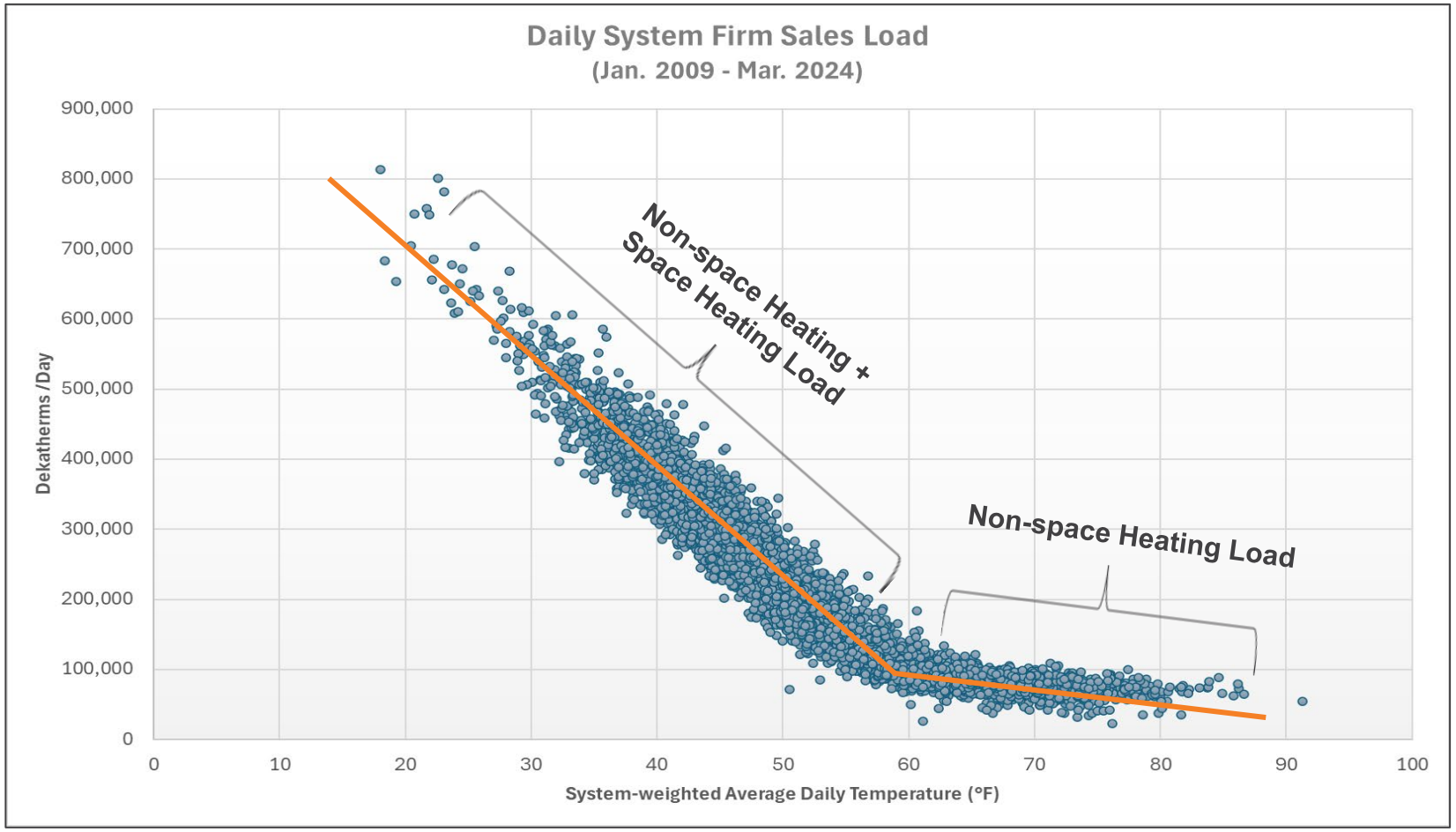


Prepared for IRP Working Group- Not to be used for investment purposes.

Estimating Usage

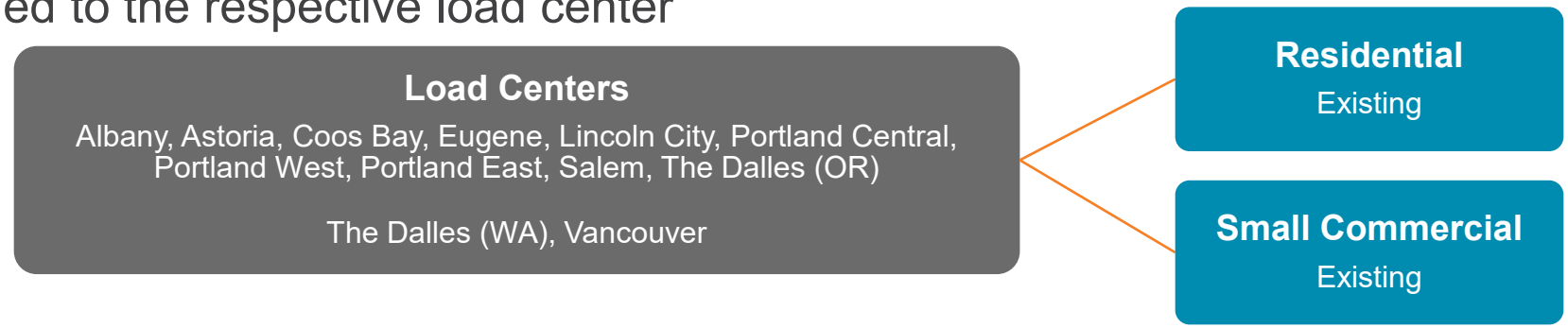
What does usage as a function of temperature look like?

- Usage can be broken into two component parts
  - **(1)** Non-space heating load
  - **(2)** Non-space heating + Space heating load
- This figure shows the daily system firm sales load, but the same relationship applies to residential and small commercial load

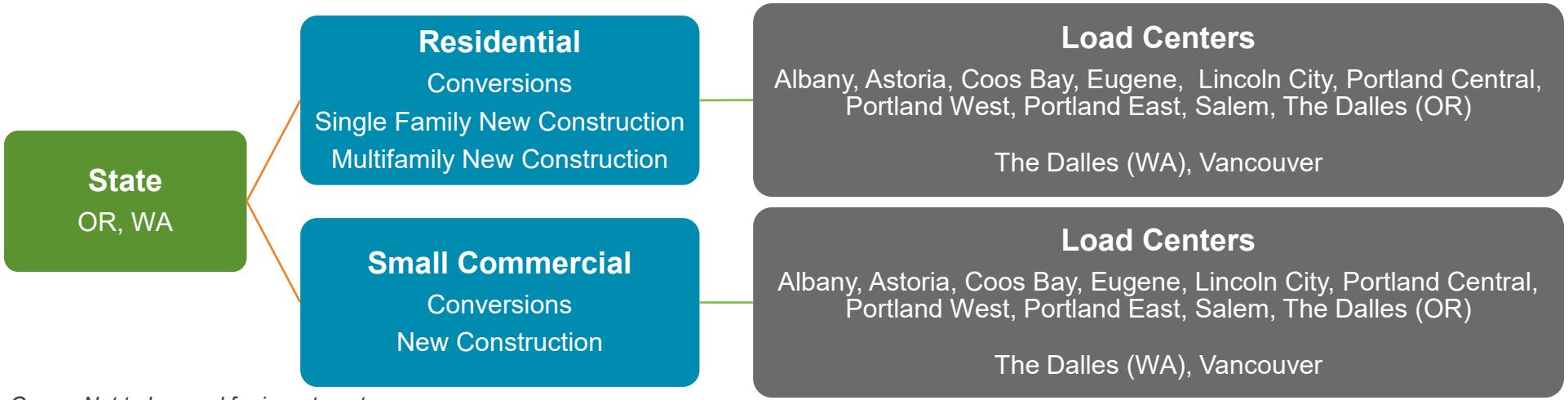


The UPC Model

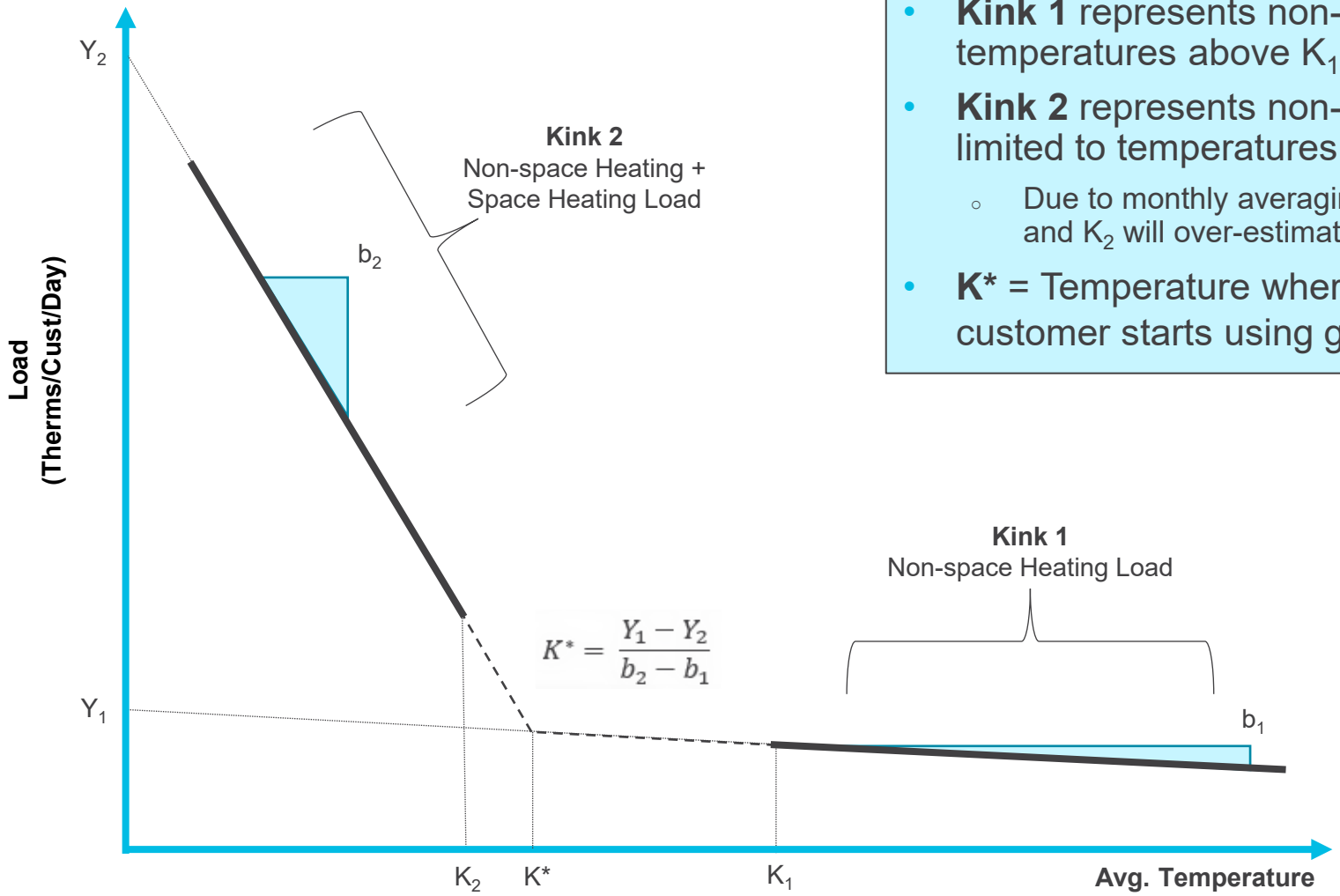
- **Existing** residential and small commercial UPC estimates are calculated using weather station data matched to the respective load center



- Due to data limitations, **new construction and conversion** residential and small commercial UPC estimates are calculated at the state level and applied to the appropriate load center



The UPC Regression and Coefficients



- **Kink 1** represents non-space heating load and is limited to data with temperatures above K_1 (i.e., to the right)
- **Kink 2** represents non-space heating plus space heating load and is limited to temperatures below K_2 (i.e., to the left)
  - Due to monthly averaging, including billing usage with temperatures between K_1 and K_2 will over-estimate usage
- **K*** = Temperature where K_1 and K_2 intersect (i.e., where the average customer starts using gas for space heating)

Regression Model and Coefficients

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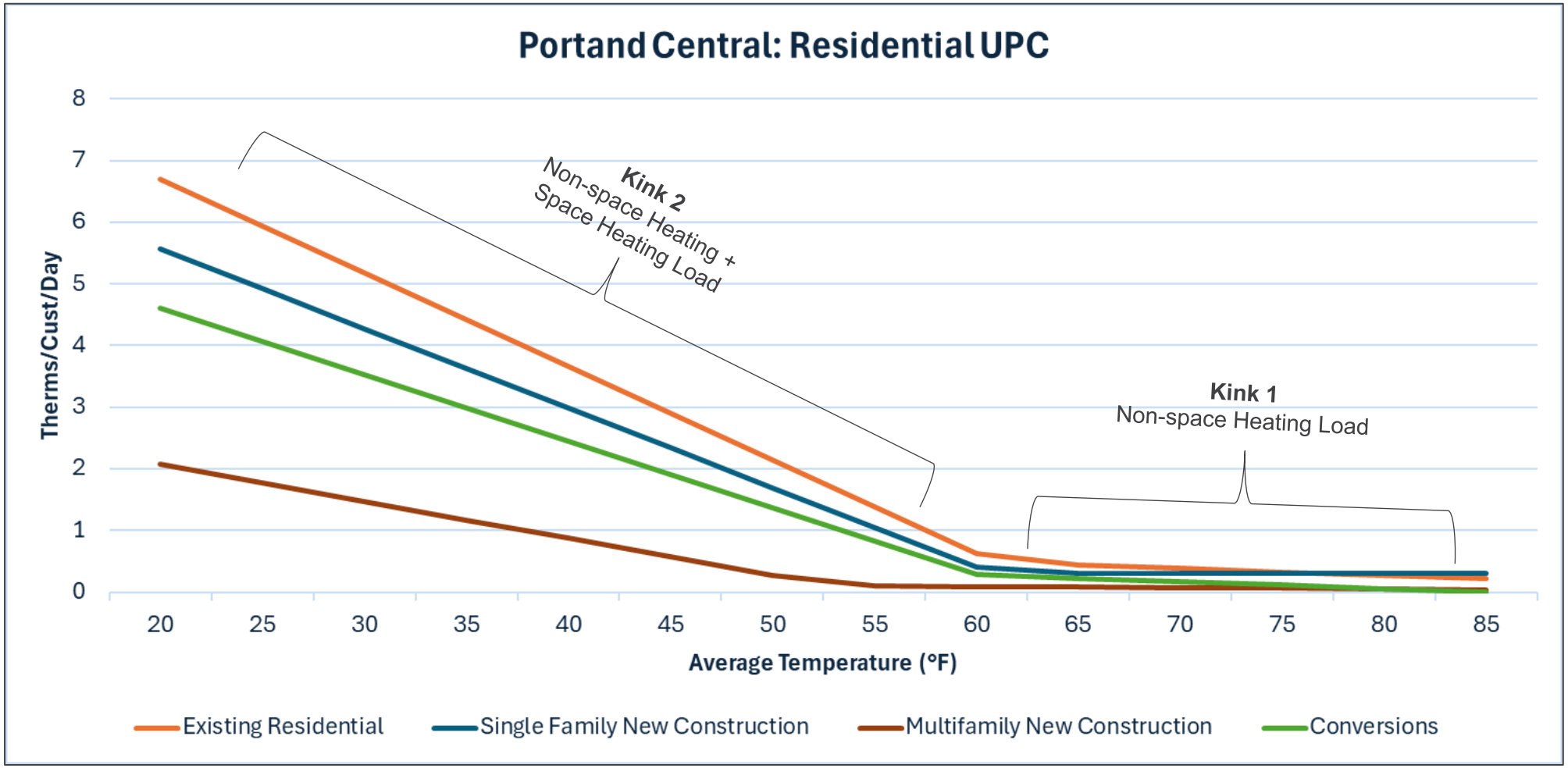
- UPC is a function of daily avg. temperature
  - T = Daily forecasted daily avg. temperature
- Conditional on T, UPC is calculated as follows:
  - If $T \geq K^*$ ➡ **Kink 1:** $UPC = Y_1 + (b_1 \times T)$
  - If $T < K^*$ ➡ **Kink 2:** $UPC = Y_2 + (b_2 \times T)$

State	Load Center	Rate Class	Market Segment	K_1	Y_1	b_1	K_2	Y_2	b_2	K^*
OR	-	R1	RES-CONV	68	0.97	-0.01	57	6.77	-0.11	59.96
OR	-	R1	RES-MFNC	65	0.22	0.00	50	3.28	-0.06	52.70
OR	-	R1	RES-SFNC	68	0.31	0.00	55	8.14	-0.13	60.75
OR	-	C1	COM-CONV	68	3.71	0.00	50	51.19	-0.81	58.39
OR	-	C1	COM-NEW	67	4.84	0.00	50	100.69	-1.66	57.69
WA	-	R1	RES-CONV	68	0.19	0.00	56	5.42	-0.08	62.27
WA	-	R1	RES-MFNC	60	0.51	-0.01	58	1.20	-0.02	56.72
WA	-	R1	RES-SFNC	60	1.32	-0.02	58	4.96	-0.08	60.52
WA	-	C1	COM-CONV	68	2.10	0.00	51	25.10	-0.40	57.14
WA	-	C1	COM-NEW	68	3.26	0.00	56	48.35	-0.69	65.75

State	Load Center	Rate Class	Market Segment	K_1	Y_1	b_1	K_2	Y_2	b_2	K^*
OR	ALB	R1	RES_EXIST	68	0.38	0.00	50	9.32	-0.15	58.34
OR	AST	R1	RES_EXIST	63	0.46	0.00	58	9.17	-0.15	59.08
OR	COOS	R1	RES_EXIST	62	0.38	0.00	56	9.59	-0.16	59.37
OR	DALO	R1	RES_EXIST	67	1.02	-0.01	50	7.24	-0.11	61.76
OR	EUG	R1	RES_EXIST	68	1.43	-0.01	50	8.78	-0.14	58.77
OR	LC	R1	RES_EXIST	60	0.49	0.00	54	8.94	-0.15	56.05
OR	PORC	R1	RES_EXIST	68	1.20	-0.01	55	9.73	-0.15	60.89
OR	PORE	R1	RES_EXIST	66	1.78	-0.02	54	11.01	-0.17	60.57
OR	PORW	R1	RES_EXIST	68	1.17	-0.01	50	10.65	-0.18	57.15
OR	SAL	R1	RES_EXIST	66	1.51	-0.01	50	10.21	-0.17	57.88
WA	DALW	R1	RES_EXIST	67	1.02	-0.01	50	7.24	-0.11	61.76
WA	VAN	R1	RES_EXIST	66	1.36	-0.01	51	9.57	-0.15	59.36
OR	ALB	C1	COM_EXIST	63	2.43	0.00	52	39.81	-0.65	57.19
OR	AST	C1	COM_EXIST	64	3.72	0.00	57	29.76	-0.45	57.49
OR	COOS	C1	COM_EXIST	62	3.60	0.00	55	45.03	-0.69	59.69
OR	DALO	C1	COM_EXIST	62	6.07	-0.05	52	36.90	-0.57	58.42
OR	EUG	C1	COM_EXIST	61	10.92	-0.11	50	44.95	-0.71	56.84
OR	LC	C1	COM_EXIST	60	5.51	0.00	51	33.86	-0.52	54.77
OR	PORC	C1	COM_EXIST	62	10.38	-0.10	50	48.96	-0.77	57.90
OR	PORE	C1	COM_EXIST	68	2.43	0.00	53	46.06	-0.72	60.58
OR	PORW	C1	COM_EXIST	68	2.84	0.00	50	49.36	-0.82	56.96
OR	SAL	C1	COM_EXIST	61	8.94	-0.09	50	46.07	-0.75	56.40
WA	DALW	C1	COM_EXIST	62	6.07	-0.05	52	36.90	-0.57	58.42
WA	VAN	C1	COM_EXIST	67	10.21	-0.10	54	41.58	-0.65	57.48

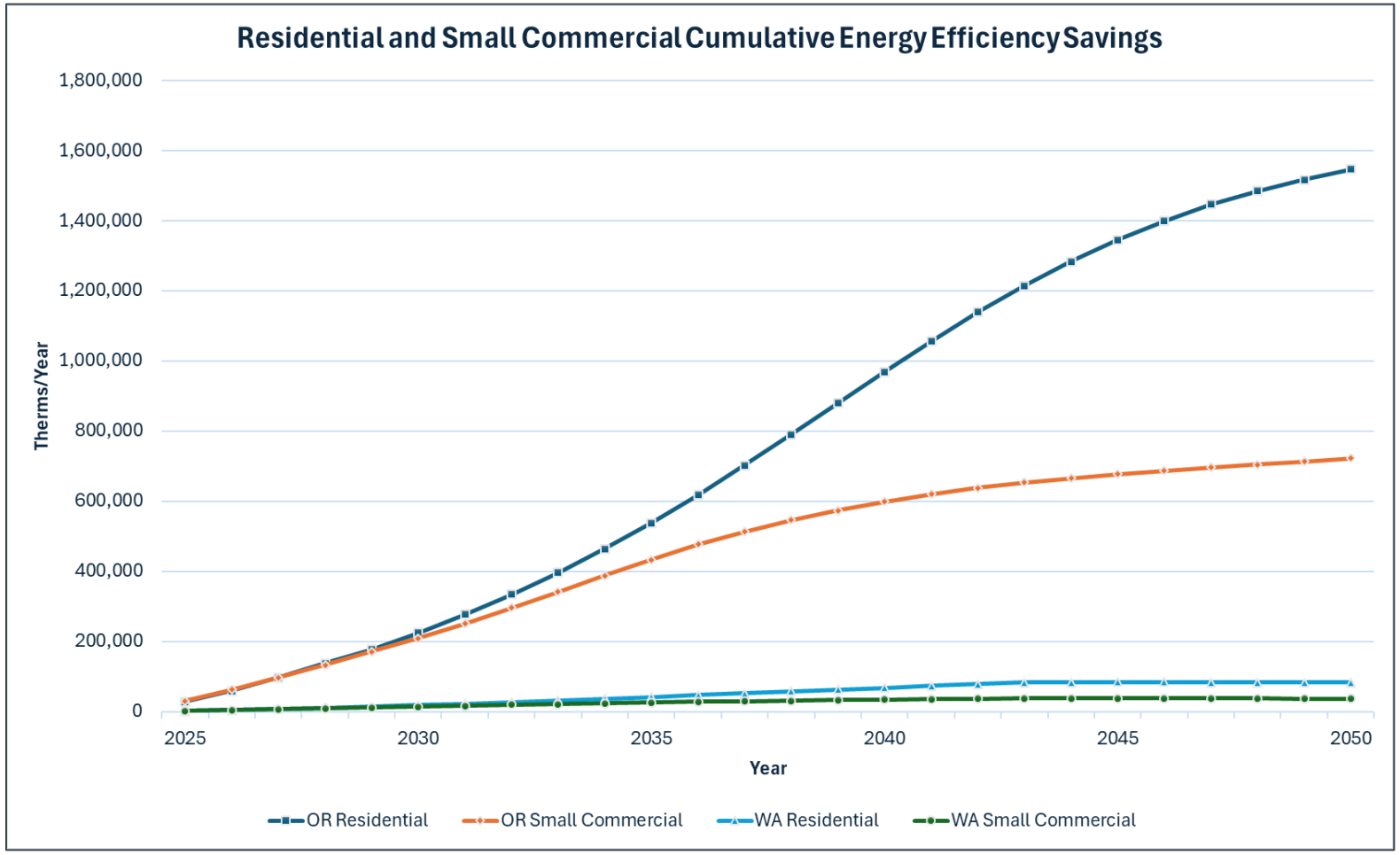
Regression Model and Coefficients

Example: PORC Load Center



Residential & Small Commercial Energy Efficiency

- The final step in load forecasting is to incorporate **energy efficiency**
  - Energy Trust of Oregon (ETO) produces an efficiency forecast for OR residential and small commercial customers
  - Applied Energy Group (AEG) produces an efficiency forecast for WA residential and small commercial customers
- Both efficiency estimates are provided at the annual level across customer rate classes and segments
  - We allocate these estimates at the daily load level based on annual load share percentages
- **Caveat:** This efficiency forecast is based on the customer forecast from Summer 2024, a revision of that customer forecast in Winter 2024 will cause OR estimates to marginally decline



Adding It All Up – The Reference Case

NW Natural®

Total Residential Daily Load

$$= \sum_{i} \sum_{j} f\left(UPC_{i,j} \middle| T_i\right) * \text{Customer Count}_{i,j} - \text{EE Residential Adjustment}_i$$

Total Small Commercial Daily Load

$$= \sum_{i} \sum_{k} f\left(UPC_{i,k} \middle| T_i\right) * \text{Customer Count}_{i,k} - \text{EE Small Commercial Adjustment}_i$$

i ∈ Load Centers

Albany, Astoria, Coos Bay, Eugene, Lincoln City, Portland Central, Portland West, Portland East, Salem, The Dalles (OR), The Dalles (WA),Vancouver

j ∈ Residential

Existing

Conversions

Single Family New Construction

Multifamily New Construction

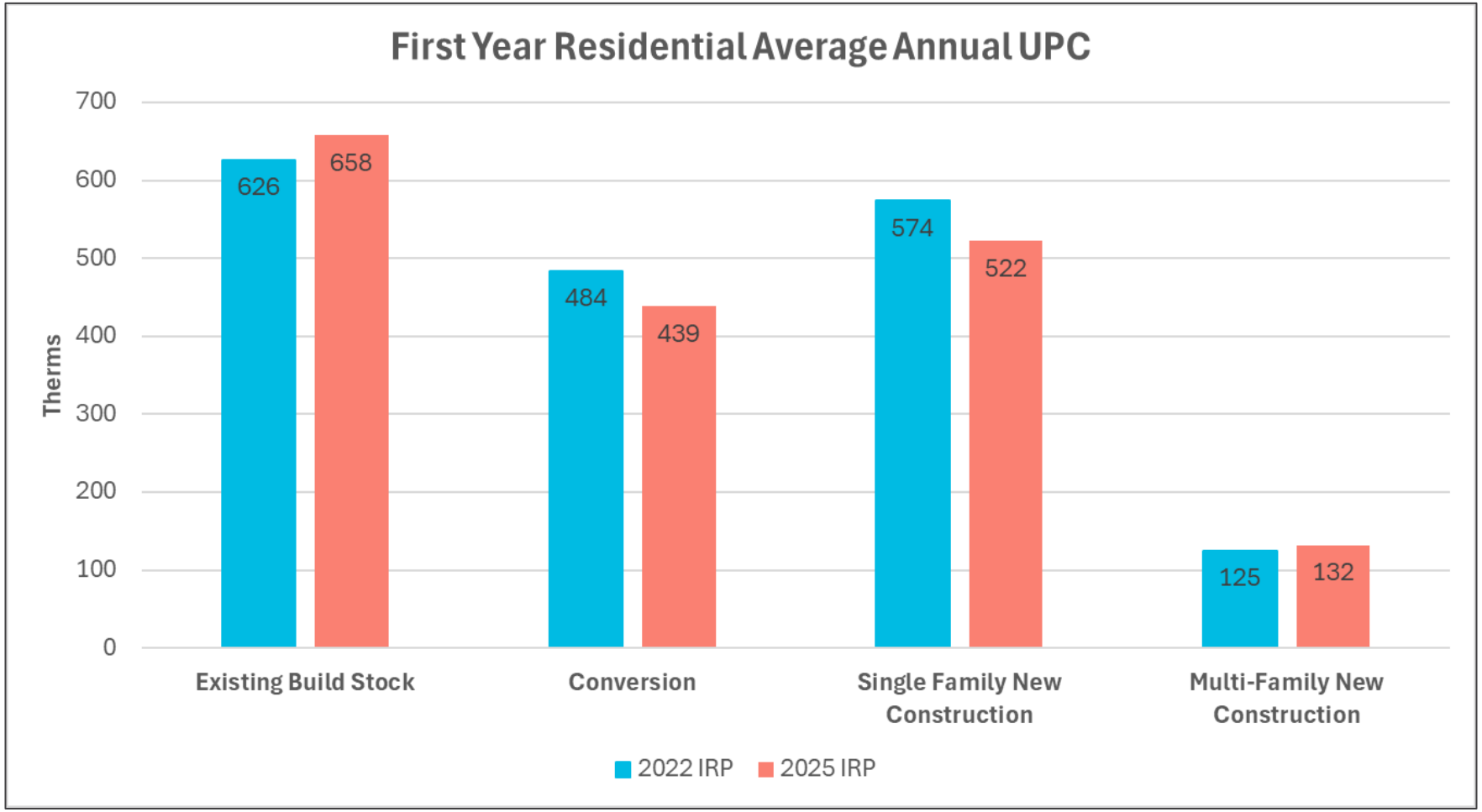
k ∈ Small Commercial

Existing

Conversions

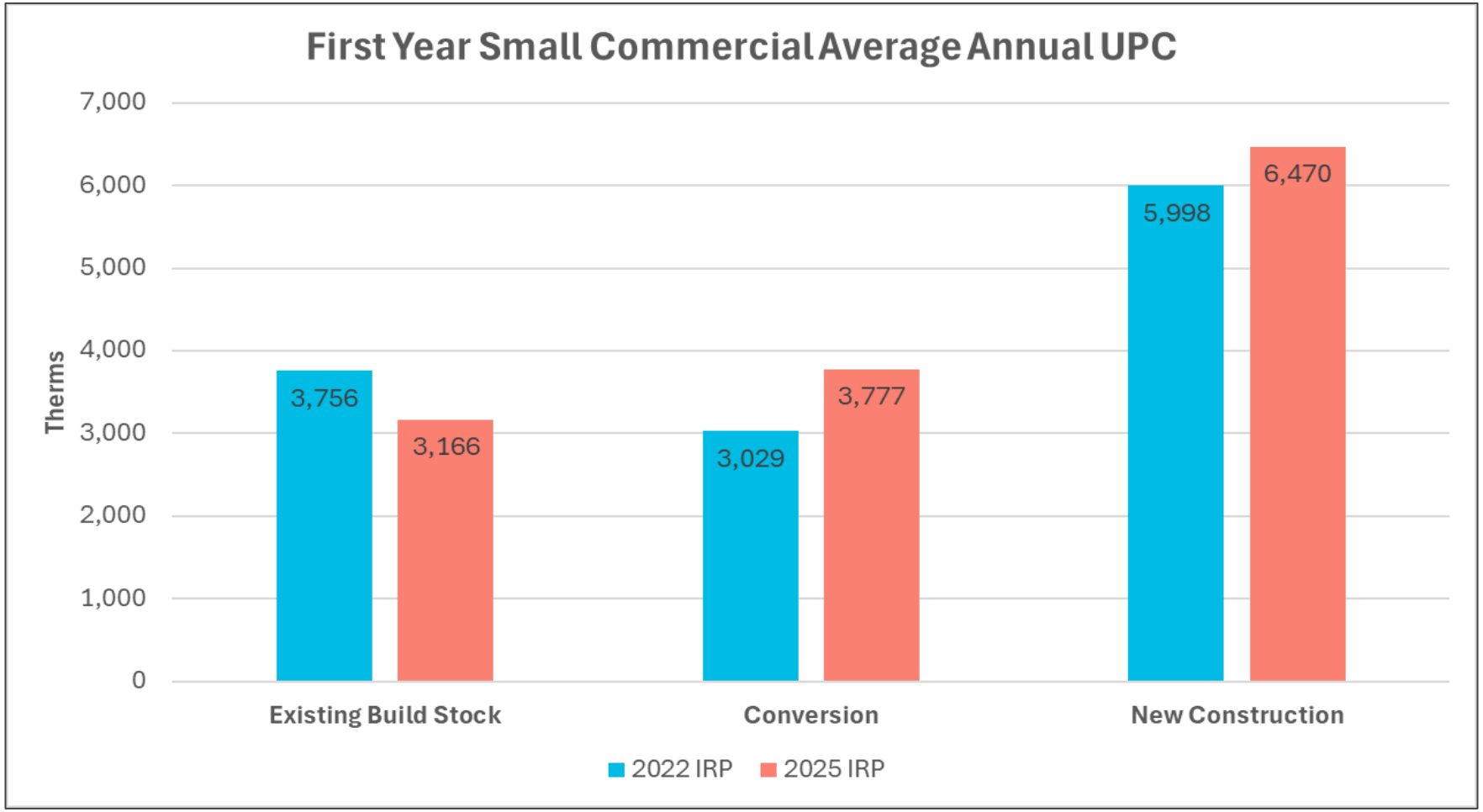
New Construction

2025 Reference Case



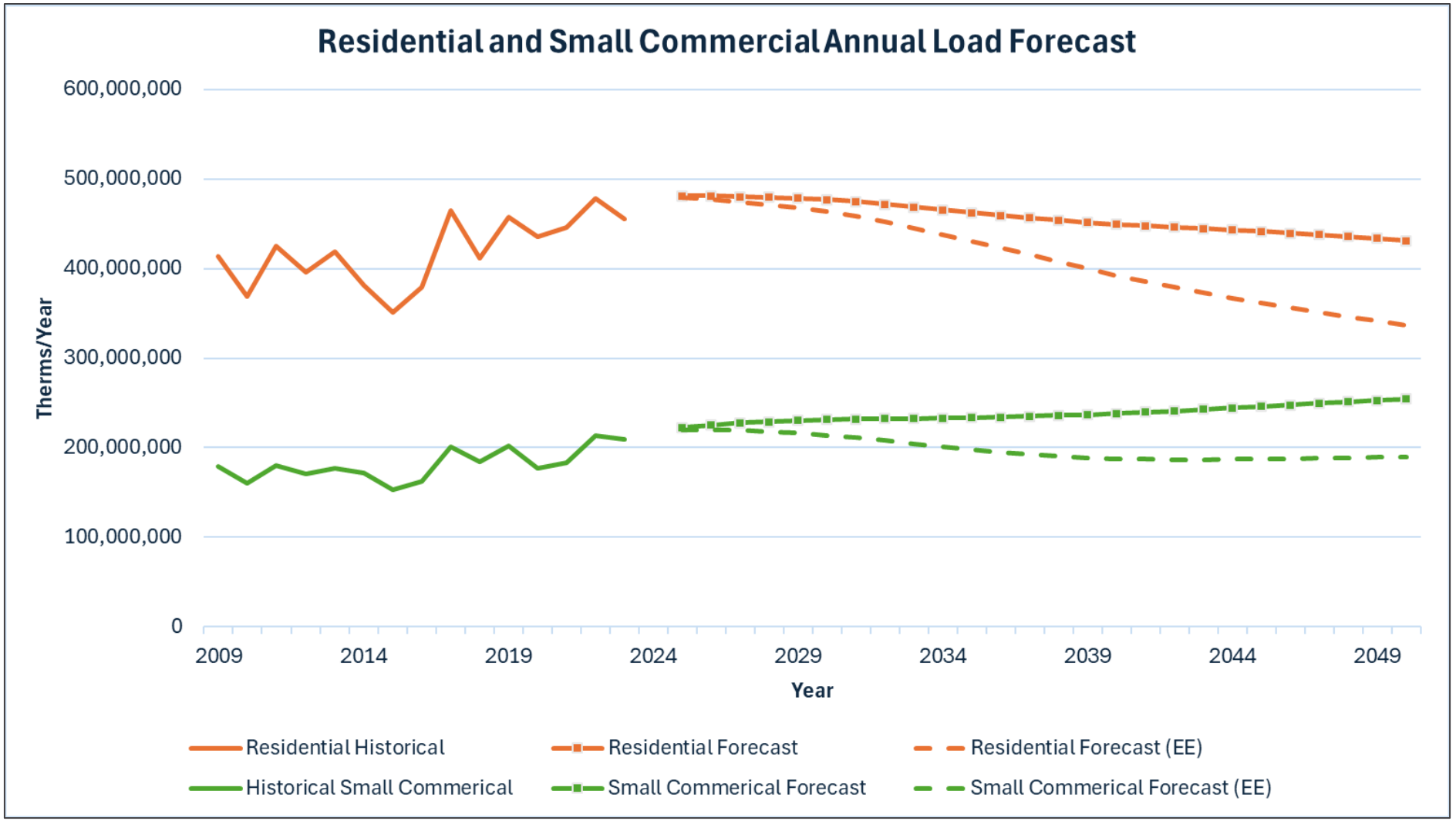
Note: First year average annual UPC estimates do not include energy efficiency estimates

2025 Reference Case



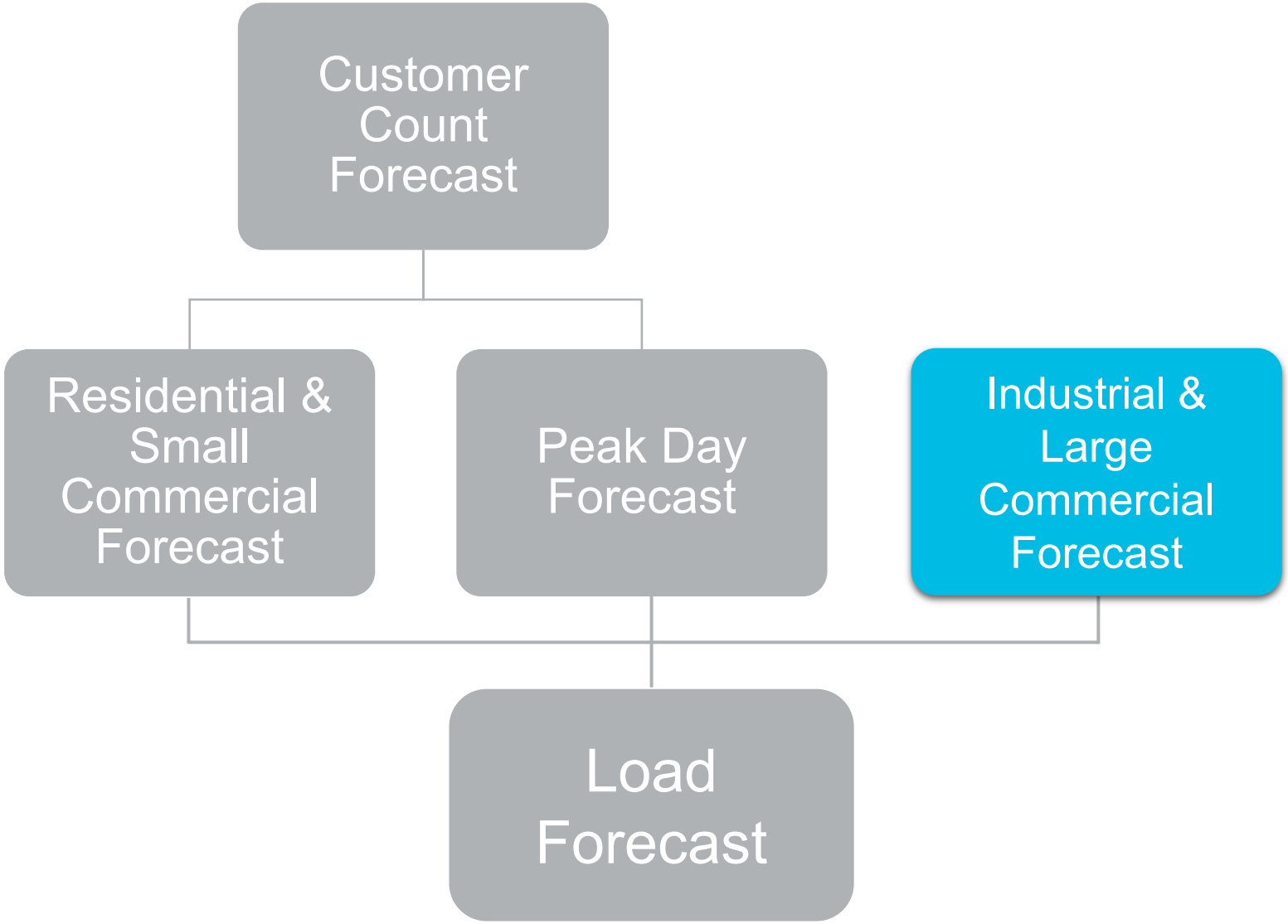
Note: First year average annual UPC estimates do not include energy efficiency estimates

2025 Reference Case

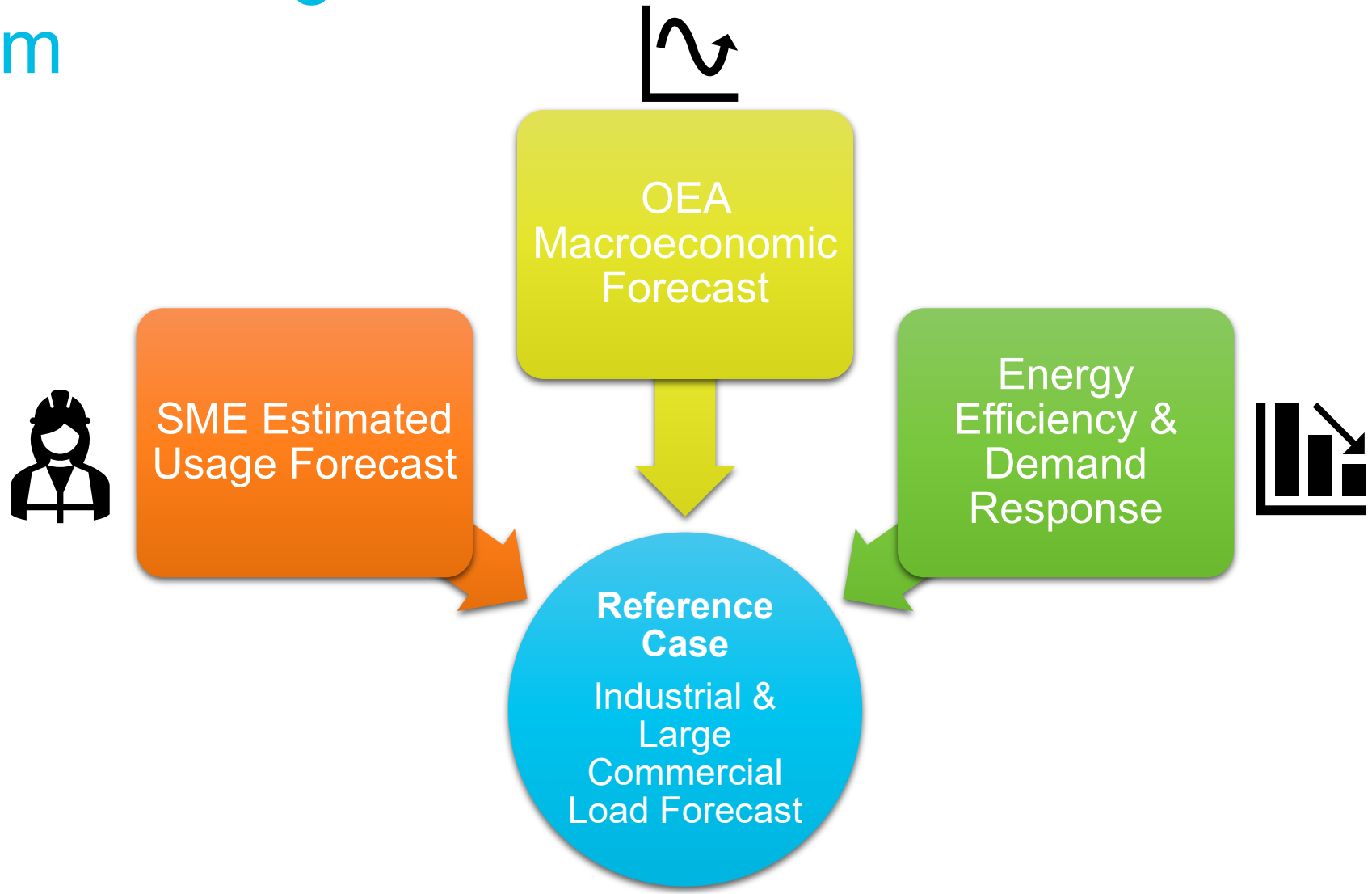


Reference Case Load Forecast: Industrial & Large Commercial

Load Forecast Flow Diagram



Industrial & Large Commercial Flow Diagram



Industrial Estimated Usage – SME

Short-term Industrial Forecast

NW Natural's SMEs provide a near-term monthly industrial load forecast by load center and type

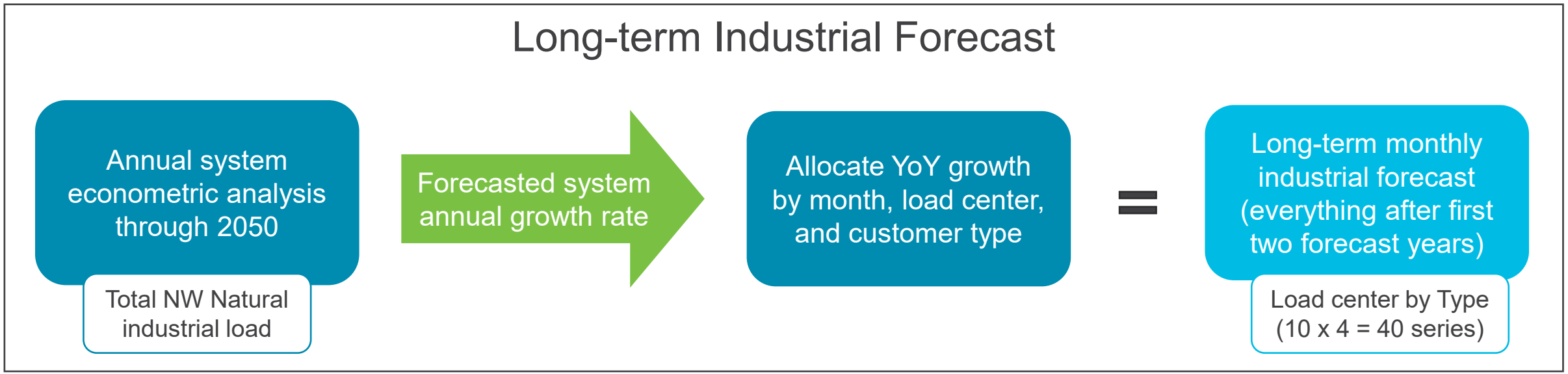
(1) Firm Sales
(2) Interruptible Sales
(3) Firm Transportation
(4) Interruptible Transportation

=

Short-term monthly industrial load forecast (first two forecast years)

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

Industrial Estimated Usage – OEA



- Technical notes
  - Regress annual historical (1994-2023) industrial load growth on changes in US industrial output (RHS driver variable, provided by Oregon Economic Administration—OEA)
  - OEA provides an annual forecast of the RHS variable over the horizon 2024-2034
    - Annual industrial load can be forecast over this time horizon
  - To extend the forecast to 2050, the RHS variable is projected to grow at the CAGR of the last 5 years (2029-2034) of OEA forecasted data
    - Annual industrial load can be forecast through 2050

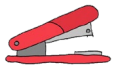
Total Industrial Estimated Usage

NW Natural®

Total Industrial Forecast

Short-term monthly industrial load forecast

Convert monthly load to daily

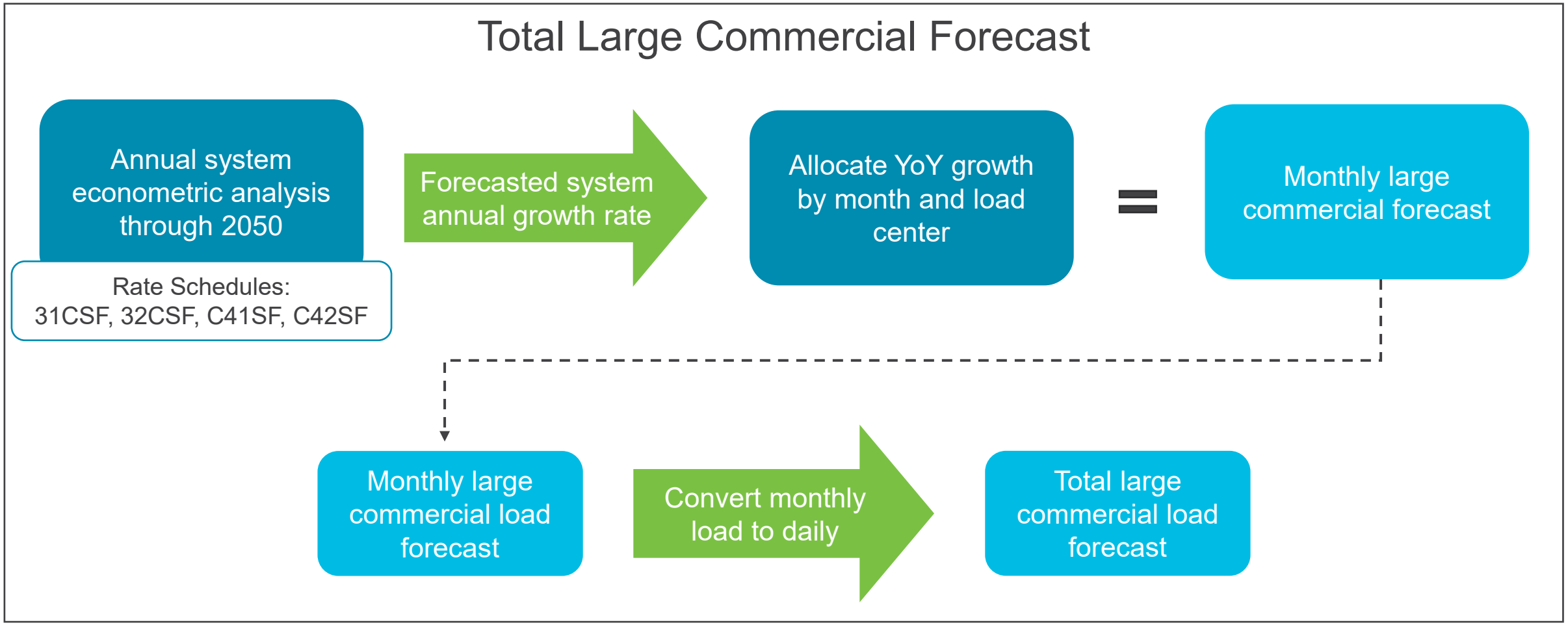


Long-term monthly industrial load forecast

Convert monthly load to daily

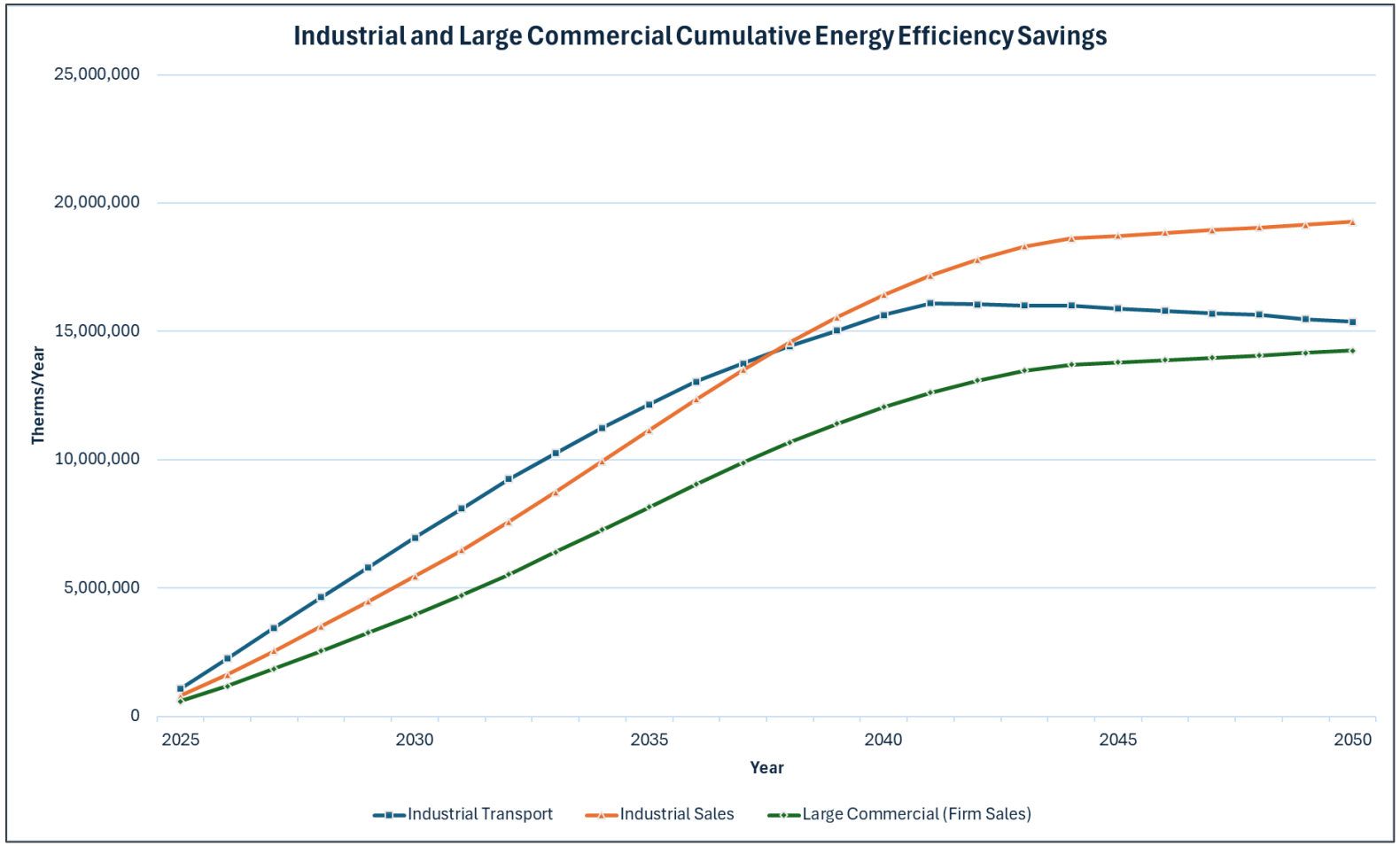
Total industrial load forecast

Large Commercial Estimated Usage – OEA

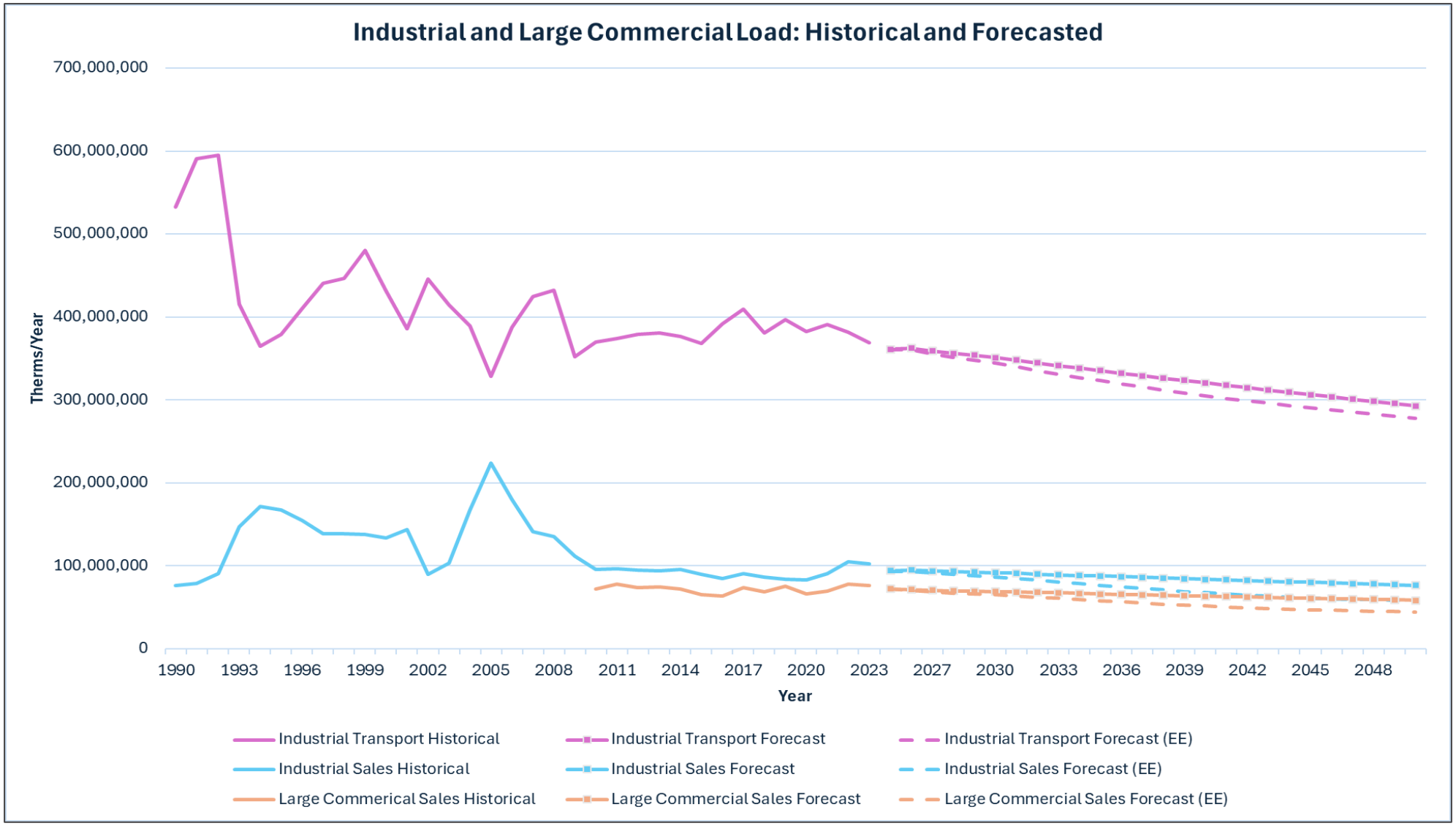


Industrial and Large Commercial Energy Efficiency

- ETO produces an efficiency forecast for OR Industrial Sales and Large Commercial (Firm Sales) customers
  - AEG produces an efficiency forecast for OR Industrial Transport customers
- AEG produces an efficiency forecast for WA Industrial Sales and Industrial Transport
- All efficiency estimates are provided at the annual level across customer segments
  - We allocate these estimates across monthly load forecasts based on annual load share percentages

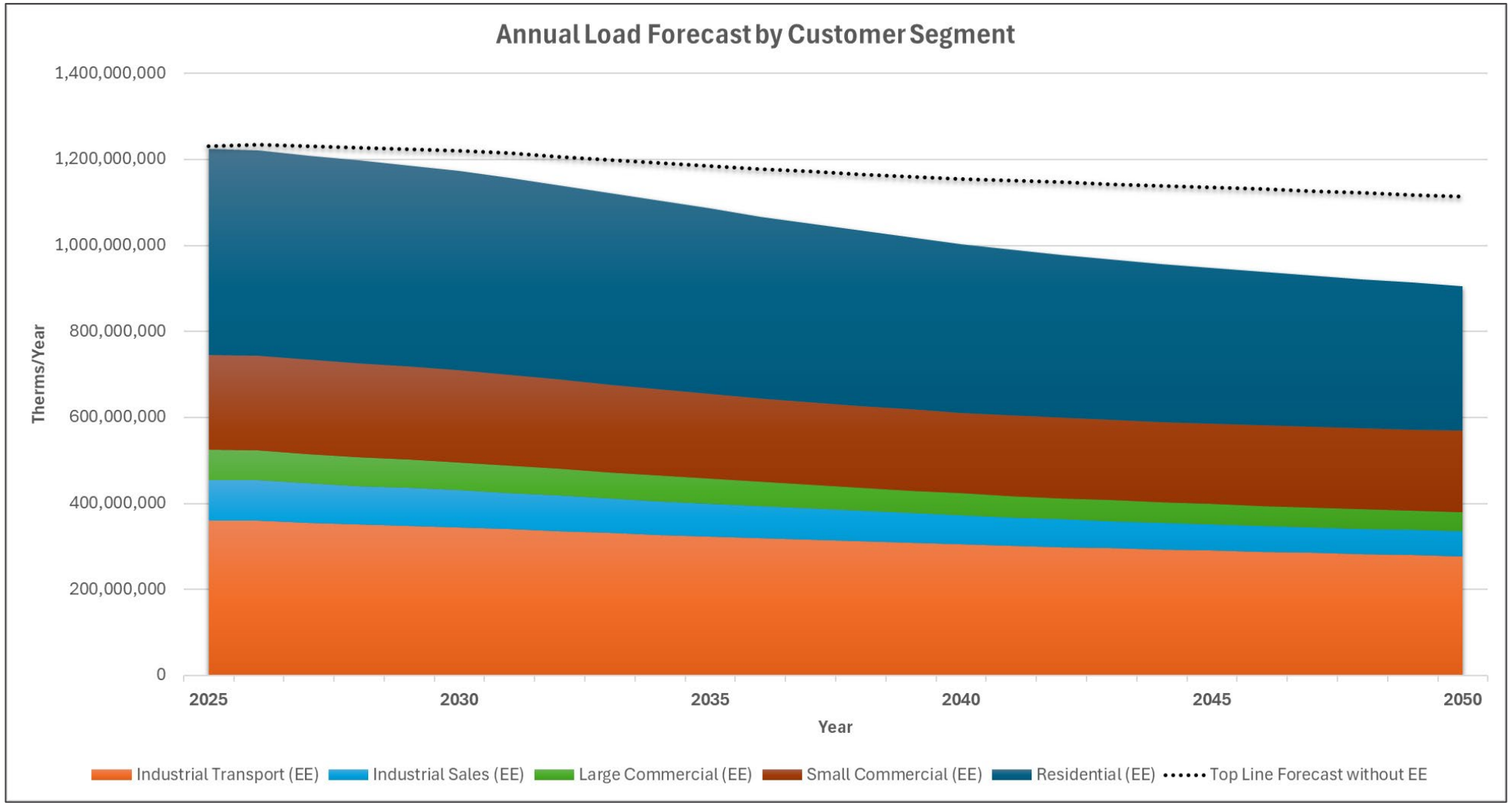


2025 Reference Case



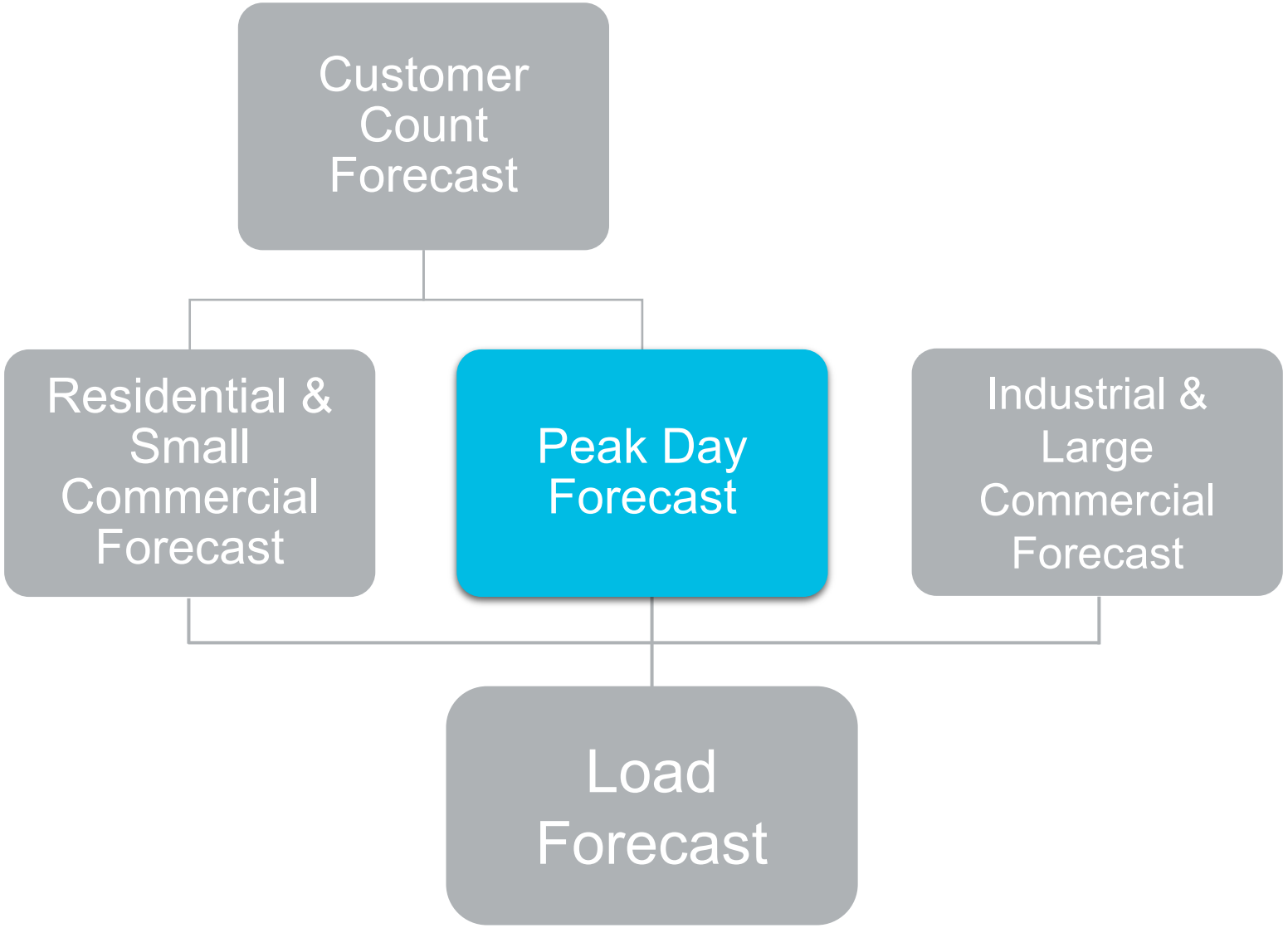
Reference Case Load Forecast: Total System

2025 Reference Case

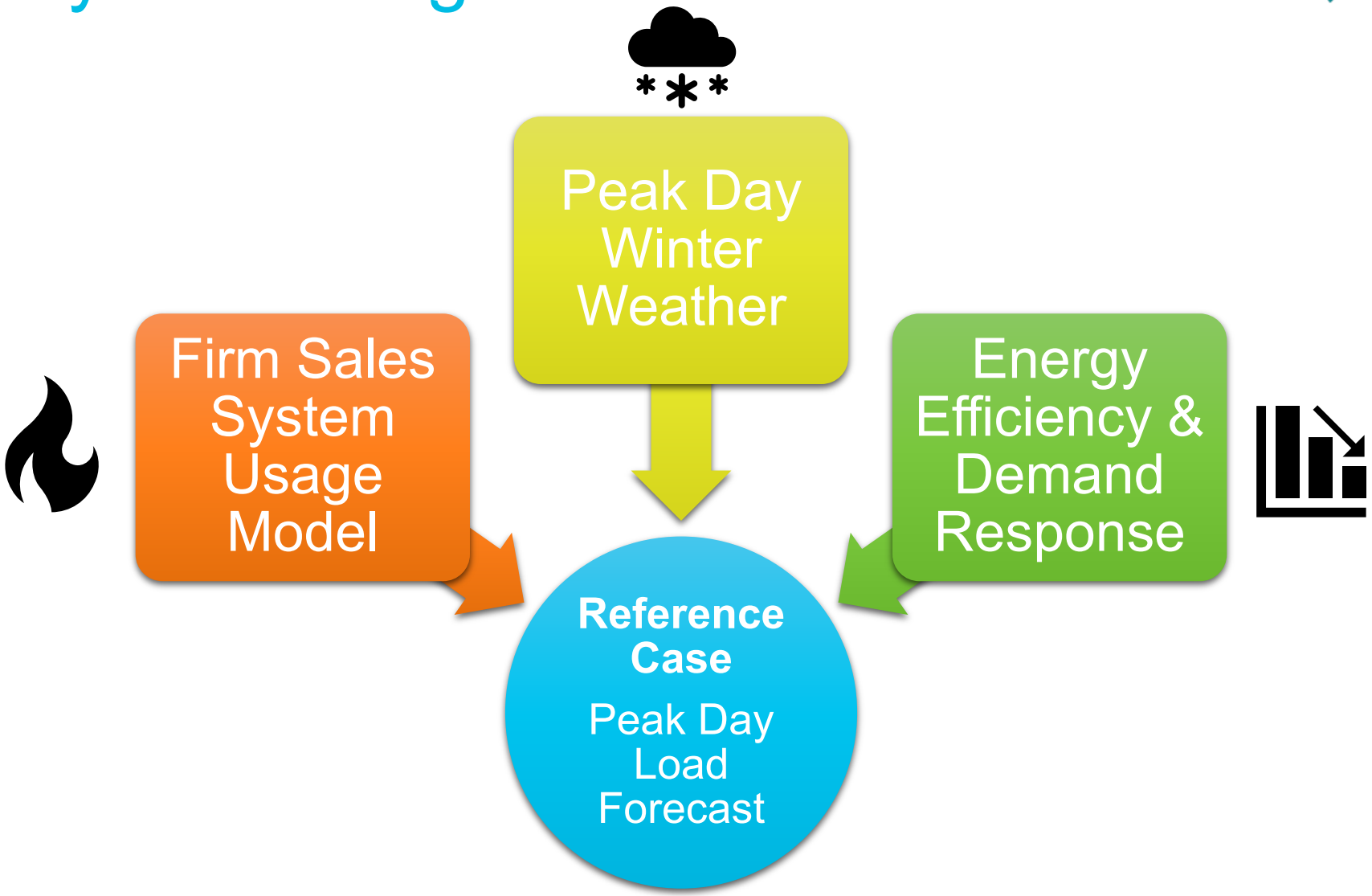


Reference Case Load Forecast: Peak Day

Load Forecast Flow Diagram



Peak Day Flow Diagram



Why Do IRPs Focus on Peak Planning?

NW Natural®

- The most likely time for customers to lose service due to resource constraints occurs at the same time when it could be one of 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 a health/safety issue for customers
- Natural gas LDC planning standards are strict due to the high-stake consequences of outages, which could occur during cold events if resources become constrained

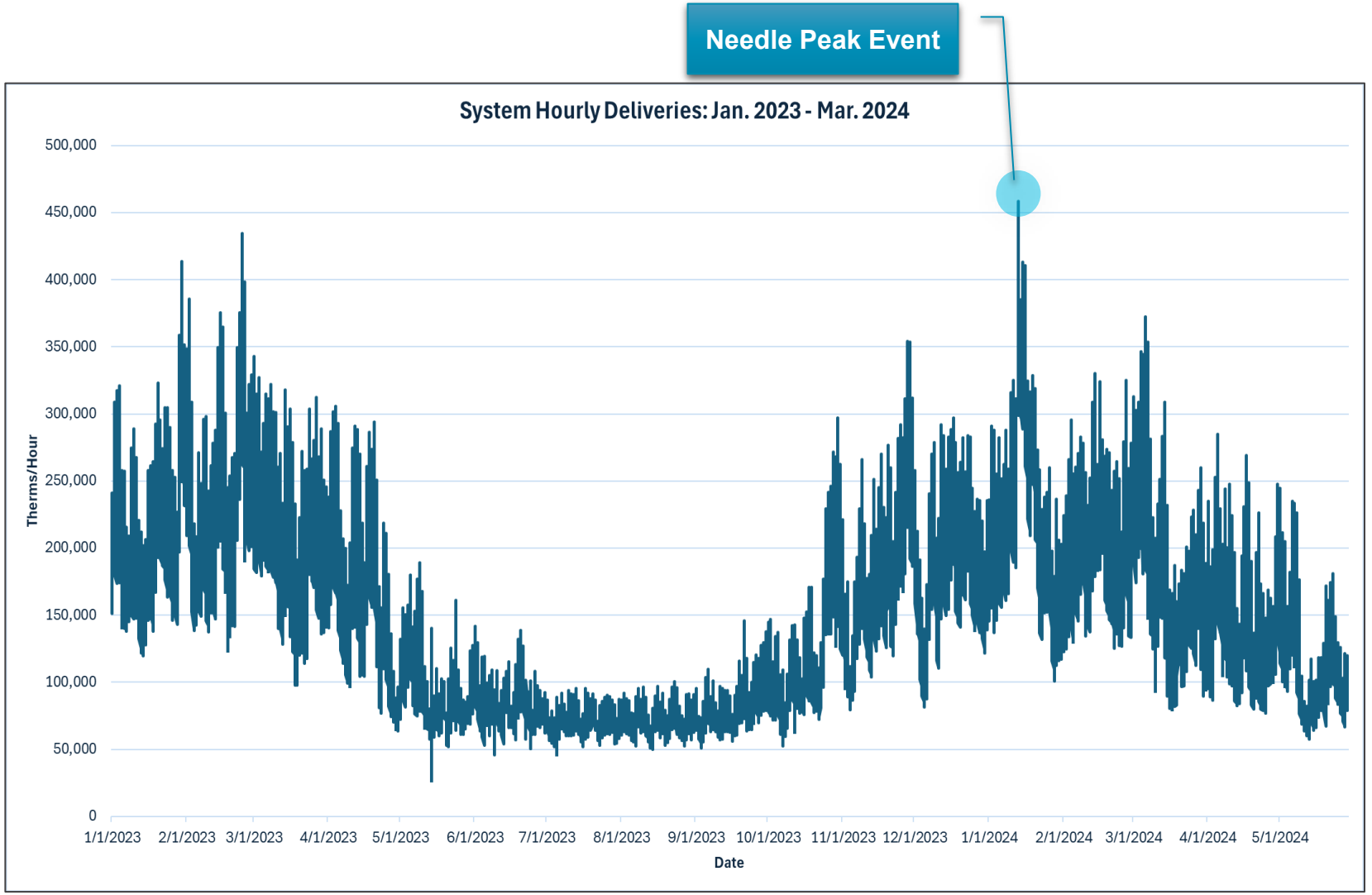
Peak Day Resource Supply Planning

- 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
  - We plan our supply capacity resources to serve the highest **firm sales** demand day going into each gas year with 99% certainty we can meet those load requirement, assuming all resources are available (i.e., no forced outages)

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

Needle Peak Demand

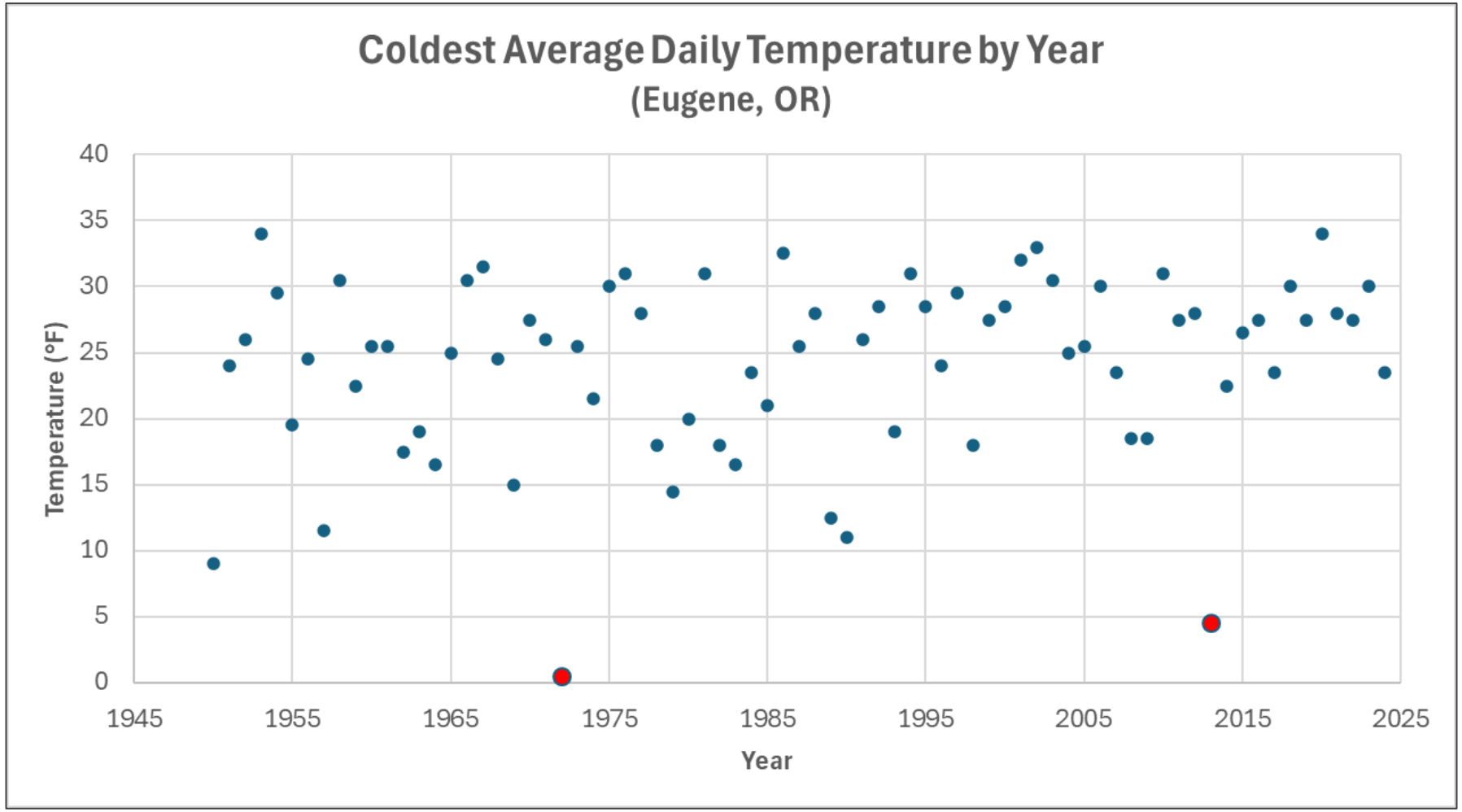
- Extreme weather causes energy usage spikes that drive building heating needs
  - These spikes, or “needle peak” events, result in much higher usage than all other times
- The more of a utility’s load that is delivered for space heating, the “peakier” the load
  - More than half of the energy NW Natural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



Weather Extremes

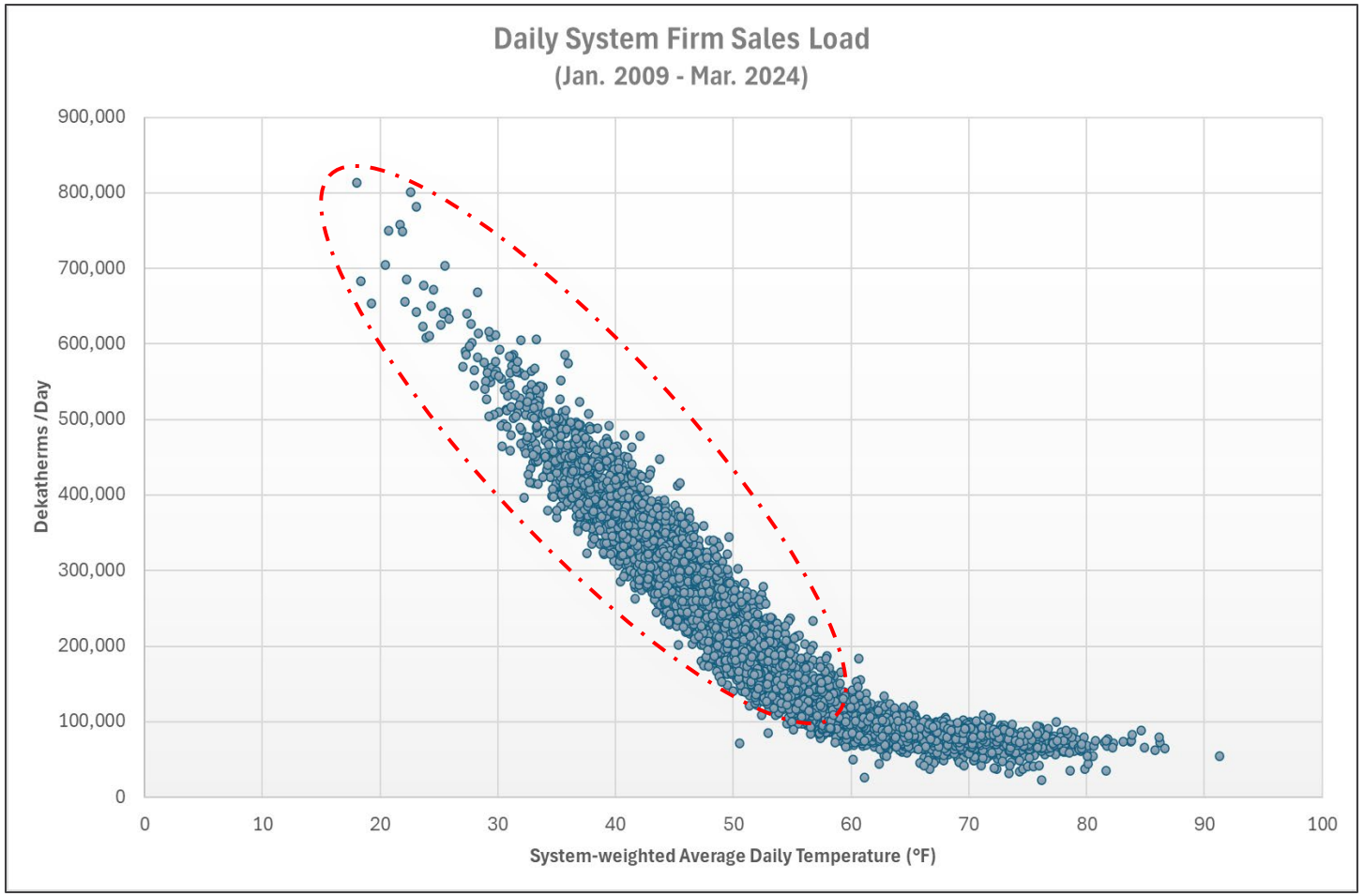
NW Natural®

Example: EUG Load Center

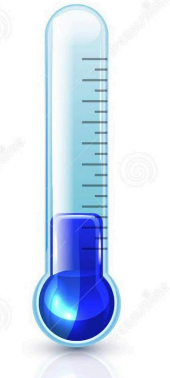


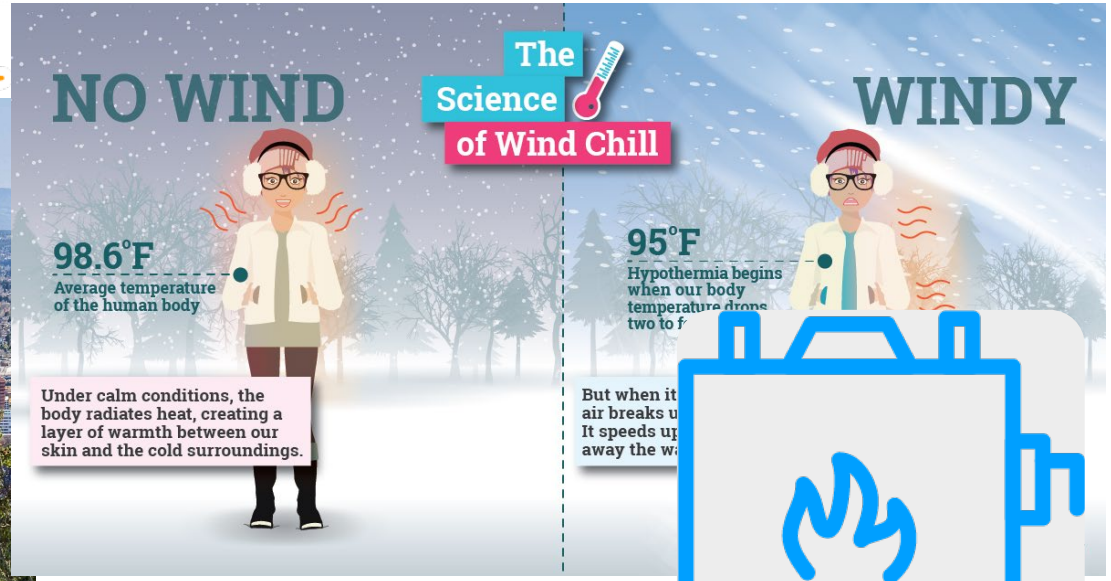
Estimating Usage – Daily System Model

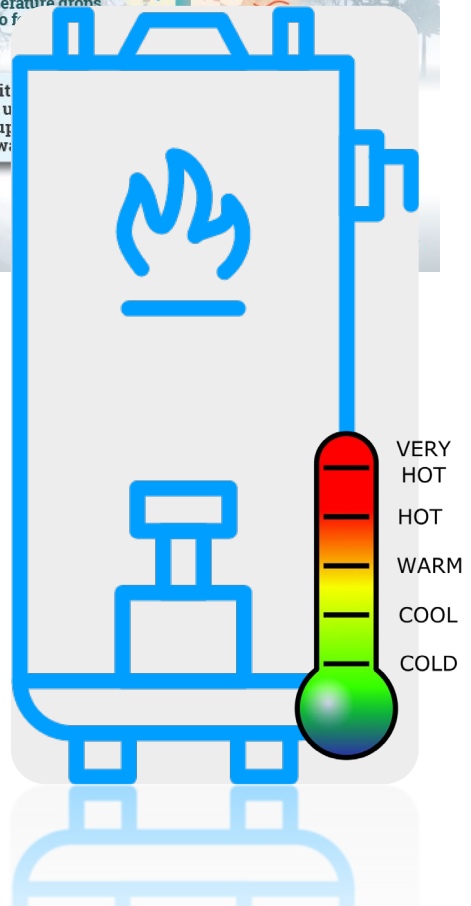
- **SCADA Metering** records gas flowing from the interstate pipeline onto NW Natural's System
  - Also, records gas flowing in and out of storage
  - Generally, very accurate – but meters can record faulty data from time to time
- Provides view of system, or regional, demand at a very granular time scale (e.g., hourly)
  - Used by gas control to monitor system on a day-to-day basis
- SCADA data is used for daily system load modeling



Demand Drivers







Daily System Regression Model

- Main Effects
  - Customer count, weather, day-of-the-week, holidays
    - Negative coefficient = Indirect relationship
    - Positive coefficient = Direct relationship
- Marginal Effects
  - Interaction term with contemporaneous temperature
- Main effects cannot be evaluated in isolation when a significant interaction is present

Main Effects		Marginal Effects	
Variable	**Coefficient Estimate**	**Variable**	**Coefficient Estimate**
Intercept	621,434 *(0.00)*	Temperature x Previous Day	144 *(0.00)*
Temperature	-11,464 *(0.00)*	Temperature x Customer Count	-0.01 *(0.00)*
Previous Day Temperature	-8,958 *(0.00)*	Temperature x Wind Speed	-62 *(0.00)*
Customer Count	0.92 *(0.00)*	Temperature x Snow Depth	492 *(0.01)*
Wind Speed	6,341 *(0.00)*	Temperature x Friday	643 *(0.00)*
Solar Radiation	-6 *(0.00)*	Temperature x Saturday	838 *(0.00)*
Snow Depth	-22,016 *(0.00)*	Temperature x Sunday	904 *(0.00)*
Friday	-39,746 *(0.00)*	Temperature x Holiday	1,286 *(0.00)*
Saturday	-61,977 *(0.00)*	*P-values shown in parentheses*	
Sunday	-58,826 *(0.00)*		
Holiday	-70,769 *(0.00)*		
COVID-19 Closure	-8,721 *(0.00)*		
Bull Run River Temperature	-1,131 *(0.00)*		

Daily System Regression Model

- For variables which have a significant interaction term (in red), notice that the one-unit change impact on demand for an average January day is much smaller relative to a peak sendout day

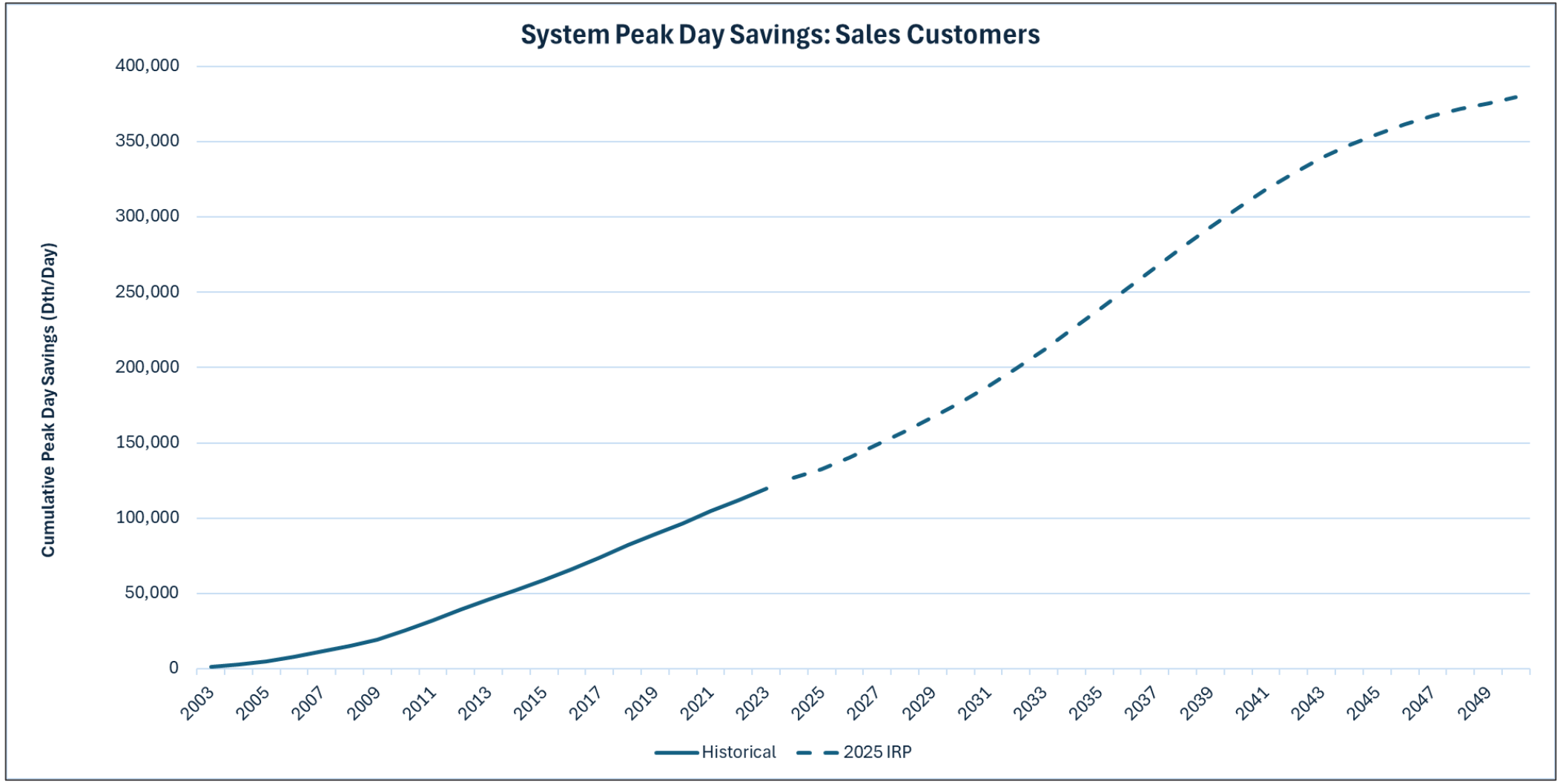
	Inputs	Marginal Effects	Inputs	Marginal Effects
Variable	**Average January Day (1985-2024)**	**Average January Day (1985-2024)**	**Peak Sendout Day (Jan. 13, 2024)**	**Peak Sendout Day (Jan. 13, 2024)**
Temperature	41	-13,749	18	-15,042
Previous Day Temperature	41	-3,033	29	-6,354
Customer Count*	802,652	0.53	802,652	0.75
Wind Speed	8	3,797	16	5,223
Solar Radiation	1,203	-6	176	-6
Snow Depth	0.10	-1,820	0.30	-13,138
Friday	0	-13,386	0	-28,158
Saturday	0	-27,589	1	-46,861
Sunday	0	-21,724	0	-42,517
Holiday	0	-18,018	0	-47,580
COVID-19 Closure	0	-8,721	0	-8,721
Bull Run River Temperature	40	-1,131	39	-1,131

*Customer counts for an average January day are assumed to be equal to the peak sendout day to facilitate the example

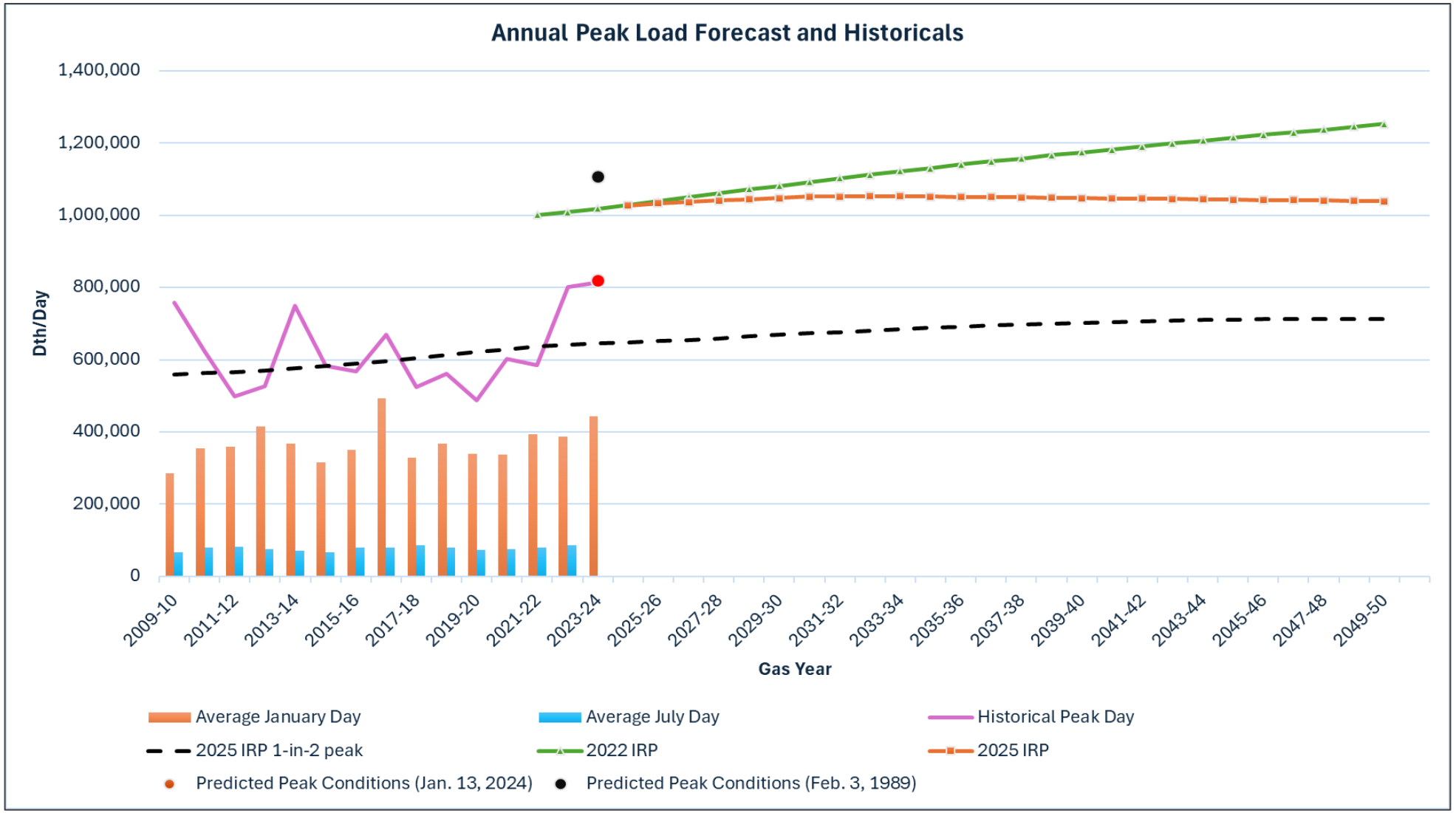
Design Peak Day Weather

- **Design peak day weather** drives the capacity requirement each winter in NW Natural's IRP due to extreme weather
  - Use Monte Carlo to simulate weather conditions from historical data
    - Temperature, previous day temperature, wind speed, solar radiation, snow depth, day of week, holiday, and water heater inlet temperature (i.e., Bull Run river temperature)
  - Customer Count is applied from the customer count forecast to forecast future requirements
  - Design peak day conditions have a 1% likelihood of occurring going into any forecasted winter
- Gas system resources focus on the daily capacity of resources to deliver gas onto NW Natural's system
  - Pipeline capacity contracts are typically specified in daily terms
  - Daily deliverability from our storage facilities are developed by system engineers
- *Note:* Distribution system planning still requires a more granular hourly calculation to ensure gas can flow throughout NW Natural's system during the morning peak demand

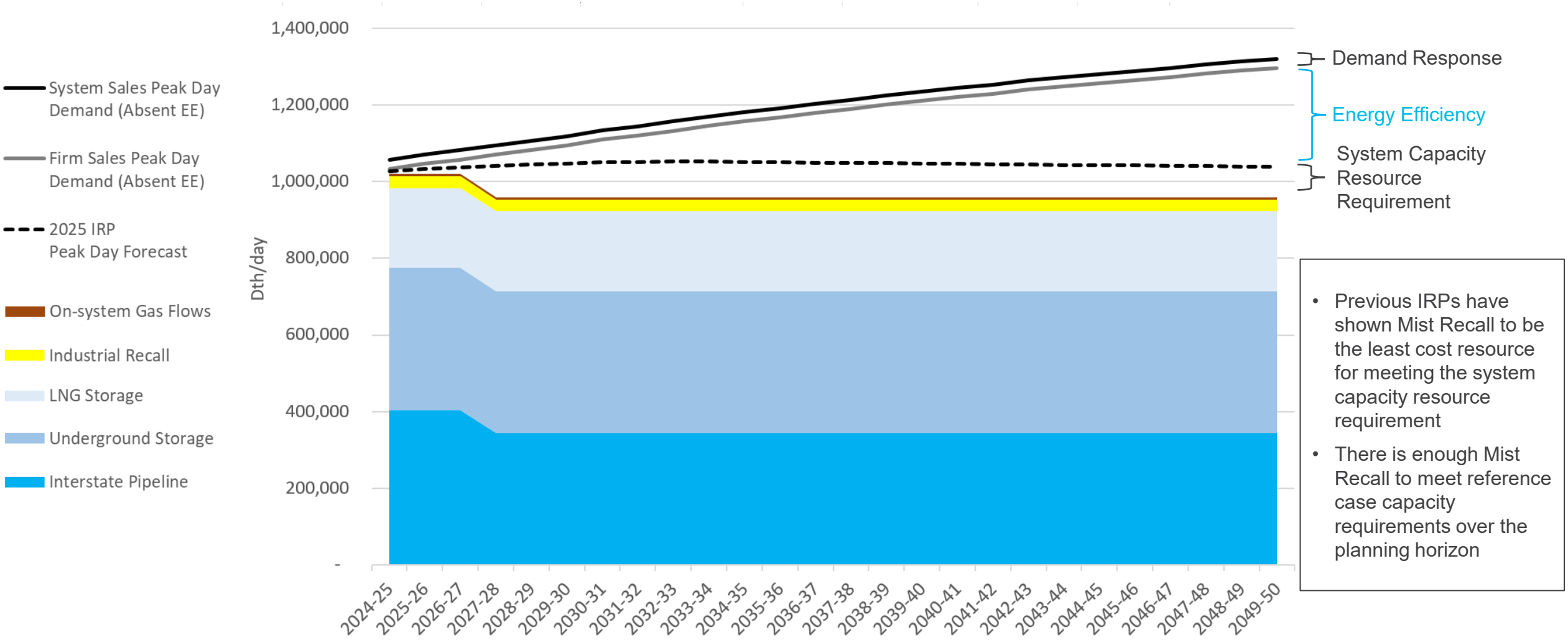
Peak Day Energy Efficiency



2025 Reference Case



Resource Stack vs. Peak Day Forecast



- Previous IRPs have shown Mist Recall to be the least cost resource for meeting the system capacity resource requirement
- There is enough Mist Recall to meet reference case capacity requirements over the planning horizon

Design Winter Weather

- Stochastic weather modeling
  - 90th percentile winter load (1-in-10)
- A **cold event** is also incorporated into design peak winter weather
  - Includes two cold days prior and two days post peak event (i.e., five-day event)
    - Cold days before and after peak are based on regression analysis using historical data
- For resource planning purposes, 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

Feedback Form

Feedback preferred by January 10, 2025

https://www.surveymonkey.com/r/NWNaturalIRP

Thank you!

We value your feedback.

IRP@nwnatural.com

IRP Website

IRP Feedback Form