Natural Gas Integrated Resource Plan - Draft

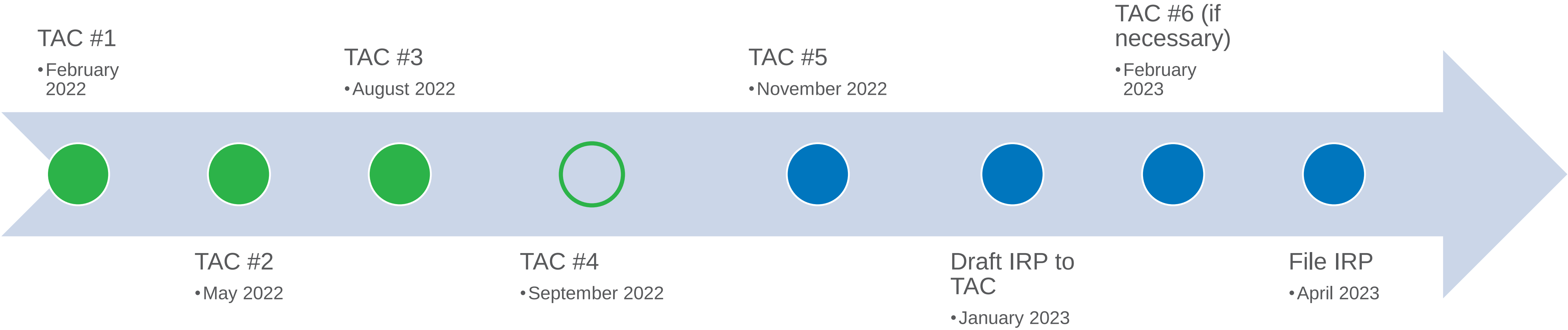
Technical Advisory Committee (TAC) # 4

September 29, 2022

Agenda

Item	Time
ETO - CPA	12:30pm – 1:15pm
Natural Gas Market Dynamics and Prices	1:15pm – 2:00pm
break	2:00pm – 2:15pm
Supply Side Resource Options	2:15pm – 3:00pm
CCA Overview	3:00pm – 3:15pm
Climate Change Weather	3:15pm – 4:00pm
Updated Load Forecast and Scenarios	4:00pm – 4:30pm

2023 – Avista Natural Gas IRP



Energy Efficiency Resource Assessment for AVA's 2023 IRP (DRAFT)

September 29th, 2022

Energy Trust of Oregon

Agenda

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

About us

Independent nonprofit

Serving 1.8 million customers of Portland General Electric, Pacific Power, NW Natural, Cascade Natural Gas and Avista

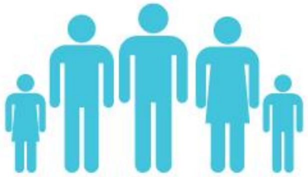
Providing access to affordable energy

Generating homegrown, renewable power

Building a stronger Oregon and SW Washington

Clean and affordable energy since 2002

From Energy Trust’s investment of $2.2 billion in utility customer funds:



Nearly 770,000 sites transformed into energy efficient, healthy, comfortable and productive homes and businesses

18,000 clean energy systems generating renewable power from the sun, wind, water, geothermal heat and biopower

$8.9 billion in savings over time on participant utility bills from their energy-efficiency and solar investments

36.2 million tons of carbon dioxide emissions kept out of our air, equal to removing 7 million cars from our roads for a year

2022 Programs – Acquiring all C/E Efficiency

- Residential – Existing and New Homes
  - Single family, moderate income, rental, manufactured homes
  - Weatherization (insulation, windows, air sealing)
  - Gas fireplaces, furnaces
  - Water heaters

- Commercial – Existing, New, Multifamily, SEM
  - Retail, offices, schools, groceries….all market segments
  - HVAC, controls, water heating, windows, insulation

- Industrial & Agriculture – Non transport sites
  - Manufacturing facilities, greenhouses
  - HVAC, O&M, process improvements

Avista & Energy Trust

- Serving Avista Territory in Oregon for over 5 years, since 2016:
  - Served over 10,500 households, over 600 commercial sites and 20 industrial sites

Energy Trust's Resource Assessment Model Overview

Resource Assessment (RA) Purpose

- Informs utility Integrated Resource Planning (IRP)

- Provides estimates of 20-year energy efficiency potential and the associated load reduction

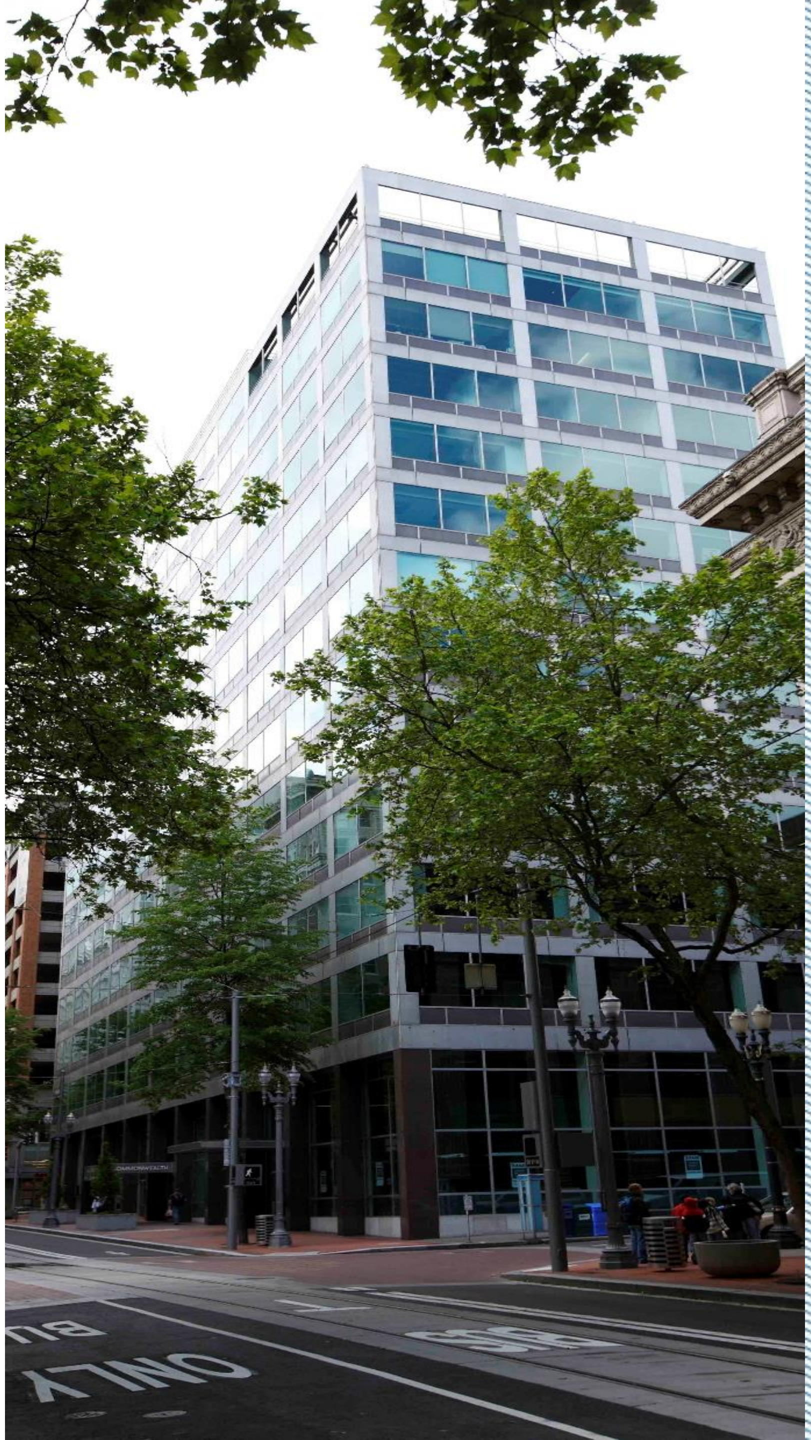
- Helps utilities to strategically plan future investment in both demand and supply side resources

RA Model Background

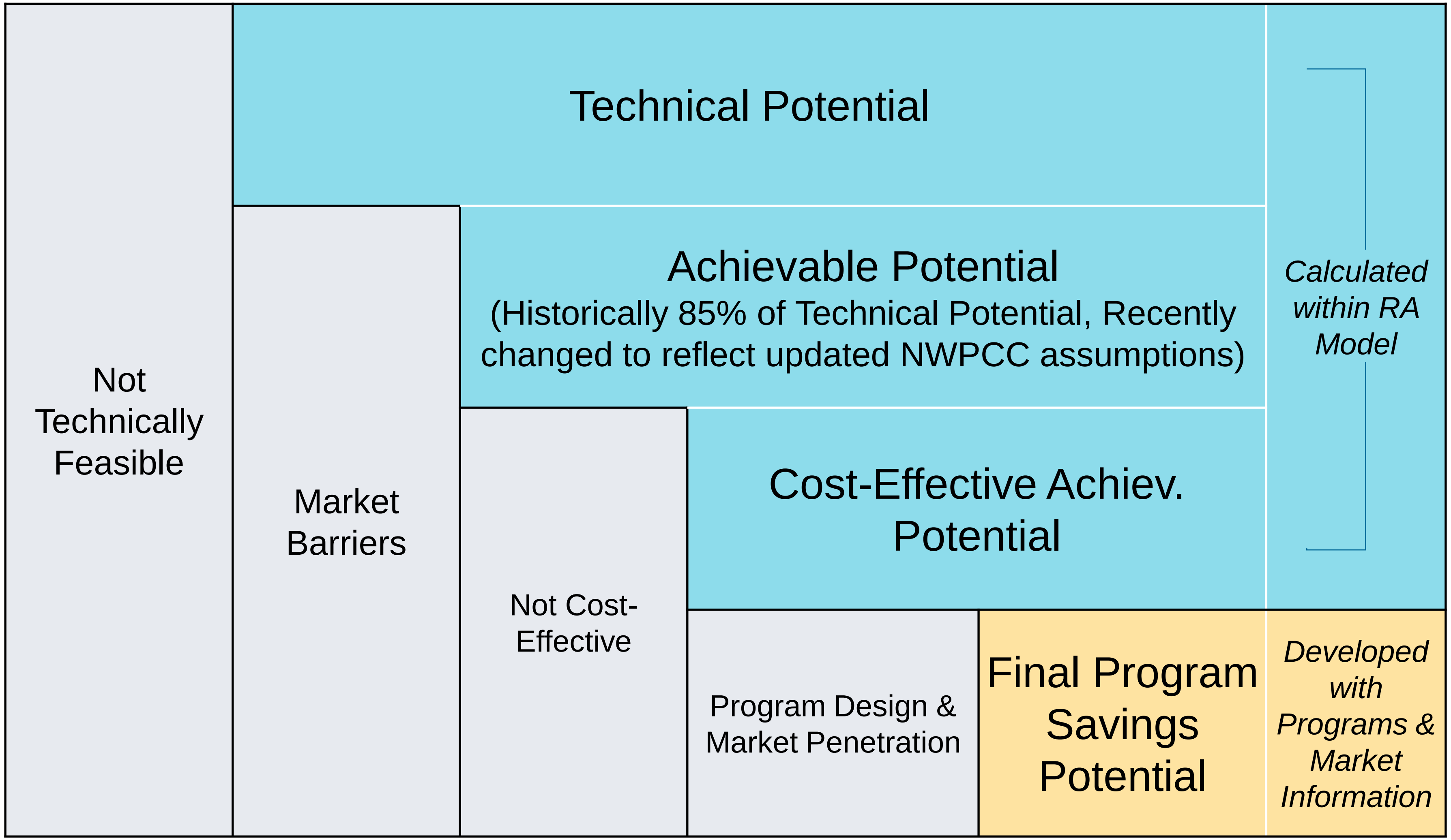
- 20-year energy efficiency potential estimates
- “Bottom-up” modeling approach – measure level inputs are scaled to utility level efficiency potential
- Energy Trust uses a model in *Analytica* that was developed by Navigant Consulting in 2014
  - The *Analytica* RA Model calculates Technical, Achievable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

Changes to Modeling Since 2020 IRP

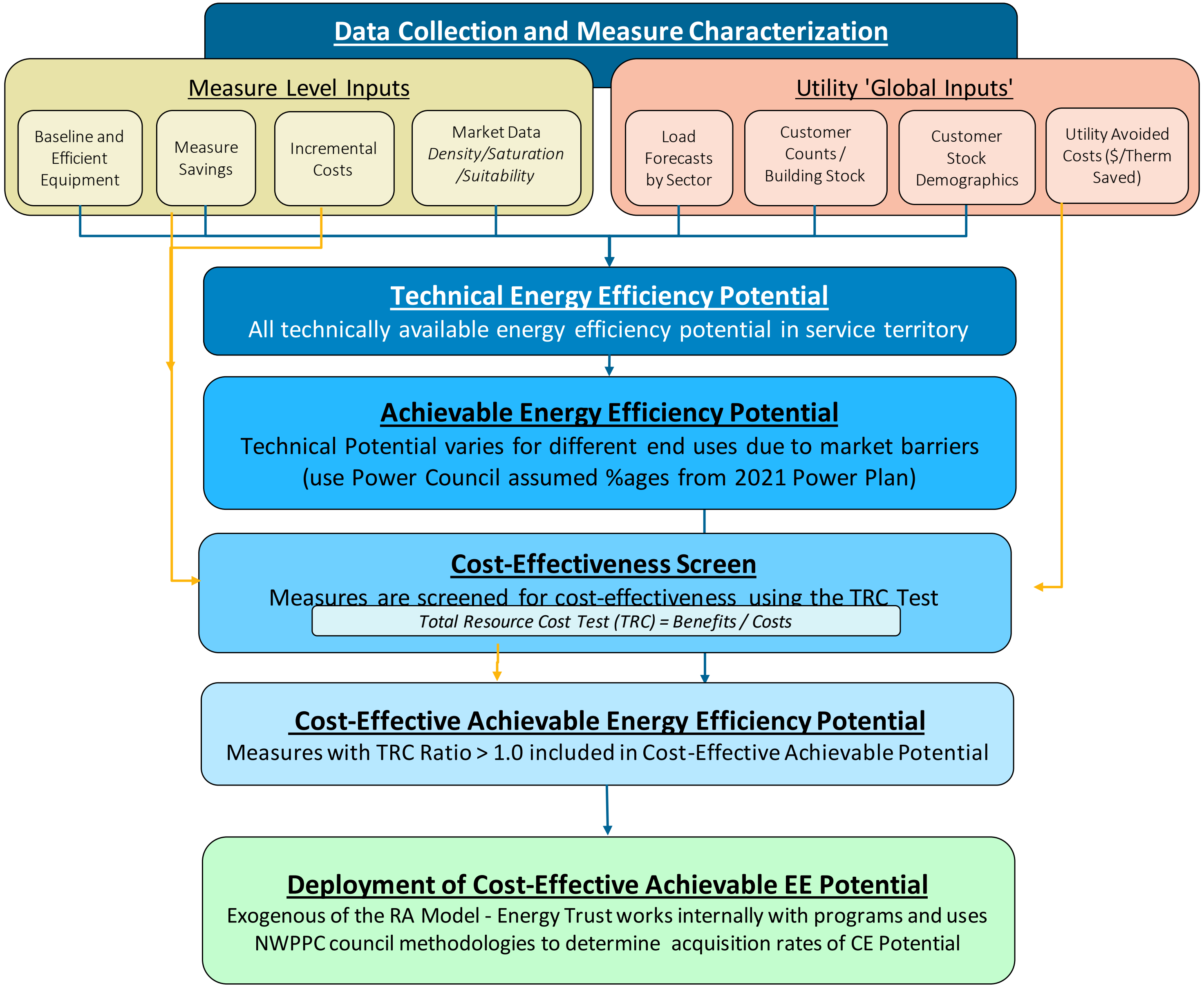
- Lost opportunity/unconstrained potential
- Align with NWPCC achievability assumptions
- Measure updates, new measures and new emerging technologies included in the model



Forecasted Potential Types



20-Year IRP EE Forecast Flow Chart



Methodology Overview

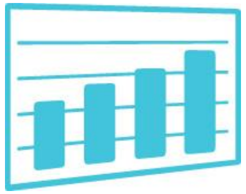
‘Bottom-up’ modeling approach:

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

Simple Example *(Illustrative Numbers)*

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

RA Model inputs



Measure Level Inputs

Measure Definition and Application:

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

Measure Savings

Measure Cost

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

Market Data (for scaling)

- Density
- Baseline/efficient equipment saturations
- Suitability

Utility 'Global' Inputs

Customer and Load Forecasts

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

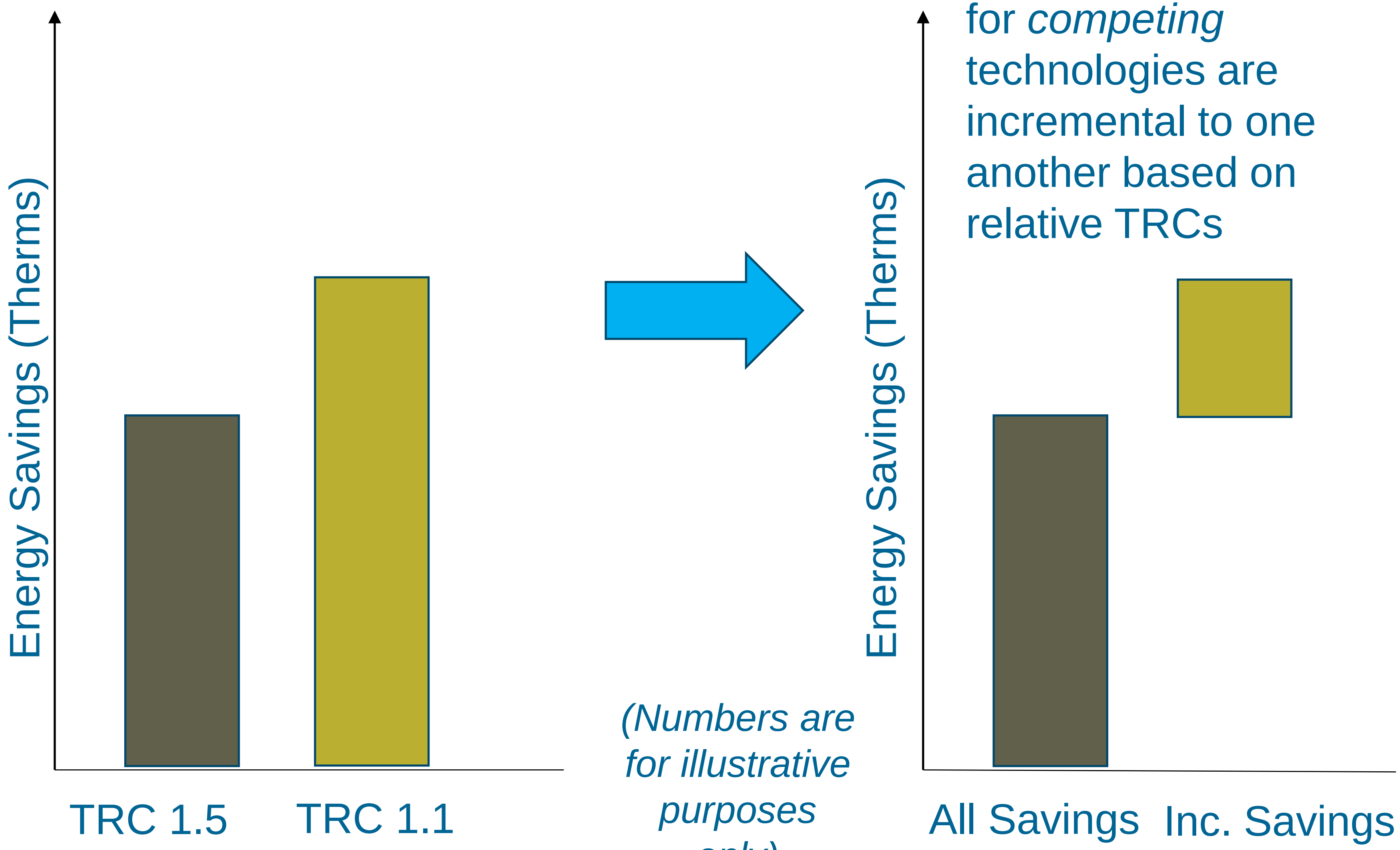
Avoided Costs (provided by utilities)

Customer Stock Demographics:

- Heating fuel splits
- Water heat fuel splits

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

Incremental Measure Savings Approach
Competition groups



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

(Numbers are for illustrative purposes only)

Cost-Effectiveness Screen

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

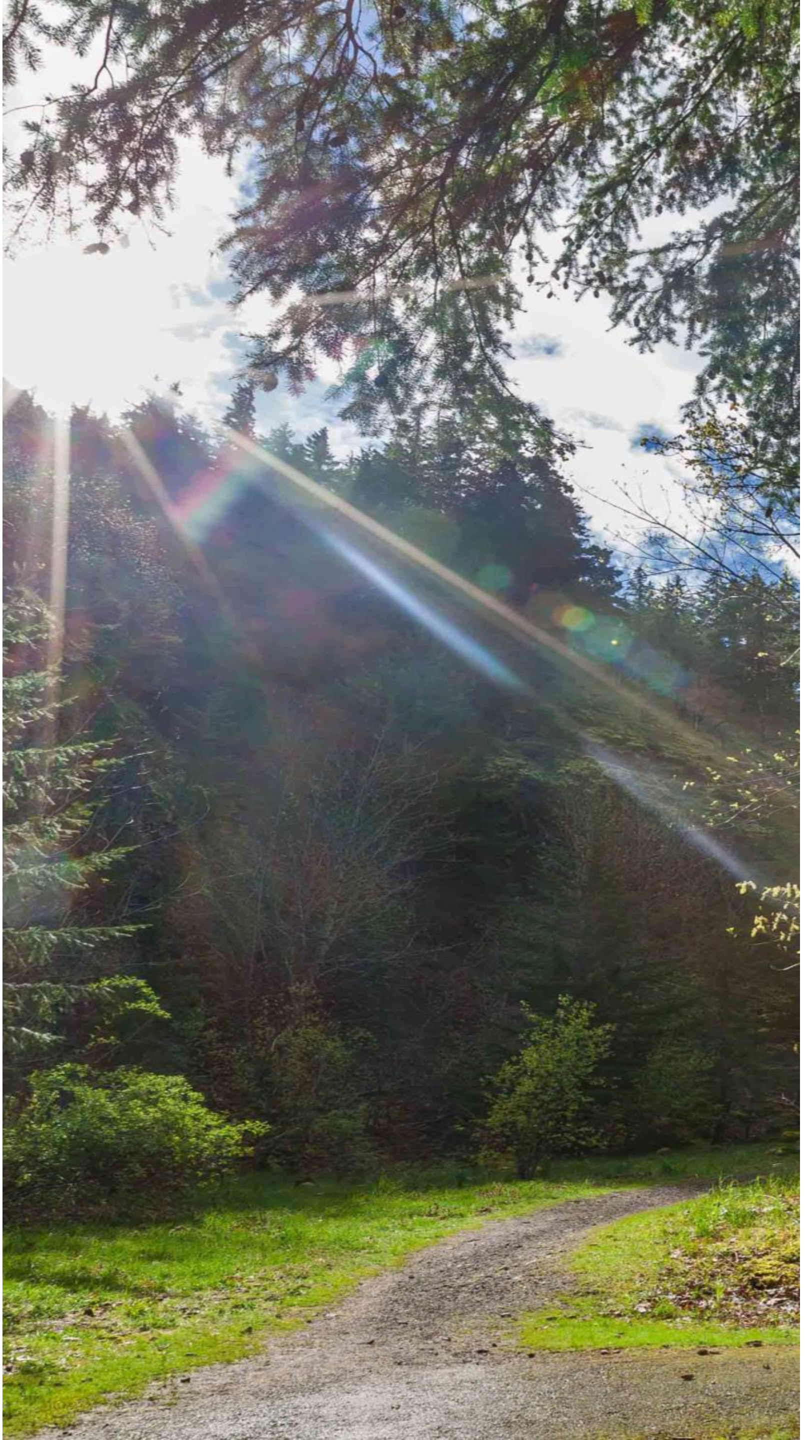
$$\text{TRC} = \frac{\textit{Measure Benefits}}{\textit{Total Measure Cost}}$$

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

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

Total Measure Costs:

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



Cost-Effectiveness Override in Model

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

Reasons:

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

Model Outputs

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

Levelized Cost

Measure Costs & Benefits

Supply Curves

IRP Savings Projections:

Methodology to Deploy Cost-Effective Achievable Potential

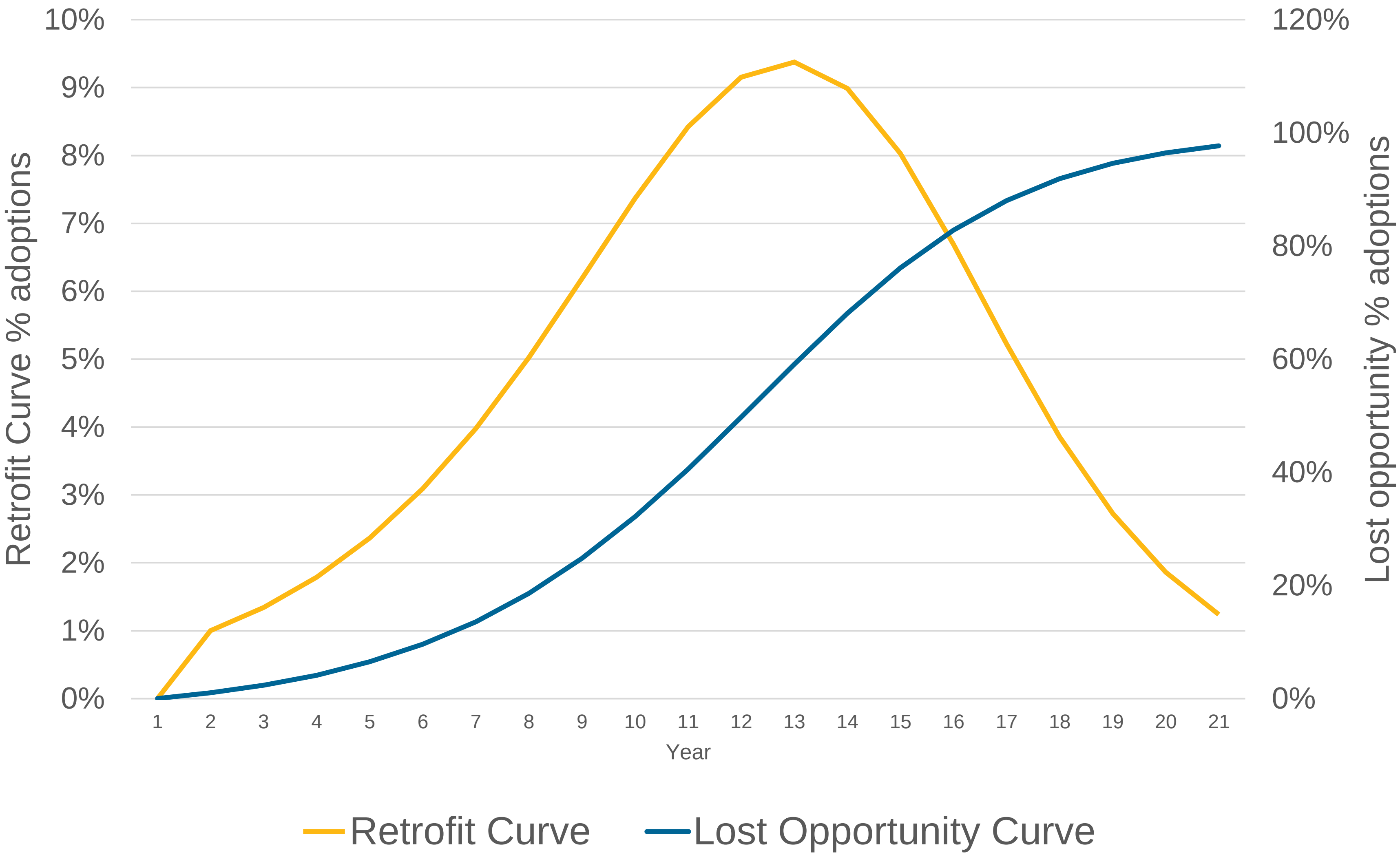
Why Deploy?

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

Ramp Rate Overview

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

Ramp Rate Examples



Ramp Rate Calibration

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

Years 1-2

- Program forecasts – based on budget and current market conditions

Years 3-5

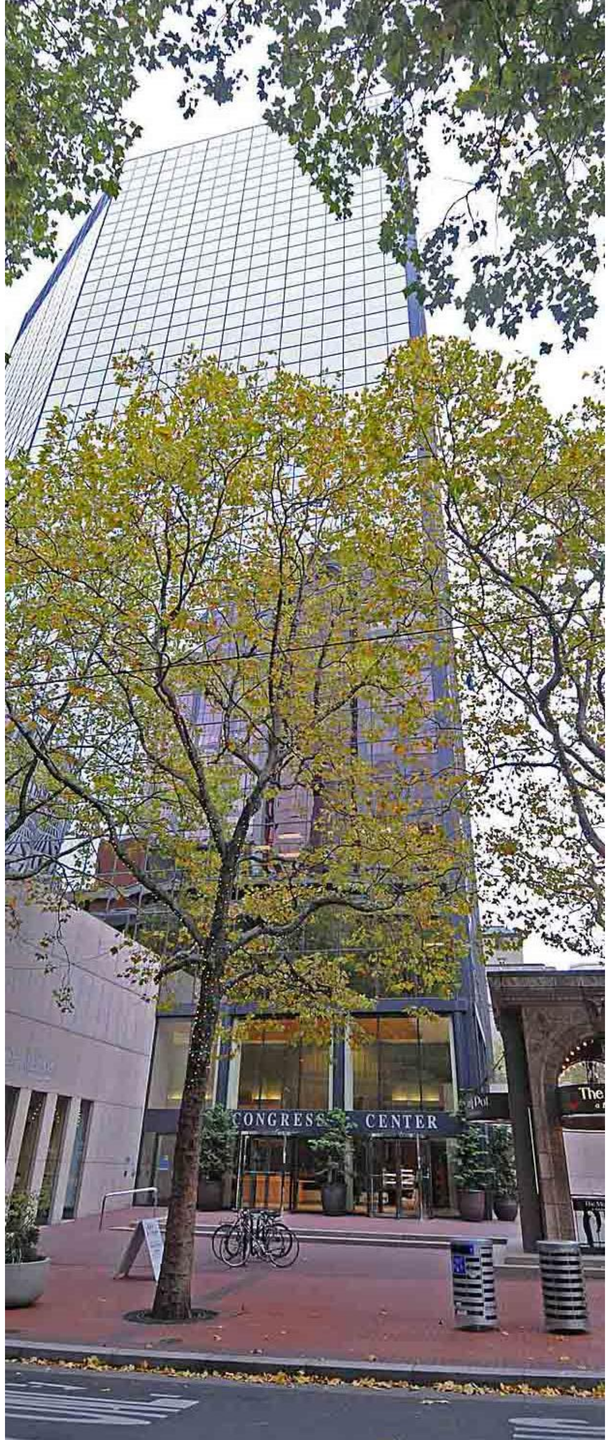
- Planning and Programs work together to create forecast

Years 6-20

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

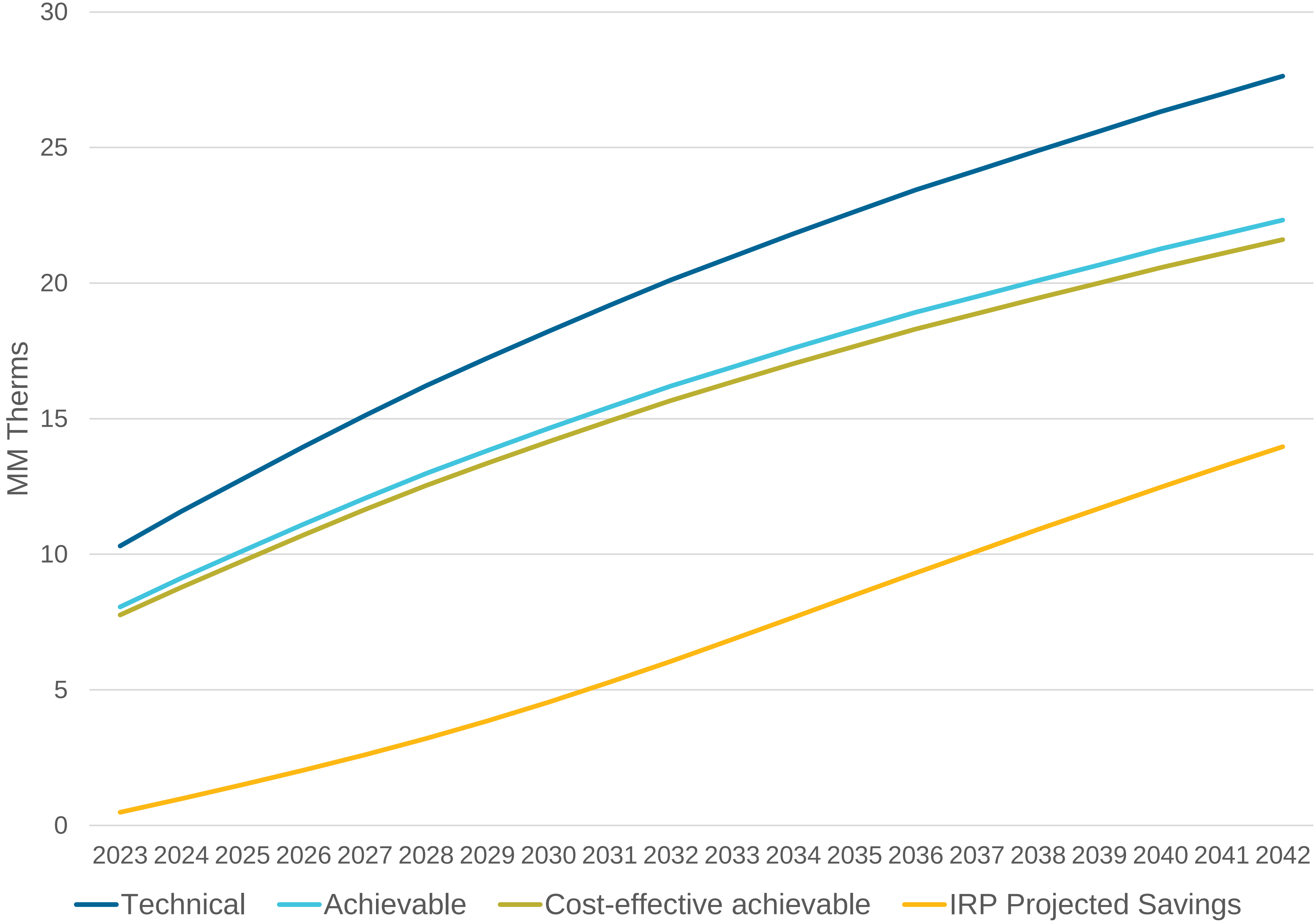
Application of Ramp Rates & Relation to RA Model Results

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

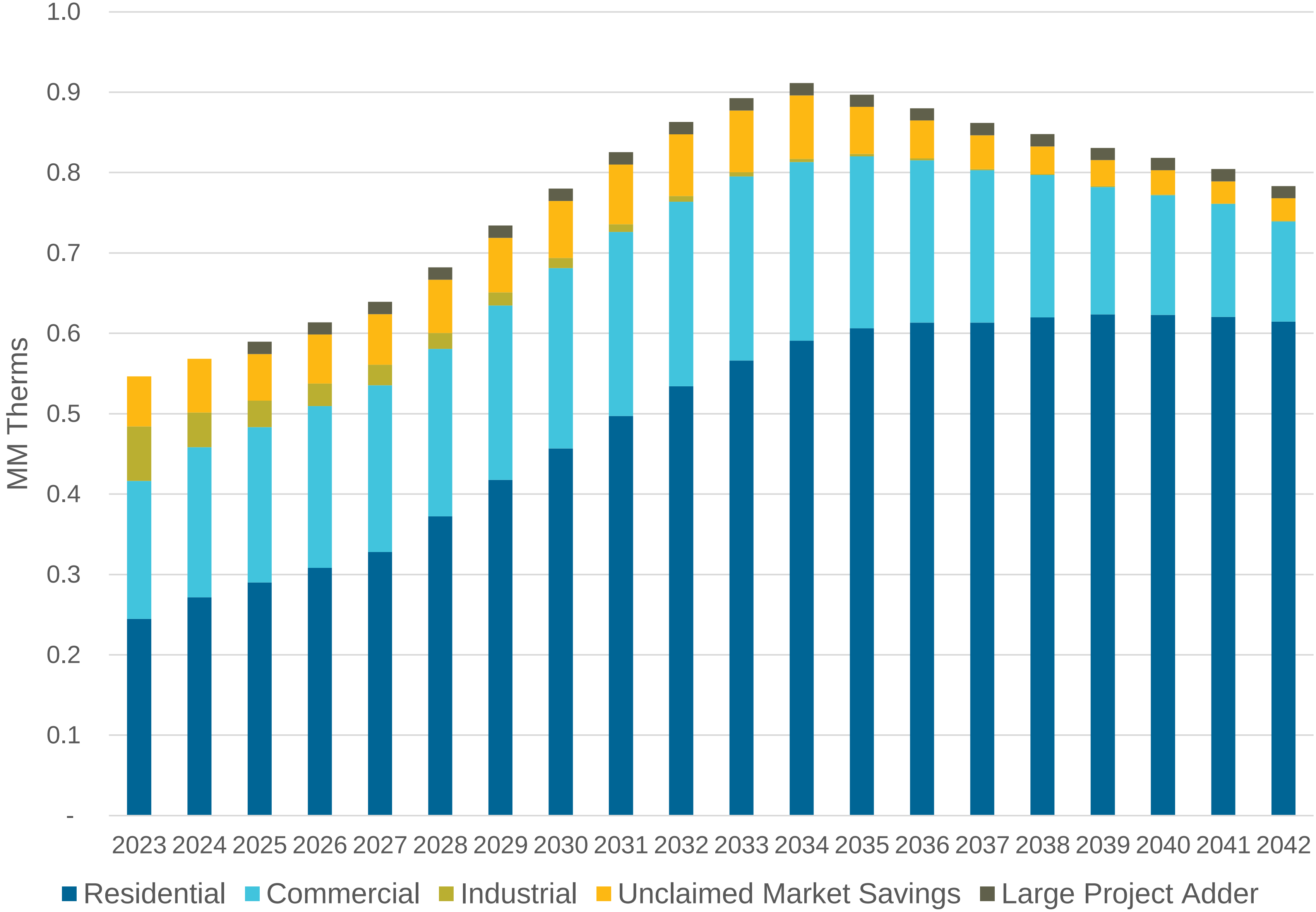


AVA’s 2023 IRP Results

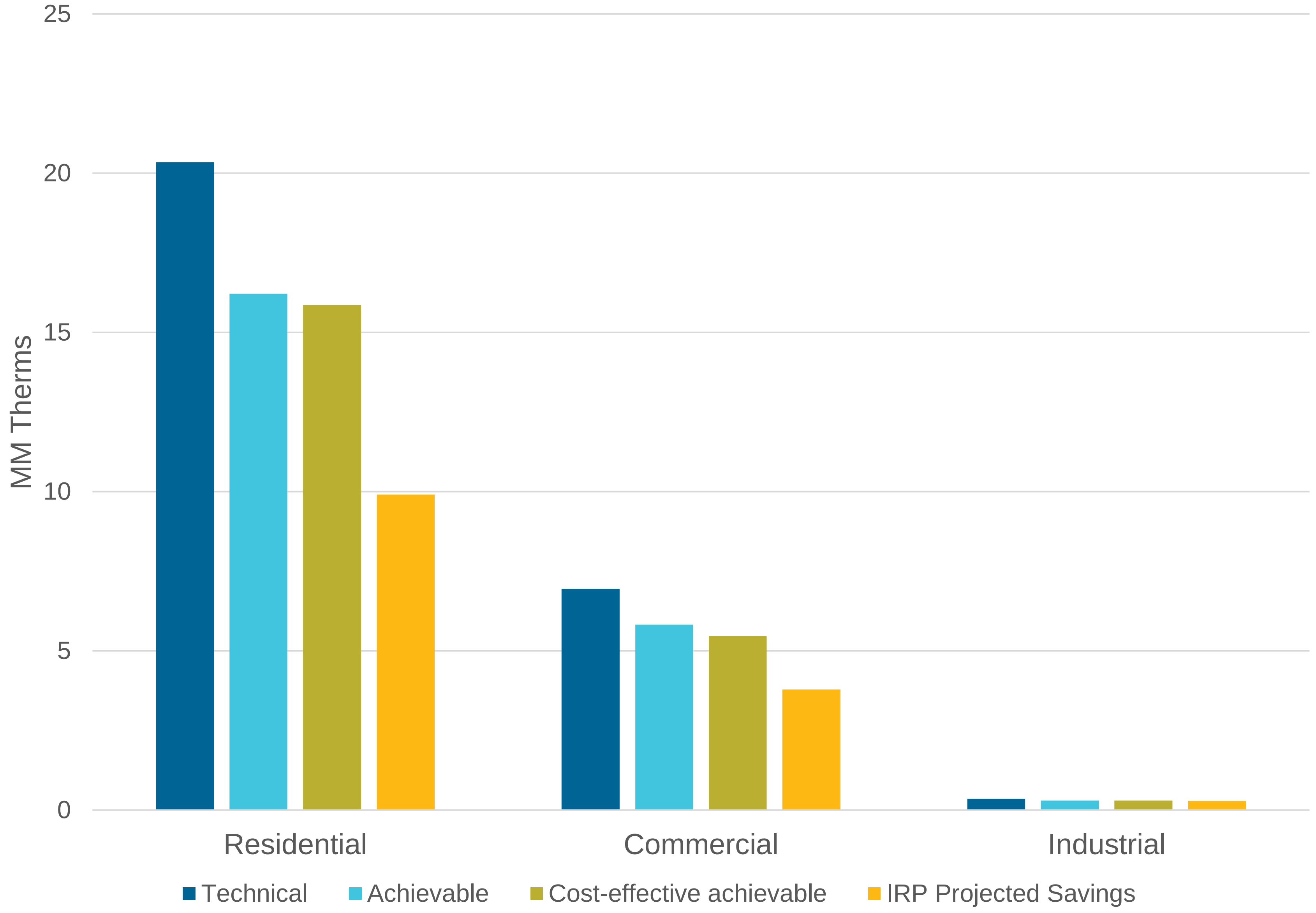
Cumulative Savings by Type and Year



Annual Deployed IRP Forecasted Savings



Cumulative Savings by Sector and Type

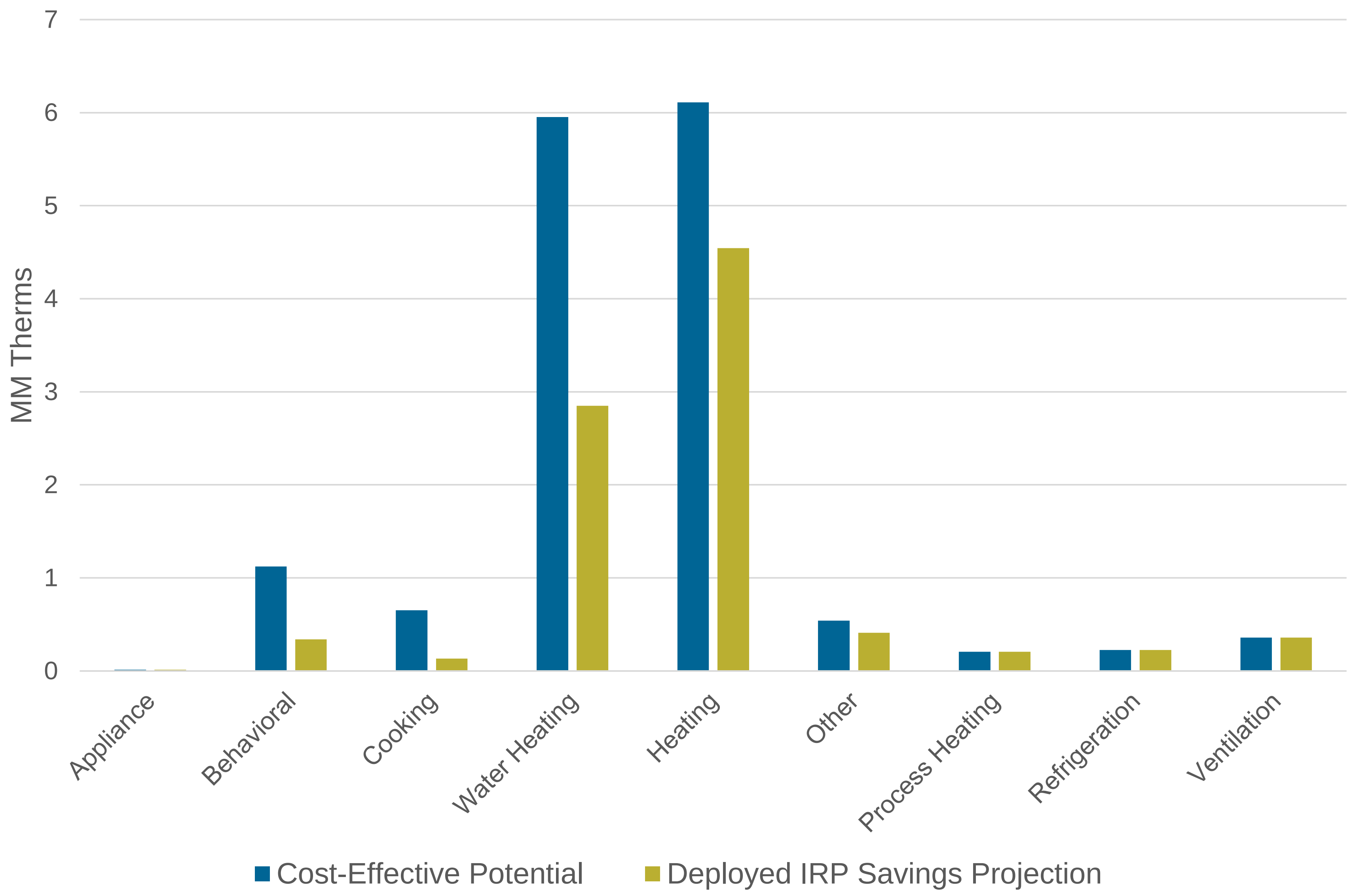


Cumulative Savings by Sector and Type (Therms)

	Residential	Commercial	Industrial	All Sectors
Technical Potential	20,345,233	6,942,478	345,190	27,632,901
Achievable Potential	16,213,842	5,817,303	293,412	22,324,557
Cost-effective Achievable Potential	15,852,804	5,458,700	293,412	21,604,916
IRP Projected Savings	9,903,449	3,782,116	283,961	13,969,526

Study years include 2023 - 2042

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



Cost Effective Override Effect

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

Measures that are Overridden	Override Applied?	Notes
Res - Attic/Ceiling insulation	TRUE	OPUC Exception
Res - Floor insulation	TRUE	OPUC Exception
Res - Wall insulation	TRUE	OPUC Exception
Res – Efficient Gas Clothes Washer	TRUE	OPUC Exception
Res – Gas heated new manufactured homes	TRUE	OPUC Exception
Com – Wall insulation	TRUE	OPUC Exception
Com – Flat roof insulation	TRUE	OPUC Exception

Cost Effective Override Effect

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

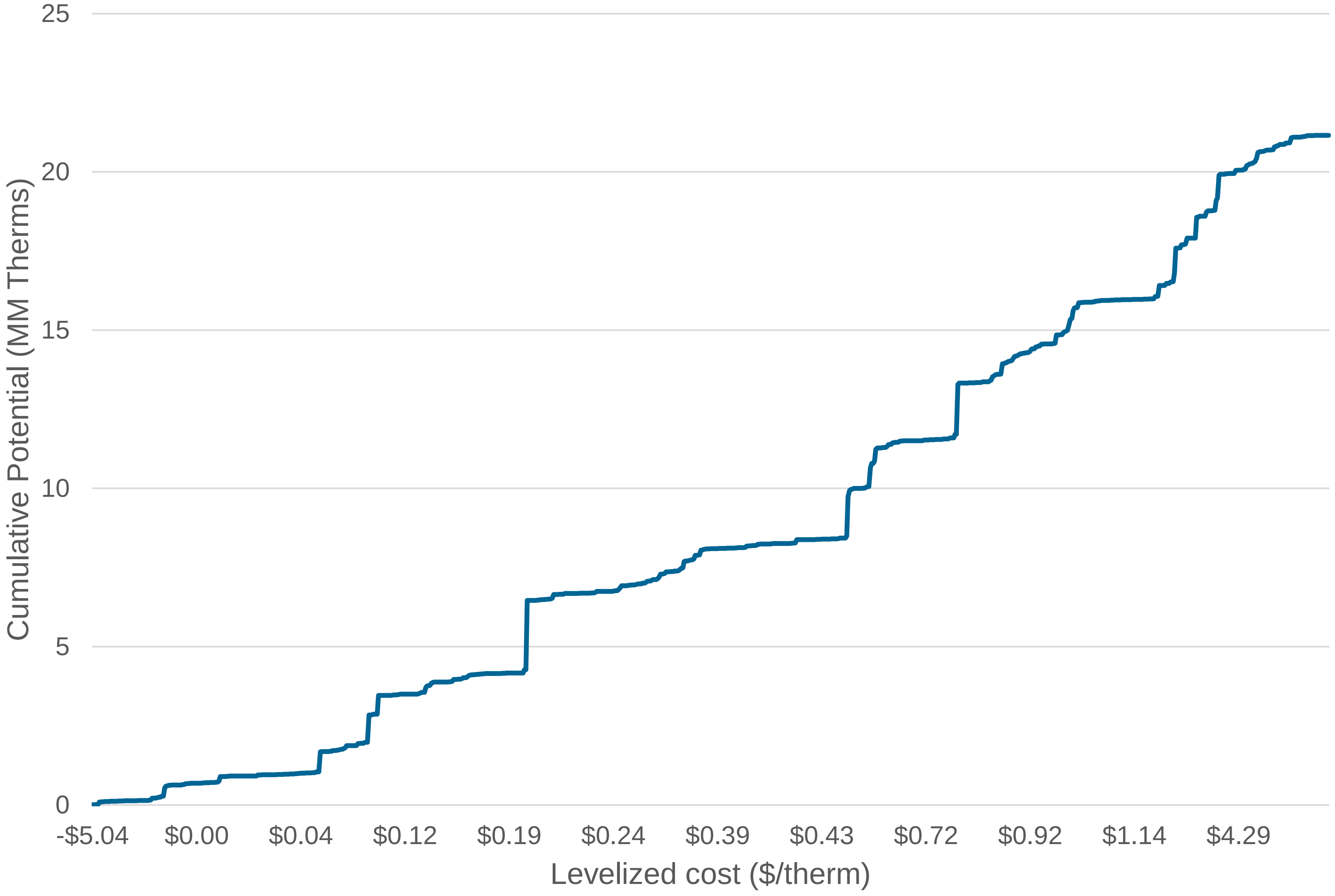
Total Cumulative Potential	Cost-Effective Potential	Deployed IRP Savings Projection
Savings with CE Override (MM Therms)	21.60	13.97
Savings with NO CE Override (MM Therms)	20.78	13.17
Variance (MM Therms)	0.83	0.80
CE Overridden % of Total Potential	**3.8%**	**5.7%**

Peak Day Factors and Cumulative Peak Day Savings Estimates

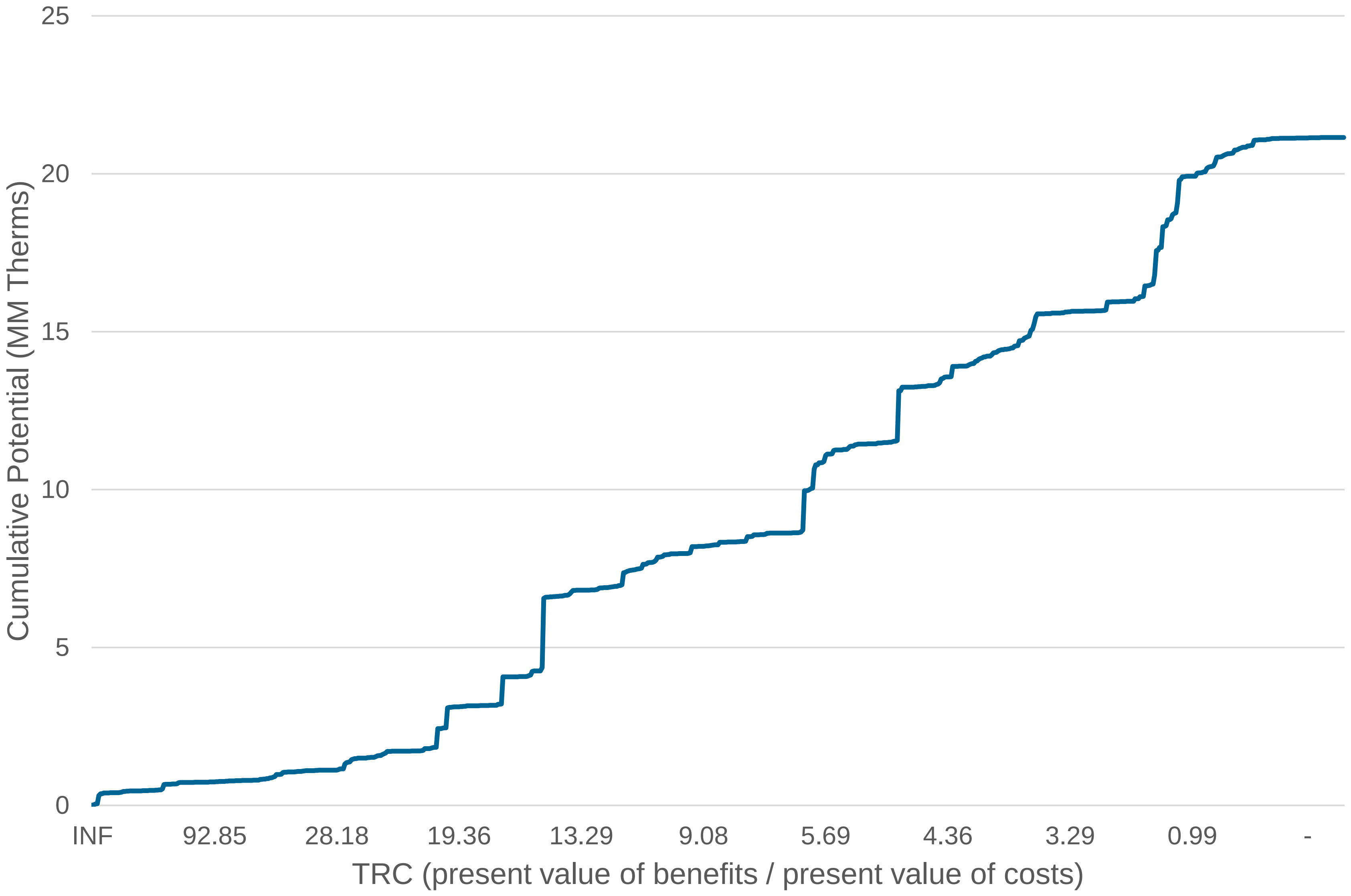
- Energy Trust also provides estimates of a peak day reduction in peak day consumption
- Peak Day factors derived from Energy Trust avoided cost calculations

	Peak Day Factor	CE Potential Peak Day Therms (cumulative)	IRP Savings Targets Peak Day Therms (cumulative)
Cooking	0.36%	643	406
Com Heating	1.77%	72,375	52,833
Domestic Hot Water	0.33%	13,711	7,569
FLAT	0.27%	577	575
Res Heating	1.98%	247,555	165,245
Res Clothes Washer	0.20%	-	-

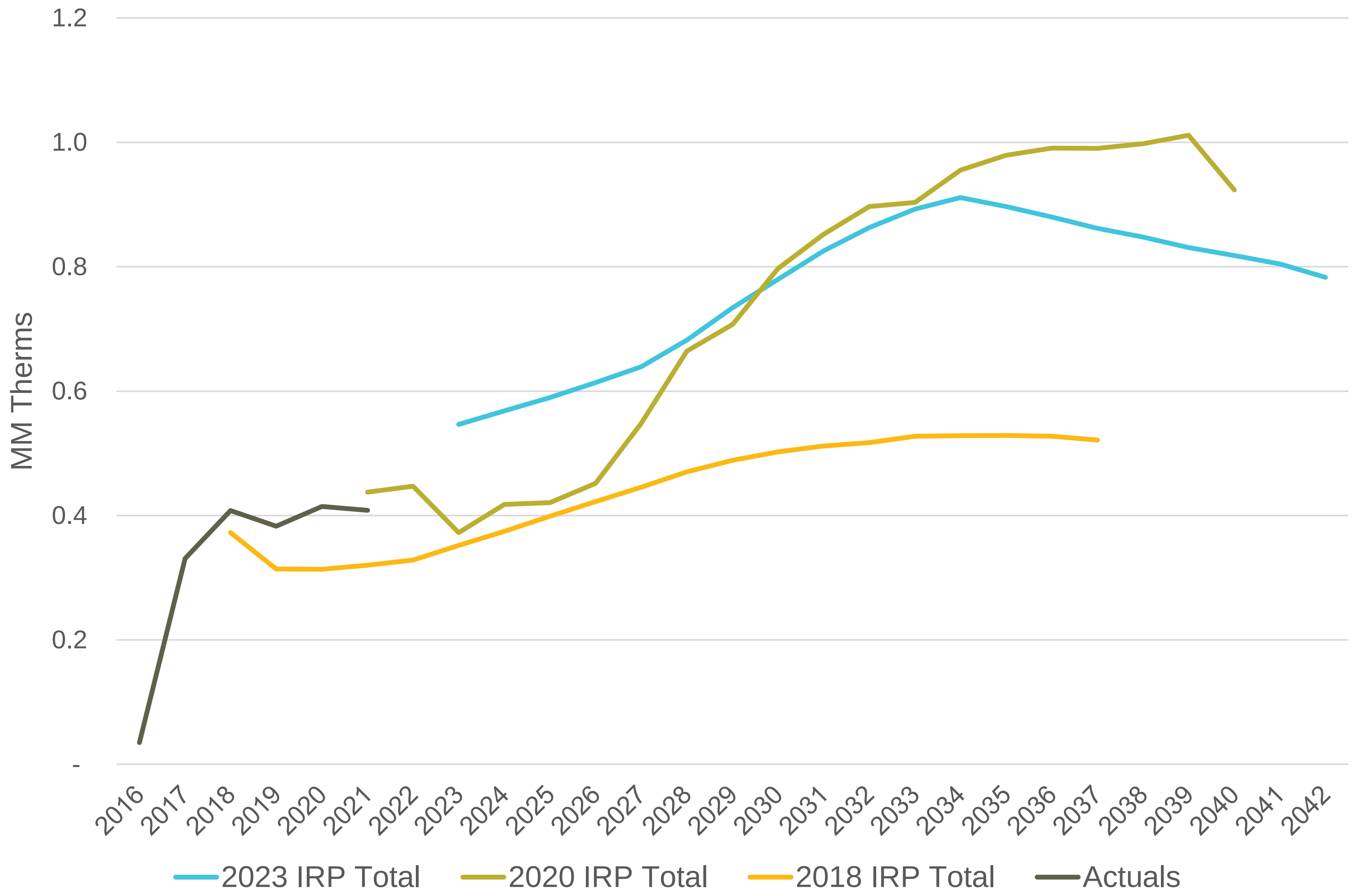
Supply Curve by Levelized Cost (20-year Cumulative Achievable Potential)



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



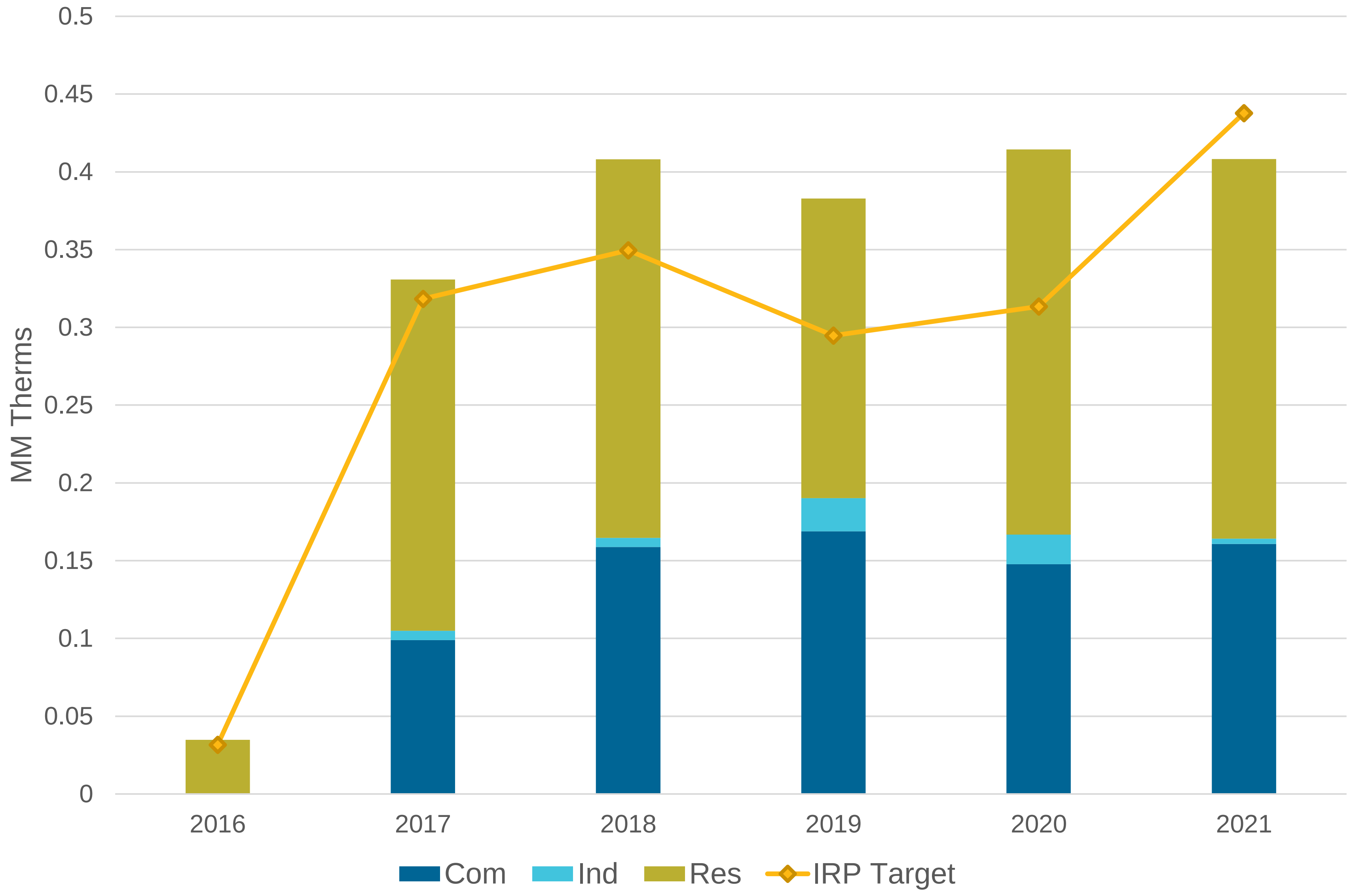
IRP Forecasts Compared to Actual Savings (Annual MM Therms)



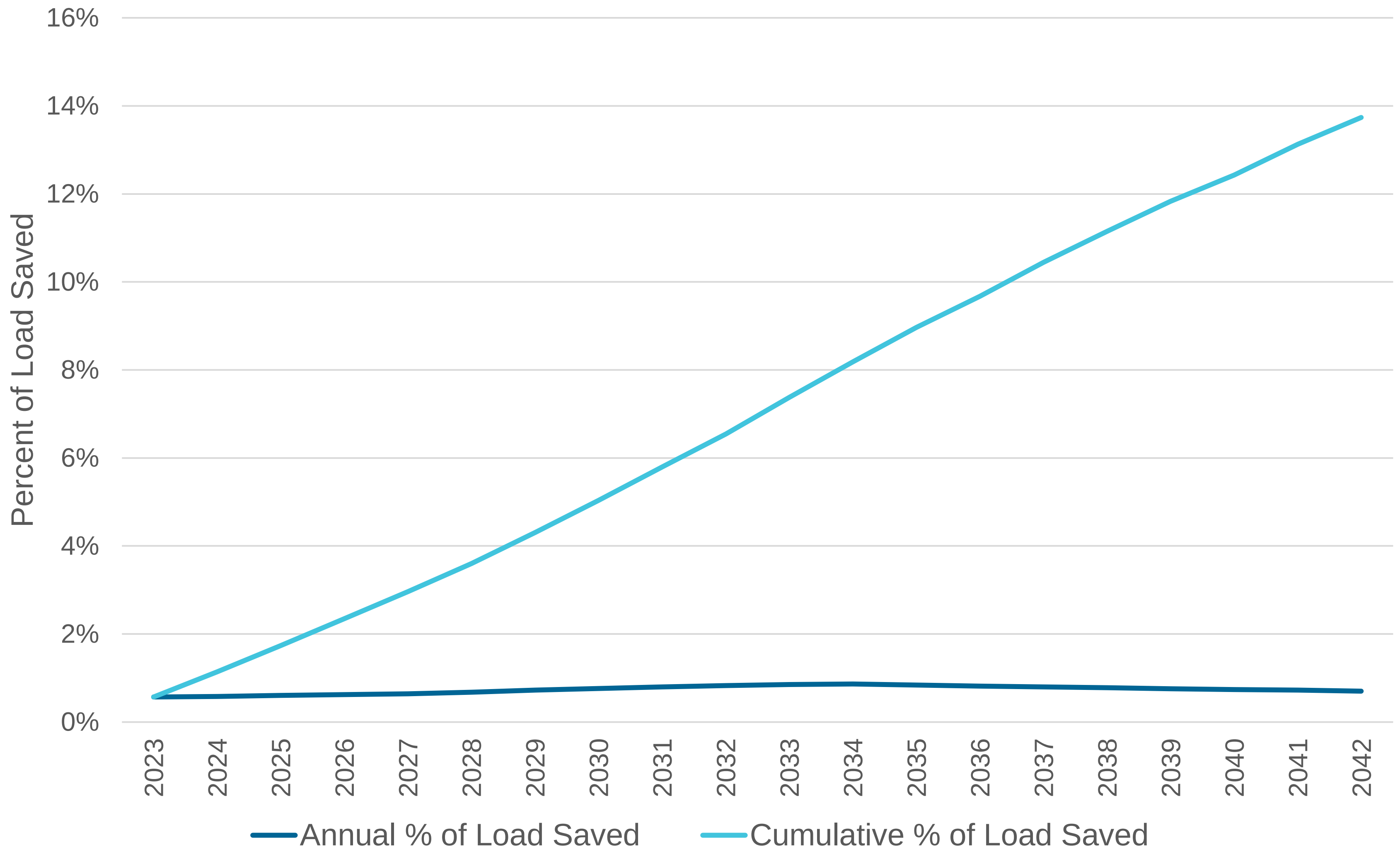
2020 and 2023 Cumulative Cost-Effective Achievable Potential Compared (MM therms)

	Difference	Share of Difference
Load and Stock Forecast	+ 1.29	36%
Emerging Technology	+ 0.84	23%
Measure Updates	+ 0.68	19%
Avoided Costs	+ 0.48	13%
Discount Rate	+ 0.34	9%
CE Override	- 0.01	0%
Total	**+ 3.63**	

Historical Performance compared to IRP targets (Annual MM Therms)



Savings as a Percent of Load Forecast



Average Annual % of Load Saved = 0.73%

Thank you

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Energy Trust of Oregon

Natural Gas Market Dynamics and Prices

Michael Brutocao

Tom Pardee

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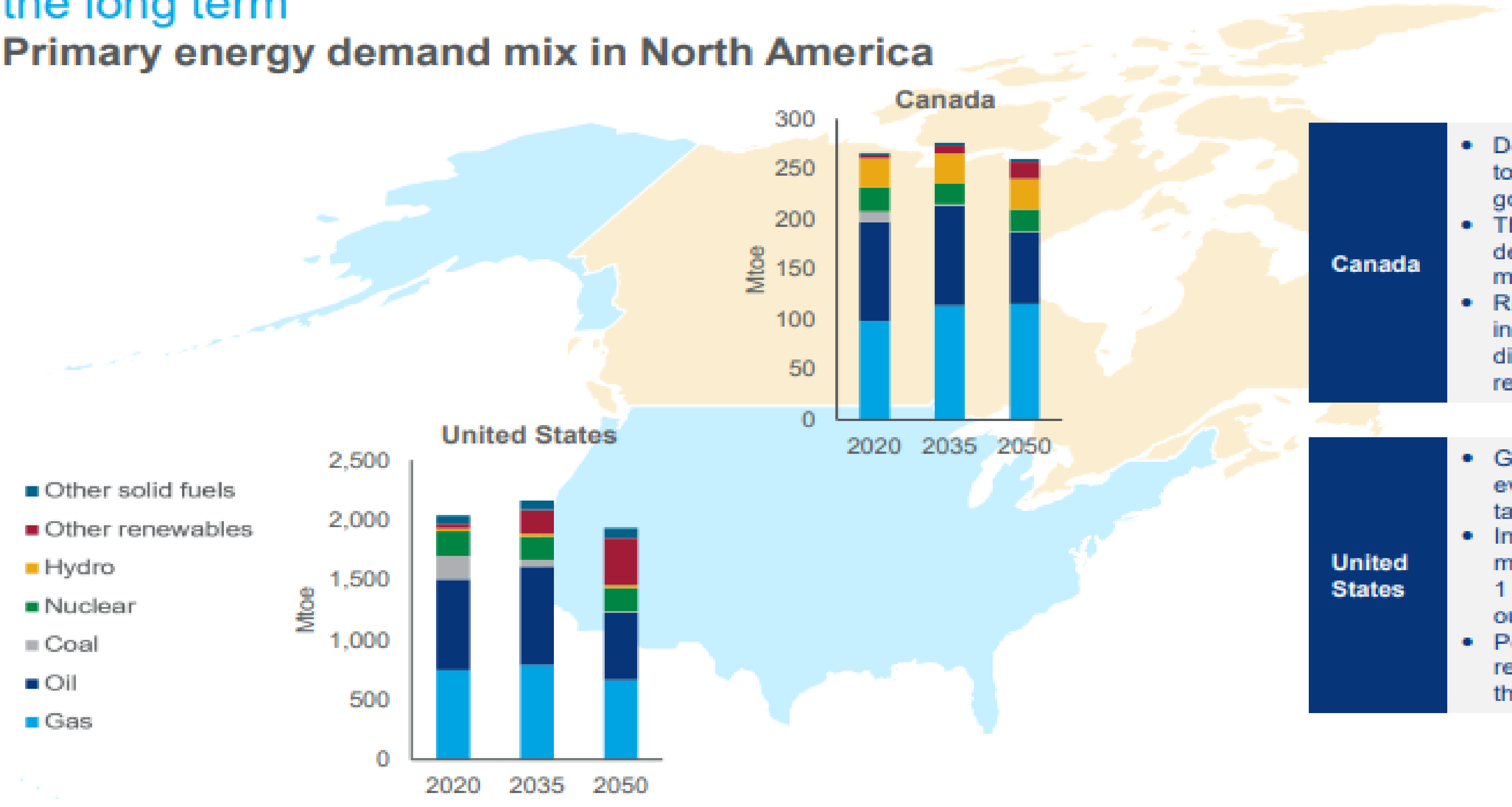
Natural gas remains strategically important in North America as it represents at least a third of total energy demand over the next 30 years

The pace of energy transition threatens gas demand growth as fossil fuel demand wanes in the long term

Primary energy demand mix in North America

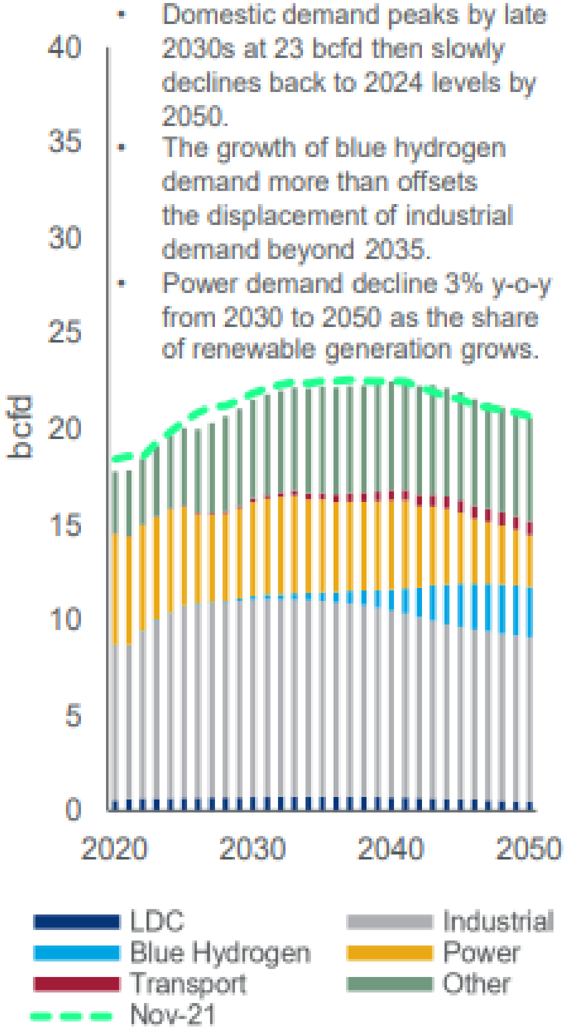


Canada	• Domestic gas demand is expected to grow mainly due to rising blue hydrogen demand as local and federal governments support the development of CCS industry. • The oil sands sector could drive incremental industrial demand growth but the future role of oil in the energy mix limits market potential beyond 2035. • Rising renewable penetration will impact gas demand in the power sector post 2040 but the impact of displacement is less severe than the US due to renewable resource potential.
United States	• Gas continues to play a vital role in the United States even as the economy announces emissions reduction targets for 2030 • Industrial demand and other demand lead growth in the mid-term to 2035 while blue hydrogen demand reaches 1 bcfd by 2030 and accelerates to the end of our outlook • Post 2024, power demand falls due to higher renewable penetration, resulting from policies that support low-carbon generation

US regional demand: the Gulf Coast stands out as domestic demand increases despite peaking in late 2030s

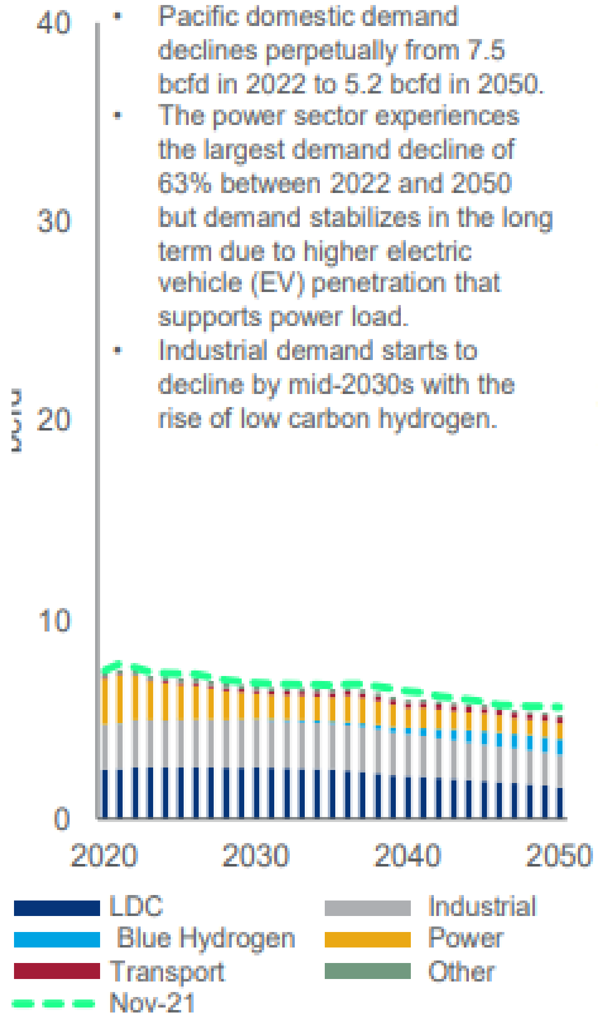
Gulf Coast

- Domestic demand peaks by late 2030s at 23 bcfd then slowly declines back to 2024 levels by 2050.
- The growth of blue hydrogen demand more than offsets the displacement of industrial demand beyond 2035.
- Power demand decline 3% y-o-y from 2030 to 2050 as the share of renewable generation grows.



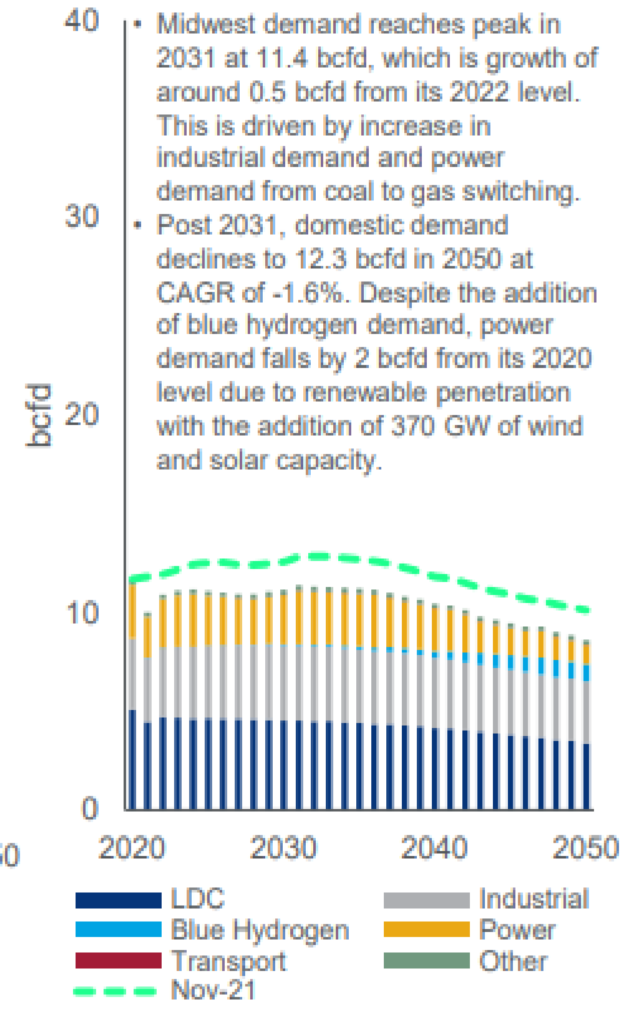
Pacific

- Pacific domestic demand declines perpetually from 7.5 bcfd in 2022 to 5.2 bcfd in 2050.
- The power sector experiences the largest demand decline of 63% between 2022 and 2050 but demand stabilizes in the long term due to higher electric vehicle (EV) penetration that supports power load.
- Industrial demand starts to decline by mid-2030s with the rise of low carbon hydrogen.



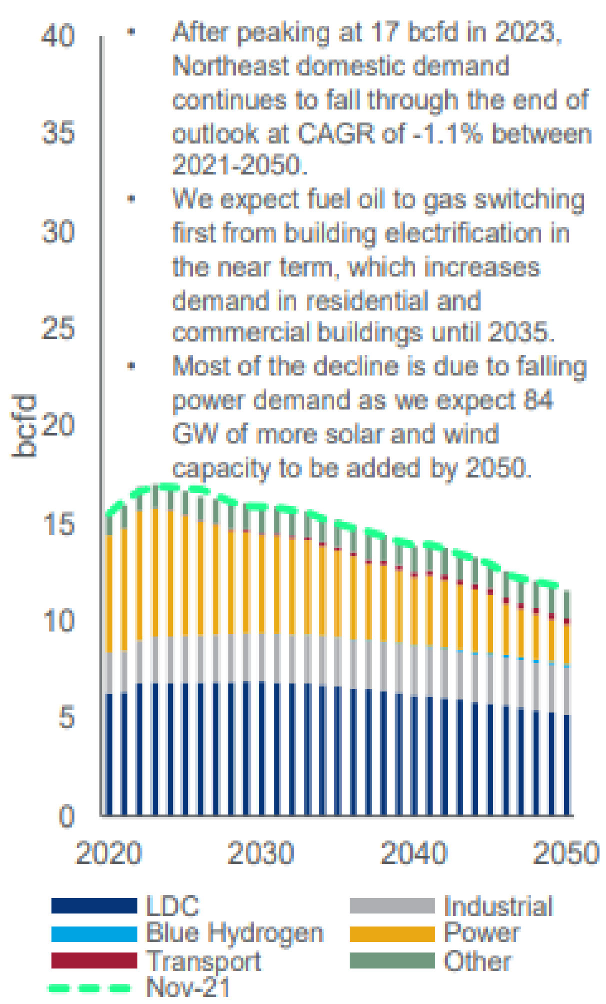
Midwest

- Midwest demand reaches peak in 2031 at 11.4 bcfd, which is growth of around 0.5 bcfd from its 2022 level. This is driven by increase in industrial demand and power demand from coal to gas switching.
- Post 2031, domestic demand declines to 12.3 bcfd in 2050 at CAGR of -1.6%. Despite the addition of blue hydrogen demand, power demand falls by 2 bcfd from its 2020 level due to renewable penetration with the addition of 370 GW of wind and solar capacity.



Northeast

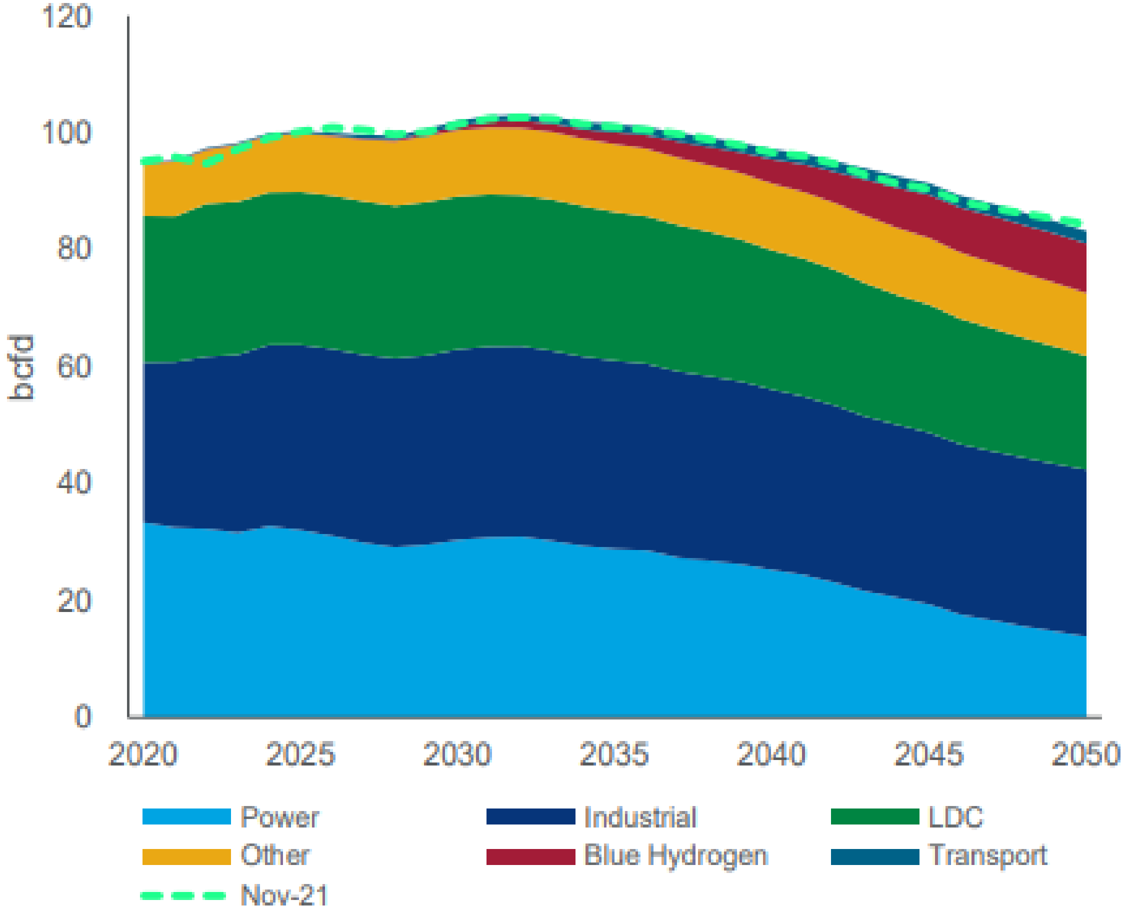
- After peaking at 17 bcfd in 2023, Northeast domestic demand continues to fall through the end of outlook at CAGR of -1.1% between 2021-2050.
- We expect fuel oil to gas switching first from building electrification in the near term, which increases demand in residential and commercial buildings until 2035.
- Most of the decline is due to falling power demand as we expect 84 GW of more solar and wind capacity to be added by 2050.



North American domestic demand reaches its peak in the early 2030s; longer term growth only from blue hydrogen and transport sectors

Energy transition impacts power demand the most with demand falling by almost two thirds between 2022 and 2050

North America gas demand by sector

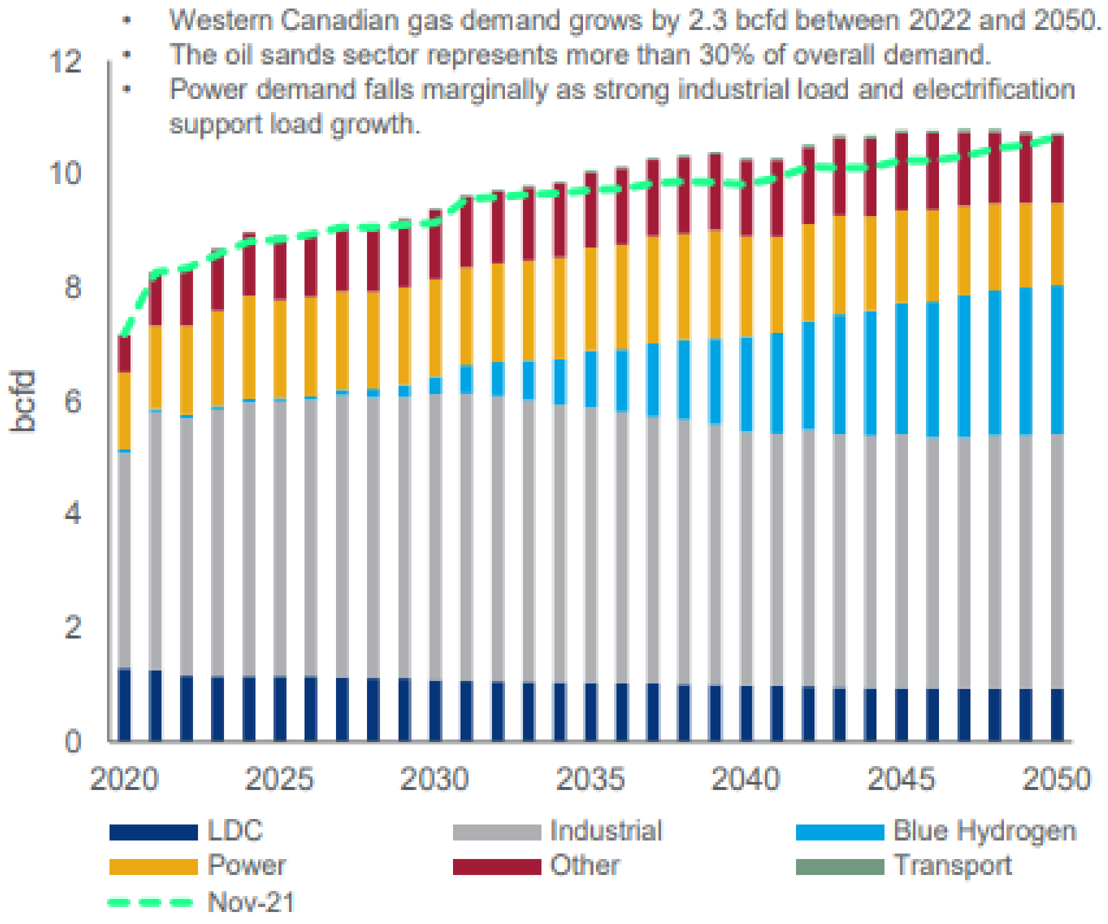


Transport	Transportation demand includes gas consumed in natural gas vehicles (NGV) and small-scale bunkers. Most of the growth is attributed to NGV demand, driven by heavy long-haul trucks and freight rails
Blue hydrogen	Low-cost natural gas supply in both US and Canada support blue hydrogen projects where demand grows to 8.5 bcfd by 2050. We expect clean energy policies, such as Canada's federal carbon price and US 45Q incentive, to drive its growth.
Other	Other demand includes lease & plant fuel and pipeline losses, which is the gas used within the industry. The two biggest components to its growth are supply and LNG export losses
LDC	Residential and commercial demand reach a peak in 2029 and declines as hydrogen and building electrification accelerate to displace gas in the long-term. Heating electrification in the US will reach 68% penetration by 2050.
Industrial	Post 2031, industrial demand deviates from GDP growth and continues to decline as we expect net zero targets and clean energy policies to drive low-carbon hydrogen to replace grey hydrogen from Steam Methane Reformers (SMRs) in the ammonia, refining, and methanol sectors.
Power	In the near term out to 2024, power demand grows due to coal-to-gas switching and retirements. Post-2024, gas demand in the power sector starts to structurally decline with the accelerated renewable build-out spurred by policy incentives.

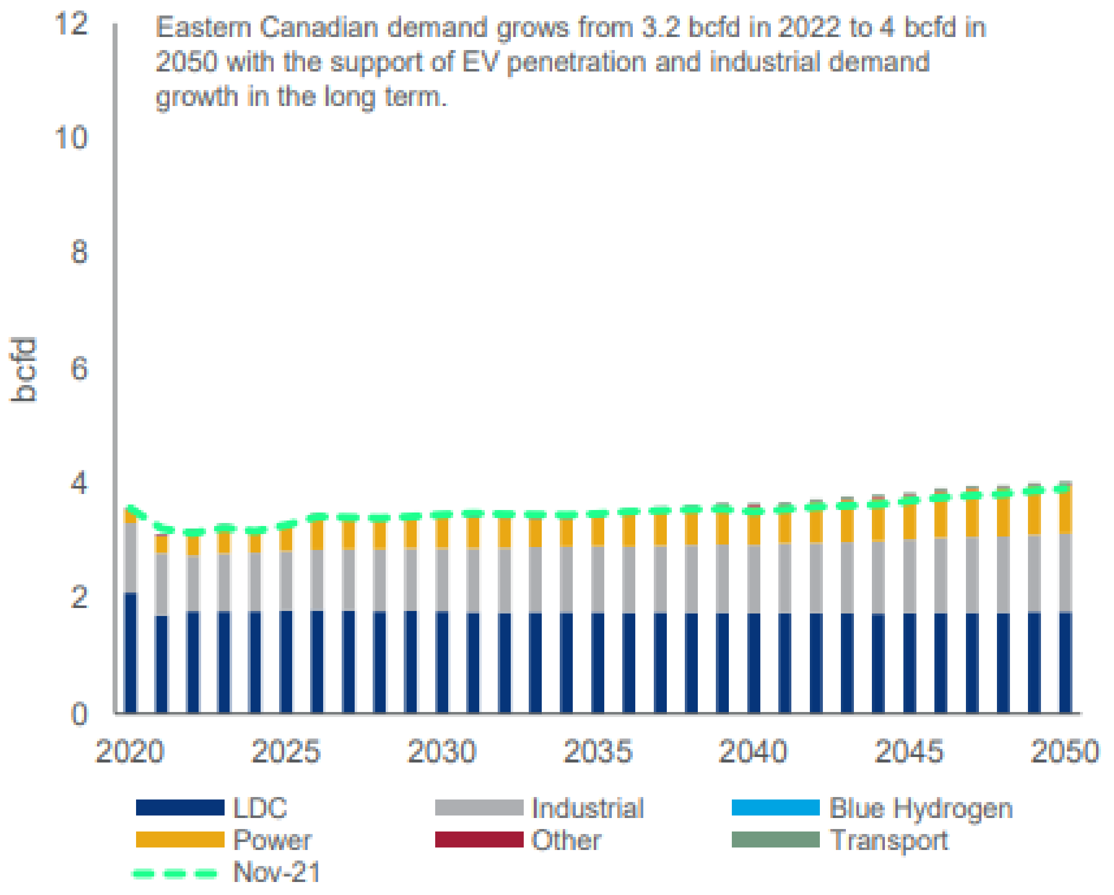
Canadian gas demand in major provinces grows over time

Blue hydrogen drives demand growth in the long term as local and Federal policies support CCS and blue hydrogen industries for resource monetization

Western Canada demand



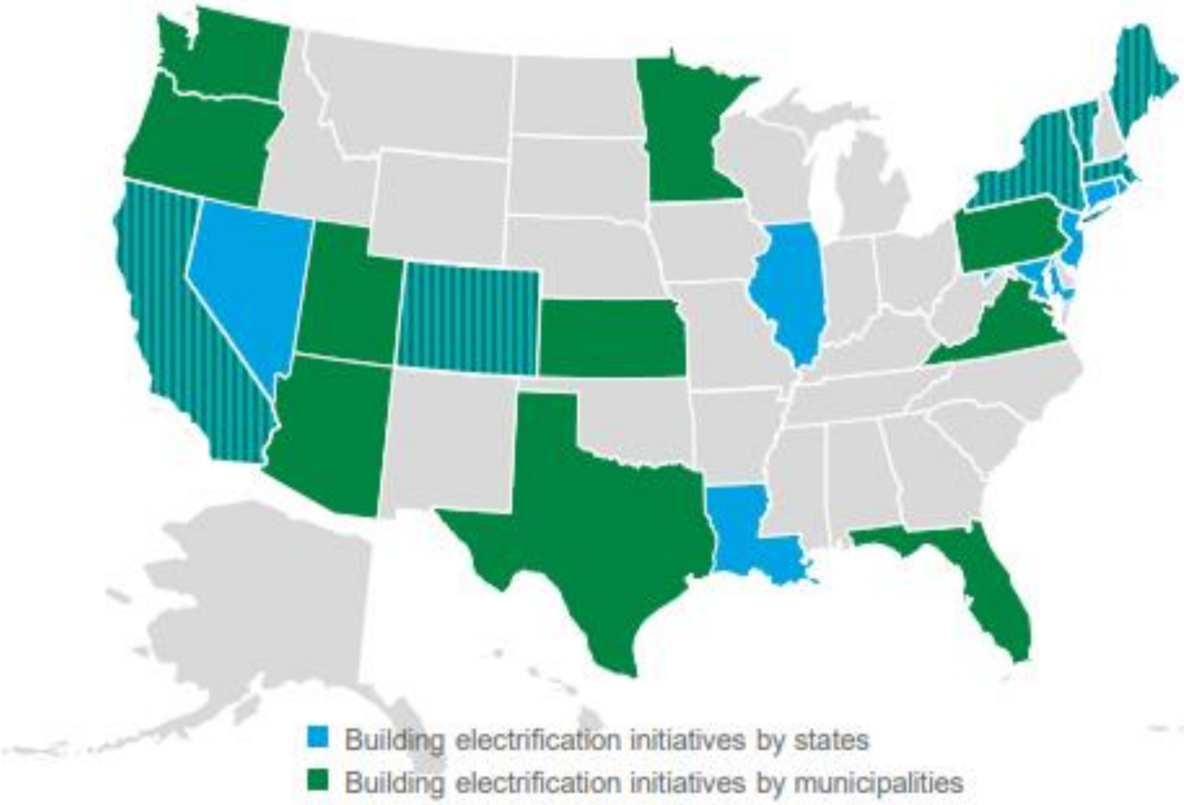
Eastern Canada demand



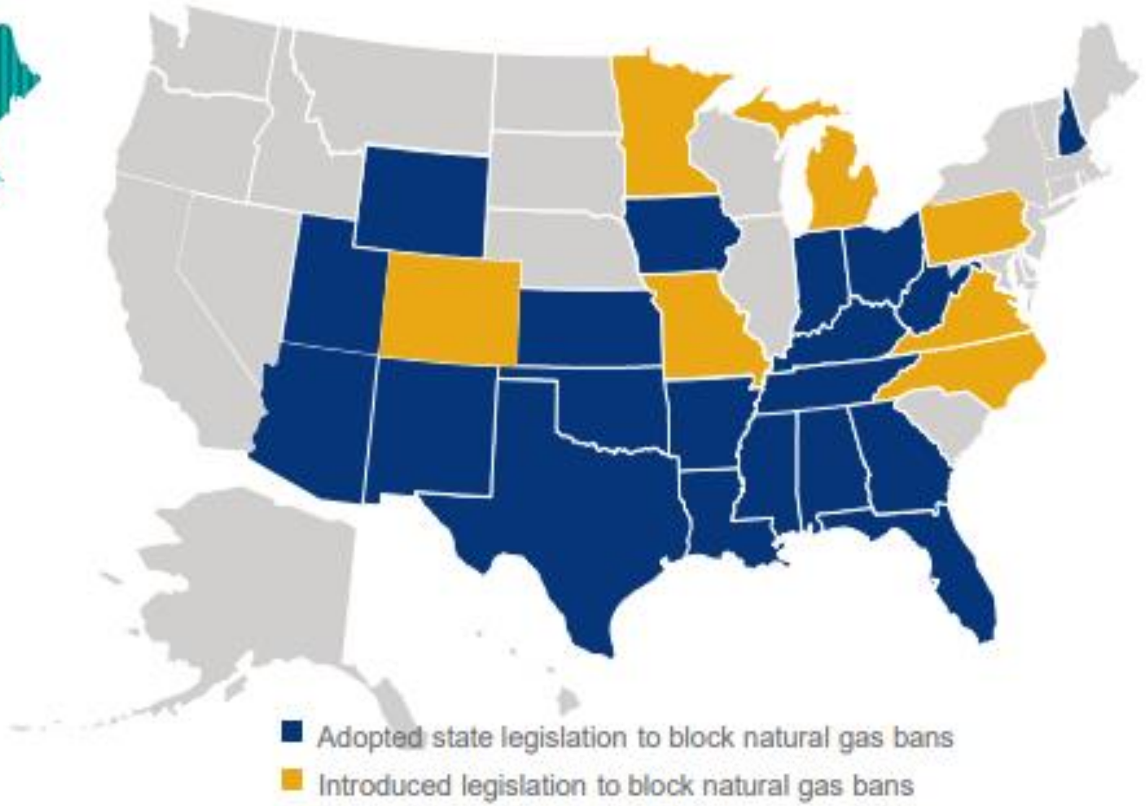
Heating electrification in the US will reach 68% penetration by 2050 for all residential and commercial heating

Pacific, New England, and the Middle Atlantic regions have strong local action and share pro-electrification policies while electrification will progress more slowly in the southern states

Local and state policies enabling building electrification initiatives



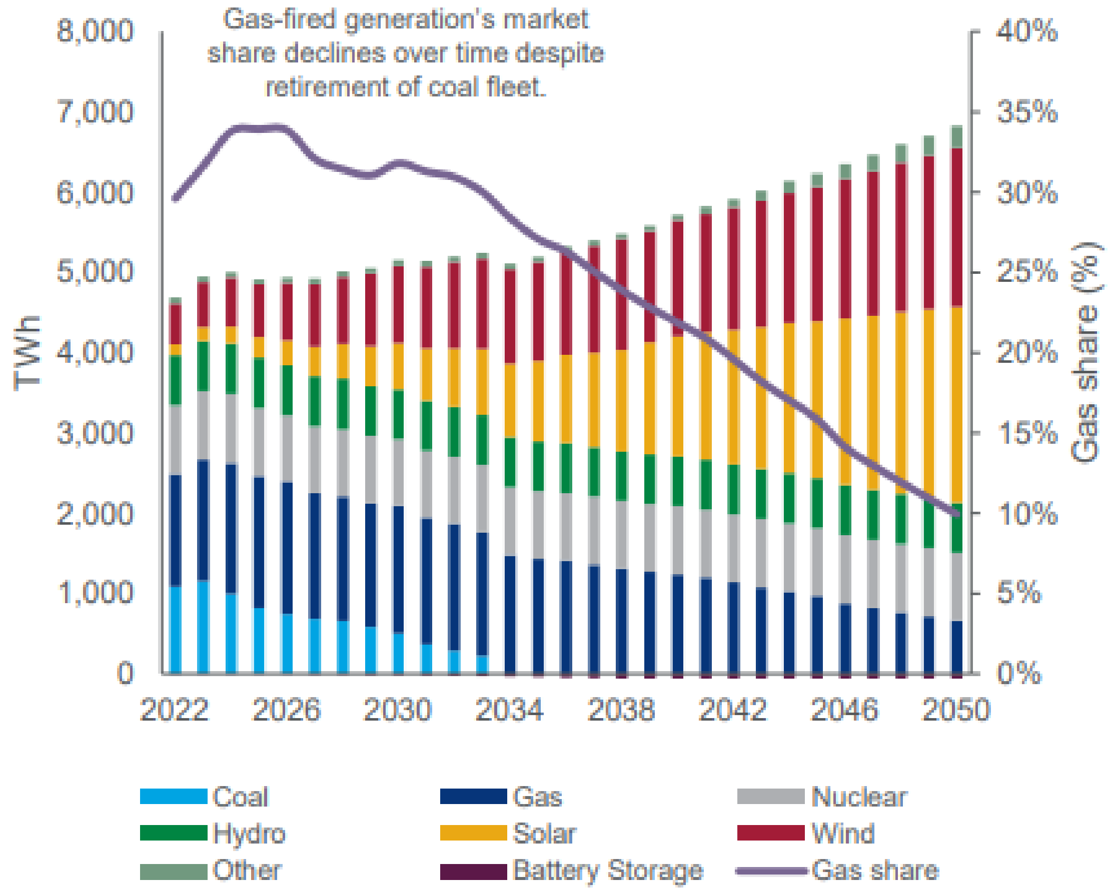
States' positions on banning gas hookups in new building



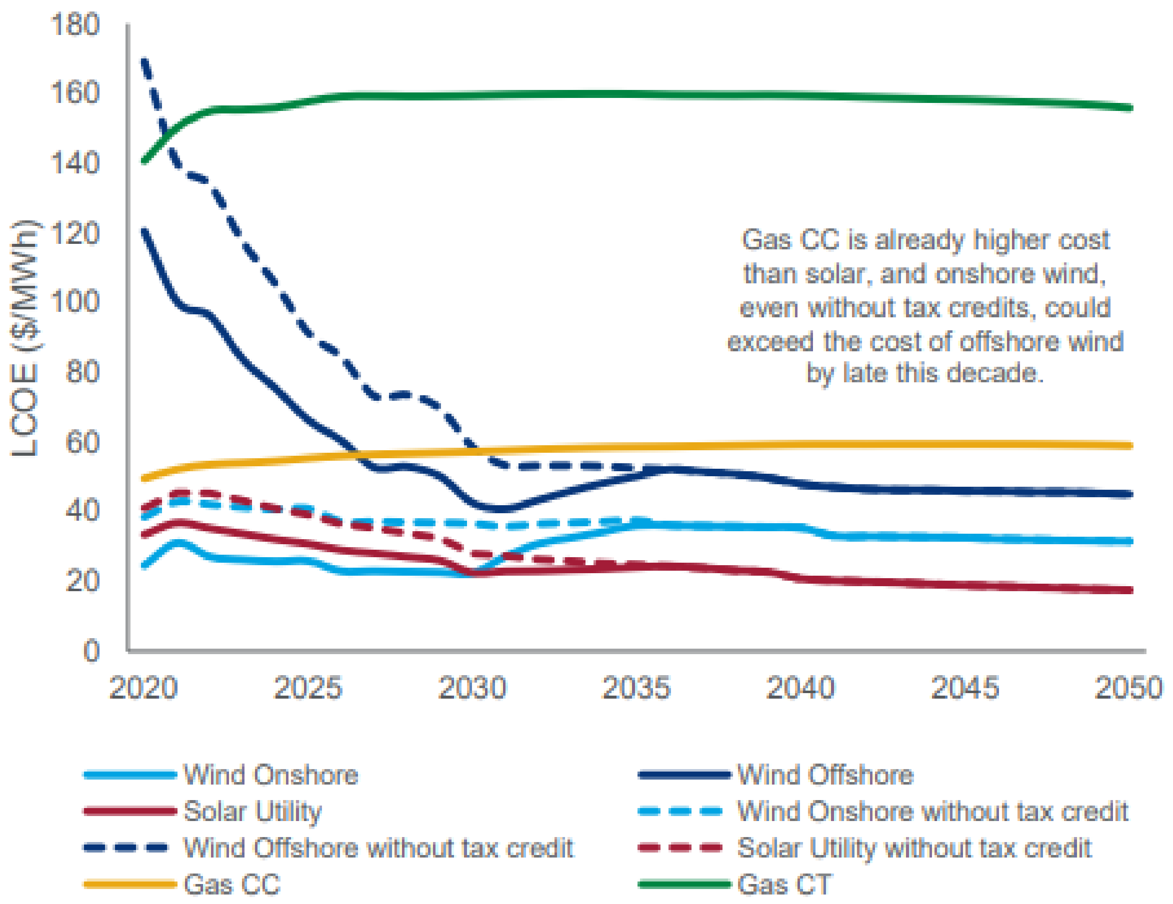
Accelerated coal retirements allows for more coal-to-gas switching in the 2020s but gas burns decline over time with higher renewable penetration

Power load has been revised higher mostly in the late 2040s due to higher EV conversion, heating electrification and stronger industrial requirements

North America power generation by type



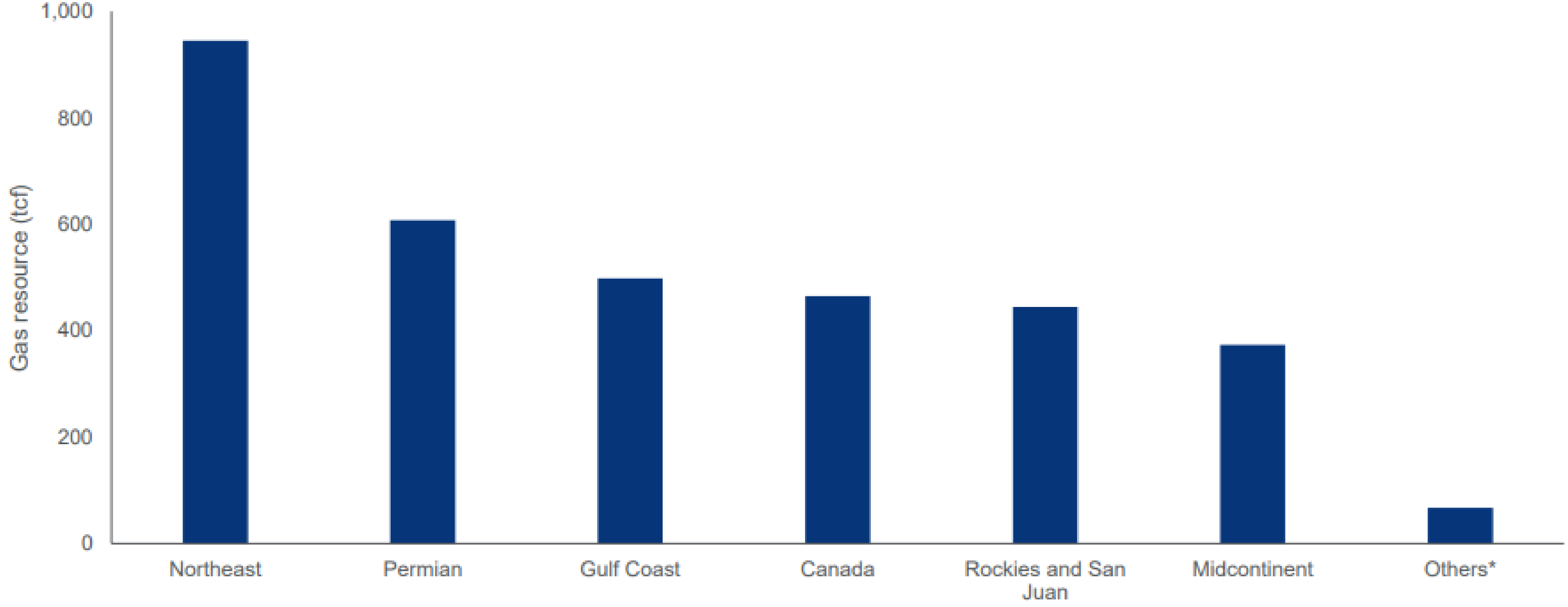
Levelized cost of energy (LCOE)



North America has large quantities of gas resources available

In addition to commodity prices, factors such as well economics, infrastructure development, and investor sentiment will dictate how much resource is ultimately produced

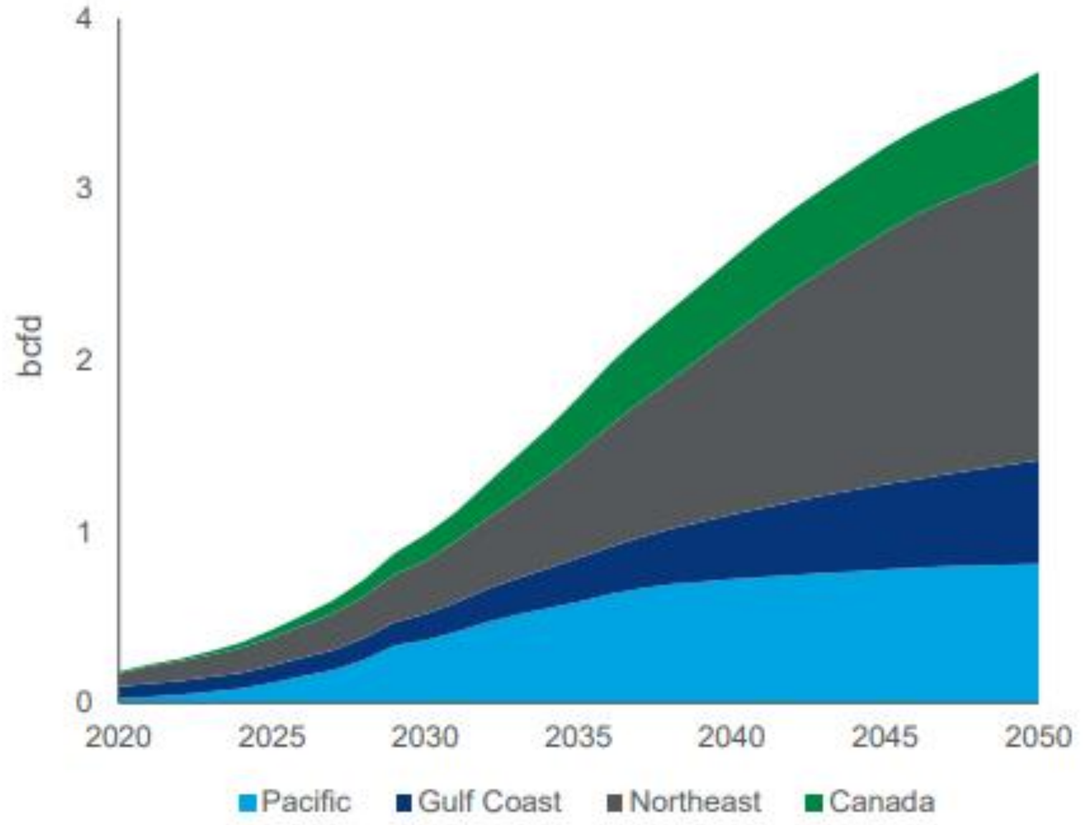
Remaining gas resources for key onshore North America regions



RNG production capacity has increased 25% since 2020, with more projects to come online in longer-term

Growth can further expand as low-carbon policies, which are currently focused on RNG consumption primarily for transportation, include additional sectors for environmental credits

RNG production outlook



Canada

British Columbia, Quebec and Ontario lead RNG production as local utilities and governments aggressively commit to net carbon-zero targets and stakeholders capitalize on credits from the Clean Fuel Standard.

US Northeast*

More RNG facilities come online as utilities and agencies seek to fulfill GHG emission reduction goals, which are one of the most aggressive in the nation. The Midwest continues to export RNG to the west coast as well as fulfilling local demand.

US Gulf Coast*

Large-scale RNG in landfill sites dominates the supply mix for the region in the near-term. The large dairy potential in the area will attract developments with appropriate regulatory support.

US Pacific

Pioneering the nation with its progressive low-carbon policies, the west leads in new dairy project developments until late 2020s. RNG demand is primarily fed into fueling NGVs in the near term, but we expect more utility programs to adopt renewable gas standards.

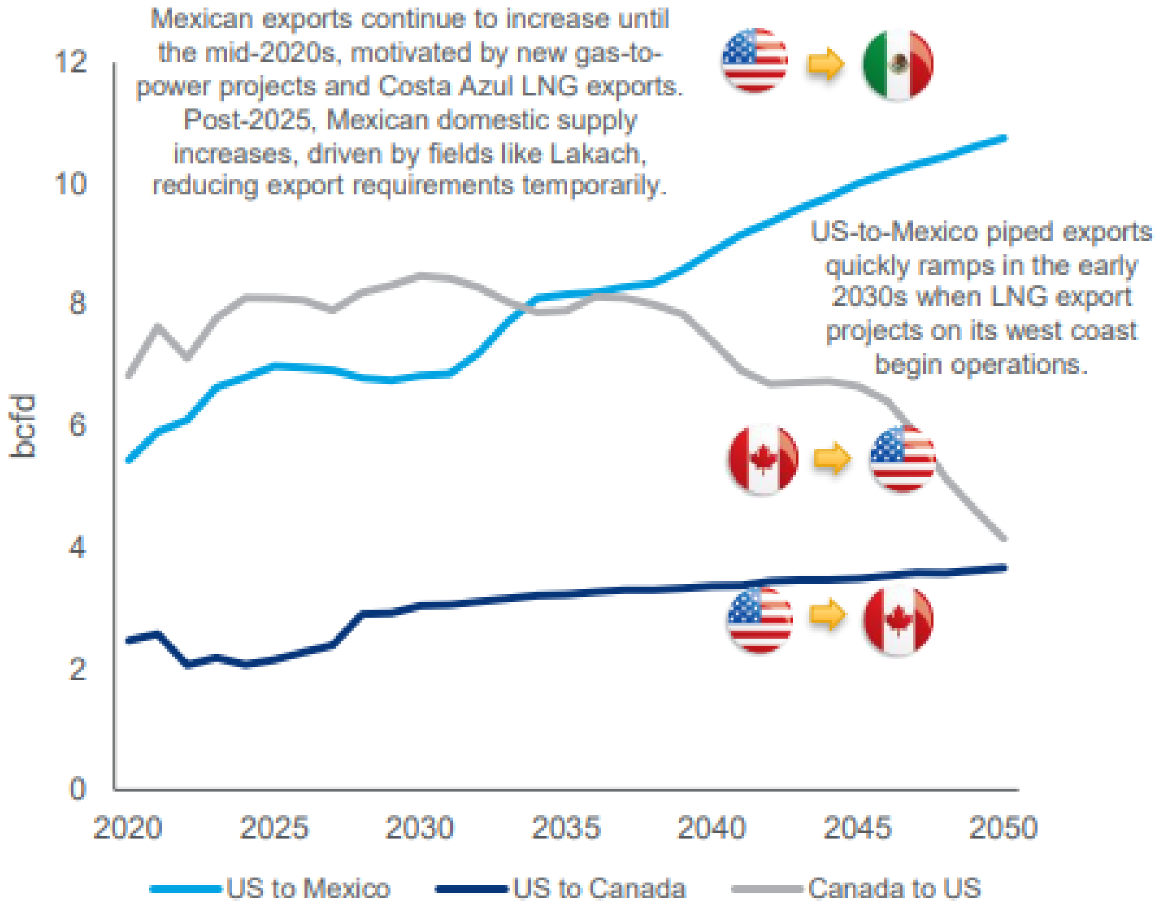
*Note: Northeast includes the Midwest, including Indiana and Ohio. The Gulf Coast includes the Southeast.

Source: Wood Mackenzie, Argonne National Laboratory RNG Database, IEA Outlook for biogas and biomethane (2020)

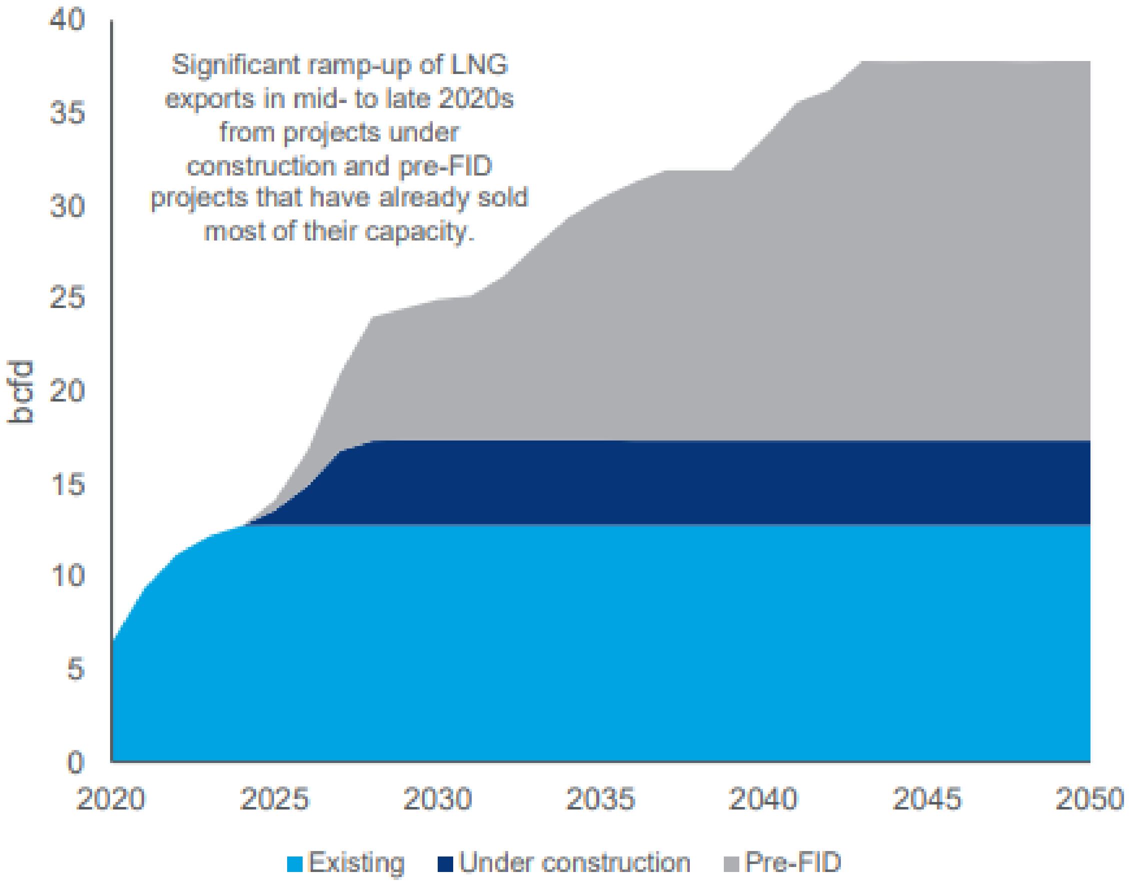
LNG exports from US, Canada and Mexico reach 38 bcfd by 2050

WCSB's low-cost resources help Canadian exports maintain market share in the Midwest and Pacific markets

North American piped trade flows



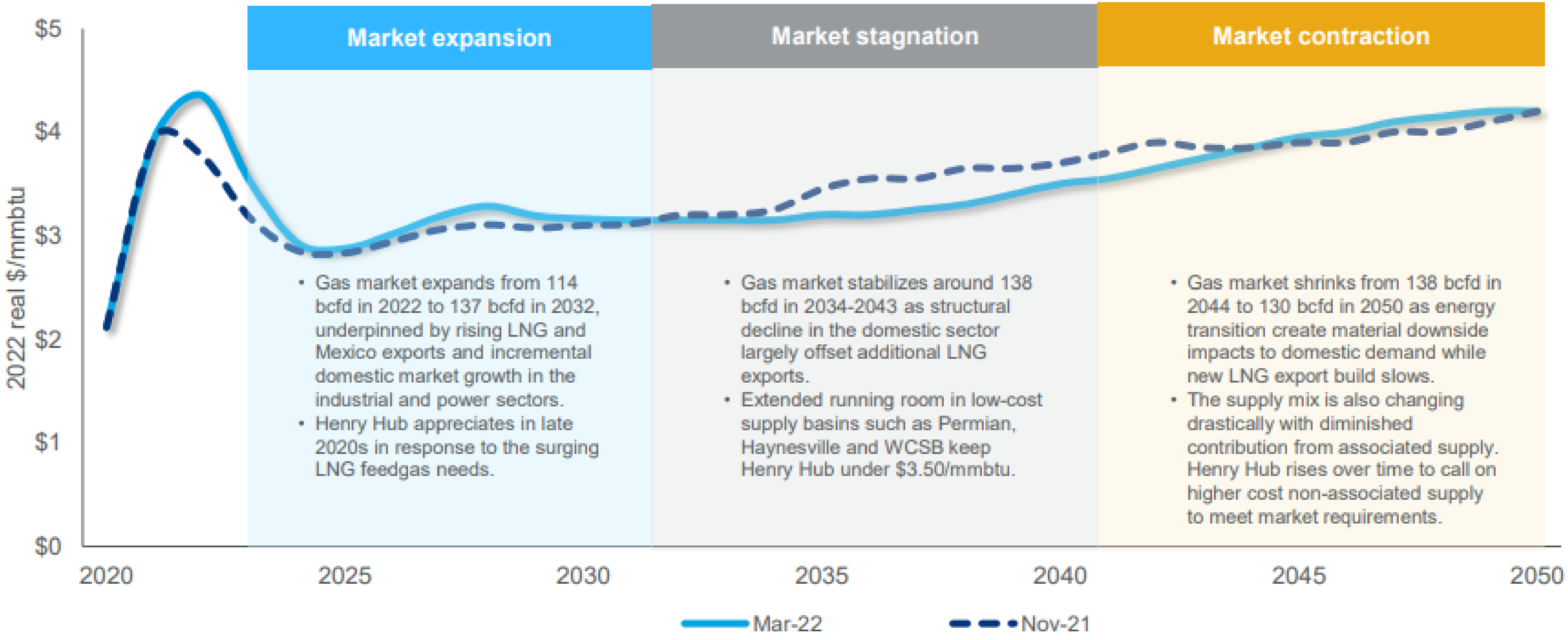
North America LNG export outlook



Henry Hub ramps upward with the next wave of LNG projects but expanded low-cost resources hold prices steady in the medium term

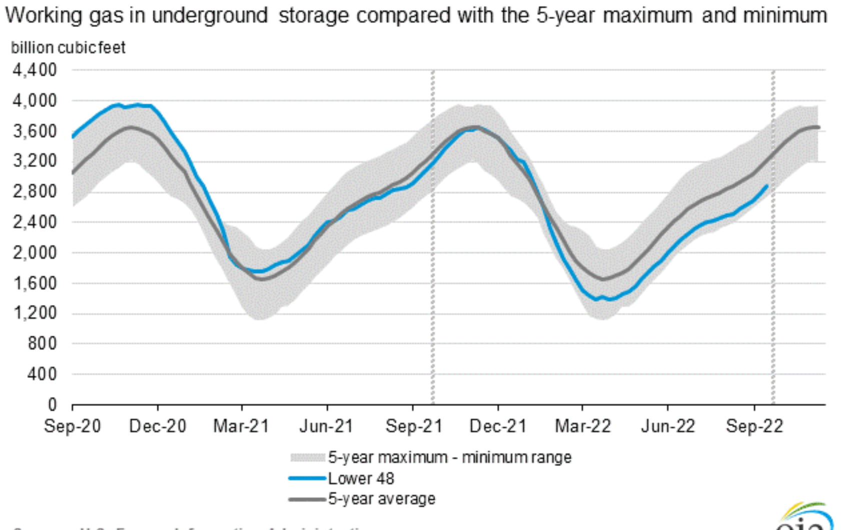
The call on non-associated supply in the 2040s raises supply costs and elevates Henry Hub to above $4/mmbtu

Henry Hub price outlook



US Storage

	Stocks billion cubic feet (Bcf)				Historical Comparisons			
					Year ago (09/16/21)		5-year average (2017-21)	
Region	09/16/22	09/09/22	net change	implied flow	Bcf	% change	Bcf	% change
East	690	661	29	29	748	-7.8	784	-12.0
Midwest	844	809	35	35	900	-6.2	907	-6.9
Mountain	168	163	5	5	196	-14.3	199	-15.6
Pacific	237	235	2	2	240	-1.3	278	-14.7
South Central	935	904	31	31	986	-5.2	1,038	-9.9
Salt	199	187	12	12	226	-11.9	253	-21.3
Nonsalt	736	717	19	19	760	-3.2	786	-6.4
Total	**2,874**	**2,771**	**103**	**103**	**3,071**	**-6.4**	**3,206**	**-10.4**



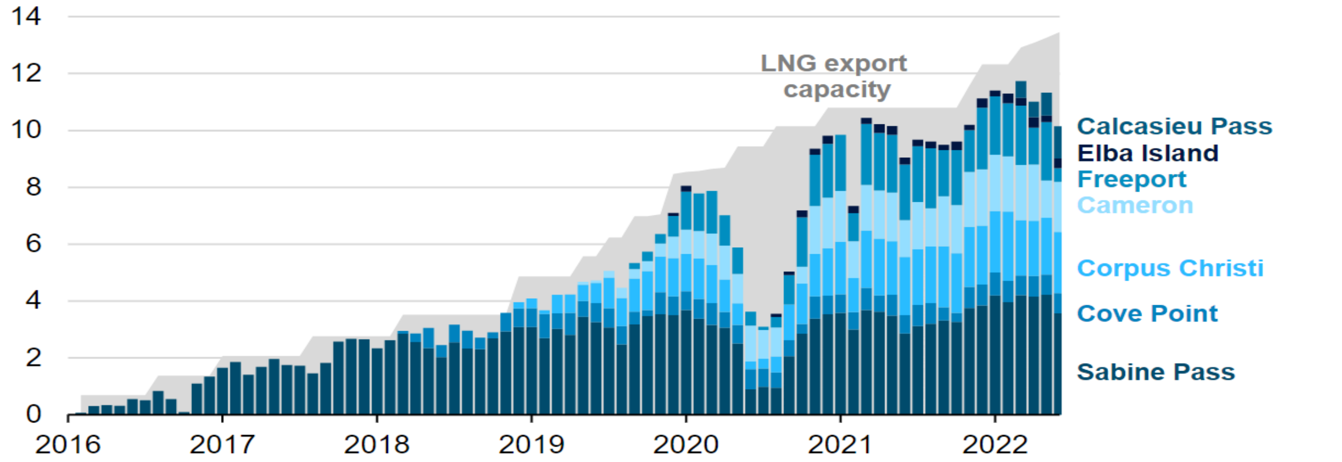
Source: U.S. Energy Information Administration

Note: The shaded area indicates the range between the historical minimum and maximum values for the weekly series from 2017 through 2021. The dashed vertical lines indicate current and year-ago weekly periods.

LNG Exports

The United States became the world's largest LNG exporter in the first half of 2022

Monthly U.S. liquefied natural gas (LNG) exports (Jan 2016–Jun 2022)
billion cubic feet per day



Data source: U.S. Energy Information Administration, *Liquefaction Capacity Table*, and U.S. Department of Energy *LNG reports*
Note: June 2022 LNG exports are EIA estimates based on tanker shipping data. LNG export capacity is an estimated peak LNG production capacity of all operational U.S. LNG export facilities.

US exports more LNG to Europe, less to Asia, Brazil, Mexico.

Exports of U.S. liquified natural gas, first half 2021 vs. first half 2022.

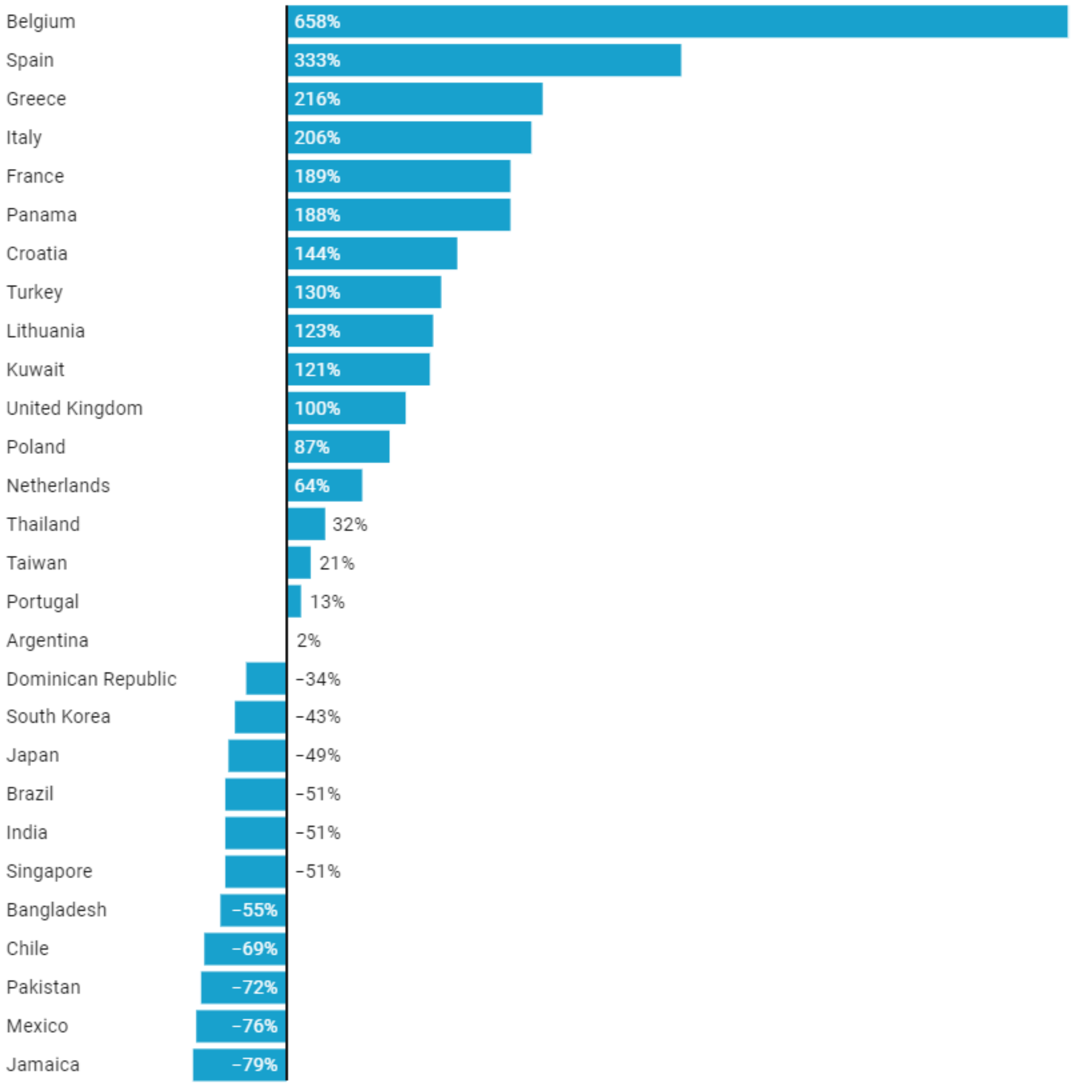


Chart: Reuters staff • Source: Refinitiv • Get the data

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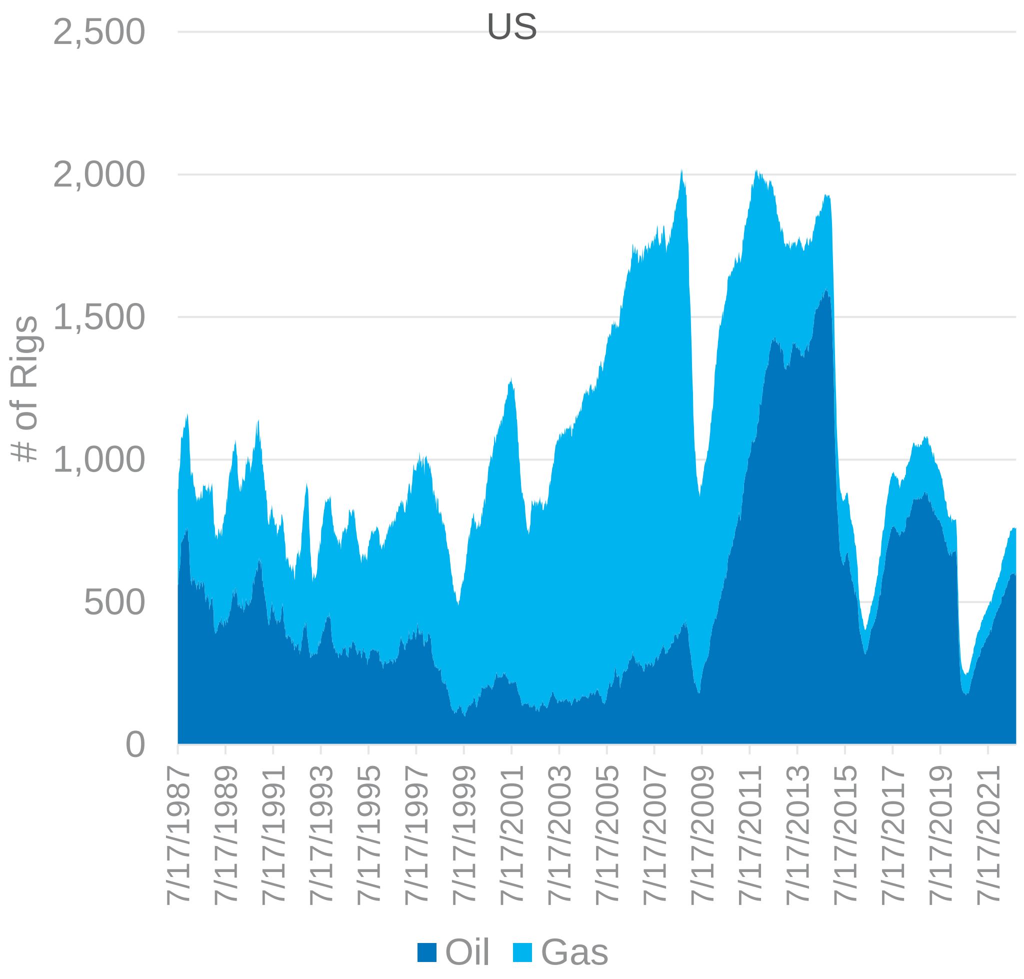
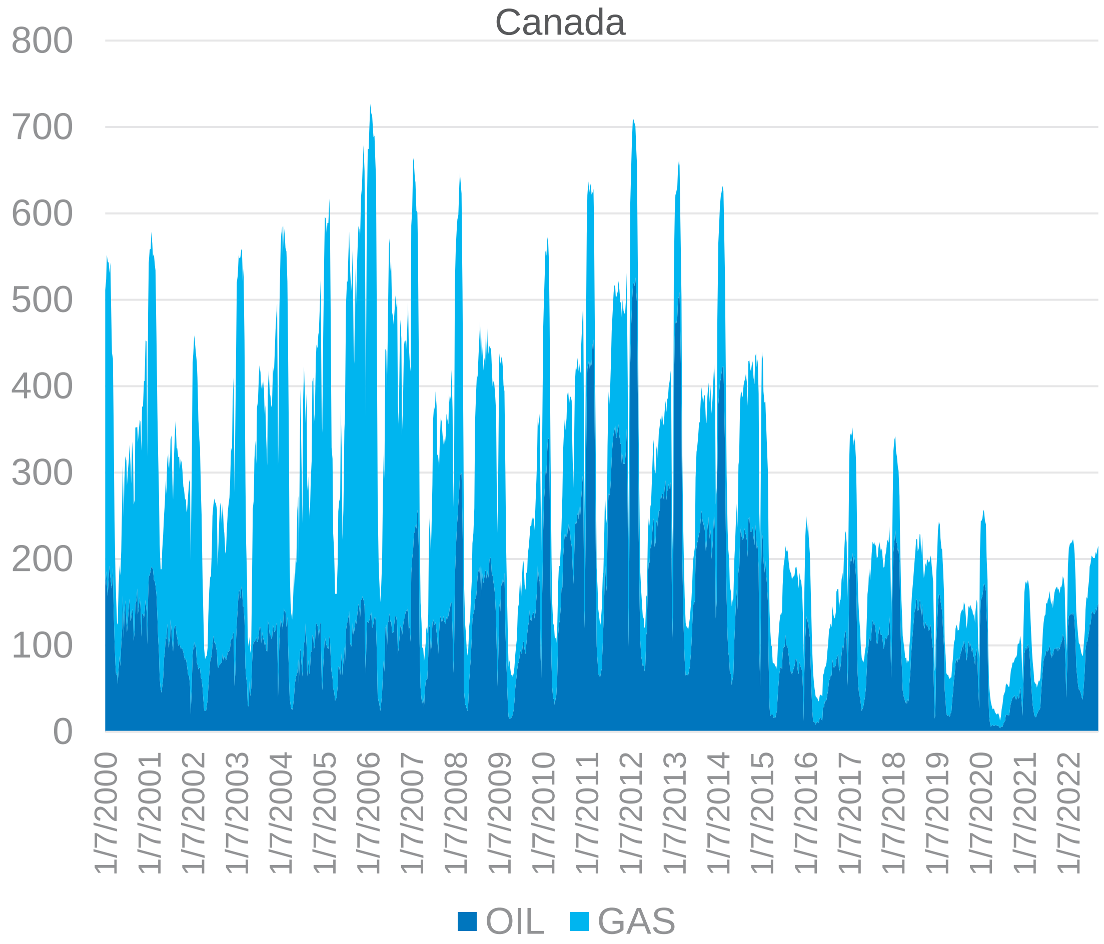
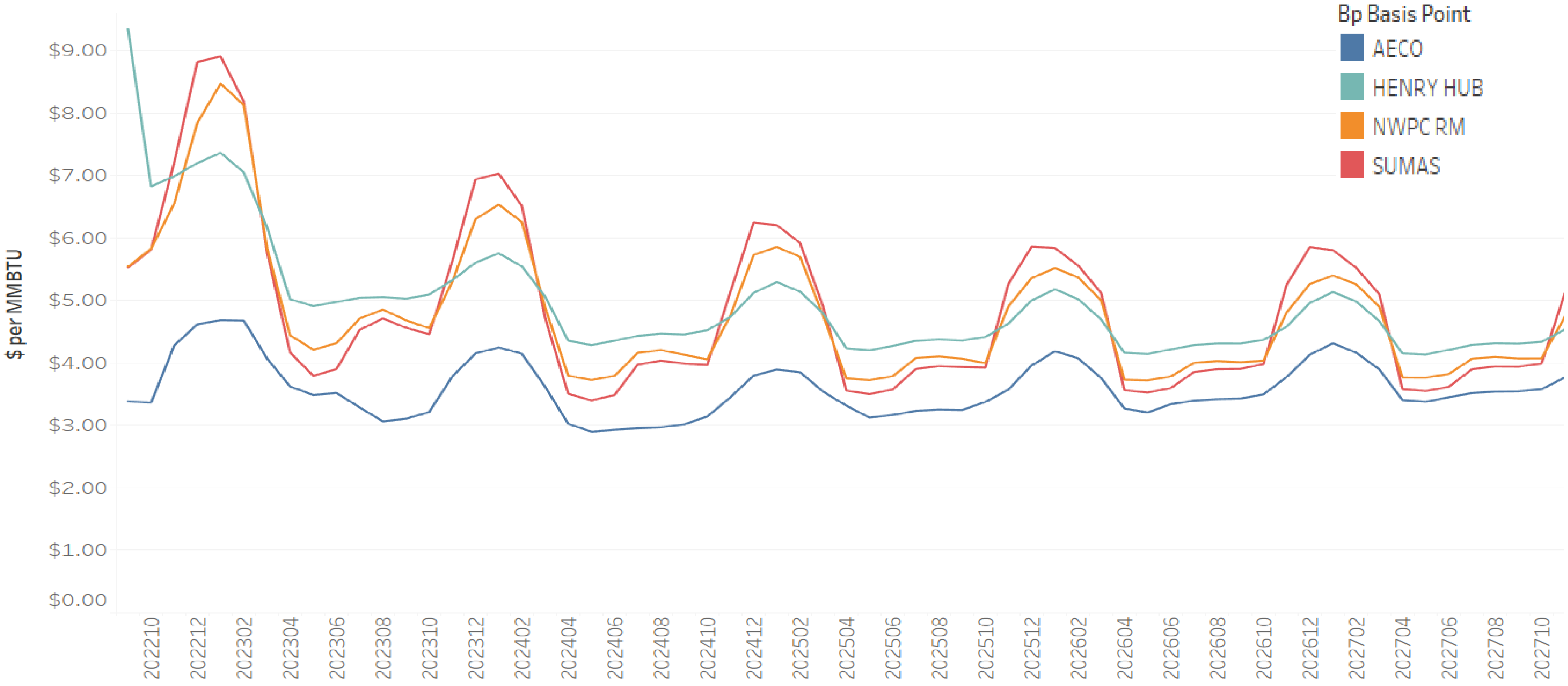
North American Rig Count





Source: Baker Hughes

Forward Prices (9/23/2022)



Daily Prices

Average Prices 9/2012 – 9/2022

	January	February	March	April	May	June	July	August	Septemb..	October	November	December
AECO	$2.37	$2.71	$2.46	$2.39	$2.51	$2.43	$2.27	$1.96	$2.01	$2.32	$2.53	$2.38
HENRY HUB	$3.22	$3.37	$3.06	$3.24	$3.44	$3.43	$3.39	$3.58	$3.53	$3.21	$3.30	$3.16
HUNT	$3.27	$4.87	$4.54	$2.88	$2.93	$2.90	$2.85	$3.24	$3.28	$3.59	$4.32	$3.87
MALIN	$3.25	$3.74	$2.93	$2.99	$3.14	$3.17	$3.22	$3.44	$3.40	$3.14	$3.42	$3.60
ROCKIES	$3.09	$3.55	$2.77	$2.52	$2.57	$2.77	$2.83	$2.76	$2.80	$2.90	$3.18	$3.30

Max Prices 9/2012 – 9/2022

	January	February	March	April	May	June	July	August	September	October	November	December
AECO	$4.52	$17.42	$7.64	$6.31	$6.85	$6.79	$5.38	$5.04	$4.71	$5.27	$4.77	$3.86
HENRY HUB	$6.88	$23.60	$7.94	$7.55	$9.29	$9.46	$9.32	$9.85	$9.24	$6.22	$5.70	$4.63
HUNT	$6.93	$49.08	$161.11	$7.60	$8.82	$8.55	$7.96	$9.00	$9.32	$14.12	$69.60	$10.78
MALIN	$6.92	$26.03	$8.13	$7.62	$9.07	$8.93	$8.93	$9.59	$9.66	$6.34	$6.21	$8.11
ROCKIES	$5.49	$29.50	$8.75	$4.63	$4.65	$4.64	$4.42	$3.90	$3.96	$3.94	$6.22	$7.12

PLEXOS Stochastics

4.3.1. Autocorrelation Model

In the autocorrelation model, the differential equation is:

$$e_t = a \times e_{t-1} + (1-a) \times r_t \times P_t \times S$$

where:

e_t is the error for time period t

a is the autocorrelation parameter (between 0 and 1)

r_t is a normal distributed random number

P_t is the expected value (profile value) in period t

S is the error standard deviation

The input parameters here are the Autocorrelation and the Error Std Dev (alternatively Abs Error Std Dev. Autocorrelation is expressed as percentage value (between 0 and 100). The higher the autocorrelation, the more the 'randomness' of the errors is dampened and smoothed out over time. The higher the standard deviation, the greater the volatility of the errors. Because the error function can produce any positive or negative value (at least in theory) it is often necessary to bound the profile sample values produced by this method. The Variable properties Min Value and Max Value are used for this purpose. The actual sample value used at any time is simply the sum of the profile value and the error (which may be positive or negative) bounded by the min and max values.

Table 2 shows some simple example input where the profile value is static but has an error function with standard deviation of 28%. In a real application the profile value would change across time *e.g.* read from a flat file. Figure 6 shows the resulting distribution of sample values from 1000 samples, which follows a normal distribution. Figures 7 and 8 shows the output sample 1 profiles with the autocorrelation parameter set to 0% and 75% respectively. Note that the overall distribution of the sample values is still normal as in Figure 6, but the individual sample volatility is damped.

PLEXOS Stochastics Continued

Without Autocorrelation

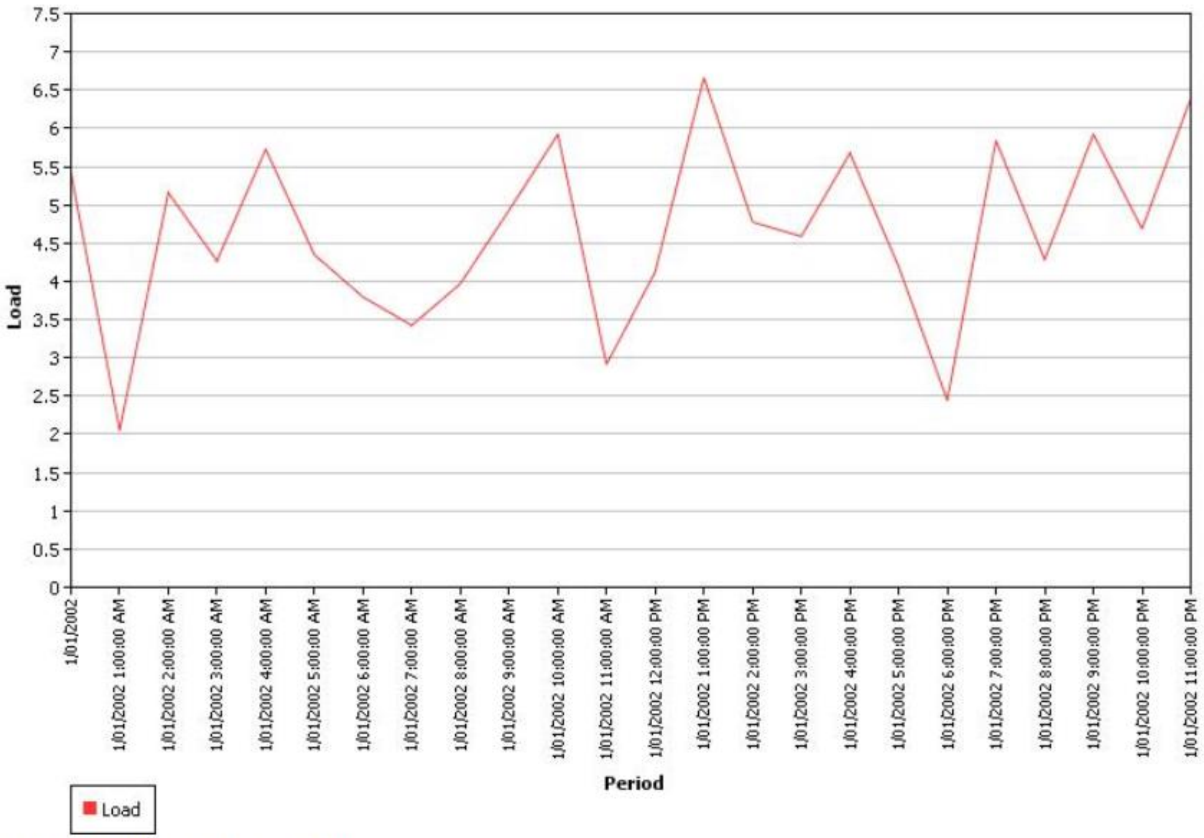


Figure 7: Sample 1 Profile with No Autocorrelation

With Autocorrelation

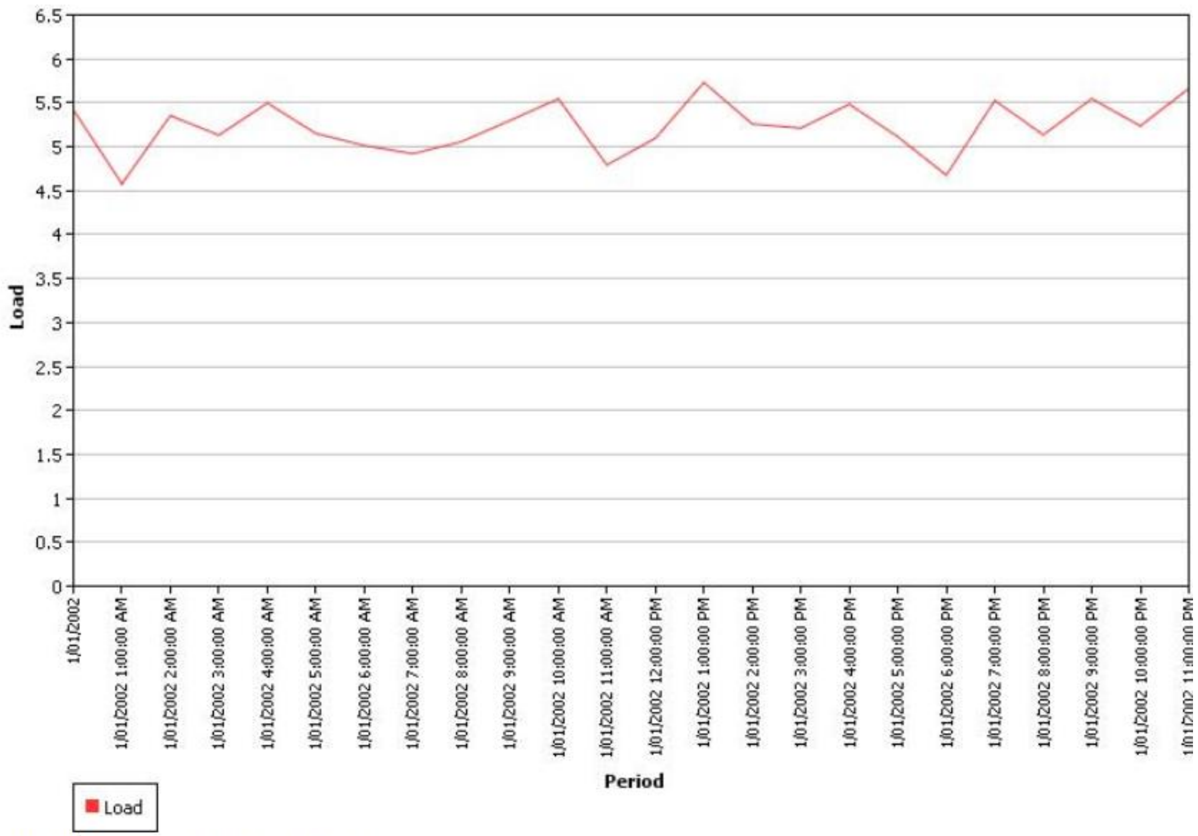


Figure 8: Sample 1 Profile with 75% Autocorrelation

Stochastics Setup

Plexos Example

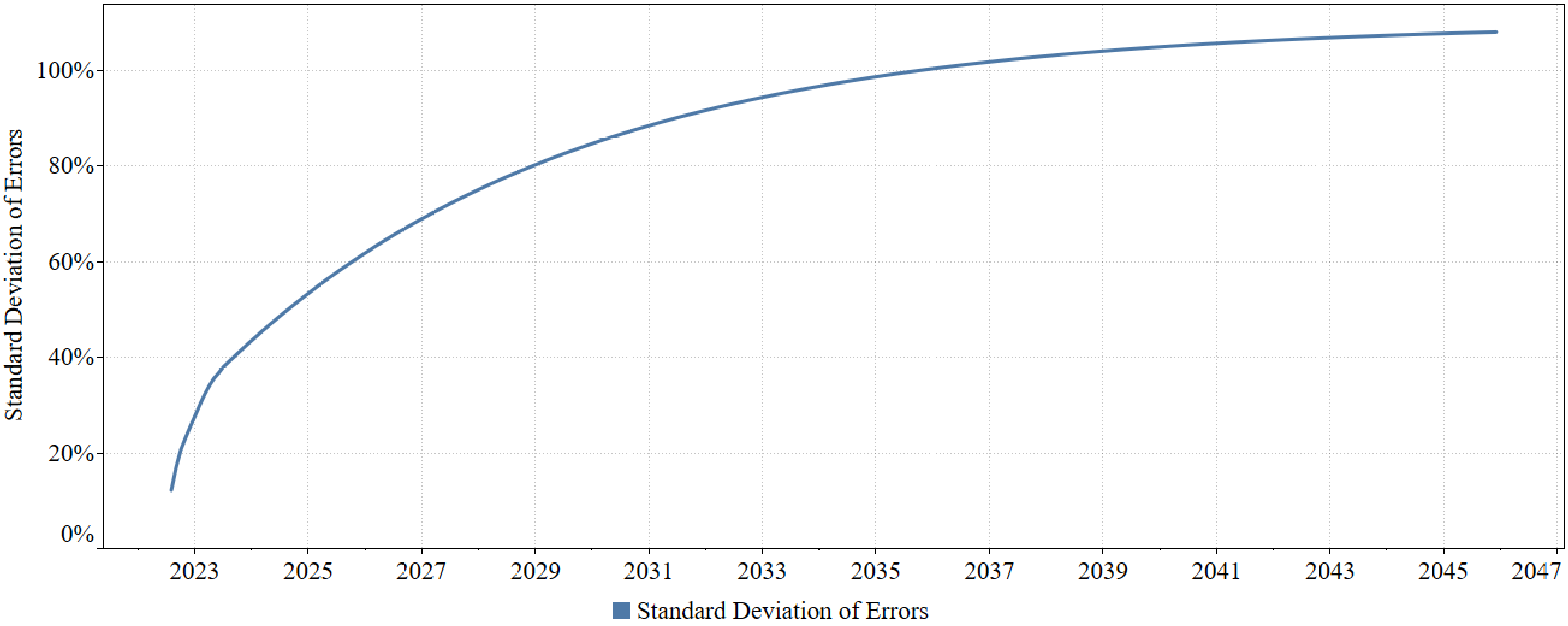
Property	Value	Units	Band
Profile	5.5	-	1
Error Std Dev	28	%	1
Min Value	1	-	1
Max Value	10	-	1
Auto Correlation	75	%	1

Avista Setup

Property	Value	Data File	Units	Band
Distribution Type	Lognormal		-	1
Profile Month	0	Henry Hub Prices	-	1
Min Value	0.5		-	1
Max Value	100		-	1
Error Std Dev	0	Standard Deviation of Errors	%	1
Auto Correlation	94.2		%	1

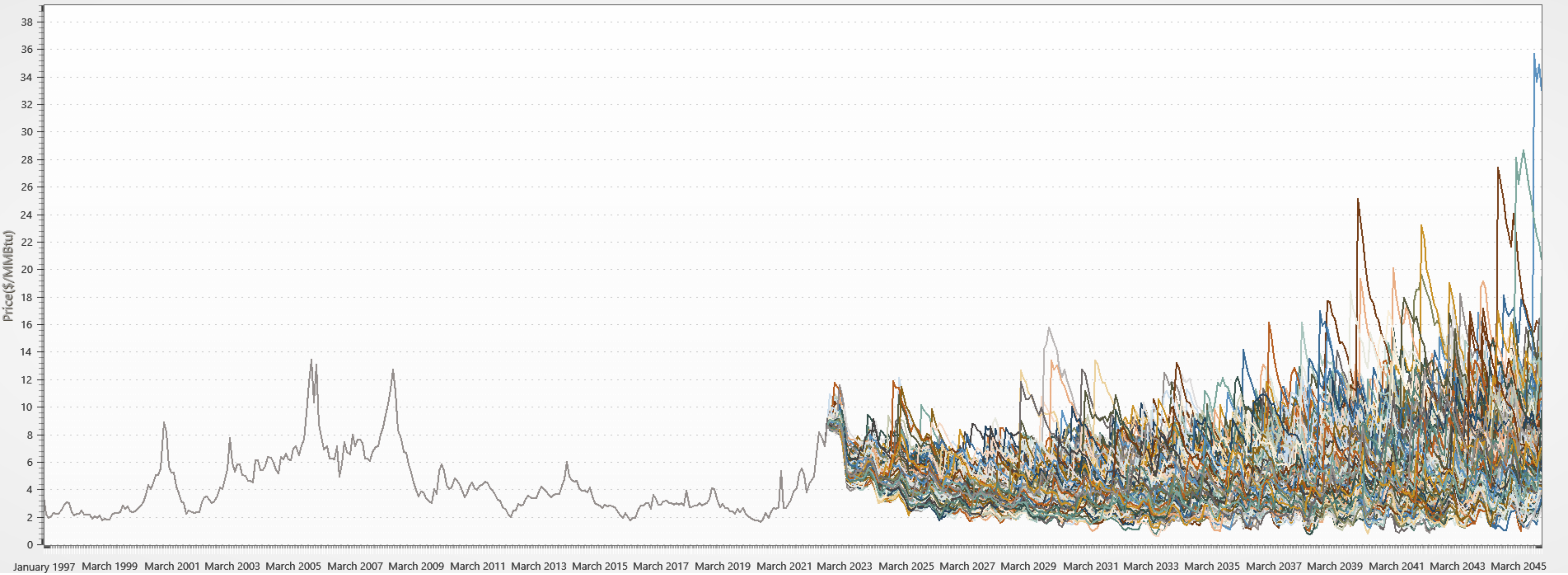
Auto Correlation calculation performed on data from 6/1/1997 – 6/1/2022 (25 years)

Input: Standard Deviation of Errors

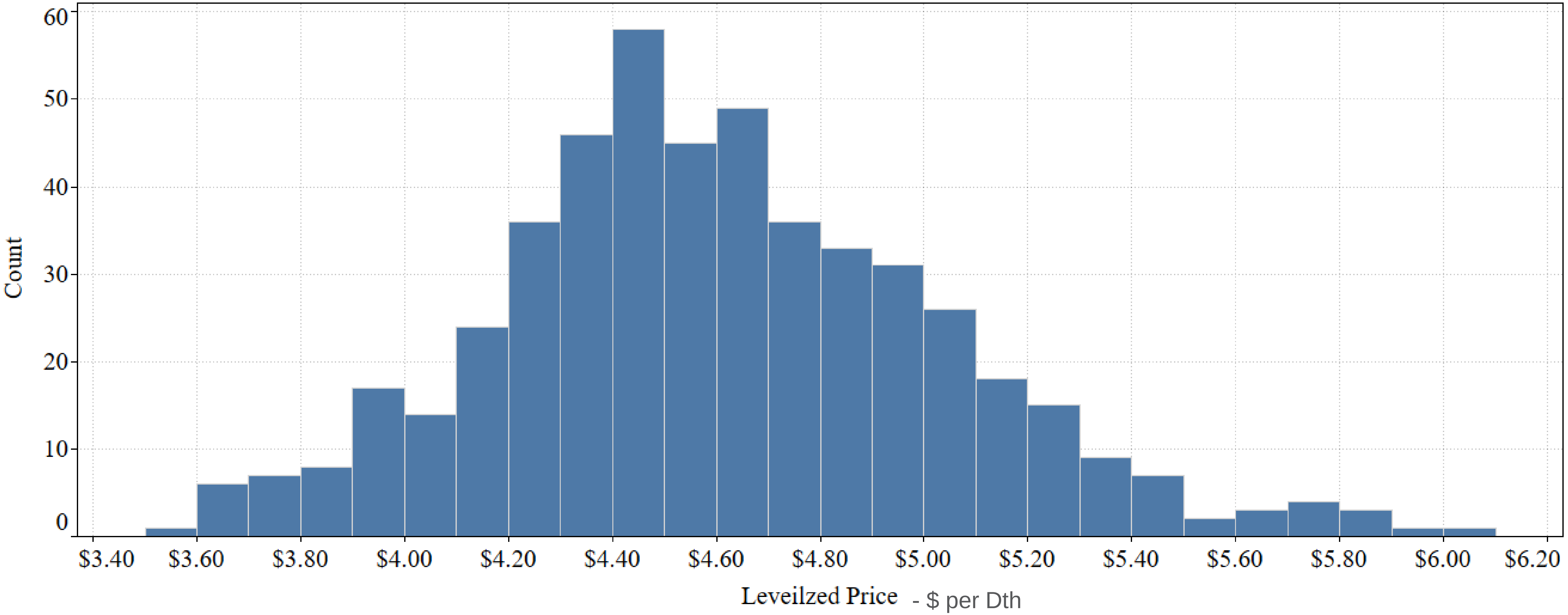


Calculations performed on data from 6/1/2011 – 6/1/2022 (11 years)

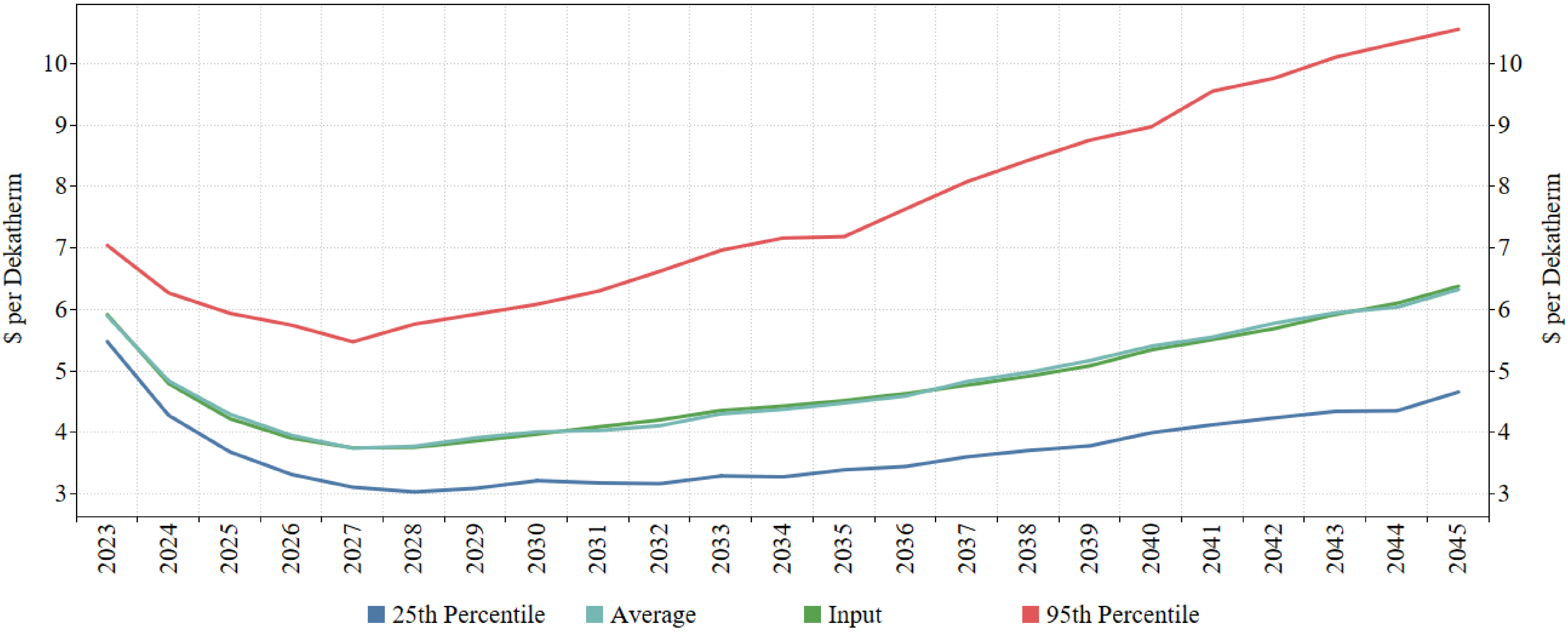
Stochastics: Henry Hub (500 Draws)



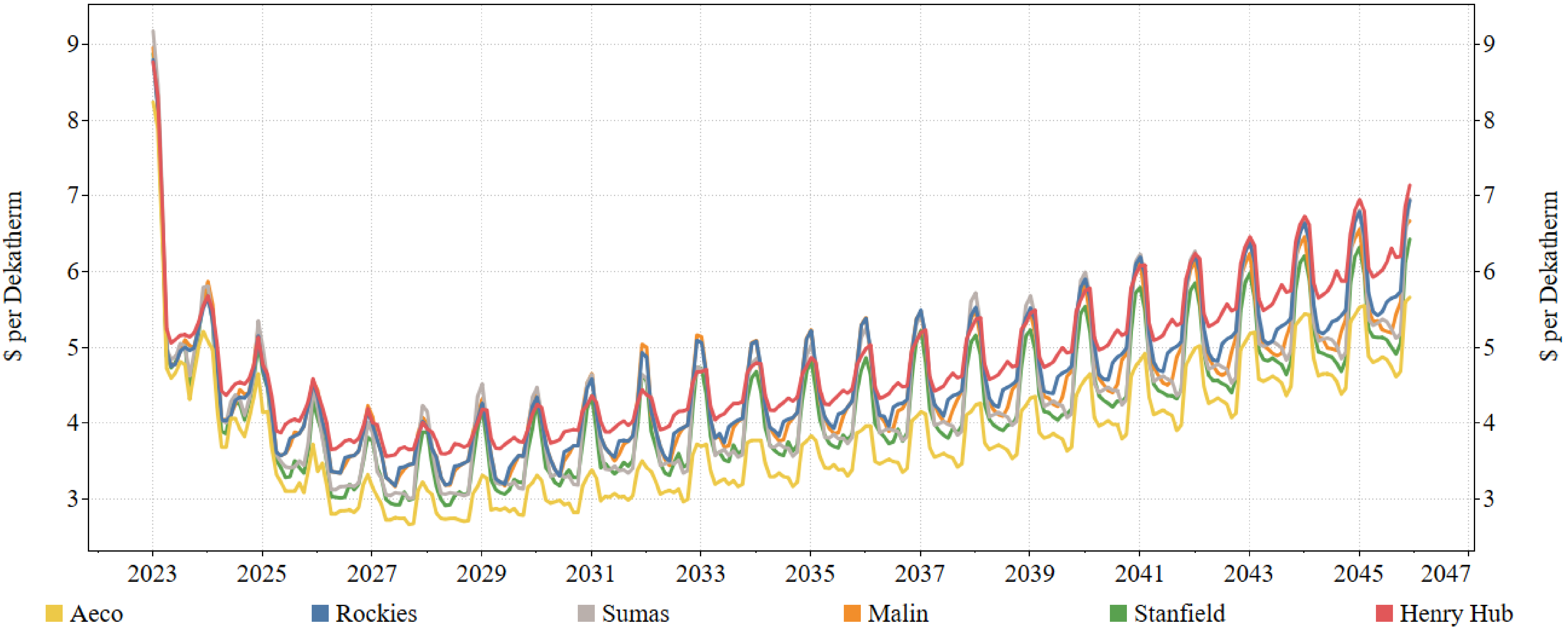
Stochastics: Henry Hub Levelized Prices (500 Draws)



Results: Henry Hub Stochastics (500 Draws)



Expected Case Price Forecasts



Supply Side Resource Options

Tom Pardee

RNG Project Development Challenges

Lessons learned from pursuing RNG projects directly with feedstock owners:

- Competition
- The California transportation market dominates the supply
- Federal RIN & California LCFS markets influence commercial terms
- Reaching commercial terms is challenging
- The utility cost of service model is a foreign concept
- Every RNG project is unique
- Economies of scale
- New RNG Projects can take 2-3 years to develop
- Limited feedstock supply
- Partnering strategy
- Picking partners

RNG Procurement & Potential Project Pipeline

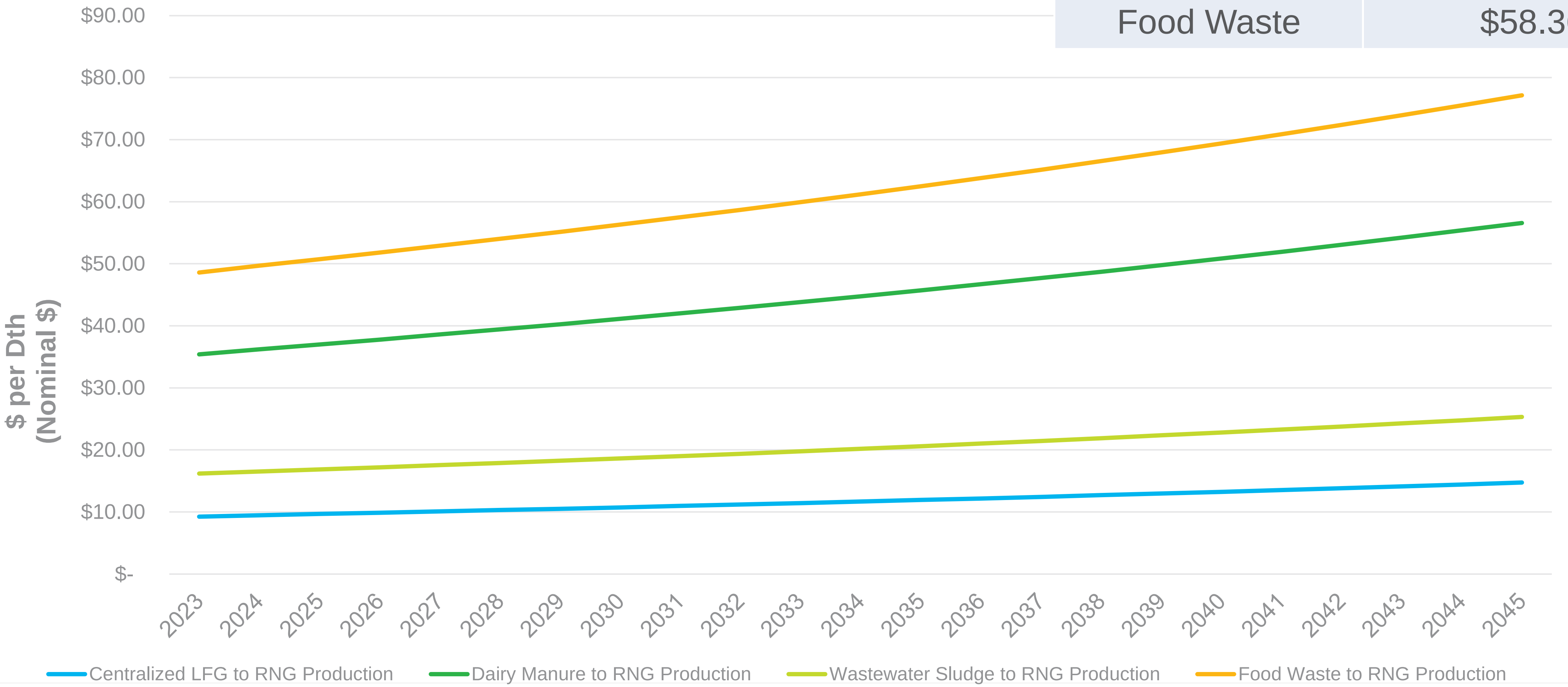
Avista has been pursuing RNG projects with a host of feedstock owners for the past few years. The table below captures these efforts by type & volume

#	Project Pathway Type	In Service Avista Territory (Y/N)	Partnering Considered	Estimated Supply (Dth/YR) (Avista only)	Est. Online Date
1	Conventional RNG	Yes	Yes	~ 200K - 350K	2024
2	Unconventional RNG	Yes	Yes	~ 150K - 250K	TBD
3	Unconventional RNG	Yes	Yes	~ 70K - 120K	2024-25
4	Conventional RNG	Yes	Yes	~ 30K - 50K	TBD
5	Conventional RNG	Yes	Yes	~ 20K - 30K	TBD
6	Innovative CC&R RNG	Yes	Yes	~ 50K - 80K	2024-25
7	Thermal Gasification	Yes	Yes	~ 70K - 200K	TBD
8	Conventional RNG	Yes	Yes	~ 60K - 140K	TBD
9	Pyro Catalytic Hydrogenation	Yes	Yes	~ 70K - 150K	TBD
10	Purchased RNG	Yes	No	~ 5K - 10.8K	2022

Action Item Feedback: “Engage with stakeholders early in the development process to discuss potential RNG project types and ownership structures and ways to mitigate or balance project risks fairly.”

RNG Cost Estimate by type

RNG Type	Levelized Price (Dth)
Landfill	$11.14
Dairy	$42.65
Wastewater	$19.29
Food Waste	$58.36



Source: Black and Veatch estimates

2018 Oregon SB 344 Report Highlights

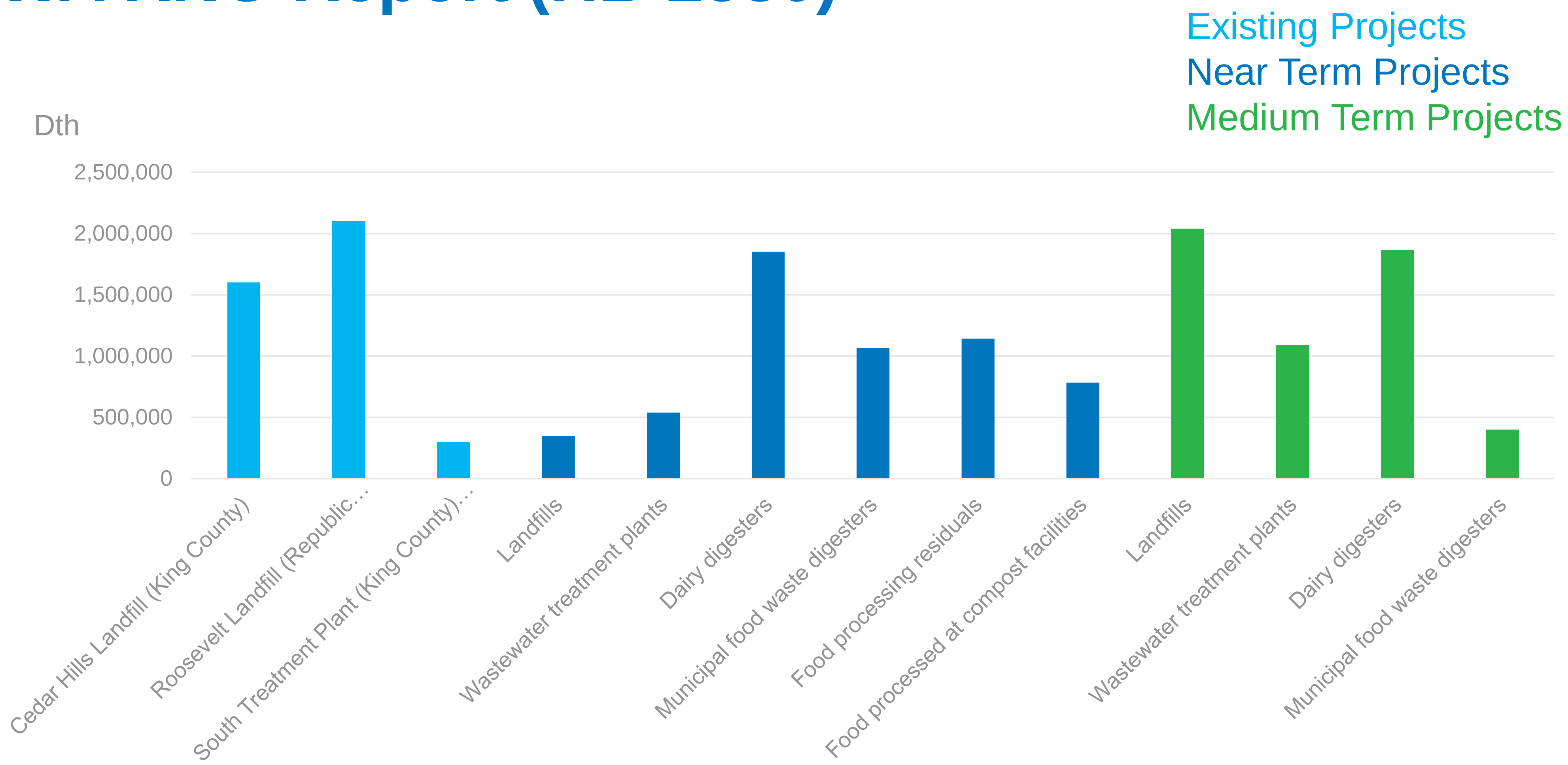
Total Potential Annual Methane Production = 50 Bcf

Source - Anaerobic	Cubic Feet of CH4 per Year
Agricultural Manure	4,639,626,825
Wastewater	1,225,228,606
Food Waste	138,571,656
Landfill	4,351,052,420
Total	**10,354,479,507**

Source - Gasification	Cubic Feet of CH4 per Year
Forest Industry Residuals	16,998,109,000
Agricultural Industry Residuals	22,686,775,000
Total	**39,684,884,000**

Oregon Department of Energy, 2018 Biogas and Renewable Natural Gas Inventory SB 334 Report

WA RNG Report (HB 2580)



WSU Energy Program, Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State

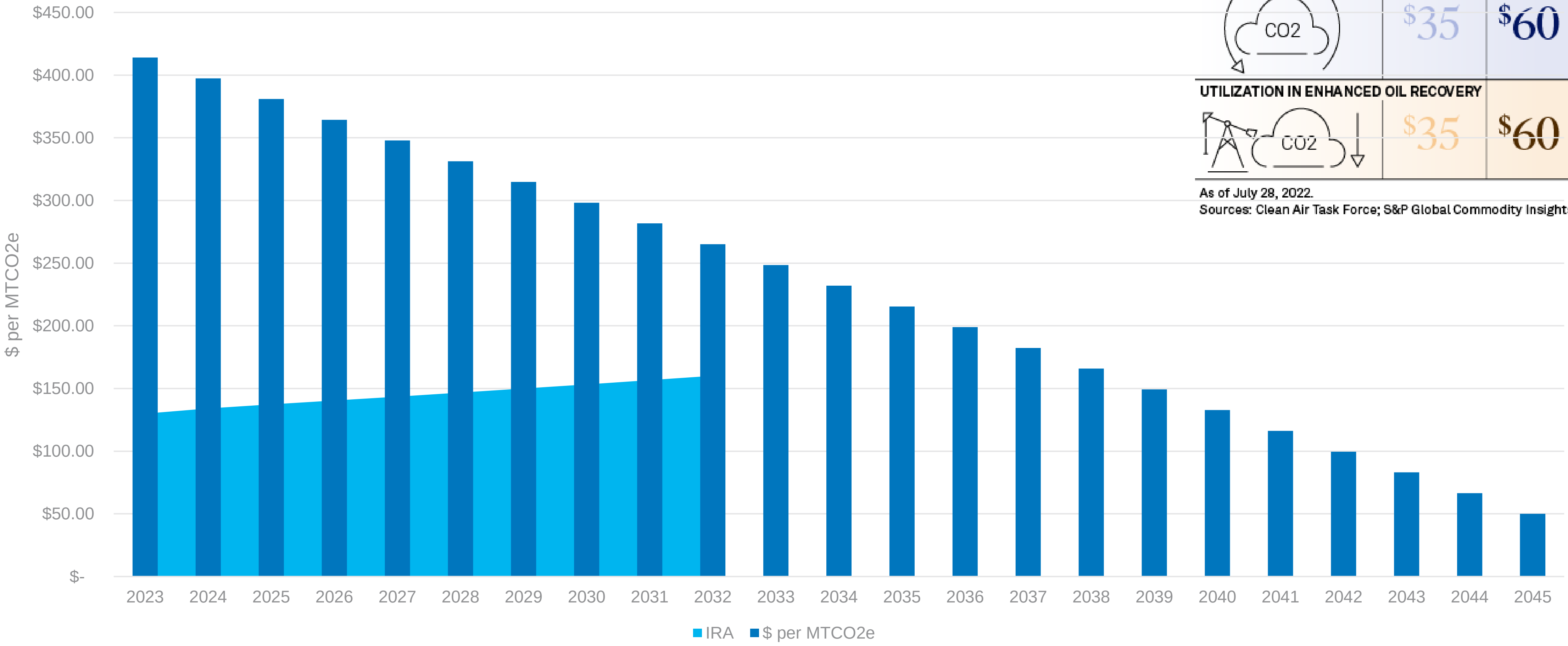
*Released December 1, 2018

Direct Air Capture

Carbon capture tax credit increases under Inflation Reduction Act ($/tonne)

	Previous	Inflation Reduction Act: POINT SOURCE	Inflation Reduction Act: DIRECT AIR CAPTURE
UNDERGROUND STORAGE	$50	$85	$180
UTILIZATION	$35	$60	$130
UTILIZATION IN ENHANCED OIL RECOVERY	$35	$60	$130

As of July 28, 2022.
Sources: Clean Air Task Force; S&P Global Commodity Insights

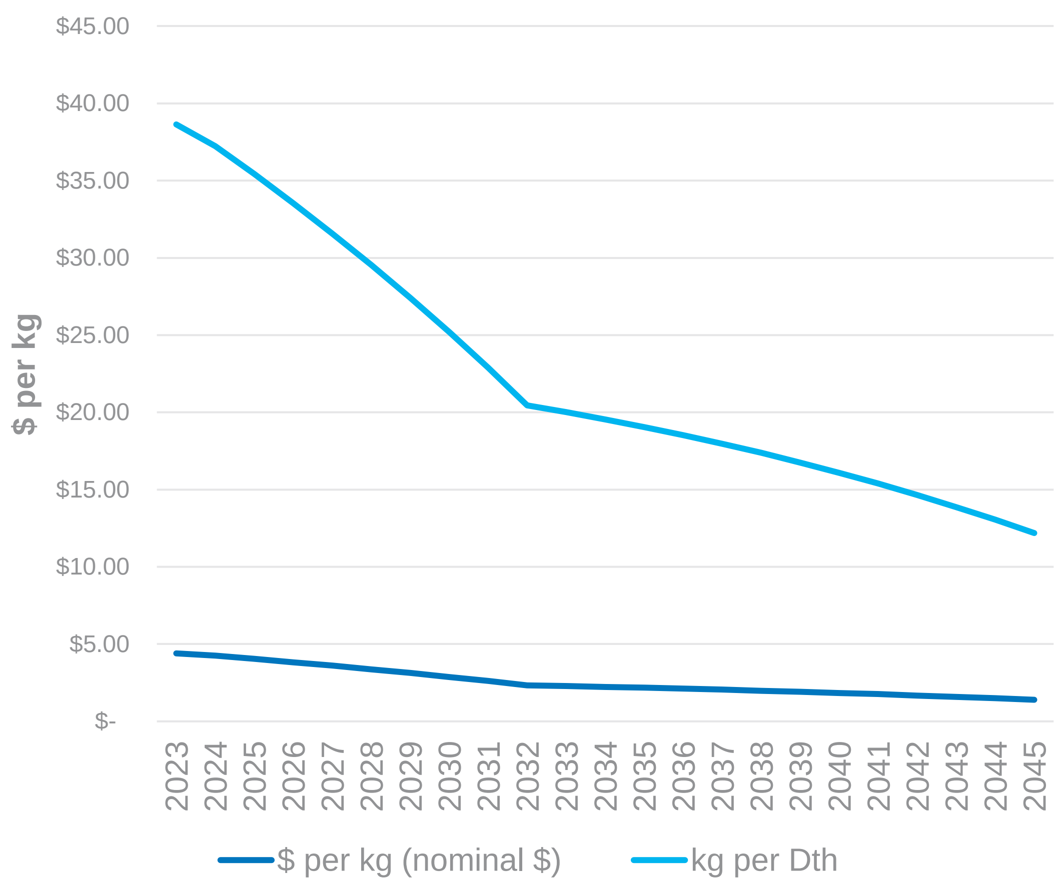


Source: science direct

AVISTA

Green Hydrogen (H2)

- Hydrogen is the most abundant element in the universe
- The lightest element and wants to escape making it harder to contain
- Highly combustible
- Tax credits from IRA assumed at a levelized credit for the full $3 per kg incentive from green H2

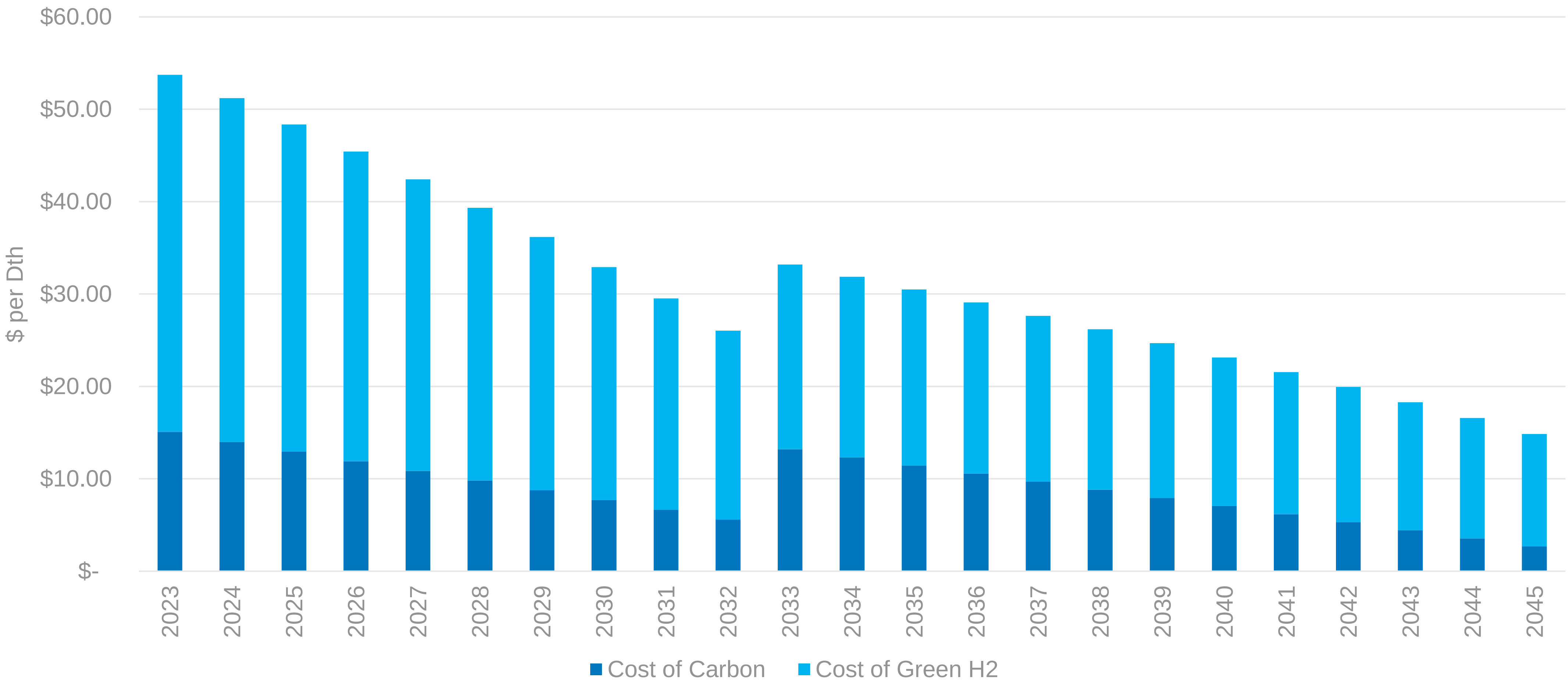


Synthetic Methane

- Can be used in existing pipelines with no upgrades
- Unlimited potential, based solely on capacity of transportation or distribution pipeline
- Sourced from carbon capture and green hydrogen
  - Assume Inflation Reduction Act (IRA) benefits of:
    - $130 per MTCO2e for carbon capture
    - $3 per kg for green hydrogen

Levelized Price (year 1)	$35.78

Synthetic Methane Costs

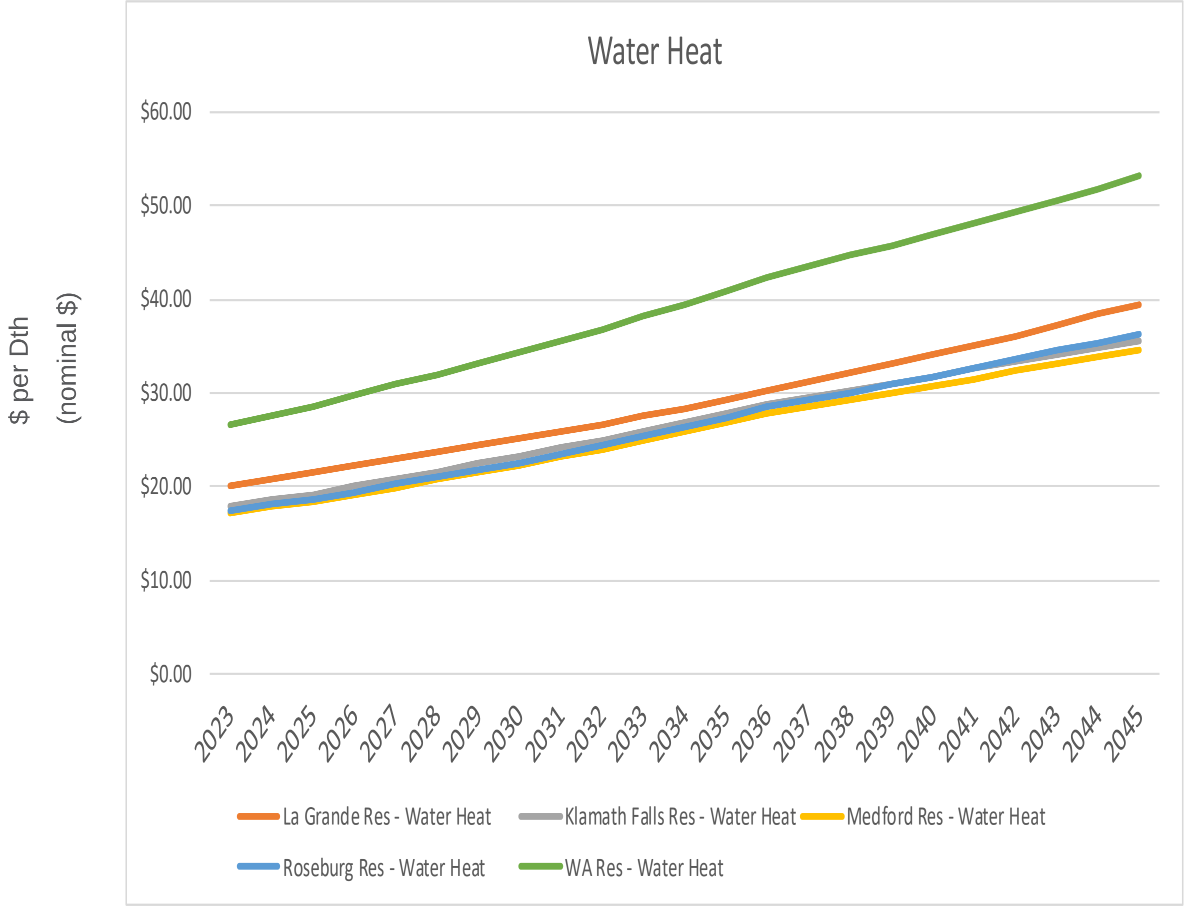


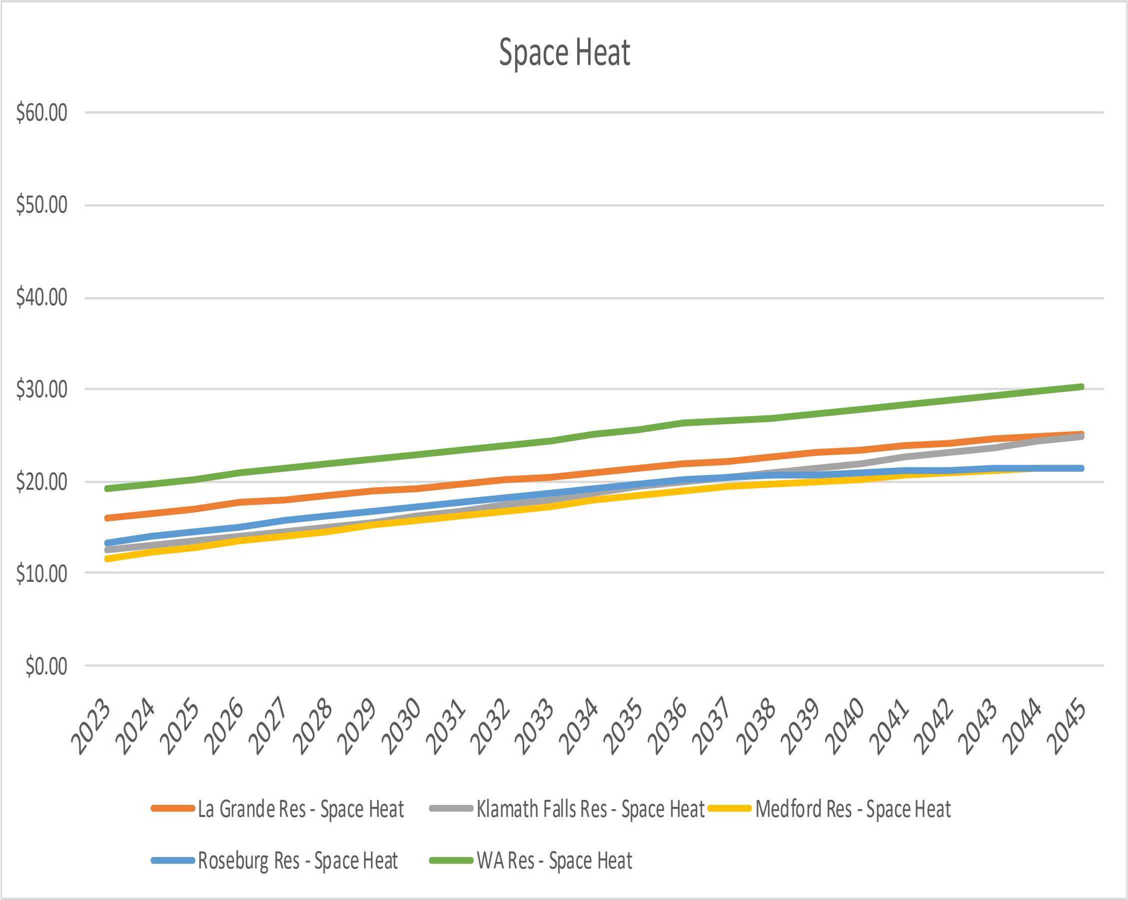
Electrification Estimates

- Look at a daily efficiency and conversion by area
- Roll up this daily efficiency into a monthly average conversion (therms to kwh)
- Uses rates by area from electric providers
  - Oregon Trail rises by 3% per year
  - All other rates rise by Avista expected cost increase and includes transmission and distribution estimates
  - Pacific Power
  - Inland Power/VERA/Modern Electric
  - Base rates are not included as it is assumed customers currently have electricity from these providers
  - Maximum rate, per MMBTU, for low use months is the cost to convert plus energy

- Conversion costs
  - Levelized 20-year costs each year by end use type
  - Includes Inflation Reduction Act cost estimates from 2023-2032 to help offset costs
  - Conversion costs grown by inflation each year
  - Estimates for equipment from Home Innovation Research Labs – February 2021 (Denver, CO)
  - Commercial estimates are double the residential conversion costs
  - LDC Capital costs for distribution pipelines and gate stations and other equipment are not included in electrification estimate

Residential Electrification – Levelized Energy Costs

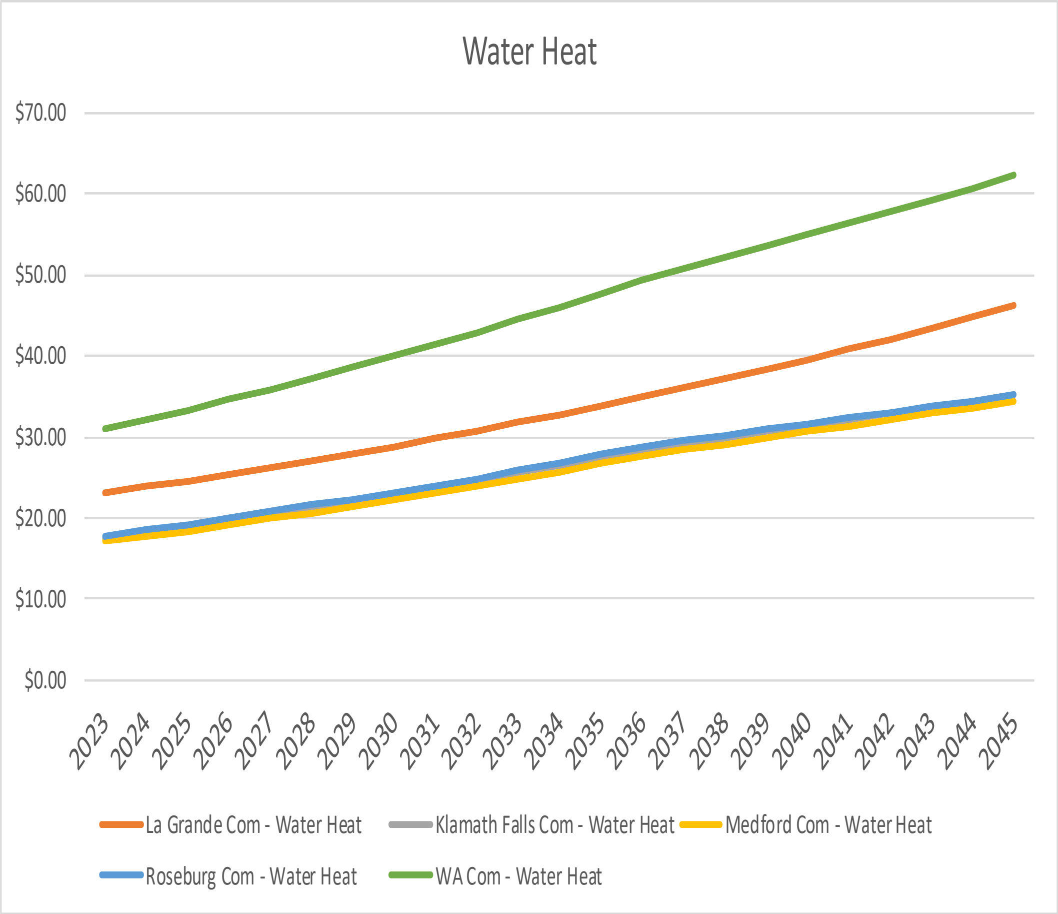


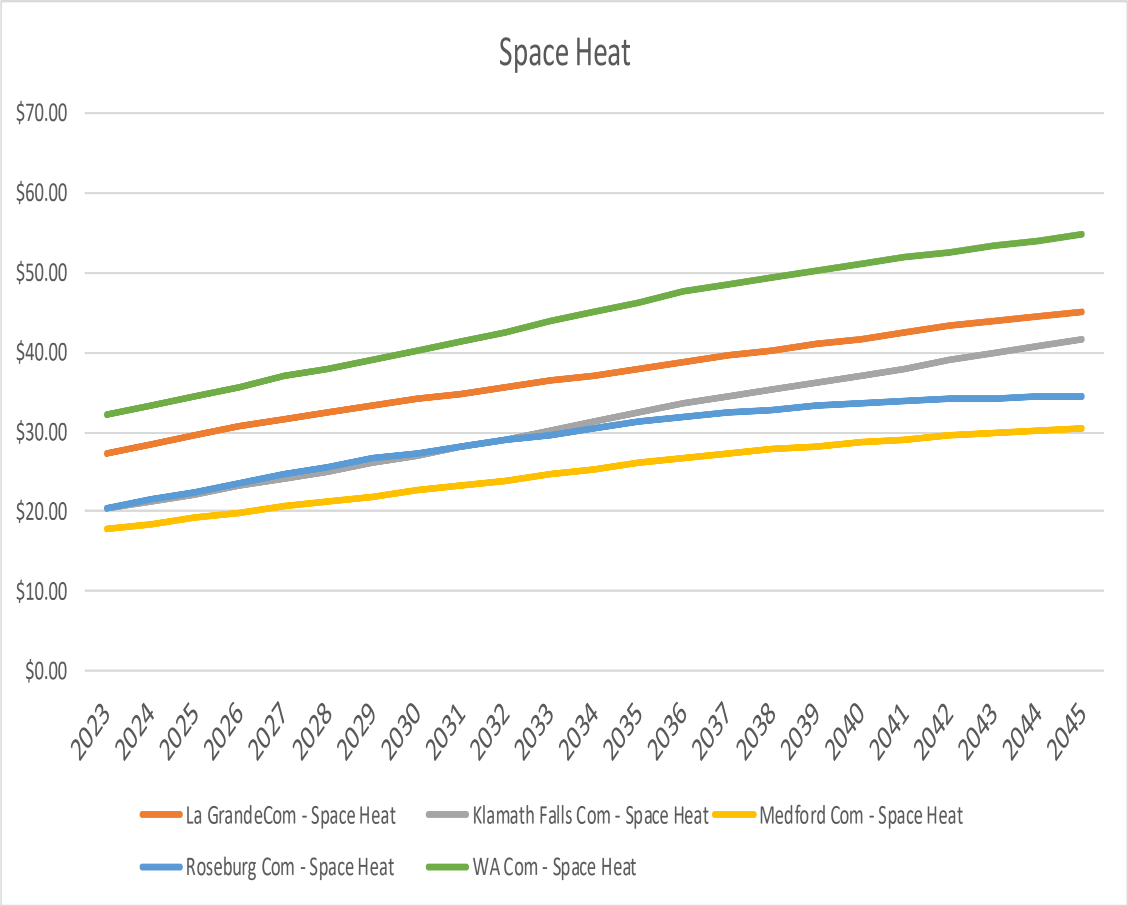


*convert from natural gas to electric with daily efficiencies by source

Commercial Electrification – Levelized Energy Costs

$ per Dth
(nominal $)





*convert from natural gas to electric with daily efficiencies by source

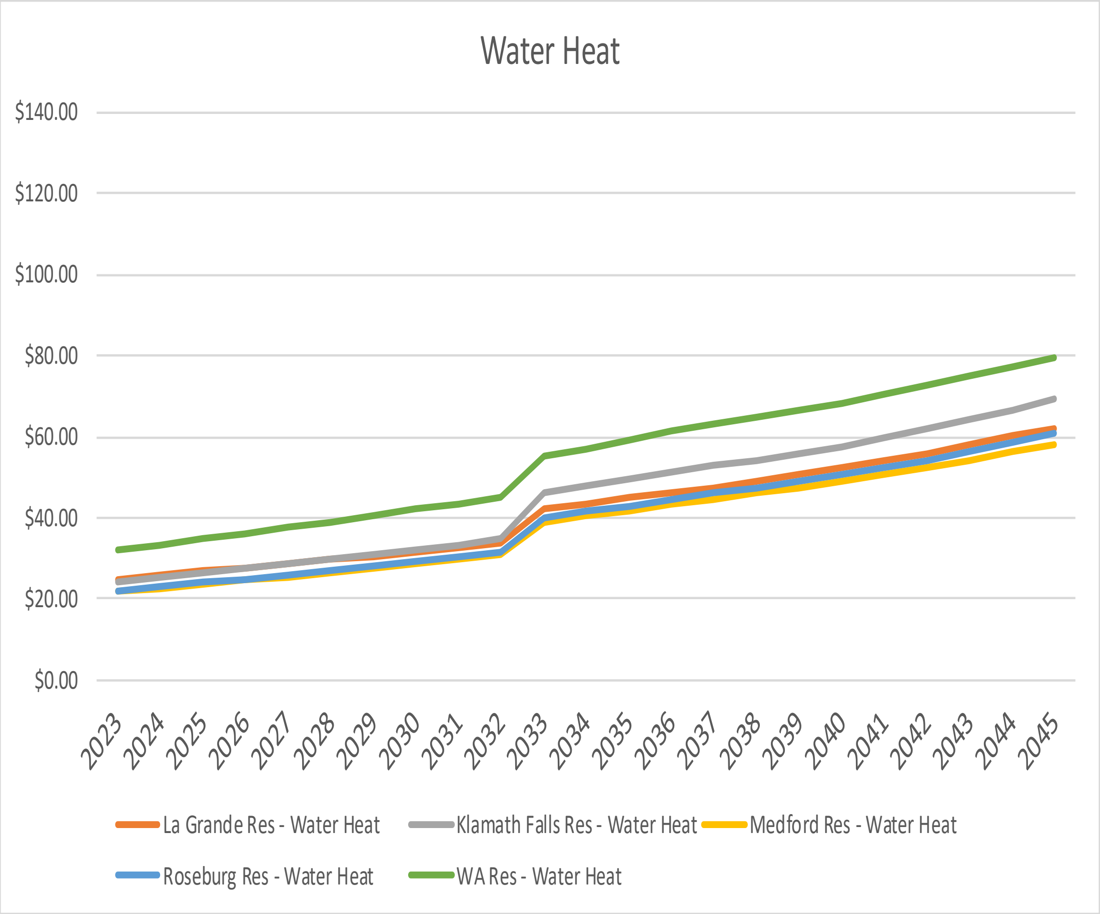
Electrification – Estimated Conversion Costs

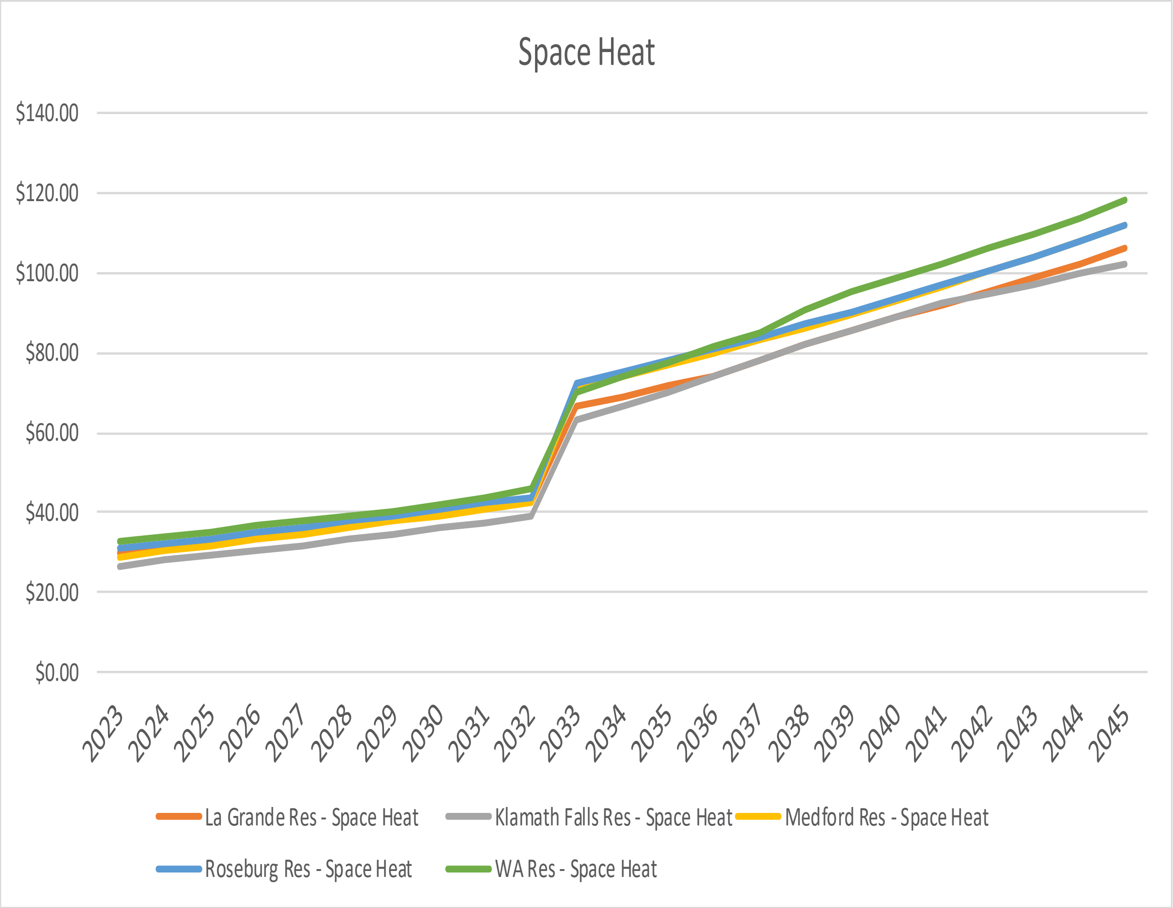
	Res - Water Heat	Com - Water Heat	Res - Space Heat	Com - Space Heat	Res - Other
Rate	3%	3%	3%	3%	3%
Years	5	5	5	5	5
Capital Amount	$ 2,325	$ 4,650	$ 5,891	$ 11,782	$ 596
Electric Panel Upgrade	$ -	$ -	$ -	$ -	$ -
IRA Tax incentives	$ 1,163	$ -	$ 2,946	$ -	$ 298
Capital Amount	$ 1,163	$ 4,650	$ 2,946	$ 11,782	$ 298

Source: Home Innovation Research Labs – February 2021

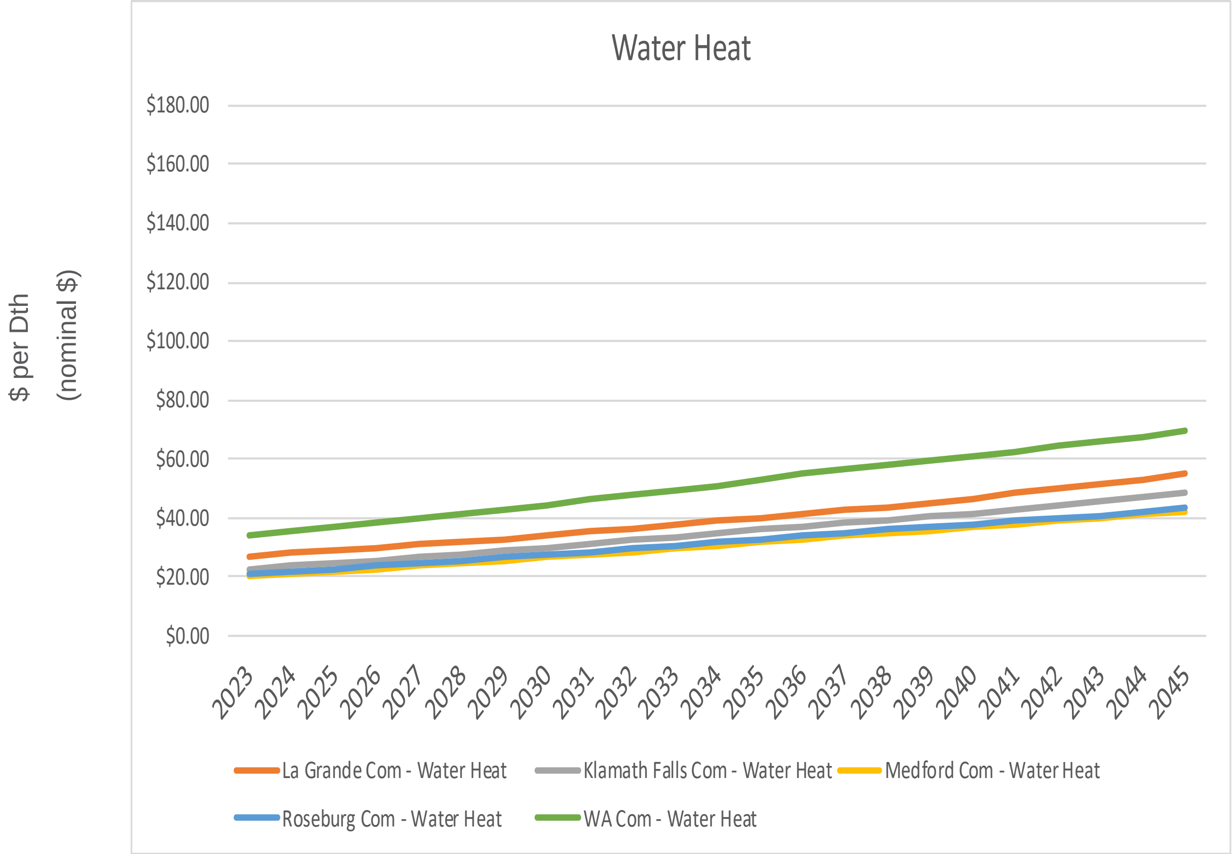
Residential Electrification Costs – Levelized (energy + conversion costs)

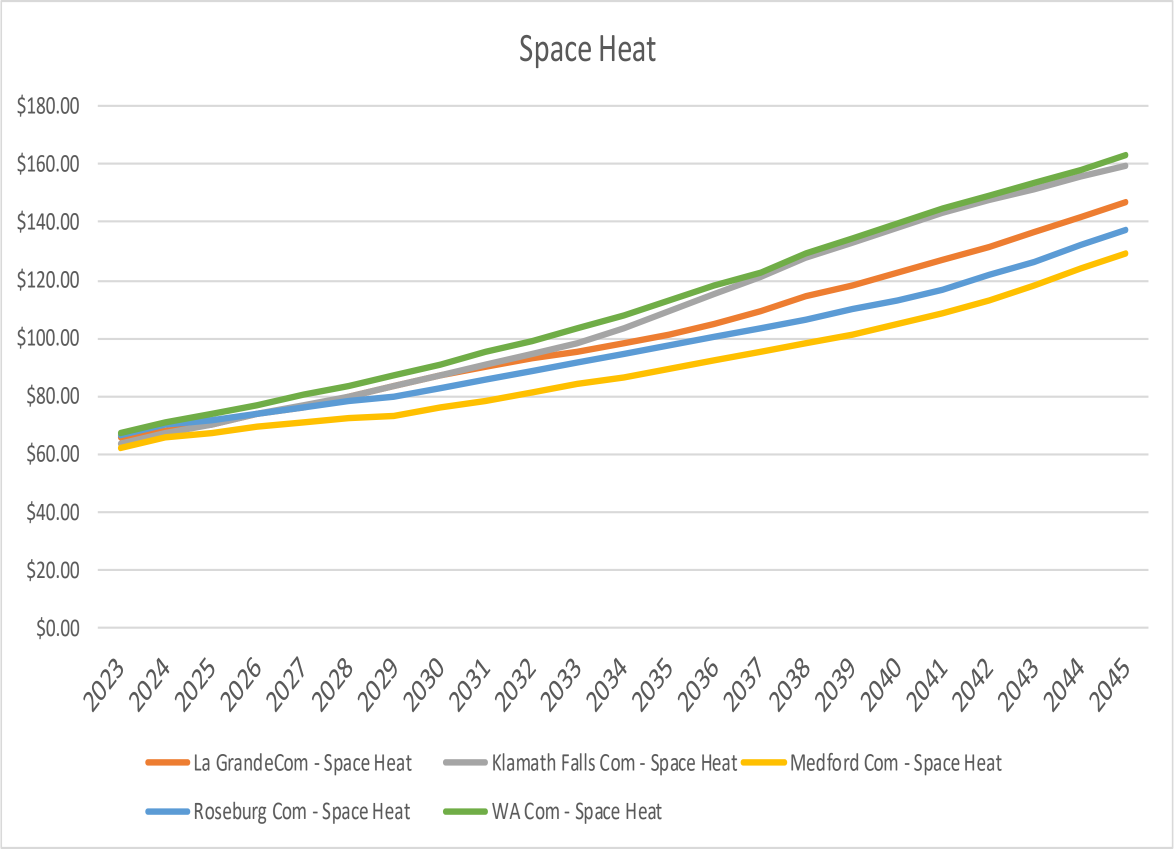
$ per Dth
(nominal $)



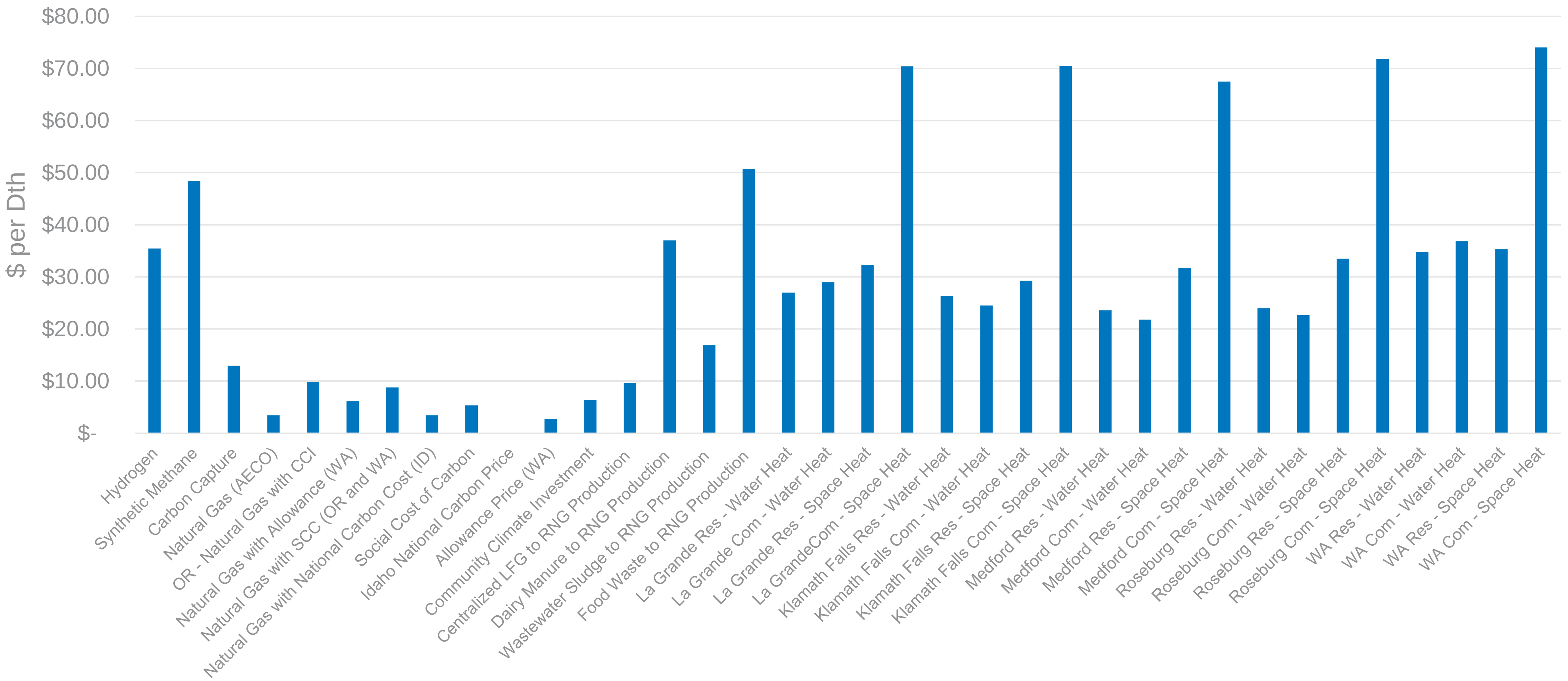


Commercial Electrification Costs – Levelized (energy + conversion costs)





Supply Side Options Summary - 2025



Request For Proposal

- Avista is going out for an RFP in the next few months
- The RFP will help determine pricing and market availability to size RNG and other fuels to help meet climate change programs in Oregon and Washington
- Avista will inform the TAC members when RFP is released

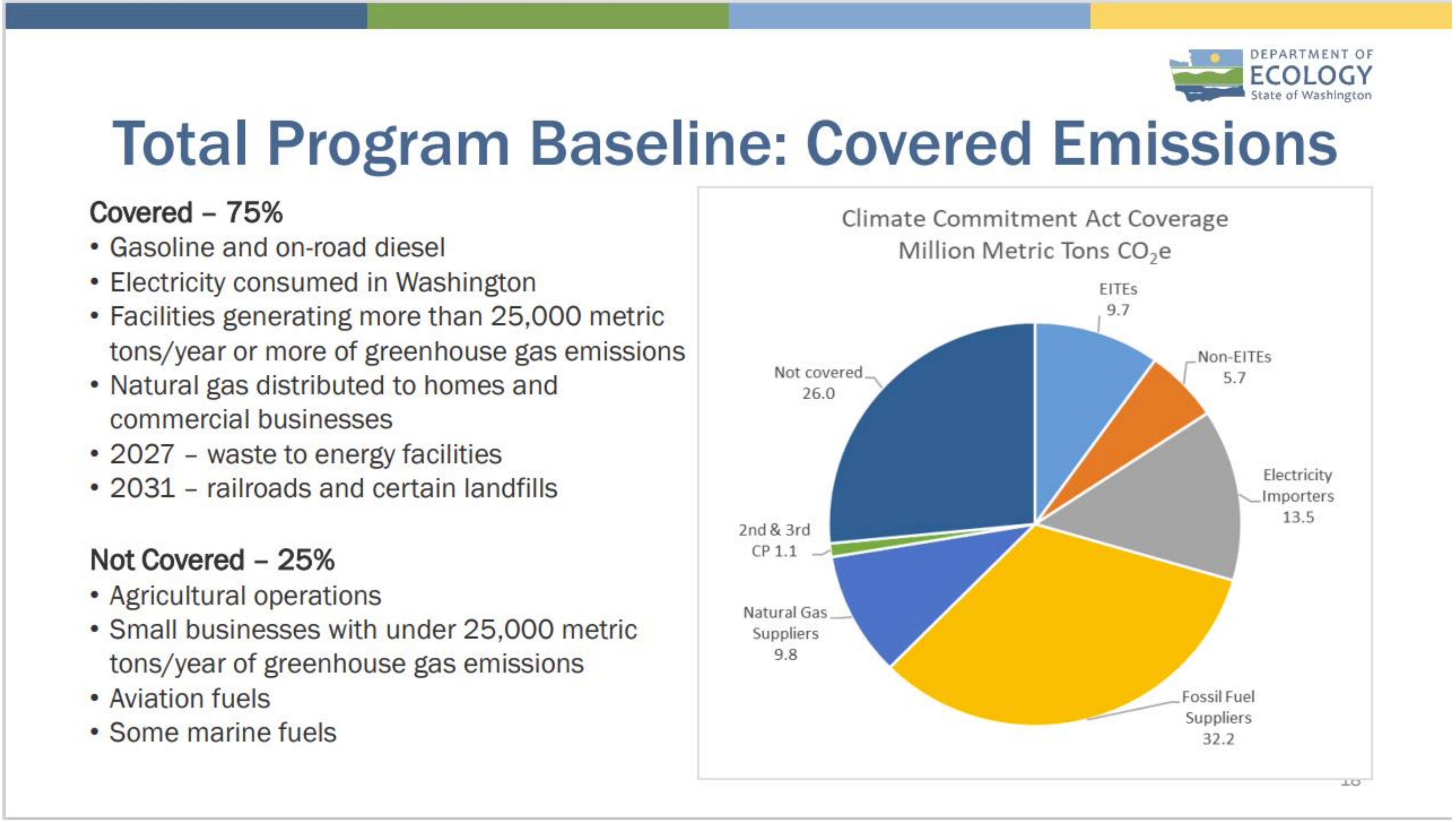
CCA Overview

Tom Pardee

Washington State Climate Commitment Act

- SB 5126, passed in the Summer 2021
- We will create a cap-and-invest program starting Jan. 1, 2023, by setting emissions allowance budgets that meet the greenhouse gas limits in RCW 70A.45.020.
- Starting on Jan. 1, 2023, the cap-and-invest program will cover industrial facilities, certain fuel suppliers, in-state electricity generators, electricity importers, and natural gas distributors with annual greenhouse gas emissions above 25,000 metric tons of carbon dioxide equivalent.
- On Jan. 1, 2027, the program adds waste-to-energy facilities.
- On Jan. 1, 2031, the program adds certain landfills and railroad companies.

Baseline Emissions



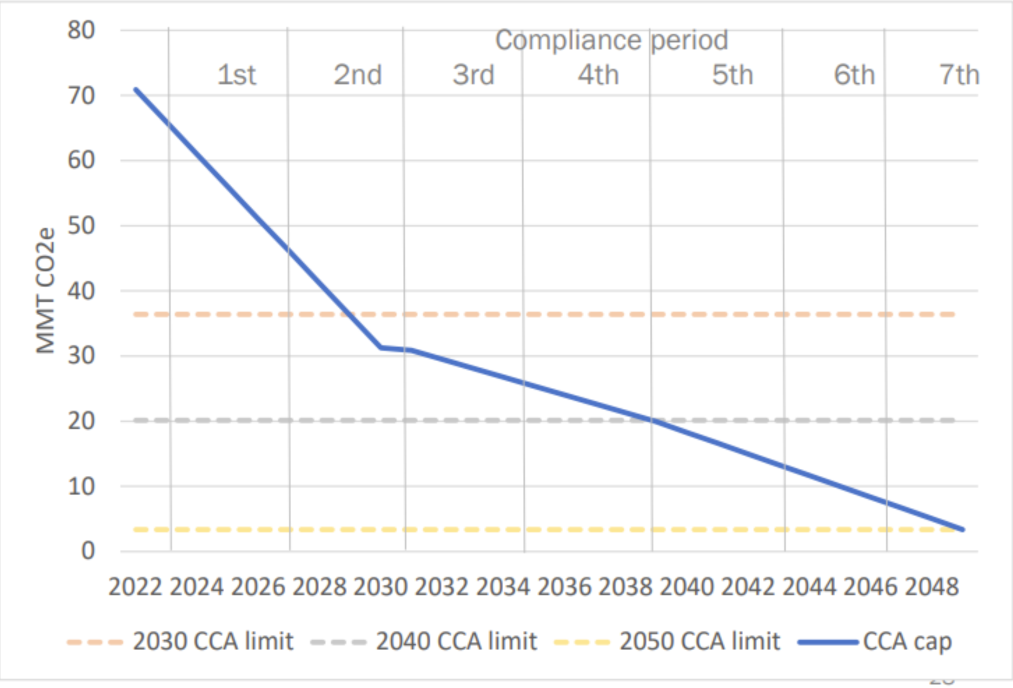
https://ecology.wa.gov/DOE/files/5b/5bdc1ffb-01dc-49de-b0cf-e5758aa5c1f6.pdf, page 18

Allowance Reduction

DEPARTMENT OF ECOLOGY
State of Washington

Total Program Allowance Budgets: Reductions

- % annual reduction based on statewide GHG limits from RCW 70A.45.020
  - By 2020: 1990 levels = 90.5 million MT CO_2e
  - By 2030: 45% below 1990 levels = 50 million MT CO_2e
  - By 2040: 70% below 1990 levels = 27 million MT CO_2e
  - By 2050: 95% below 1990 levels = 5 million MT CO_2e
- Compliance periods
  - 2023 – 2026
  - 2027 – 2030
  - 2031 – 2034
  - 2034 – 2037
  - 2038 – 2041
  - 2042 – 2045
  - 2046 – 2049



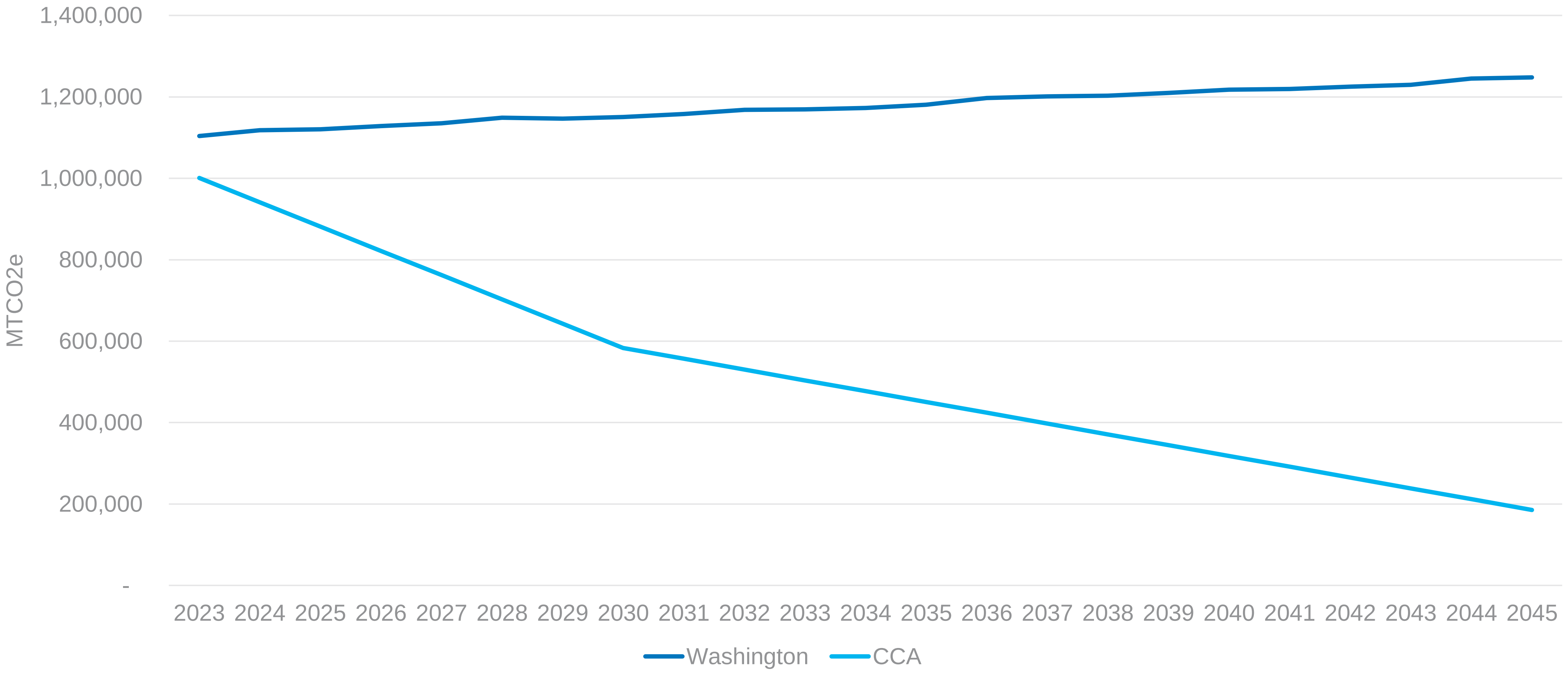
https://ecology.wa.gov/DOE/files/5b/5bdc1ffb-01dc-49de-b0cf-e5758aa5c1f6.pdf, page 28

Major Rule Components

- 7% initial years decline in cap
  - Cap is average deliveries for customers less than 25,000 MTCO2e from 2015-2019
- Offset projects can qualify
  - 8% in first timeframe, 6% in second 4-year timeframe and 6% thereafter
- Allowances given to meet the initial target
  - 93% first year of which 35% can be used for compliance by the LDC
    - Free allowance reduce 5% each year until reaching zero.
  - All allowance revenue from the auctions is to be used to offset costs for low-income residential customers.
  - Allowances do not expire and may be banked
  - No cost allowances may not be traded, transferred or sold

Emissions

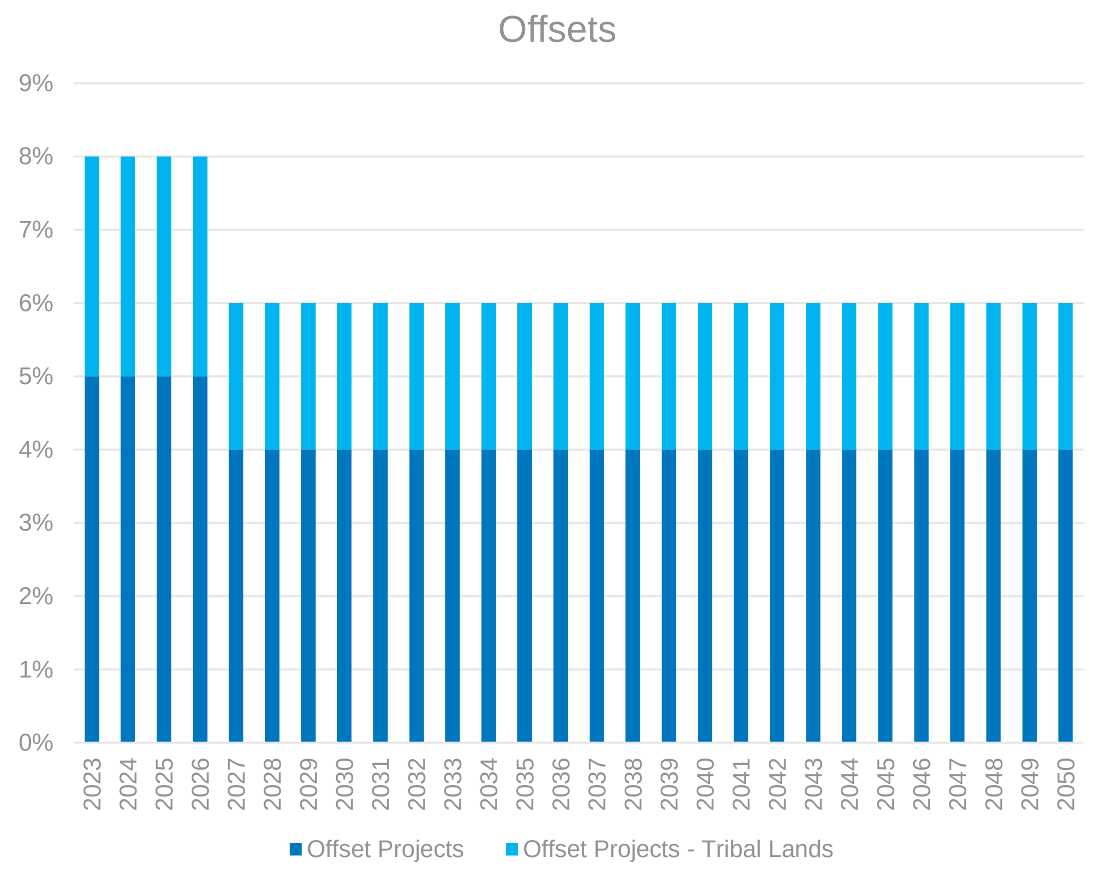
(Metric Tons of Carbon Dioxide equivalent (MTCO2e)



Offsets

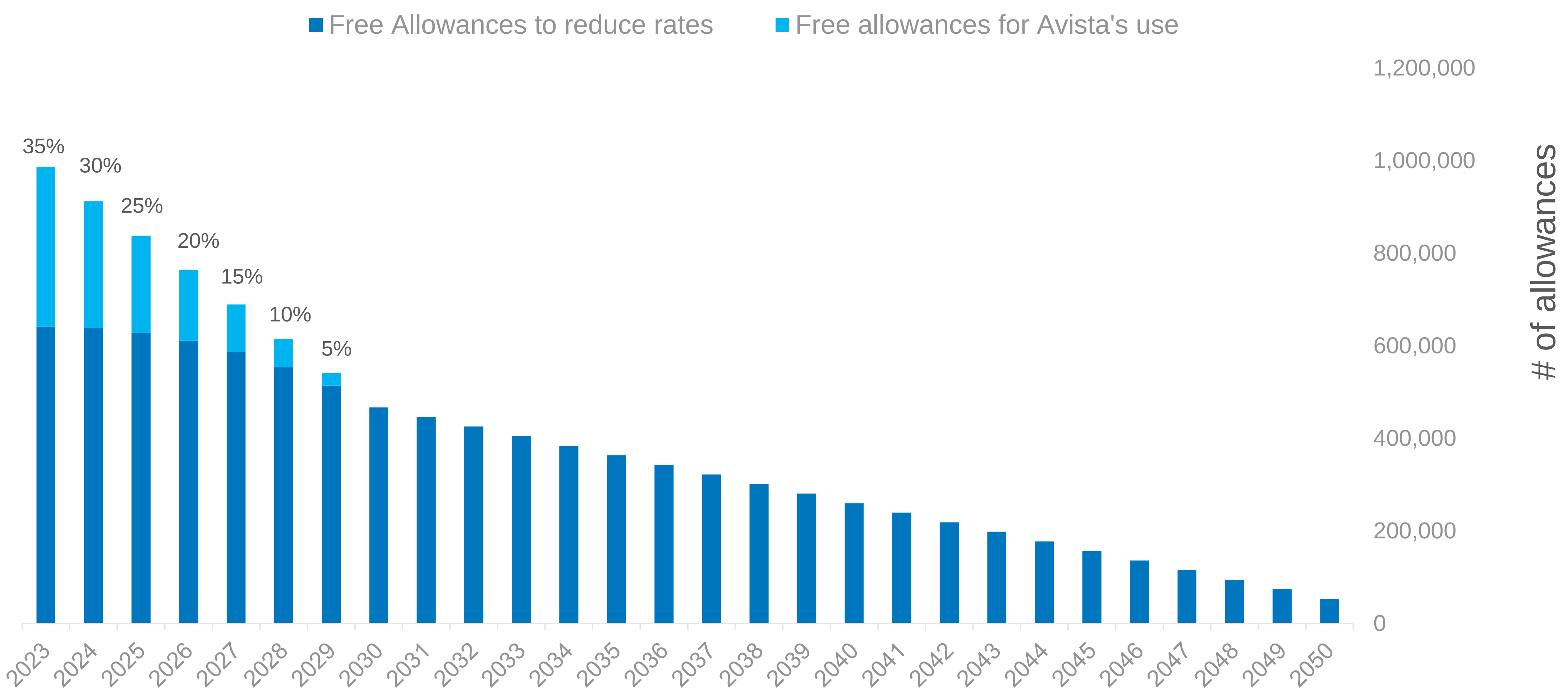
- Interchangeable with allowances and purchased if cheaper than allowance price

- Offsets remove allowances from the cap

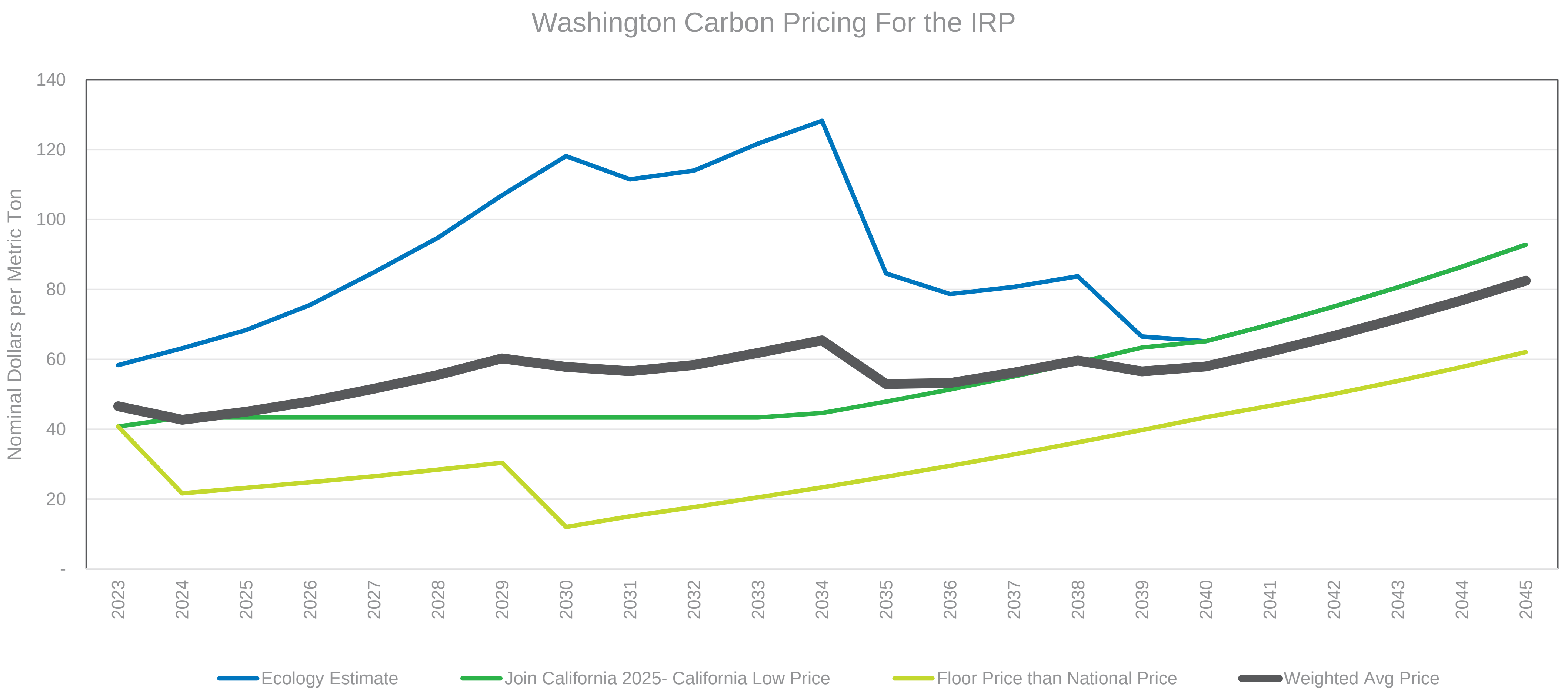


AVISTA

Free Allowances



Allowance Price



CCA Summary

	Climate Commitment Act (CCA) Washington
Start Date	January 1, 2023
Avista Compliance obligation	All emissions less than 25,000 MTCO2e
Compliance Periods	4 years (2023 – 2026)
2050 Goal	95% below 2015-2019 avg.
First Year offset	7.00% - (2023-2030) 1.95% - (2031-2050)
Violation	$10k per MTCO2e
Offset projects	All projects are below cap (remove available allowances) -Up to 8% for four years (3% tribal) -After first four years 6% (2% tribal)
Program offsets	Allowances

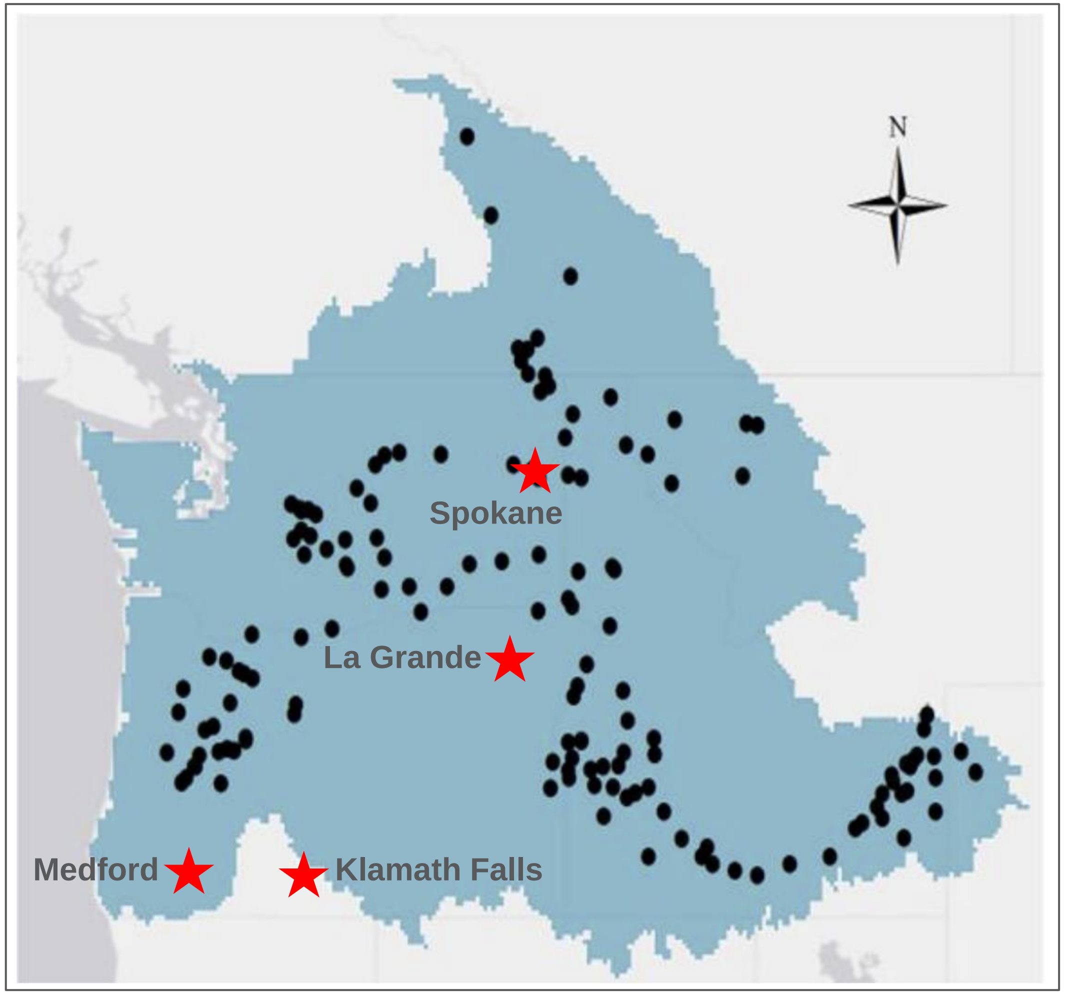
Climate Change Weather

Mike Hermanson

Tom Pardee

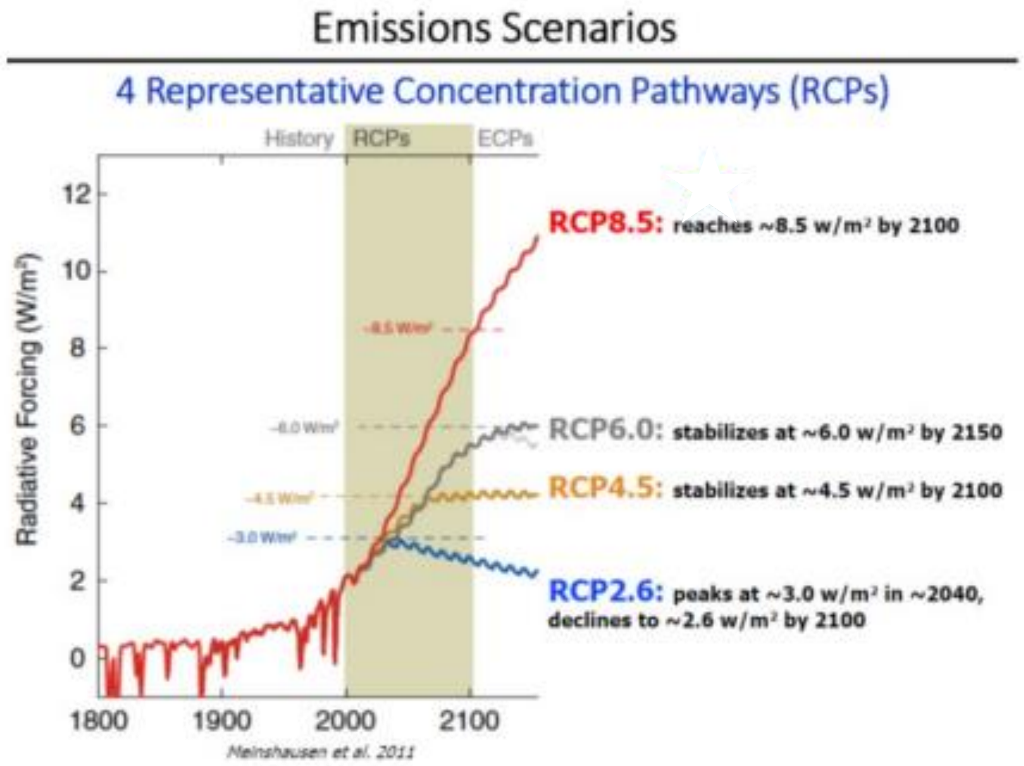
Climate Change Data Sources

- Climate and Hydrology Datasets for RMJOC Long-Term Planning Studies: Second Edition
  - River Management Joint Operating Committee (RMJOC)
    - BPA, US Army Corps of Engineers, US Bureau of Reclamation
  - Research Team
    - University of Washington, Oregon State University
- Daily Max/Min Temp available for 1950-2099



Global Climate Models

- Global Climate Models (GCMs)
  - Coarse resolution ranging from 75 to 300 km grid size
  - Provides projections of temperature and precipitation
  - Multiple Representative Concentration Pathways (RCP 8.5)
  - 10 GCM models used in study
    - CanESM2 (Canada)
    - CCSM4 (US)
    - CNRM-CM5 (France)
    - CSIRO-Mk3-6-0 (Australia)
    - GFDL-ESM2M (US)
    - HadGEM2-CC (UK)
    - HadGEM2-ES (UK)
    - inmcm4 (Russia)
    - IPSL-CM5-MR (France)
    - MIROC5 (Japan)



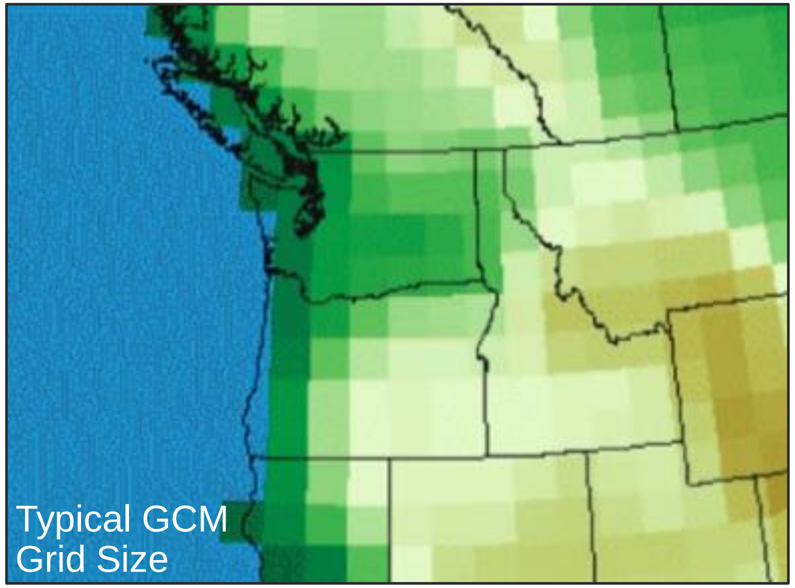
Representative Concentration Pathways

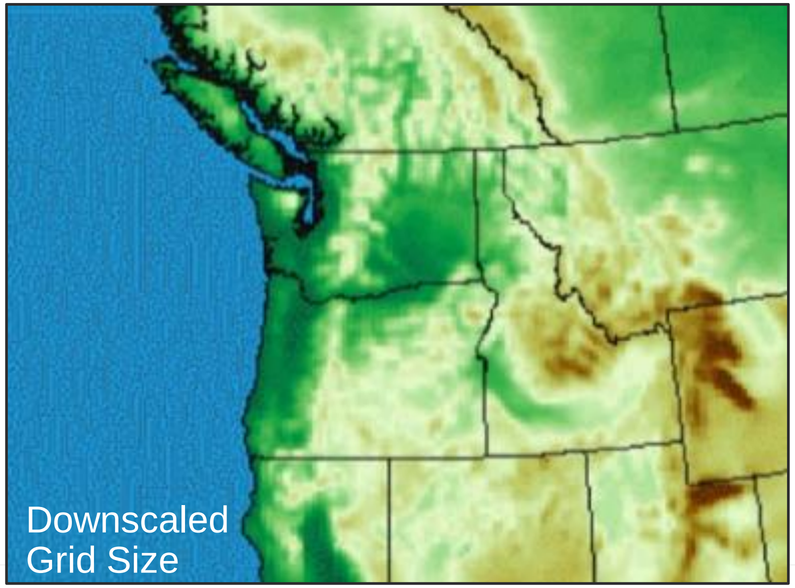
- Description by Intergovernmental Panel on Climate Change (IPCC)
  - RCP2.6 – stringent mitigation scenario
  - RCP4.5 & RCP6.0 – intermediate scenarios
  - RCP8.5 – very high GHG emissions
- RMJOCII Study evaluated RCP4.5 and RCP8.5
- RCP4.5 and RCP6.0 similar within the IRP planning horizon

	Scenario	2046-2065		2081-2100	
		Mean	Likely range	Mean	Likely range
Global Mean Surface Temperature Change (C°)	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	**1.4**	**0.9 to 2.0**	**1.8**	**1.1 to 2.6**
	RCP6.0	**1.3**	**0.8 to 1.8**	**2.2**	**1.4 to 3.1**
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8

Downscaling Techniques

- Downscale GCM data to finer resolution necessary to model hydrology
  - Statistical methods to represent variation within large grid size
  - Two methods used (BCSD, MACA)
    - Bias Corrected Spatial Disaggregation
    - Multivariate Adaptive Constructed Analog
- 18 modeled data sets available for Spokane, Medford, and La Grande
- 9 modeled data sets available for Klamath Falls



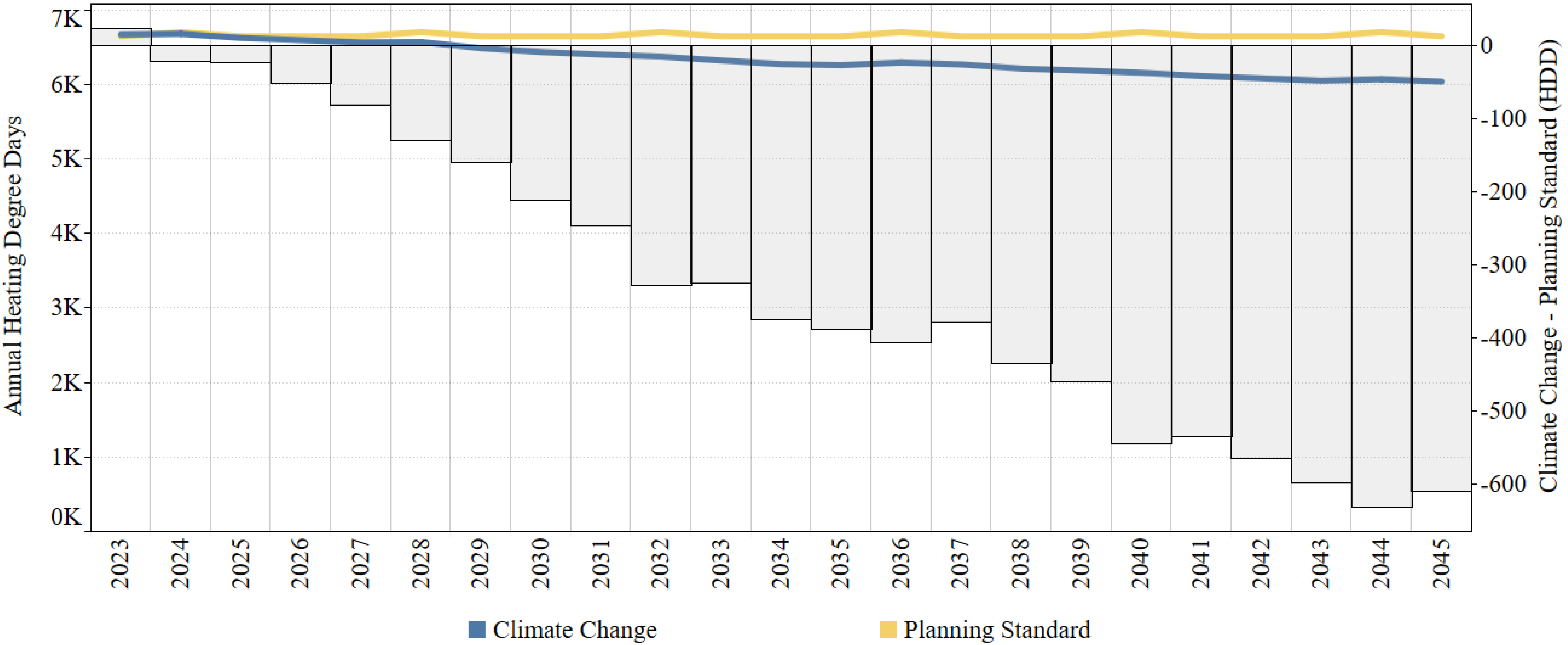


Weather Summary

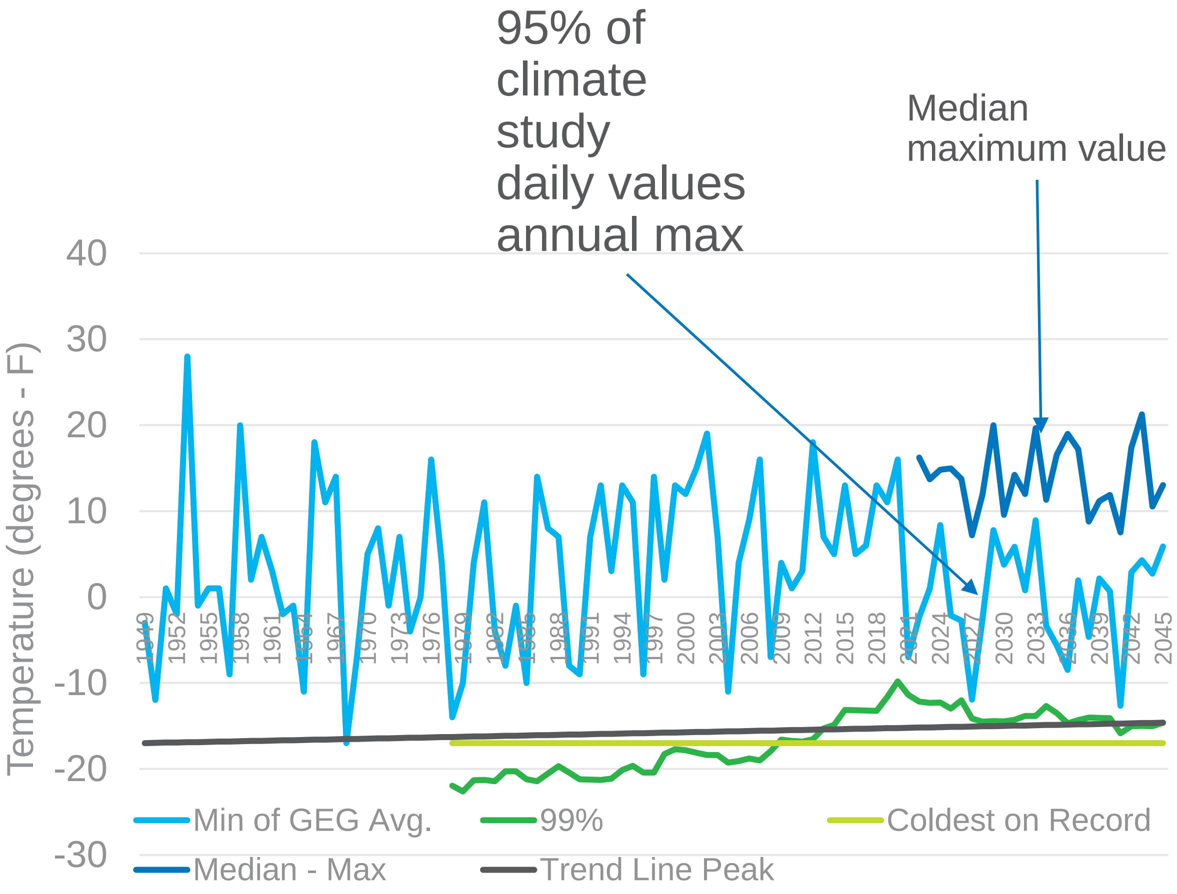
- Average daily weather by planning region for the prior 20 years including climate change weather data.
  - Example:
    - 2022 data is from 2002 – 2021
    - 2030 data is from 2010 – 2029
  - Median of daily values for all climate study results by area

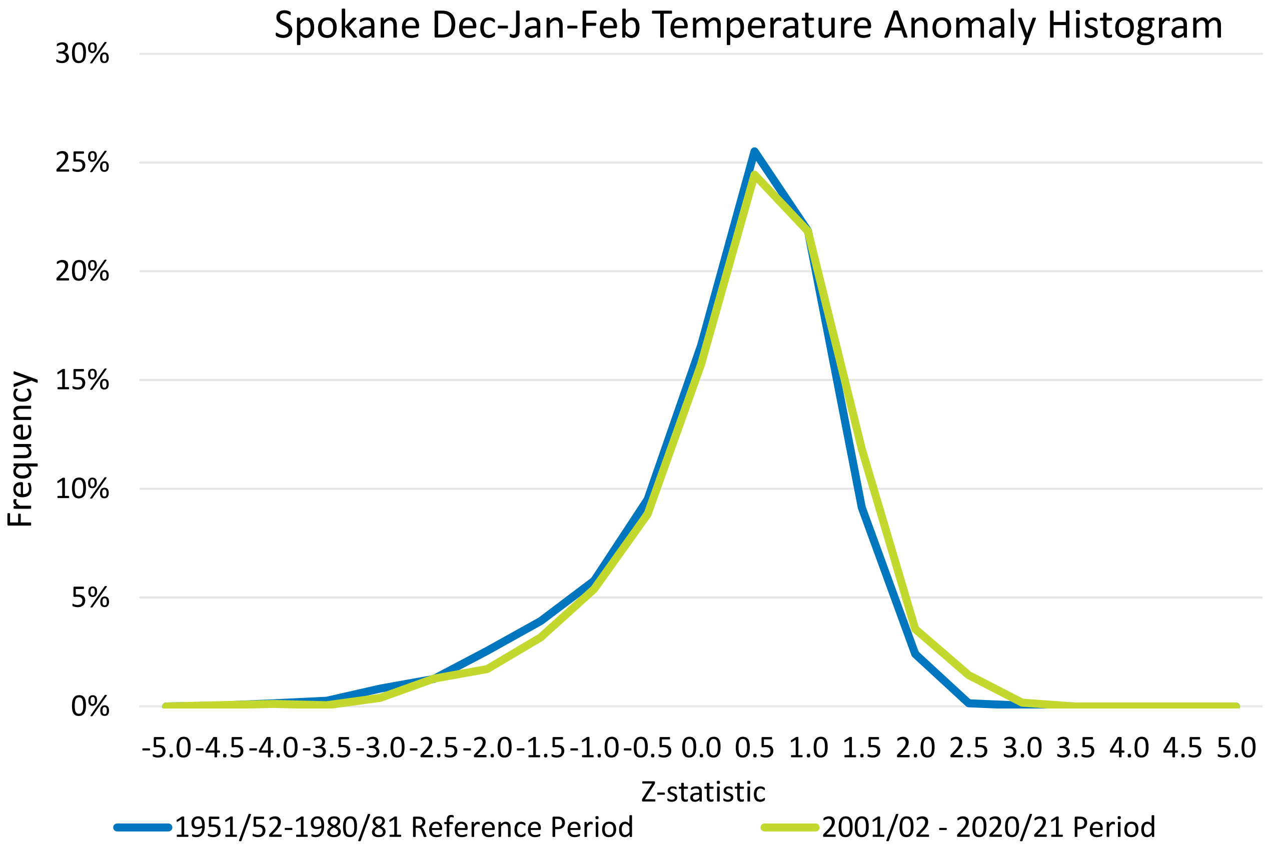
- A peak event by planning region based on the past 30 years of the coldest average day, each year, combined with a 1% probability of a weather occurrence
  - Calculation now includes future projected peak values and is trended to the 2045 value from the historic coldest on record to smooth out volatility of peak day temperatures
  - Using the median values as peak day drastically reduces the temperatures for the design weather day
  - Taking the 95th percentage of climate models daily results and utilizing the highest annual value to include in the peak calculation reduces this risk of unserved customers

Idaho – Washington

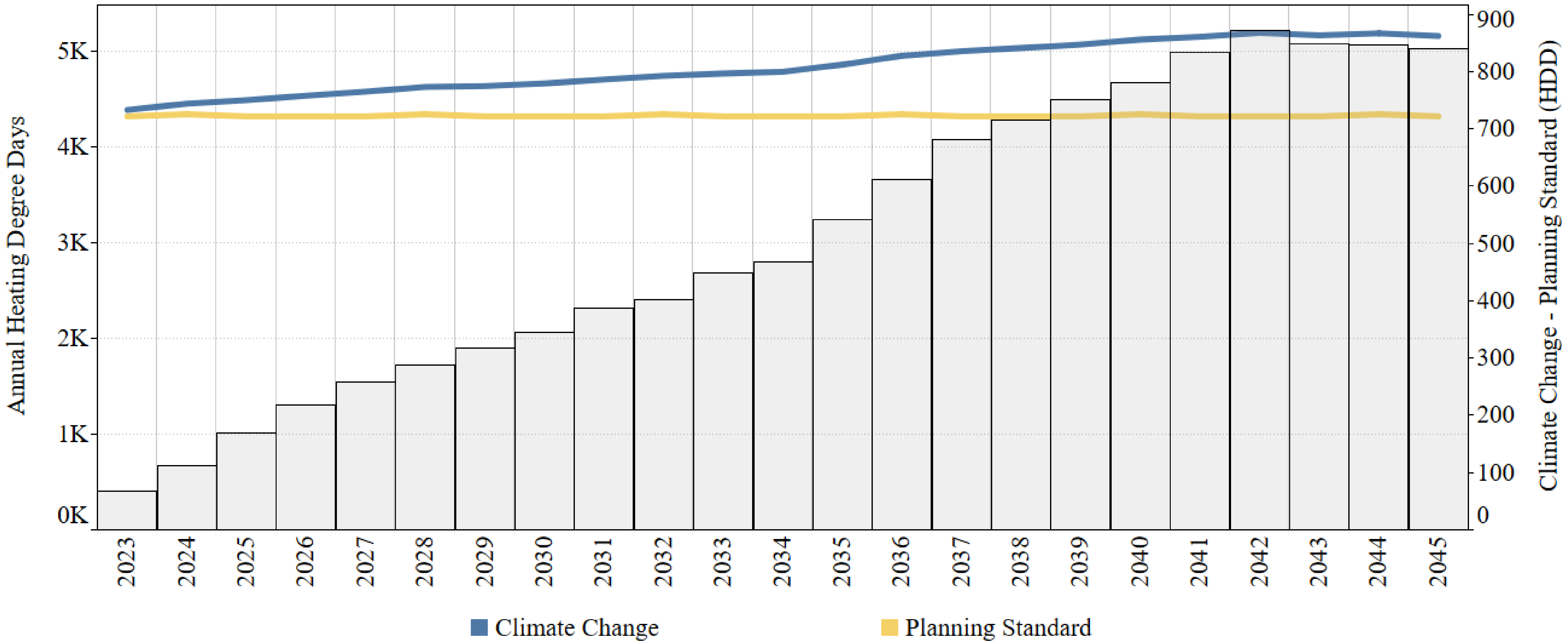


Idaho – Washington



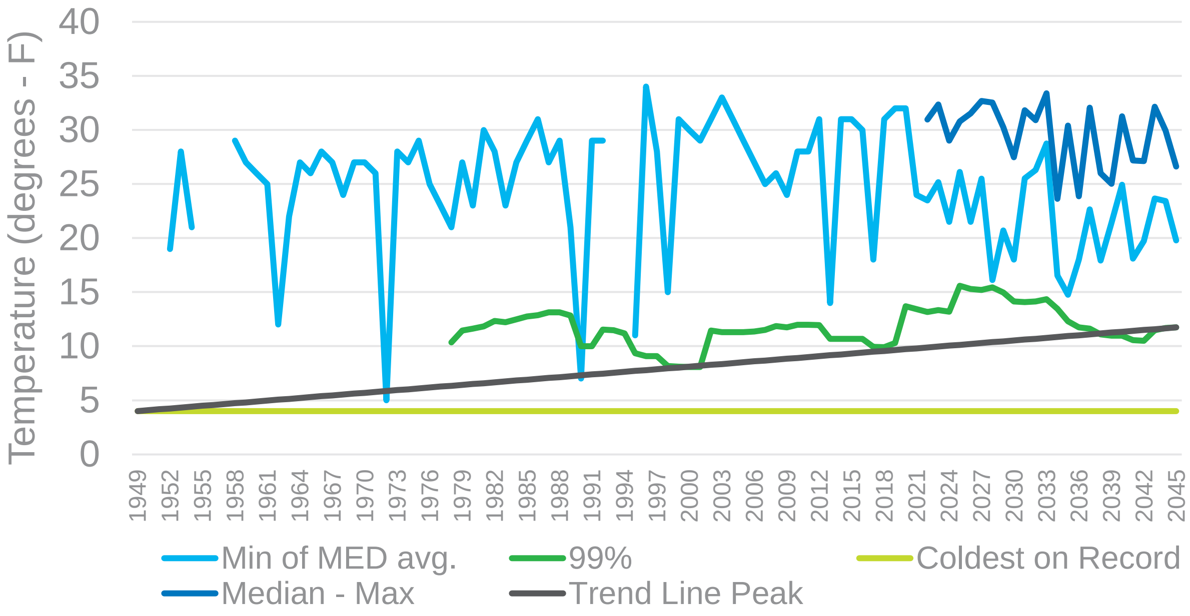


Medford

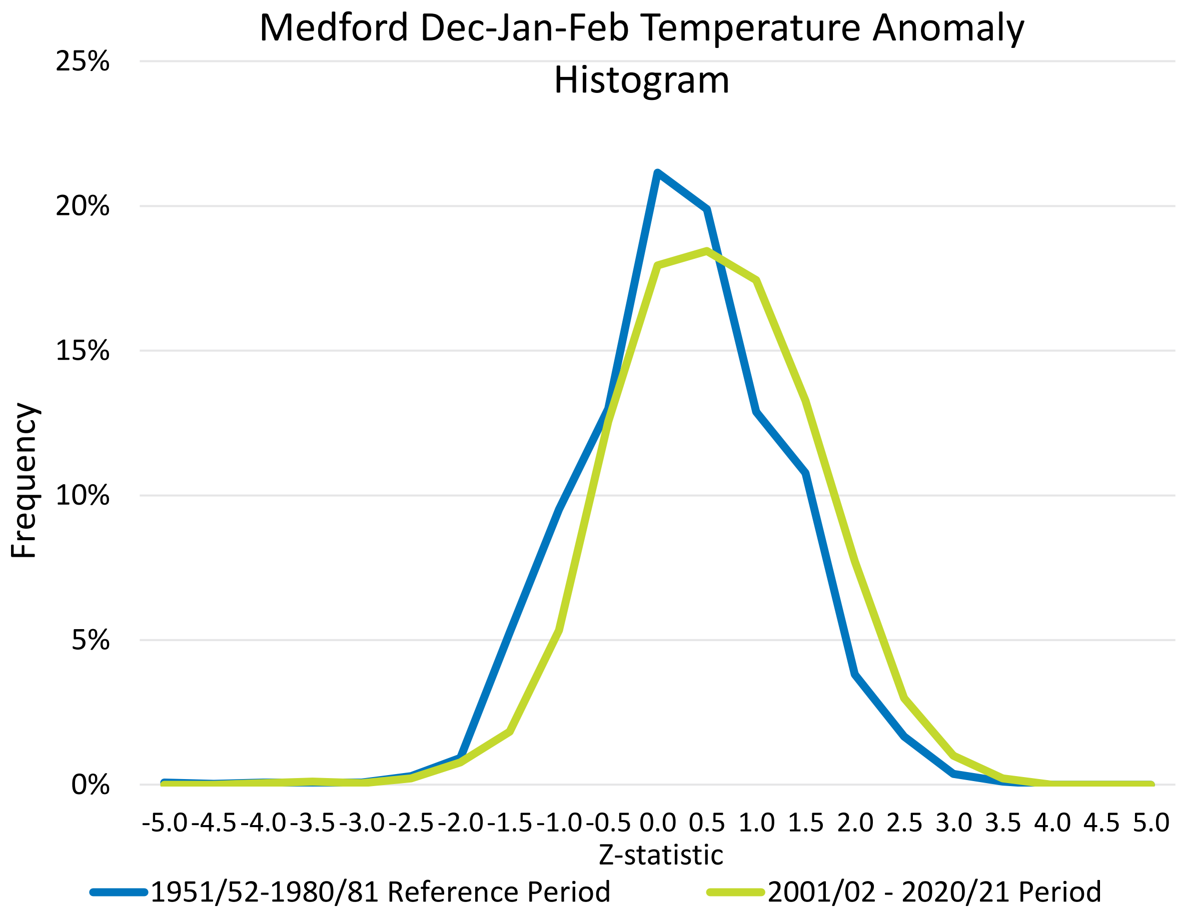


AVISTA

Medford

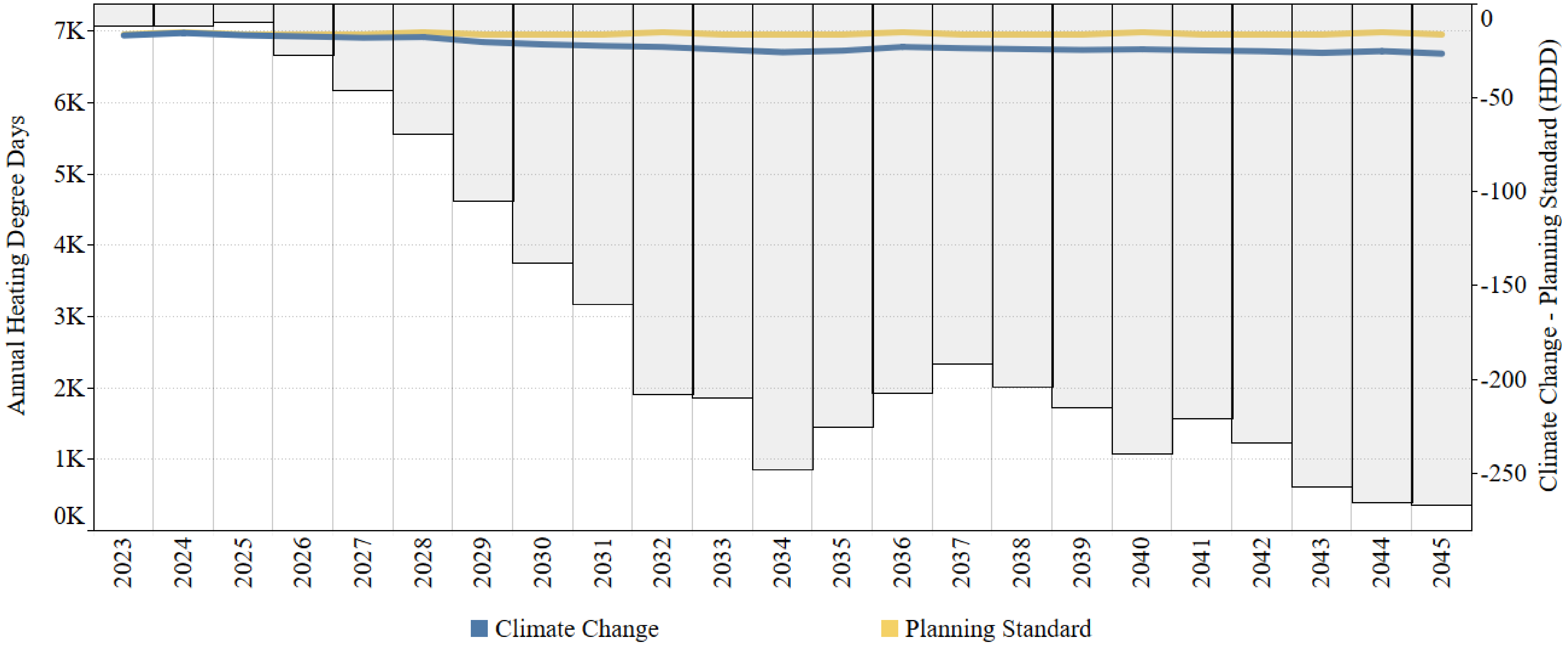


Temperature (degrees - F)
40
35
30
25
20
15
10
5
0
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
2024
2027
2030
2033
2036
2039
2042
2045
Min of MED avg.
99%
Coldest on Record
Median - Max
Trend Line Peak

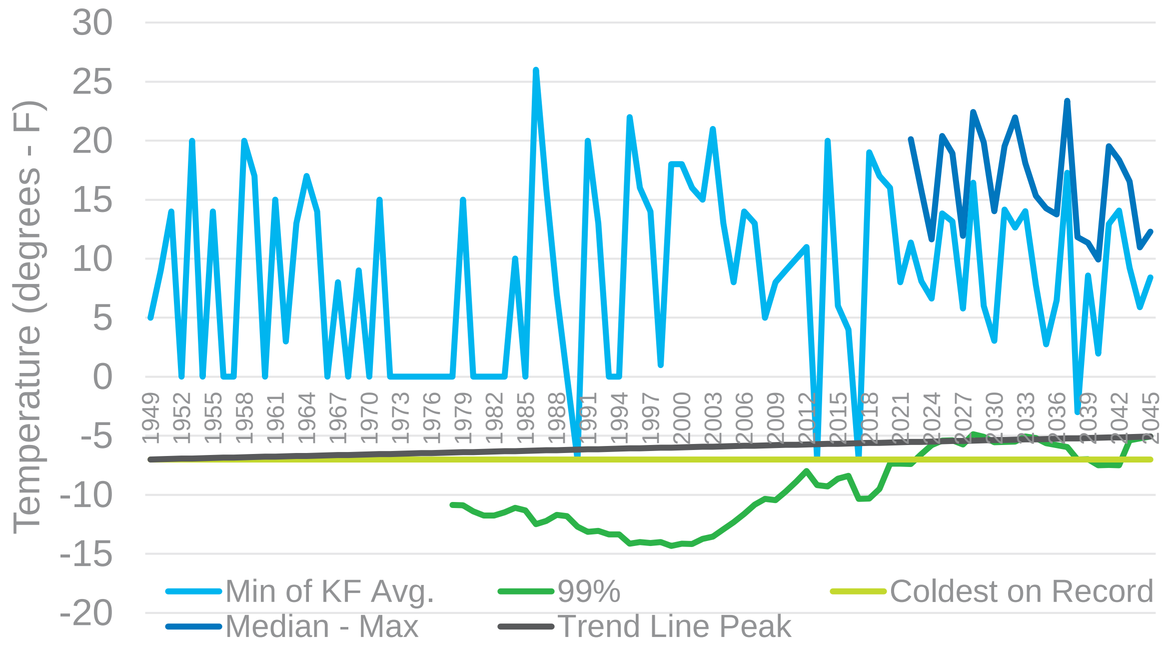


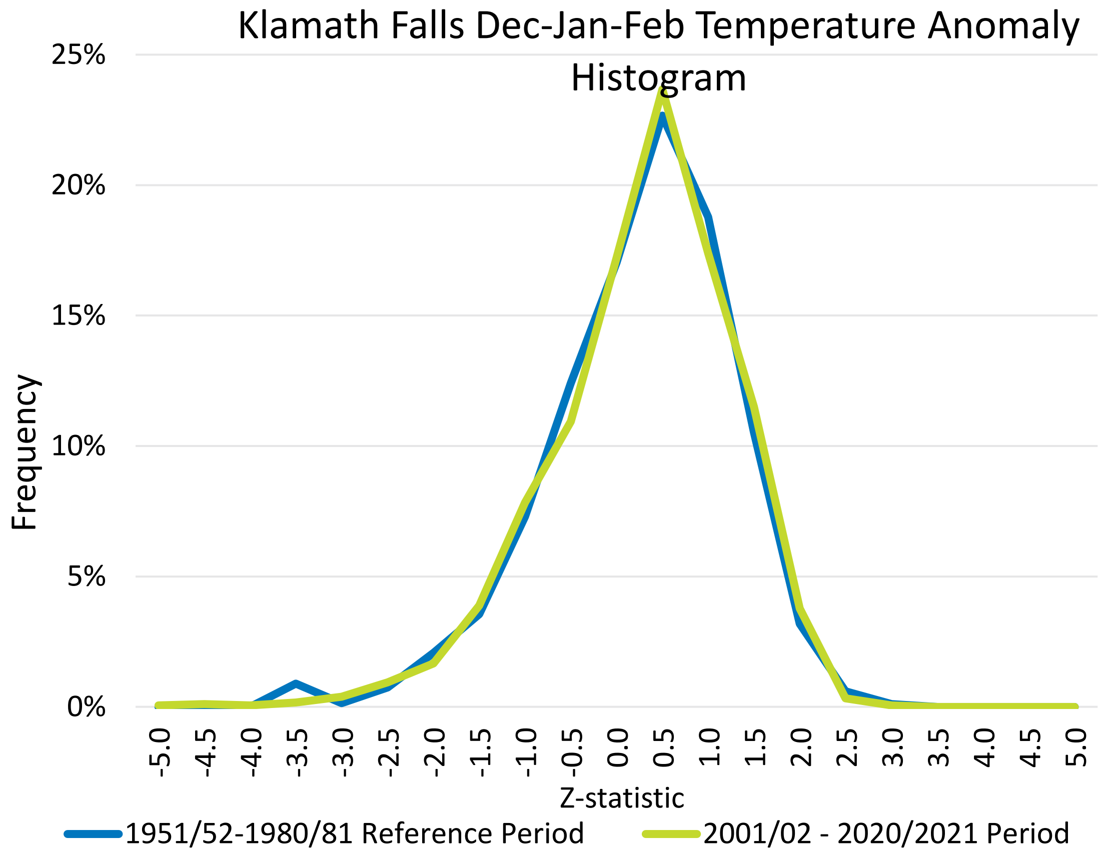
Medford Dec-Jan-Feb Temperature Anomaly Histogram
Frequency
25%
20%
15%
10%
5%
0%
-5.0 -4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Z-statistic
1951/52-1980/81 Reference Period
2001/02 - 2020/21 Period

Klamath Falls

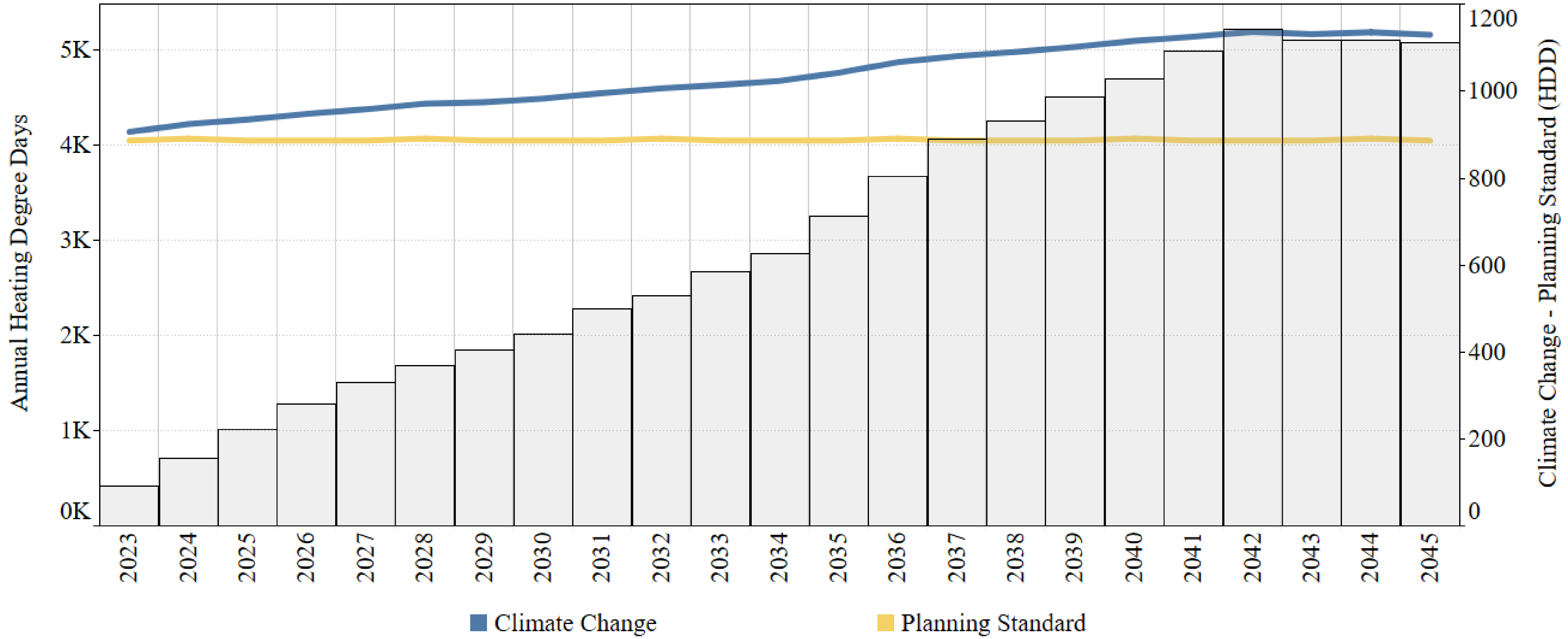


Klamath Falls



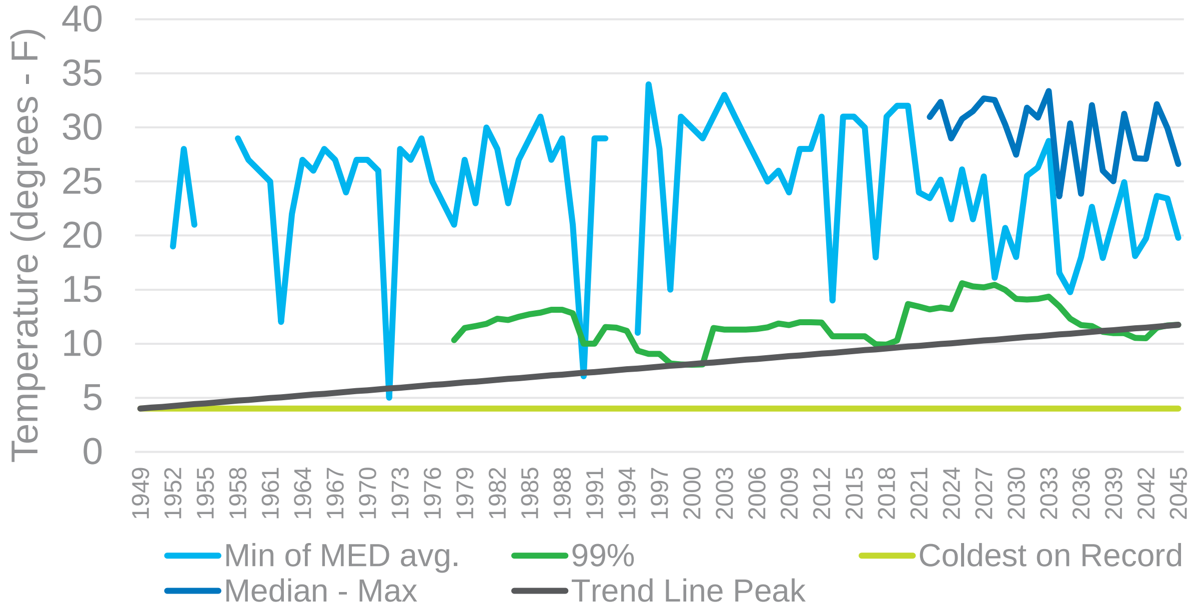


Roseburg

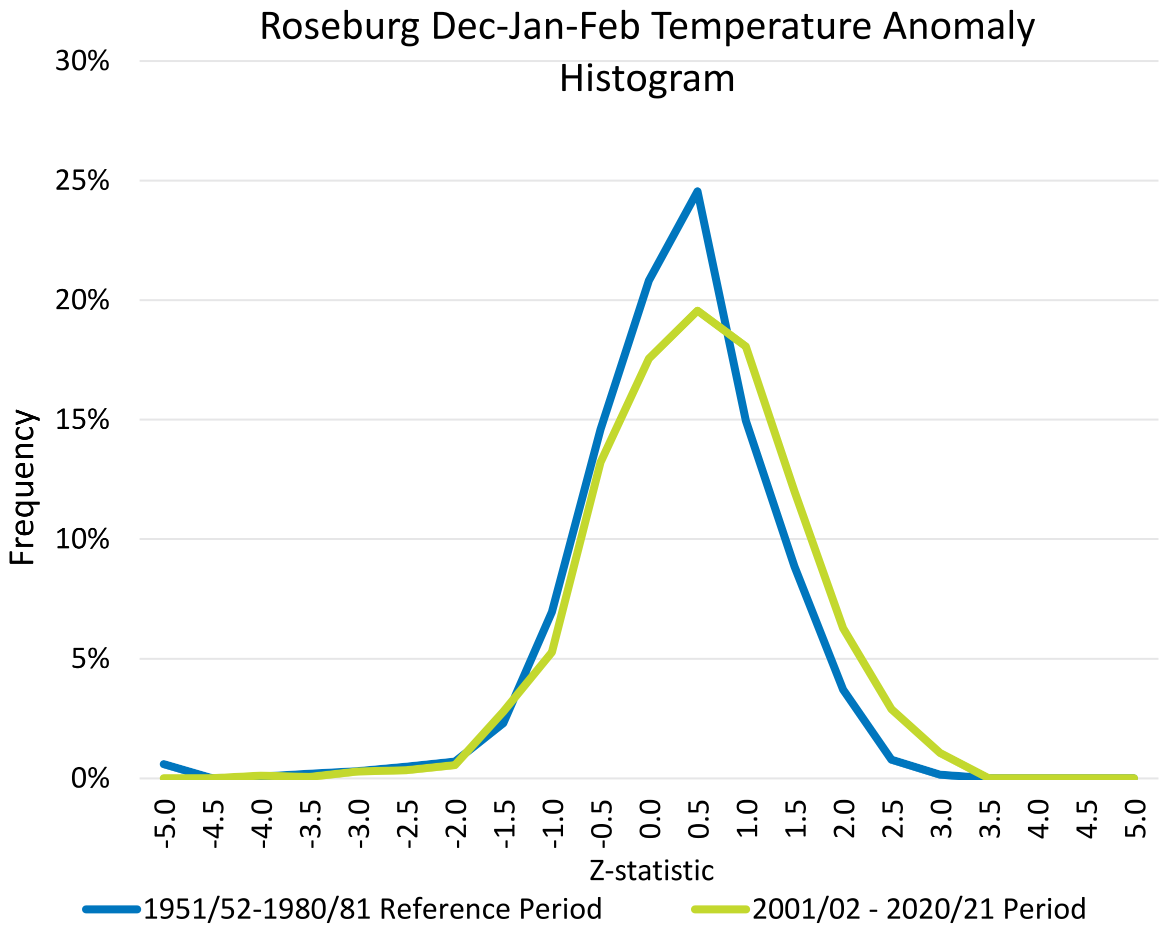


Annual Heating Degree Days
0K
1K
2K
3K
4K
5K
0
200
400
600
800
1000
1200
Climate Change - Planning Standard (HDD)
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
Climate Change
Planning Standard

Roseburg

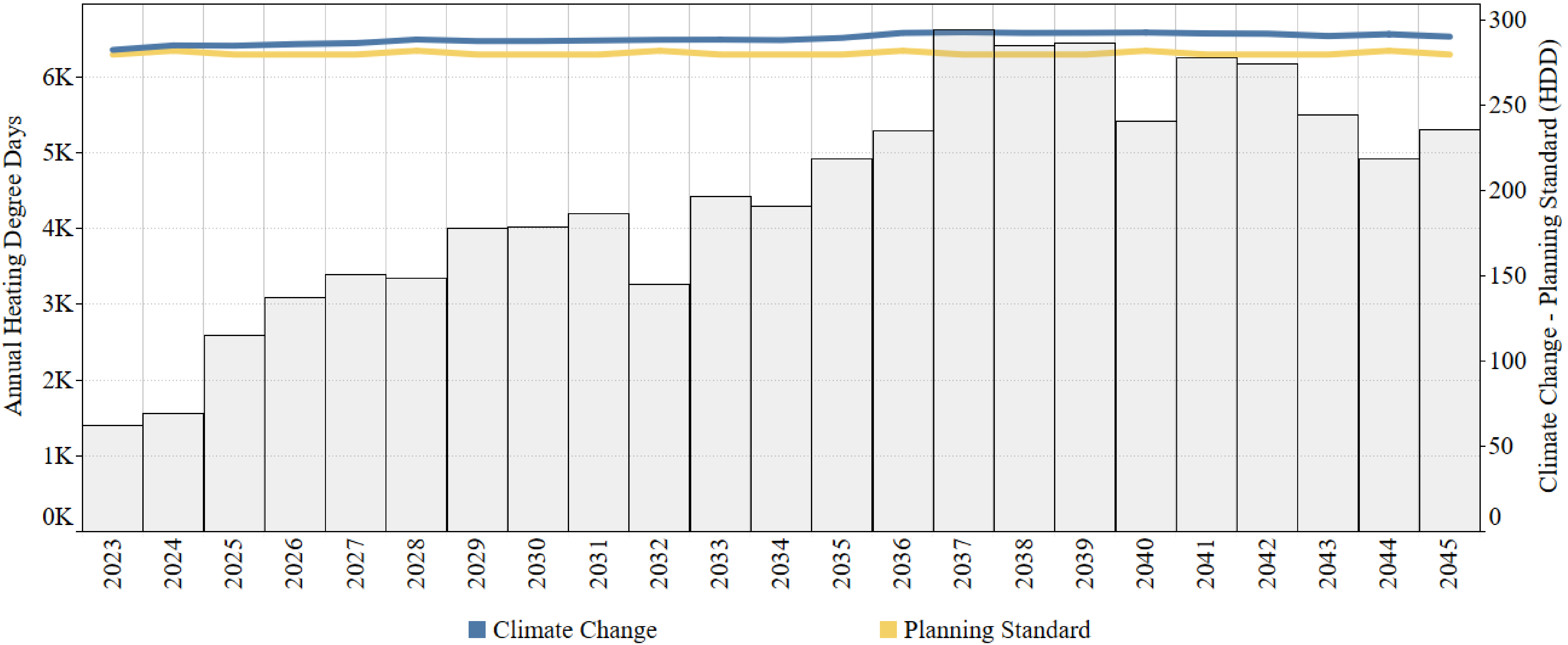


Temperature (degrees - F)
40
35
30
25
20
15
10
5
0
1949 1952 1955 1958 1961 1964 1967 1970 1973 1976 1979 1982 1985 1988 1991 1994 1997 2000 2003 2006 2009 2012 2015 2018 2021 2024 2027 2030 2033 2036 2039 2042 2045
Min of MED avg.
99%
Coldest on Record
Median - Max
Trend Line Peak



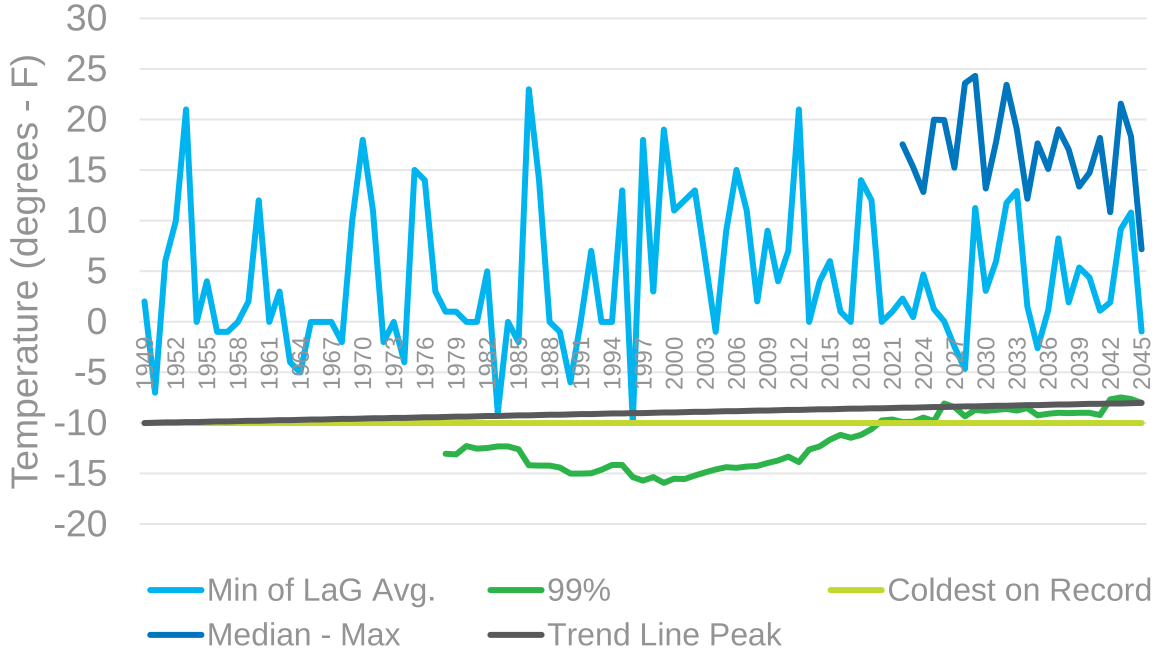
Roseburg Dec-Jan-Feb Temperature Anomaly Histogram
Frequency
30%
25%
20%
15%
10%
5%
0%
-5.0 -4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Z-statistic
1951/52-1980/81 Reference Period
2001/02 - 2020/21 Period

La Grande

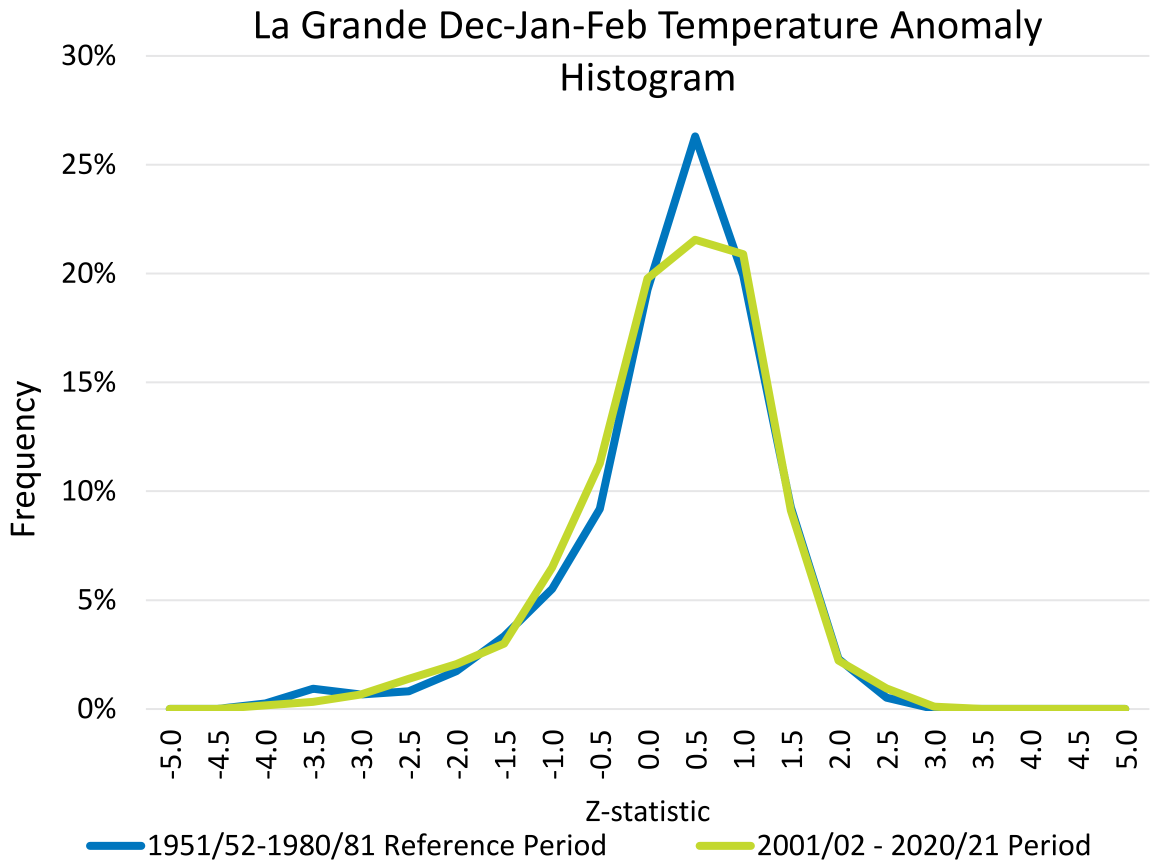


Annual Heating Degree Days
0K
1K
2K
3K
4K
5K
6K
Climate Change - Planning Standard (HDD)
0
50
100
150
200
250
300
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
Climate Change
Planning Standard

La Grande



30
25
20
15
10
5
0
-5
-10
-15
-20
Temperature (degrees - F)
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
2024
2027
2030
2033
2036
2039
2042
2045
Min of LaG Avg.
99%
Coldest on Record
Median - Max
Trend Line Peak



La Grande Dec-Jan-Feb Temperature Anomaly Histogram
30%
25%
20%
15%
10%
5%
0%
Frequency
-5.0
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Z-statistic
1951/52-1980/81 Reference Period
2001/02 - 2020/21 Period

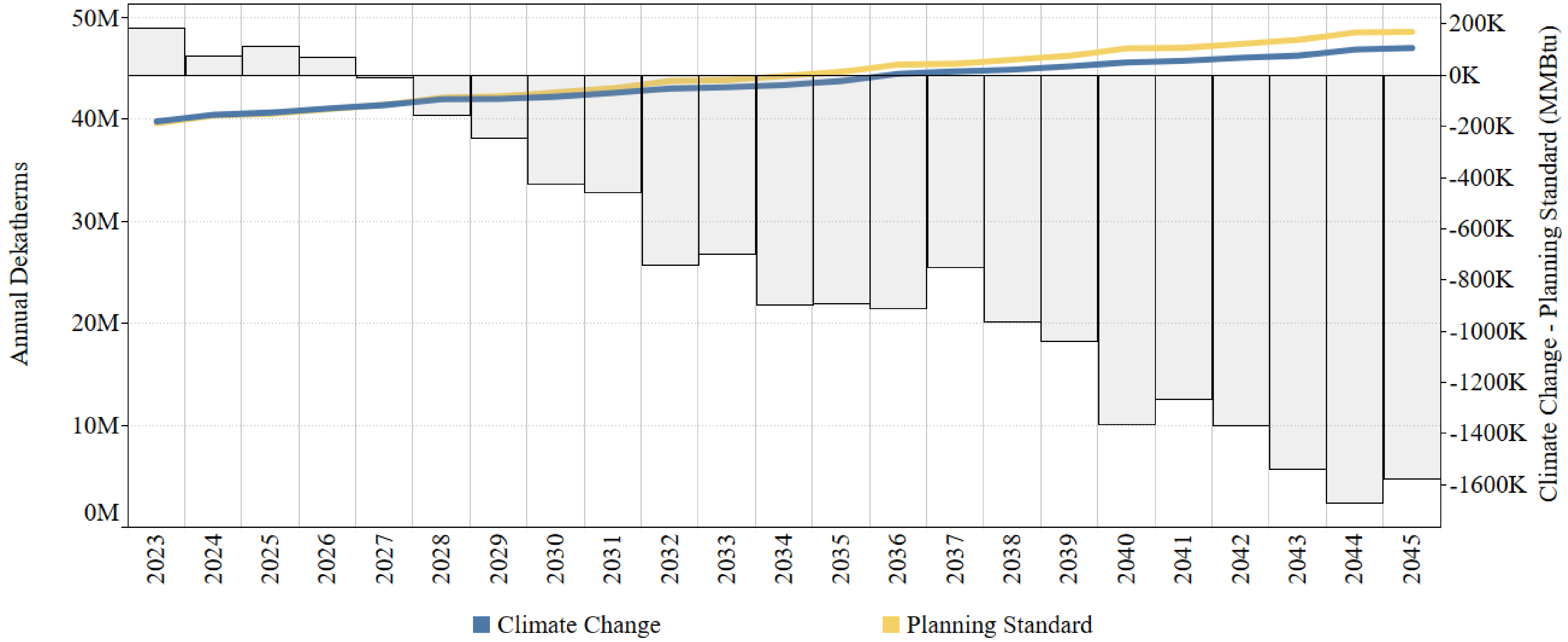
Peak Temp Changes
(degrees Fahrenheit)

Planning Region	Coldest on Record	2021 IRP Peak	Trended Peak 2045
La Grande, Oregon	-10	-11	-8.0
Klamath Falls, Oregon	-7	-9	-5.1
Medford/Roseburg, Oregon	4	11	11.7
Spokane, ID/WA	-17	-12	-14.6

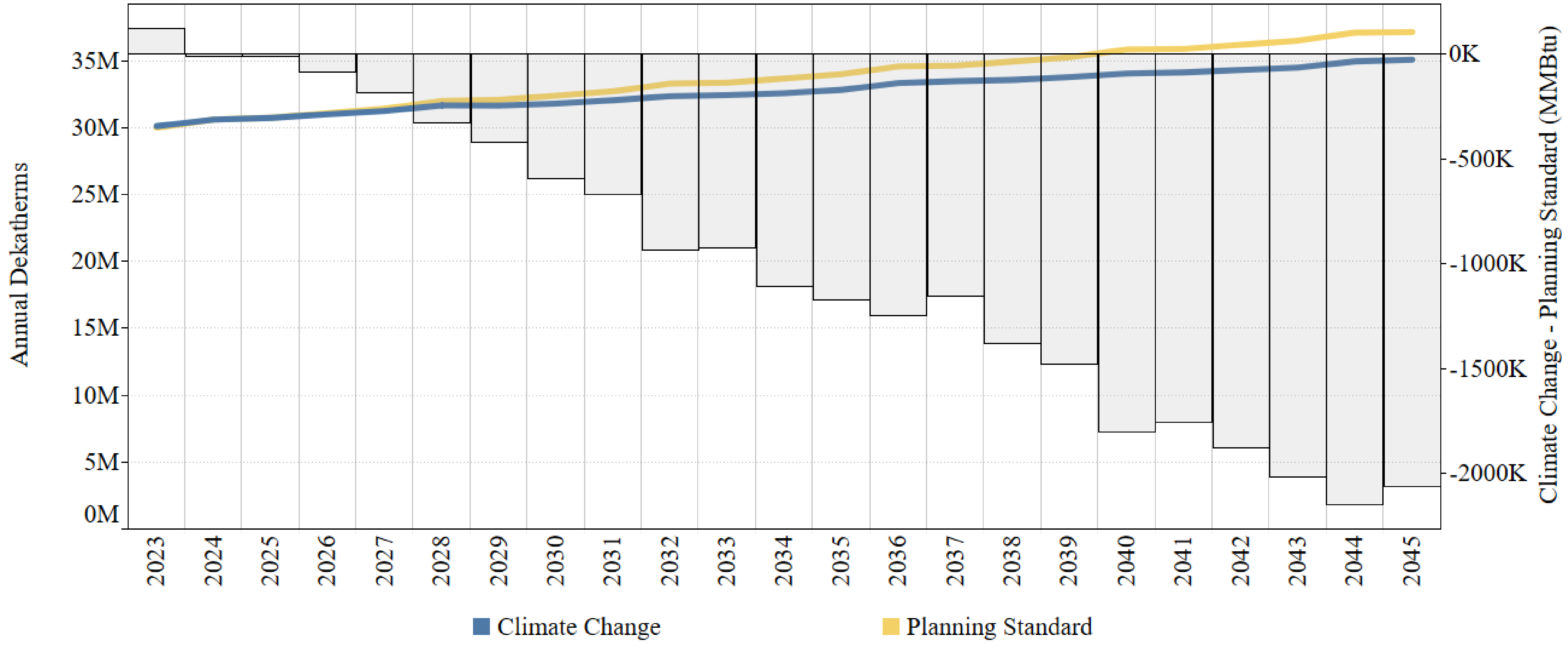
Updated Load Forecast
(includes climate change weather)

Michael Brutocao

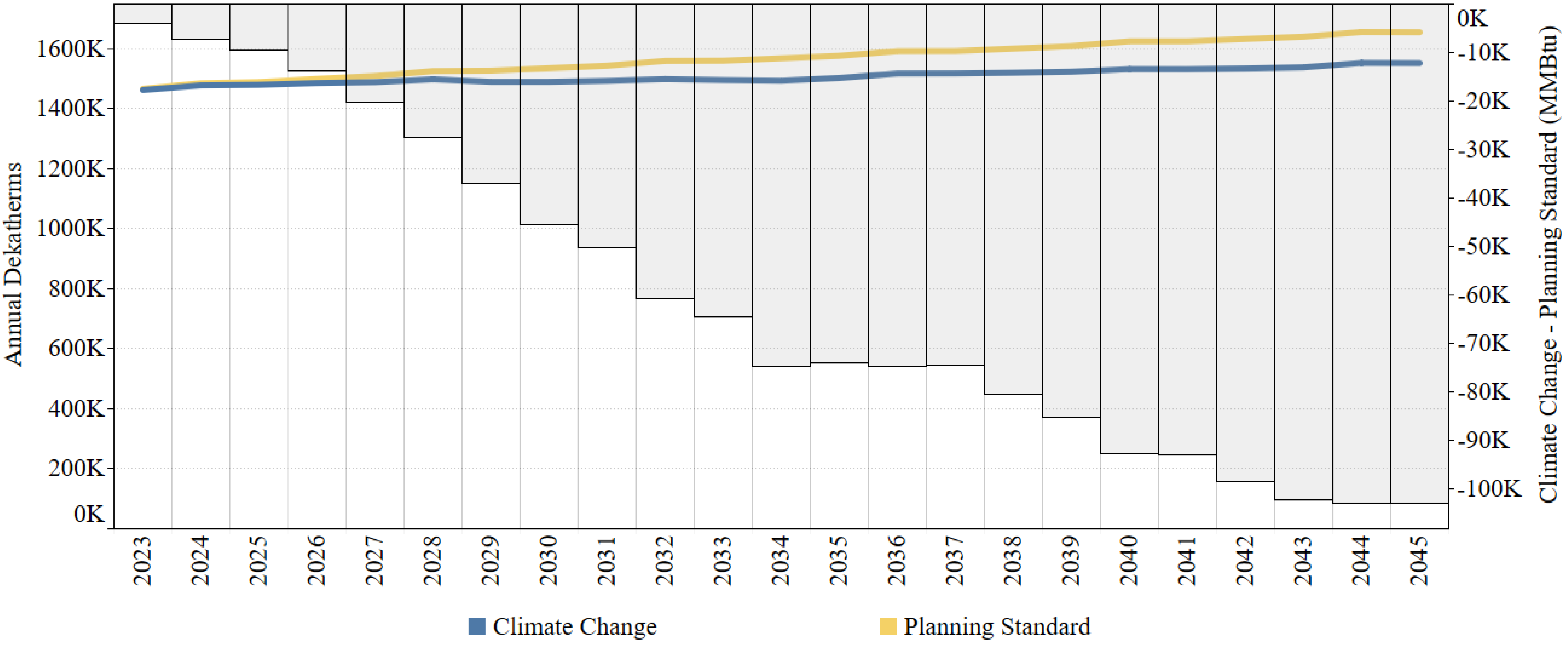
Annual System



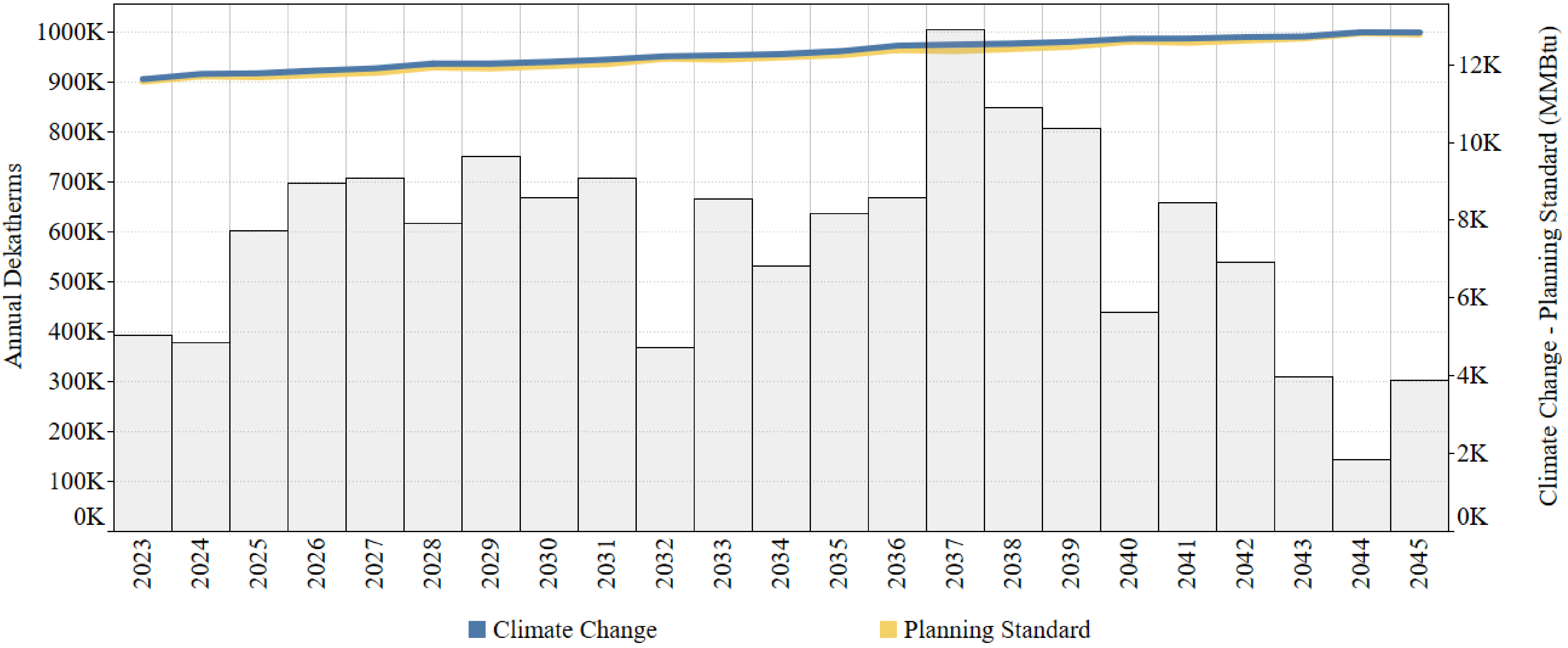
Annual Idaho – Washington



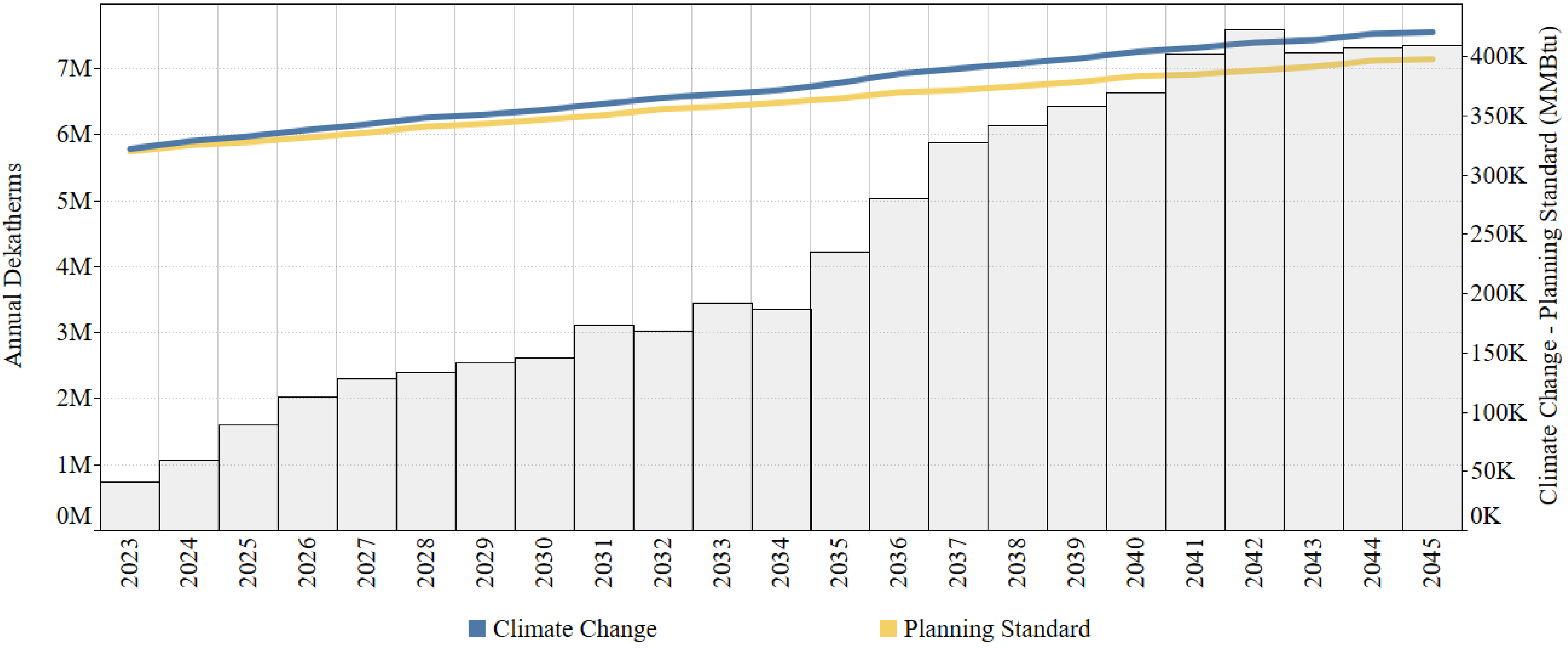
Annual Klamath Falls



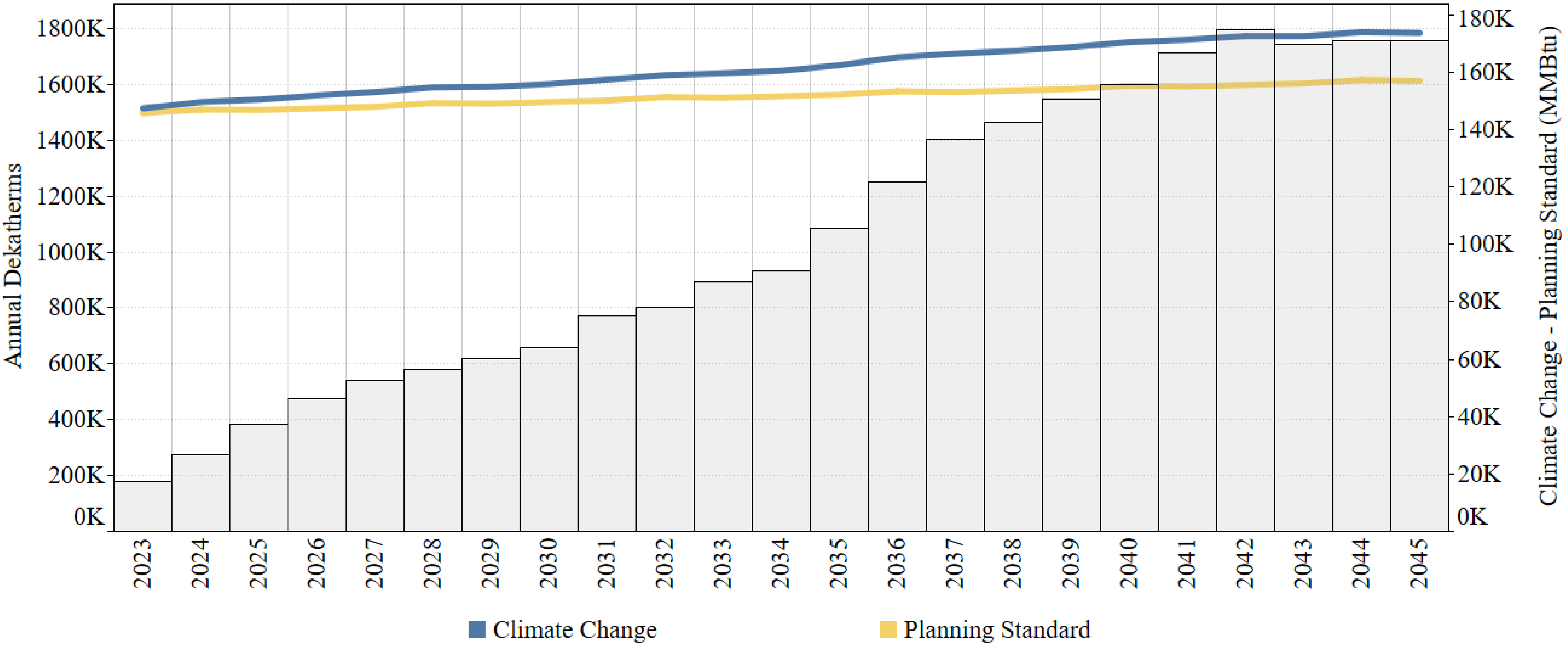
Annual La Grande



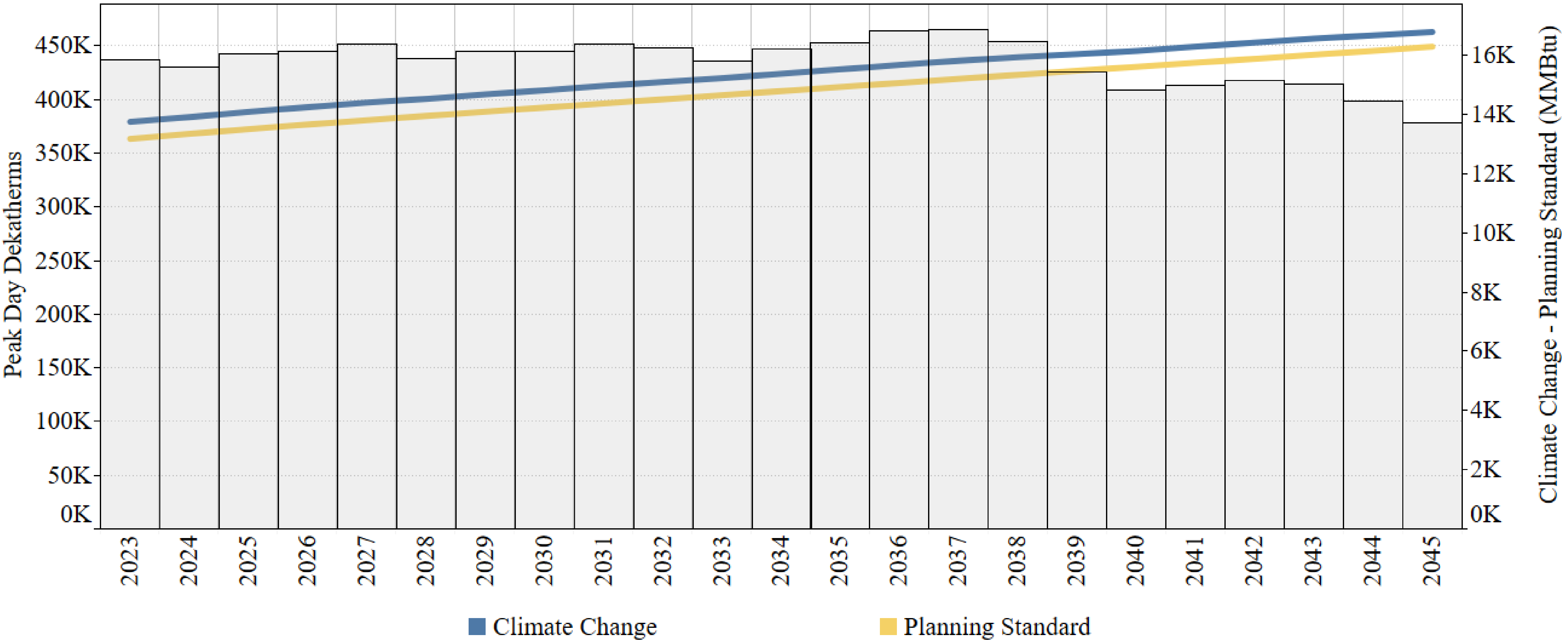
Annual Medford



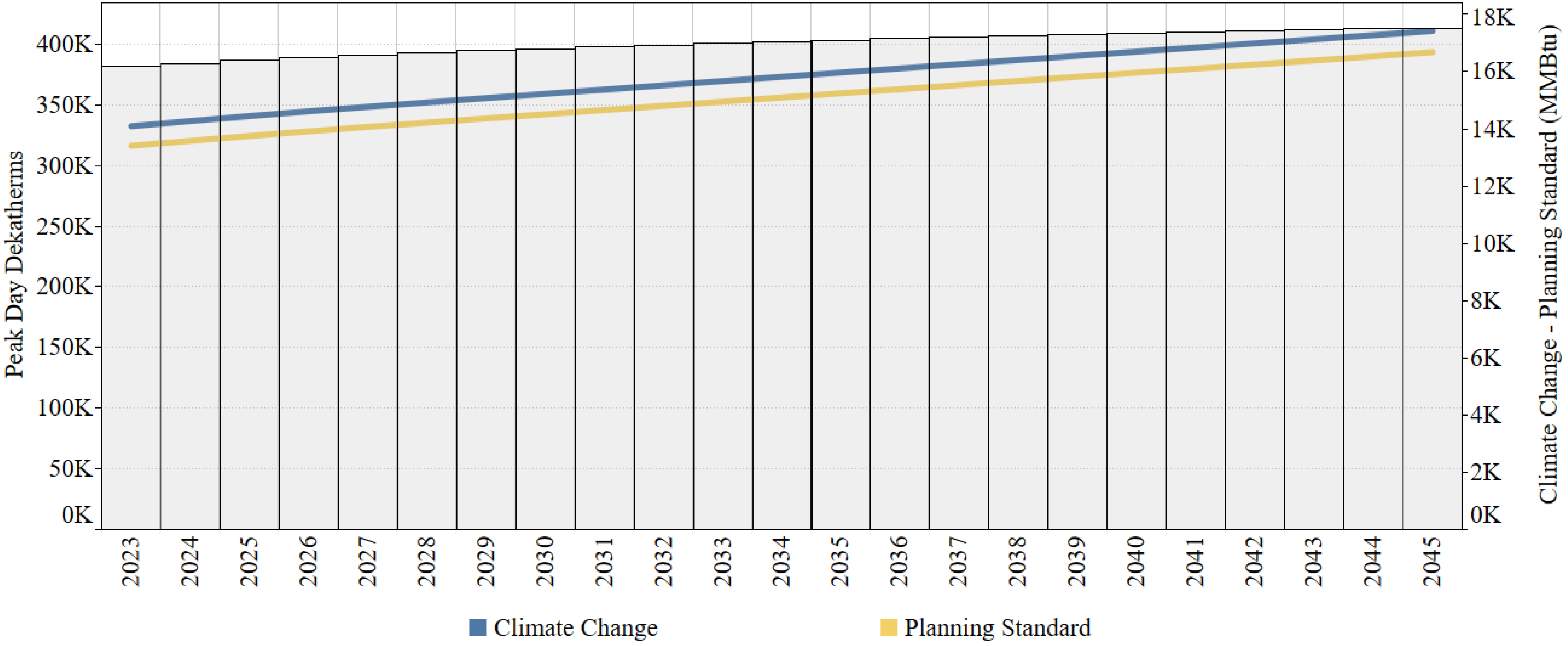
Annual Roseburg



System Peak Day (Feb 28)

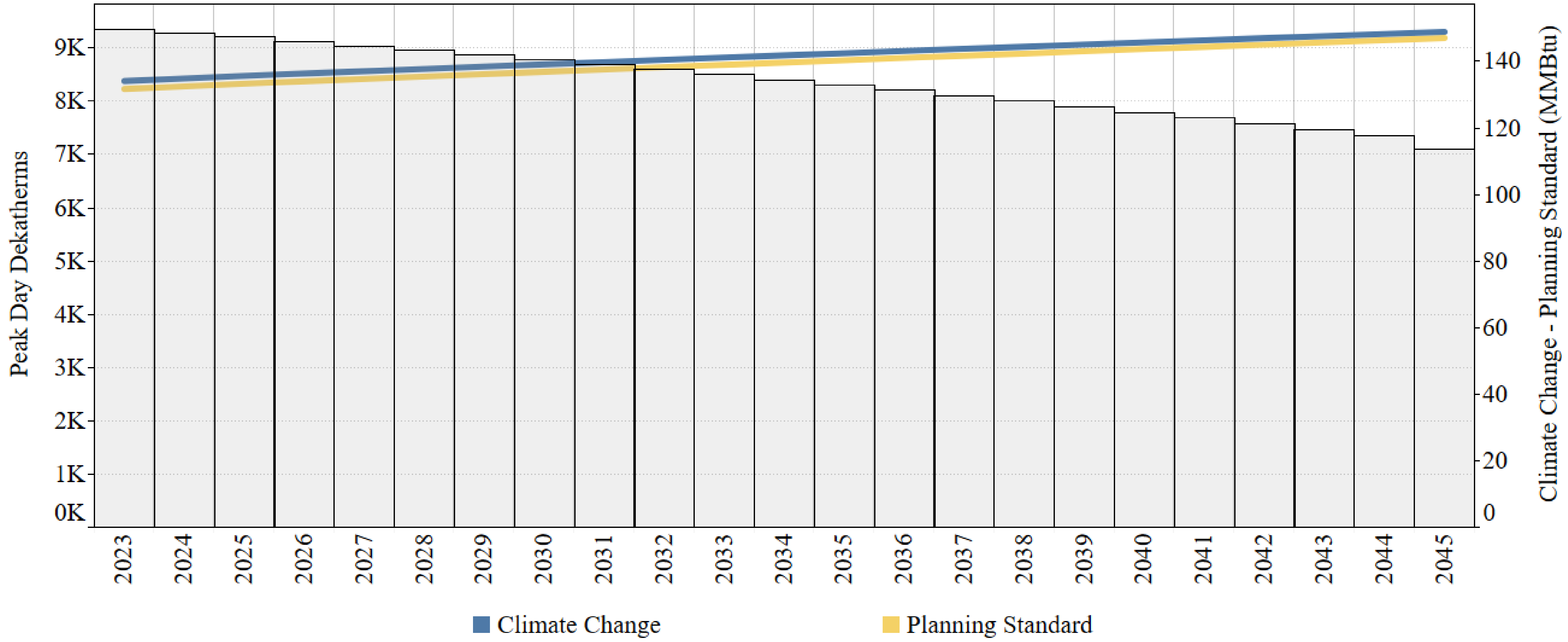


Idaho – Washington Peak Day (Feb 28)

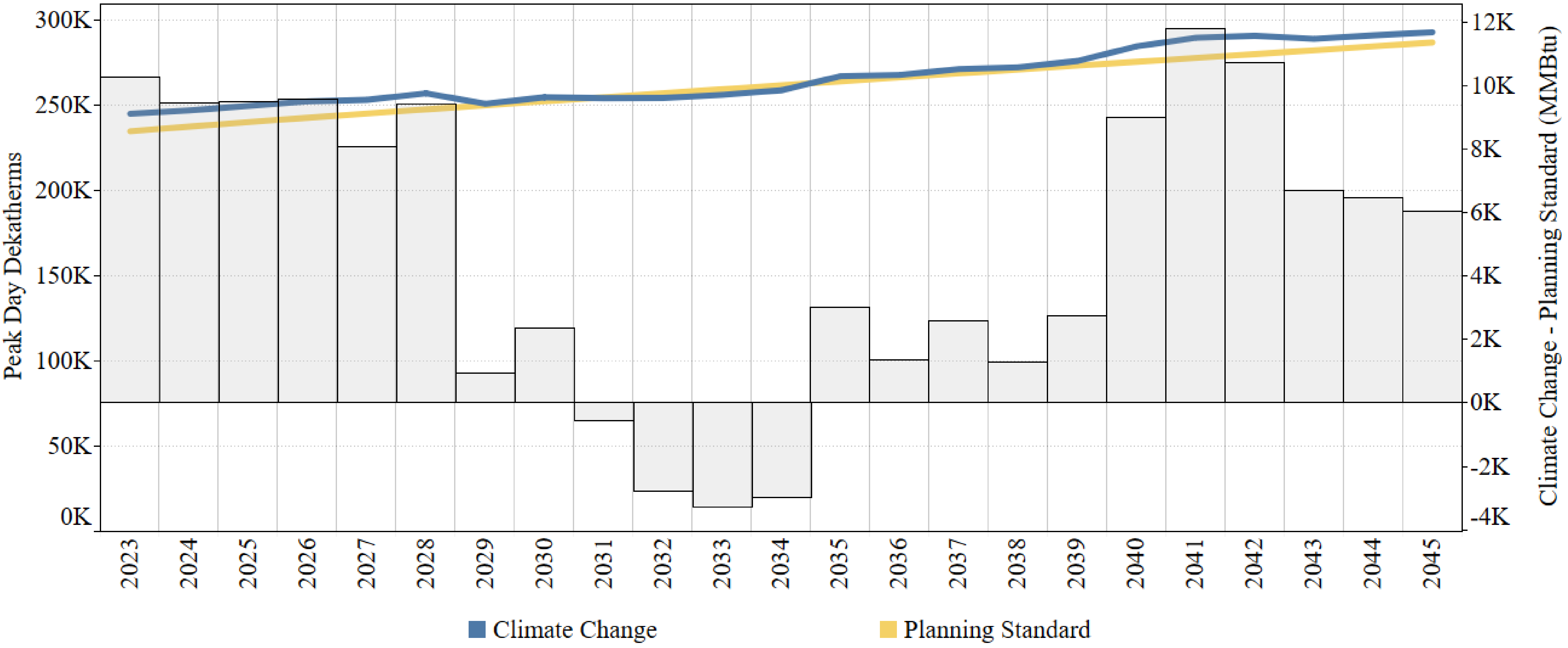


AVISTA

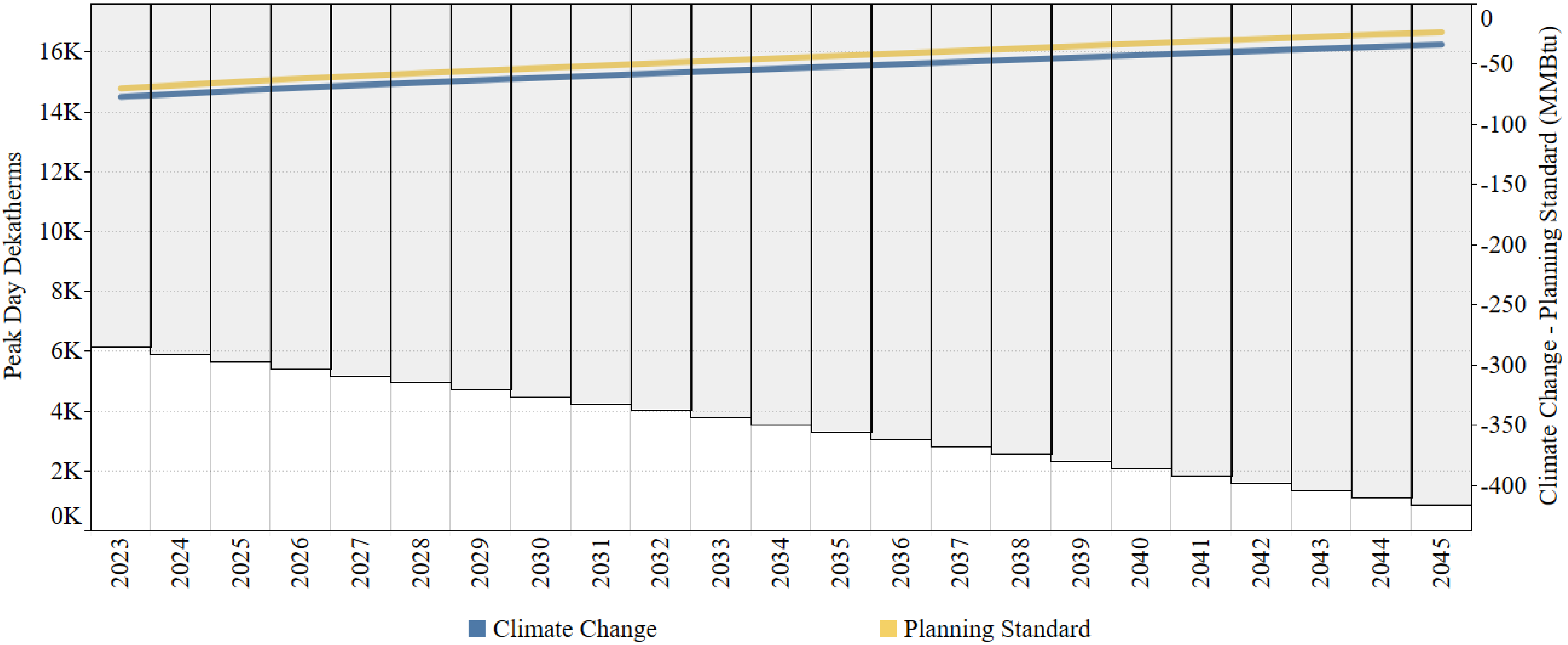
La Grande Peak Day (Feb 28)



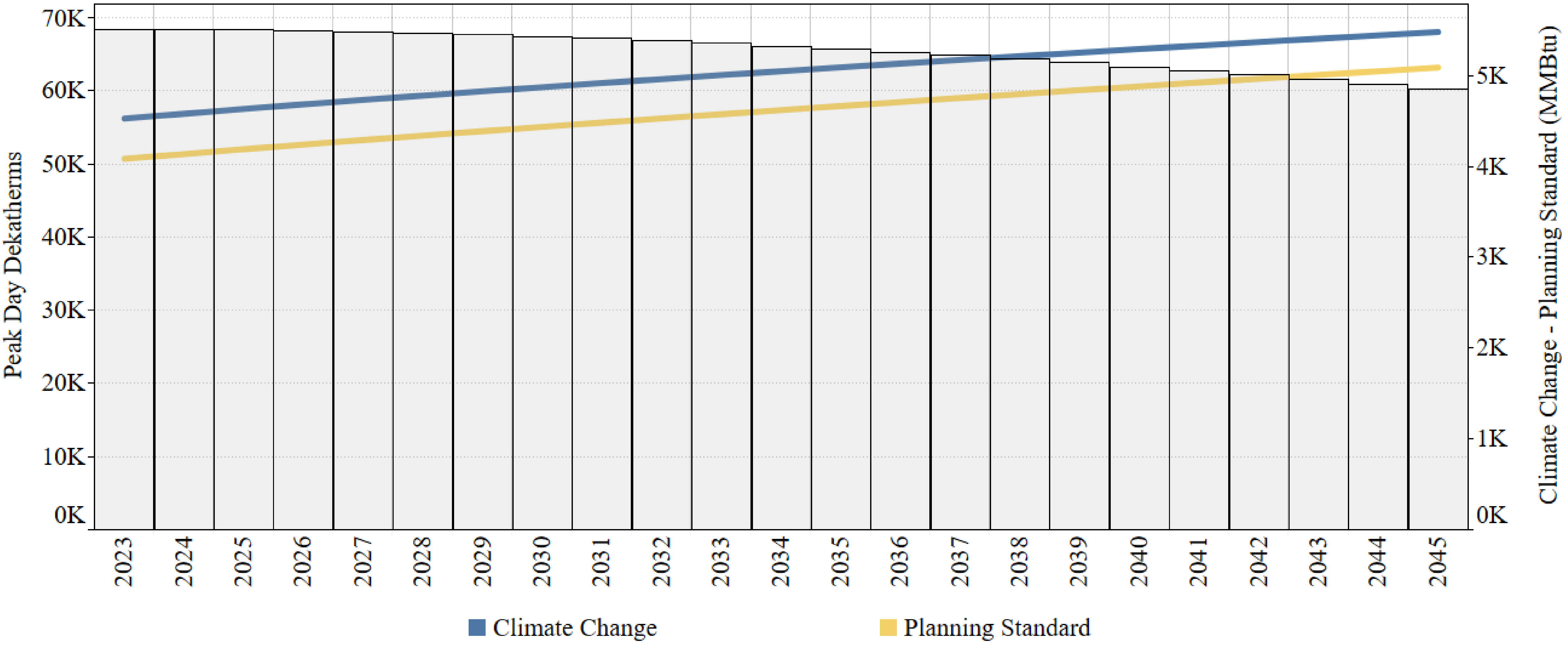
System Peak Day (Dec 20)



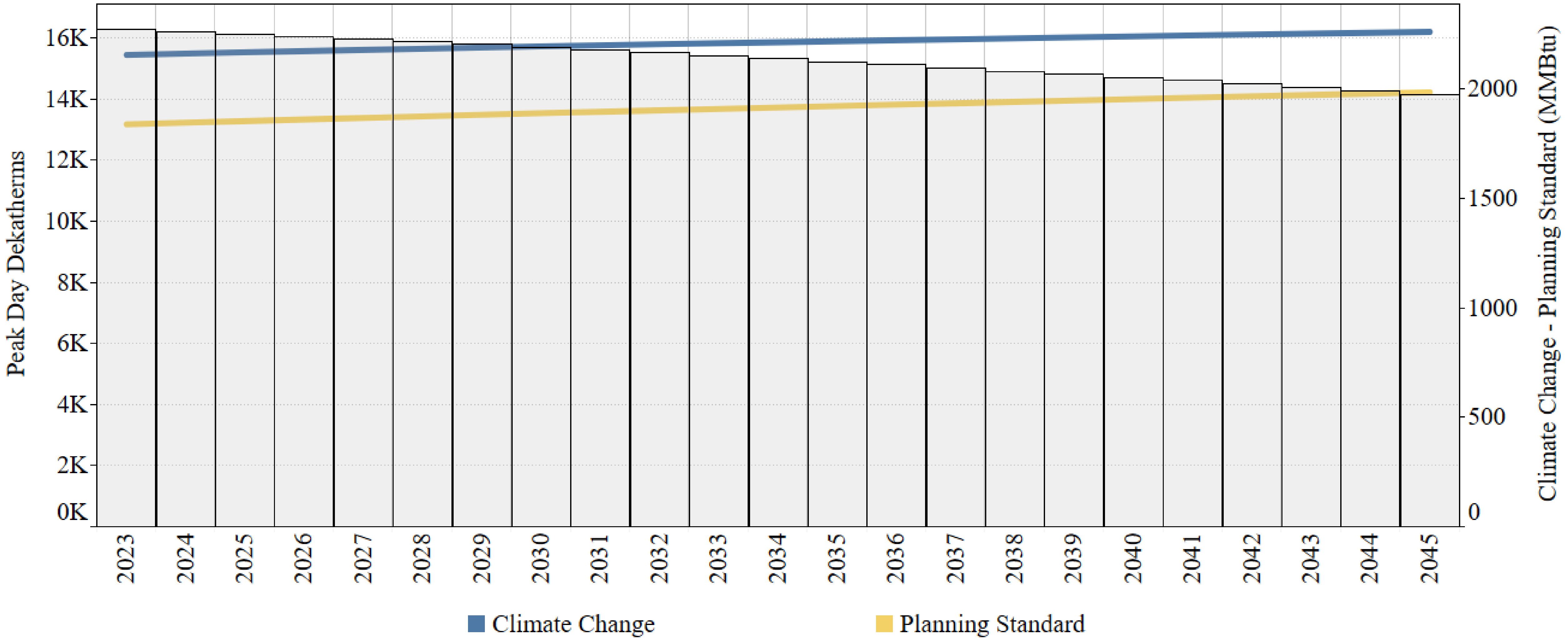
Klamath Falls Peak Day (Dec 20)



Medford Peak Day (Dec 20)



Roseburg Peak Day (Dec 20)



Scenarios

- **Preferred Resource Case** – Our expected case based on assumptions and costs with a least risk and least cost resource selection
- **Preferred Resource Case Low Prices** – Same as PRS, but includes low price curve for natural gas
- **Preferred Resource Case High Prices** - Same as PRS, but includes high price curve for natural gas
- **Electrification Expected Conversion Costs –** Expected conversion costs case to show the risk involved with energy delivered through the natural gas infrastructure moving to the electric system
- **Electrification Low Conversion Costs –** A low conversion cost case to show the risk involved with energy delivered through the natural gas infrastructure moving to the electric system
- **High Customer Case** – A high case to measure risk of additional customer and meeting our emissions and energy obligations
- **Limited RNG Availability** – A scenario to show costs and supply options if RNG availability is smaller than expected
- **Interrupted Supply** – A scenario to show the impacts and risks associated with large scale supply impacts and the ability for Avista to provide the needed energy to our customers
- **Carbon Intensity –** Include carbon intensity of all resources from Preferred Resource Case including upstream emissions on natural gas
- **Social Cost of Carbon** – A scenario to value resources in all locations using the Social Cost of Carbon @ 2.5% and includes upstream emissions
- **Average Case** – Non climate change projected 20-year history of average daily weather and excludes peak day
- **Hybrid Case** – Natural Gas used for space heat below 40º F while transferring all other usage to electricity.

2023 – Avista Natural Gas IRP