Technical Appendix F: Electricity Demand Forecast

Contents

Introduction

The electricity demand forecast is a power plan requirement. Per the Northwest Power Act, as part of its regional power plan, the Council is required to develop and include "a demand forecast of at least twenty years....".[1] The forecast doubles as both a key and early input to the planning process, as well as a final plan output. Therefore, two distinct forecast cycles are performed, separated in time, and with unique purposes. The first cycle occurs at the beginning of the power planning process and produces the *frozen-efficiency* forecast. The purpose of this forecast is to create an actionable set of demand inputs for the downstream power planning models and tools. The term *frozen-efficiency* means that the forecast does not assume new potential for demand side resources. Rather, the potential for those resources is captured in the energy efficiency, demand response, and behind-the-meter solar supply curves to provide resource options for the power planning models to consider alongside supply side options.[2] The second forecast cycle occurs at the end of the planning process when the selected demand side resources from the plan are factored into the demand forecast. This is known as the *sales forecast*.

Exactly how the future of electricity demand unfolds is uncertain. Therefore, the electricity demand forecast refers to a set of future outcomes that forms a range of potential demand. It is considered a long-term forecast since it projects demand out twenty years. It's more than just a glimpse of a far-off future; it also provides insights into the near term (one to three years) and mid-term demand for electricity. In fact, the forecast futures are developed specifically around the acknowledgement of near, mid, and long-term demand uncertainty.

The demand forecast is locational - each of the 13 balancing authorities that operate in the Northwest are represented. In addition, an overall system-wide energy and peak forecast is also produced. For time-scale, the forecast is divided into hourly, monthly and annual demand segments. Forecasting is done on the sector level - residential, commercial and industrial - and for other special classes such as electric vehicles, data centers, and rooftop solar.

[1] Northwest Power Act, Section 4(e)(3)(F).

[2] Technical Appendices H, I, and J cover the development of potential supply curves for conservation, demand response, and rooftop solar, respectively.

Table F - 1: Demand Forecast Overview

Forecast horizon	2025 – 2046
Geographic unit locations	13 balancing authorities (referred to as Zones) and the entire Northwest region (System)
Future weather	3 climate model patterns 1 typical year pattern that reflects historical normals 26 weather stations
Forecast Pathways	5 unique pathways formed by combining input data sets which capture uncertainty and variability
Demand futures	20 5 pathways across 4 weather patterns
Forecast output time-scale	Annual, monthly, daily, hourly
Sectors	Residential, Commercial, Industrial
Other Classes	Data Centers, Electric Vehicles, Rooftop Solar, Energy Efficiency
Structure	A set of integrated models which incorporate end-use concepts into an econometric modeling framework

Forecast Framework

To develop the Ninth Plan Forecast, the Council enlisted Itron[3] to help us develop a new forecasting framework. The framework may be thought of as a set of integrated models. Individual energy regression models that create a forecast of monthly energy demand are integrated with electricity end-use, and zonal energy shaping models to produce daily and hourly energy demand.

[3] https://na.itron.com/en/categories/energy-forecasting.

Figure F - 1: Forecast Framework

Monthly Energy Models

- Forecast of overall demand for each zone
- Weather sensitive
- Disaggregated by sector (Res, Com , Ind)
- Further disaggregation by end-use

Shaping Models

- Hourly shaping for each zone
- End-use shaping (heat pump heat, water heat,…
- Weather sensitive
- Bottoms-up calibrated with top-down

New/Special Load Sources

- Energy and Shapes
- Rooftop Solar
- EE (2025, 2026 8th plan targets)
- Data centers
- Electric vehicles
- Building electrification

The monthly energy models are built out for each of the 13 balancing authorities, which are considered the 13 forecast zones for the demand forecast. These are individual regression models built up from historical data sets that cover the years 2010 through 2024. The zonal regression models are primarily a function of variables that cover heating demand, cooling demand, and all other demand, as shown in Figure F - 2

$$Demand(Zone, Month) = f(XHeat, XCool, XOther, other)$$

Figure F - 2: Monthly Energy Forecast Variables

XHeat Variable

- Res and Com sectors
- Building stock
- Saturation of electric heating related end-uses (like heat pumps, resistance heating,…)
- Efficiency of end-uses
- Economic factors like income, employment,…
- Weather – Zonal specific HDD splines

XCool Variable

- Res and Com sectors
- Building stock
- Saturation of electric cooling related end-uses (heat pumps, central AC,…)
- Efficiency of end-uses
- Economic factors like income, employment,…
- Weather – Zonal specific CDD splines

XOther Variable

- Res and Com sectors
- Building stock
- Saturation of non heating or cooling end-uses (electric water heating, electric cooking, …)
- Efficiency of end-uses
- Economic factors like income, employment,…

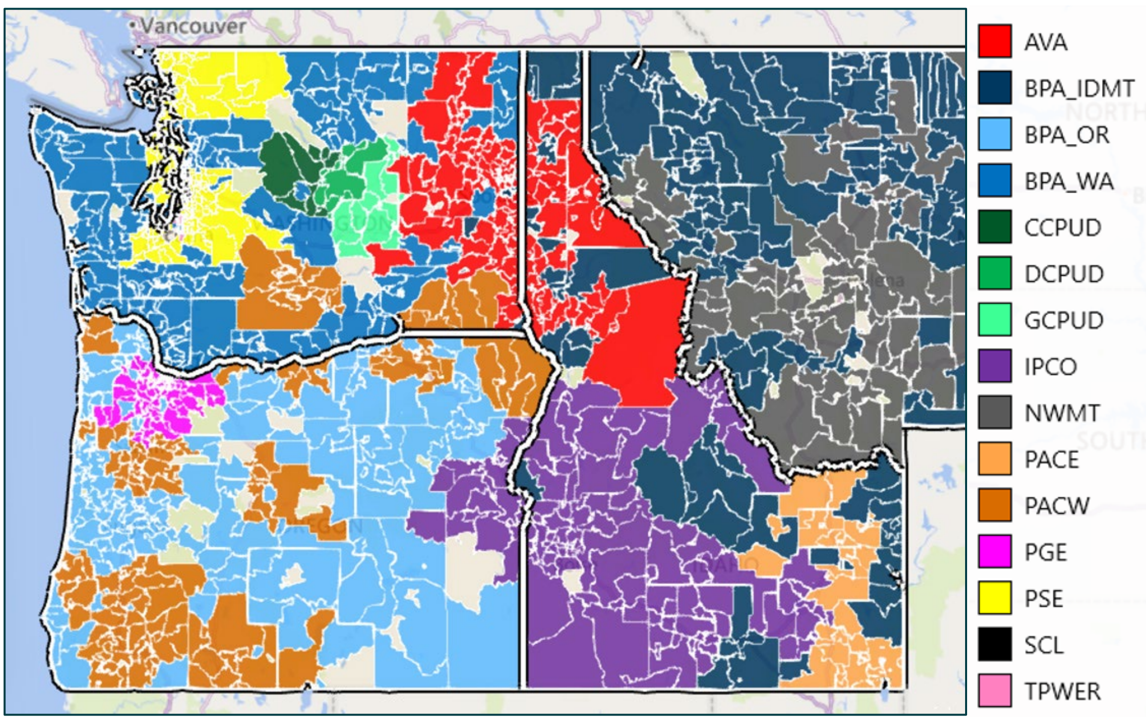
Forecast Zones

The forecast framework was set up to create 13 individual forecasts in the region, in addition to an overall system or regional forecast. The forecast zones and their associated abbreviations are in Table F - 2.

Table F - 2: Forecast Zones

Acronym	Name	Acronym	Name
AVA	Avista	PACE	PacifiCorp East
BPA	Bonneville Power Administration	PACW	PacifiCorp West
CHPD	Chelan County	PGE	Portland General
DOPD	Douglas County	PSE	Puget Sound
GCPD	Grant County	SCL	Seattle City Light
IPCO	Idaho Power	TPWR	Tacoma Power
NWMT	Northwestern		

Figure F - 3: Forecast Zone Map[4]



[4] In the figure, the Bonneville zone is broken out into individual states; however, in the forecast there is only one Bonneville zone.

Forecast Futures

There is uncertainty as to how the future demand for electricity might unfold over the next twenty years. Accordingly, one of the objectives of the forecast was to create an informative spread of potential demand futures, focusing on four primary sources of demand and planning uncertainty.

1. Future weather – some demand sectors such as residential and commercial are highly temperature sensitive
2. Magnitude – mid, higher, and lower trajectories the magnitude of the overall future demand are included to reflect uncertainty
3. Timing of growth - accounting for variance in early, mid, or late in the planning horizon
4. Shape of future demand – reflecting differences in seasonal, flat, or peaky demand requirements

Table F - 3 and Table F - 4 provide an overview of how the 20-year forecast futures were developed by combining a set of forecast model inputs that define specific demand pathways with variations on future weather patterns.

Table F - 3: Pathway Input Components

Model Input Set	Trajectory	Magnitude	Timing	Location	Shape
Economic Forecast	Higher and lower economic growth forecasts	Moderate, sector-wide	Throughout	Throughout	Lifts or lowers demand floor and ceiling
Data Centers	Mid, low and high growth	Significant – very large single loads	Early	Heavy in data center friendly zones	Relatively flat
Electric Vehicles	Higher and lower growth in vehicles	Moderate on residential and commercial sector	Mid to Late	Zones with large urban areas especially	Very peaky
Building Electrification	Higher and lower	Moderate on residential and commercial	Late	Zones within the states of Oregon and Washington	Seasonal, especially winter, and very peaky
Hydrogen Production	Higher and lower	Moderate, single-large load type	Late	Heavier in potential hydrogen zones	Relatively flat, added post-processing

Table F - 4: Pathway Design

#	Description	Economic Growth	Data Center	Transportation	Building Electrification	Hydrogen Production
P1	**High Growth**	Higher	High	Higher	Higher	Higher
P2	**Low Growth**	Lower	Low	Lower	Lower	Lower
P3	**Early Growth**	Higher	High	Lower	Lower	Lower
P4	**Late Growth**	Higher	Medium	Higher	Higher	Higher
P5	**Mixed Bag**	Higher	Medium	Higher	Lower	Higher

The use of the term *higher* does not necessarily mean it is judged as an especially high case. Similarly with the term *lower*. It is meant to indicate that two potential trajectories were tested, with one being higher than the other.

Combining the five pathways (P1, P2, P3, P4, P5) with each of the four future weather patterns (discussed more below) culminates in twenty demand forecast futures.

Load Data (Historical)

The forecast model relies on historical load data by balancing authority. A complete hourly, daily, and monthly set spanning the years of 2008 through 2024 for each balancing authority was compiled for the forecast.

The historical data was sourced from the EIA Hourly Electric Grid Monitor tool[5]. A few things to note:

1. Data scrubbing was performed to repair occasionally erroneous reported hourly load data.
2. The hourly load data for the balancing authorities PACE and NWMT was modified and reduced to reflect the portion of the load that is in region.
    a. PACE: the in-region load (E. Idaho) portion was estimated to be roughly 10% of the overall PACE Balancing Authority load
    b. NWMT: the in-region load (W. Montana) portion was estimated to be roughly 31% of the overall NWMT Balancing Authority load.

[5] https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/US48/US48.

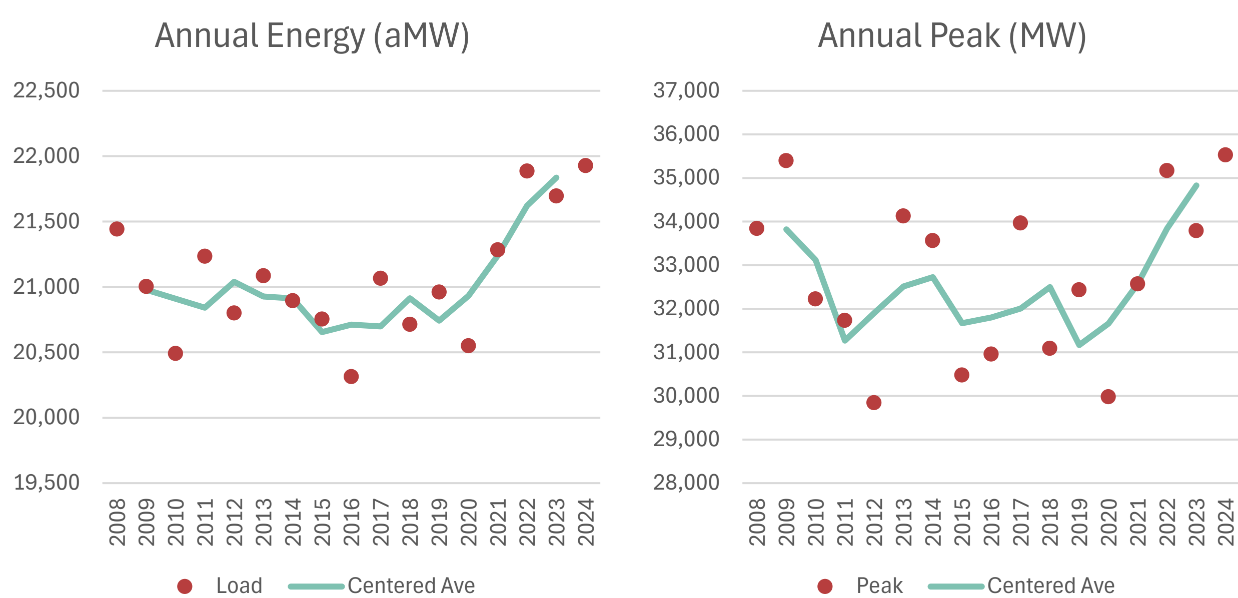
The zones vary in terms of geographic size, weather, and demand for electricity. Overall system-wide demand historically peaks in the winter season. However, some zones are summer peaking, and others alternate between seasons.

Table F - 5: Load Characteristics by Zone

Zone	Percent of Region Load	Peak Season	Zone	Percent of Region Load	Peak Season
Region	100	Winter	SCL	5	Winter
BPA	30	Winter	GCPD	3	Summer
PSE	13	Winter	TPWR	3	Winter
PGE	12	Mix, but lately summer	PACE	3	Summer
PACW	11	Mix	NWMT	2	Mix
IPCO	10	Summer	DOPD	1	Winter
AVA	7	Mix	CHOD	1	Winter

Generally, the demand for electricity has been rising in the region since 2020 for both annual energy and peak.

Figure F - 4: Region-wide Annual Demand for Electricity



Weather

Weather is a key driver of electricity demand. The demand for space and water heating in the winter, and cooling in the summer can fluctuate significantly based on temperatures. The relationship between actual, historical weather, and demand must first be understood and modeled. Then, a future weather pattern is required to forecast demand across the planning horizon.

Historical

Historical hourly weather data, primarily dry-bulb temperature, was collected and compiled for 26 weather stations across the region. The raw weather data sets were acquired from AccuWeather.[6]

The weather station temperature data was compiled into heating degree day (HDD) and cooling degree day (CDD) values across multiple temperature cut-points. Heating degree days are a measure of how cold the temperature was for a single day, or period of days. As an example, for a winter day with an average temperature of 20 degrees F, the HDD value for a cut-point of 55 degrees is calculated as 55 – 20 = 35 HDD_{55}. Analogous to the HDD metric, cooling degree days are a measure of how warm a day or period of days were. Suppose the average temperature for a summer day was 80 degrees F. With a CDD cut-point of 70 degrees, the CDD value is 80 – 70 = 10 CDD_{70}. The HDD cut-points are set at 5-degree increments from 35 degrees to 70 degrees F. The CDD cut-points are also set at 5-degree increments from 85 degrees to 55 degrees F.

For the forecast zones that contain more than one weather station, the station values are weighted based on load proportions.

Table F - 6: Weather Stations

Station	Location	Zone	Station	Location	Zone	Station	Location	Zone
KBFI	Seattle-Boeing, WA	PSE, SCL	KGTF	Great Falls, MT	NWMT	KPIH	Pocatello, ID	IPCO, PACE
KBIL	Billings, MT	NWMT	KHIO	Hillsboro, OR	PGE	KRNT	Renton, WA	PSE
KBLI	Bellingham, WA	PSE	KHRI	Hermiston, OR	BPA	KSEA	Seattle-Tacoma, WA	SCL
KBOI	Boise, ID	IPCO	KMFR	Medford, OR	PACW	KSFF	Coeur d'Alene, ID	AVA
KEAT	Wenatchee, WA	CHPD, DOPD	KMSO	Missoula, MT	NWMT	KSLE	Salem, OR	PACW, PGE

[6] https://www.accuweather.com.

Station	Location	Zone	Station	Location	Zone	Station	Location	Zone
KEPH	Ephrata, WA	GCPD	KMWH	Moses Lake, WA	GCPD	KTIW	Tacoma, WA	TPWR
KEUG	Eugene, OR	BPA	KOMK	Omak, WA	BPA	KTWF	Twin Falls, ID	IPCO
KGEG	Spokane, WA	AVA	KPAE	Everett, WA	BPA	KYKM	Yakima, WA	PACW
KGPI	Glacier Park, MT	BPA, NWMT	KPDX	Portland, OR	PACW, PGE			

Future Patterns

The historical weather and load data for each zone is used to create a model of how demand responds to weather. To forecast future demand, a future weather pattern is necessary. To reflect the uncertainty of future weather, four patterns were developed for the Ninth Plan demand forecast. One normalized weather pattern, called Typical Meteorological Year (TMY), and three unique climate model patterns (Climate A, C, G).[7]

TMY Weather

While the bulk of the Ninth Power Plan analysis assumes climate model informed weather, the Council also creates a load forecast based on TMY weather. This is used to produce a weather-normalized load outlook, which can help to isolate the impact of structural and economic changes over time. To build the 20-year future TMY pattern, a historical 20-year record of weather from 2003-2022 was used to calculate average HDD and CDD values for each month for each station and zone. Next, daily weather shapes from select historical months were used to create a realistic, single annual weather pattern calibrated to monthly 20-year averages. The pattern is then repeated each year – this defines the TMY weather pattern.

Climate Scenario Weather

Three future weather patterns were derived from climate scenario data provided by the River Management Joint Operating Committee (RMJOC). Technical Appendix D – Climate Model Data and Assumptions provides more detail on the climate model data used in the Ninth Plan.

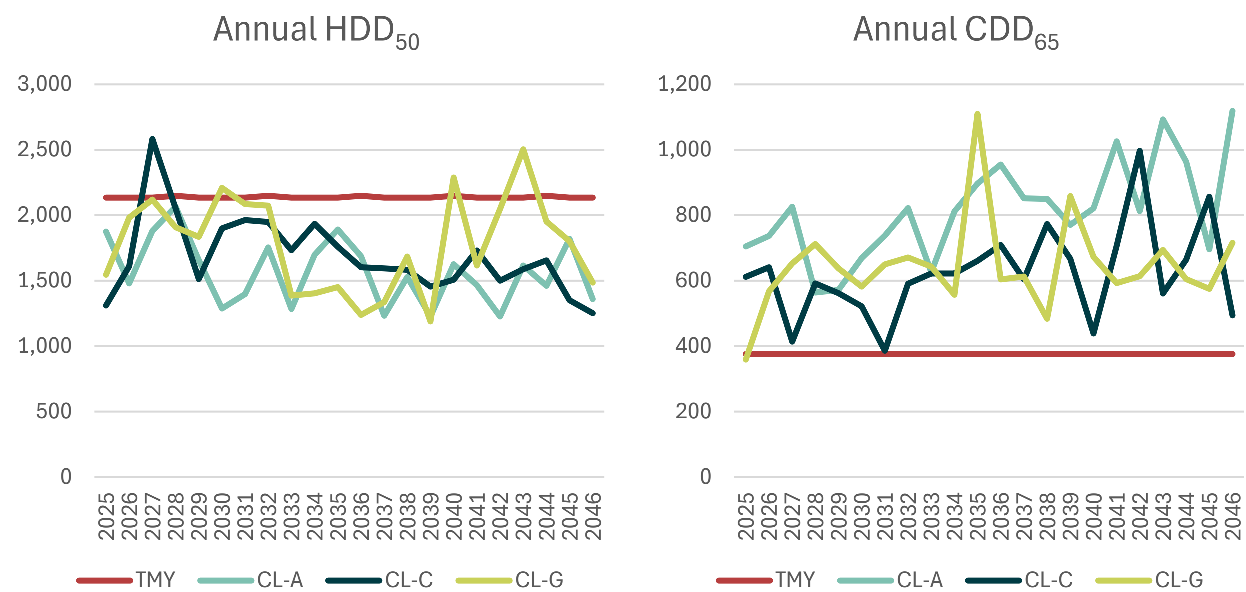
Unlike the TMY weather pattern, the climate scenario pattern temperatures each vary from year to year. For example, in Climate Scenario A pattern, some summers are warmer than others, and some winters are cooler than others.

[7] See Technical Appendix D – Climate Model Data and Assumptions for more information on the Council's selection of these climate models and the temperature trends in the data.

In most years, the climate scenario weather patterns exhibit warmer winter and summer temperatures than the TMY pattern (20-year normal). Though these climate scenario patterns are generally warmer than the 20-year norm, they do exhibit extremes in terms of cold winter temperatures.

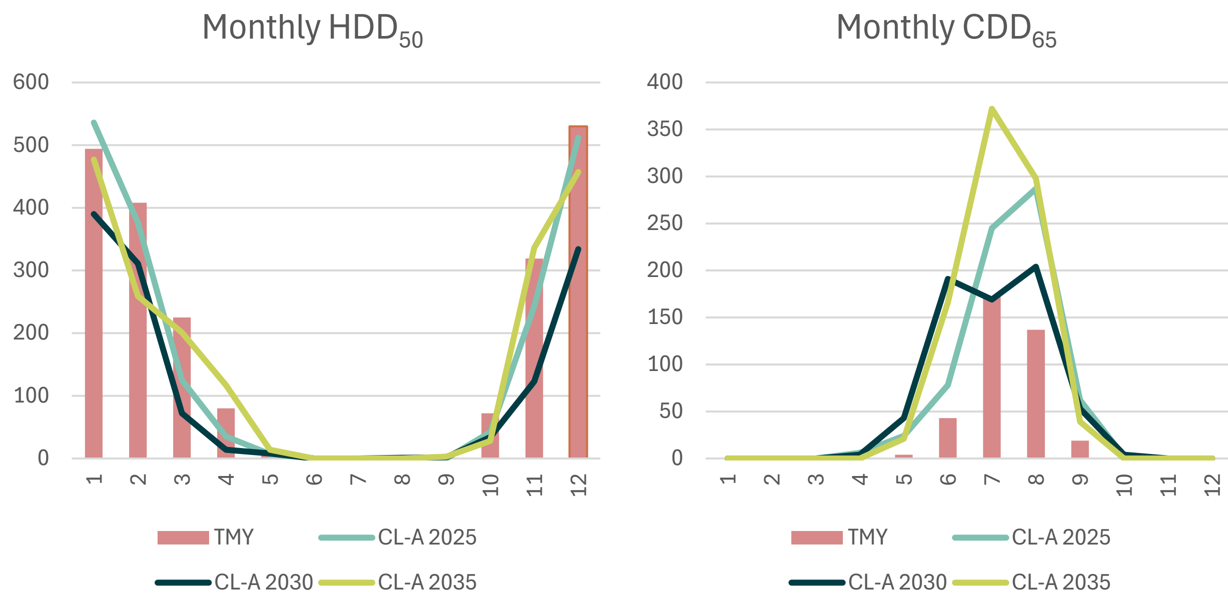
To illustrate, HDDs and CDDs with select cut-points are graphed below. Figure F - 5 shows the sum of HDD_{50} and CDD_{65} on an annual basis by planning year. Remember, the lower the sum of the HDDs the warmer the winter is, and the higher the sum of CDDs, the warmer the summer is. These values are for the BPA zone, which covers a wide geographic area of the Northwest and is a winter peaking zone.

Figure F - 5: Sum of Annual HDD_{50} and CDD_{65} for the BPA zone



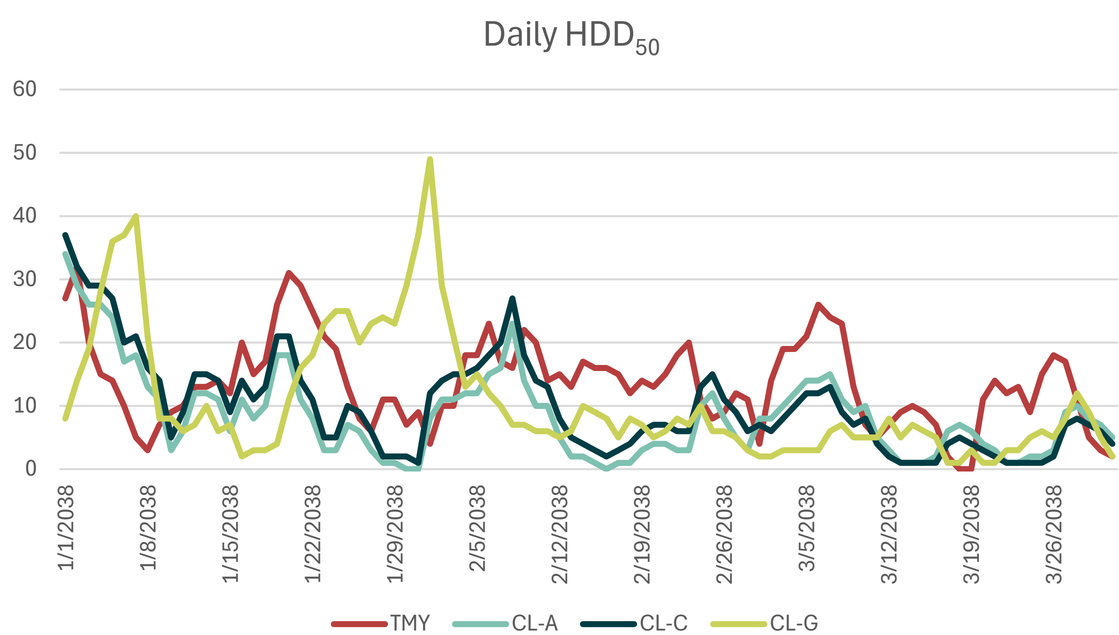
The sum of monthly HDDs and CDDs are shown in Figure F - 6 below for the TMY pattern, and a few select years from the Climate-A weather pattern. As can be seen, the weather pattern for the climate scenario contains substantial year-to-year variability.

Figure F - 6: Sum of Monthly HDD_{50} and CDD_{65} for the BPA zone



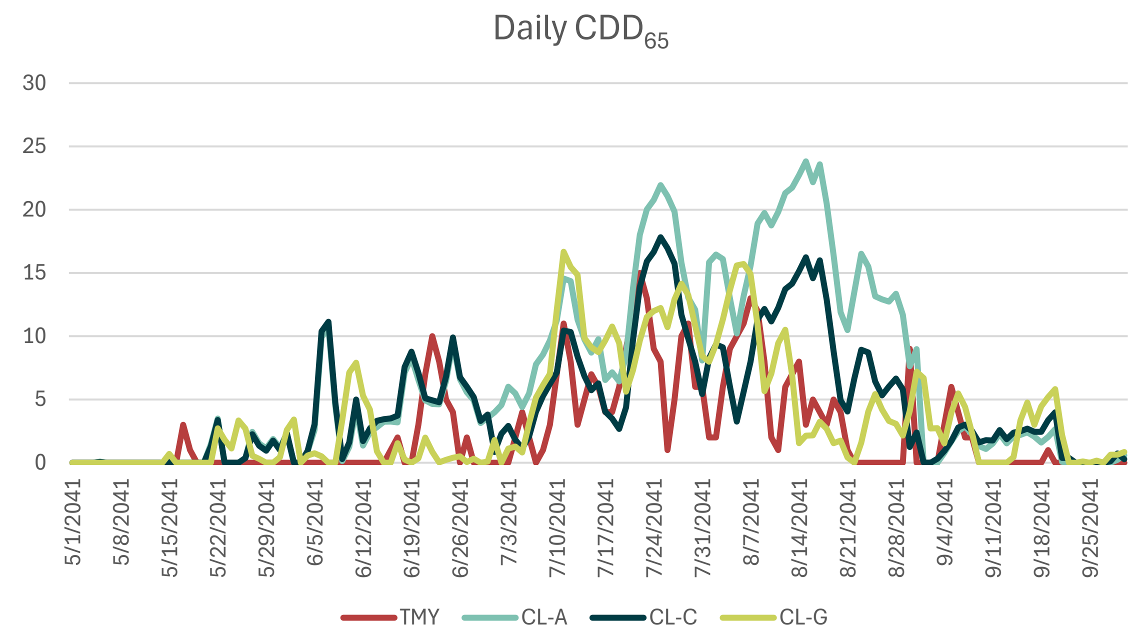
Though generally the climate scenario weather patterns result in milder winters, there are extreme cold events in the future patterns. For example, graphing daily HDD_{50} for the winter of 2038, Climate Scenario G pattern hits a high of 50 HDD_{50}, which means that day hovers around 0 degrees F, even though for the entire winter, Climate Scenario G pattern is warmer than the TMY pattern.

Figure F - 7: Daily HDD_{50} for the BPA zone Winter of 2038



As would be expected, there are extreme heat events in the climate scenario patterns. For example, Figure F - 8 below shows the CDD_{65} values for each day for the summer of 2041. The Climate Scenario A pattern contains some days where the average daily temperature is nearly 90 deg F.

Figure F - 8: Daily CDD_{65} for the BPA zone Summer of 2041



Economic Input Data

Two sets of economic input data were constructed for the forecast model: benchmark and low. The benchmark economic data set was sourced from the S&P Global Market Intelligence Long-Term Annual report from January of 2025. Economic drivers impact the demand forecast for the residential, commercial, and industrial sectors. The key drivers include:

- Population
- Household Size
- Employment
- Gross State Product (GSP)
- Unemployment Rate
- Real Personal Income (RPI)

The economic drivers are available at the state level (ID, MT, OR, WA). These drivers are then allocated to the appropriate forecast zone. For zones that contain multiple states (BPA, PACW), the state level drivers are weighted. The data is used in the forecast model to establish historical relationships between demand and economic conditions. The forecast of economic conditions then acts as a driver in the forecast models.

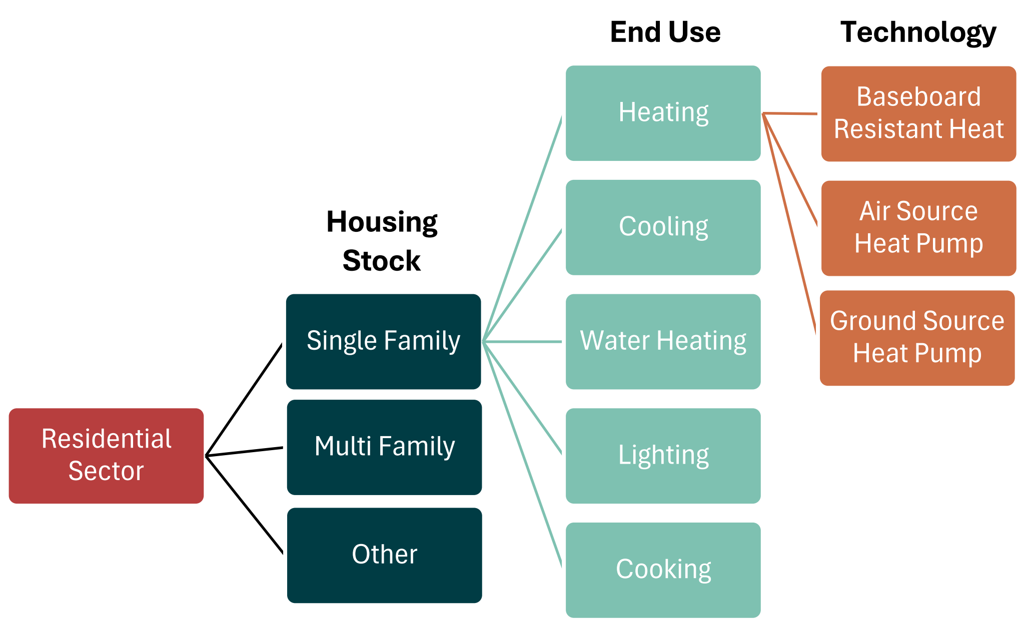
Low Economic Growth Case

A data set with a persistently lower economic growth rate was developed as an input for the Low Growth (Pathway 2) future. For each of the four Northwest states, the growth rates for the economic drivers of population, employment, manufacturing employment, real personal income (RPI), and gross state product (GSP) were reduced on an annual basis throughout the forecast horizon. For example, the annual growth rate for GSP in the state of Washington across the 20-year horizon (2027-2046) was reduced from the benchmark rate of 2.51% to a low rate of 2.19%. The reduced economic growth rates impact demand growth for the residential, commercial, and industrial sectors.

Residential Sector

The residential sector demand is modeled as a function of housing stock, end-use saturation, efficiencies and shapes, economic factors, and weather. At the core of the forecast is a regression model that produces a forecast of monthly energy demand for the residential and commercial sectors. This is the Itron Statistically Adjusted End Use (SAE) approach. Not a traditional end-use model, the SAE approach incorporates end-use information into an econometric modeling framework. A traditional end-use model sums up individual forecasts of demand for each electrical end-use (see Figure F - 9). An econometric model specifies the statistical relationship that is believed to hold between various economic factors and weather to demand.

Figure F - 9: Example of an End-Use Structure



In the SAE regression, there are three model variables: a heating variable, a cooling variable, and a base variable. The heating variable incorporates structural changes in space heating end-use appliance saturation (such as heat pumps) and average stock efficiencies, building shell improvements and economic factors such as personal income, and finally weather related to heating (heating degree days). The cooling variable is similar but focused on space cooling end-uses such as central AC or heat pumps, and weather related to cooling (cooling degree days). The base variable captures the remaining residential non weather-related end-uses, such as lighting, water heat, and cooking.

The model establishes the historical relationship between:

1. Demand
2. Building stock
3. End-use characteristics
4. Weather

The model is then used to forecast future demand as a factor of building stock growth, changes in end-use saturations and efficiencies, and future weather. While the efficiency level for newly installed equipment is held constant, the overall average stock efficiency level may increase over the time horizon as older units turn over.

This section will discuss how the residential sector inputs were developed for the monthly energy model. There are several factors that affect the overall demand for electricity in the residential sector.

Housing Stock

At the base of the residential demand forecast is the existing housing stock and how it might change in the future. The housing stock estimate and forecast is a key baseline dataset for the demand forecast and energy efficiency, rooftop solar, and demand response potential studies. For the Ninth Plan, a housing stock data set was created, covering the years 2010-2050. The data set contains an annual estimate and forecasts of single family, multi-family, and other housing stock for each of the four states (ID, MT, OR, WA). The estimate for Montana is adjusted to represent just the western region of the state.

Single-family is defined as a residential unit with 1 to 4 units, multi-family 5 units or more, and Other is a manufactured or mobile home. The forecast was initially developed for the entire state of Montana and was then scaled down to represent homes west of the Continental Divide (in-region). The percentage of homes in Western Montana was estimated using US Census data by county and results in a 39.7% scaling factor.

An estimate of historical housing stock is necessary for the forecast model to fit to historical demand, and a forecast is needed to project future demand. The process steps follow:

1. The existing housing stock in 2020 was set as a base to work with. This year was selected based on the 2020 US Census.[8]
2. Housing stock estimates for the past were set by moving backward from the 2020 base by estimating the number of housing additions (new) and losses for each year.
3. Similarly, housing stock estimates for the future were set by moving foward from the 2020 base by estimating the number of housing additions (new) and losses for each year.
4. Adds (housing starts) by state were estimated using the S&P Global Market Intelligence August 2024 report.
5. Indivdual housing loss rates by state were estimated using the loss methodology[9] proposed in the US Census.

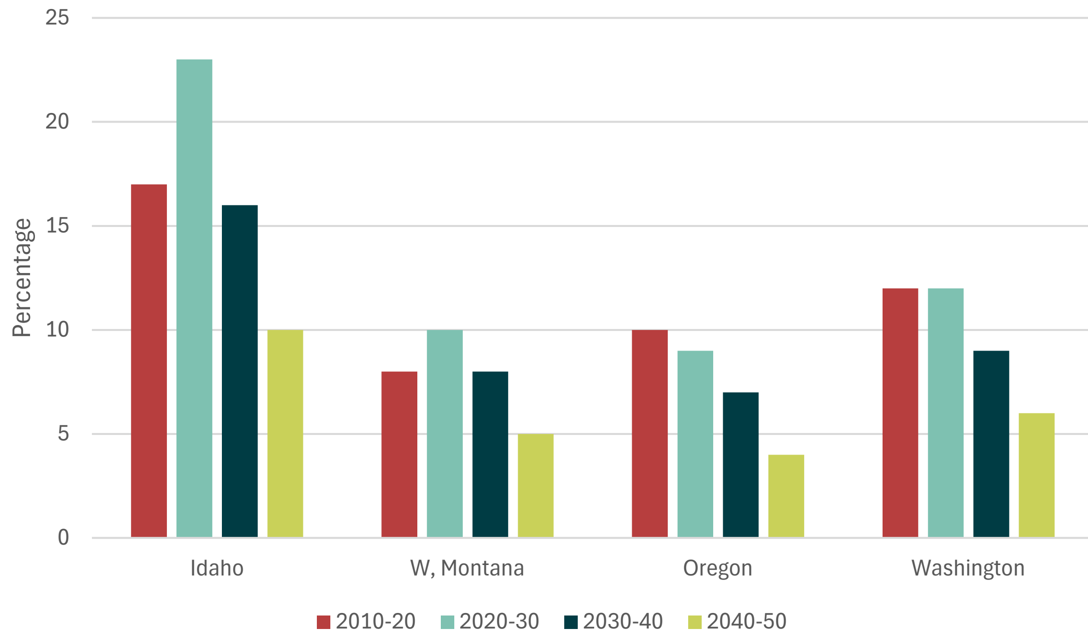
In the region, 53% of the residential units are in Washington. However, in terms of annual growth rate, Idaho is growing the fastest. All four states are seeing a trend towards more multi-family housing. Of the four states, Washington has the highest percentage of multi-family units (23% in 2030), while Idaho has the highest percentage of single-family units (83% in 2030).

Table F - 7: Total Housing Units

Year	Idaho	W. Montana	Oregon	Washington
2020	756,174	220,305	1,819,203	3,213,902
2030	929,824	241,516	1,990,758	3,603,401
2040	1,081,525	259,867	2,130,629	3,930,900
2050	1,191,056	273,127	2,223,413	4,155,420

[8] https://www.census.gov/programs-surveys/decennial-census/decade/2020/2020-census-results.html.
[9] https://www2.census.gov/programs-surveys/popest/technical-documentation/methodology/2020-2023/2023-hu-meth.pdf.

Figure F - 10: 10-Year Housing Unit Growth Rates by State



Residential End Use

The historical and forecast saturations and efficiency levels of residential end-uses are an input variable to the model. Saturation level refers to the percentage of housing units with a specific end-use and technology. Efficiency level is the average of the equipment efficiency for that specific end-use across the entire housing stock, so it is a mixture of both new and older units. The estimated saturations and efficiencies include the effects of codes and standards, but not the savings from future energy efficiency programs.

Twenty residential end-uses are represented in the forecast model.

Table F - 8: Residential End Uses Represented in Forecast

End - Use	Description	Category	Shape Source[10]
EFURN	Electric furnace and resistant room space heaters	Heating	NEEA
HPHEAT	Heat pump space heating	Heating	NEEA
GPHEAT	Ground-source heat pump space heating	Heating	NEEA
SECHT	Secondary heating	Heating	NEEA
CAC	Central air conditioning	Cooling	NEEA

[10] https://neea.org/northwest-end-use-load-research-project.

End - Use	Description	Category	Shape Source[10]
HPCOOL	Heat pump space cooling	Cooling	NEEA
GHPCOOL	Ground-source heat pump space cooling	Cooling	NEEA
RAC	Room air conditioners	Cooling	NEEA
EWHEAT	Electric water heating	Base	NREL ResStock
ECOOK	Electric cooking	Base	NREL ResStock
REF 1,2	Refrigerator, and second Frig.	Base	NREL ResStock
FRZ	Freezer	Base	NREL ResStock
DISH	Dishwasher	Base	NREL ResStock
CWASH	Electric clothes washer	Base	NREL ResStock
EDRY	Electric clothes dryer	Base	NREL ResStock
TV	TV sets	Base	NREL ResStock
FURNFAN	Furnace fans	Heating	NREL ResStock
LIGHT	Lighting	Base	NREL ResStock
MISC	Miscellaneous	Base	NREL ResStock

Saturation and Efficiency Levels

An estimate of historical saturation and efficiency levels are used to calibrate to historical demand. An estimate of the future trajectory of both saturation and efficiency levels is used as an input to the forecast model to project future demand. A stock and flow analysis was performed, by state and end use, to build a data set with historical and future saturation and efficiency estimates.

A number of data sources were used to support the analysis, including the Residential Building Stock Assessments (RBSA)[11] as published by the Northwest Energy Efficiency Alliance (NEEA) from 2011, 2017, and 2022. In addition, data from the Annual Energy Outlook (AEO)[12] from the U.S. Energy Information Administration (EIA) was also used.

The stock and flow analysis is set up to track the annual changes in the end-uses in the housing stock over a period of over 40 years. The data set is initialized in the year 2010 with an estimate of the number of end-use specific units by state and housing type (SF, MF, Other). Information from the 2011 RBSA was used to set the initial conditions, and the model was then calibrated to data from the 2017 and 2022 RBSAs. The stock and flow model then steps through each year calculating the changing saturations and efficiency levels all the way through to the end of the planning horizon 2047. The logic assumes annual loss of specific end-use units due to building demolition and equipment

[11] https://neea.org/residential-building-stock-assessment.
[12] https://www.eia.gov/outlooks/aeo/info_nems_archive.php.

reaching end-of-life. Annual additions of the end-use units are assumed from equipment replacements (due to EOL), new unit installs in existing buildings that did not have that end-use previously, and new construction.

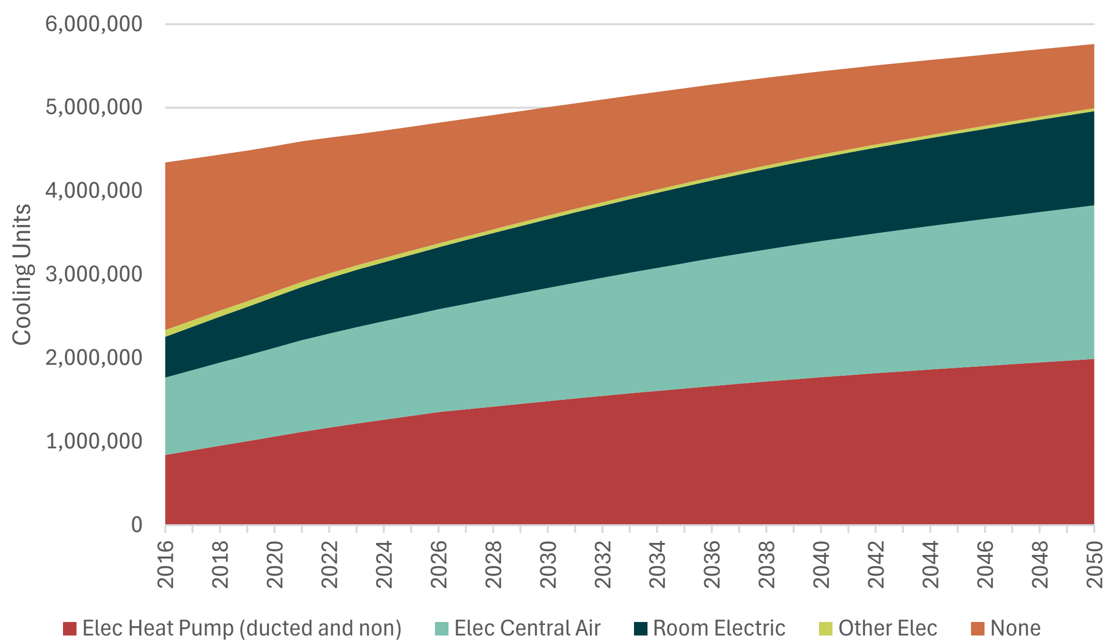
Various efficiency measure units were used, depending on the data available and type of end use, including:

1. HSPF – heating seasonal performance factor
2. COP - coefficient of performance
3. SEER – seasonal energy efficiency ratio

Cooling and Space Heating

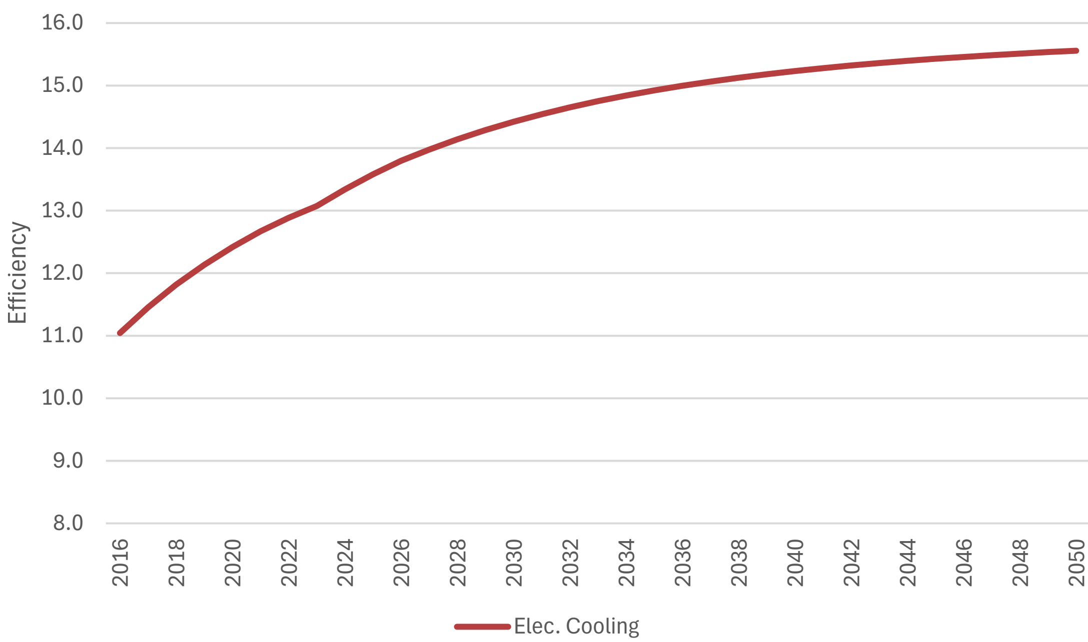
The analysis shows a significant upward trend in cooling installations across the Northwest. For example, for single-family (SF) homes, in 2020 the overall share of housing units with some sort of electric cooling was estimated to be 61.6%. By 2030, it is estimated that 74.1% of SF homes will have some form of electric cooling. For the cooling end-use technology breakdown, roughly 40% of the homes that have electric cooling are expected to have heat pumps, and around 36.5% are expected to use central AC.

Figure F - 11: Number of Cooling Units by Tech - Single Family



With cooling unit stock turnover and new construction, the overall average efficiency for cooling in the residential sector increases over time as new units are added at better efficiencies (frozen from 2027 onward).[13]

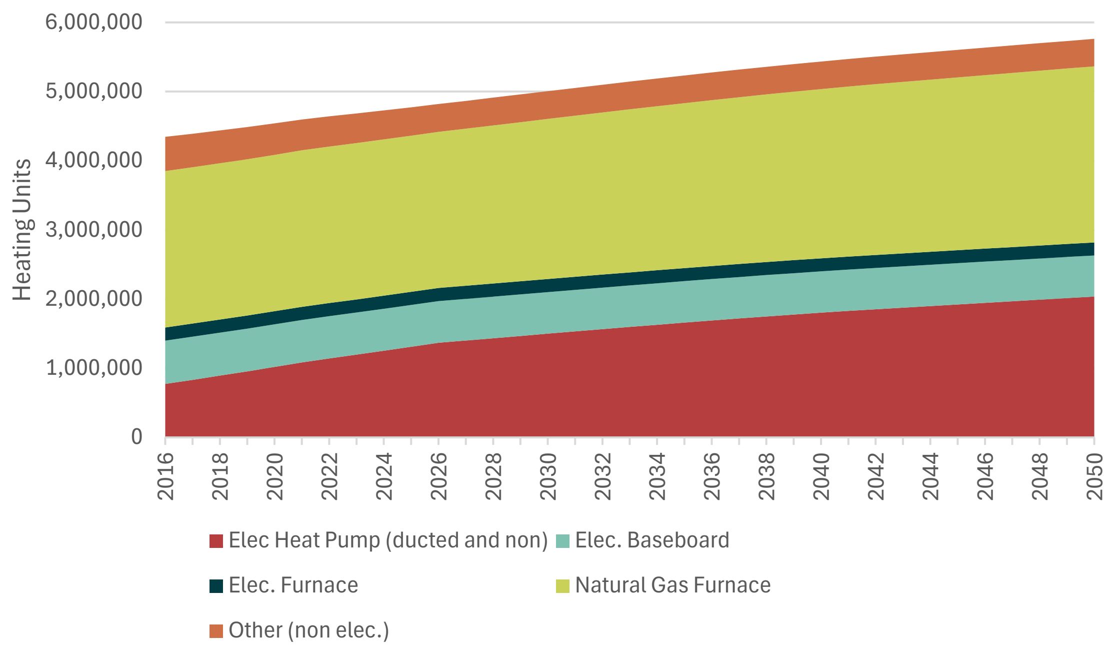
Figure F - 12: Average Unit Efficiency for Cooling (all tech) – Single Family



Heat pump saturations are also trending up for space heating, as might be expected since heat pumps can be used for both heating and cooling. Gas furnaces continue to hold the largest share for single family home heating.

[13] The common practice efficiency levels (also known as "current practice") for new equipment sold today is often more efficient than the average of the existing stock, which includes older, less efficient units, that are no longer available for purchase.

Figure F - 13: Number of Heating Units by Tech - Single Family



As with cooling, due to unit stock turnover and new construction, the overall average efficiency for heating in the residential sector is projected to increase over time as new units are added at better efficiencies (frozen from 2027 onward). Figure F - 14 shows the estimated average efficiency over all space heat pump units in the region.

Figure F - 14: Average Unit Efficiency for Heat Pump Space Heating – Single Family

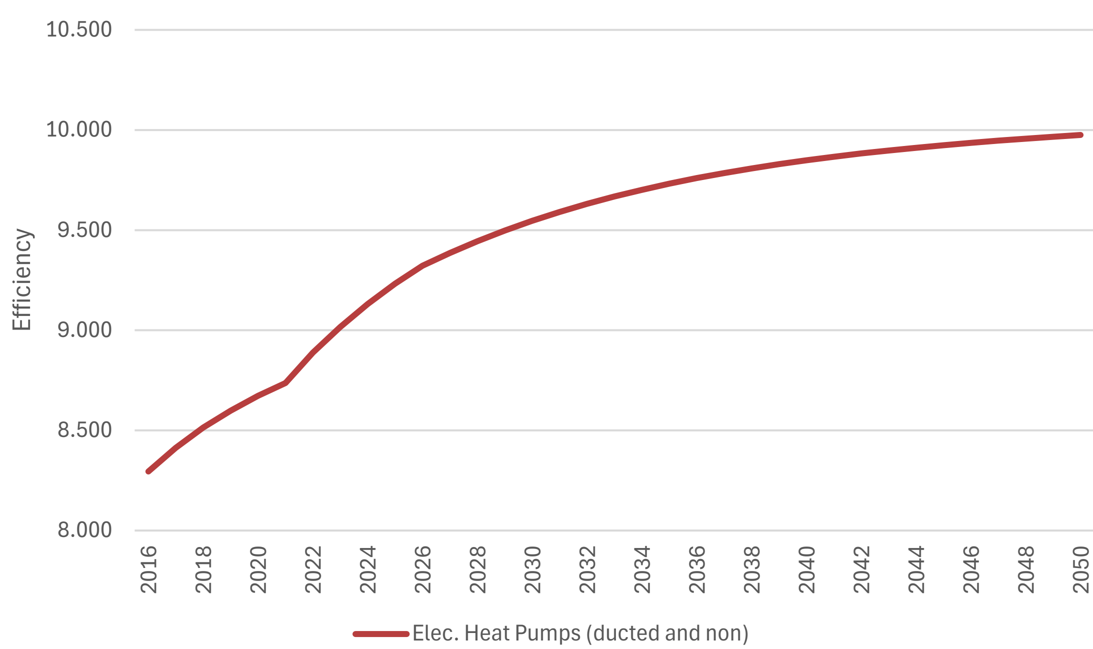
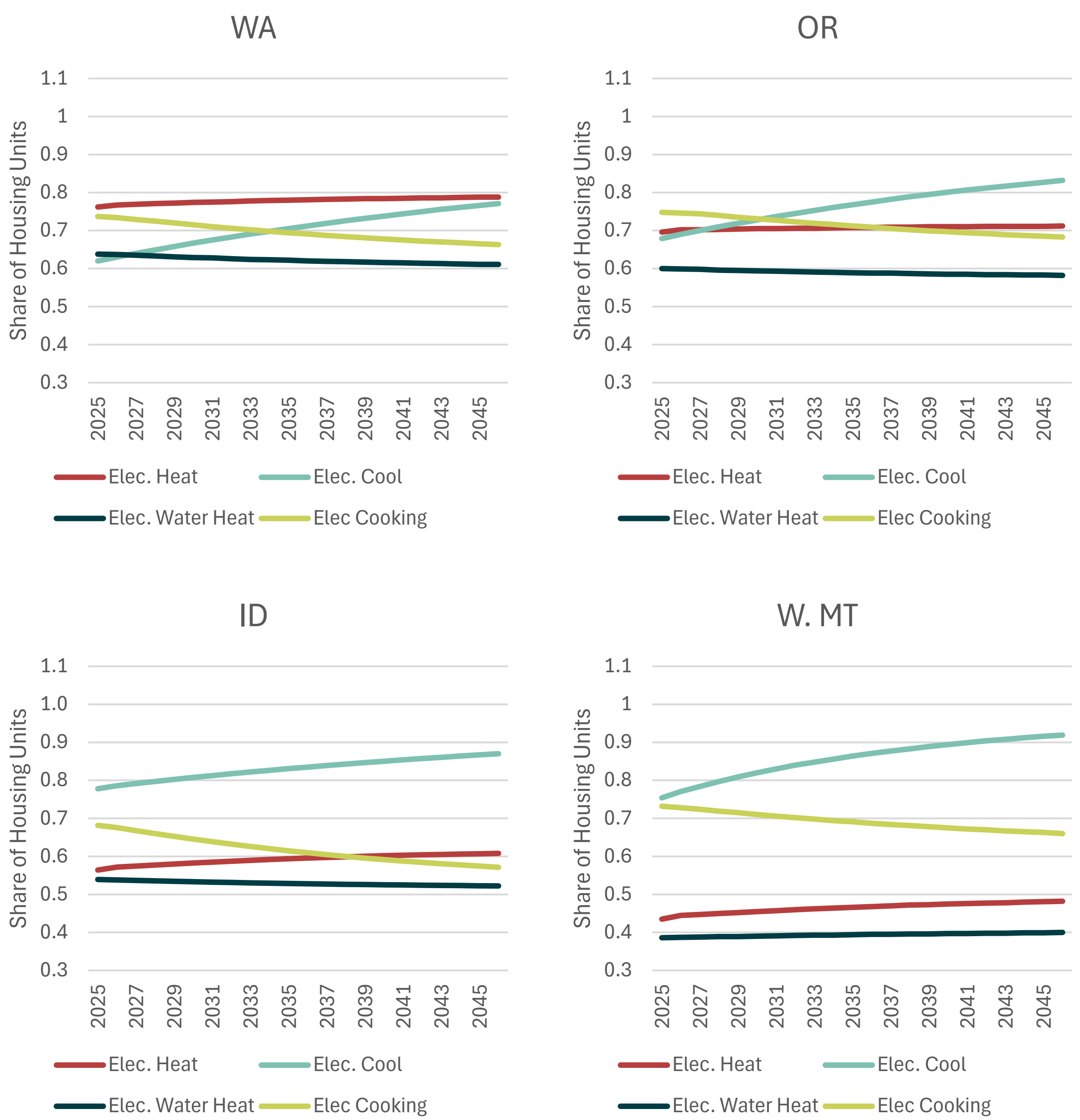


Figure F - 15 summarizes the end-use data by state, across all residential sector building types (SF, MF, Other) and technologies.

Figure F - 15: Residential Sector Saturations by State



End-Use Shapes

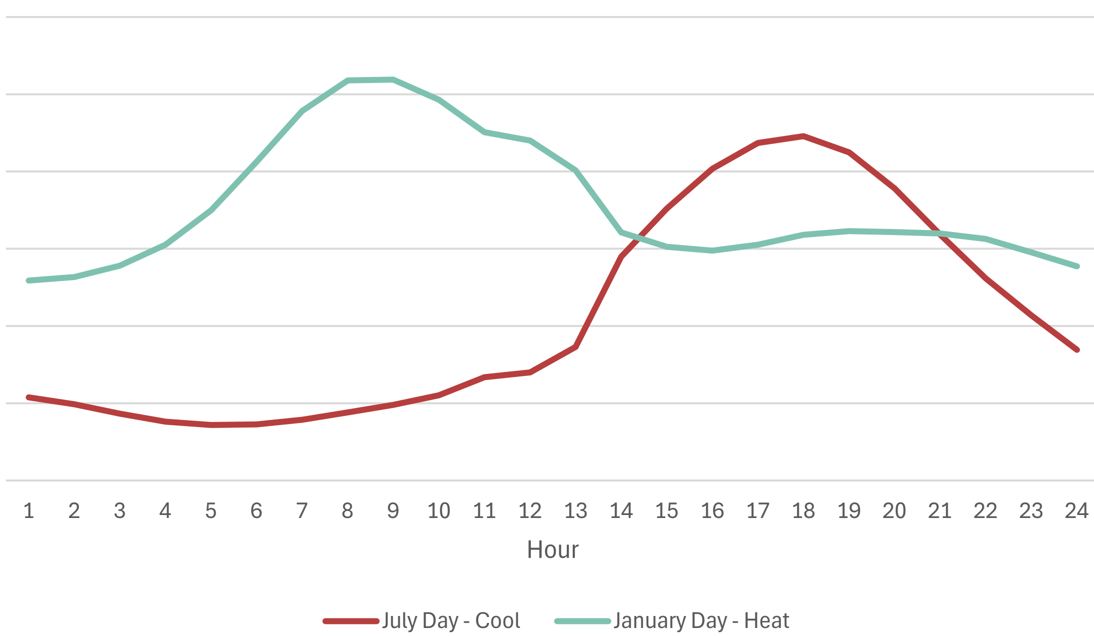
The zonal regression models use the end-use saturation and efficiency data to produce an energy forecast. To shape the energy, hourly weather sensitive end-use demand shapes were generated for historical weather and the future weather patterns used in the forecast. These shapes are later applied to the estimated energy consumption from each end-use and calibrated to each zone's overall demand shape. This is used to create an hourly forecast by sector.

Weather sensitive hourly end-use shapes were derived using information from the NEEA[14] and NREL[15] residential data sets. See

Table F - 8 for the source by end-use.

Figure F - 16 shows example end-use shapes used for modeling heat pump space heating and cooling. The input shapes are derived from average kWh per unit calculations. The heat pump shapes display the peaky aspects of space heating and cooling; a characteristic morning heating ramp in the winter, and a late-afternoon cooling ramp in the summer. These shapes are applied to the forecasted seasonal demand (MWh) from heat pumps through the forecast horizon.

Figure F - 16: Example Heat Pump End-Use Hourly Shape



High Building Electrification in the Residential Sector

The High Growth and Late Growth forecast futures contain a high building electrification input data set. In this input data set, the Council boosted the electric saturations over the base level for space heating, water heating, and cooking. This analysis focused on only zones in Washington and Oregon.

[14] https://neea.org/northwest-end-use-load-research-project.
[15] https://resstock.nrel.gov.

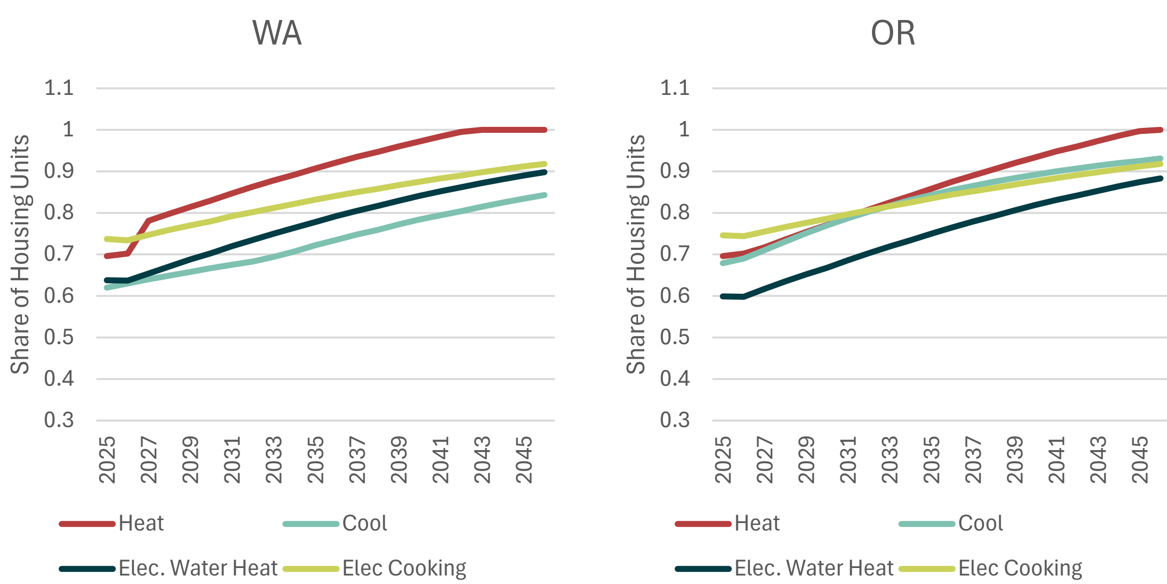
Both states have identified building electrification as an effective way to reduce greenhouse gas emissions in their respective state energy strategies[16,17]. This was accomplished by:

- Setting new building construction to be mostly electric – primarily this is setting space heat to heat pump technologies
- Moving natural gas end-use equipment (such as a gas furnace) to an electric heat pump as the gas unit ages out and needs to be replaced

While building electrification is mostly related to heating use (impacting winter consumption), the modeling does try to capture additional cooling installation as new heat pumps can be used for heating and also cooling in a residence that otherwise might not have had a cooling unit already.

The following figures show the higher saturation rates for electric end-uses by state. Idaho and W. Montana were left the same as the baseline projections.

Figure F - 17: High Electrification Saturations by State



Commercial Sector

Like the residential sector, commercial demand is modeled as a function of building stock (square footage), end-use saturation, efficiency and shapes, economic factors and weather. An input data set was compiled which captures estimates of historical values and a projection of future values for

[16] https://energystrategy.oregon.gov/electrification.
[17] https://www.commerce.wa.gov/energy-policy/state-energy-strategy.

these demand factors. This is an input to the SAE regression model with the three model variables, heating, cooling, and other.

This section discusses how the commercial sector inputs were developed for the monthly SAE energy model.

Building Stock

At the base of the commercial sector demand forecast is an estimate of the existing commercial building stock and how changes might unfold over the course of the planning horizon. For the Ninth Power Plan, a building stock data set was created for the four Northwest states, covering the years 2010-2050. The data set contains estimates of annual commercial floor space (square footage) by state for specific building types. The building types and end-uses align with the US Energy Information Administration (EIA) Annual Energy Outlook (AEO).

Table F - 9: Commercial Sector Building Types and End-Uses

Building Type	End-Uses (for each building type)
Assembly	Space Heating
Education	Cooling
Food Sales	Ventilation
Food Service	Water Heating
Health Care	Cooking
Lodging	Refrigeration
Large Office	Lighting
Small Office	Office
Merchant/Service	Misc
Warehouse	
Other	

Several sources informed the commercial building square foot stock forecast. The Council's 2021 Power Plan[18], NEEA's Commercial Building Stock Assessments[19] (2009, 2014, 2019, and preliminary 2024), and 2023 EIA AEO[20] data.

[18] https://www.nwcouncil.org/2021-northwest-power-plan.
[19] https://neea.org/commercial-building-stock-assessment.
[20] https://www.eia.gov/outlooks/aeo.

Commercial square footage is projected to grow at steady rates, comparable to the past 20 years. In the region, 47% of the commercial buildings floor space is estimated to be in Washington, with Oregon at 37%. All four states are projected to see growth, with the highest growth rates in Idaho and Montana. Figure F - 18, Figure F - 19, and Table F - 10 show the growth in commercial sector across the states.

Figure F - 18: Commercial Building Total Square Footage

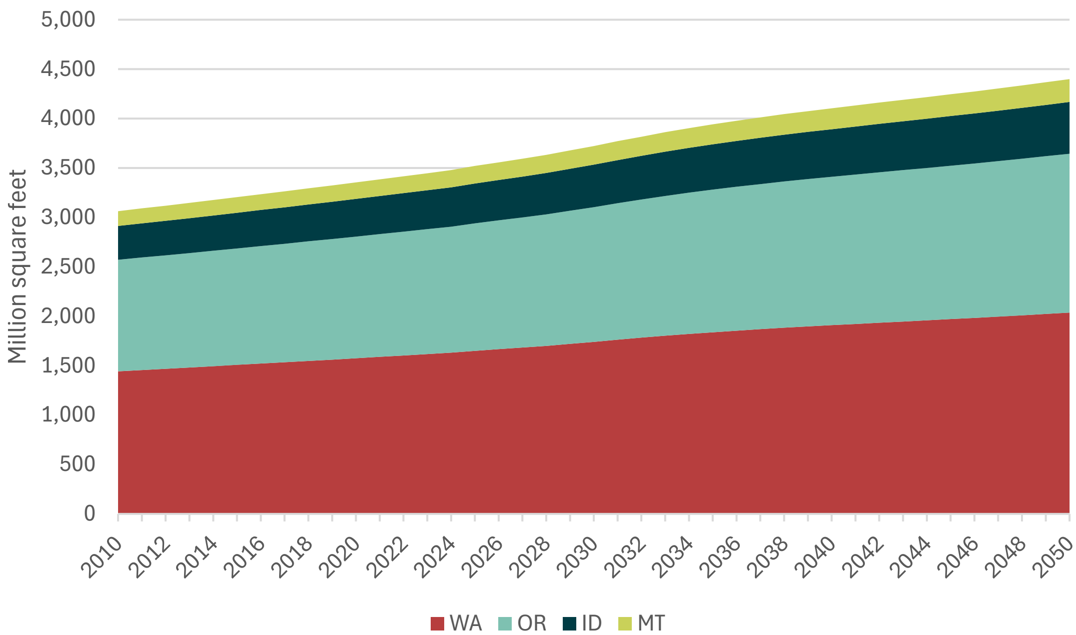


Figure F - 19: Commercial Building Total Square Footage Growth Rate

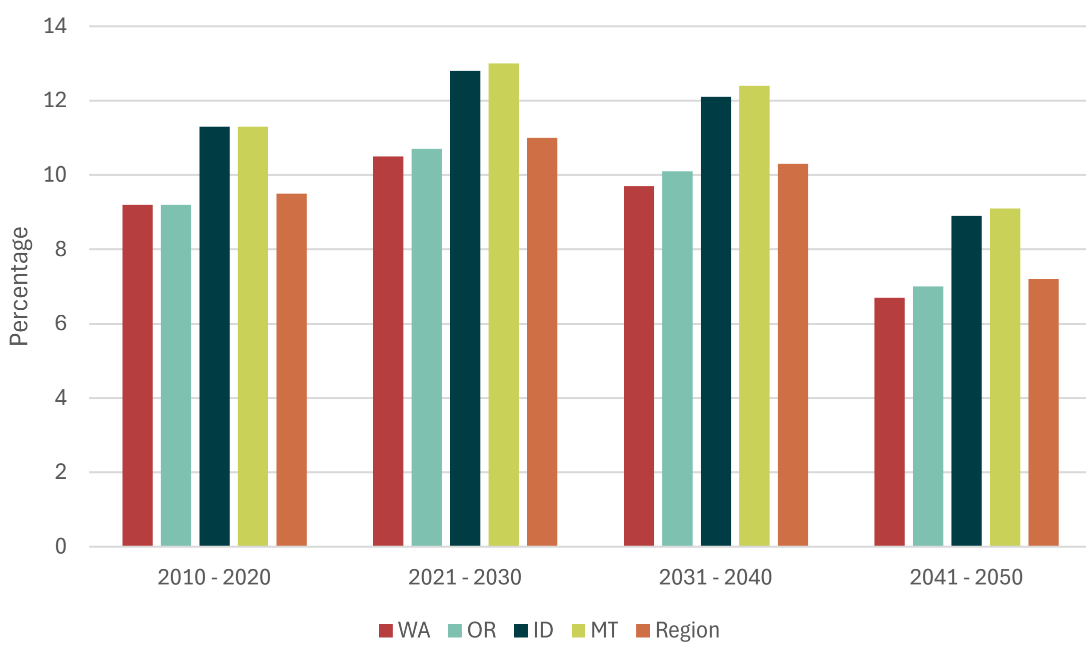


Table F - 10: Total Commercial Floor Space (millions of square feet)

Year	Idaho	W. Montana	Oregon	Washington
2020	381	167	1,231	1,575
2030	430	189	1,363	1,740
2040	481	212	1,501	1,910
2050	524	231	1,607	2,037

Commercial End-Use

As with the residential sector, the historical and forecast end-use saturation and efficiency levels are an input variable to the forecast model. Saturation level refers to the portion of the square footage with a specific end-use, and the efficiency level is the average efficiency level of that end-use across the square footage. The estimates of saturations and efficiency levels are intended to capture codes and standards, but not the estimated savings from future energy efficiency programs, with the efficiency of new equipment frozen at 2027 levels.

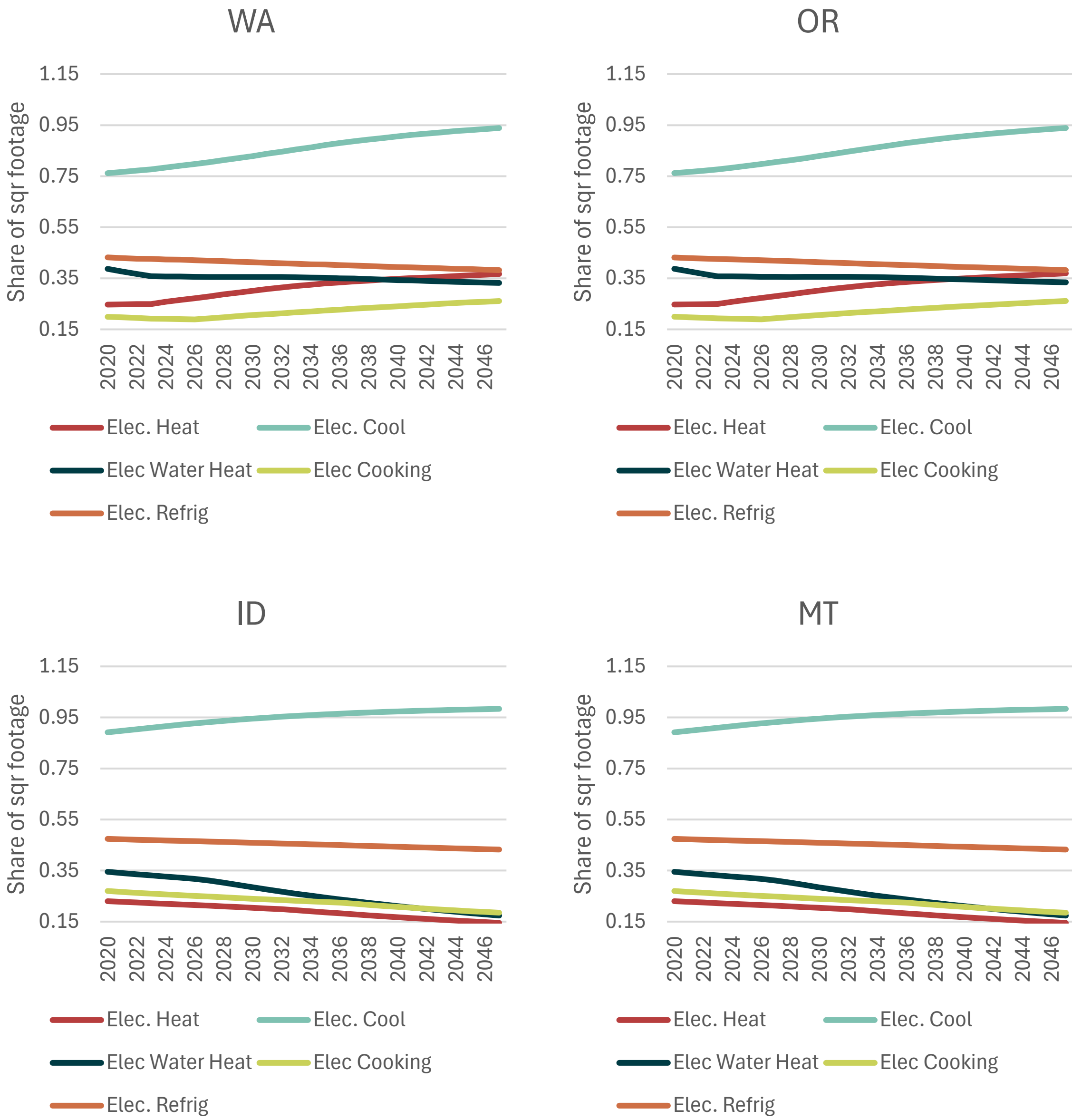
Saturation and Efficiency Levels

The estimate of historical saturation and efficiency levels of end-uses in commercial buildings are used to calibrate to historical demand. The estimated trajectory of future saturation and efficiency levels of end-uses in commercial buildings is an input to the forecast model to help project future demand. A stock and flow analysis was conducted by state and end-use to build up the data set.

The stock and flow analysis was set up to track the annual changes in end-uses in the commercial building stock over a period of 40 years, from 2010 to 2050. The commercial work relied heavily on information from the EIA AEO 2023, as well as the NEEA CBSA from 2009, 2014, 2019 and preliminary 2024. Adjustments were made to the saturation projections for heating for Washington (and Oregon) based on information from the 2021 Washington State Energy Codes, which went into effect in 2024. These codes encourage installation of efficient electric heat pumps in new construction. These adjustments pushed the saturation projections of electric heating up for Washington and were also applied to Oregon.

As in the residential sector, the projected overall saturation and efficiency levels for all sector square footage of the building stock is rolled up and input to the forecast model.

Figure F - 20: Commercial Sector End-Use Saturations by State

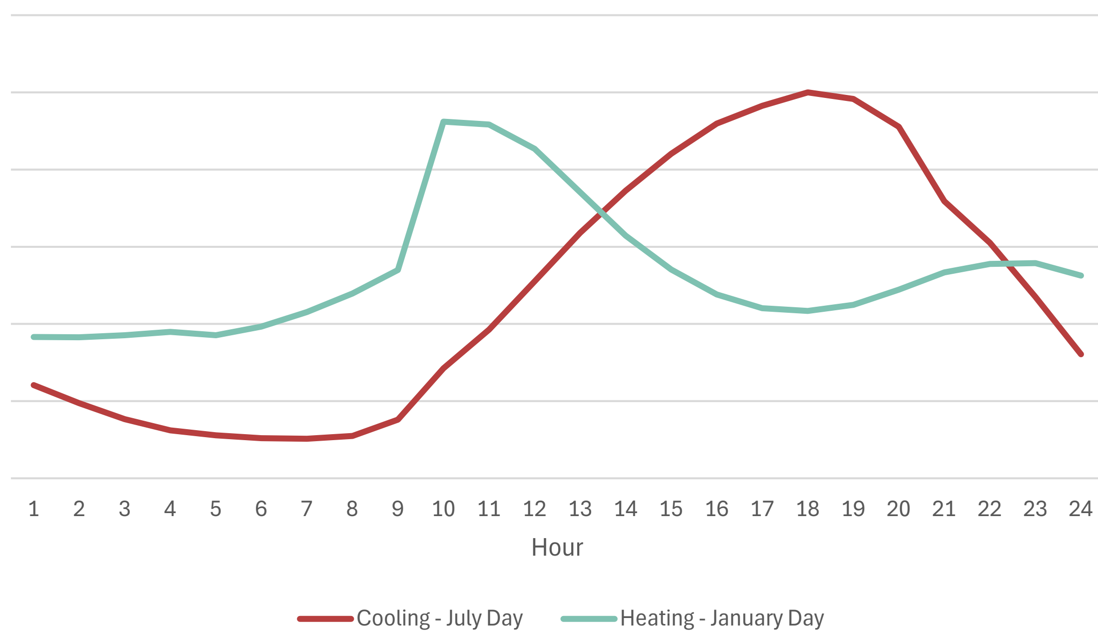


End-Use Shapes

To shape the commercial energy forecast, hourly, weather sensitive end-use demand shapes were generated for historical weather and the future weather patterns used in the forecast. These shapes are later applied to the estimate energy consumption from each end-use and calibrated with each zone's overall demand shape.

Weather sensitive hourly end-use shapes were derived using information from NREL Comstock[21] data sets. Figure F - 21 shows an example of the end-use shapes for space heating and cooling for a summer and winter day. As with the residential end-use example, the shapes represent an average kWh per unit demand for space heating and cooling. These shapes are applied to the forecast of seasonal heating and cooling demand (MWh) to generate an hourly forecast.

Figure F - 21: Commercial End-Use Hourly Shape Examples



High Building Electrification in the Commercial Sector

The High Growth and Late Growth forecast futures contain a high building electrification input data set. In this input data set, the Council boosted the electric saturations over the base level for space heating, water heating, and cooking. This was accomplished by:

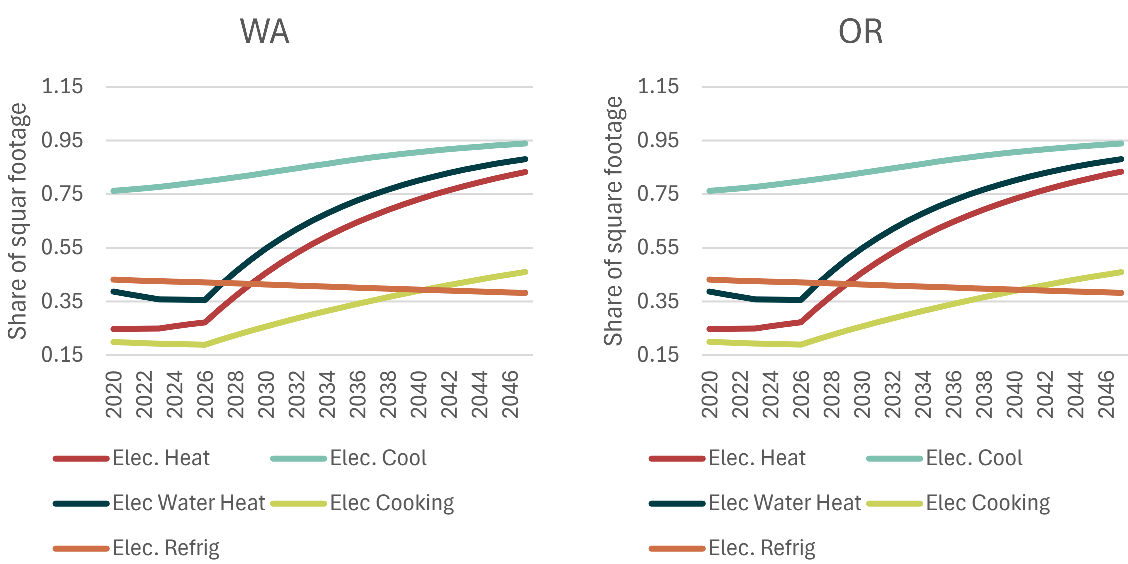
- Setting new building construction to be mostly electric – primarily this is setting space heat to heat pump technologies
- Moving natural gas end-uses to an as the gas unit ages out and needs to be replaced

As with the residential sector, only zones in the states of Washington and Oregon were modeled to have high building electrification.

[21] https://comstock.nrel.gov.

Figure F - 22 shows the higher saturation rates for electric end-uses by state. Idaho and W. Montana were left the same as the baseline projections.

Figure F - 22: Commercial Sector End-Use Saturations by High Electrification



Industrial Sector

An industrial demand variable is also an input to the SAE regression model. The key components that drive industrial demand in the model are:

1. An estimate of the energy intensity of each sector (MWh/employee)
2. An estimate of past and future employment for each sector, when available

The sectors in the model are based on the EIA North American Industrial Classification System (NAICS)[22] codes.

Table F - 11: Industrial Sector Codes

Sector	NAICS Code	Sector	NAICS Code
Agriculture	11	Glass	3272
Mining	21	Aluminum	3313
Construction	23	Iron and Steel	3311,3312
Food	311	Fabricated Metals	332

[22] https://www.eia.gov/tools/glossary/index.php?id=Industrial%20sector.

Sector	NAICS Code	Sector	NAICS Code
Wood	321	Machinery	333
Paper	322	Computer and Electronics	334
Bulk Chemical	3251,3252,3253	Electrical Appliances Components	335
Plastics and Rubber	326	Transportation Equipment	336
Cement Lime	3273,3274	Balance of Manufacturing	multiple

The industrial demand input is developed for each of the four states and applied to the zones within the state. The intensity component by sector (MWh/employee) is sourced from the EIA, which is a nation-wide average number. Past and future employment data by sector and each specific state was sourced from the S&P Global Market Intelligence Long-Term Annual report from January of 2025. This provides an outlook on employment changes in the overall industrial sector. The individual sector results are then combined to produce an overall industrial intensity input.

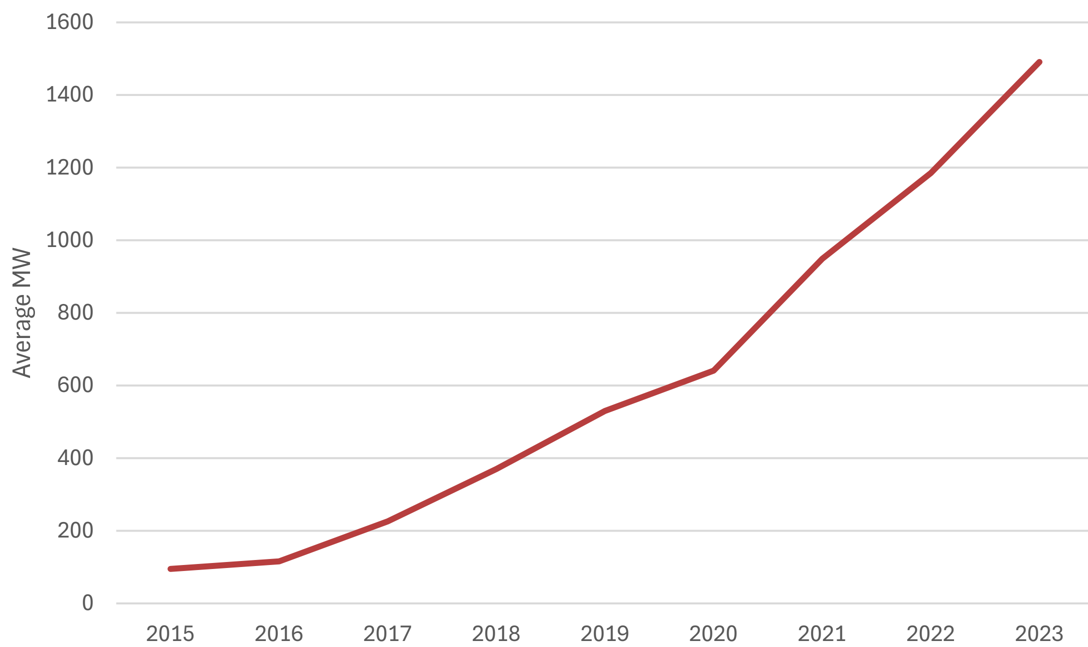
Data Center Forecast Input

Data centers and chip fabricators have the potential to add significant amounts of demand to the Northwest power system in the upcoming decades. While both industries have existed in the Northwest for decades, in the past few years there has been an increase in development, particularly for data centers. Part of this drive is due to the advancement of artificial intelligence. Data centers (single large loads) present a uniquely challenging forecast assignment. Unlike most load sources, the constraint on tech load growth may be due to infrastructure needs, construction timelines, permitting, supporting power infrastructure and supply, etc.

In the forecast model, data center demand is separated into its own demand category. Estimates of the data center demand are identified in the historical record and separated for the regression model fits. The demand forecast model then uses an externally derived data center forecast as an input.

The graph below shows an estimate of data center loads in the Northwest (the estimate is only for data centers and does not include chip fabrication load).

Figure F - 23: Estimate of Historical Data Center Demand

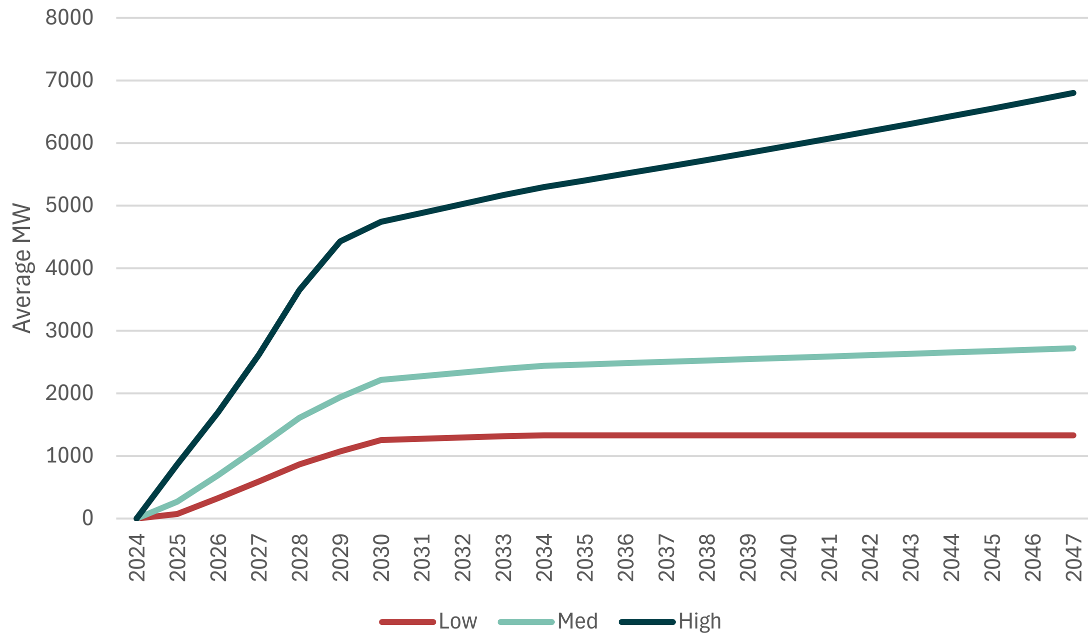


Due to challenges in acquiring actual data center load levels, these values are calculated using EIA sales data and utility data (when available). They are estimates and likely differ from actual values. Notably, this estimate, and the forward-looking forecast, may not include smaller embedded data centers and data closets. The EIA data is aggregated by residential, commercial, and industrial sales. When a utility is reporting high levels of sales growth in the commercial or industrial segment, and there are also known data centers entering the utility service area, the Council assumes the sales growth is attributable to either data centers or chip fabs. This approximation method may overcount the amount of tech growth in utilities that are seeing other industrial/commercial growth concurrent with tech growth, and it may undercount tech growth for utilities experiencing decay in non-tech industrial/commercial sales.

Historical data center demand is not evenly distributed across the forecast zones (balancing authorities) in the region. The zones most impacted recently include BPA, GCPD, PACW, PGE and DOPD.

There is significant uncertainty in future data center growth for the region. Therefore, three trajectories of future data center demand were developed as a forecast input – a low, medium and high. The medium input was used for the Late Growth and Mixed Bag futures, the high input for the High Growth and Early Growth futures, and the low input for the Low Growth future. The input represents expected incremental data center demand starting from year 2024 for each forecast zone. Figure F – 24 shows the rolled-up region view; all three outlooks suggest a good chance of rapid growth in the near term, but past 2030, the growth picture becomes more uncertain

Figure F - 24: Data Center Input for region



The medium input, for utilities with past data center growth, assumes that data centers will continue to arrive in the utility service area at the same magnitude they have arrived over the past four years. For utilities that are projecting data center load at large scale for the first time, the medium forecast assumes that 80% of the projected load materializes.

The low forecast uses utility IRP low forecasts if available. If a low forecast is not available, either 40% of the utility forecast for new data center growth is used (if the utility does not have identifiable data center growth in their sales data), or the data center average growth over the past eight years (if the utility has data center growth in their sale data).

The high forecast employs utility IRP medium-case forecasts when available, and/or 100% of announced data center projects (at time of forecast publication).

Electric Vehicles

Electric cars, vans, trucks, and buses are relatively recent and rapidly growing electric end-use. Electricity consumption for transportation is very impactful to the demand forecast for several reasons:

1. It is a steadily growing load which will drive annual energy consumption
2. It affects multiple sectors – residential and commercial primarily
3. Residential charging often occurs during times when the system is peaking, therefore it presents an opportunity for demand-side management
4. It is concentrated in specific locations, primarily large urban centers

In late 2025, there were approximately 393,000 electric vehicles registered in the states of Oregon and Washington. This is nearly double the number of electric vehicles in 2022. Oregon and Washington have both adopted the California Clean Cars II rules which will require 100% of new vehicles sales to be zero-emission by 2035.

Transportation demand is an input to the demand forecast model. The model requires three main inputs:

1. Annual demand – historical and forecast (MWh) for light duty vehicles (LDV), medium and heavy-duty vehicles (MDV, HDV) and busses by forecast zone
2. An allocation of vehicle charging locations – home, workplace, public
3. Vehicle charging profile options (managed and unmanaged)

In the model, electric vehicle demand is assigned to the sector where the vehicle is expected to be charged. The demand is shaped and layered onto the residential and commercial demand depending on the charging allocation assignment and profile.

Input Electric Vehicle Demand

The input data set includes a projection of annual energy (MWh) by vehicle type and forecast zone out through year 2047. Two input data sets were developed: a higher case, and a lower case that is roughly 15% less (in terms of demand). Both projections are designed to meet Oregon and Washington state policies that 100% of new sales are to be zero-emission vehicles by 2035. The lower case assumes that the overall demand for transportation is less, meaning there are fewer cars on the road. A data set built up from historical LDV registration by state was used to set a base of vehicle stock. The states of Oregon[23] and Washington[24] maintain electric vehicle dashboards that provide the number of electric vehicles registered and in some cases the county. For Idaho and Montana, a variety of sources were used to estimate the electric vehicle stock, including the US Department of Energy Alternative Fuels Data Center.[25] County data was used to allocate the state-wide EVs to specific forecast zones. Estimates of annual vehicle miles traveled and kWh per mile were used to estimate annual historical demand.

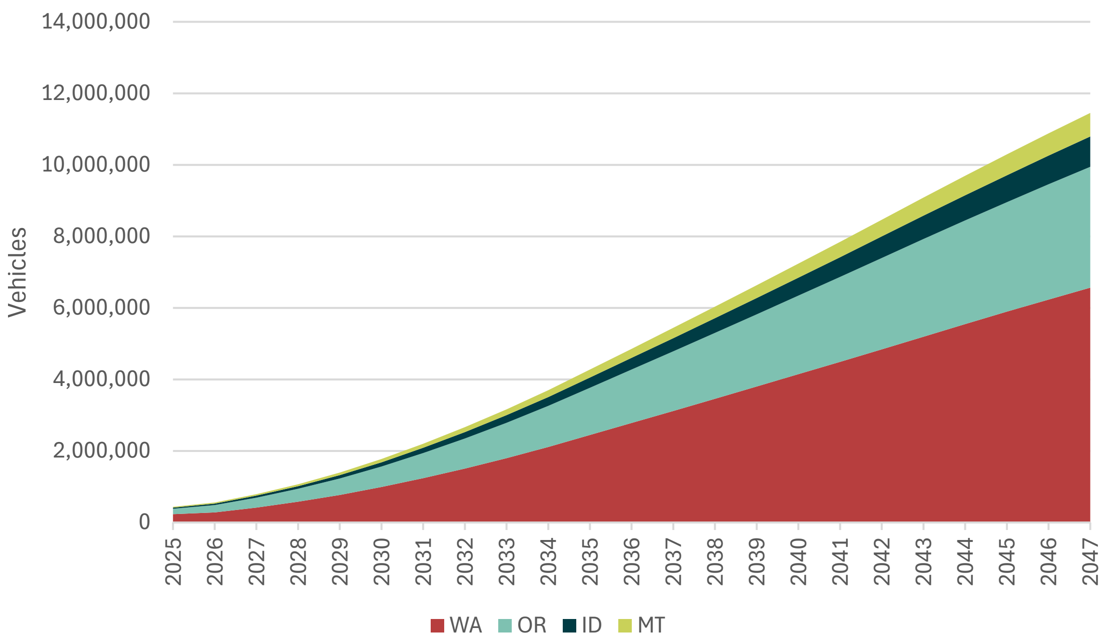
A forward projection of EVs was developed using the system dynamics model Energy Policy Simulator (EPS) from Energy Innovations and RMI.[26] This tool provides state level forecast with breakout of vehicles by fuel and type. Judgement was also applied to the forecast, to best reflect the region's

[23] https://www.oregon.gov/energy/Data-and-Reports/Pages/Oregon-Electric-Vehicle-Dashboard.aspx.
[24] https://data.wa.gov/Transportation/Electric-Vehicle-Population-Data/f6w7-q2d2/about_data.
[25] https://afdc.energy.gov/transatlas#/?year=2023&state=ID&fuel=ELEC.
[26] https://energypolicy.solutions.

transportation system. Data from CALSTART[27] was used to inform the forecast of electric buses, and trucking (MDV, HDV).

Figure F - 25 through Figure F - 27 show the transportation input to the forecast model for the higher transportation case.

Figure F - 25: Projected LDV Electric Vehicles by State



[27] https://calstart.org.

Figure F - 26: Projected LDV Demand by Zone

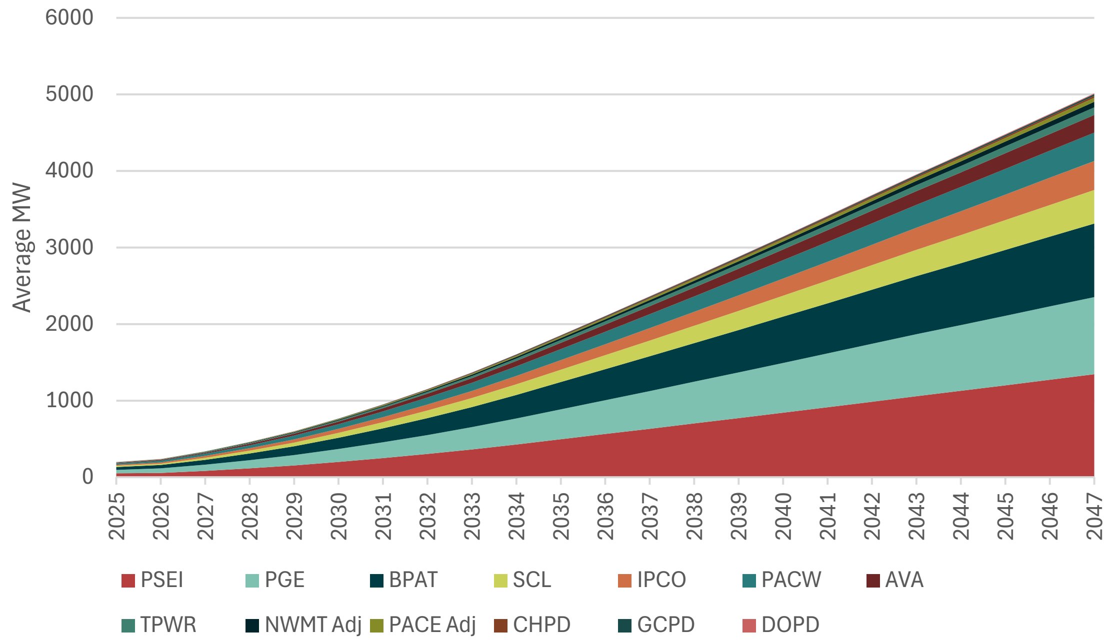
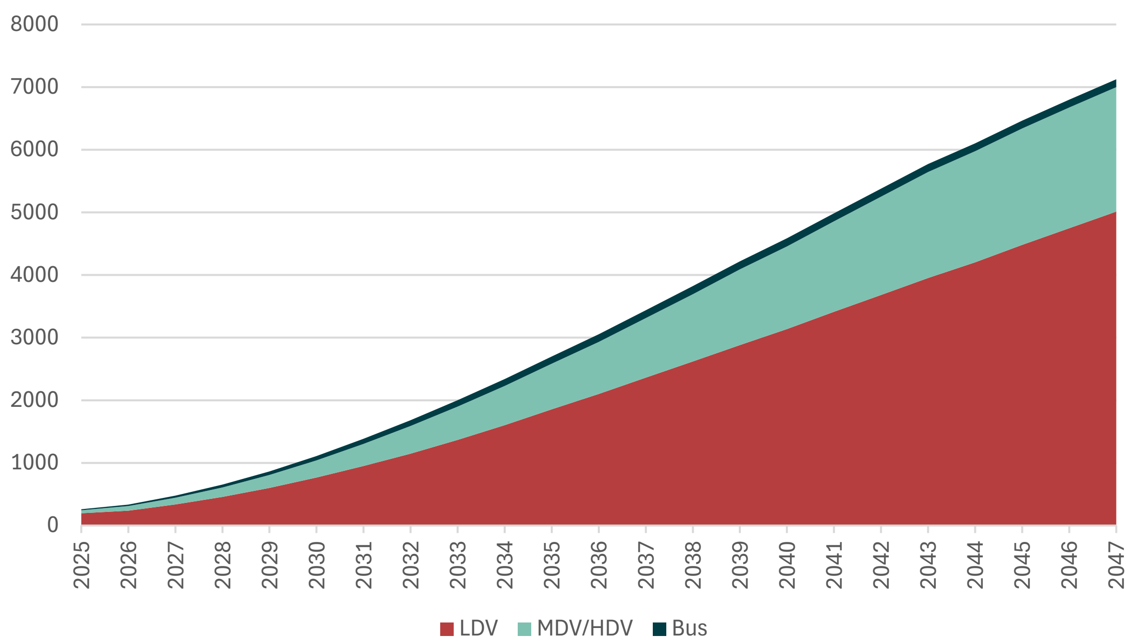


Figure F - 27: Projected Transportation Demand by Vehicle Class



Electric Vehicle Charging Profiles

Multiple charging profiles were developed to apply to the vehicle energy demand. The LDV class profiles were developed using the US Department of Energy/NREL EVI-Pro Lite tool[28]. The MDV/HDV and bus charging profiles were sourced from the California Energy Commission (CEC)[29].

Table F - 12: Charging Profile Suite

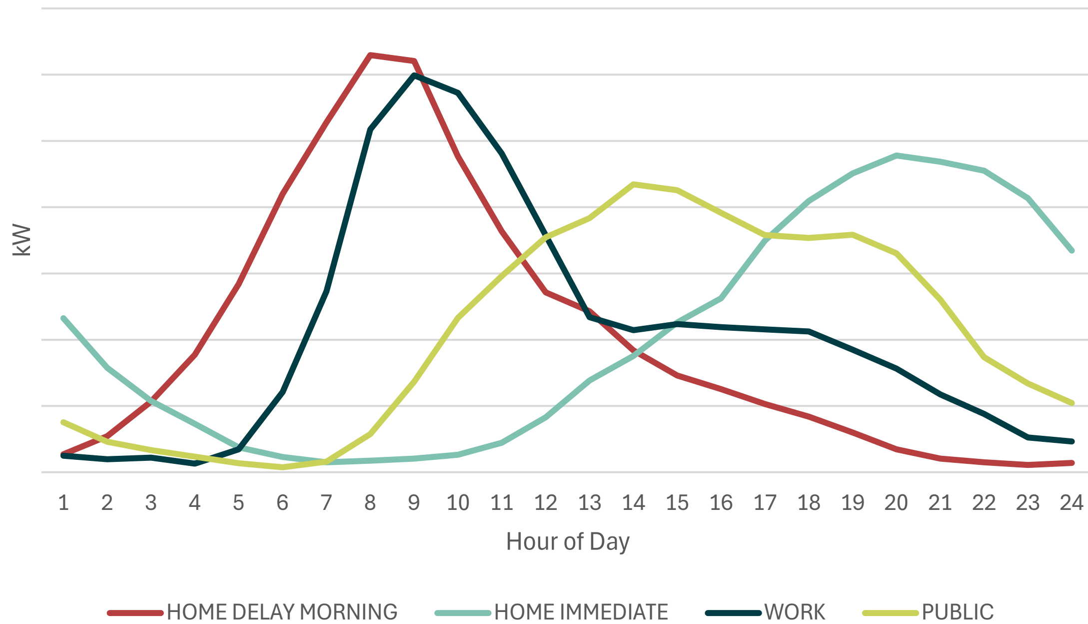
Class	Type	Profile	Source
LDV	Home Level 1 Home Level 2	Immediate Delayed Midnight (managed) Delayed Morning (managed)	NREL EVI-Pro Lite
LDV	Work Level 2 Public Level 2 Public DC Fast	Immediate	NREL EVI-Pro Lite
HDV, MDV, Bus			CEC

Much of the LDV charging is expected to take place at home. This demand is allocated to the residential sector. The charging shape that is used in the forecast is primarily the immediate (un-managed) profile, which peaks in the evening as commuters return home after the workday and plug their vehicle in. The Council expect over time that the LDV charging demand will be managed, possibly through implementations of time of use rates, but we kept much of the charging in the forecast to be un-managed. This allows the Council to assess the potential of demand response in relation to other resources to ultimately inform the Ninth Power Plan's cost-effective resource strategy.[30]

Another finding from the work is that simply spreading out the EV charge over locations – home, work, and public can significantly even out the demand over the day. For example, the Figure F - 28 shows the model EV daily profiles for multiple sites.

[28] https://afdc.energy.gov/evi-x-toolbox#/evi-pro-loads.
[29] https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics-collection.
[30] More information on the demand response potential is available in Technical Appendix I – Demand Response Methodology and Potential.

Figure F - 28: Daily EV Charging Profiles



Rooftop Solar

Rooftop photovoltaic (PV) pertains to the use of solar panels mounted on top of buildings, to generate electricity from sunlight. It may also be referred to as behind the meter solar (BTM). The electricity produced can be used on-site at the residence or business to reduce customer demands on the grid. Though the Northwest traditionally has been a relatively small player in the rooftop solar market, installations of PV systems have been growing in recent years and have an impact on future demand.

We developed a data set with historical and forecast annual PV capacity by sector (Res, Com, Ind) for each forecast zone. The amount and shape of electricity generated by the installed PV capacity is calculated in the demand model using location-specific global horizontal irradiance (GHI) values. This solar generation is then subtracted from the demand in the sector and zone that it was produced in.

Because rooftop solar is becoming more available in the Northwest, the Council decided to include some rooftop solar potential as a demand side resource option to test in scenario modeling.[31] Therefore, the Council including only a conservative projection of rooftop solar demand reduction in the demand forecast better allows the resource model to select additional solar installation levels if cost effective as compared to other resource options.

[31] More information is available in Technical Appendix J – Rooftop Solar Methodology and Potential

Rooftop Solar Installations in the Northwest

To support the forecasting work, the Council compiled complete data sets of PV installations by zone and sector from 2011 through 2025. Data from the EIA 861[32] report was especially useful, as well as EIA Short[33] and Long Term Energy[34] Outlooks.

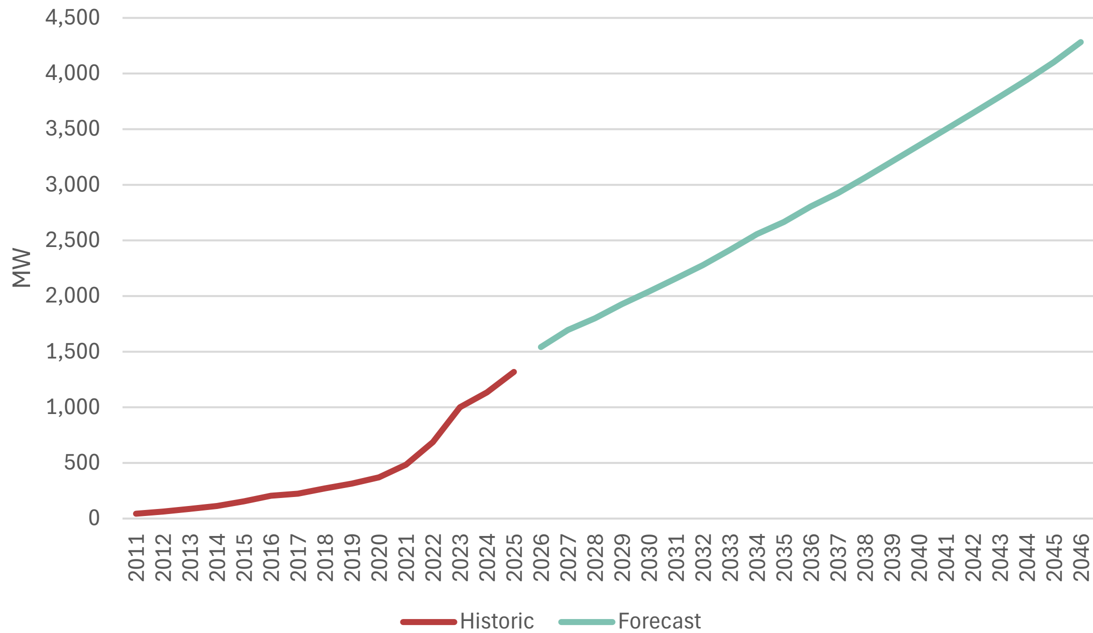
Some key findings of the PV work:

1. 2023 was a record year of installs in the region – around 315 MW – which continued a strong trend of growth since 2020
2. 2024 installs declined from 2023 – to around 134 MW – possible factors include higher financing costs and a few installer companies filing for bankruptcy
3. The Northwest is a small player in the solar market, but does seem to be following national trends
4. Installs rebounded slightly in 2025 to 185 MW, and EIA and industry groups expect continued growth to follow
5. Installed rooftop PV in the region as of 2025 is 1,318 MW, meaning 24% of the current existing capacity was installed in a single year (2023)

To create a projection of future PV installation in the region, the Council developed a basic trend model (Brown's Double Exponential Smoothing Method) based on historical data combined with judgment gleaned from the EIA short- and long-term outlooks. Figure F - 29 and Figure F - 30 below display the regional results – both actual installations and forecast.

[32] https://www.eia.gov/electricity/data/eia861.
[33] https://www.eia.gov/outlooks/steo.
[34] https://www.eia.gov/outlooks/aeo.

Figure F - 29: Installed PV Capacity in the Region

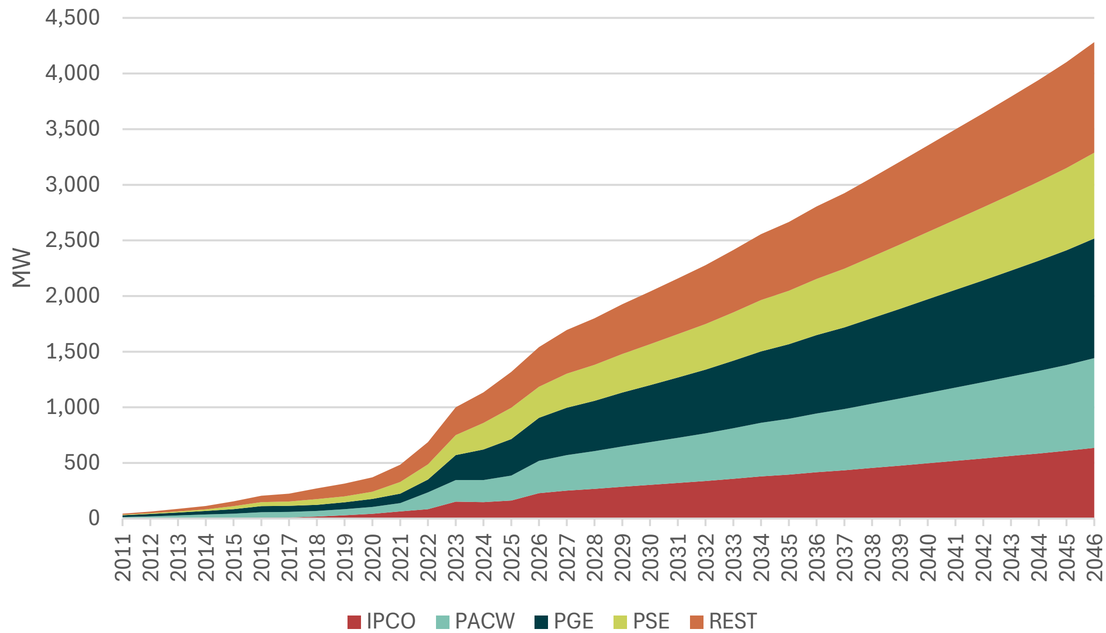


Much of the installed PV capacity is projected to be in the residential sector and is concentrated primarily (75%) in four zones (balancing authorities) – Idaho Power, PacifiCorp West, Portland General, and Puget Sound Energy.

In addition to the solar embedded in the demand forecast, rooftop solar is also treated as a resource option in the power plan to evaluate cost-effective strategies. The 20-year potential for rooftop solar generation is estimated to be 4,273 average MW, which corresponds to nearly 27,000 MW of capacity[35].

[35] See Appendix J – Rooftop Solar Methodology and Potential.

Figure F - 30: Installed PV Capacity by Zone



Rooftop Solar Shapes and Generation

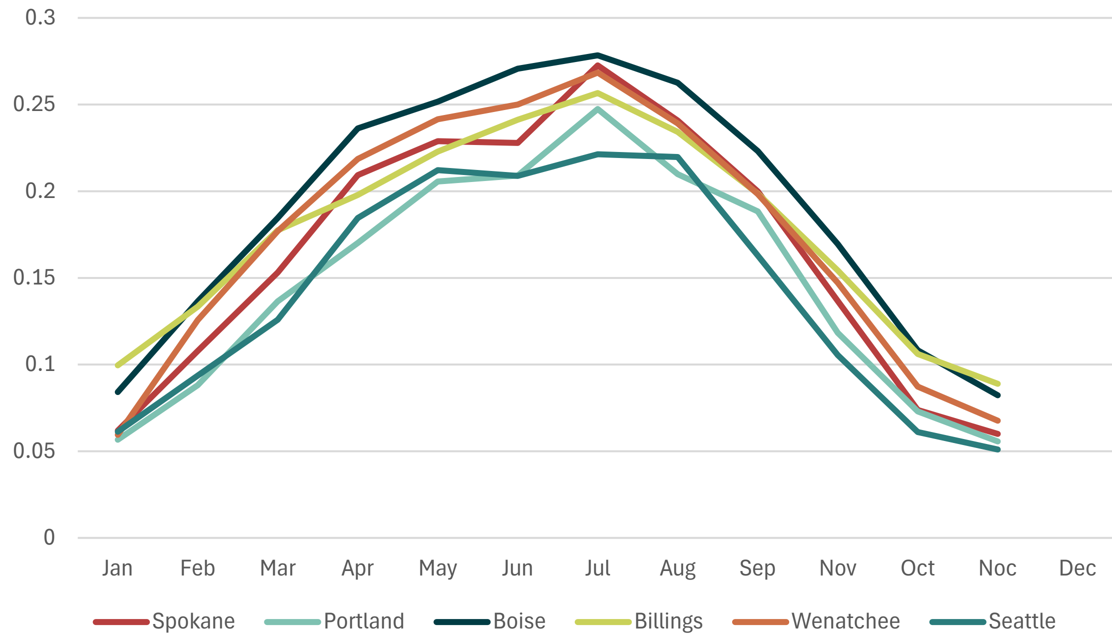
Solar generation profiles were developed and input to the demand model to spin PV capacity into generation, as a function of GHI. Solar generation data from the National Renewable Energy Lab (NREL)[36] was used to model locational profiles. Note that the rooftop solar profiles here are very similar but not an exact one-to-one match with the full climate model informed profiles.[37]

The overall regional rooftop capacity factor (generation/capacity) is around 15.6%. For example, 2000 MW of installed capacity would produce 310 aMW. Generation varies by location and season. See

Figure F - 31 for an example of the solar capacity factors by month.

[36] https://atb.nrel.gov/electricity/2024/residential_pv.
[37] See Appendix D – Climate Model Data and Assumptions.

Figure F - 31: Monthly Solar Generation Profiles



In the summer, the region's demand often ramps up in the late afternoon. There is still sizeable solar generation during this time, which is beneficial in lowering the peak requirements. However, in the winter, the peak often occurs in early morning when there is little to no solar generation.

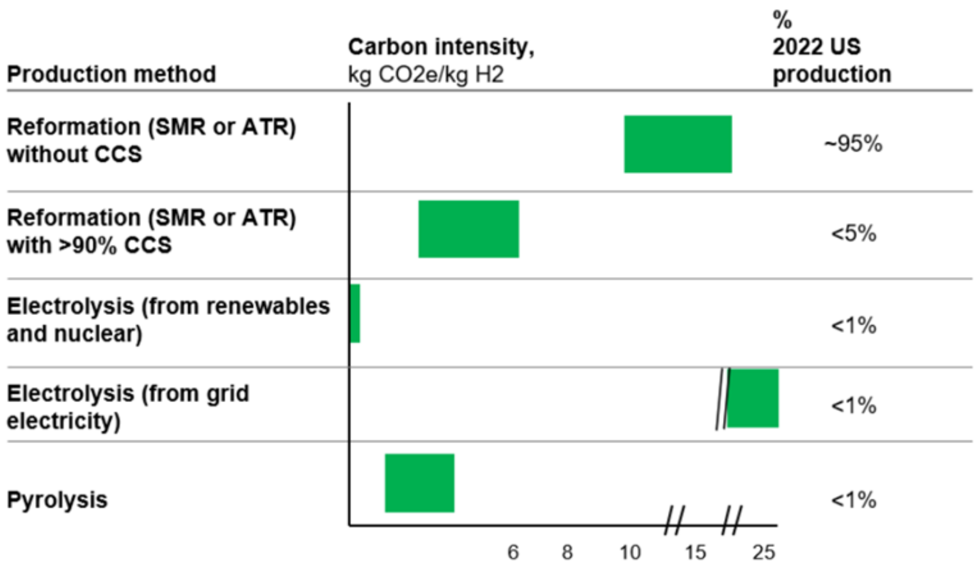
Hydrogen Load Forecast

For the Ninth Power Plan, a hydrogen fuel forecast was developed to represent the electricity required to create clean hydrogen in the Northwest. This forecast is specific to hydrogen used for non-power system uses, like the industrial sector. It can also be viewed as a rough proxy for general industrial and medium/heavy duty transportation decarbonization via electrification. For the Ninth Power Plan, the hydrogen demand is modeled to be curtailable, therefore this demand is not included in the peak forecast, but it is included in the energy forecast.

Hydrogen, if created using low carbon processes, can be used to decarbonize hard-to-reach economic sectors like high-heat industrial applications and medium/heavy duty transportation. Hydrogen can be used as a fuel directly, or as an intermediary step when developing other fuels like ammonia or drop in liquid fuels.

Hydrogen is not commonly found in nature and typically requires another energy source to create. Today, in the US, most hydrogen is made with natural gas as the primary energy source. If clean electricity is used as the primary energy input, hydrogen can be created with a low carbon footprint. Other non-electric hydrogen creation sources can yield low carbon hydrogen as well, including natural gas if carbon capture is employed. The figure below is taken from a 2023 US Department of Energy report and estimates the carbon associated with creating hydrogen via different energy inputs and processes.[38]

Figure F - 32: Hydrogen Production Carbon Intensities



Little, if any, hydrogen is produced in the Northwest today using electricity as the primary energy source.[39] Resultingly, the Ninth Plan Northwest hydrogen demand forecast is rough due to nascent nature of the industry. The forecast largely relies on two sources. First is publicly shared information from the Northwest hydrogen hub. Second is the US Department of Energy's 2023 report, "U.S. National Clean Hydrogen Strategy and Roadmap". The high-level steps used to create the forecast follow:

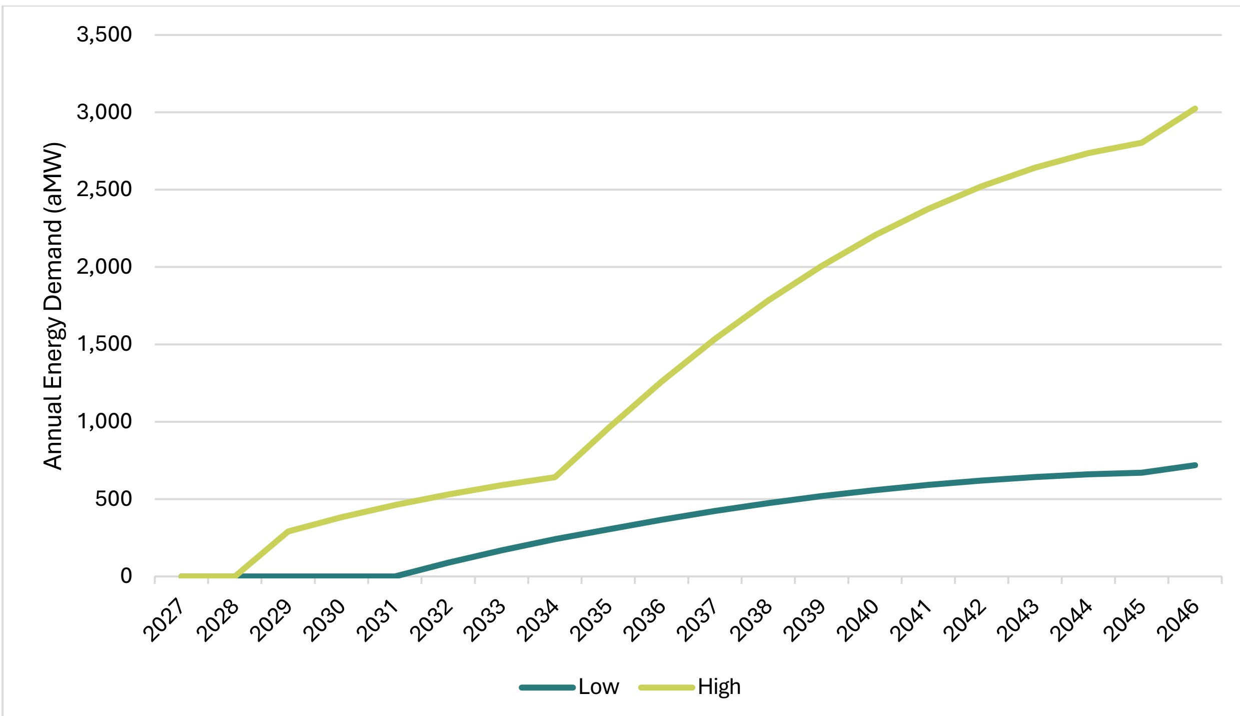
1. Both forecasts (high and low) start with estimates of hydrogen production from the Northwest Hydrogen Hub. For the high case, the hub projects are assumed to come online in 2029, and in the low case, 2032. Production is assumed to be ramped up smoothly over the following years until a level of 0.11 MMT/year is reached for the low case, or 0.15 MMT/year for the high case.
2. After the Northwest Hydrogen Hub ramp, the high case shows accelerating hydrogen usage. This is based on the national DOE "Clean Hydrogen Strategy and Roadmap" report that came out a few years ago. The report is national, a Northwest share is made by prorating how much energy the Northwest uses for non-electric industrial usages and transportation. This ends up being around 1.5 MMT/year in 2050. The low case hydrogen usage grows at the same speed as it did over the six-year hydrogen hub low ramp in, reaching 0.35 MMT/year in 2050.

[38] US DOE, 2023, U.S. National Clean Hydrogen Strategy and Roadmap.
[39] At time of writing the 5 MW Douglas County renewable hydrogen pilot facility was just coming online

In both the low and high case, an increasing amount of hydrogen is assumed to be either produced outside of the Northwest (and imported in) or produced in the Northwest using a non-electric feedstock. By 2045 half the hydrogen in the forecast comes from a non-electric facing technology. This essentially cuts the electric load forecast in half for 2045 compared to all the hydrogen being produced in the Northwest using electrolysis.

The final forecast, for the low and high pathways, are shown below.

Figure F - 33: Forecast Range for Hydrogen Demand



After the Ninth Plan hydrogen forecast was finished, the Federal government withdrew grant funding for the Northwest Hydrogen Hub (originally a grant of up to 1 billion dollars was awarded). This may negatively impact the development of hydrogen projects in the Northwest, particularly in the near-term. In the long term, local and state governments in the Northwest have decarbonization goals for the industrial and heavy-duty-vehicle / marine / aviation sectors. The Ninth Plan does not include a specific decarbonization focused forecast for those sectors. While the hydrogen forecast was created specifically for electric loads associated with hydrogen production, it can also be viewed as a rough proxy for electric loads associated with decarbonizing those sectors.

Energy Shaping

The monthly energy for each zone that is produced by the energy regression models are shaped into daily and hourly intervals. The end-use shapes are applied to the disaggregated energy forecast results. In addition, individual hourly profiles are built out for each of the forecast zones. A regression model is fit for each separate hour (24 in total) for the zones. The inputs to the model include hourly historical demand data, historical weather data (HDD, CDD), calendar month, day of week, and holidays. The hourly shaping models are then used to build out a comprehensive, weather sensitive zonal demand profile based on historical data and comprised of a system, heat, cool and baseline profile. This is the profile that the shaped end-use demand is calibrated to.

Finally, new technology demand is layered on based on input shapes. This can include the electric vehicle demand and any additional building electrification. For example, for the futures that include high building electrification, the additional heating, cooling, water heating and cooking demand is layered onto the demand profile using the specific end-use shape associated with the end-use. For instance, for space heating, it is assumed that the technology used is a heat pump, so the specific heat pump profile is applied to all new space heating electrification demand.

Forecast Results

The frozen-efficiency demand forecast shows robust demand growth in nearly all of the forecast futures. **Error! Reference source not found.**34 and **Error! Reference source not found.**35 display the results of the forecast for the region's annual demand energy and demand peak for the three climate model weather patterns. Please note that Hydrogen demand is excluded from the energy and peak results in the discussion and figures. To understand the full future forecast for energy, add the additional hydrogen as forecast and shown in Figure F - 32. The Council assumed the hydrogen load was elastic and is not in the peak forecast.

Figure F - 34: Annual Forecast Energy Range for Region

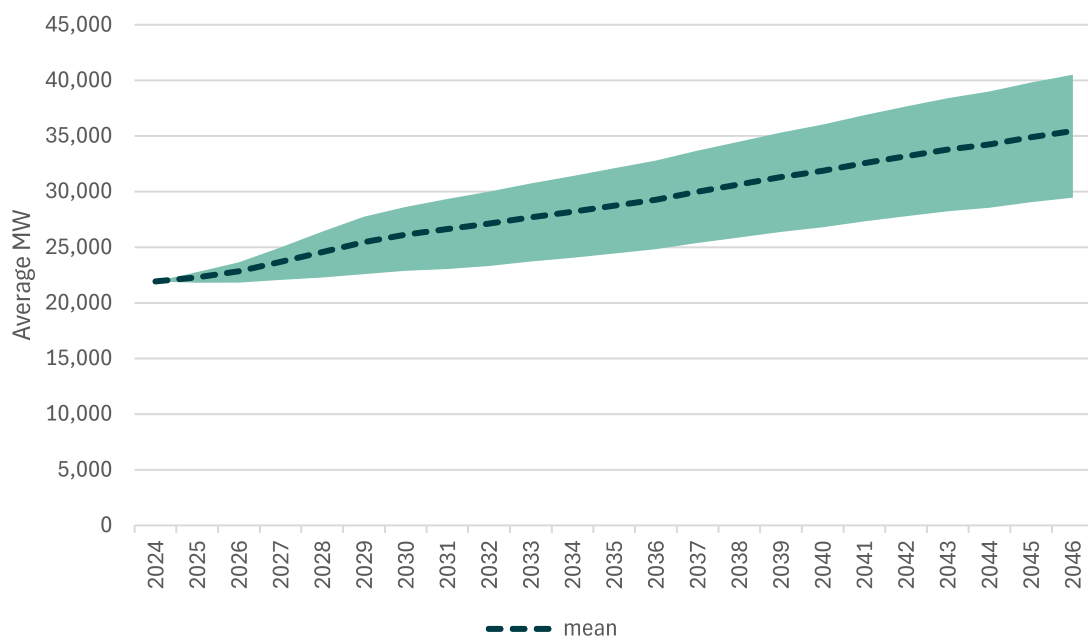
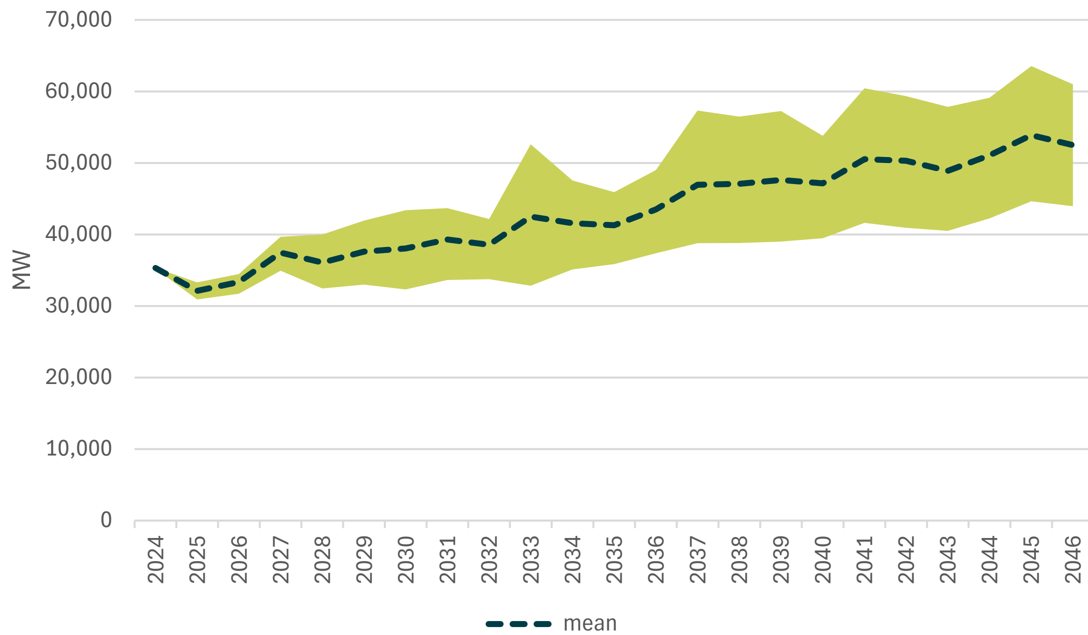


Figure F - 35: Annual Forecast Peak Range for Region



As expected, peak demand is much more volatile, since even though an overall weather pattern may be mild in terms of overall heating degree and cooling degree days, it may be sprinkled with extreme cold and/or hot temperature events.

Looking at the forecast horizon from 2025 through 2046, average annual energy growth rates range from 1.4% to 2.8%. In terms of total energy growth in average MW, the futures range from a high of 17.820 aMW to a low of 7,645 aMW.

Forecast average annual peak rates are growing faster, ranging from a low of 1.8% to 3.1%.

Figure F - 36: Energy Growth Rate

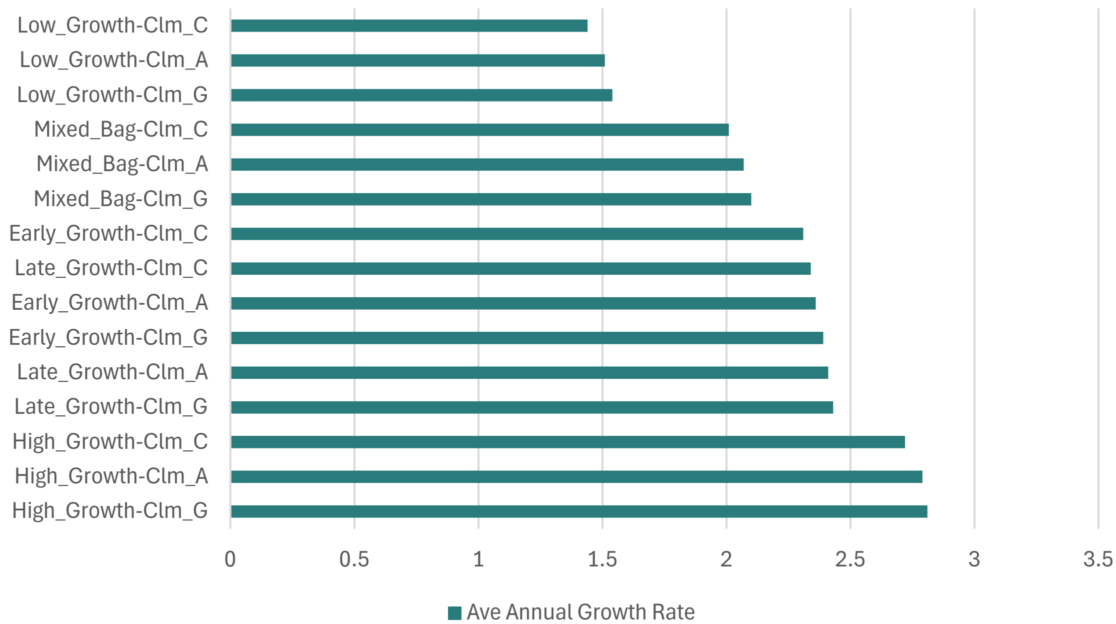


Figure F - 37: Energy Growth (aMW)

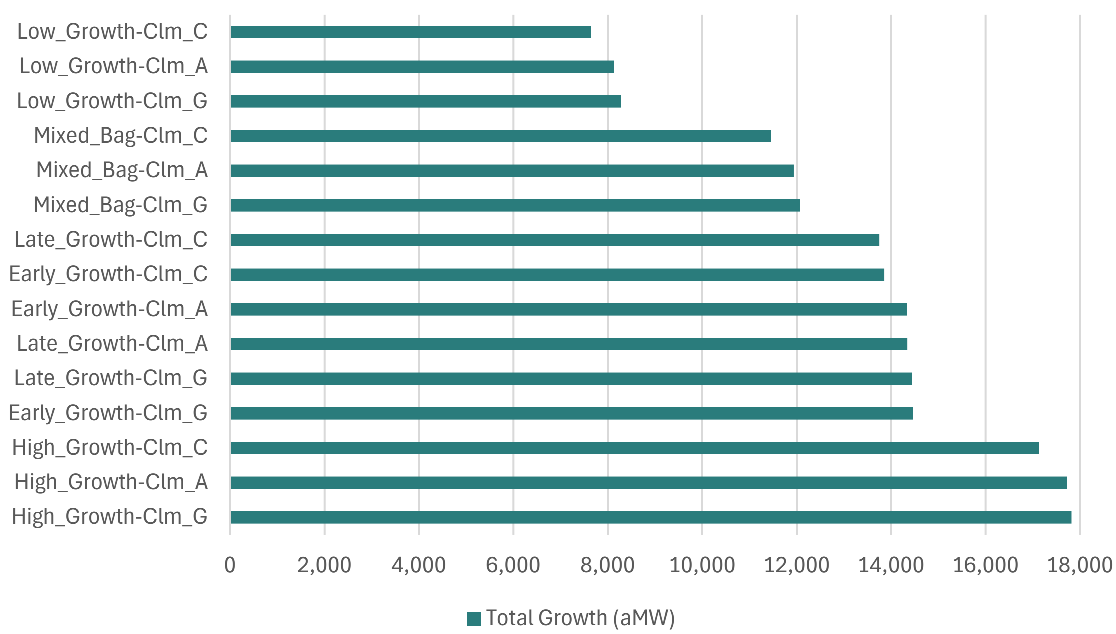
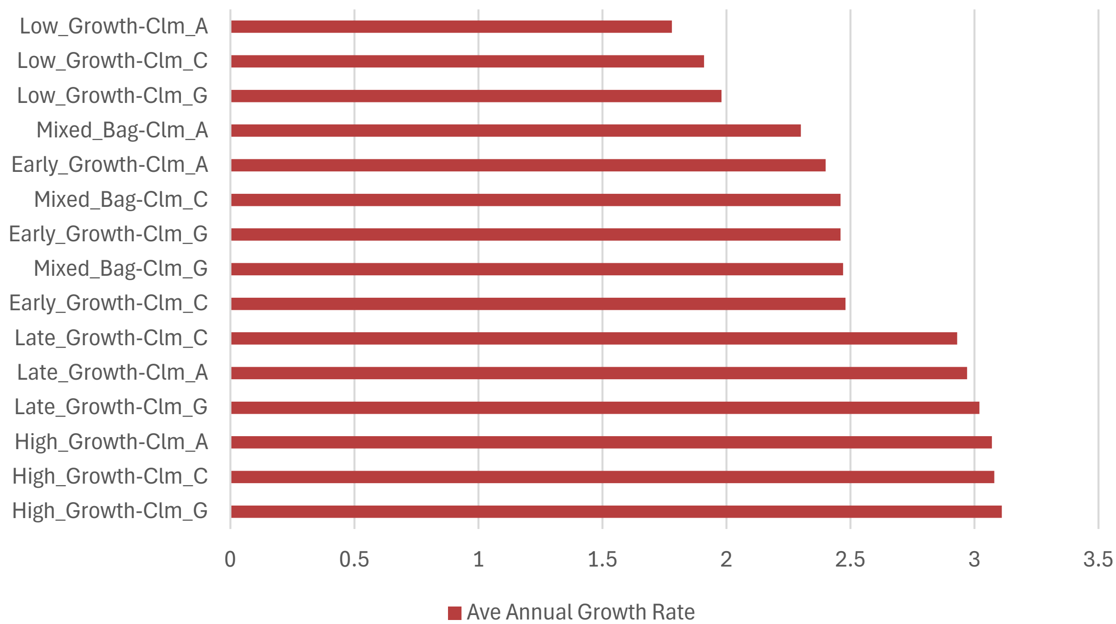


Figure F - 38: Peak



Energy

The forecast projects growth across the residential, commercial, industrial, electric vehicle, and data center sectors. Note that for the data center and electric vehicle sectors, the demand shown is incremental to 2024.

Looking at the sector level, the range of forecast uncertainty varies. Figure F - 39 shows the range of demand by sector, across all economic pathways and weather patterns. Note, in this figure, the residential and commercial sectors contain the electric vehicle charging and building electrification which are embedded within those sectors.

Figure F - 39: Regional Energy Forecast Range by Sector

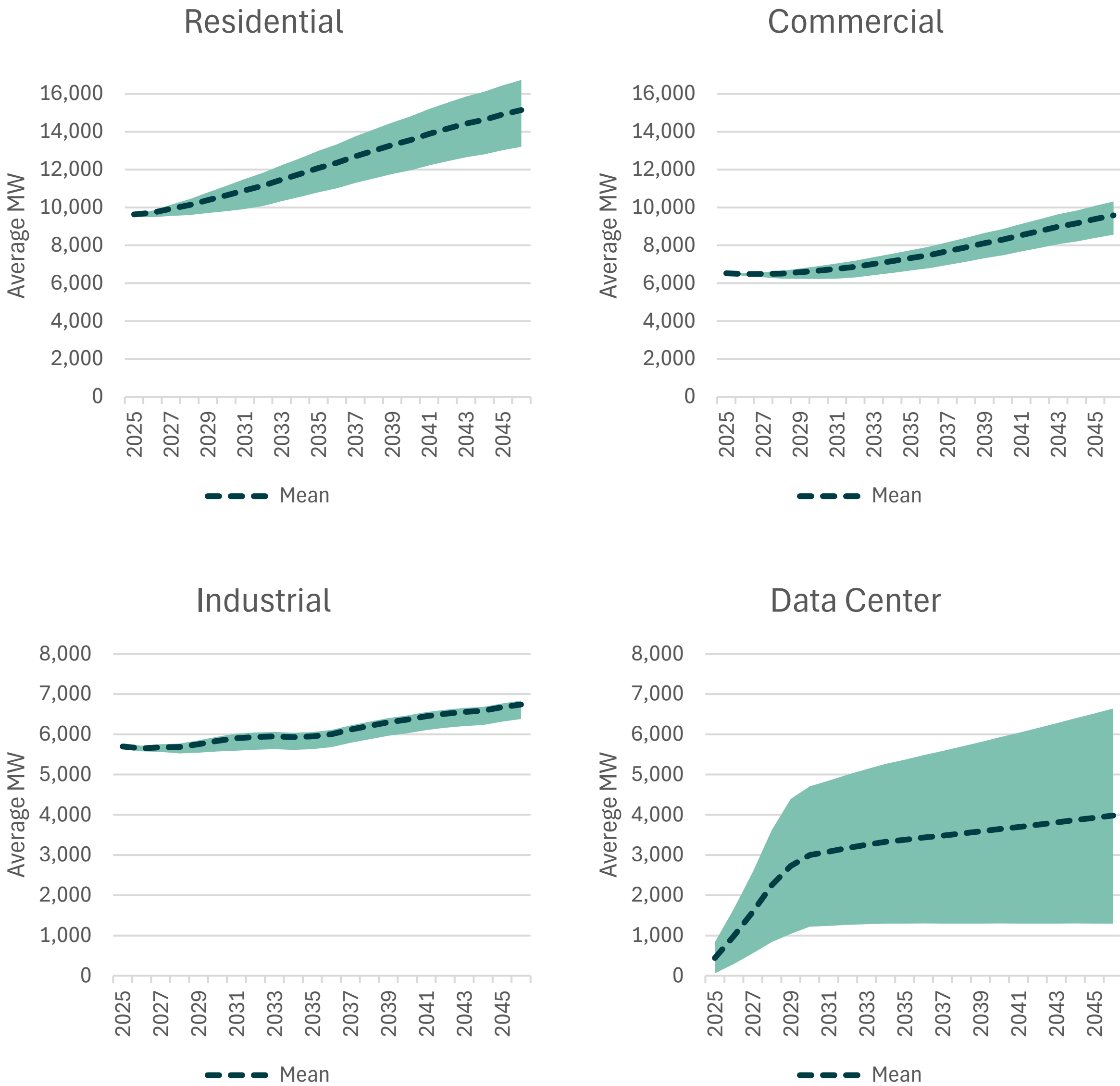
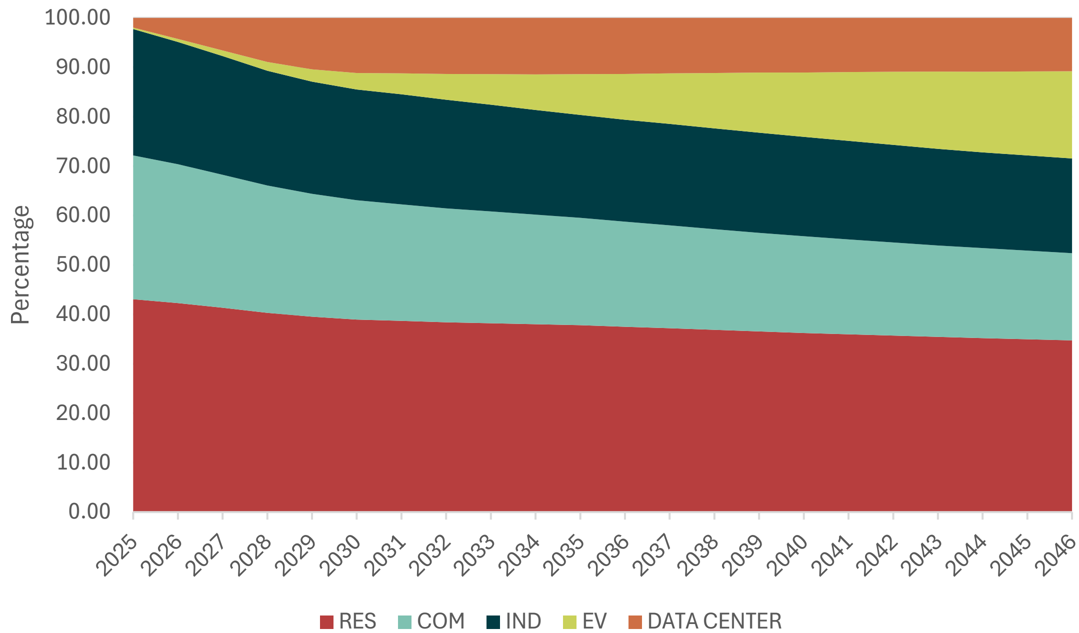


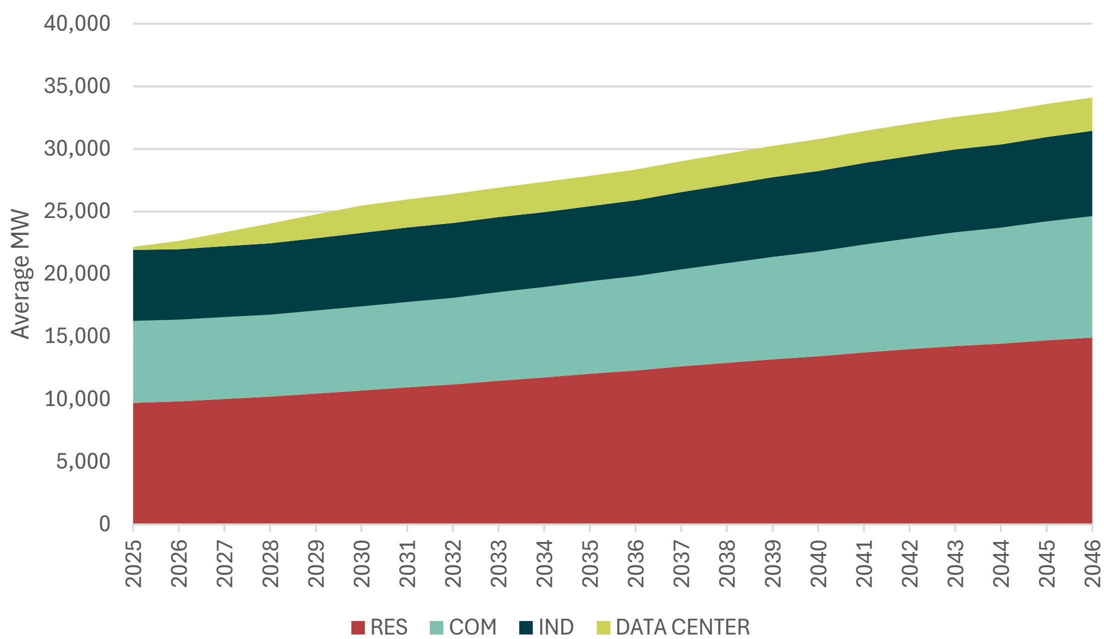
Figure F - 40 shows the average breakout of the forecast by sector across all the futures, expressed as a percentage of the total annual demand. In this representation, the electric vehicle demand is pulled out of the residential and commercial sectors.

Figure F - 40: Regional Energy Forecast Range by Sector across all Futures



For an example of a specific future, Figure F - 41 shows the forecast for Mixed Bag Climate A. with the electric vehicle demand included in the residential and commercial sectors.

Figure F - 41: Regional Energy Forecast Mixed Bag – Climate A

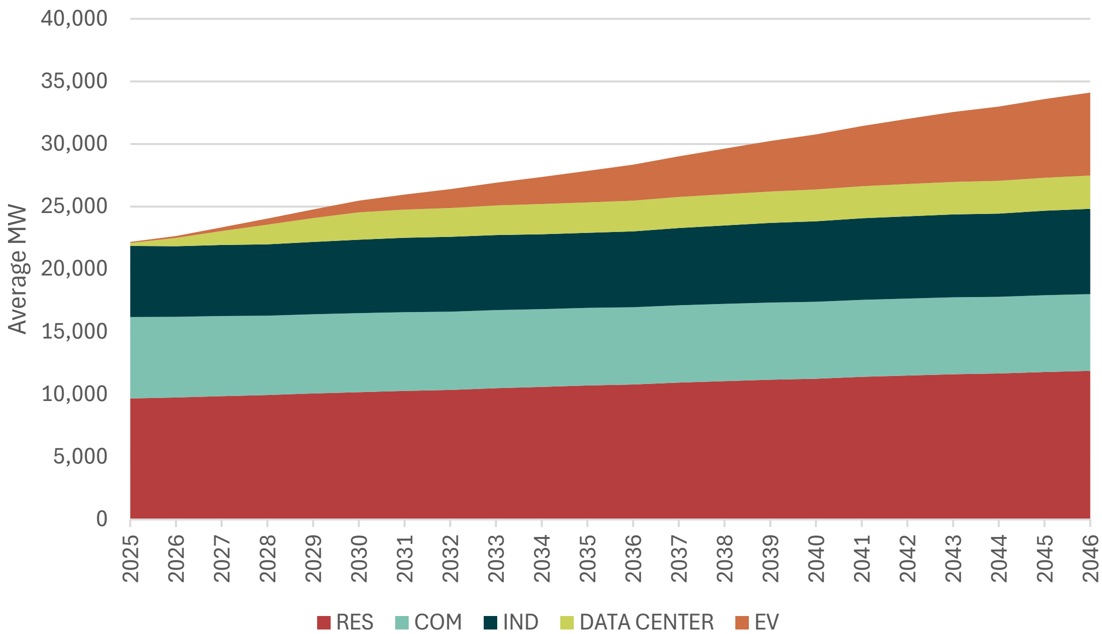


In this future, the total growth in average MW (aMW) from 2025 to 2046 is 11,937 aMW. Of this growth in energy:

- 44% is from residential
- 26.5% is from commercial
- 9.5% is from industrial
- 20% is from data centers

Much of the residential and commercial growth is tied to electric vehicle load growth. If we pull out the electric vehicle demand out of the residential and commercial sectors, we see more muted growth in residential and commercial.

Figure F - 42: Regional Energy Forecast Mixed Bag – Climate A with EV Separate



Electric vehicles alone accounts for over half of the overall demand growth in this future. The residential sector, excluding electric vehicles, accounts for 18% of the growth, and the commercial sector is flat.

Figure F - 43 displays the forecast for the High Growth future, with further disaggregation of the electric vehicle and building electrification demand.

Figure F - 43: Regional Energy Forecast High Growth

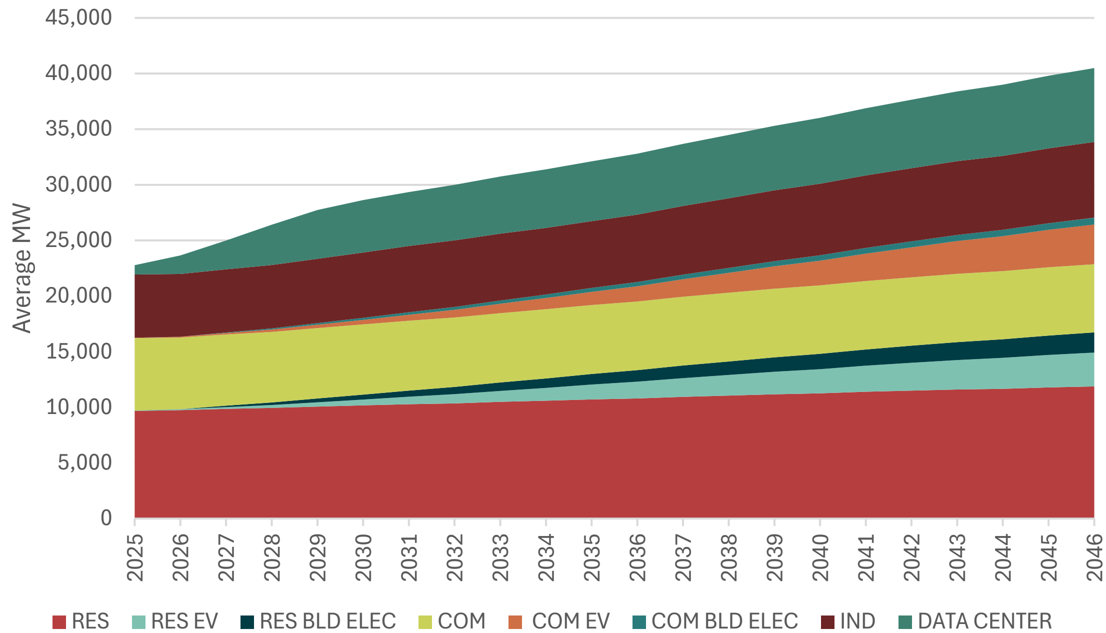


Table F - 13 shows the percentage of the overall system-wide growth that each sector contributes in each future with the Climate A pattern. The total energy growth is the delta between the forecast in the years of 2046 and 2025.

Table F - 13: Percentage of the Overall Growth by Sector Across all Climate Futures

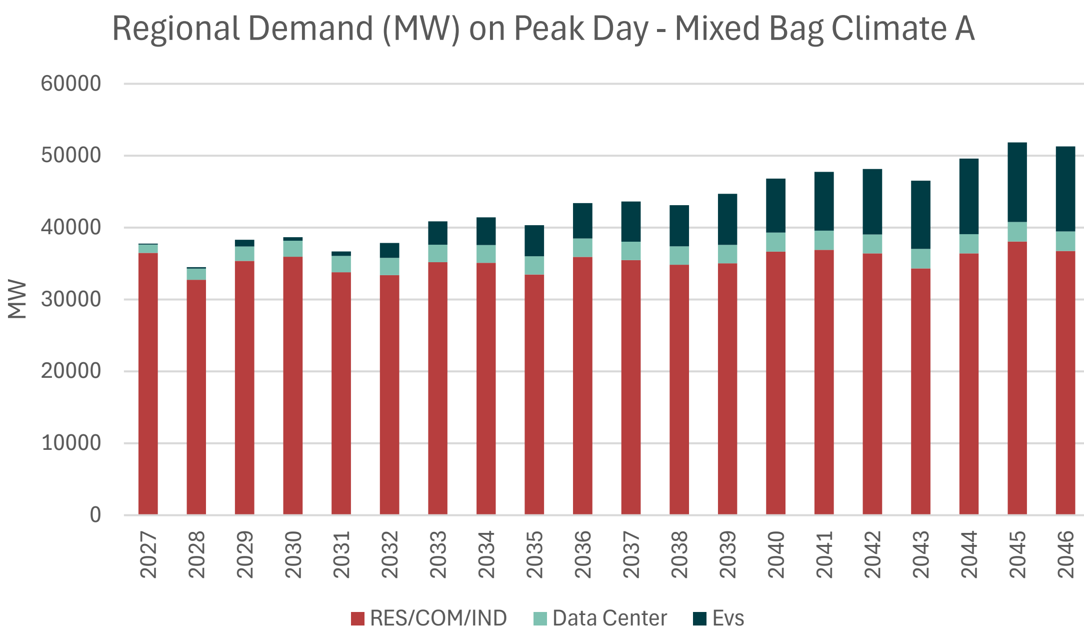
Future	RES	COM	IND	Data Center	EV	Bld. Elec.
Low Growth	16.5	-10.3	9.0	15.4	69.4	0
Mixed Bag	18.0	-3.5	9.5	20.5	55.4	0
Early Growth	15.0	-2.9	7.9	40.9	39.1	0
Late Growth	15.0	-2.9	7.9	17.1	46.2	16.6
High Growth	13.4	-2.6	7.1	36.5	41.1	14.8

Peaks

Forecasted peak demand is growing at a higher rate than energy demand. This is due to electric vehicle and building electrification demand primarily. As mentioned earlier, in the frozen-efficiency demand forecast, electric vehicles present a relatively unmanaged charge. In this situation, electric vehicle demand generally peaks in the late afternoon/early evening time, which is often also when the system peak occurs. Building electrification demand often peaks in the morning and evening times due to space heating requirements, which also contributes to peaks in those futures with high building electrification.

Historically, the region's peak demand has always occurred in the winter season. However, in the forecast, summer peak events are starting to appear. For example, in the future of Mixed Bag Climate A, 40% of the annual peak events are in the summer. This move to more summer peak events is due to warmer future temperatures, higher building cooling saturations, and more electric vehicles.

Figure F - 44: Regional Annual Peaks



When looking at the forecasted coincident peak across all the future economic conditions and weather patterns, a few aspects are clear. Forecasted data center energy growth is contributing to the peaks, especially early in the forecast period. Even though the data center hourly load pattern is modeled to be fairly level, the energy growth acts as a rising floor for the system peaks. Later in the horizon, electric vehicle charging is driving much of the forecasted peak growth. Potential building electrification in the residential and commercial sectors also begins to drive peak demand, though not to the degree of EV charging. Table F - 14 summarizes the contribution to the coincident peak from the residential/commercial/industrial sectors, data centers, and electric vehicles across all the futures. In these categories, the electric vehicle demand is separated from the residential and commercial sectors, while building electrification is kept in those sectors.

Table F - 14: Demand Contribution on System Peak (MW), Averaged Across All Futures

Year	Total	Res/Com/Ind	Data Center	Electric Vehicles
2027	37,464	35,727	1,600	137
2028	36,081	33,507	2,360	213
2029	37,594	34,030	2,809	755
2030	38,033	34,192	3,086	755

Year	Total	Res/Com/Ind	Data Center	Electric Vehicles
2031	39,292	35,629	3,060	604
2032	38,551	32,973	3,286	2,291
2033	42,487	36,852	3,284	2,350
2034	41,578	35,535	3,437	2,606
2035	41,295	34,356	3,381	3,558
2036	43,511	35,475	3,535	4,500
2037	46,950	38,728	3,585	4,637
2038	47,083	38,506	3,518	5,059
2039	47,616	37,280	3,664	6,672
2040	47,156	36,219	3,753	7,184
2041	50,535	38,874	3,783	7,878
2042	50,309	37,907	3,837	8,565
2043	48,889	35,881	3,913	9,095
2044	51,061	37,691	3,961	9,409
2045	53,880	39,467	4,033	10,380
2046	52,499	37,534	4,009	10,956

Table F - 15 displays the percentage of the coincident system peak that each demand category contributes. As before, this is the average contribution across all futures.

Table F - 15: Average Percent of Peak Contribution Across All Futures

Year	Res/Com/Ind	Data Center	Electric Vehicles
2027	95.4	4.2	0.4
2028	93.0	6.4	0.6
2029	90.7	7.3	2.0
2030	90.0	7.9	2.0
2031	90.9	7.6	1.5
2032	85.7	8.3	6.0
2033	86.6	7.6	5.8
2034	85.5	8.1	6.4
2035	83.3	8.0	8.7

Year	Res/Com/Ind	Data Center	Electric Vehicles
2036	81.7	7.9	10.4
2037	82.4	7.5	10.2
2038	81.7	7.3	10.9
2039	78.4	7.5	14.1
2040	77.0	7.7	15.3
2041	77.0	7.3	15.7
2042	75.5	7.4	17.1
2043	73.5	7.8	18.7
2044	73.9	7.5	18.5
2045	73.4	7.3	19.3
2046	71.6	7.4	21.0

Sales Forecast

The final forecast output, or the "sales forecast," represents the forecasted future loads after accounting for the cost-effective amount of demand side resources as described in Chapter 4, Action Item RES-1.

Conservation and voltage regulation, as outlined in the resource strategy, reduces hourly load throughout the day. Demand response does not reduce overall demand, but instead shifts electricity use to a different time. In the case of electric vehicles, demand response shifts vehicle charging from late afternoon and evening to the early morning hours.

The estimate of the conservation, demand response, and voltage regulation across the entire planning horizon was applied to the frozen-efficiency load forecast. Conservation and voltage regulation reduce demand in the residential, commercial, and industrial sectors. Demand response shifts the load pattern in the residential and commercial sectors, and particularly the electric vehicle demand.

The resulting peak and energy sales forecast for the region is shown in Figure F - 45. This includes all the forecast futures. Figure F - 46 and Figure F - 47 break out the energy (aMW) and peak (MW) forecast individually and includes the frozen-efficiency forecast as a comparison. Figure F - 48 summarizes the percent load reduction to the frozen-efficiency forecast that the conservation and demand response provides. Generally, the peak hour reduction is higher in terms of percentage than the annual energy reduction, due to demand response shifting electric vehicles charging away from typical peak hours.

Figure F - 45: Regional Annual Sales Forecast

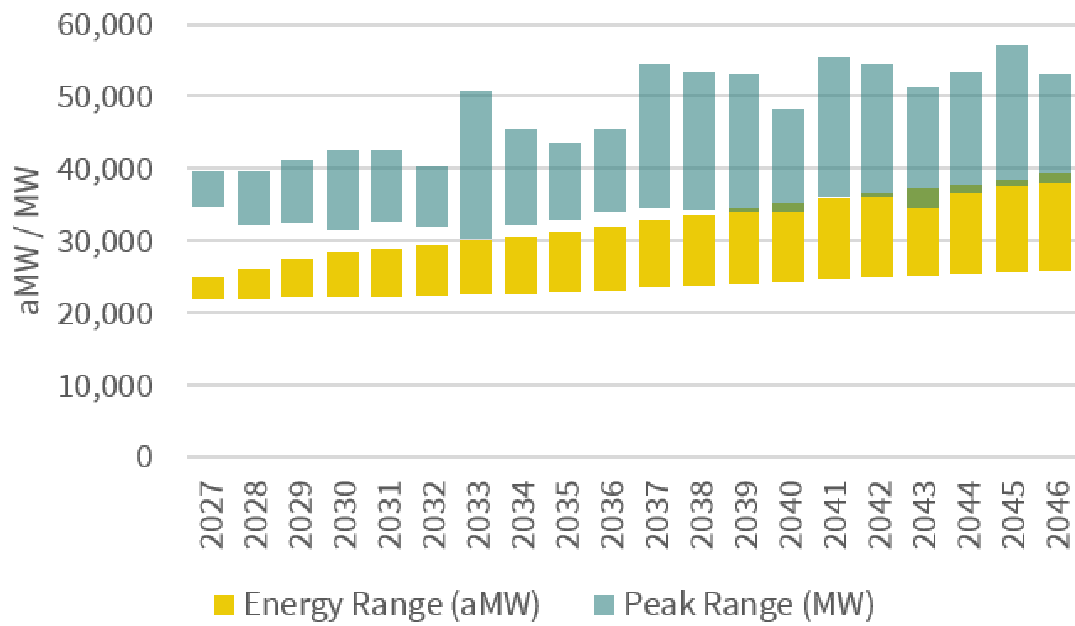


Figure F - 46: Regional Annual Energy Forecast

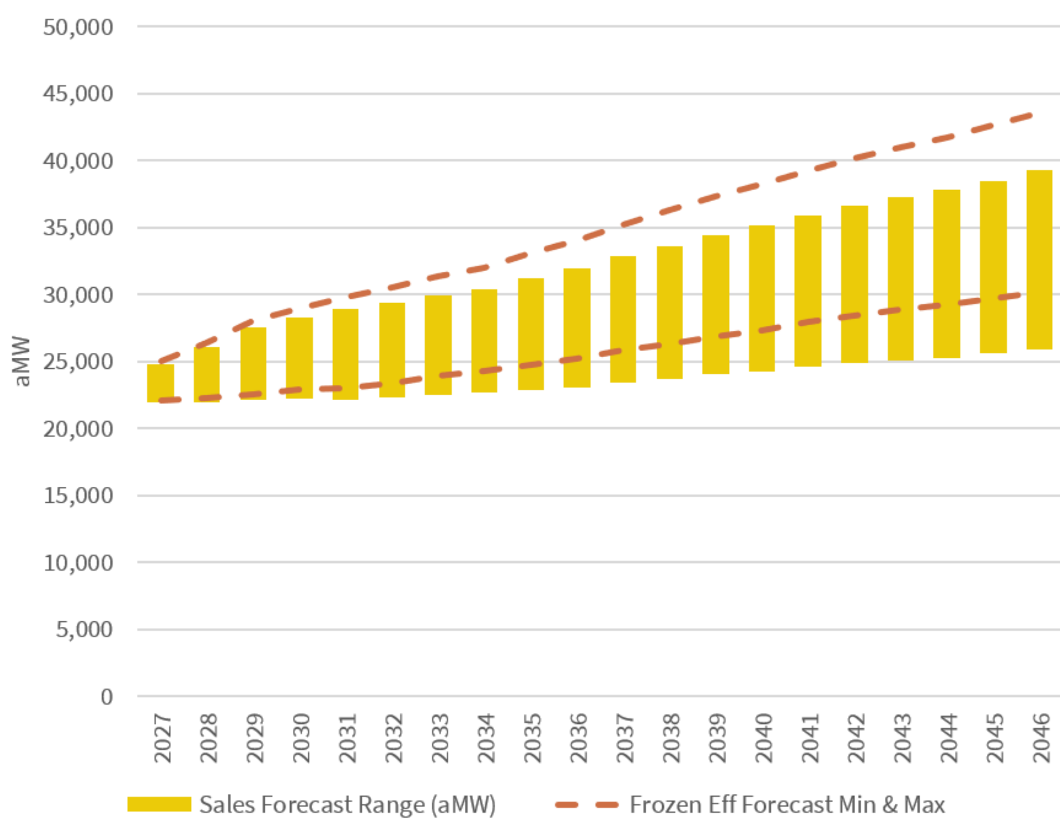


Figure F - 47: Regional Annual Peak Forecast

Figure F - 48: Regional Load Reduction Percentage