Attachment A

Grid Capacity Study

For the Cities of Bellevue and Redmond, WA

May 21, 2026

AECOM

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Prepared for:

The City of Bellevue and the City of Redmond

Prepared by:

AECOM
1111 3rd Ave #1600
Seattle, WA 98101
www.aecom.com

A Letter from the Planning Directors

Redmond
WASHINGTON

May 21, 2026

Dear Bellevue & Redmond Councilmembers,

At the end of 2024, following adoption of the Bellevue 2044 Comprehensive Plan, the Bellevue City Council requested an analysis of the adequacy of power for Bellevue during the 20-year planning period. The City of Redmond, facing many of the same concerns regarding planning for future growth, joined with Bellevue to initiate this report.

The report reflects the close collaboration Bellevue and Redmond had with Puget Sound Energy (PSE). The cities appreciate the planning that PSE is undertaking to provide reliable power as the region shifts to using more clean electricity as the primary power source. Continuing to work together will ensure that power resources will be available at the time needed to support economic development, electrification, and population growth.

The report builds on existing collaboration and brings to light new ways we can collaborate to ensure that clean, reliable electricity is delivered to our communities now and into the future, concurrent with growth demands and changing energy needs. We look forward to working together with PSE to ensure adequate electrical capacity in our cities.

Emil King, Director
Community Development Department, City of Bellevue

Carol V Helland

Carol Helland, Director
Planning & Community Development Department, City of Redmond

Table of Contents

Tables

Figures

List of Acronyms

Acronym	Definition
ACC II	Advanced Clean Cars II
ACT	Advanced Clean Trucks
ADMS	Advanced distribution management systems
CCA	Climate Commitment Act
CEIP	Clean Energy Implementation Plan
CETA	Clean Energy Transformation Act
CFS	Clean Fuel Standard
DERMs	Distributed energy resource management systems
DERs	Distributed energy resources
EIA	Energy Information Administration
EPR	Electric Progress Report
EV	Electric vehicle
GEB	Grid-interactive efficient building
GIS	Geographic information system
IOU	Investor-owned utility
IRP	Integrated Resource Plan
ISP	Integrated System Plan
kV	Kilovolt
MVA	Megavolt-ampere
MW	Megawatt
NEEA	Northwest Energy Efficiency Alliance
NEM	Net energy metering
NWA	Non-wires alternative
PSE	Puget Sound Energy
RPAG	Resource Planning Advisory Group
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SME	Subject matter expert
SQI	Service Quality Index
TAZ	Transportation Analysis Zone
TVR	Time-varying rate
V2G	Vehicle-to-grid
WUTC	Washington Utilities and Transportation Commission

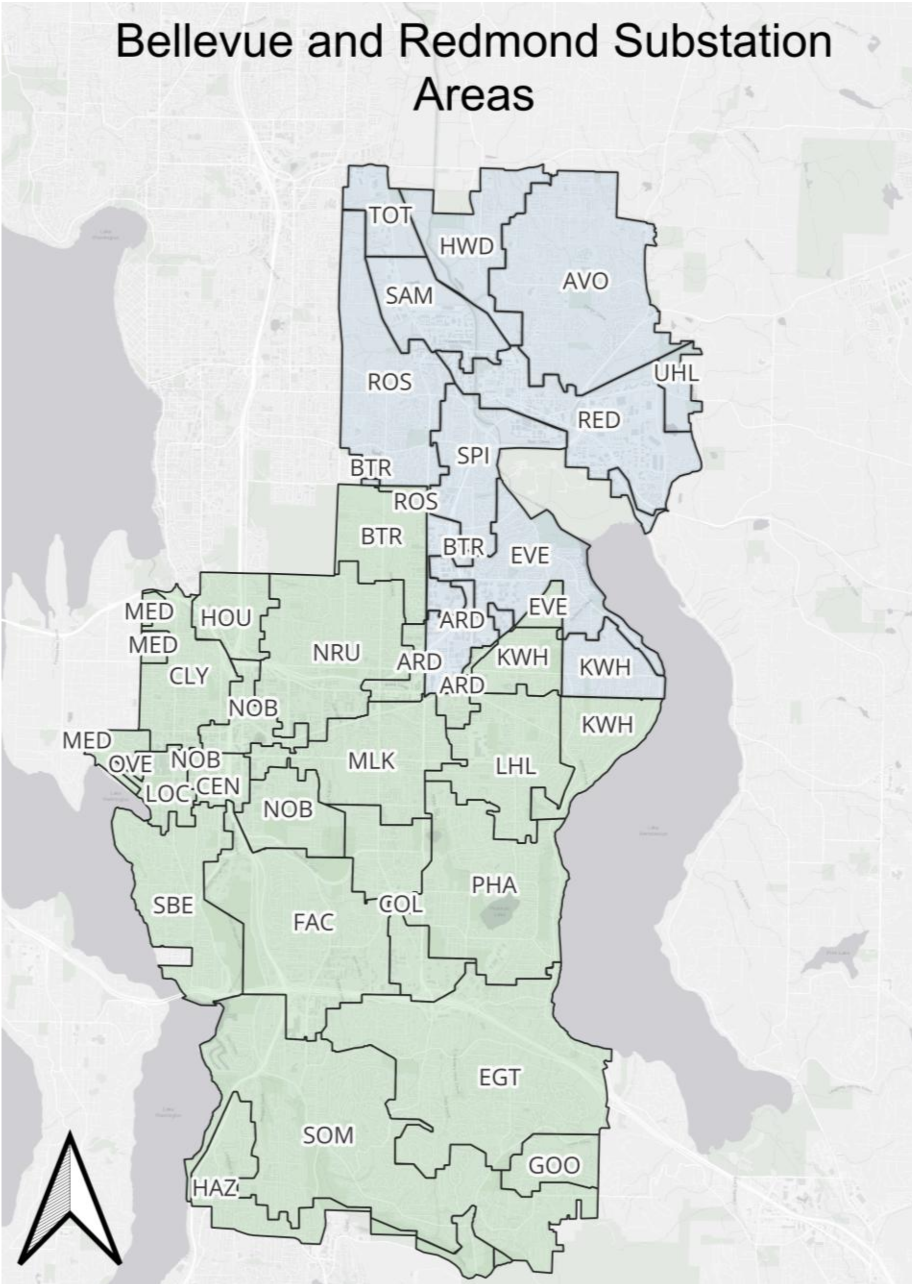


Figure 1. Bellevue and Redmond Substation Areas

Abbr.	Name
ARD	Ardmore
AVO	Avondale
BTR	Bridle Trails
CEN	Center
CLY	Clyde Hill
COL	College
EGT	Eastgate
EVE	Evergreen
FAC	Factoria
GOO	Goodes Corner
HAZ	Hazelwood
HOU	Houghton
HWD	Hollywood
KWH	Kenilworth
LHL	Lake Hills
LOC	Lochleven
MED	Medina
MLK	Midlakes
NOB	North Bellevue
NRU	Northrup
OVE	Overlake
PHA	Phantom Lake
RED	Redmond
ROS	Rose Hill
SBE	South Bellevue
SOM	Somerset
SPI	Spiritbrook
SAM	Sammamish
TOT	Totem Lake
UHL	Union Hill

Section 1. Executive Summary

Purpose of the Study

The cities of Bellevue and Redmond (the "Partner Cities") collaborate with Puget Sound Energy (PSE) to support the health, safety, and welfare of residents and businesses. Both cities are expecting significant growth in housing, commercial development, and electrification in the coming years. Without timely planning, investment, and delivery of electrical infrastructure, grid capacity constraints may become a significant barrier to housing production, economic development, and the cities achieving their climate goals. In Redmond, it was reported that insufficient electric infrastructure capacity and delays in utility system upgrades have already resulted in development projects being delayed, materially redesigned, or terminated because power could not be made available within development timelines. PSE also has an obligation to rate payers not to overbuild the system before there is a need. Collaboration in planning will ensure that power is deployed at the correct time to ensure that power constraints are not the factor limiting future growth.

This Grid Capacity Study, developed for the Partner Cities, provides a substation-level assessment of the local electric grid's ability to accommodate future population and employment growth identified in each city's Comprehensive Plan. The study also examines how increasing electrification of buildings and transportation will shape future energy demand. This information provides a basis to guide next steps for the Partner Cities as they continue working with PSE to ensure a resilient, reliable, and clean grid amid ongoing growth and decarbonization. For the purposes of this analysis, the local grid is defined as the substations that serve the Partner Cities. The study does not evaluate the capacity of individual distribution feeders, the broader transmission network beyond the substations, or generation resources.

This initiative also incorporated a series of collaborative workshops that brought together staff from both cities and PSE. These sessions were designed to strengthen coordination, improve information sharing, and support more aligned long-range planning for the region's energy needs.

Policy Landscape Driving Electrification and Grid Modernization

National and state decarbonization policies directly accelerate the adoption of electric vehicles (EVs), electric heating, and cleaner industry processes, shifting more energy use onto the electric grid and driving significant growth in electricity demand. To keep pace with these changes, cities and utilities must plan proactively to ensure the electric grid has enough capacity to serve future needs.

The grid is evolving and modernizing to meet these growing needs, growing more responsive, dynamic, and decentralized as distributed energy resources (DERs) and smart control technologies continue to develop. **Figure 2** shows the evolution of the grid from a traditional one-way flow of energy to a more integrated two-directional flow.

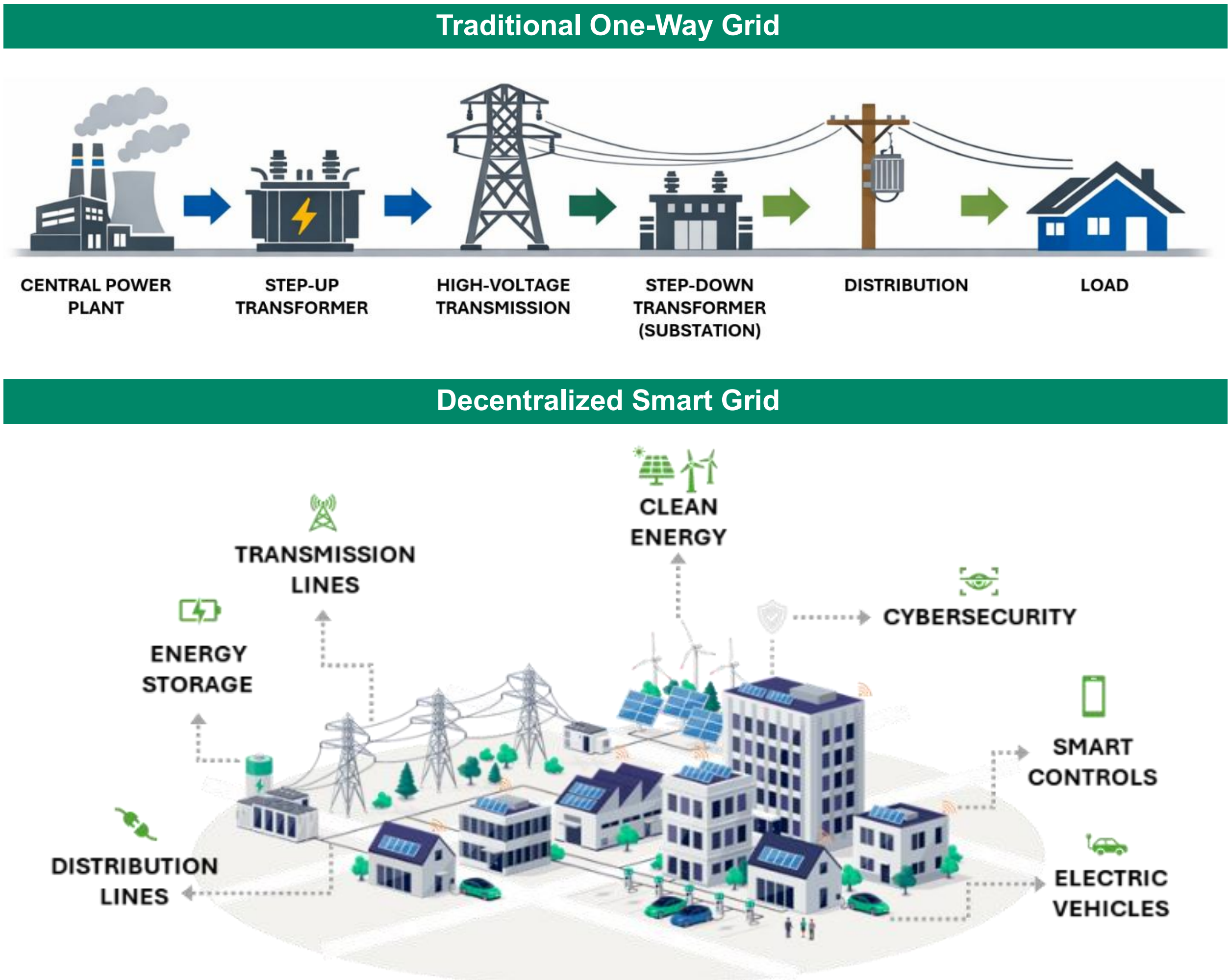


Figure 2. The Evolution of the Grid

In Bellevue and Redmond, a suite of statewide clean-energy and carbon-reduction policies (**Figure 3**) is reshaping the local electric grid, requiring faster adoption of clean resources and modernization of existing infrastructure. Based on current policy trajectories, transportation and building electrification across the Partner Cities could increase total electricity demand by roughly 70% by 2050.

At the same time, utilities and cities must contend with the increasing complexity of planning for large and often uncertain new loads, such as major commercial developments or emerging high-energy-use facilities, which can introduce significant variability in demand forecasts and strain long-term planning. These challenges underscore the importance of flexible, data-informed load forecasting approaches to better anticipate when and where grid capacity will be needed. This growth, if not thoughtfully prepared for and managed, has the potential to place 20% of local substations at risk of exceeding their capacity by 2050.

This study assesses how electrification in both the residential and commercial sectors will impact the substations serving the Partner Cities, providing a forward-looking view of future grid needs. Additional detail on the applicable policies is provided in **Appendix D**.

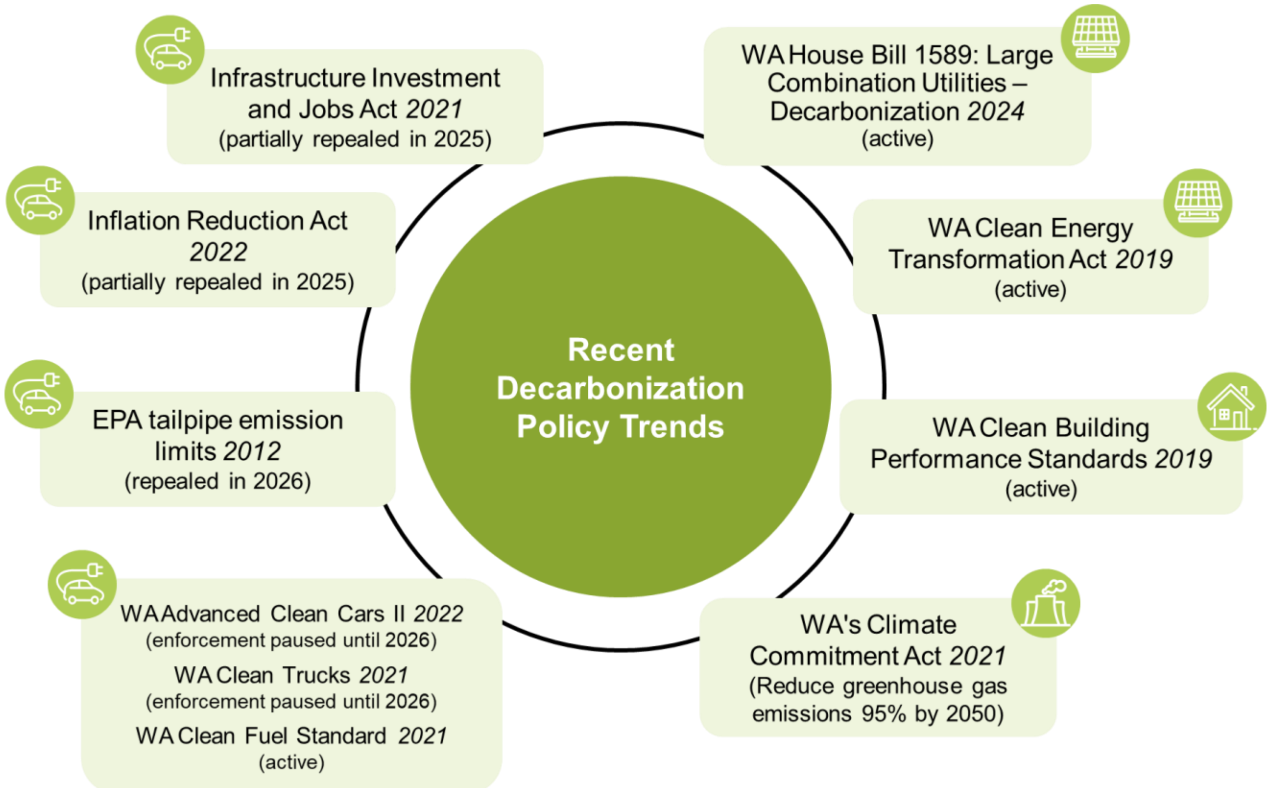


Figure 3. Decarbonization Policies

The Role of Electrification in Growth Planning

Electrification plays a central role in growth planning and electric demand forecasting because it directly shapes how communities will consume energy in the decades ahead. As adoption increases, cities and utilities must anticipate substantial shifts in where and when energy is needed. Electrification is therefore both a driver and a constraint on urban development: it creates opportunities for cleaner, more efficient communities, while also requiring early coordination with utilities to ensure that substations and grid infrastructure can accommodate rising loads.

> Building and transportation electrification are reshaping both the *magnitude* of electricity demand and the timing of *when* that load is placed on the electric grid.

Integrating electrification into growth planning requires alignment between utility forecasts and local policy goals. In developing their long-term planning assumptions, the Partner Cities assume a higher level of electrification in buildings and faster EV adoption than is reflected in PSE's baseline forecast. This difference reflects distinct planning roles and scopes: the Partner Cities plan around community-wide growth, local policies, and adopted climate and electrification targets, while PSE's long-term assumptions are developed at a regional scale to support system-wide utility planning and to meet applicable state laws and clean energy requirements. By planning together, both parties can ensure that future development is supported by a resilient, reliable, and increasingly clean electric grid.

Key Findings

The impact of load growth was evaluated by analyzing the substations under peak winter conditions. Although ambient temperatures reduce equipment thermal capacity in summer, making the grid highly vulnerable to constraints, substations in the region experience peak electrical demand during the winter due to increasing electrification. The following key findings were gathered through the analysis:

- PSE substations are anticipated to have enough capacity with planned infrastructure improvements to serve the expected needs of the Partner Cities over the next ten years, even when considering the impact of electrification.
- PSE initiates additional planning when a substation transformer or feeder group is forecast to reach 75% of its rated capacity. Current loads exceed 80% of capacity for some substations during the summer, indicating that some substations are in immediate need of improvement. These constraints have caused development projects in Redmond to be delayed, altered, or abandoned in recent years. PSE has substation upgrades planned at seven substations and load transfers planned to decrease loads at an additional five substations.
- Despite planned substation improvements and load transfers, substation improvement plans do not consider the location of growth within the Partner Cities beyond a ten-year forecast.
- The sensitivity analysis identified that the primary driver of demand change is population growth and its impact on electrification.
- In Bellevue, substations serving Downtown Bellevue, the Wilburton commercial area, BelRed, and Somerset (the Clyde Hill, North Bellevue, Northrup and Somerset substations) are likely to see the most constrained capacity by 2035.
- In Redmond, substations serving Education Hill, Bear Creek, and Downtown Redmond (the Avondale, Redmond, and Spiritbrook substations) are likely to see the most constrained capacity by 2035.
- Continued coordination between the Partner Cities and PSE and expanded use of demand-side resources and demand management will be important to sustainable growth.
- When compared to state and national averages, circuit reliability in the Partner Cities was better overall. However, three circuits in Bellevue and four circuits in Redmond exhibited significantly worse reliability than other circuits over the past several years. These circuits should be closely monitored and considered for potential investment opportunities.

Growth sensitivities analyzed as part of this study indicate that adjustments to population growth assumptions had the strongest influence on projected substation load compared to changes in electric vehicle adoption and building electrification rates. In this report, population growth is used as a comprehensive proxy for multiple underlying drivers of electric demand, including growth in the number of dwelling units, expansion of commercial development, and increases in vehicle ownership. Changes to this single assumption therefore affect several load-driving factors simultaneously. Under a low growth and electrification scenario, three substations in Bellevue and three substations in Redmond that were previously projected to reach concerning levels of utilization by 2035, even after anticipated upgrades, are no longer projected to be overloaded. These findings highlight the importance of regularly revisiting growth assumptions as demographic trends, development patterns, and policy conditions continue to evolve.

Recommendations for Preparing the Grid for an Electrified Future

Strengthen Data Sharing and Transparency to Improve Forecasting Confidence

Strengthened coordination between the Partner Cities and PSE improves planning efficiency, reduces data collection redundancy, and ensures infrastructure investments support shared climate and reliability goals. Establishing regular communication channels and joint planning protocols enables faster, more aligned decision-making. Our engagement found that the Partner Cities already maintain many communication channels with PSE, such as formal memorandums of understanding on franchise agreements and strategic programs, joint grant efforts, and other community programs. However, additional coordination is needed to support more consistent and thorough data sharing related to growth assumptions and improve alignment between city and utility forecasting and planning cycles.

Share Information on Large Customer and Block Loads

Align on large loads that are expected to emerge in Partner City territory. As these loads are unique and not typically reflected in historical growth trends or regional forecast averages, early identification can help assess immediate capacity needs, identify potential grid constraints, and inform timely infrastructure investments. It is recommended that the Partner Cities and PSE share information on large load and permit applications, development confidence factors, and geospatial zoning layers to align on these expected loads.

Harmonize Forecasting Horizons

Planning ahead is essential to support a clean energy future. Large grid infrastructure projects such as building or expanding electric substations take years to plan, permit, and construct. Aligning forecasting time horizons will help to support both near-term development and long-range growth.

Promote Regulatory Responsiveness

Our engagement highlighted that each party is operating within their respective differing regulatory frameworks, planning and approval timelines, and project review processes. Identifying where these frameworks and process conflict will be the first step to implementing a more coordinated approach and then advocating for regulatory approaches that better support long-term planning.

Address Permitting Process

Improving and coordinating permitting processes is essential to scaling the electric grid efficiently as electrification accelerates. While permitting often involves multiple agencies and regulatory requirements, streamlining these processes can significantly reduce delays for critical grid upgrades that are already known to be needed. A more coordinated approach to permitting, paired with a unified strategy for upcoming grid investments, can help ensure that upgrades are sequenced effectively, maximize customer value, and align with decarbonization plans. Early alignment on project timelines, technical requirements, and review processes can reduce uncertainty and improve project delivery. By aligning permitting workflows, cities and utilities can accelerate the implementation of priority grid projects, improve system reliability, and better position the grid to support future growth and clean energy adoption.

Enhance Demand-Side Management and Distributed Generation Technologies

Leveraging demand-side resources—such as energy efficiency programs, managed charging, DERs, and flexible load programs—can reduce peak demand and defer costly infrastructure upgrades. Collaboration between the Partner Cities and PSE in expanding these programs empowers customers to actively support grid flexibility and decarbonization. The very technologies that may put a strain on the grid are sometimes the same technologies that can lift that strain.

Communicate Value to Residents

Developers and residents are integrated stakeholders of grid planning and modernization. Clear communications on upcoming projects, the grid's ability to accommodate future demand, and demand-side management will be important to build confidence and collaboration.

Advance to Substation- and Feeder-Level Power Flow Analysis for Priority Areas

Granular power flow studies will be increasingly important as electrification accelerates. In this study, no substations are projected to face capacity constraints by 2030. However, by 2040, up to five substations could be at risk of overloading if growth is not proactively addressed.

Incorporate Sensitivity Scenarios into Ongoing Grid Planning

Developing a range of electrification scenarios (as is being developed for PSE's 2027 Integrated System Plan).[1] can help evaluate how varying levels of customer electrification rates and economic growth trajectories could impact future grid capacity needs. Scenario-based planning allows decision-makers to test a variety of plausible futures, identify potential system constraints early, and prioritize investments that are robust under changing conditions. By evaluating multiple paths rather than relying on a single forecast, planners can better manage long-term uncertainty, reduce the risk of over- or underbuilding infrastructure, and support cost-effective investments that help maintain- system reliability while protecting customer affordability over time.

Extend Planning Horizons for Local Capacity Assessments

While utility planning efforts at the local and substation level often focus on a ten-year outlook, extending forecasting horizons at the local level can give cities, utilities, and other partners a clearer picture of long-term electricity needs. Looking further ahead allows planners to anticipate future growth, identify potential challenges early, and consider a wider range of solutions, including flexible and cost-effective options like DERs.

Enhance Grid Resilience for Climate and Electrification Stressors

A safe and reliable service means that electric systems perform well on normal operating days but also restore quickly during severe events. As electrification increases dependency on our grid and climate risks intensify, risk planning such as equipment rehabilitation, vegetation management, and other emergency controls technologies will be increasing important.

[1] PSE. RPAG Meeting, May 15, 2025. https://www.cleanenergyplan.pse.com/rpag-meeting-may-1'2025

Section 2. Understanding Growth Targets and Electrification-Driven Demand

Before examining how future growth may affect grid capacity, it is important to first understand the underlying growth assumptions and how increased electrification is expected to drive electricity demand. A summary of the study methodology is provided in this section, with additional details available in **Appendix B.**

Growth Targets

The Puget Sound region is projected to grow by more than 1.5 million people between 2020 and 2050, generating more than 1.1 million additional jobs between 2020 and 2050.[2] Within this broader regional growth, the Partner Cities are planning for a substantial share of new housing and employment, as assigned by the Puget Sound Regional Council and outlined in their Comprehensive Plans. This anticipated growth underscores the cities' regional significance and highlights the increasing need for expanded infrastructure, housing, and transportation to support thriving communities.

> As hubs for technology innovation, business development, and urban expansion, the Partner Cities are experiencing rapid transformations in their job markets and population dynamics.

The City of Bellevue is planning for an additional 35,000 housing units and 70,000 jobs by 2044. The City of Redmond's assigned growth targets are 20,000 housing units and 24,000 jobs by 2044, however, the city adopted higher targets when it adopted Redmond 2050. These targets are 58,380 housing units and 118,509 jobs by 2050, an increase of approximately 29,800 housing units and 31,600 jobs over 2019. The higher adopted targets were used in this analysis (**Table 1**).[3,4]

Table 1. Comprehensive Plan Growth Targets for Partner Cities

City	Growth Metric	2019	2044	Growth
Bellevue	Population	148,100	232,100	+84,000
Bellevue	Housing Units	63,200	98,200	+35,000
Bellevue	Jobs	157,800	227,800	+70,000
Redmond	Population	73,337	109,003	+35,666
Redmond	Housing Units	31,739	51,739	+20,000
Redmond	Jobs	97,905	121,905	+24,000

As population and job growth accelerate, the Partner Cities together with the State of Washington and PSE continue to lead on environmental sustainability through policies that promote building electrification, clean transportation, and a transition to renewable energy (**Table 2**). These shifts, while essential to meeting climate goals, will increase demand on the

[2] Puget Sound Regional Council. Vision 2050. https://www.psrc.org/planning-2050/vision-2050
[3] City of Bellevue Comprehensive Plan 2044, City of Redmond Comprehensive Plan 2050
[4] The City of Redmond is planning for an additional 20,000 housing units and 24,000 jobs by 2044.

electric grid. To achieve the Partner Cities' sustainability commitments and growth targets, the local grid must be prepared, resilient, and capable of supporting the additional electric load.

Table 2. Key Relevant Electrification and Clean Energy Policies

Policy Name	Impacted Sector	Policy Impact
WA Advanced Clean Cars II	Transportation Electrification	Authorizes the Department of Ecology to adopt California's vehicle emission standards, requiring automakers to increase the sales of electric and zero-emission vehicles (passenger cars, light-duty, and some medium-duty) to 100% by 2035.
Clean Fuel Standards	Transportation Electrification	The Clean Fuel Standard requires fuel suppliers to gradually reduce the carbon intensity of transportation fuels to 45% below 2017 levels by 2038.
Washington State Energy Code (Residential + Commercial)	Building Electrification – New Construction	As Washington strengthens its energy-performance standards, the updated energy codes are increasingly steering new buildings toward heat pumps and away from fossil-fuel systems. Although fossil-fuel equipment is still allowed in new construction, the overall trend is shifting toward all-electric building designs.
Clean Buildings Performance Standard	Building Electrification – Existing Buildings	Large commercial and multifamily buildings are required to meet energy-performance targets. Buildings that exceed these limits must lower their energy consumption. Although electrification is not required, many may adopt high-efficiency electric heating to meet compliance.
Washington's Clean Energy Transformation Act (CETA)	Building and Transportation Electrification	Commits Washington to an electricity supply free of greenhouse gas emissions by 2045, impacting how buildings, homes, vehicles, and appliances are powered.

Modeling Methodology

PSE actively forecasts and plans for future electricity needs across its service area and at individual substations, in alignment with the Washington Utilities and Transportation Commission (WUTC) requirements.[5] These forecasts build on historical customer electricity usage and are adjusted for expected growth, changing weather patterns, and improvements in energy efficiency.

While PSE's forecasts align with WUTC requirements, differences naturally arise between a utility's forecasting approach and the planning needs of individual cities. Utility forecasts are generally market- and region-driven, whereas Partner Cities' forecasts reflect local policy objectives, the pace of planned development, and vehicle and building electrification trends specific to the Partner Cities. These differences in assumptions, inputs, and methodologies

[5] Additional details on WUTC requirements are provided in Appendix D.

made it necessary to develop a Partner City–specific load forecast to better understand how future electricity demand may vary and impact the local grid serving the Partner Cities.

This section outlines PSE's methodology for modeling future electric load and identifies where assumptions in PSE's forecast differ from the goals and policies of the Partner Cities. The **Building Electrification Load Growth** and **Transportation Electrification Load Growth** subsections describe the methods used to develop the Partner Cities' forecast and compare those results to PSE's most recent forecast, completed in 2024. Additional details on the forecasting methodology are provided in **Appendix B**.

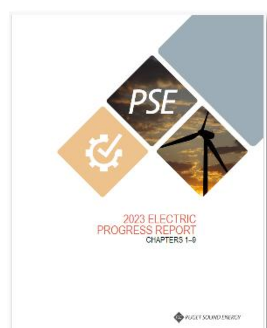
Why Understanding Local Electric Load Growth Matters for Grid Planning

Forecasting electric load is a critical part of grid planning because it directly shapes infrastructure sizing, when new investments are needed, and how reliably the system can serve customers. In this study, electric load refers to the amount of electricity being used at any given moment. To maintain reliability and service continuity, utilities must design substations and distribution infrastructure to meet peak demand - the times when electricity use is at its highest.

As building and transportation electrification accelerate, combined with continued population and job growth, electricity demand is expected to increase significantly. At the same time, there is considerable uncertainty around how quickly new technologies will be adopted, how policies may evolve, and how consumer behavior may shift. Managing this uncertainty is essential: it determines the level and timing of grid investments required to keep the electricity service reliable, affordable, and sustainable while supporting the Partner Cities' long-term growth and climate goals.

How PSE Plans for Future Electricity Needs

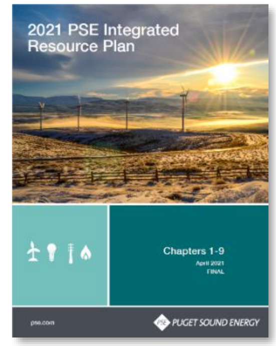
PSE plans for future electricity needs by evaluating projected changes in electricity demand and identifying the resources, infrastructure upgrades, and investments required to maintain reliable service. For long-term resource planning, PSE develops system-level demand forecasts that look decades ahead and consider factors such as growing electrification, and the condition of existing grid infrastructure. This approach reflects regulatory requirements, industry-standard utility planning practices, and the need to make prudent, long-term investment decisions that ensure system reliability, affordability, and compliance with state clean energy laws across PSE's service territory.



In addition to this long-range planning, PSE conducts more detailed local area planning on a shorter horizon, ten years. These local plans focus on identifying specific infrastructure needs such as substations, distribution feeders, and other grid assets.

Through recurring studies and planning documents, PSE works to keep the system reliable, affordable, and aligned with Washington's clean-energy goals. Two key documents guiding this work are the Electric Progress Report (EPR) and the Integrated System Plan (ISP).

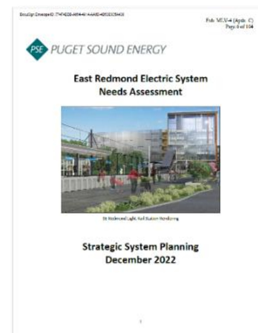
PSE's EPRs were recurring, detailed planning documents that monitored and updated progress toward meeting clean-energy targets and resource needs (updated every two years, most recently in 2023). These documents were required documentation as part of Clean Energy Implementation Plan (CEIP) compliance. PSE also had an Integrated Resource Plan (IRP) which served as the utility's core long-term planning document, laying out a 20-year outlook of electric and gas resource needs (updated every four years, most recently in 2021).



Recent state legislation (HB 1589 Large Combination Utilities – Decarbonization, 2024) required PSE to consolidate its IRP and CEIP into one comprehensive planning process: the ISP, due January 1, 2027. The Resource Planning Advisory Group (RPAG) supports the ISP through regular meetings covering methodology, customer strategies, and resource assumptions.

> There is a major statewide structural shift toward more integrated system planning.

In addition to its major system-wide planning efforts, PSE conducts annual planning to identify local constraints and grid infrastructure upgrades needed over the next ten years. These system-level plans are supplemented by more localized capacity studies that focus on specific areas or substations.



In these localized assessments, PSE evaluates the available capacity of local infrastructure by considering historical load trends, anticipated new loads, and emerging electrification patterns, such as EV adoption. The urgency of potential investments is assessed alongside these capacity reviews by factoring in equipment age and system reliability. Whenever possible, PSE prioritizes lower-cost solutions such as switching load between circuits or adding new feeders before pursuing larger and more complex substation upgrades.

PSE Data and Documents Informing the Analysis

This grid capacity analysis draws on multiple planning inputs, including PSE's 2023 EPR, ten-year substation-level forecasts provided by PSE, and publicly available information related to PSE's forthcoming 2027 ISP. Together, these sources informed the analysis summarized in **Table 3**. In the EPR and ISP, growth projections are primarily based on county-level data, and the degree to which these projections have been adjusted to reflect local-level conditions is not clearly defined.

Table 3. Use of PSE Documents

Document and Description	Limitations in Forecasting Study	Modeling Assumptions	How Document Informed Partner Cities' Forecast
PSE's 2023 EPR describes how territory-wide the utility plans to meet future energy needs with more clean energy, energy efficiency, and demand-side solutions while reducing reliance on short-term market power.	A notable limitation of the 2023 EPR is the limited treatment of increased building electrification in existing buildings, such as fuel switching from fossil fuel space heating, water heating, or appliances to all electric alternatives.[6] Additionally, EV adoption projections vary up to 61% in 2045 compared to Partner Cities' targets.	The 2023 EPR uses an EV adoption analysis completed by Guidehouse to estimate the appropriate charger type, quantity, and associated electric demand. The 2023 EPR uses learnings from historical growth and historical conditions to estimate future residential and commercial customer growth.	The 2023 EPR serves as a reference to help understand variances in inputs and assumptions between PSE forecast and Partner Cities'-specific goals.
PSE's 2027 ISP, now in development, will outline how the utility plans territory-wide to meet future energy needs with reliable, affordable clean energy across its electric and gas systems.	The 2027 ISP is still in progress. Final results are not available.	For new construction projects, residential buildings are assumed to be fully electric, reflecting likely compliance pathways under updated energy code requirements. New commercial buildings are modeled with limited fossil fuel use but with higher overall energy efficiency, reflecting expected improvements in building performance over time rather than full electrification. The ISP models varying levels of aggression on existing building electrification, i.e. the pace at which homeowners are replacing their gas-burning furnaces with electric heat pumps. EV adoption forecasts presented in 2027 are more ambitious compared to the 2023 EPR; however, the adoption projection still varies by more than 25% in 2050 compared to Partner Cities' targets.	Referenced assumptions on charging port needs per EV and load per port. See **Appendix B** for details.

[6] PSE noted that the electrification analysis was incorporated into the 2023 Gas IRP.

Document and Description	Limitations in Forecasting Study	Modeling Assumptions	How Document Informed Partner Cities' Forecast
Partner City-specific substation five and ten-year forecasts using 2024 as a baseline.	The five and ten-year forecasts are not disaggregated by load type, such as EVs, building electrification, or new commercial and industrial development.	These forecasts are used as the basis of understanding current and future grid capacity in the cities. The forecasts are based on the 2023 EPR methodology which aligns with the WUTC requirements.	The forecast serves as a reference to compare the Partner City and PSE forecasts. As the Partner Cities' forecast focuses on electrification growth, actual load in 2024 was used to establish a baseline to conduct the comparison.

Building Electrification Load Growth

For this study, the Partner Cities' building electrification analysis includes both existing buildings and new construction. Because the Partner Cities aim to reduce greenhouse gas emissions 95% by 2050, substantial growth in building electrification is expected, requiring widespread adoption of electric technologies such as heat pumps, heat pump water heaters, and induction cooktops across both new and existing buildings.

How much is 1 MW?
A typical U.S. home uses about 1 to 2 kilowatts (kW) of power on average, with higher usage when equipment like air conditioners or electric heaters is running. One megawatt (MW) of electricity can supply approximately 500 to 1,000 homes at a given time, depending on their individual demand.

Existing Buildings

The forecast assumes that more homes and businesses will switch from fossil-fuel equipment (such as natural-gas furnaces or water heaters) to electric alternatives over time. The analysis models this transition beginning with about 60% adoption in 2025 and increasing to 99% by 2030, reflecting both voluntary fuel-switching and equipment replacement at the end of its useful life. Local assessor data was used to estimate how many buildings exist today, and information from the Northwest Energy Efficiency Alliance (NEEA) helped determine how many of those buildings currently rely on natural gas or other fuels. Permit data from Partner Cities for natural gas furnace replacement trends was used to understand heat pump adoption in existing buildings.

New Construction

All new residential and commercial buildings are assumed to be fully electric, consistent with Washington State's increasingly stringent energy-code requirements. To estimate new-construction growth between 2025 and 2050, each Partner City provided detailed new-building permit and inspection datasets, organized by Transportation Analysis Zones (TAZs) and categorized by single-family, multifamily, and commercial building types.

What is a Transportation Analysis Zone (TAZ)?

A TAZ is a specialized geographic unit used for transportation modeling, forecasting commute patterns, and planning infrastructure. These zones are used by the Partner Cities and local agencies to aggregate census data on population, households, and employment. Consequently, population and job growth was estimated by TAZ in the Partner Cities' Comprehensive Plan. To make the cities' forecasting apples-to-apples with PSE's forecasting, the growth at each TAZ was translated to the substation level. On average, approximately ten to fifteen TAZs map to a single utility substation.

City of Bellevue Projected Load Growth from Building Electrification

Figure 4 shows the City of Bellevue's projected growth in building electrification, highlighting new electrical load in the building sector driven by the Partner Cities' climate goals. The increase is primarily attributed to electrification in new construction, with comparatively smaller contributions from existing building electrification. Electrification of existing buildings levels off between 2040 and 2045, reflecting the assumption used in the Partner Cities scenario that most end-of-life equipment replacements will be completed by that time. By 2050, approximately 75% of new electrical load growth in buildings is driven by new construction, with the remainder due to existing building electrification.

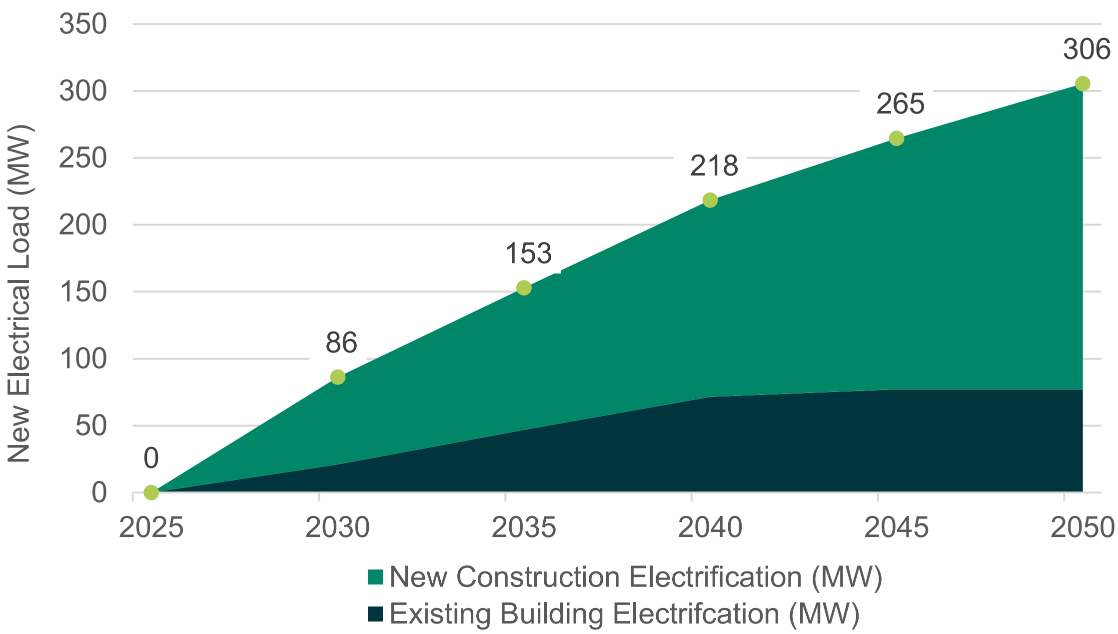


Figure 4. City of Bellevue Building Electrification Forecast

City of Redmond Projected Load Growth from Building Electrification

Figure 5 shows Redmond's projected building electrification growth. Overall, Redmond's building electrification follows a steady growth trajectory, with total new load increasing by approximately 156 MW through 2050. Electrification of existing buildings slows after 2040 as end-of-life equipment replacements reach full conversion from fossil-fuel systems. Projected growth patterns indicate that approximately 80% of new load in Redmond is attributable to new construction electrification through 2050, with the remainder due to existing building electrification.

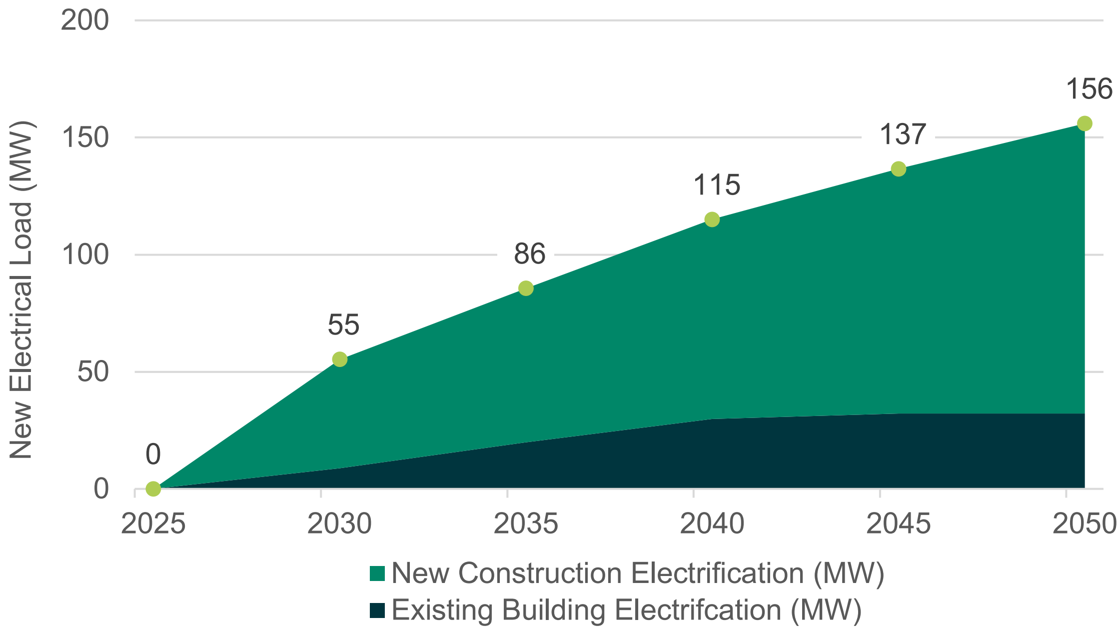


Figure 5. City of Redmond Building Electrification Forecast

Transportation Electrification Load Growth

To understand how transportation electrification will affect future electricity needs in Bellevue and Redmond, this study estimated the electric load associated with charging both passenger vehicles and commercial fleets as the population grows and as electric vehicles are used at a higher rate. The analysis followed a three-step approach (**Figure 6**).

First, this study forecasted how many EVs will be registered in the Partner Cities along with the number of vehicles that regularly travel into the cities. This forecast included both personal EVs and commercial vehicles such as service fleets. Second, the analysis estimated how many charging ports would be needed to support those future EVs reflecting the range of places where residents, commuters, and commercial operators are likely to plug in. Finally, a daily charging-load profile was applied to understand how that charging activity translates into electricity demand over the course of a typical day. This profile helps illustrate not just how much electricity will be needed, but also when that demand is most likely to occur, which is essential for grid planning.

To develop these estimates, the study primarily relied on transportation-electrification forecasts already prepared by the Partner Cities and supplemented them with PSE assumptions and data where additional information was needed. The Partner Cities are planning for a higher percentage of vehicle electrification than PSE. The Partner Cities are planning for EV adoption at approximately three times the overall state trend. A summary of the transportation electrification related datasets, assumptions, and inputs used for the analysis is provided in **Appendix B**.

Figure 6. Transportation Electrification Load Growth Methodology Process

City of Bellevue Projected Load Growth from Transportation Electrification

In Bellevue, both passenger and commercial EV adoption are projected to grow rapidly, averaging about 10% per year.

> By 2050, this growth translates to roughly **137,000 additional EVs** on the road. As a result, the electricity needed to power these vehicles is expected to rise sharply. EV charging load is forecasted to increase from **7 megawatts (MW) in 2025** to **103 MW by 2050**, an average annual growth rate of about 11%.

Passenger EVs make up the vast majority of electric vehicles and account for more than 90% of total EV-related electricity demand. However, commercial EVs such as delivery vans, service trucks, and fleet vehicles place a much higher load per vehicle on the grid because they often rely on faster, higher-powered charging stations. As shown in **Figure 7** and **Figure 8**, as commercial fleets electrify, their impact on peak electricity demand will become increasingly important for local grid planning.

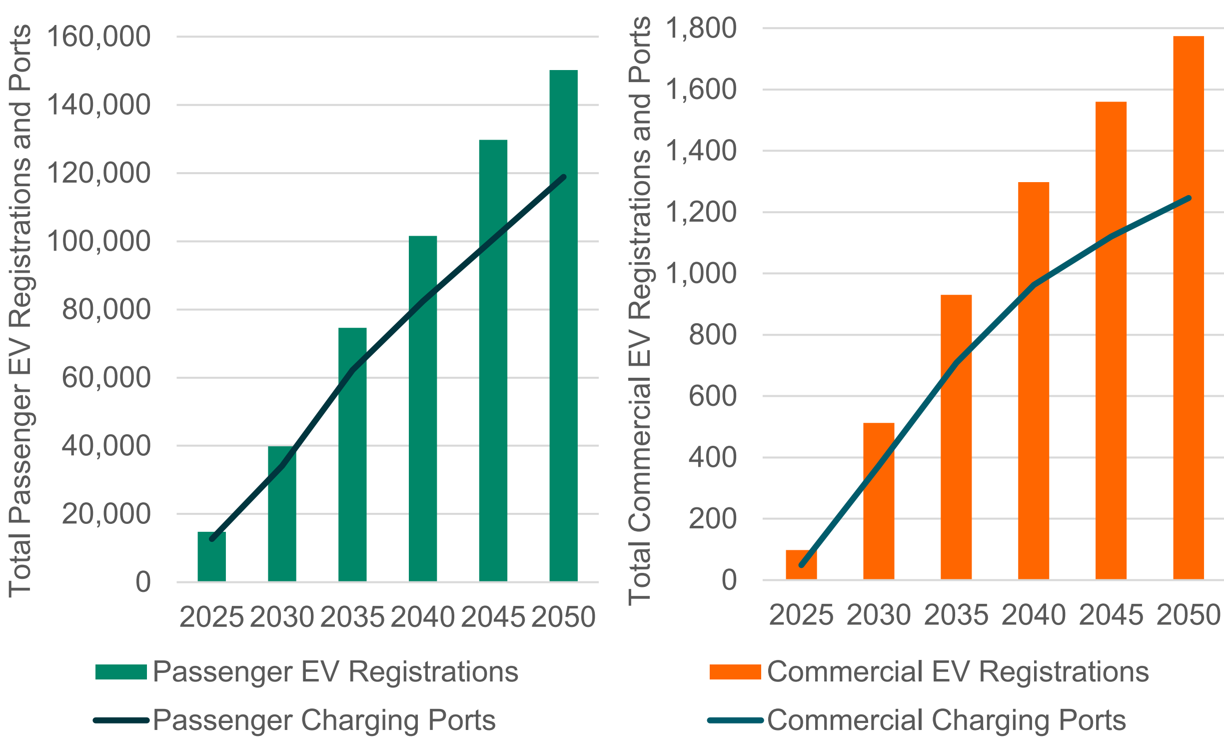


Figure 7. City of Bellevue Transportation Electrification Forecast

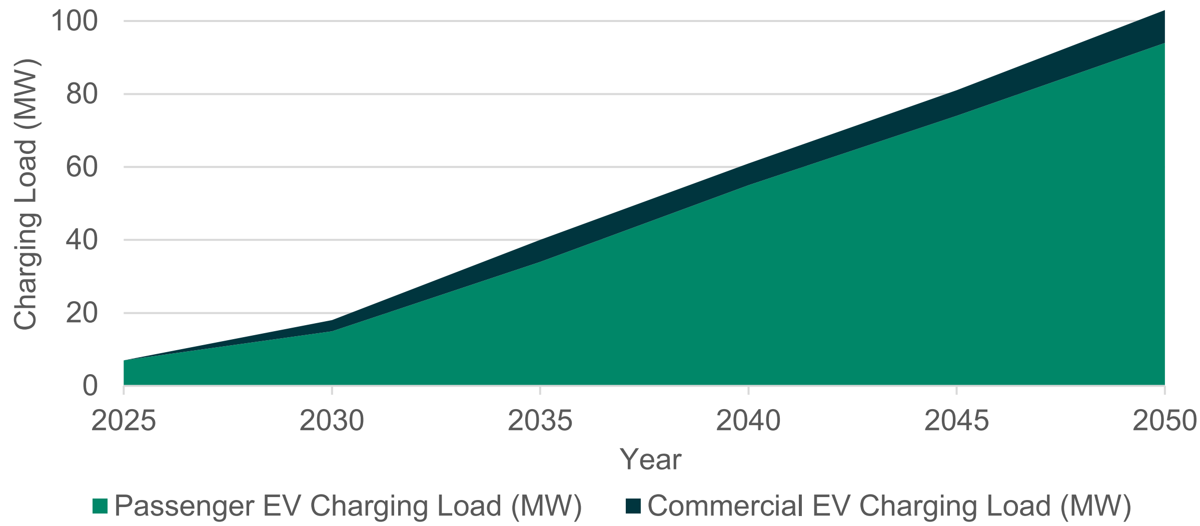


Figure 8. City of Bellevue Charging Load Forecast

City of Redmond Projected Load Growth from Transportation Electrification

In Redmond, passenger and commercial EV adoption is also expected to grow by an average of 10% per year (**Figure 9**).

> By 2050, the City of Redmond is projected to have **69,000 additional EVs** on the road. Correspondingly, electricity demand from EV charging is forecasted to increase from **4 MW in 2025** to **55 MW by 2050**, reflecting an average annual growth rate of about **11%**.

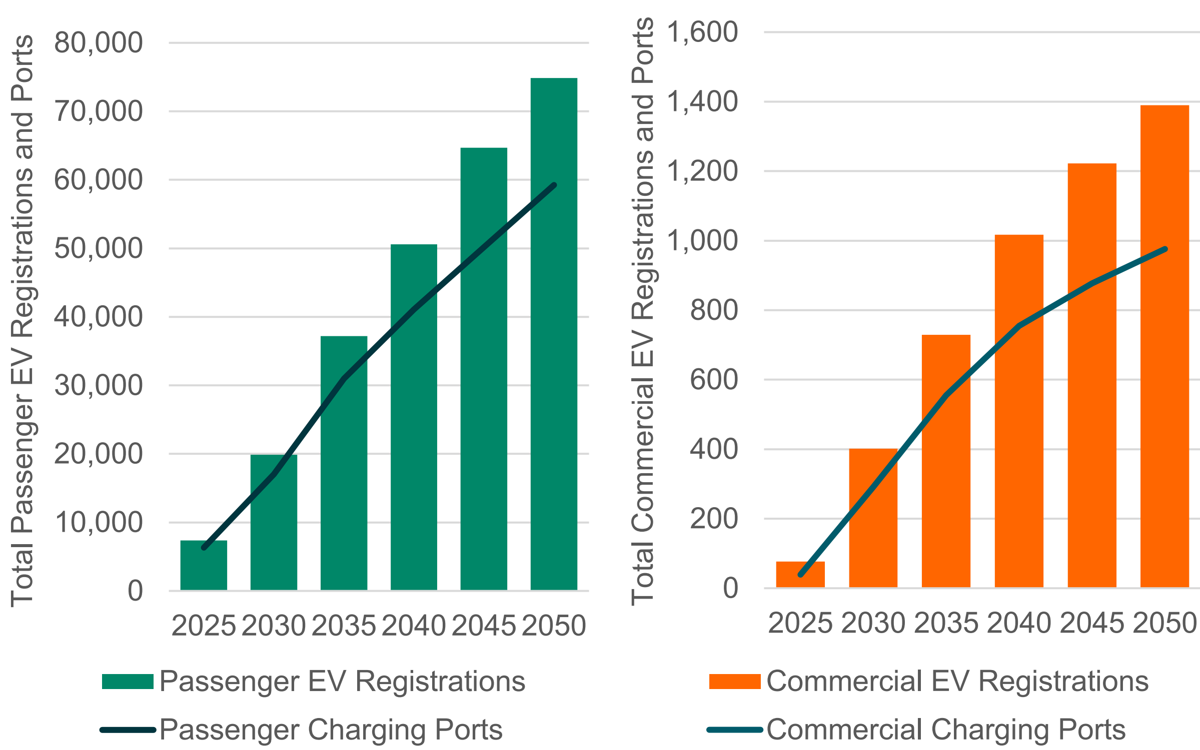


Figure 9. City of Redmond Transportation Electrification Forecast

As shown in **Figure 10**, passenger EVs account for the majority of total electricity demand - about 87% of the EV-related load. However, commercial EVs, including fleet and service vehicles, have a much higher electricity load per vehicle because they typically rely on faster, higher-powered charging infrastructure.

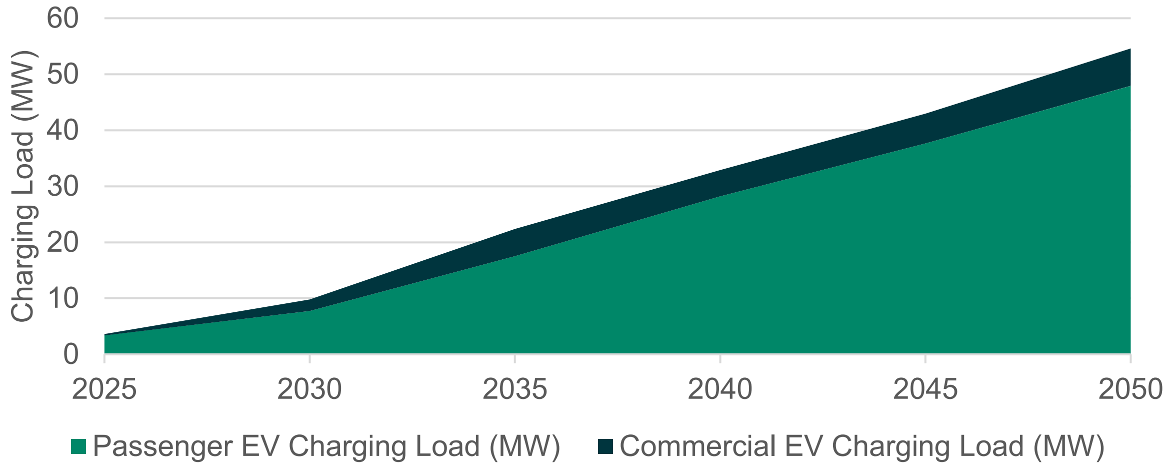


Figure 10. City of Redmond Charging Load Forecast

Total Load Growth at Substations

Total load growth was analyzed to assess the combined effects of population and job growth and the electrification of buildings and transportation on overall electricity demand at the substation level. Because total load growth and electrification impacts vary geographically, the study examines load changes at the substation level to capture localized effects. Details on the methodology used to aggregate load to the substation level are provided in **Section 3**, along with a description of how total load is translated into peak demand.

In addition to electrification impacts, projected population and job growth are fundamental drivers of total load growth at the substation level. Anticipated increases in residents and employment contribute to higher electricity demand through new housing, commercial development, and associated energy use. These growth assumptions underpin both building and transportation electrification projections and inform where and when load increases occur geographically. As a result, population and employment forecasts are integral inputs to the total load estimates evaluated in this study.

City of Bellevue

In Bellevue, building-related electrification—including new construction driven by population growth and the electrification of existing buildings—accounts for 76% of total load growth on average. The Clyde Hill substation, serving much of North Bellevue and the northern part of Downtown Bellevue, is expected to observe the largest load growth (56 MW) driven by City Center North **(Figure 11)**. This area is currently experiencing growth due to several residential and mixed-use projects and anticipates further growth over the next 20 years. Downtown Bellevue is designated a Regional Growth Center in VISION 2050,[7] the plan governing growth in the region served by the Puget Sound Regional Council, and as it continues to expand, it is expected to attract increased activity and higher density, high rise multifamily development. The Center substation, serving the east side of Downtown Bellevue and the west side of Wilburton, and the North Bellevue substation, serving the northeastern part of Downtown Bellevue and western parts of Wilburton and BelRed, are the other substations expected to see large load growth due to new developments and electrification of existing buildings and vehicles. The Medina and Overlake substations, both primarily serving the City of Medina, and the Goodes Corner substation, primarily serving the area southwest of Bellevue, are expected to have less than 5 MW of electrification load growth through 2050. These substations are expected to experience lower growth because they serve a relatively small number of residential customers and very limited commercial load within city limits.

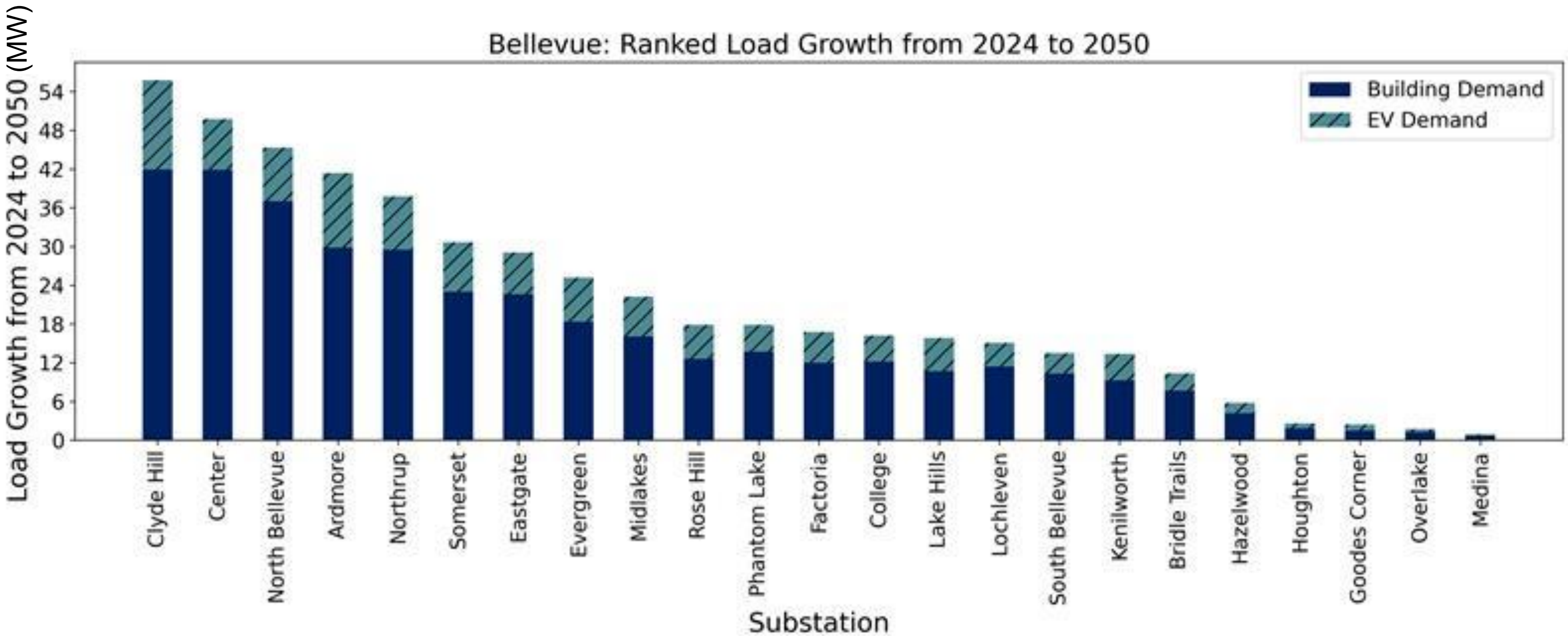


Figure 11. City of Bellevue Load Growth Forecast at Substation Level in 2050

[7] Puget Sound Regional Council. Vision 2050. https://www.psrc.org/planning-2050/vision-2050

City of Redmond

In Redmond, building-related electrification, including new construction driven by population growth and the electrification of existing buildings, accounts for 71% of total load growth on average. The Redmond substation is expected to observe the largest load growth (71 MW). The Redmond substation, serving northern Downtown Redmond and Southeast Redmond, has a 5% increase in transportation electrification load compared to the average as it hosts over 31,000 passenger vehicle registrations, nearly double the next highest registration count (the Ardmore substation, serving the southern tip of Overlake: 17,000) **(Figure 12)**. The Union Hill substation, primarily serving unincorporated areas west of Redmond, the Hollywood substation, primarily serving unincorporated areas north of Redmond, the Totem Lake substation, primarily serving the City of Kirkland, and the Sammamish substation, primarily serving a neighborhood and golf course in Redmond, are expected to have less than 8 MW of electrification load growth as they serve undeveloped parks and smaller low-density residential territories in Redmond.

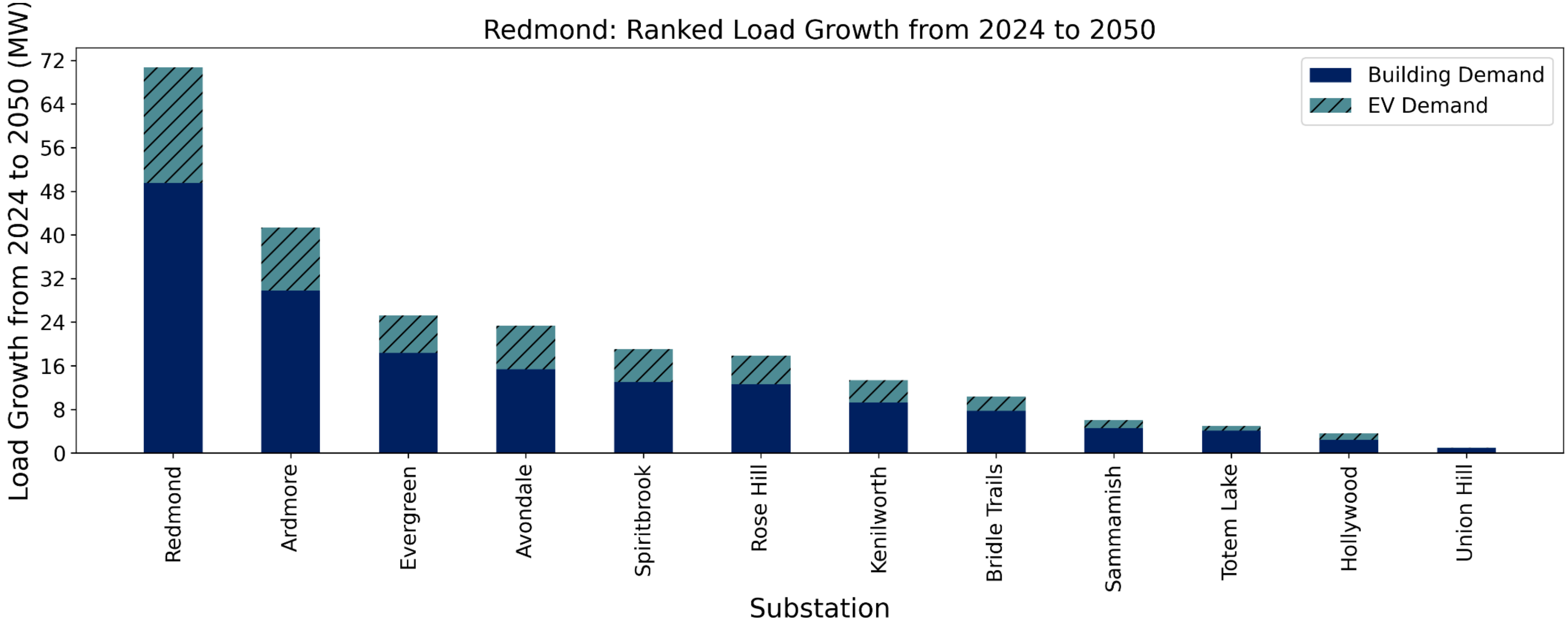


Figure 12. City of Redmond Load Growth Forecast at Substation Level in 2050

Understanding Differences Between Partner Cities' and PSE Load Forecasts

The Partner Cities' and PSE's forecasts differ fundamentally in scope and methodology. The Partner Cities are required under state law to plan for a certain level of population and jobs over a 20-year period. This means that the Partner Cities must ensure that there is sufficient development capacity to meet the housing and employment needs of future populations along with supporting infrastructure such as utilities, including power. By contrast, PSE develops 5- and 10-year demand forecasts for electricity using an econometric, system-level modeling approach that combines trends in customer growth, usage patterns, weather, economic conditions, and electrification. Projections of future conditions rely primarily on past trends. The purposes are very different – the Partner Cities are required to make resources available to meet specific growth targets while PSE is required to ensure that infrastructure meets the needs as they arise so that they are not building excess infrastructure. Both the Partner Cities and PSE aim to support the cities' growth with reliable power. Close coordination around planning can meet this goal.

The Partner Cities do not forecast electrical load directly. Under state law, the Partner Cities adopt job and population (or housing unit) targets. The level of growth is based on the state county growth forecasts, refined by Puget Sound Regional Council and agreed upon by each county with the input of all of the cities. The Partner Cities use these overall growth targets and more specific distribution of the growth identified in the Comprehensive Plans to implement changes to meet that level of growth. In addition, the Partner Cities identify targets for electrification of the transportation system and buildings. These are partially based on past trends but also support the program and policy direction of the Partner Cities. While the Partner Cities do not directly forecast load requirements, they do identify what types of uses (such as a high-rise mixed-use building or a medical biotechnology building) can locate in the different parts of the city and this does have implications for the load. The estimated load forecast from this Study for the Partner Cities is based on the population and job targets as well as the targets for electrification that the cities adopted.

Block loads are incorporated into PSE's five- and ten-year substation load forecasts through an econometric model. Customer counts and electricity use per customer are forecast separately by residential and non-residential customer classes using historical data and projections of population, employment, income, prices, and weather. These components are combined to produce a regional, system-wide energy demand forecast, which is then adjusted for known factors such as energy efficiency programs, building codes, customer-owned solar, and emerging loads like electric vehicles.

PSE also forecasts system peak and hourly demand using statistical models that relate historical demand to temperature and calendar effects, with additional adjustments to reflect electrification and demand-side resources. These long-term forecasts look ahead for decades and are developed on a regional scale to support resource planning, infrastructure investment, reliability requirements, and compliance with state clean energy laws. Outputs from the system-wide demand forecast provide a broader planning context for local forecasting. System-level forecasts are broken down and then refined further by examining actual peak load data at individual substations.

At the local level, PSE's system planners develop 5- and 10-year load forecasts using current electrical loading on individual distribution feeders, aggregated to the substation level. Actual operating conditions are monitored continuously, and following each summer and winter season, planners review system performance and formally declare seasonal peak loads. These observed summer and winter peaks are used to calibrate and refine short- and mid-term local forecasts, so they remain consistent with both recent operating conditions and longer-term system trends. Local forecasts also incorporate known major demand additions and reductions. These adjustments, referred to as block loads, are based on information provided by system planners and major customer accounts and capture large, discrete changes in demand that are not reflected in historical growth trends or regional forecast averages.

These differing approaches, one rooted in policy-driven growth targets and land use planning, and the other in observed system performance and econometric forecasting, can lead to gaps in how emerging demand is identified and timed. In particular, large or rapidly developing loads may not be fully captured in traditional forecasting inputs early enough to inform infrastructure planning. Addressing these gaps requires more structured and continuous coordination between the Partner Cities and PSE, including earlier visibility into planned development, clearer communication of electrification assumptions, and more consistent sharing of data on anticipated loads. Strengthening collaboration in load forecasting and data exchange will improve alignment between growth planning and infrastructure delivery, reducing uncertainty and enabling more timely and efficient system investments.

Load Sensitivities

To better understand how uncertainty in future growth and technology adoption could influence electric load outcomes, two sensitivity analysis scenarios were conducted for the Partner Cities' forecast. These scenarios evaluated how changes in key assumptions affect peak electricity demand in 2035. In particular, adjustments to population growth assumptions influenced several related drivers of electric demand, including the number of dwelling units, the amount of commercial development, and the number of new vehicles. The sensitivity analysis focused on changes to the following three factors:

- Population growth, which drives changes in residential units, commercial development, and vehicle ownership
- Electric vehicle adoption rates
- Building electrification rates

The low and high load scenarios were developed to bound potential future electricity demand outcomes under differing assumptions about growth and electrification. The low load scenario (**Table 4**) assumes slower-than-expected population growth, resulting in reduced development activity and lower adoption of electrification technologies. In contrast, the high load scenario (**Table 5**) assumes population growth consistent with current projections, along with full achievement of electrification targets across buildings and transportation. Together, these scenarios illustrate how variations in growth and technology uptake can materially influence future load and peak demand requirements.

Population growth represents the most significant impact on load.[8] Population changes had downstream impacts on building electrification and EV use, with 70% of a change in population impacting building electrification and 30% impacting EV use. Direct changes in EV and building electrification adoption assumptions result in smaller load impacts. While residential EVs represent the largest portion of reduced load (83%), commercial EVs are a larger load reduction per vehicle (assuming 0.71 kW per commercial EV, 0.03 kW per passenger EV). Analysis on the impact of these sensitivities on grid upgrade needs are presented in **Appendix B**.

The results also suggest that no variable has a significant impact on changes to the overall load, at least in 2035, which suggests that the assumptions for the purposes of this study produce relatively stable results. For instance, the 10% increase or decrease in population results in a respective estimated 2% increase or decrease in demand (16 MW of the 751 MW total expected).

[8] For every 10% change in population, the load is estimated to change 16 MW in total load in 2035. A 10% change in EV adoption equates to a 7 MW change in load in 2035. A 10% change in building electrification adoption equates to a 5 MW change in load in 2035.

Table 4. Low Scenario Sensitivity Results - 2035

Sensitivity Scenarios	Percent Change Applied	MW Output	Description
Population Change	- 25%	-40 MW	This scenario models a 25% reduction in projected growth to reflect slower development, delayed adoption, or economic uncertainty. It is helpful for testing system resilience and planning needs under more conservative conditions
Adoption of EVs	- 40%	-26 MW	The study estimates the impact of less state and federal policy support for EVs resulting in fewer EV models available, insufficient charging network, fewer incentives, and less consumer appeal as a 40% reduction in passenger and commercial EV sales, aligning with estimates on the potential impact of repealing the EV tax credit.[9]
Adoption of Building Electrification Technologies	- 18%	-9 MW	This scenario assumes lower electrification adoption in existing buildings, with 80% of end-of-life equipment replacements electrified by 2035. In contrast, the Partner City scenario assumes a higher adoption rate, reaching 100% all-electric replacements by 2030. This scenario is useful for illustrating a less ambitious transition pathway and provides a lower adoption benchmark for planning purposes.
Total Load Decrease	**-**	**-74 MW**	A combination of the percent decreases in reduction to population, EV adoption, and building electrification.

[9] Princeton University ZERO Lab. Potential Impacts of Electric Vehicle Tax Credit Repeal on US Vehicle Market and Manufacturing. https://zenodo.org/records/15001499?

Table 5. High Scenario Sensitivity Results - 2035

Sensitivity Scenarios	Percent Change Applied	MW Output	Description
Population Change	+10%	+ 16MW	Population growth is uncertain. Adjusting for a 10% higher growth scenario allows the Partner Cities to understand the impacts of unexpected higher growth. This is supported by recent periods where Bellevue and Redmond experienced population growth beyond planned targets.
Adoption of EVs	N/A	N/A	Increased adoption of EVs was not considered since this study assumed an aggressive uptake of EVs as part of the baseline analysis.
Adoption of Building Electrification Technologies	N/A	N/A	The baseline analysis assumed that 99% of buildings would be electrified, which is the ceiling for building electrification.
Total Load Increase	**-**	**+ 16 MW**	Only population increases were tested.

Section 3. Evaluating Grid Capacity for a Growing, Electrified Community

Existing Conditions Assessment

The City of Bellevue is served by 23 PSE substations, and the City of Redmond is served by 12 PSE substations as shown in **Figure 13.** Six of these substations are located along city boundaries and provide service to areas in both cities. To delineate between cities, loads were separated by the substation transformer bank serving each city.

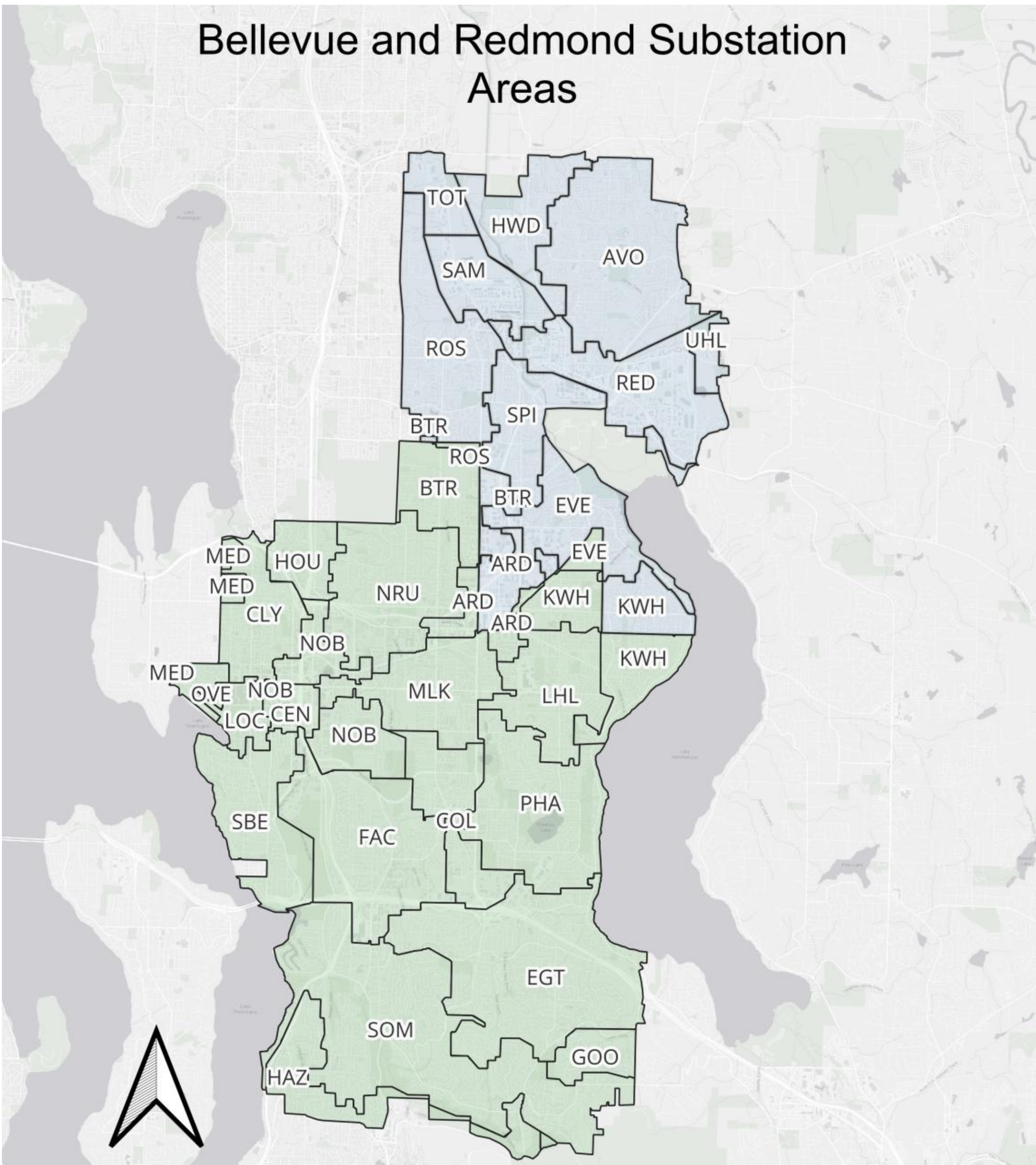


Figure 13. Substations Serving Partner Cities

Figure 14 compares each city's winter and summer base loads with the available substation capacity. Note that PSE is winter peaking, but because the transformers have a higher winter rating, there is more available capacity in the winter. There is therefore more headroom in the winter to add electric heating loads without needing to upgrade the physical transformer. This section will further explore how that capacity is distributed among the cities' substations.

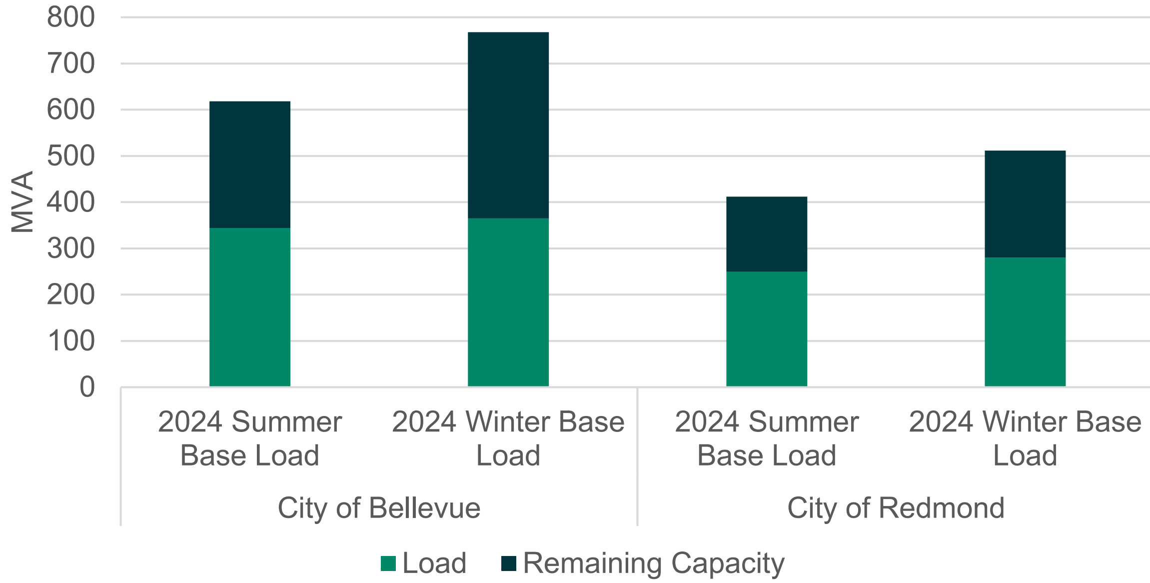


Figure 14. 2024 Substation Utilization

Both the City of Bellevue and City of Redmond have DER and NEM capacities - tools that can help reduce peak electricity demand and alleviate stress on the local grid. Approximately 8.8 and 5.9 Megavolt-Ampere (MVA) of net metering capacity is currently deployed across the substations serving the City of Bellevue and Redmond, respectively, providing localized resources that can help reduce net system demand during peak periods. Net metering capacity is expected to continue growing within the Partner Cities and is anticipated to play an increasingly important role in helping manage rising electricity demand over time.

Distributed Energy Resources (DERs) decentralize energy production and storage through rooftop solar and batteries.

Net Energy Metering (NEM) allows PSE customers with home renewable energy systems (like solar) to export excess electricity to the grid.

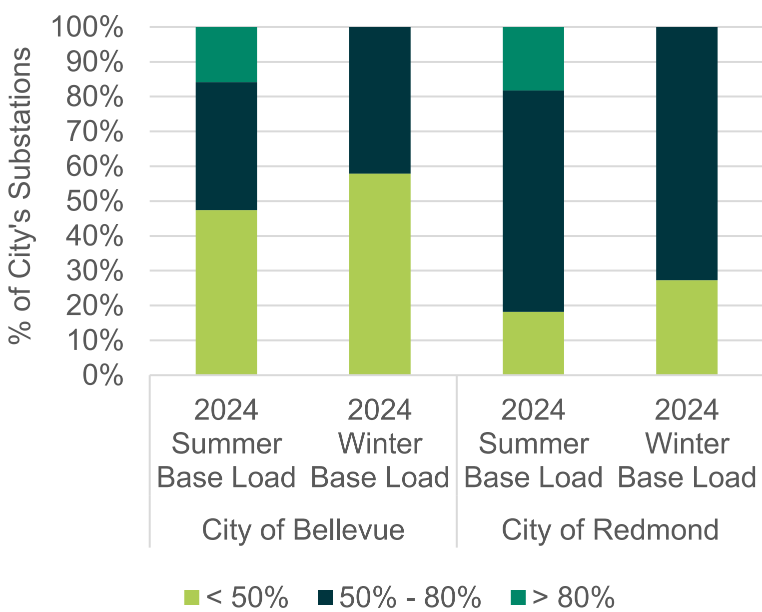


Figure 15. Substation Utilization

Currently summer utilization is when the grid is most strained, because of the lower summer capacity ratings of the transformers. Accordingly, 16% and 18% of substations for City of Bellevue and Redmond, respectively, exceed 80% utilized in the summer of 2024 (shown in **Figure 15**). Throughout this section, we will explore how those peaks are anticipated to change and how the highly utilized substations will shift as PSE completes projects and load transfers.

Study Approach

The approach to understanding the impact of the Partner Cities' forecasted growth on the grid and its capacity was conducted in six steps as outlined in **Figure 16.**

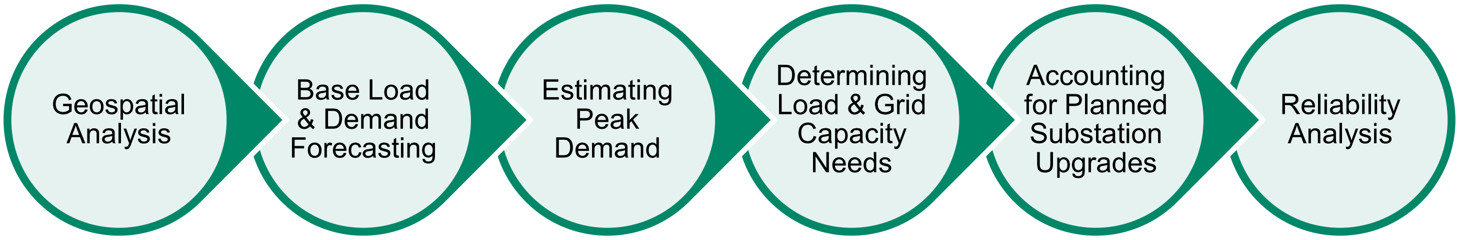


Figure 16. Grid Capacity Study Approach

1. Geospatial Analysis

This analysis was completed at the substation level within each city's boundaries to provide the most consistent and reliable results. Geospatial TAZ data files were provided by the Partner Cities (**Figure 17**). To conduct the geospatial analysis, EV and building data were first aggregated from the TAZ level up to each substation area, using geospatial boundary files for the substations To map building locations, parcel-level building data provided by the Partner Cities was matched with publicly available King County geospatial files for the ZIP codes within Bellevue (98004, 98005, 98006, 98007, 98008, 98009) and Redmond (98033, 98052, 98053, 98073, 98074). Approximately 5% of buildings could not be matched to these files. For this study, we assumed these unmatched buildings are distributed throughout the cities rather than concentrated in any one substation area.

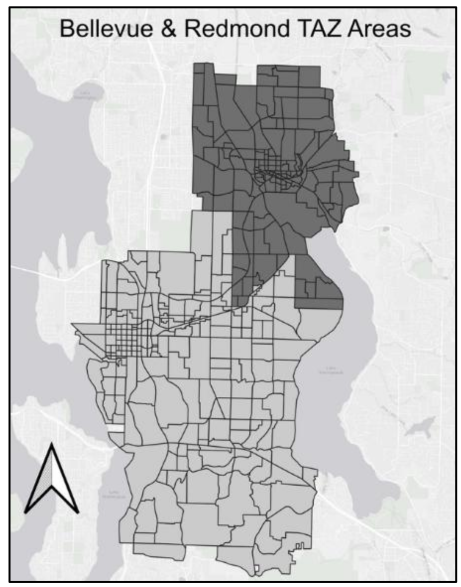


Figure 17. TAZ Areas

This analysis was not conducted at the TAZ level or feeder level for several reasons. While TAZs provide fine-grained geographic details, many cover very small areas with only a few buildings, which could skew results if any unmapped buildings were located within those zones. In addition, some TAZs cross multiple substation service areas, making it difficult to reliably assign growth and load to a specific substation without detailed circuit level information. Circuit-level data needed to match buildings to individual electrical circuits was not available for this study. Given these factors, the substation level offered the most accurate and practical foundation for understanding future electricity demand across the Partner Cities.

Substation service areas located within the parkland northeast of Redmond that are disconnected from the main service territory were excluded from this analysis. These include Farrel-McWhirter Park and Redmond Watershed Preserve served by the Union Hill, Avondale, and Cottage Lake substations. These facilities primarily serve park areas that contain very few buildings within city boundaries and therefore were not considered representative of city-level load growth for this study. A small area served by the Sahalee substation on the edge of Marymoor Park was also excluded due to data limitations. Although these areas were not directly studied, areas within the contiguous city limits served by the Union Hill substation were included in the analysis, and the Partner Cities noted that capacity constraints in this area have previously affected development in Redmond.

Following the substation overlay process, a small number of buildings, approximately 0.5% of those matched to King County geographic information system (GIS) data were identified as falling outside the Bellevue and Redmond substation service areas. These buildings were excluded from the analysis to maintain consistency and accuracy of the results.

Some substation areas extended beyond the boundaries of either Bellevue or Redmond. To account for this situation, we conducted a geo-analysis and a visual check to identify which substations were completely within the city areas and which were partially within the city areas (ranging from most of the area to some of the area). These substations were included in the results to help qualify potential issues, particularly in cases with partial or minimal overlap. We used conservative estimates with a preference for "partial" or "minimal" compared to "all."

2. Base Load and Demand Forecasting

Using winter peak load as the baseline allows this study to assess future load growth against the period of highest operational risk and infrastructure constraint. Electrification forecasts through 2050 were developed using the methodology described in **Section 2**, which incorporates building and transportation electrification, population growth, and policy-driven adoption trends.

Why Was a Winter Peak Analyzed?

PSE's 2024 winter peak substation loads were used as the baseline for this analysis because Puget Sound Energy is a winter-peaking utility, meaning the single hour of highest electricity demand typically occurs during the winter. In the Puget Sound region, cold temperatures drive increased use of electric resistance heating and heat pumps, resulting in higher system demand than during summer conditions.

Although winter peak demand is higher than summer peak demand, substations generally have greater available capacity during winter conditions. Substation equipment, including transformers, is thermally limited and operates more efficiently in colder ambient temperatures, allowing higher loading without exceeding temperature or safety limits. During summer periods, higher ambient temperatures reduce equipment cooling capability and effectively lower usable capacity, even when total system demand is lower. As a result, summer loading conditions are often closer to substation capacity limits.

In the Pacific Northwest, extreme cold events drive the highest electricity demand and present the greatest reliability risk. Accordingly, PSE plans and builds its system to withstand worst-case winter conditions, when the risk of outages is highest. In addition, increasing levels of renewable generation and energy storage tend to contribute more effectively to summer peak needs than winter peak needs, further reinforcing winter conditions as the system-defining planning case.

3. Estimating Peak Demand

Electrification is reshaping traditional grid-planning assumptions including how and when peak demand occurs. Understanding future peak demand requires examining how different types of electricity use overlap during the hours when the grid experiences the most stress. Each end use has its own daily pattern. In this study, EV charging is estimated to peak around 7:00 P.M., as drivers return home and plug in their vehicles. Building electrification peaks earlier in the day, around 8:00 A.M., when heating demand is highest. PSE's system-wide winter coincident peak typically occurs in the early evening, around 6:00 to 7:00 P.M.

Because these peaks do not occur at the same time, the study models how these load shapes overlap to determine the combined, or "coincident," peak that substations must be able to serve. This approach provides a more accurate picture of future grid needs than simply adding each category maximum independently, ensuring that planning reflects the real moments when demand is highest as electrification accelerates. The forecasted coincident peak load is added to the 2024 base load to estimate total future demand in five-year increments - 2030, 2035, 2040, 2045, and 2050.

What is Coincident Demand?

Utilities operate under the understanding that not all loads occur at the exact same time.

7:00 PM	8:00 AM	6:00 PM
Residential EV owners and commercial fleet managers tend to plug their vehicles in to charge at the end of the workday with the intention of achieving a full charge by morning.	In the winter, heat pumps typically experience two daily peaks – in the morning when residents wake up and evening when they return home. The winter morning peaks are new – created by the electrification of heating.	The electric grid peaks in the evening when residents return from work and school, simultaneously turning on AC/heating, lighting, televisions, cooking appliances, and charging devices.

4. Determining Substation Load and Grid Capacity Needs

We assessed future electricity demand at the substation level and evaluated whether the existing grid can reliably meet that demand over time. To do this analysis, the total future demand is compared against the winter peak utilization limit for each substation, which represents the maximum load the substation can safely serve during PSE's highest-demand season. By comparing projected future demand to these limits, the study identifies where substations may face constraints and when those constraints are likely to emerge.

5. Accounting for Planned Substation Upgrades and Load Transfers

As demand grows, utilities often address emerging constraints through targeted investments such as adding new transformers, upgrading equipment, or reconfiguring circuits to increase a substation's ability to serve load. In some cases, load can also be shifted, or transferred, from one substation to another with available capacity, helping delay or reduce the need for more extensive infrastructure upgrades.

While sufficient capacity may exist across the broader Partner Cities area in aggregate, load growth is not evenly distributed across the system. As a result, capacity constraints can emerge at individual substations where localized growth and electrification outpace the readiness of existing infrastructure.

What is Capacity vs. Utilization?

Substation capacity is the maximum amount of electrical power a substation can safely handle and distribute to the surrounding community.

Substation utilization measures how much of a substation's total capacity is used during times of high electricity demand (i.e., peak conditions).

Utilization is vital because it explains *why* a utility may need to invest in new infrastructure even if a substation is not "full" 100% of the time. Utilities typically set thresholds to create a safety buffer that protects both the hardware and customers, which is 75% in PSE's case.

For this study, we incorporated the known load transfers identified, which were provided by PSE. We also included planned substation capacity increases that PSE has proposed in its recent planning reports, reflecting upgrades expected by 2030 and 2035.[10] These planned improvements are integrated into the analysis to provide a more realistic picture of how future grid constraints may evolve.

It is important to note that while net-metering information is available for each substation, it was not included in the load-growth calculations for this analysis. Instead, this data will be used to help identify potential opportunities for load relief, such as how distributed solar generation may help reduce strain on the grid.

It is important to note that this study is not intended to replace the detailed engineering assessments that utilities conduct, such as power-flow studies. Those technical evaluations are essential for determining the precise electrical performance of circuits, verifying equipment ratings, and confirming whether specific upgrades are required. Instead, this study provides a high-level planning perspective that helps identify where future capacity constraints may emerge based on projected load growth, electrification trends, and known substation limits. The results are meant to inform long-range planning and support proactive coordination, while recognizing that any future grid investments will ultimately require more detailed engineering review by PSE.

6. Reliability Analysis

> As Bellevue and Redmond continue to grow and more energy uses transition to electricity, maintaining reliability becomes increasingly important.

Reliability Findings and Insights highlights which substations have a higher share of circuits with known historic reliability issues. For consistency, the reliability analysis is presented across the full city area and at the substation level. A more detailed, circuit-by-circuit reliability and resilience assessment is available in **Appendix A**.

Reliability is typically measured using two standard indicators: the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI). SAIDI measures the total duration of power interruptions a customer experiences in a year, while SAIFI measures the frequency of those interruptions. Details on how the study calculated SAIDI and SAIFI can be found in **Appendix A**.

What are SAIFI and SAIDI?

System Average Interruption Duration Index (SAIDI) measures how long the average customer is without power over a given period (in this case, a year). Lower SAIDI values indicate better reliability.

System Average Interruption Frequency Index (SAIFI) measures how often the average customer experiences a power outage over a given period (in this case, a year). Lower SAIFI values mean outages occur less frequently.

The analysis begins by comparing the average reliability of all circuits in Bellevue and Redmond against national and state benchmarks to provide an overall picture of current system performance. It uses five years of reliability data, specifically SAIDI and SAIFI values from 2020 through 2024, as the foundation for this assessment. These same five-year averages are then applied consistently throughout the remainder of the reliability analysis to ensure comparability across cities and substations. The analysis also aggregates circuit SAIDI and SAIFI by substation to determine whether certain areas could be strengthened.

[10] PSE. 2025 Plan. https://www.oasis.oati.com/woa/docs/PSEI/PSEIdocs/PSE_Plan_2025_Final.pdf

City of Bellevue Results

Overall energy demand from EVs and building electrification across Bellevue is projected to increase by approximately 244 MW by 2050, reinforcing the need for proactive grid planning to support the city's long-term growth and sustainability objectives. The analysis shows that the projected increase in total city energy demand, as described in **Section 2**, directly affects both current and planned substation capacity.

The results identify several substation areas that may warrant future attention, which PSE is likely to evaluate further as those facilities approach higher levels of utilization. The overview also notes several recent substation upgrades completed by PSE, which have contributed to strengthening available capacity. In addition, it summarizes system reliability, showing that most circuits in Bellevue are performing above national and state averages. The overview also highlights a few circuits and locations that may merit additional attention, which are examined in greater detail in the resilience analysis included in the **Appendix A**.

Analysis and Key Findings

As discussed in **Section 2**, this study captures future growth based on known Comprehensive Plan targets and generalizes anticipated job growth as commercial office demand. All capacity assessments are evaluated at peak winter utilization, consistent with PSE's winter-peaking system and planning practices. Because detailed information on specific future projects is not available at this time, actual growth may differ from these assumptions, particularly if higher-intensity uses such as data centers, industrial facilities, or municipal projects occur. As a result, areas identified as having available capacity may still experience utilization constraints if unanticipated high-demand development materializes.

Results from the substation analysis suggest that the Clyde Hill, North Bellevue, Northrup, and Somerset substations are the most likely to experience capacity pressures in the near term (**Figure 19**). These substations show higher utilization levels under projected growth and electrification scenarios, suggesting they may require closer monitoring and potential upgrades sooner than other substations. We anticipate that the Clyde Hill substation may face the most significant challenge, with prospective utilization estimated to increase to approximately 100% of its current capacity by 2035.

Pressure drivers of growth at the four substations forecasted to experience the most constraints include the following.

- **Clyde Hill substation (serving North Bellevue and northern part of Downtown Bellevue):** Growth at the Clyde Hill substation is driven by the northwest corner of Downtown that is fed by Clyde Hill (identified as City Center North in the Comprehensive Plan). This area is currently home to residential, commercial, and mixed-use buildings, with several projects currently proposed or under development. The growth in the northern part of Downtown accounts for over 80% of the load growth for this substation's service area. Downtown Bellevue is designated a Regional Growth Center in VISION 2050,[11] and it is expected to see continued growth in high-density housing.

Bellevue Comprehensive Plan

The substations that are forecasted to see the most constrained capacity can typically be connected back to pressure drivers of growth in the Comprehensive Plan and upzoning. The growth is amplified by the assumption that new construction will have electrified heating. This growth is expected to be concentrated in areas such as Downtown Bellevue, the BelRed corridor, and Wilburton, based on the study's forecast results.

[11] Puget Sound Regional Council (October 2020). Vision 2050: A Plan for the Central Puget Sound Region. https://www.psrc.org/sites/default/files/2022-11/vision-2050-plan.pdf

- **North Bellevue substation (serving Downtown and the Wilburton commercial area):** Growth is driven by mixed-use development around the Grand Connection – a series of cohesive, connected and pedestrian-focused spaces through Bellevue's central business district, connecting Downtown across Interstate 405 to the Wilburton neighborhood. Redevelopment in Wilburton and development around the Wilburton Light Rail station also contribute to pressure at this substation. This substation is projected to see growth from the Wilburton/N.E. 8th Street development plans. Land use was updated in the area in 2024, allowing for a scale of development around the station similar to what is found in Downtown Bellevue.[12]
- **Northrup substation (serving BelRed and Bridle Trails):** This substation is projected to see growth around the two light rail stations in BelRed (Spring District and BelRed). Land use planning for these station areas was first adopted in 2009 and was recently updated in 2024. Mixed use development around the Spring District station has a more commercial focus and more residential focus around the BelRed station.
- **Somerset substation (serving the Newport, Somerset, and Newport Shores neighborhoods):** Growth at the Somerset substation is driven by planned neighborhood-serving commercial centers, multifamily housing, and mixed-use development in the Newport area. While zoning has not changed and population and commercial growth are expected to be minimal, the substation serves more residential units and EVs than any other substation. Transition from fossil fuel heating to electrified alternatives combined with EV adoption in the substation area is what is expected to drive much of the growth.

The resulting capacities shown in **Figure 18** reflect substation conditions after implementation of all planned upgrades and load transfers identified in PSE's 2025 system plan (**Table 6**). For example, PSE's planned upgrades of two transformers at the North Bellevue substation from 25 MVA to 40 MVA are expected to relieve capacity constraints once completed by 2035 (see **Substation Capacity Upgrades** for details on planned upgrades).

Table 6. Planned Substation Upgrades Incorporated into Analysis in Bellevue[13]

Substation	Impact	Estimated Year
Center	15 MVA	2035
Midlakes	25 MVA	2030
North Bellevue	30 MVA	2035
Rose Hill	25 MVA	2030[14]

In contrast, the Clyde Hill, Northrup, and Somerset substations are likely to continue experiencing increasing constraints. By 2040, our analysis estimates that utilization could reach approximately 124% at the Clyde Hill substation, 102% at the Northrup substation, and 109% at the Somerset substation. These substations may also be relieved by upgrades to other substations. Additional solutions such as load shifting are likely to be evaluated in PSE's future planning cycles as electricity demand continues to grow.

[12] City of Bellevue. Wilburton Vision. https://bellevuewa.gov/city-government/departments/community-development/planning-initiatives/wilburton-vision
[13] Please note that PSE has planned to add a Vernell substation, which is currently in the permitting process as of this writing. Vernell is not represented in this map or included in the capacity analysis, as the exact location and service area of the substation were not disclosed at the time of analysis.
[14] Mostly serves the City of Redmond.

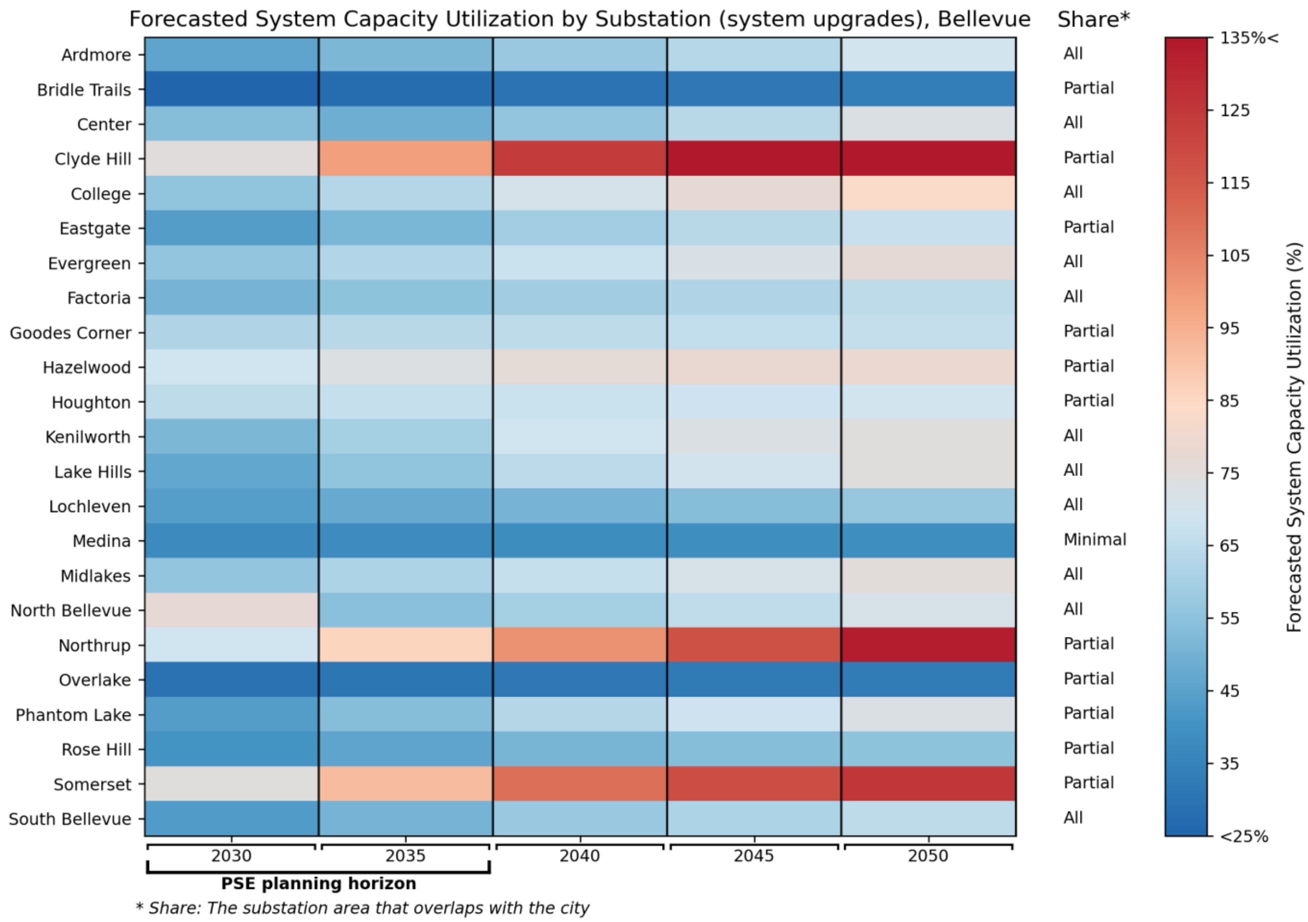
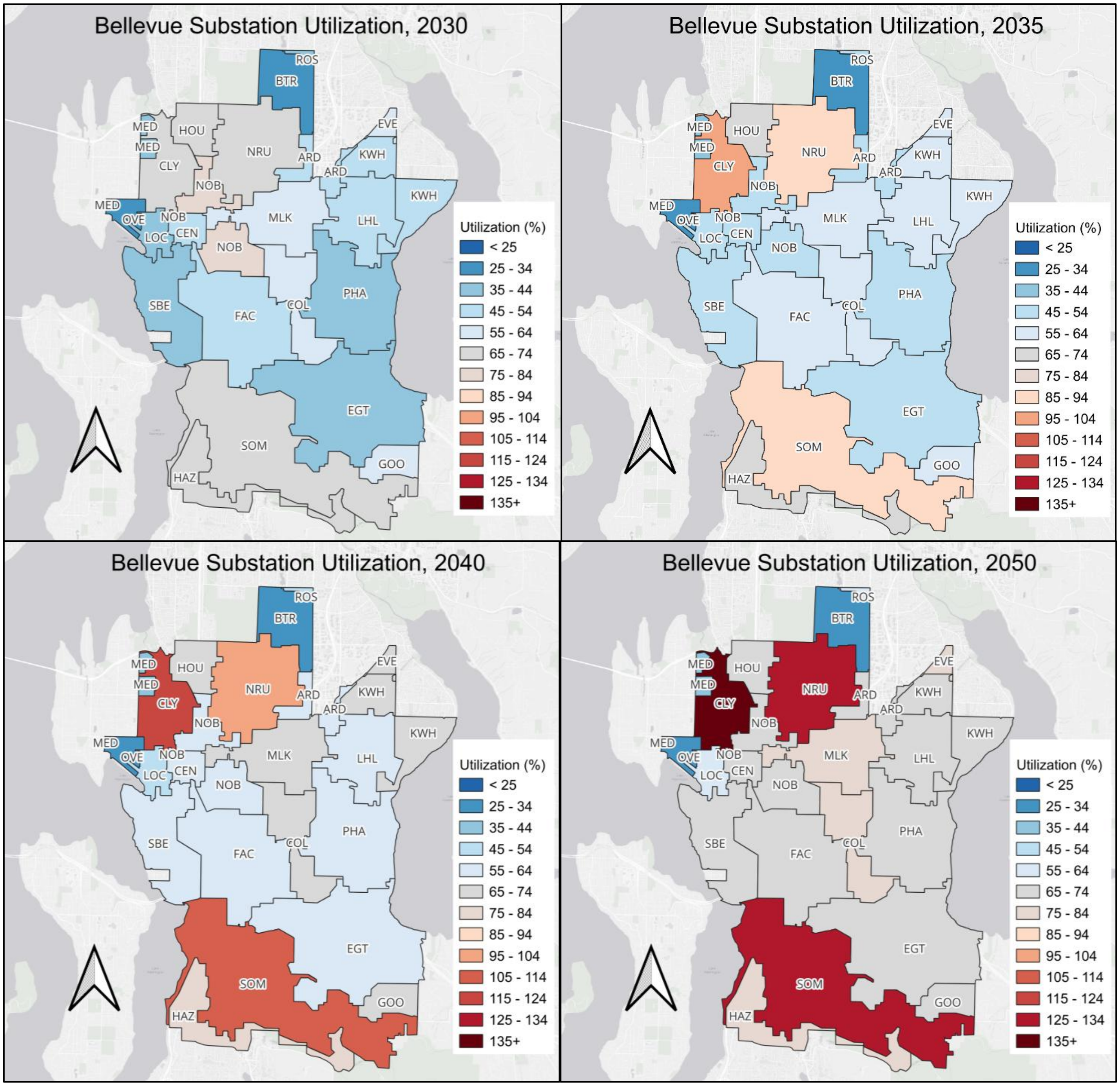


Figure 18. City of Bellevue Forecasted Winter Peak Utilization by Substation

Substation size and capacity play a critical role in determining how much electricity a local area can reliably receive and distribute. Among the four substations identified as having potential capacity challenges in the next several years without the planned upgrades, the North Bellevue substation stands out as the largest substation. It is currently rated at 64 MVA for winter utilization and is expected to increase to 102 MVA following the planned transformer upgrades. In contrast, the Clyde Hill, Northrup, and Somerset substations are each rated at 32 MVA, which limits their ability to absorb the significant load growth anticipated from electrification and new development. These smaller capacity ratings help explain why these substations are projected to reach higher utilization levels sooner and may require more attention in future planning cycles.

Addressing these emerging capacity constraints will require strong collaboration and coordination among the Partner Cities, PSE, and regional permitting agencies. Substation upgrades often involve lengthy planning horizons, multi-year construction windows, and complex permitting and siting processes. Early coordination around permitting, land use considerations, and long-term development patterns is especially important for substations with limited existing capacity, ensuring that infrastructure investment keeps pace with community growth and the accelerating shift toward electrification.

We also demonstrate the utilization geospatially to provide a high-level overview of where capacity constraints may occur. The Clyde Hill and Northrup substations are located in the north and northwest parts of Bellevue, while the Somerset substation is located in the south (see **Figure 19**). Our analysis suggests that the area served by the Clyde Hill and Center substations have the highest growth rates of total building electrification and EVs from 2030 – 2050 at an additional 42 MW in building electrification and 14 MW in electricity from EV for the area served by the Clyde Hill substation for a total of more than 55 MW when adding current load, along with an additional 42 MW in building electrification and 7 MW in electricity from EV for the area served by the Center substation for a total of nearly than 50 MW when adding current load. This expected growth is closely followed by the area served by the North Bellevue substation. The Center substation is one of the larger substations in the area, with a winter capacity rating of 64 MVA. Following PSE's planned transformer upgrade, the substation's total capacity is expected to increase to approximately 83.2 MVA by 2035. As a result, the Center substation is not projected to face capacity constraints over the study period.



2045 map not pictured (included in Appendix E)

Figure 19. City of Bellevue Substation Utilization (2030 – 2050)

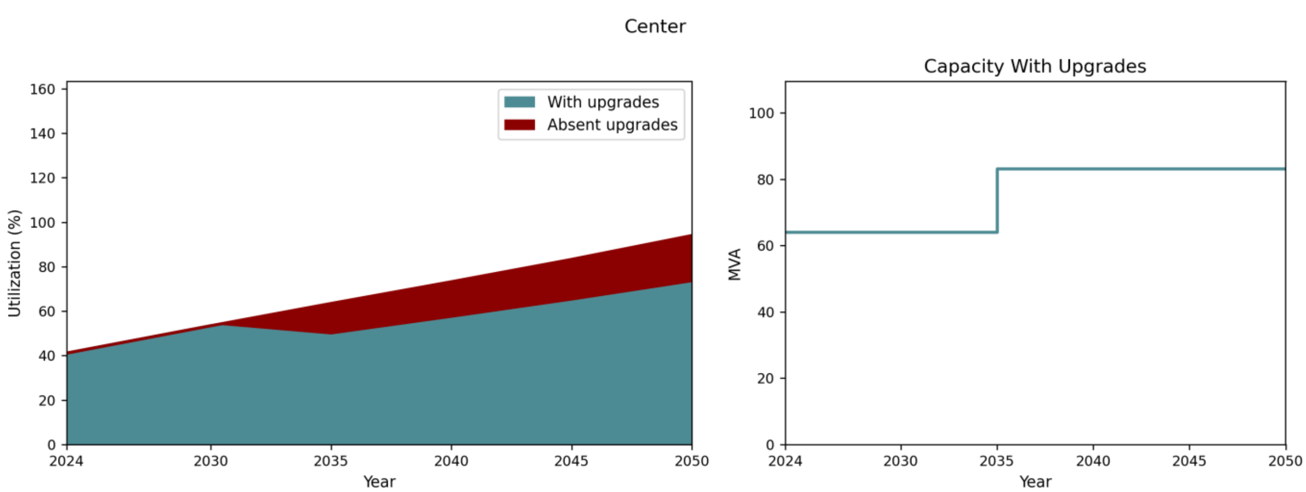
Substation Capacity Upgrades

PSE plans to upgrade capacity at four substations in the Bellevue area over the next decade. Two of these upgrades – the Midlakes and Rose Hill substations[15] – are expected to be completed before 2030, followed by upgrades at the Center and North Bellevue substations by 2035. PSE acknowledged that upgrades to the Midlakes and Rose Hill substations were driven by increased demand. Most of the planned capacity increases at the Center, Midlakes, and Rose Hill substations range from 15 to 25 MVA, while the upgrade at the North Bellevue substation is substantially larger at 30 MVA. In addition to these upgrades in Bellevue directly, PSE plans to develop the Vernell substation with two 40 MVA distribution transformers, which will be looped into the Sammamish and North Bellevue 115 kilovolt (kV) line. This project could expand capacity planning in the area served by the North Bellevue substation and support future load growth served by the North Bellevue substation. Other alternatives available include shifting load from constrained substations to nearby substations with excess capacity. To this end, upgrades to other parts of the grid, including the Totem Lake, Pine Lake, Hollywood, Norkirk, Maplewood, and Sweptwing substations, are located outside the Bellevue area but interact with the grid. Some of these substations are in Redmond (see **City of Redmond Results**).

These enhancements are essential for managing future electricity demand and reducing projected system constraints. For example, without its planned upgrade, the Midlakes Substation is projected to exceed 100% utilization by 2030. With the upgrade in place, utilization is expected to drop to roughly 56%, underscoring the importance of timely infrastructure investments to maintain a reliable and resilient electric grid.

Figure 20,

Figure 21, and **Figure 22** show how the planned substation upgrades reduce substation utilization and how total substation capacity increases as those upgrades come online. These upgrades to utilization take into account changes from building electrification and EV uptake but do not take into account 5-year PSE load growth. The left-hand graph illustrates the average reduction in utilization over each five-year period, giving a smoothed view of how upgrades help relieve load. The righthand graph, by contrast, shows total substation capacity in the specific year when each upgrade is fully reflected. For example, if an upgrade is scheduled to occur at any point between 2030 and 2035, its full capacity is shown in 2035, which marks the end of that planning interval. This approach provides a clear view of both the timing and impact of planned infrastructure improvements.



15 This substation also serves Redmond.

Figure 20. Center Substation (2024 – 2050)

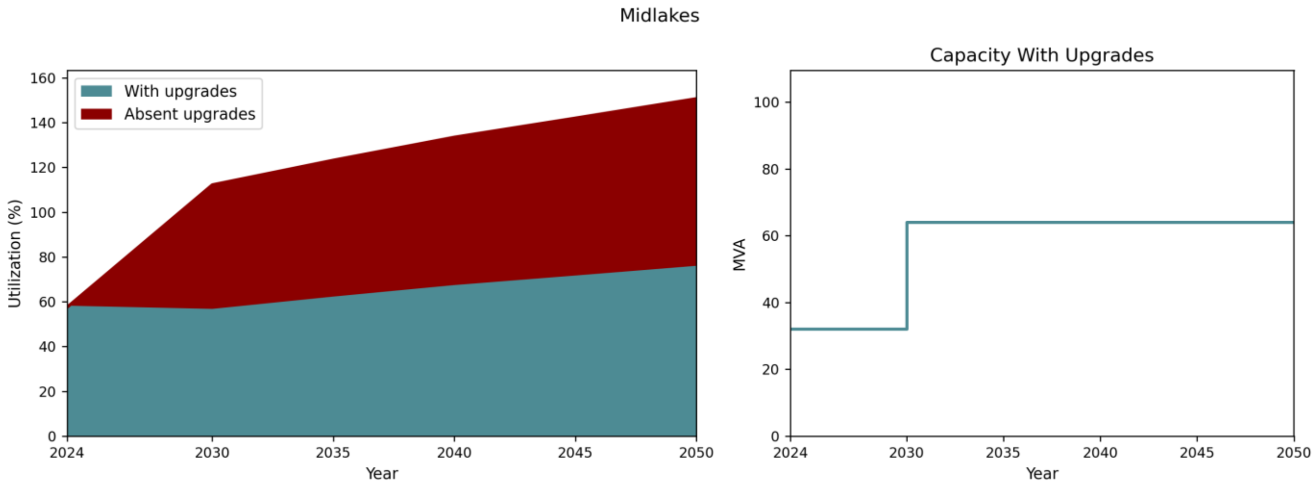


Figure 21. Midlakes Substation (2024 – 2050)

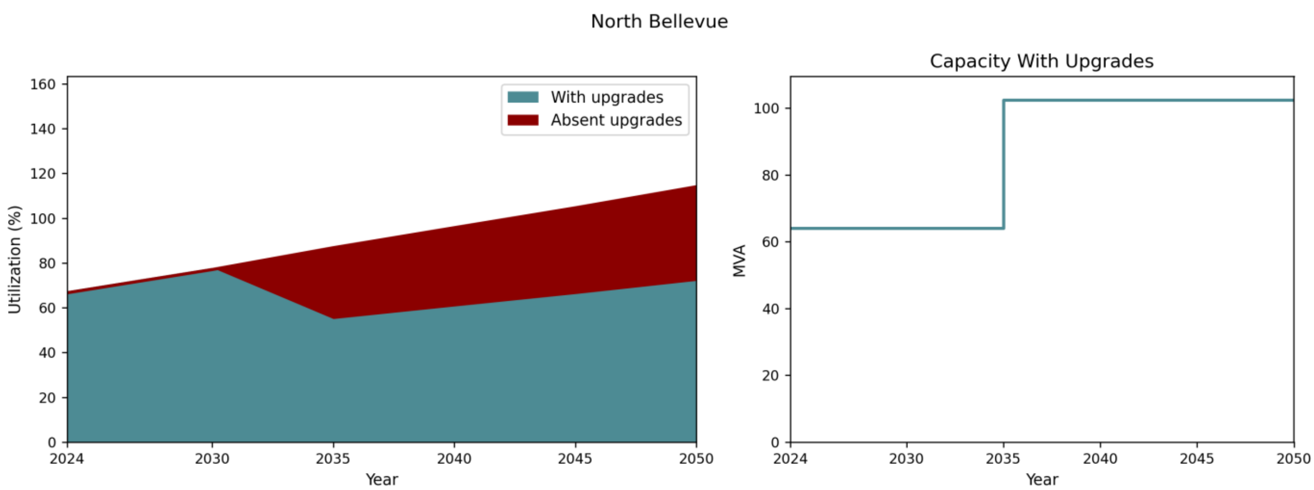


Figure 22. North Bellevue Substation (2024 – 2050)

Reliability Findings and Insights

When reviewing year-by-year SAIDI and SAIFI averages from 2020 to 2024, as shown in **Figure 23** and **Figure 24**, the substations in Bellevue consistently perform better than national benchmarks and outperform all comparison metrics included in this analysis. Notably, Bellevue experienced a decline in both SAIDI and SAIFI during the statewide increase in the frequency and duration of disruptions in 2022, demonstrating stronger stability than the Washington statewide average during that year. Overall reliability performance has remained steady, with only a slight increase in SAIDI in recent years. Given the limited five-year window, this data appears to reflect normal year-to-year variation rather than a clear upward trend, though future data will help confirm whether a longer-term pattern is emerging.

To provide additional context, the study also compared Bellevue's reliability to that of a nearby urban area with similar characteristics. Across the same five-year period, Bellevue's SAIDI and SAIFI values are generally more consistent and showed slightly better performance than the comparison city. This finding further reinforces Bellevue's strong reliability performance relative to both statewide and peer benchmarks.

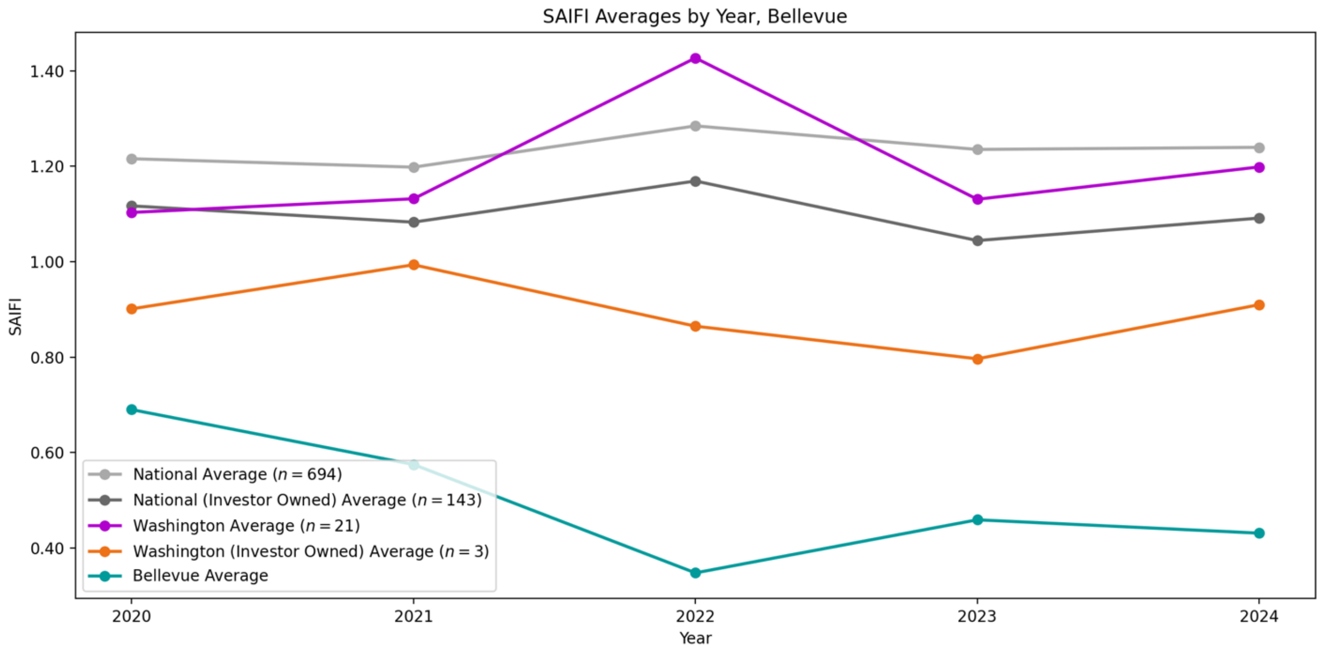


Figure 23. City of Bellevue SAIFI Averages by Year

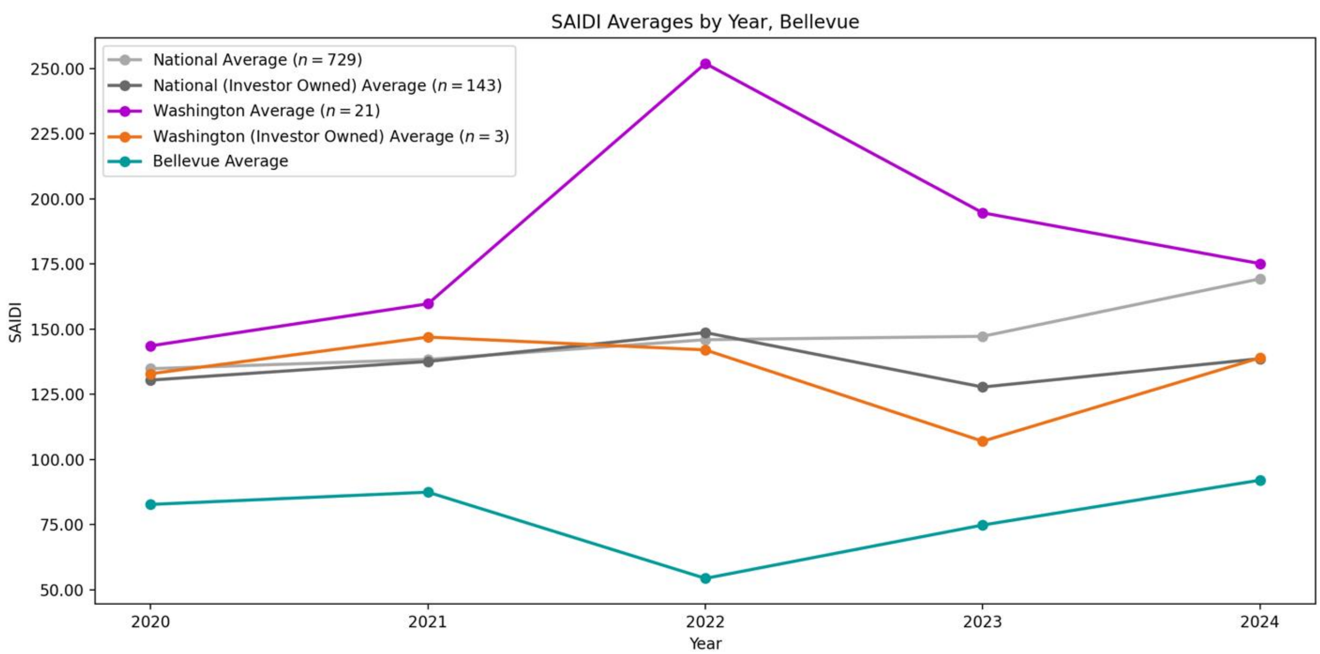


Figure 24. City of Bellevue SAIDI Averages by Year

An analysis of outage causes from 2020–2024 shows that equipment failure accounts for more than 43% of all interruptions, making it the leading contributor to outages in Bellevue. Tree-related impacts including those occurring during major event days represent another 24% of outages. In terms of duration, outages caused by trees also resulted in some of the longest average interruption times, with an average duration of 18 hours, reflecting the complexity of clearing vegetation and restoring damaged infrastructure. Bellevue's reliability patterns closely mirror those observed in Redmond over the same period. Additional detail on outage causes, durations, and resilience considerations is provided in **Appendix A**.

As shown in **Figure 25,** most of the general ranking of reliability of circuits at the substation level is located in the south of Bellevue, including the Goodes Corner substation in the southeast. The Hazelwood and Somerset substations are also in the southern part of the city. The other concentration of top-ranked substations, such as Bridle Trails, is in the north and northwest. The pattern of higher-ranked circuits, particularly in the south around a substation like Somerset, may reflect localized conditions that merit additional attention.

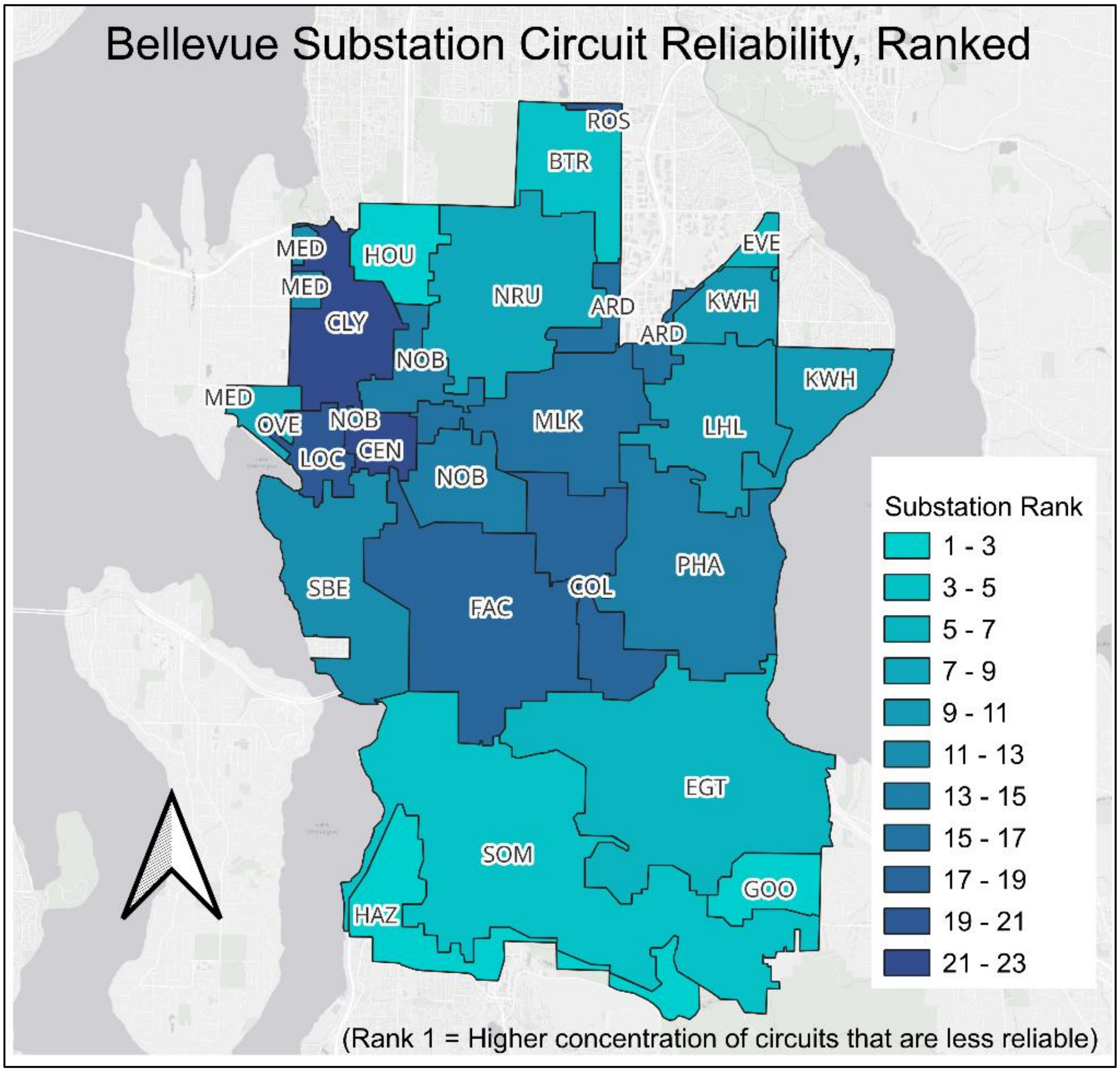


Figure 25. City of Bellevue Substation Circuit Reliability[16]

City of Redmond Results

Energy demand from EVs and building electrification across Redmond is projected to increase by almost 40% by 2050, reinforcing the need for proactive grid planning to support the city's long-term growth and sustainability objectives. The results identify several substation areas that may require future attention. In addition, it summarizes overall system reliability, showing that most circuits in Redmond are performing above state and national averages. A small number of circuits and locations that may warrant additional attention are identified and examined further in the resilience analysis presented in **Appendix A**.

[16] Includes outages from storms

Analysis and Key Findings

Figure 26 considers upgrades planned for the Hollywood, Rose Hill, Totem Lake, and Union Hill substations (see **Table 7**) based on PSE's planning documents. All capacity assessments are evaluated at peak winter utilization, consistent with PSE's winter-peaking system and planning practices. The study results indicate that three substations – Avondale, Redmond, and Spiritbrook, could face capacity constraints beginning around 2035 if no additional upgrades are made to the substations or the broader electric system. By 2035, utilization for all three of these substations will exceed 90% under current conditions, with all substations reaching approximately 100% or greater by 2040.

Table 7. Planned Substation Upgrades Incorporated into Analysis in Redmond

Substation	Impact	Estimated Year
Hollywood	25 MVA	2035
Rose Hill	25 MVA	2030[17]
Totem Lake	25 MVA	2030
Union Hill	25 MVA	2030

PSE initiates additional planning when a substation transformer or feeder group is forecast to reach 75% of its rated capacity, or earlier in cases where load growth is occurring more rapidly than anticipated. This early planning threshold provides sufficient time to evaluate alternatives and implement solutions before equipment reaches its maximum capacity. When loads across a study group of three or more interconnected substations reach approximately 85% capacity, the need to add additional substation capacity is triggered to preserve operational flexibility and system reliability. Operating a substation near its capacity limits accelerates equipment wear, reduces operational flexibility, and increases risk under contingency conditions, particularly when accommodating large, unforecasted loads. While options such as local load transfers can help address near-term constraints, their effectiveness is often constrained by existing grid configurations and the magnitude of the new demand.

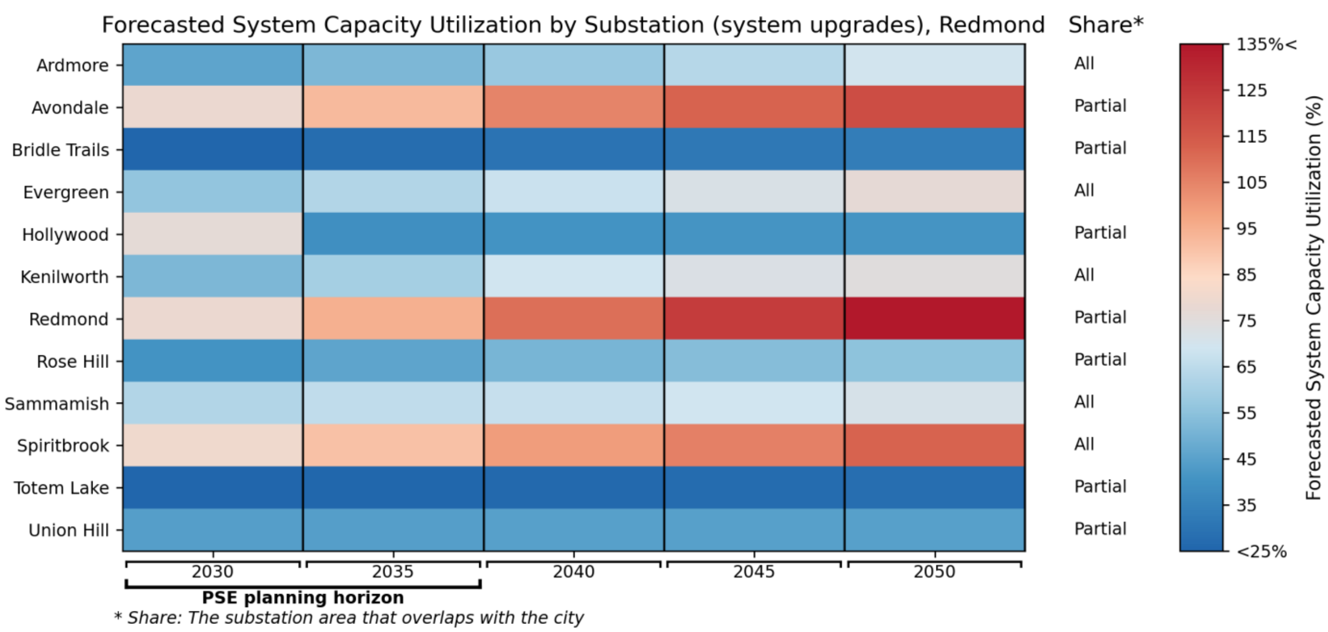


Figure 26. City of Redmond Forecasted Winter Peak Utilization by Substation

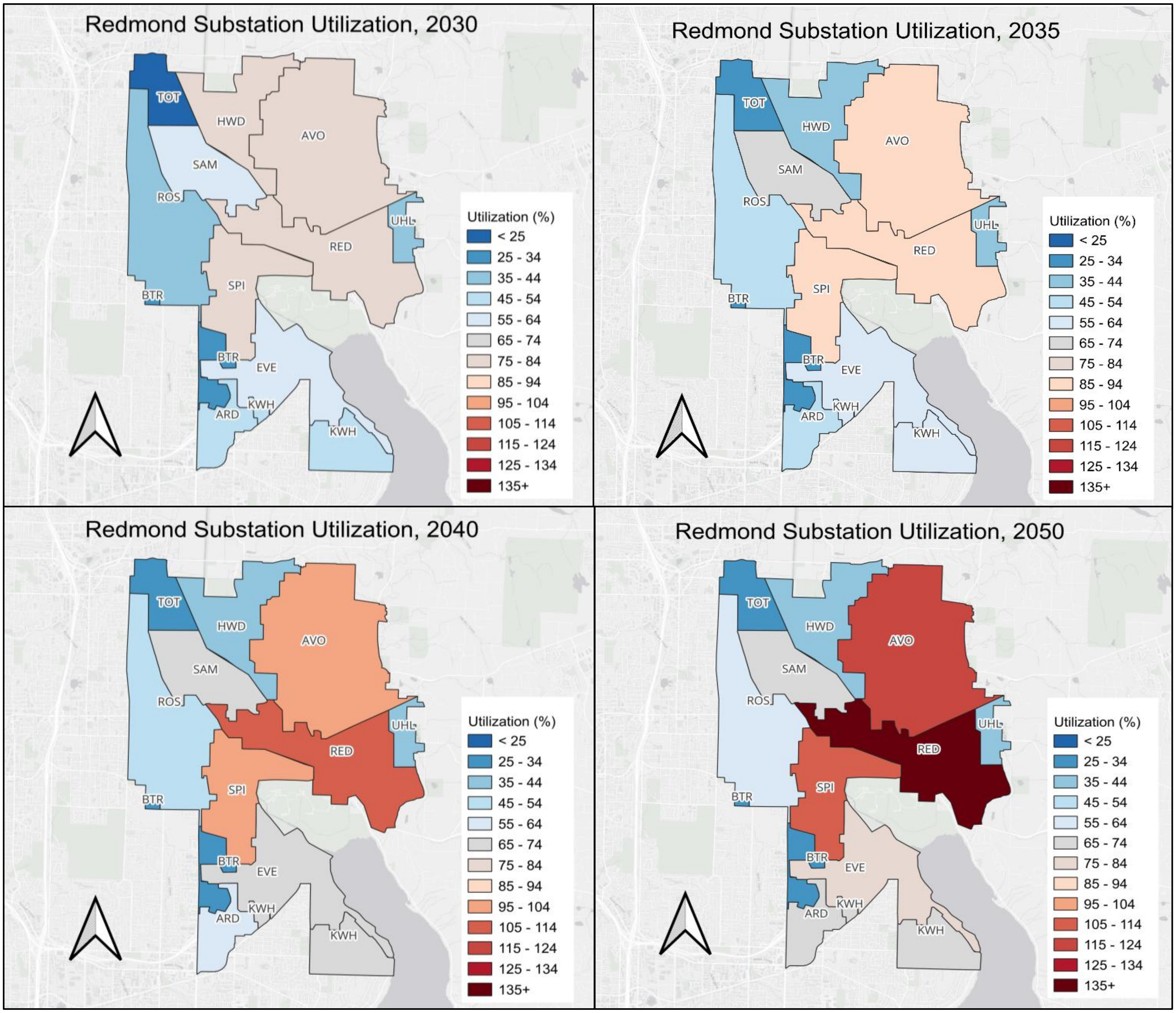
[17] Also serves the City of Bellevue.

The Avondale and Spiritbrook substations are relatively smaller substations in terms of capacity, each with a winter rating of 32 MVA. Both substations are currently operating at approximately 60 – 70% of their rated capacity, with ongoing growth in electrification within their service areas contributing to increasing demand. Redmond substation has a higher winter capacity rating of 64 MVA but is experiencing the highest projected electrification-driven load growth across the service territory, resulting in greater capacity pressure at this location. For comparison, the projected amount of vehicle electrification demand alone in Redmond almost equals the entire total of building electric demand for the smallest six substations in the area. It should be noted that the City of Redmond has experienced the rejection or amendment of projects due to power availability which may be reflective of capacity constraints at a more granular level than the substation.

Figure 27 highlights that constraints appear to be concentrated in a similar area, which is the eastern part of the city. Drivers of growth at the three substations forecasted to experience the most constraint include the following.

- **Avondale substation (serving Education Hill and Bear Creek):** Pockets of commercial and mixed-use residential growth in North Redmond, Bear Creek, and Downtown are the primary drivers of growth in the Comprehensive Plan at the Avondale substation.
- **Redmond substation (serving northern Downtown Redmond and southeast Redmond):** Growth at the Redmond substation is driven by development downtown and in the Marymoor Village, a Countywide Growth Center. With the recent opening of the Marymoor Village Light Rail Station, Marymoor Village is transitioning from a local center to a Countywide Growth Center.
- **Spiritbrook substation (serving Downtown Redmond and northern Overlake):** Downtown Redmond and Overlake are both regional growth centers identified in VISION 2050.[18] This means that they are expected to be primary centers for growth in the region. As part of the update to the Comprehensive Plan, significant increases in capacity for development in Overlake were adopted in 2024. The Ardmore and Evergreen substations that also serve Overlake have enough capacity to handle the increase in load. A countywide Manufacturing and Industrial Center is also proposed in Southeast Redmond. A recent market study of the area found adequate power access is very important to potential tenants with high-tech and advanced manufacturing users typically needing higher power.

[18] Puget Sound Regional Council. Vision 2050. https://www.psrc.org/planning-2050/vision-2050



2045 map not pictured (included in Appendix E)

Figure 27. City of Redmond Substation Utilization (2030 – 2050)

Substation Capacity Upgrades

PSE plans to address four relatively immediate needs related to substation constraints within Redmond, particularly at the Rose Hill substation and the Union Hill substation by 2030. Growth in the Union Hill substation area remains relatively flat as it feeds very few buildings and industrial uses within the city boundaries and park areas such as Perrigo Park, Farrel-McWhirter Park, and the Redmond Watershed Preserve. Without these upgrades, our analysis suggests that utilization would have exceeded 80% by 2030. These upgrades are fairly substantial. Our projections indicate that the upgrades to the Totem Lake substation would nearly double capacity. However, from a utilization perspective based on our modeling, the substation's utilization without upgrades over the next ten years is approximately between 50 – 60%, and 25 – 30% after the upgrades.

The apparent utilization at the Totem Lake substation is influenced by load shifts that were recommended as part of prior large load approvals. These shifts moved loads from the Totem Lake substation to neighboring substations and associate feeders, increasing loading on those systems while reducing apparent loading at the Totem Lake substation. While these substations are included with PSE's planning study area and help defer overall capacity needs by redistributing load over time, they are not represented in this report since they do not serve Bellevue or Redmond. As a result, the projections show lower apparent utilization at the Totem Lake substation, even though the upgrades primarily delay the need for future capacity in this region as load continues to grow.

Figure 28, Figure 29, Figure 30, and **Figure 31** illustrate the change in substation utilization from planned upgrades, along with the total capacity, based on our load growth forecasts detailed in **section 2**.Please note that the right-hand graph for capacity with upgrades highlights the capacity by the specific year in which the upgrade is reflected, while the left-hand graph takes the average reduction from the upgrade over the five years. On the right-hand side, if an upgrade occurs sometime between 2030 and 2035, the capacity is shown in 2035 as the endpoint of that time category in the analysis.

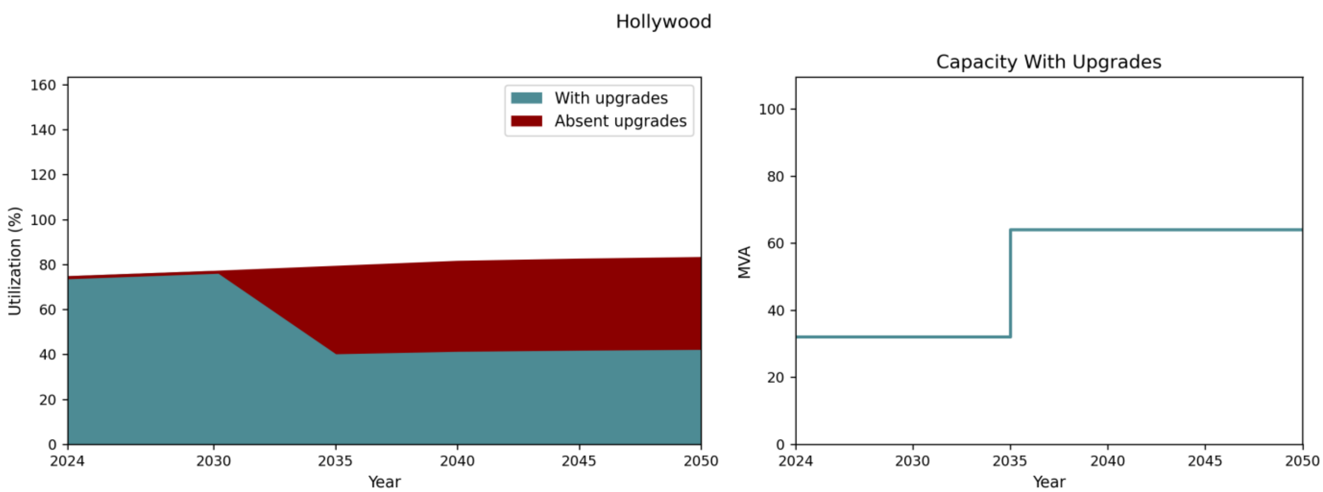


Figure 28. Hollywood Substation (2024 – 2050)

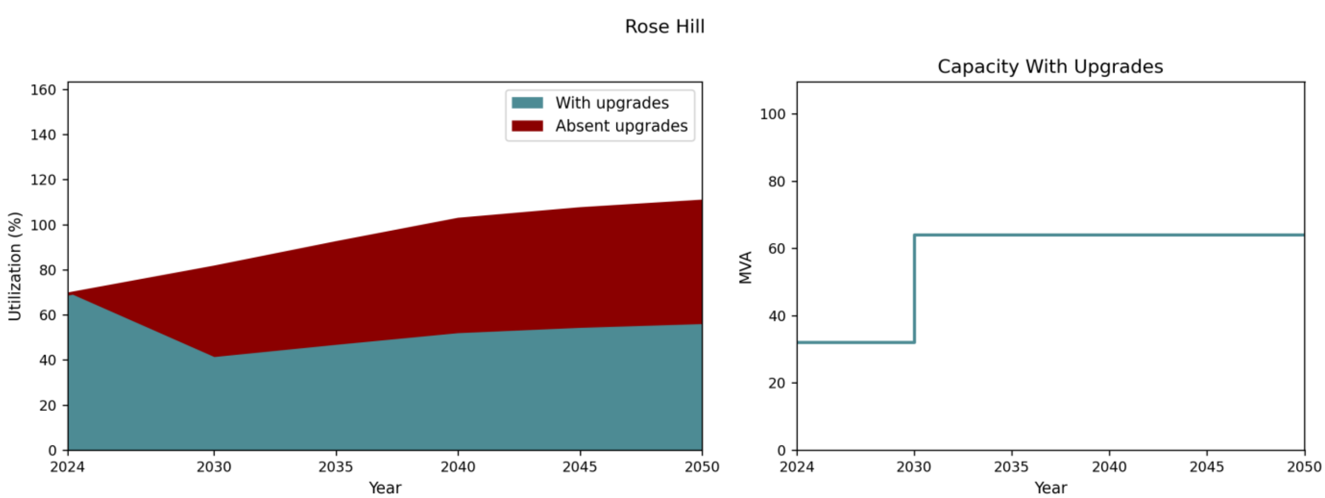


Figure 29. Rose Hill Substation (2024 – 2050)

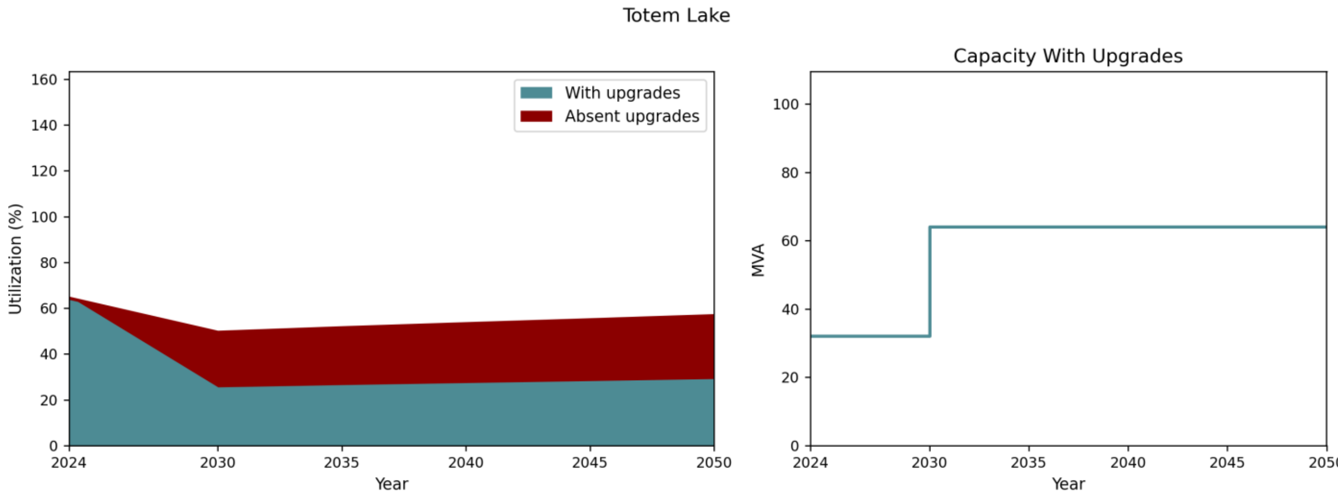


Figure 30. Totem Lake Substation (2024 – 2050)[19]

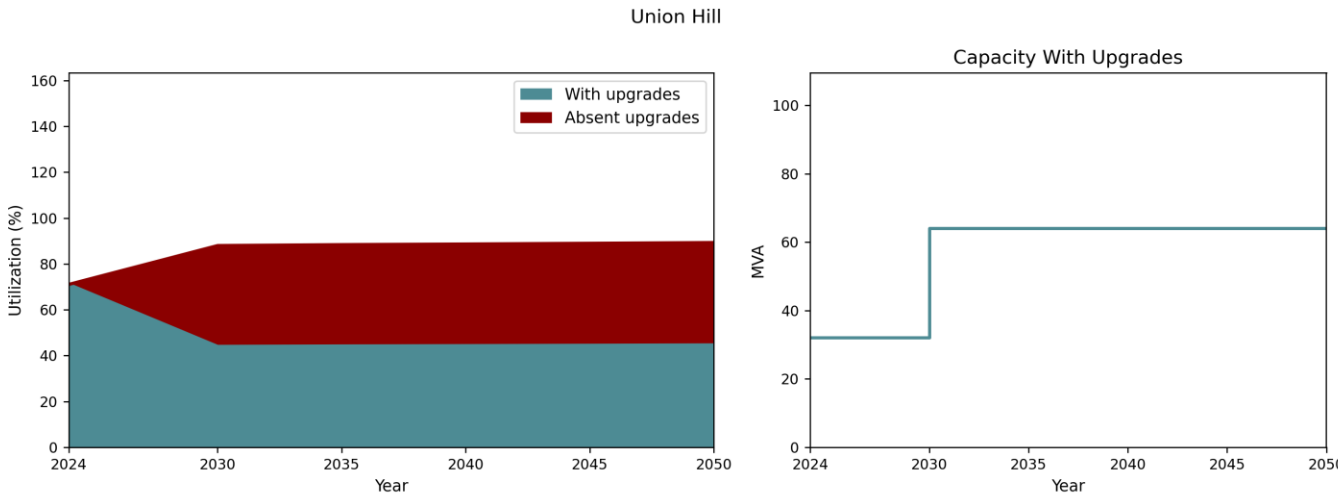


Figure 31. Union Hill Substation (2024 – 2050)

Reliability Findings and Insights

As shown in **Figure 33** and **Figure 32**, Redmond's electric system performs notably well on reliability metrics, with SAIDI and SAIFI averages that compare favorably against both state and national benchmarks. While SAIDI values were higher in 2020, this data point appears to be an anomaly rather than a representative trend. The remaining four years of data show consistent performance and are more indicative of typical reliability conditions in Redmond. Further review indicates that the elevated 2020 SAIDI value was driven by an extreme outlier affecting a single circuit and does not reflect systemwide performance. The study also compared Redmond's reliability metrics with those of a nearby urban area with similar characteristics. This comparison shows that Redmond's SAIDI and SAIFI performance is slightly better than that of the comparable urban area.

[19] Without upgrades, utilization still goes down due to local feeder level load transfers out of Totem Lake substation.

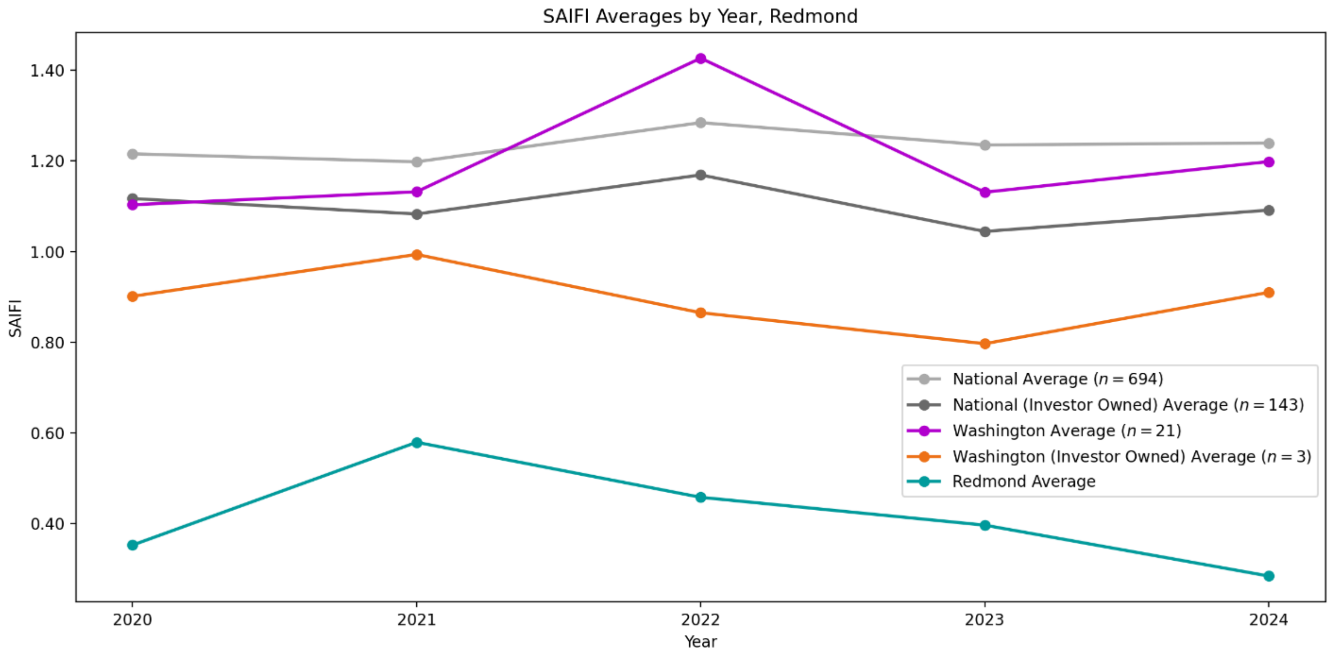


Figure 32. City of Redmond SAIFI Averages by Year

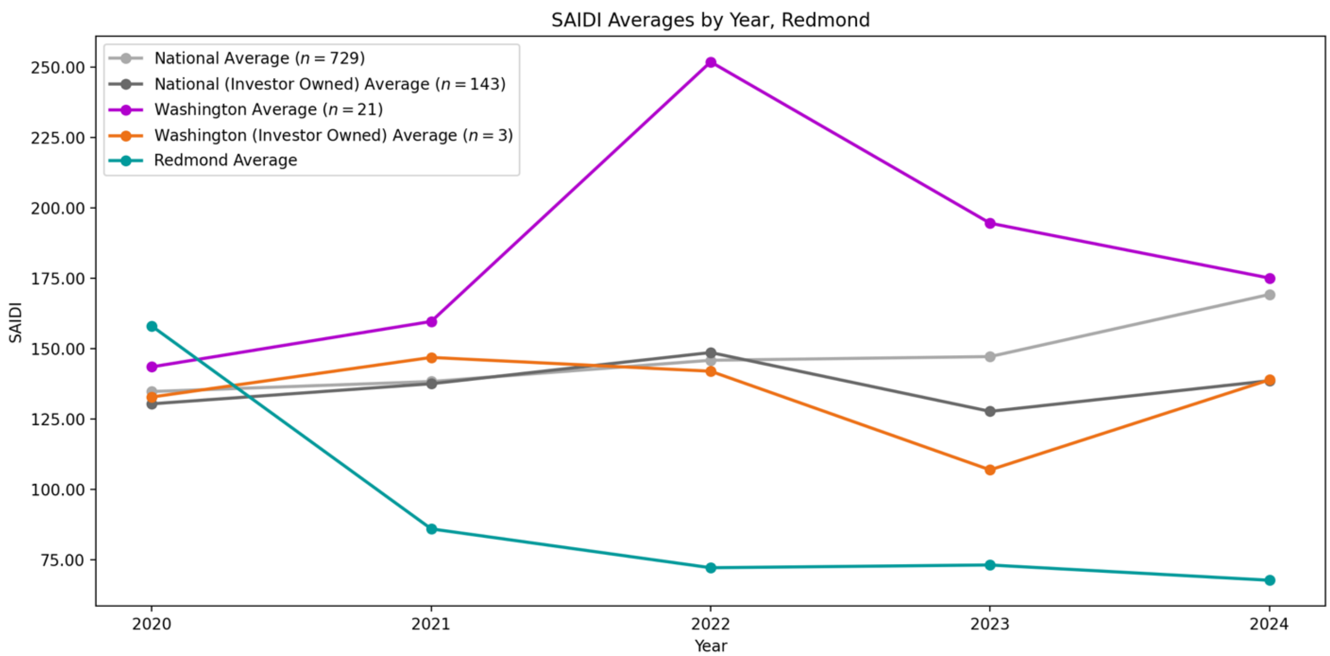


Figure 33. City of Redmond SAIDI Averages by Year

When analyzing the causes of the study, equipment failure constitutes approximately 40% of all outages from 2020 – 2024, with impacts from trees, causing an additional 23% of outages. In terms of duration, impacts from trees constituted one of the highest average durations at 21 hours. Additional information is included in **Appendix A**.

Generally speaking, areas with higher concentrations of circuits that could be cause for further review are located in the north and east of the city and in the northwest of the city as shown in **Figure 34** (the Totem Lake and Ardmore Substations).

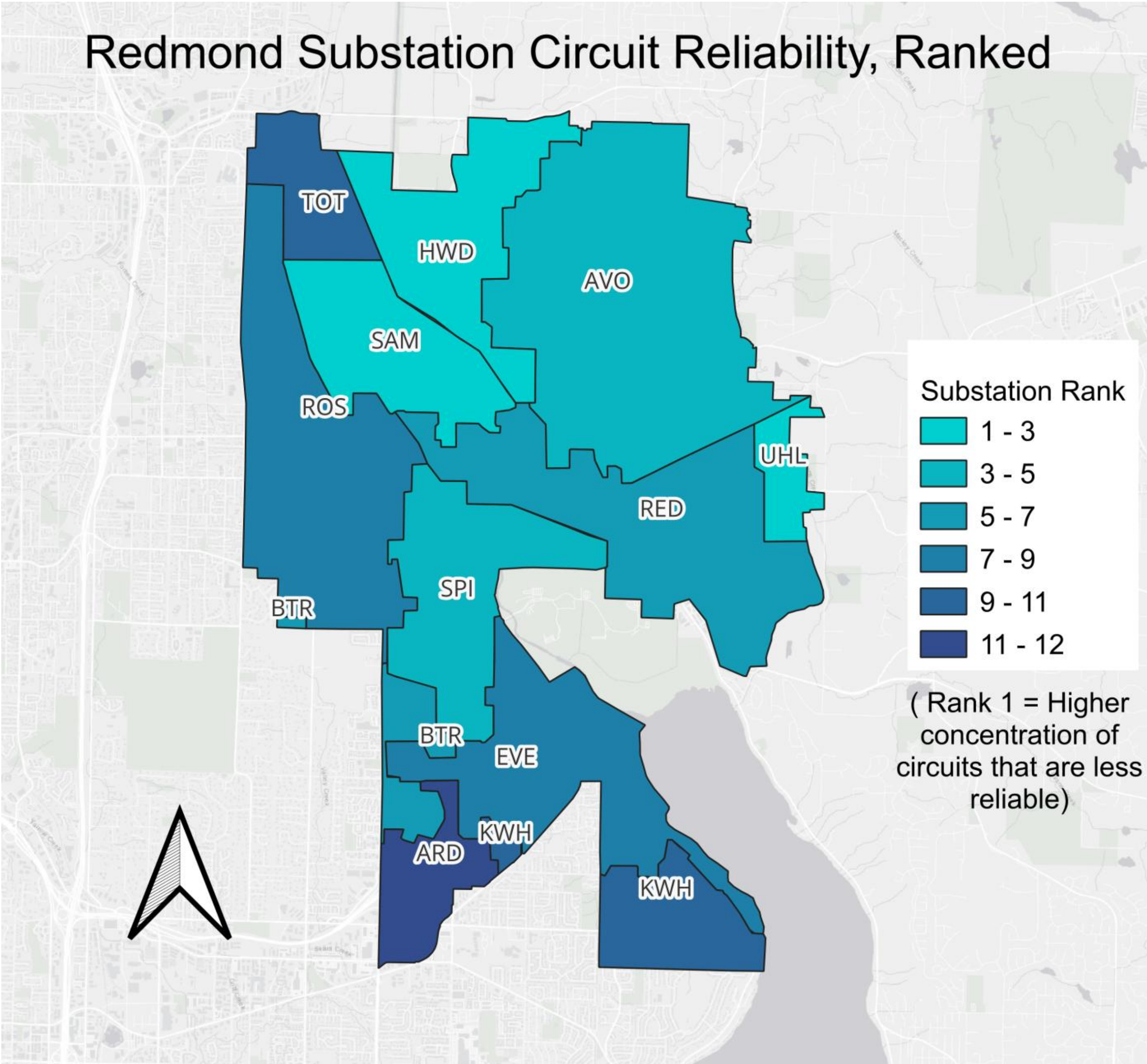


Figure 34. City of Redmond Substation Circuit Reliability[20]

[20] Includes outages from storms

Section 4. Recommendations for Responding to Evolving Growth

This study combines technical grid capacity analysis with insights gathered through a series of collaborative engagement workshops between the Partner Cities and PSE. Together, these efforts provide both a quantitative assessment of future grid conditions and a qualitative perspective on the planning, coordination, and implementation challenges associated with rapid growth and electrification.

The engagement component of the project was designed to strengthen coordination and shared understanding among participants. The engagement workshop objectives included developing a common view of regional economic growth and electrification goals, such as expanded building electrification, increased EV adoption, and the transition to 100% renewable energy by 2045, establishing alignment on how electric demand is forecasted and planned for, and clarifying roles and responsibilities related to demand forecasting and long-term grid planning.

Strengthening the relationship and partnership between the Partner Cities and PSE will allow for more informed grid infrastructure investment and planning efforts to avoid gaps in future grid capacity needs. This collaboration will lead to more timely investments, better electrification progress, and climate mitigation outcomes. The workshops and relationship building efforts resulted in various recommendations and action items for the Partner Cities and PSE to consider moving forward.

Key Engagement Takeaways

The following takeaways were highlighted as key points throughout the workshop series:

- **Shared recognition of transition challenges and opportunities**: Participants agreed that electrification and decarbonization offer major benefits but require significant infrastructure investment, careful management of costs, and attention to equity, permitting, and public perception.
- **Electrification and EV adoption are major demand drivers**: Both the Partner Cities and PSE recognize the value of sharing data on building trends, such as the underlying data behind forecasted residential and commercial units by the Partner Cities, the prevalence of electric space heating, water heating, and cooling by PSE, as well as EV uptake. Establishing a shared understanding of this data and a structured approach for exchanging this information would enable all parties to better anticipate local capacity needs and plan for future load growth.
- **Earlier coordination and shared engagement are critical in the future planning cycles:** the workshops highlighted the need for earlier data sharing, improved visibility into system constraints, and coordinated public messaging to support infrastructure investments and explain energy transition tradeoffs to the community. The varied forecast cycles highlight the opportunity for continuous coordination to ensure that forecasting updates reflect the most current development activity. Establishing recurring touchpoints such as semiannual or quarterly alignment meetings, developing a structured approach for alignment between the Partner Cities Comprehensive Plans and PSE's infrastructure planning processes, and streamlining the permitting processes for timely execution of grid projects will help to improve planning and implementation coordination.
- **Work Group Collaboration:** improving communication between similar work groups and roles at the Partner Cities and PSE will help to enable more accurate and timely information exchange and planning cycles. The groups can also utilize shared platforms for data exchange to enhance visibility.

Building on this foundation, the following recommendations are intended to help the Partner Cities and PSE translate study findings into actionable steps.

Coordinated Planning

Coordinated, forward-looking planning is essential to navigating changing conditions, markets, and policies. As projections for growth and electrification continue to shift over time, the Partner Cities and PSE must remain nimble by creating structures and channels that support continuous communication.

Strengthen Data Sharing and Transparency to Improve Forecasting Confidence

Improve data sharing and transparency among Partner Cities and PSE to increase confidence in forecasting.

Actions: PSE and the Partner Cities should continue to work collaboratively to establish consistent, transparent, and timely data practices that strengthen shared understanding of load growth, electrification trends and system impacts. This collaboration includes maintaining regular coordination among subject-matter experts to align assumptions, interpret emerging data, and communicate findings with a unified voice. Together, both parties should maintain a common data dictionary, routinely review and update shared assumptions, and implement clear processes for disseminating new data or forecast changes so planning decisions remain aligned, credible, and responsive to evolving conditions.

PSE should leverage recurring communication forums to validate growth and electrification forecasts against local development activity, evolving electrification adoption trends, infrastructure constraints, and interconnection timelines, ensuring projections reflect real-time conditions at both the system and substation levels The Partner Cities should provide up-to-date parcel-level, permit, and land-use data that reflects real-world conditions, including new development, redevelopment, changes in building use, and electrification retrofits. This data should be maintained with regular updates and sufficient granularity and confidence to support credible forecasting, enable validation of growth and electrification assumptions, and ensure alignment between local development activity and utility system planning.

Share Information on Large Customer and Block Loads

Align on large customer and block loads expected to emerge.

Actions: Identify potential future large loads, such as technology centers, major institutional facilities, and industrial developments. As these loads are unique and not typically reflected in historical growth trends or regional forecast averages. Early identification can help assess immediate capacity needs, identify potential grid constraints, and inform timely infrastructure investments. It is recommended that the Partner Cities and PSE share information on large load and permit applications, development confidence factors, and geospatial zoning layers to align on these expected loads.

Harmonize Forecasting Horizons

Align forecasting time horizons to the extent possible to ensure short, mid, and long-term projections support coordinated planning and investment decisions.

Actions: Clearly define forecast durations, update cycles, and key milestones so near-term development activity and long-range growth and electrification trajectories are consistently reflected across parties. It is understood that planning differences between PSE and the Partner Cities are intentional and role-based to reflect each party's distinct responsibilities, and that utility load forecasts focus on high-certainty inputs and risk avoidance while city growth projections emphasize long-term vision and policy objectives. Regular checkpoints should be used to reconcile differences between planning assumptions, refresh forecasts as conditions change, and document how updates cascade across planning processes to maintain consistency and transparency among all parties. Consider using joint localized forecasts to establish shared targets with the Cities to focus on specific substations for DER and NEM growth. All parties could benefit from utilizing a recurring engagement cycle on shared platforms to provide better insights into forecasting and planning efforts across multiple departments or work groups. The Partner Cities should continue coordinating with PSE to better understand PSE's forecasting processes and both recurring and irregular project timelines to help align their actions.

Promote Regulatory Responsiveness

Collaborate with state and local regulators to better align regulatory frameworks around shared objectives,

Actions: PSE and the Partner Cities should jointly explore opportunities to improve alignment between state regulatory frameworks that govern electric infrastructure planning and development. While both parties are operating appropriately within their respective statutory authorities under Washington state law, differing planning horizons, approval timelines, and project review processes can create friction and uncertainty that complicate timely infrastructure delivery. PSE and the Partner Cities should engage in a coordinated review of how utility planning requirements and local land use and permitting regulations interact in practice, with the goal of identifying opportunities to improve coordination, sequencing, and regulatory clarity. This effort could include joint engagement with state agencies, peer jurisdictions, and policy makers to share lessons learned and to advocate for regulatory approaches that better support coordinated long-term planning, predictable project delivery, and shared climate and growth objectives, without diminishing appropriate local or utility oversight.

Address Permitting Processes

Understanding permitting requirements supports timely grid investments by reducing uncertainty, accelerating infrastructure delivery, and aligning local approvals with utility planning and capital deployment schedules.

Actions: PSE and the Partner Cities should work together to address permitting processes by clarifying requirements, standardizing documentation, and improving coordination across agencies involved in review and approval. Establishing clear timelines, predictable review milestones, and early coordination on complex infrastructure projects, such as substation upgrades will reduce delays and uncertainty. Agree on permitting readiness standards and application packages, standardized drawings, and consistent technical documentation, to reduce review cycles and rework. PSE should identify grid investment projects most impacted by permitting timelines (e.g., substations, feeders, and major system upgrades) and proactively flag them for early coordination with Partner Cities. Engage Partner Cities early in project scoping for grid investments to surface local permitting requirements, environmental considerations, and community constraints before formal submittal. The Partner Cities should identify opportunities to streamline and standardize permitting requirements for grid infrastructure projects, including consistent application materials, review criteria, and approval pathways across departments. Establish clear permitting timelines, checkpoints, and escalation paths for utility projects to improve predictability and reduce delays for critical grid investments. Engage early with PSE during project scoping to identify local land-use, environmental, transportation, or community considerations that could affect permitting or construction schedules. Share anticipated policy changes, zoning updates, or community priorities that could affect future grid investments, enabling PSE to account for permitting risks in project planning.

Enhance Demand-Side Management and Distributed Generation Technologies

Programs should promote off-peak EV charging and heat pump usage and support increased deployment of distributed generation, including solar, to reduce peak demand and system strain.

> **Heat pump modulation** is the process of pre-heating or pre-cooling a building during off-peak hours so that the building is comfortable when occupants enter.

Actions: Improve promotion of these programs and coordination on utility tariffs so new multi-dwelling units and workplaces enable coordinated load-shifting. Incentivize heat pump modulation to reduce grid stress while maintaining consistent indoor comfort. PSE should continue to bolster and expand demand-side management programs. Time-varying rate (TVR) designs can be very effective – PSE's TVR pilot saw 94% of enrolled participants take action to reduce energy usage during the winter season on-peak periods during its first year.[21] Increase programs and incentives for the adoption of solar and other distributed generation technologies to help make them more accessible. The Partner Cities should promote and incentivize EV-ready and managed-charging-ready building codes that make managed charging the default for new development. This approach includes requiring controllable EV supply equipment in new multi-unit residential, office, and retail buildings, with open and interoperable standards that enable future utility demand-response and grid management programs.

Communicate Value to Residents

Leverage existing communication channels to better "Explain the Why" and the value projects and programs bring to all residents.

Actions: Focus on joint and shared messaging between all parties to the local residents of the Partner Cities, whether it is on upcoming grid projects, investment in emerging technologies, or programs to shift resident energy use and EV charging. Communications should translate technical investments into tangible community benefits, such as improved reliability, cost control, and local economic growth. By clearly explaining how grid planning supports long-term growth and sustainability, the Cities and PSE can strengthen trust in the electric system's ability to accommodate future demand. This clarity can help developers move forward with new projects and encourage building owners to invest in electrification with greater confidence. In addition, outreach should highlight the role residents and businesses play as active partners in demand-side management. Communicating the value of participation in programs such as managed charging, energy efficiency, and flexible load initiatives can foster shared responsibility for managing growth while maintaining affordability and reliability.

Technical Recommendations

The following technical recommendations build directly on the grid capacity analysis and support industry best practices to address identified capacity risks, data gaps, and areas of uncertainty. These recommendations are intended to strengthen the technical foundation of local grid planning by improving forecasting alignment, increasing analytical resolution, and integrating both traditional infrastructure investments and emerging grid technologies. Additional discussion of emerging grid technologies is provided in **Appendix C**.

[21] Renewable Energy World. A look inside Puget Sound Energy's time-varying rates pilot program. https://www.renewableenergyworld.com/power-grid/smart-grids/a-look-inside-puget-sound-energys-time-varying-rates-pilot-program/

Advance to Substation- and Feeder-Level Power Flow Analysis for Priority Areas

Build on the substation-level capacity assessment by conducting more granular power flow studies for the four to six substations identified as having the highest projected capacity risk. Feeder-level and circuit-level analysis would improve visibility into localized constraints, seasonal peaking behavior, and contingency conditions, enabling more precise identification of where capacity upgrades, operational changes, or non-wires alternatives may be effective.

Incorporate Sensitivity Scenarios into Ongoing Grid Planning

Continue to use high- and low-growth sensitivity scenarios to test the resilience of grid plans under varying population, electrification, and economic growth outcomes. Embedding scenario analysis into regular planning processes can help identify thresholds where infrastructure investments become necessary and support more flexible, adaptive investment strategies over time.

Extend Planning Horizons for Local Capacity Assessments

While near-term planning remains essential, extending local grid studies beyond the standard ten-year horizon can help identify longer-term capacity risks driven by electrification and redevelopment. Additionally, use local trends for forecasting local power usage as different areas may have different electrification efforts that can significantly impact some of the substations. This forward-looking perspective supports more proactive investment decisions and aligns infrastructure planning with comprehensive land-use and climate goals.

Enhance Grid Resilience for Climate and Electrification Stressors

Electrification increases dependency on electric systems in parallel with climate risks intensifying, increasing the need for climate-driven risk planning. It will be important to continue equipment rehabilitation and vegetation management on worst performing circuits in the Partner Cities (equipment & trees drive 35–75% of outage duration), especially where utilization is rising. Current and emerging technologies such as AI-enabled forecasting, automation, and real-time controls can help utilities manage power flows more effectively and identify potential system constraints before they lead to outages. Machine learning tools can improve storm impact forecasting and restoration efforts. As decarbonization shifts electricity supply away from fossil fuels toward more variable renewable resources, technologies such as advanced inverters, battery storage, and microgrids can play an important role in maintaining grid stability and resilience.

Roles and Responsibilities

The increased collaboration and communication throughout the workshop series underscored the importance of maintaining ongoing coordination beyond the scope of this study. Participants identified a need for continued touchpoints aligned with regular planning and forecasting cycles to support consistent information sharing and joint decision-making.

Through the engagement process, both the Partner Cities and PSE identified relevant roles, working groups, and functional teams on each side that can serve as points of coordination going forward. Establishing clear roles and responsibilities for these groups can help institutionalize collaboration on activities such as demand forecasting, grid planning, data sharing, and infrastructure implementation, ensuring alignment as electrification and growth continue.

The work groups will bring together subject matter experts (SME) with similar roles between the parties to allow for SME-to-SME coordination. Key work groups include Planning and Load Forecasting, Community Development, Intergovernmental Relations and Public Policy, Permitting Tracking, and Capital Planning, among others, and key roles within these groups will include analytical personnel, data providers, data reviewers, and communications leads. This SME-to-SME collaboration will enable direct technical engagement between SMEs across organizations, fostering faster issue resolution, clearer data interpretation, and more consistent, well-aligned joint planning and forecasting efforts.

Section 5. Conclusion

As Bellevue and Redmond prepare for continued growth and rapid electrification, this Grid Capacity Study highlights the importance of proactive and coordinated planning to maintain a reliable, resilient, and affordable electric system. By aligning long-range land use and climate goals with utility planning, and by developing balanced electrification scenarios, the Partner Cities and PSE can better manage rising electricity demand and reduce the risk of infrastructure delivery delays. Strengthened collaboration, extended forecasting horizons, and a unified approach to grid investments can position the region to meet its decarbonization commitments while supporting equitable and sustainable community development in the decades ahead.

Near-Term Priorities and Considerations for Future Exploration

Work with PSE to Analyze Detailed Power Flow Studies for Priority Substations: For the four to six substations with the most significant projected capacity constraints, the Partner Cities and PSE should pursue more detailed, substation- and feeder-level power flow studies. These studies should evaluate localized loading conditions, circuit configurations, and seasonal peak behavior to more precisely identify where and when constraints may occur. Results from these detailed power flow analyses should inform a refined upgrade roadmap by clarifying which constraints can be managed through operational or lower-cost solutions, such as feeder reconfiguration, load transfers, or targeted DERs, versus those that require capital investments at the substation level.

Streamline Permitting Through City–Utility Coordination: Establish a joint City–Utility working group focused on streamlining permitting for grid infrastructure projects. This group would review existing permitting requirements to identify outdated or duplicative measures and evaluate opportunities to shorten review and approval timelines without compromising safety or oversight. Regular coordination through this working group can help clarify roles and expectations, standardize submittal requirements where feasible, and address permitting challenges early in project development.

Public Engagement and Joint Messaging: Develop coordinated community engagement and messaging strategies for public communications related to grid planning, electrification, and customer programs. Joint outreach can ensure consistent, clear messaging about upcoming infrastructure projects and available opportunities for residents and businesses to participate in energy efficiency, demand response, and electrification incentive programs.

Leverage DERs and managed load programs: Net-metered and energy storage resources already exist at many substations across the Partner Cities. A potential area for further exploration is how expanded and more targeted use of DERs and managed load programs, such as storage dispatch and managed EV charging could help reduce or shift peak demand at constrained substations and improve local system flexibility.

Climate Change Impacts: Climate change is expected to influence future electricity demand in the region, particularly through warmer summers and more frequent heat events that increase cooling needs. Over time, increased air-conditioning adoption and longer cooling seasons could alter load shapes, raise summer peak demand, and place additional stress on substations that are already constrained under summer operating conditions. Incorporate climate-informed demand scenarios into future planning to account for increased cooling needs, evaluate potential shifts in seasonal peak demand, and proactively identify substations and infrastructure that may require upgrades under warmer summer conditions.

Limitations of Study

The following limitations in our analysis must be acknowledged.

- **Limitations in projections:** Because we lack visibility into PSE's underlying load-growth assumptions, differences between the PSE and Partner Cities forecasts are difficult to attribute to specific factors such as electrification, building growth, or other drivers.
- **Limitations in existing building heating system data:** Broad assumptions were made about the percentage of existing buildings using fossil-fuel heating systems across commercial, single-family, and multifamily sectors. As future datasets improve, more localized and accurate assumptions about existing building electrification can be incorporated.
- **Limitations in the diversity of new commercial building load profiles:** Simplified assumptions were used when modeling commercial building load growth, based on a representative medium office building. Future work could incorporate a wider range of commercial building types to better understand how variations in building characteristics affect peak load and the timing of peak demand.

Appendix A. Resilience Assessment

PSE uses nationally recognized standards from the Institute of Electrical and Electronics Engineers to measure and track electric system reliability. Reliability is commonly described by how often power outages occur and how long they last. Utilities use two standard measures: SAIFI, which tracks outage frequency, and SAIDI, which tracks outage duration (see **Reliability Analysis** for detailed reliability results). Together, these metrics help show how quickly the electric system responds to outages and how vulnerable it is to disruptions. Most reliability measures focus on day-to-day system performance, excluding major storm events, to better reflect routine operations and restoration practices.

While there is no single universal definition of resilience, infrastructure resilience generally refers to the ability of systems to withstand disruptions, respond to hazards, and adapt or evolve over time to better handle future challenges.

This appendix begins with an overview of system reliability and then moves into a discussion of resilience by focusing not only on reliability as an aggregate across the cities but also disaggregated by circuit. It then examines the causes of reliability issues to extrapolate and begin to understand potential next steps to move more closely toward a resilience analysis. This appendix treats the City of Bellevue and the City of Redmond separately. The report then provides a joint set of recommendations for Bellevue and Redmond for moving more toward resilience, since the analysis identified similar opportunities for both cities to work with PSE on resilience.

Safe and Reliable Service

A system can be regularly reliable but not resilient, that is, it performs well on normal operating days but fails during severe events. A resilient grid can improve reliability by enhancing restoration times, lowering the risk of supply shortages during extreme weather, and improving planning for extreme conditions. A resilient grid also directly influences public safety by keeping emergency services operating and reducing safety hazards during outages.

Photo Credit: PSE

Technical Approach

Information on SAIDI, SAIFI, and the causes of circuit-level disruptions across the five years was provided by PSE. Bellevue’s data was provided through the annual reliability reports prepared for the city by PSE, and the data for Redmond was provided directly by PSE. These results were examined on a year-by-year basis and on a five-year average from 2020 to 2024.

To highlight circuits with higher-than-average identified reliability issues, the study derived a series of averages from the U.S. Energy Information Administration (EIA-861) data as a baseline for comparison. The EIA maintains one of the most comprehensive records of reliability metrics in the U.S., which the study used to develop a series of averages to evaluate circuit performance.

Given that PSE is an investor-owned utility (IOU), we developed a set of averages to use as thresholds to test circuits with potentially higher reliability issues, either from duration or frequency of outages. These include a national average, a national average focused specifically on IOUs, a Washington average, a Washington IOU average, and, in addition to these averages, PSE’s own Service Quality Index (SQI). SQI is the only threshold that was not averaged, as it represents the floor PSE sets for unacceptable performance under either steady-state or SAIFI conditions. These circuits are highlighted only at the circuit level and not by individual customers impacted, as outlined in **Section 3** of the study. This study was unable to determine which types of customers (commercial, industrial, residential, etc.) are on each circuit.

City of Bellevue Results

Bellevue's distribution system generally performs well compared to average reliability levels, but a small subset of circuits shows noticeably higher SAIDI and SAIFI values. This section highlights those circuits, examines their causes, and identifies opportunities for targeted improvements and coordination between PSE and the city.

Reliability Overview

Despite the generally positive performance from PSE's local circuits compared to average reliability (see **Section 3**), circuit-level data from this period reveal several circuits that have significantly higher SAIDI and SAIFI levels than average. PSE has made Bellevue aware of these and other circuits in its reliability reports on a year-to-year basis; however, this analysis combines results across this period to begin to understand which circuits may be causing recurrent problems or which have deviated sufficiently from mean averages in a single year or over two years such that they exceed acceptable levels. **Figure A-1** and **Figure A-2** highlight the circuits that have exceeded average thresholds for SAIDI and SAIFI, applied independently.

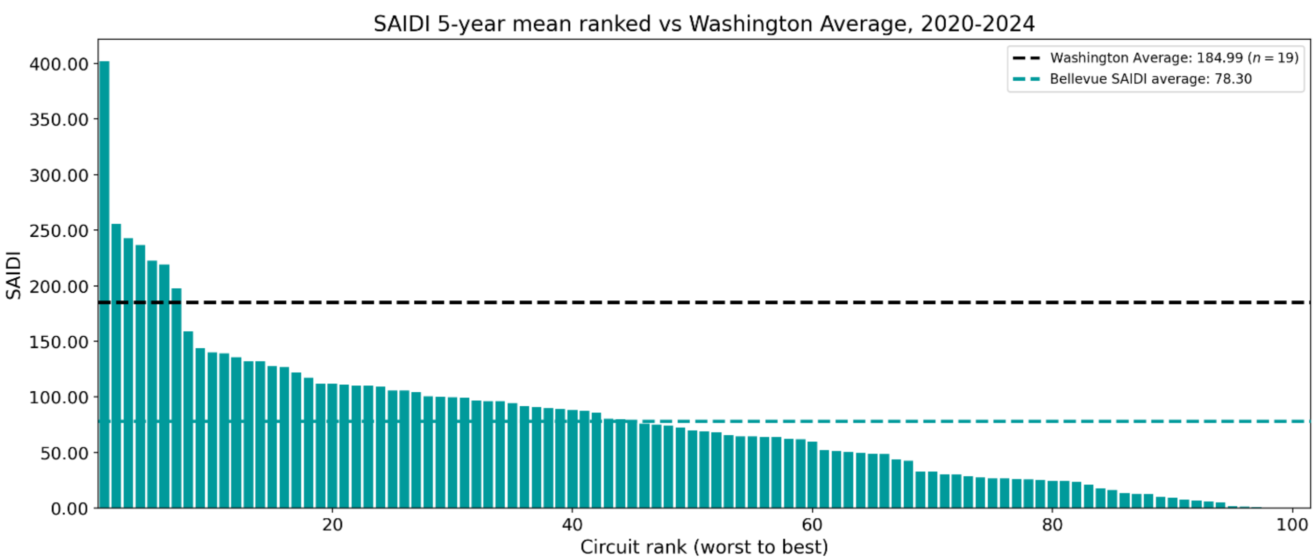


Figure A-1 City of Bellevue SAIDI vs. State Average

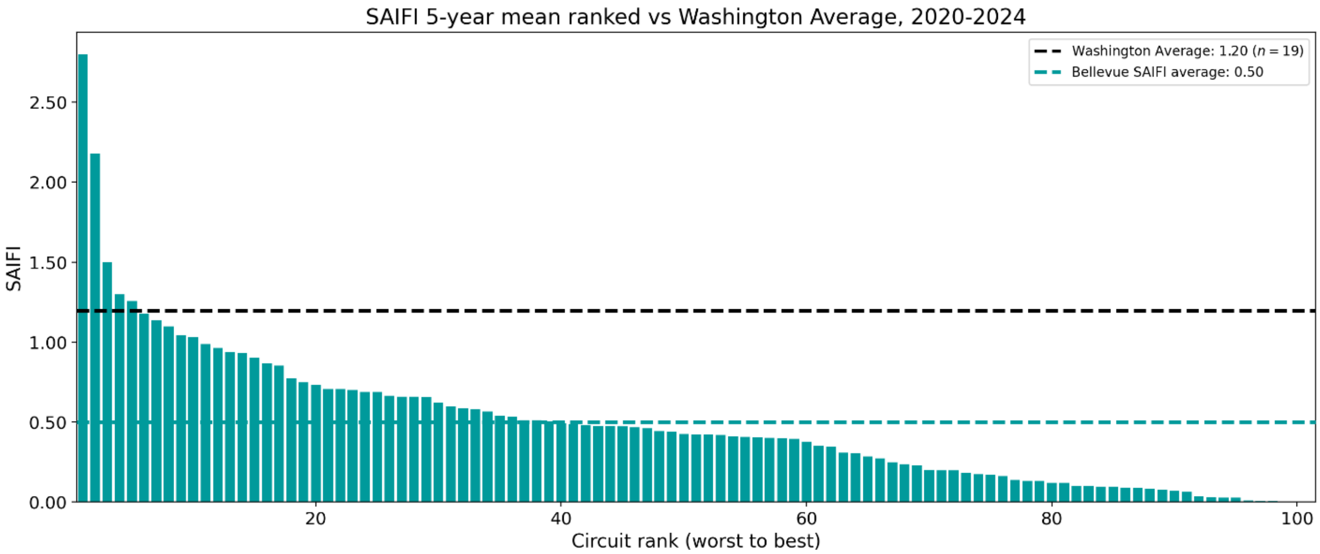


Figure A-2. City of Bellevue SAIFI vs. State Average

The study also analyzed the circuit-level data by determining whether circuits exceeded both SAIFI and SAIDI thresholds for all five years and for each individual year in **Figure A-3** and **Figure A-4**. Only four circuits had averages that exceeded the Washington thresholds across all five years. An additional four circuits exceeded the national IOU and Washington IOU SAIDI and SAIFI thresholds, which are included in **Table A-1**. These circuits exceeded these thresholds because the national IOU and Washington IOU thresholds are lower than the other thresholds for SAIDI and SAIFI. This finding does not necessarily mean that each year these circuits had averages worse than the average Washington thresholds, but that in aggregate, each of these circuits exceeded the thresholds when averaged. A year-by-year analysis complements a five-year average by showing that different circuits occasionally appear across different years to exceed both thresholds, with SOM-16 being the most frequent among the outliers, appearing across almost every year surveyed. For Bellevue, 2023 seems to have had the largest number of circuits that exceeded both Washington SAIFI and SAIDI thresholds, at nine different circuits exceeding the threshold.

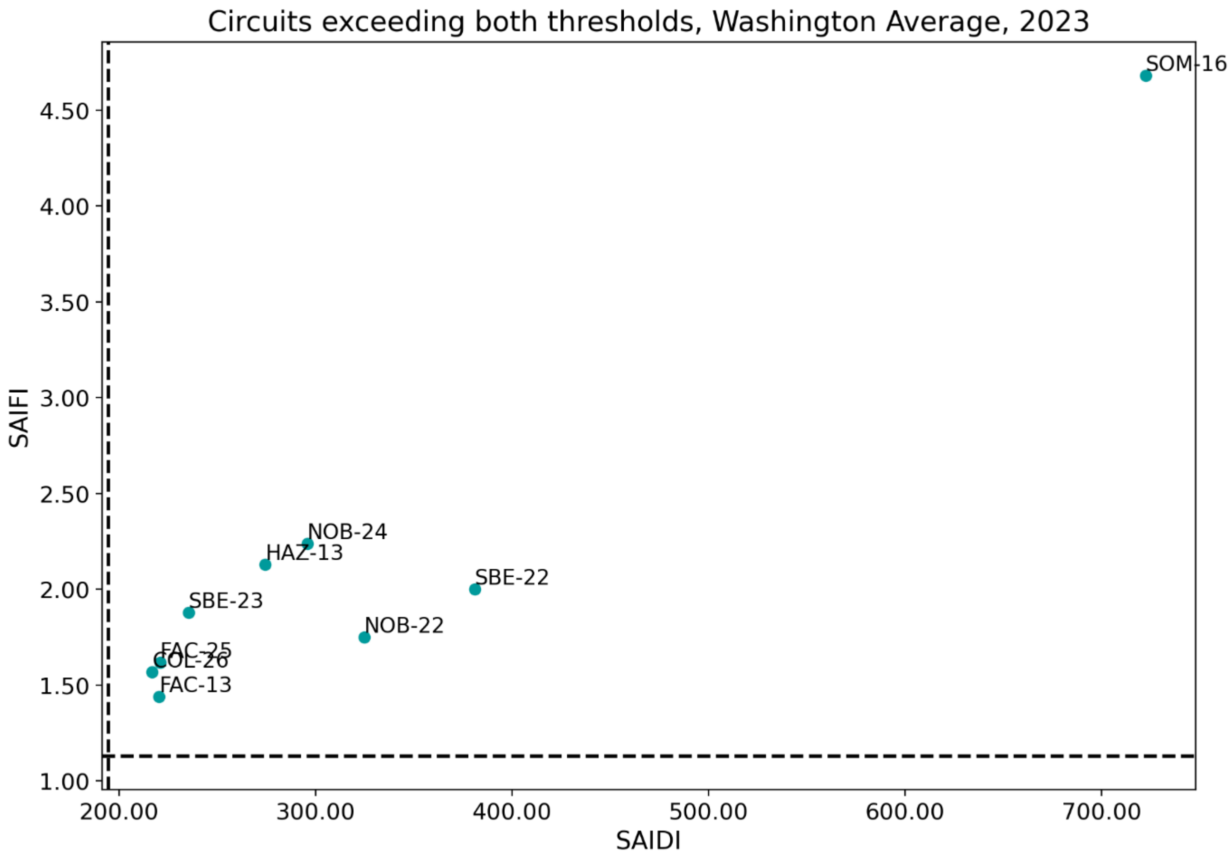


Figure A-3. City of Bellevue Circuits Exceeding Thresholds (2023)

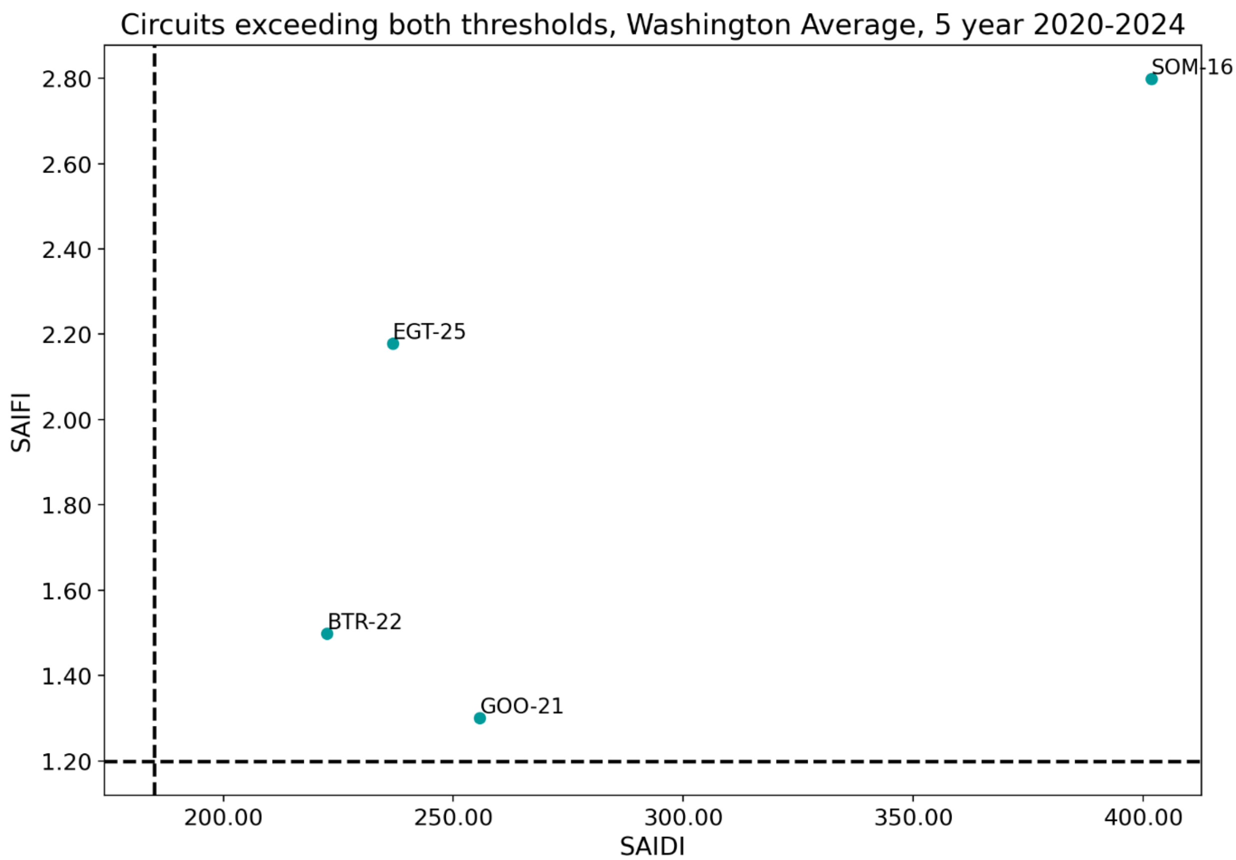


Figure A-4. City of Bellevue Circuits Exceeding Thresholds (2020 – 2024)

Causes of Disruptions Analysis

This section seeks to provide a high-level overview to examine the circuits that exceeded at least one threshold across all five years and to assess the risk exposure of these circuits. Where possible, we also added investments that PSE made in physical infrastructure, which may have helped remediate some of these issues. Additionally, looking at the causes in **Table A-1**, particularly in terms of frequency, the percentage breakdown, and in terms of average hours, helps better understand potential operational improvements that could be made. Returning to the proxy analysis outlined in the overview, a result that indicates that a component or cause is lower in frequency but higher in duration may suggest opportunities for operational synergies that the city authorities and PSE could begin to address jointly. Note that the category labelled “other” does not indicate that the cause was unknown; rather, it reflects causes that are relatively small in terms of frequency.

Table A-1. City of Bellevue Causes of Disruptions by Circuit

Circuit	Thresholds exceeded	Average SAIDI	Average SAIFI	Cause	Percentage Cause	Average Duration (Hours)
SOM-16	National, National (IOU), PSE SQI, Washington, Washington (IOU)	401.792	2.798	Equipment Failure	41	5
				Tree	25	16
				Scheduled Outage	13	3
				Bird Or Animal	11	2
				Other	11	4
EGT-25	National, National (IOU), PSE SQI, Washington, Washington (IOU)	236.852	2.178	Tree	46	16
				Equipment Failure	26	5
				Scheduled Outage	11	3
				Bird Or Animal	7	1
				Other	10	2
GOO-21	National, National (IOU), PSE SQI, Washington, Washington (IOU)	255.76	1.3	Tree	44	24
				Equipment Failure	26	7
				Scheduled Outage	10	2
				Bird Or Animal	10	4
				Other	10	2
BTR-22	National, National (IOU), PSE SQI, Washington, Washington (IOU)	222.556	1.498	Tree	54	22
				Equipment Failure	21	5
				Scheduled Outage	8	5
				Bird Or Animal	7	2
				Other	10	6
BTR-21	National (IOU), Washington (IOU)	242.566	1.178	Equipment Failure	42	5
				Tree	20	26
				Unknown Cause	16	4
				Dig Up Underground	7	4
				Scheduled Outage	7	2
				Other	9	4
NRU-27	Washington (IOU)	219.204	1.098	Equipment Failure	42	7
				Scheduled Outage	38	4
				Tree	10	3
				Other	10	8
EGT-15	Washington (IOU)	139.164	1.034	Tree	66	16
				Equipment Failure	17	17
				Scheduled Outage	11	2
				Other	6	4
HAZ-12	Washington (IOU)	140.316	0.964	Equipment Failure	47	5
				Tree	25	26
				Scheduled Outage	12	2
				Other	16	2

Table A-1 illustrates that the dominant causes of higher unreliability circuit performance are equipment failure and tree-related remediation issues, which constitute approximately 60% – 85% of all disruptions across all circuits. Of these circuits, only SOM-16 has had publicly disclosed investments as part of the reliability strategy, with underground cables and equipment replaced in 2020, an overhead splice and PM switch replaced in 2023, and a failed overhead insulator replaced in 2024. Targeted investments in equipment rehabilitation and vegetation management on the lowest-performing circuits may offer opportunities to improve reliability, particularly where forecasted load on these circuits is expected to increase. Outages caused by trees, vegetation, and similar hazards are relatively common on distribution systems, especially during events involving heavy precipitation, high winds, and other severe weather conditions. In addition, outages related to birds and animals, while typically smaller in scale, present an opportunity for improved coordination between the Cities and PSE to strengthen preventive measures and response protocols.

Table A-2 provides a more comprehensive view across all of Bellevue's circuits and shows a distribution of outage causes by frequency. This data suggests that the circuits experiencing higher impacts are not distinguished by unique outage drivers, but rather by how frequently those drivers occur on the affected circuits.

Table A-2. City of Bellevue Cause of Disruption Summary

Cause Description	Frequency (2020 – 2024)	Percentage of Failures	Average Customers Affected	Maximum Customers Affected	Average Duration (Hours)	Maximum Duration (Hours)
Equipment failure	1827	43%	64	3,474	5	116
Tree (right of way unknown)	997	24%	295	4,214	18	165
Scheduled outage	691	16%	22	1,022	6	523
Bird or animal	328	8%	26	591	2	10
Unknown cause	114	3%	176	2,566	4	18
Dig up underground	76	2%	103	2,854	4	23
Car/ equipment accident	50	1%	157	2,286	7	77

*Only causes with ≥ 50 frequency are included in this chart

Although not included in **Table A-2** due to the limited number of incidents - nine occurrences between 2020 and 2024, natural disaster events had a relatively large impact when they did occur. On average, these events affected nearly 420 customers per incident, with a maximum impact of more than 1,700 customers. The average outage duration associated with natural hazard events was nearly 35 hours, and in some cases exceeded 116 hours. This pattern, particularly with respect to extended outage durations, indicates a potential opportunity for increased coordination between city authorities and the utility to improve preparedness and response for high-impact, low-frequency events.

City of Redmond Results

Redmond shows reliability results that are largely similar to those observed in Bellevue, which is unsurprising given the cities' proximity and the fact that they are served by the same IOU. However, there are modest differences in how outages are distributed across individual circuits.

Reliability Overview

Despite the generally positive performance from PSE's local circuits compared to average reliability (see **Section 3**), the circuit-level data for Redmond show several circuits with significantly higher SAIDI and SAIFI levels than average. This analysis combines results across the entire period to begin identifying which circuits may be causing recurrent problems, or which have deviated far enough from mean averages in a single year or across two years that they exceed acceptable levels. **Figure A-5** and **Figure A-6** highlight the circuits that exceeded average thresholds for SAIDI and SAIFI independently. These figures visually underscore that higher levels of concern are concentrated within a relatively small subset of circuits, which PSE has begun to address, as outlined in its reliability reports to the city.

When compared to Bellevue, the circuit performance in Redmond is relatively the same, particularly when examining SAIFI values, but it differs somewhat when examining SAIDI values. It is also important to note that a direct comparison should be cautioned without more robust statistical analysis, since the number of circuits and other factors differ. With that said, several of the SAIDI values in Redmond are more pronounced at the upper end for circuits with higher unreliability issues compared to Bellevue.

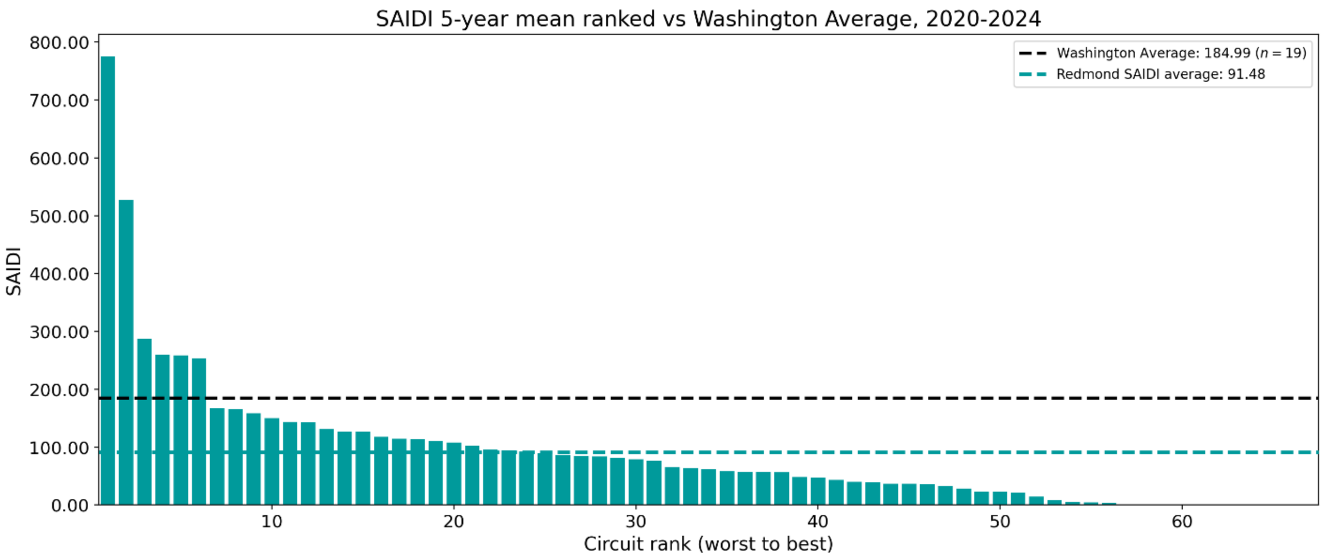


Figure A-5. City of Redmond SAIDI vs. State Average

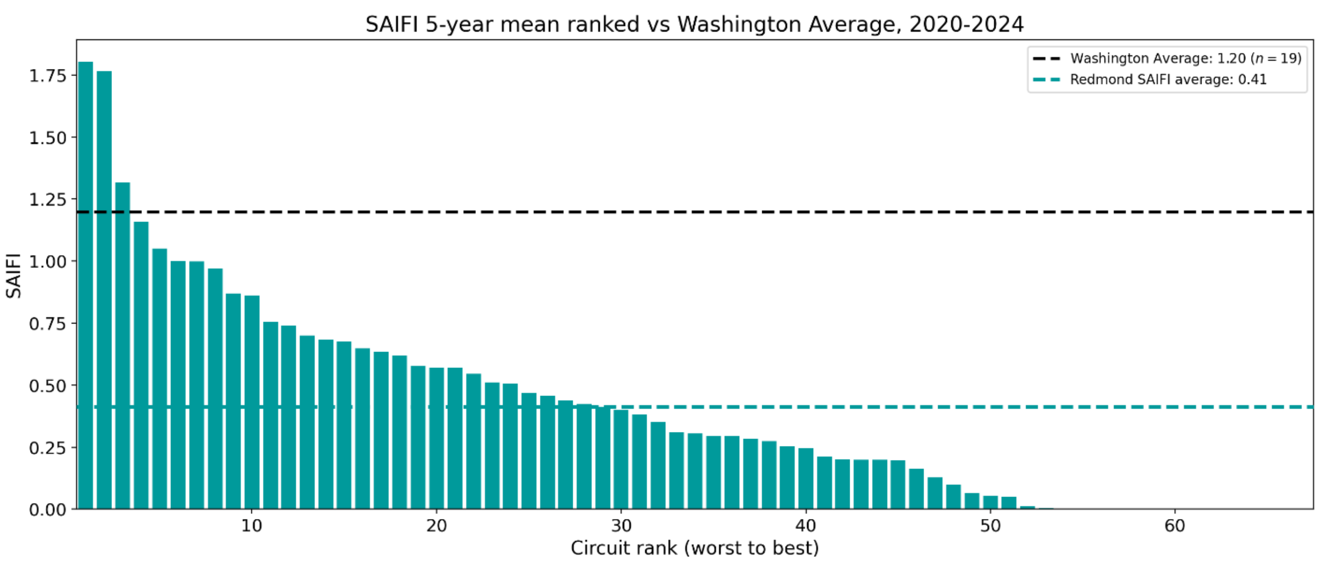


Figure A-6. City of Redmond SAIFI vs. State Average

The study also analyzed the circuit-level data by determining whether circuits exceeded both SAIFI and SAIDI thresholds for all five years and for each year in **Figure A-7** and **Figure A-8**. Only three circuits had averages that exceeded the Washington thresholds across the full five-year period. Two more circuits exceeded the national IOU and Washington IOU SAIDI and SAIFI thresholds, which are included in **Table A-3.** These circuits exceed those thresholds because the national and Washington IOU thresholds are lower than the other thresholds for SAIDI and SAIFI.

Appearing in the five-year average does not necessarily mean that each year these circuits performed worse than the average Washington thresholds, but that in aggregate their averages exceeded the thresholds. This finding is particularly the true for SAIDI, where a small fraction of the circuits had large enough SAIDI values in a single year or two to exceed the average across the five-year period A year-by-year analysis complements the five-year average by showing that different circuits appear in different years exceeding both thresholds, with some circuits recurring more frequently than others.

Six circuits exceeded the Washington average in 2020, with 12 in 2021 (the highest year between 2020 and 2024) followed by four in 2022, four in 2023, and three in 2024. The distribution of the 2021 data in **Figure A-7** differ slightly from Bellevue's circuits, which generally had higher SAIFI and SAIDI values in most years, meaning a stronger concentration along a more diagonal-looking line between SAIFI and SAIDI. In Redmond's case, the results are more spread out, suggesting that higher SAIFI and higher SAIDI are not as closely correlated in some years.

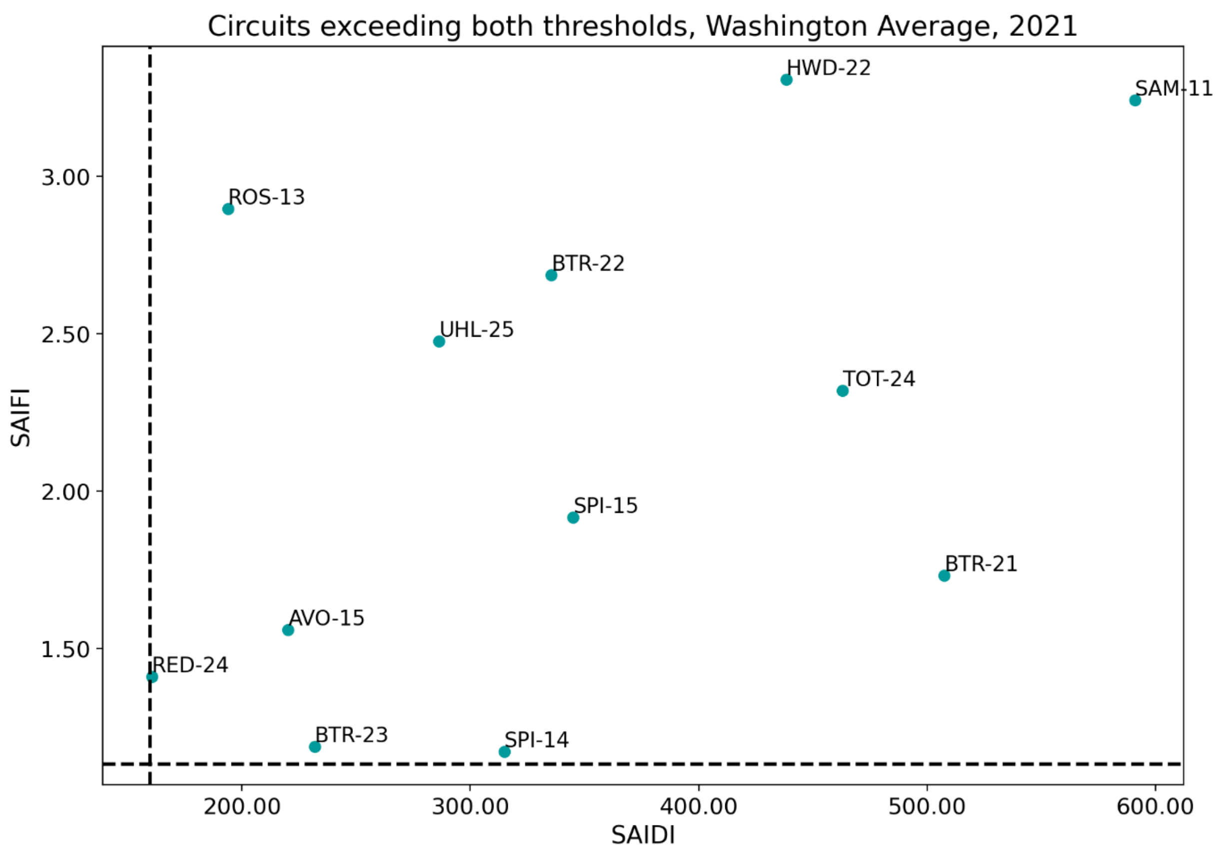


Figure A-7. City of Redmond Circuits Exceeding Thresholds (2021)

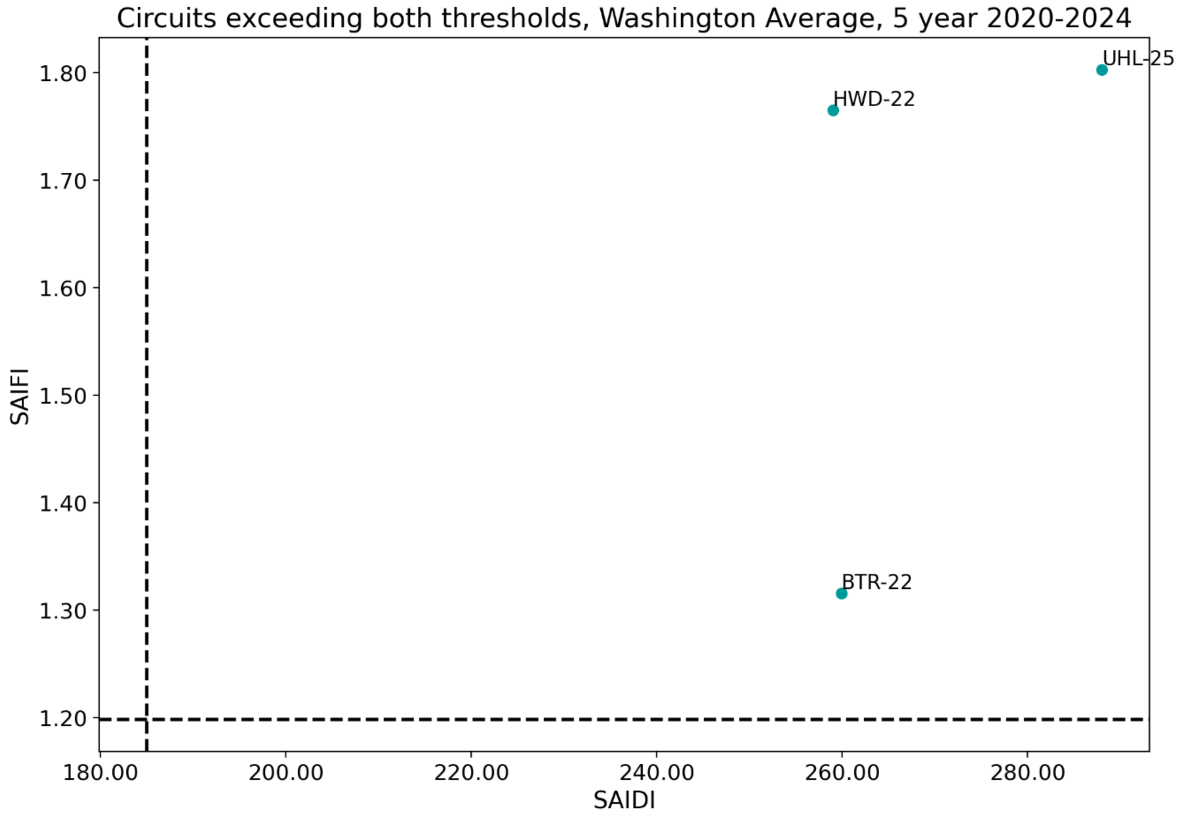


Figure A-8. City of Redmond Circuits Exceeding Thresholds (2020 – 2024)

Causes of Disruptions Analysis

This section provides a high-level overview of the circuits that exceeded at least one threshold across all five years and examines the risk exposure associated with these circuits. This section does not include any investments or reported investments in physical infrastructure because the data was not available at the time of the study. Examining looking at the causes—particularly their frequency, percentage breakdown, and average outage duration—can help identify operational improvements that could be made to response.

Please note that some of these circuits appear in Bellevue's analysis as well. This repetition is because several circuits overlap between the two areas. The average SAIDI, SAIFI, and causes differ slightly since the denominators and the specific households impacted, as well as the causes affecting them, differ across the two city areas. The category labeled "other" does not indicate an unknown cause but reflects causes that are relatively small in frequency.

For Redmond, the dominant causes of higher concern remain equipment failure and tree-related issues, constituting between 70 – 80% in most of the circuits in **Table A-3**. A focused emphasis on equipment rehabilitation and vegetation management for the worst-performing circuits may present opportunities for targeted remediation, particularly if forecasted load growth is expected on those circuits. Outages caused by trees, vegetation, and similar hazards are relatively common on distribution systems, especially during events involving heavy precipitation, high winds, and other severe weather conditions. In addition, outages related to birds and animals, while typically smaller in scale, present an opportunity for improved coordination between the Cities and PSE to strengthen preventive measures and response protocols. These targeted actions may be especially beneficial in preparing for lower-probability, higher-impact natural hazard events, as discussed further in **Opportunities to Strengthen Resilience through Partnership**.

Table A-3. City of Redmond Causes of Disruptions by Circuit

Circuit	Thresholds exceeded	Average SAIDI	Average SAIFI	Cause	Percentage Cause	Average Duration (Hours)
UHL-25	National, National (IOU), PSE SQI, Washington, Washington (IOU)	288.016	1.803	Tree	67	12
				Equipment Failure	14	4
				Bird Or Animal	7	3
				Scheduled Outage	5	1
				Other	7	9
HWD-22	National, National (IOU), PSE SQI, Washington, Washington (IOU)	259.005	1.765	Equipment Failure	41	5
				Tree	32	16
				Scheduled Outage	11	5
				Bird Or Animal	8	3
				Other	7	6
BTR-22	National, National (IOU), PSE SQI, Washington, Washington (IOU)	259.927	1.316	Tree	54	21
				Equipment Failure	21	5
				Scheduled Outage	8	5
				Bird Or Animal	7	2
				Other	10	6
BTR-21	National (IOU), Washington (IOU)	253.576	1.001	Equipment Failure	42	7
				Tree	20	27
				Unknown Cause	16	4
				Dig Up Underground	7	4
				Scheduled Outage	7	2
				Other	9	4
SAM-11	Washington (IOU)	168.031	1.050	Equipment Failure	38	3
				Tree	35	25
				Scheduled Outage	27	55

Table A-4 provides a broader view across all Redmond circuits and shows a similar pattern in the percentage breakdown of outage causes. This data suggests that circuits with higher overall impacts are not driven by unique causes, but rather by a higher frequency of common outage drivers. In most cases, individual circuits do not experience significantly longer outage durations compared to the broader Redmond distribution system. However, a small number of circuits stand out due to tree-related disruptions that resulted in unusually long outages during specific years.

Table A-4. City of Redmond Cause of Disruption Summary

Cause Description	Frequency (2020 – 2024)	Percentage of Failures	Average Customers Affected	Maximum Customers Affected	Average Duration (Hours)	Maximum Duration (Hours)
Equipment failure	861	40%	84	2,569	8	2,120
Tree (right of way unknown)	492	23%	278	4,059	21	165
Scheduled outage	402	19%	20	592	9	501
Bird or animal	211	10%	72	2,766	2	9
Unknown cause	53	2%	147	2,135	4	47

*Only causes with ≥ 50 frequency are included in this chart

Similar to Bellevue, and although it was not included in the table because it occurred only a limited number of times during 2020–2024, natural hazards affected a large number of customers in Redmond. On average, more than 9,000 customers were impacted per event, with maximum outages exceeding 62,000 customers. Average outage duration during natural hazard events is substantially higher than routine causes at 32 hours. This pattern suggests opportunities for strengthened engagement between city authorities and PSE, especially in terms of preparedness, coordination, and emergency response.

Opportunities to Strengthen Resilience through Partnership

Overall, both Redmond and Bellevue's results suggest that day-to-day reliability performance is significantly better than average, with only a few circuits acting as outliers. PSE has identified these circuits and begun to remediate them, as outlined in its Bellevue reliability reports. Moving from reliability to resilience highlights several areas that merit consideration for both cities. These can be organized into three categories: robustness (or grid hardening), response, and adaptation and transformation.

Robustness

PSE is making good progress on improved robustness by undergrounding a number of lines and addressing some of the higher-frequency outage circuits. For lower-probability, high-impact events, however, it may be useful for the city to work jointly with PSE to conduct additional simulations (for instance understanding the probability and system impacts of winter storms, seismic impacts, or other hazard events on distribution and transmission performance). This analysis could help both parties understand which hazards certain circuits are most susceptible to, based on the hazard classes most likely to affect Washington. If PSE also wants to consider very low-probability but high-impact events, such as tsunamis, it may be worth evaluating potential mitigation options for parts of the grid in Bellevue and Redmond.

Response

This study finds that coordinated response and recovery efforts present some of the most impactful short- and medium-term opportunities for strengthening grid resilience through collaboration between PSE and the Partner Cities. The reliability analysis indicates that outages related to trees, vegetation, and animal interference disproportionately contribute to longer outage durations, particularly during severe weather or natural hazard events. These findings highlight a clear opportunity for enhanced city–utility coordination focused on incident response. Many of these outages involve downed lines or damaged equipment that require prompt site control, inspection, and remediation. By leveraging municipal emergency response capabilities, such as traffic control, public safety coordination, access facilitation, and communications support, the Partner Cities can help PSE secure affected areas more quickly and safely. Strengthening joint response protocols for vegetation, especially during high-impact events, could help shorten restoration times, reduce customer impacts, and improve overall system resilience. This type of collaboration is particularly valuable for managing low-probability but high-consequence disruptions, where coordinated response and situational awareness play a critical role in limiting outage duration and community disruption.

Adaptation and Transformation

There are multiple pathways through which the Partner Cities and PSE can support long-term adaptation and system transformation. In the context of this study, a logical next step is to build on the robustness and response opportunities identified above by developing a clearer understanding of which areas are served by the most impacted circuits and which circuit-level areas are projected to experience future growth. Improved visibility at the circuit level can help target investments toward locations where reliability improvements would deliver the greatest customer benefit. In parallel, opportunities to enhance coordinated response between the Partner Cities and PSE could be strengthened through the extension or refinement of existing partnership agreements related to natural hazards and disaster response. Formalizing roles, responsibilities, and mutual-assistance protocols in advance of major events can improve coordination during high-impact disruptions and support faster, more effective restoration. Together, these steps can help align long-term resilience planning with near-term operational improvements, improving outcomes for customers as load and climate-related risks continue to evolve.

Appendix B. Forecasting Methodology

Transportation Electrification

Partner Cities Load Forecast

The Washington State Open Data Portal provides historical passenger vehicle registration data with information on the vehicle type and registration zip code. To forecast the future number of passenger EV registrations, the 2024 Bellevue Electric Vehicle Roadmap was referenced. The EV Roadmap provides projections on EV registrations through 2050 aligning with population, housing, and job growth targets as well as emissions reduction targets from the 2021-2025 Sustainable Bellevue Plan. A key assumption was reached in agreement with the City of Redmond to utilize the City of Bellevue's forecasted EV adoption rate for Redmond, as the two cities would have a similar adoption rate due to similar socioeconomics. The datasets were used to calculate the total number of registered EVs through 2050 in the Partner Cities. We acknowledge that the Roadmap projects are now two years old, and the EV landscape is shifting with the rollback of the federal Inflation Reduction Act EV tax credit and uncertainty around Advanced Clean Cars II.

The 2024 Bellevue Electric Vehicle Roadmap and the PSE Resource Planning Advisory Group presentations for the 2027 ISP provide assumptions on the number of charging ports needed per EV. As shown in **Table B-1**, these results were used as proportions to determine charging port needs based on forecasted number of EVs. The PSE Resource Planning Advisory Group presentation was also referenced to estimate the peak demand from EV charging.[22]

Table B-1. Partner City Transportation Electrification Load Forecast Inputs and Assumptions

Data Input/Topic	Data Value	Data Source	Notes and Assumptions
Passenger Vehicle EV Registrations	Bellevue: 2025 - 14,811 2030 - 39,860 2035 - 74,598 2040 - 101,524 2045 - 129,726 2050 - 150,165 Redmond: 2025 - 7,380 2030 - 19,869 2035 - 37,185 2040 - 50,607 2045 - 64,665 2050 - 74,854	Bellevue EV Roadmap	City of Redmond utilizes the City of Bellevue's forecasted EV adoption rate for Redmond, as the two cities would have a similar adoption rate due to socioeconomics. Vehicle registration data is from the Washington State Open Data Portal. It is assumed that total vehicle registration growth in Redmond is proportional to the City of Bellevue as targeted rate of growth and socioeconomics are similar.

[22] Prior to the rollback of the EV tax credit in September 2025, EVs made up approximately 25% of new car sales in Bellevue. To date, EV purchase rates have dropped slightly but remained at 20% of new registrations within Bellevue in December 2025, indicating that Bellevue and Redmond may be less impacted by the removal of the EV tax credit than other parts of the U.S.

Data Input/Topic	Data Value	Data Source	Notes and Assumptions
Commercial Vehicle EV Registrations	Bellevue: 2025 - 98 2030 - 513 2035 – 930 2040 – 1,298 2045 – 1,560 2050 – 1,774 Redmond: 2025 - 77 2030 - 402 2035 - 729 2040 – 1,017 2045 – 1,222 2050 – 1,390	PSE Resource Planning Advisory Group – June 18th, 2025	PSE forecasts commercial EV registrations territory wide. Partner Cities assumed to have the same adoption rate. Commercial vehicle registrations in the Partner Cities provided by the Washington Department of Licensing.
Passenger Vehicle Charging Needs	U.S. Department of Energy's EVI-Pro Lite tool output	Bellevue EV Roadmap	Passenger charging needs include daytime influx population, which accounts for about 34% of all vehicles within Bellevue's limits on a given day. Charging needs for Redmond are directly proportionate to Bellevue based on the number of vehicle registrations.
Commercial Vehicle Charging Needs	1.5 EVs per port (on average)	PSE Resource Planning Advisory Group – June 18th, 2025	Commercial charging needs are directly proportionate to PSE's territory wide forecast based on the number of vehicle registrations in each Partner City. Charging needs does not account for the influx of commercial vehicles registered outside the Partner Cities' area.
Electric Load	Passenger Vehicles: 0.6 kW peak demand per port (on average) Commercial Vehicles: 7 kW peak demand per port (on average)	PSE Resource Planning Advisory Group – June 18th, 2025	PSE forecasts the installed charger capacity based on charging port count and likely charger power. PSE also estimates observed or realized demand that accounts for diversification of load based on likely charging patterns. PSE's observed load profile was solely developed for 2050, estimating peak demand to occur at 7:00 PM. The unmanaged load was referenced to estimate demand on a typical weekday.

PSE Load Forecast

PSE's 2023 EPR transportation electrification forecast considers the Zero Emission Vehicles Standard of 2020 and the Clean Fuel Standard of 2021. Policies not considered in the forecast are the Clean Cars 2030 goal and Inflation Reduction Act. The forecasted percentage of purchased EVs, including passenger and commercial vehicles, across PSE's territory is shown in **Figure B-1**. Note that the Partner Cities' EV forecast ranges from 13% in 2025 to 92% in 2045, a significant difference than PSE's forecast.

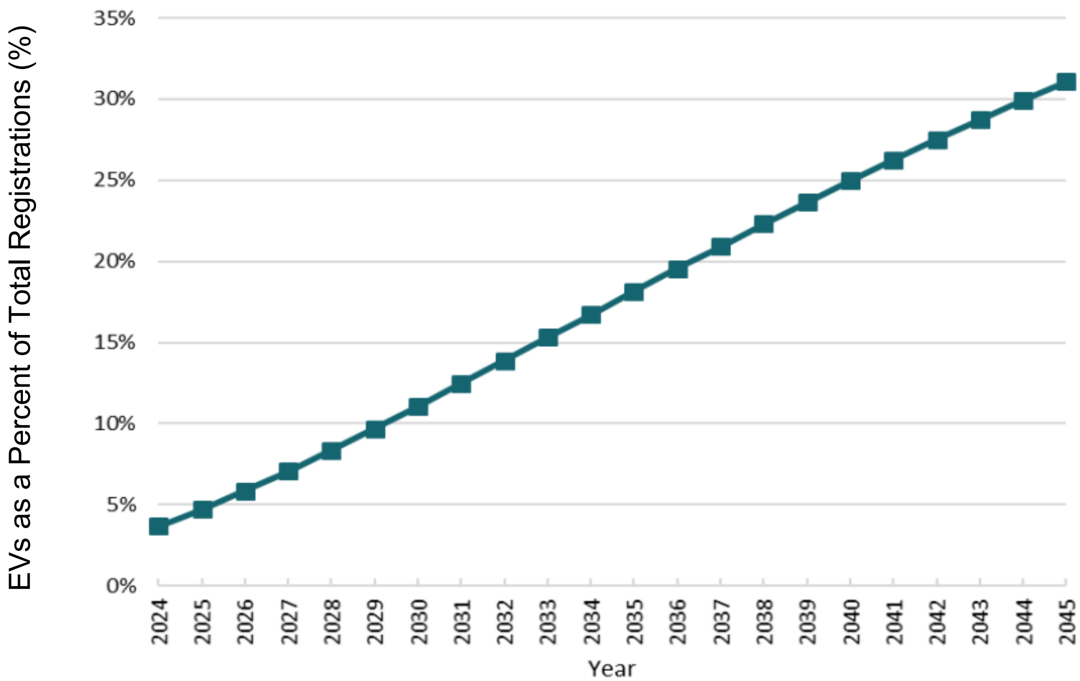


Figure B-1. EV Registration Percentage (Source: 2023 EPR)

PSE references analysis completed by Guidehouse to estimate the appropriate charger type, quantity, and associated electric demand (**Figure B-2**). EV load is expected to account for an estimated 5% of peak demand in 2025, 6% in 2030, and 10% in 2035. High and low EV scenarios were developed which represent the 90th and 10th percentile of forecasted load.[23]

[23] The PSE IRP does not make it clear if the variability in EV peak demand is based on a range of possible EVs on the road or based more on variability of EVs signed up with a demand response program.

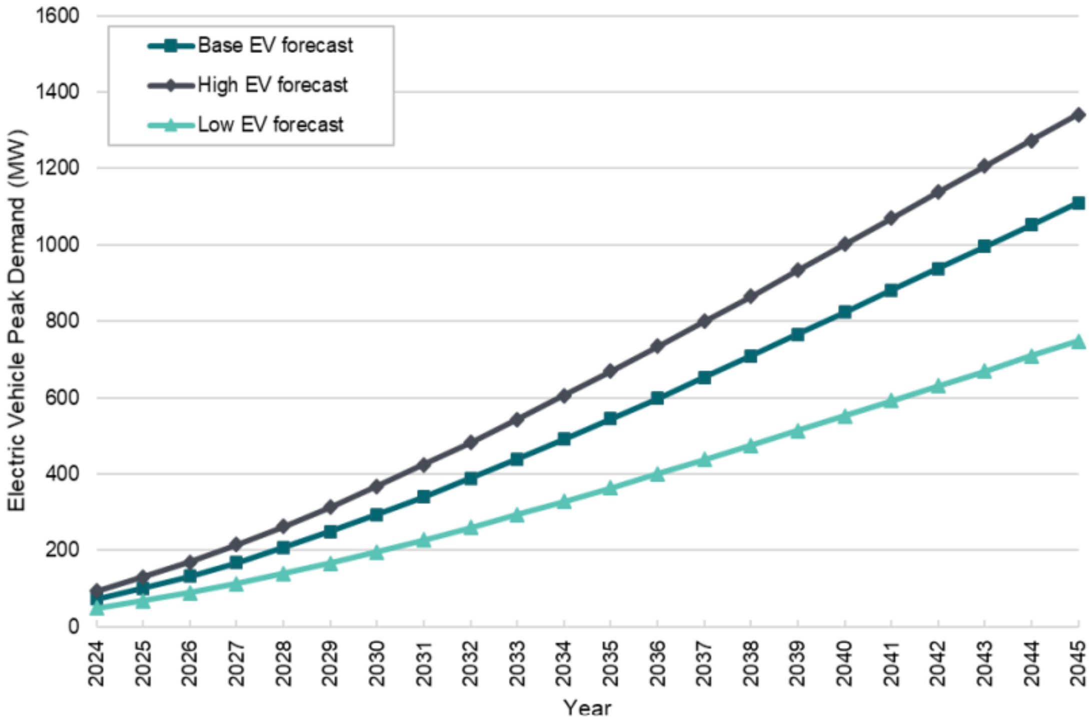


Figure B-2. EV Peak Demand (Source: 2023 EPR)

PSE's 2027 ISP overall demand forecasts are currently under development.

Building Electrification

Building Electrification Data

Population growth figures provided by the Partner Cities are included in this report to provide context on overall growth assumptions and to support high-level comparisons with PSE's load forecasting approach. These population values were not used directly as modeling inputs because the translation of population growth into housing and employment projections had already been completed as part of local planning efforts and was reflected in the Transportation Analysis Zone (TAZ) data provided by the cities.

For modeling purposes, the analysis relied on TAZ data supplied by the Partner Cities. This dataset includes detailed projections of new housing units and commercial growth area by zone, which allowed future development to be spatially allocated without additional calculations or adjustments. Use of TAZ-level inputs ensured consistency with local land use and transportation planning assumptions and enabled more detailed, substation-level analysis.

Building electrification inputs characterize the existing building stock, anticipated building growth, current adoption of electrified end uses such as high-efficiency heat pumps, and assumptions regarding existing fuel types by building category. Together, these datasets provide the basis for translating electrification policies and development trends into incremental electric demand, including impacts on seasonal peak conditions where applicable.

Table B-2 highlights growth and electrification energy data for the residential and commercial sectors provided by the Partner Cities.

Table B-2. Partner City Building Electrification Load Forecast Inputs and Assumptions

Dataset Topic	Bellevue	Redmond	Data Source
Population Growth	2019: 148,100 2044: 232,100 Total Growth: 57%	2019: 69,689 2044: 118,478 Total Growth: 70% 2050: 129,783	City of Bellevue Comprehensive Plan 2044 City of Redmond Alternative Growth Scenario [24]
Job Growth	2019: 157,800 2044: 227,800 Total Growth: 44%	2019: 86,879 2044: 112,387 Total Growth: 29% 2050: 118,509	City of Bellevue Comprehensive Plan 2044 City of Redmond Alternative Growth Scenario
New Construction Electrification / Future Energy Codes	Statutory requirements direct the Washington State Energy Code (WSEC) revision process to achieve a 70% reduction in energy consumption by 2031, relative to the 2006 code baseline. Align with Existing Building Electrification target of 100% all-electric by 2035.	Statutory requirements direct the Washington State Energy Code (WSEC) revision process to achieve a 70% reduction in energy consumption by 2031, relative to the 2006 code baseline. Align with Existing Building Electrification target of 100% all-electric by 2035.	RCW 19.27A.160 Partner City provided Electrification Goals
Location of New Construction & Growth	Transportation Analysis Zone (TAZ) data shows projected housing and job growth by TAZ.	Transportation Analysis Zone (TAZ) data shows projected housing and job growth by TAZ.	Partner City provided Data
Existing Building Electrification Implementation Rate	2026: 60% 2028: 70% 2030: 80% 2032: 85% 2034: 98% 2035: 99%	2026: 60% 2028: 70% 2030: 80% 2032: 85% 2034: 98% 2035: 99%	Partner City provided permitting data

[24] Redmond's Comprehensive Plan reflects the growth targets assigned by the County, but the Redmond City Council approved higher growth targets. Those higher growth targets are reflected in Table B-2 and were used for this analysis to align with what the city is using for their planning work.

Dataset Topic	Bellevue	Redmond	Data Source
% of Existing buildings that use Natural gas	Redmond and Bellevue Multifamily buildings: 6% Single-family buildings: 77% Commercial buildings: 9%		Multifamily Buildings: NEEA 2022 Residential Building Stock Assessment. Table A11.4 Single Family Buildings: King County Assessor data and city provided data. Commercial Buildings: NREL ComStock 2025.3: Heating source by building area for King County

Sensitivities Analysis

Three sensitivities were analyzed as described in **Table 4** to identify the impact of changing population growth and electrification rate assumptions. The sensitivities were combined to analyze a low and high scenario. Combined these factors had the ability to change the load by over 15% lower or 5% higher in the year 2035. These changes often do not have significant impact on substation loading, that is, substations that were lightly loaded continue to be lightly loaded and substations that are overloaded continue to be overloaded. There are only three substations in the City of Bellevue (the Clyde Hill, Northrup, and Somerset substations) and three substations in the City of Redmond (the Avondale, Redmond, and Spiritbrook substations), where the combined impact of these sensitivities could be the difference between needing to plan for upgrades and not. This finding further confirms the need to regularly revisit growth and electrification assumptions as more data becomes available and monitor actual growth via load requests.

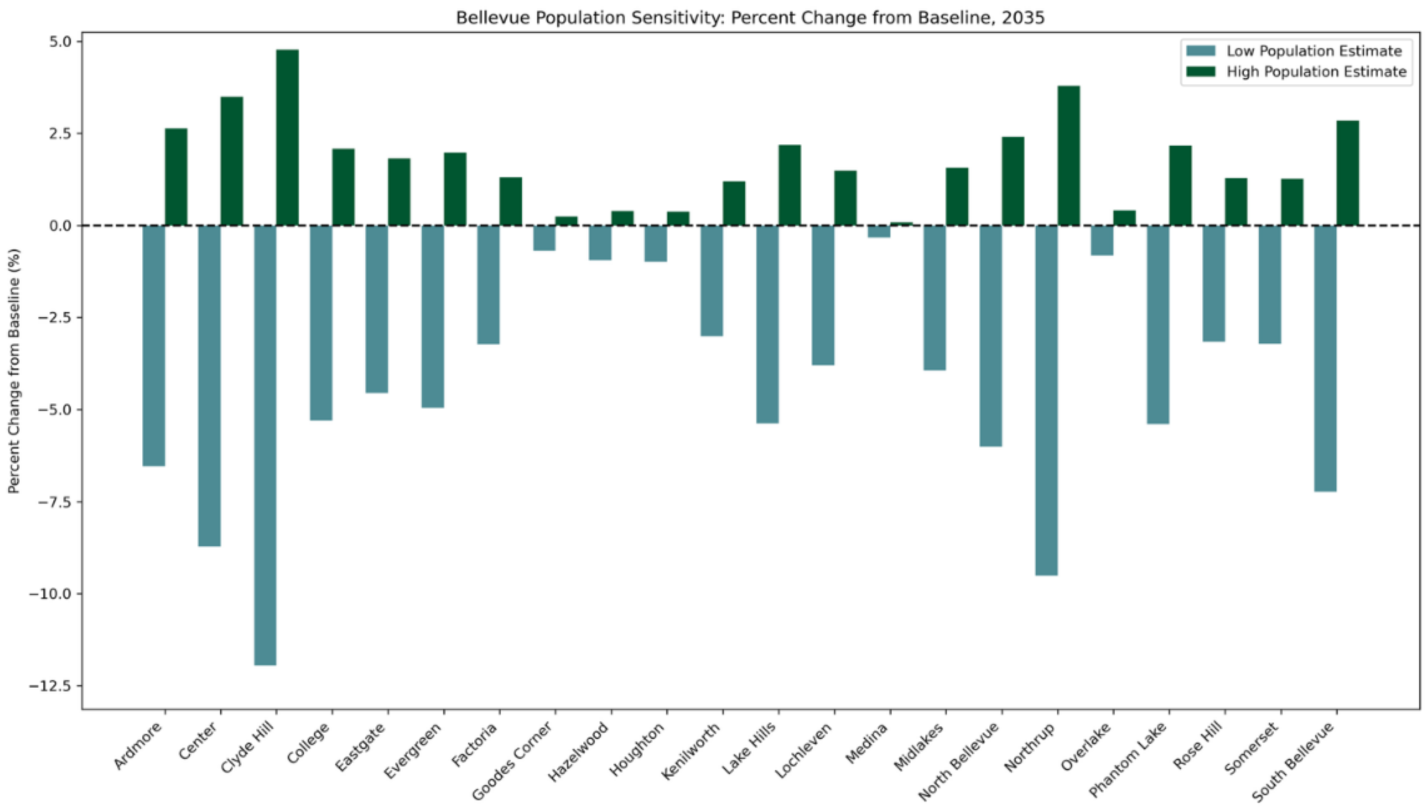


Figure B-3. Bellevue Population Sensitivity

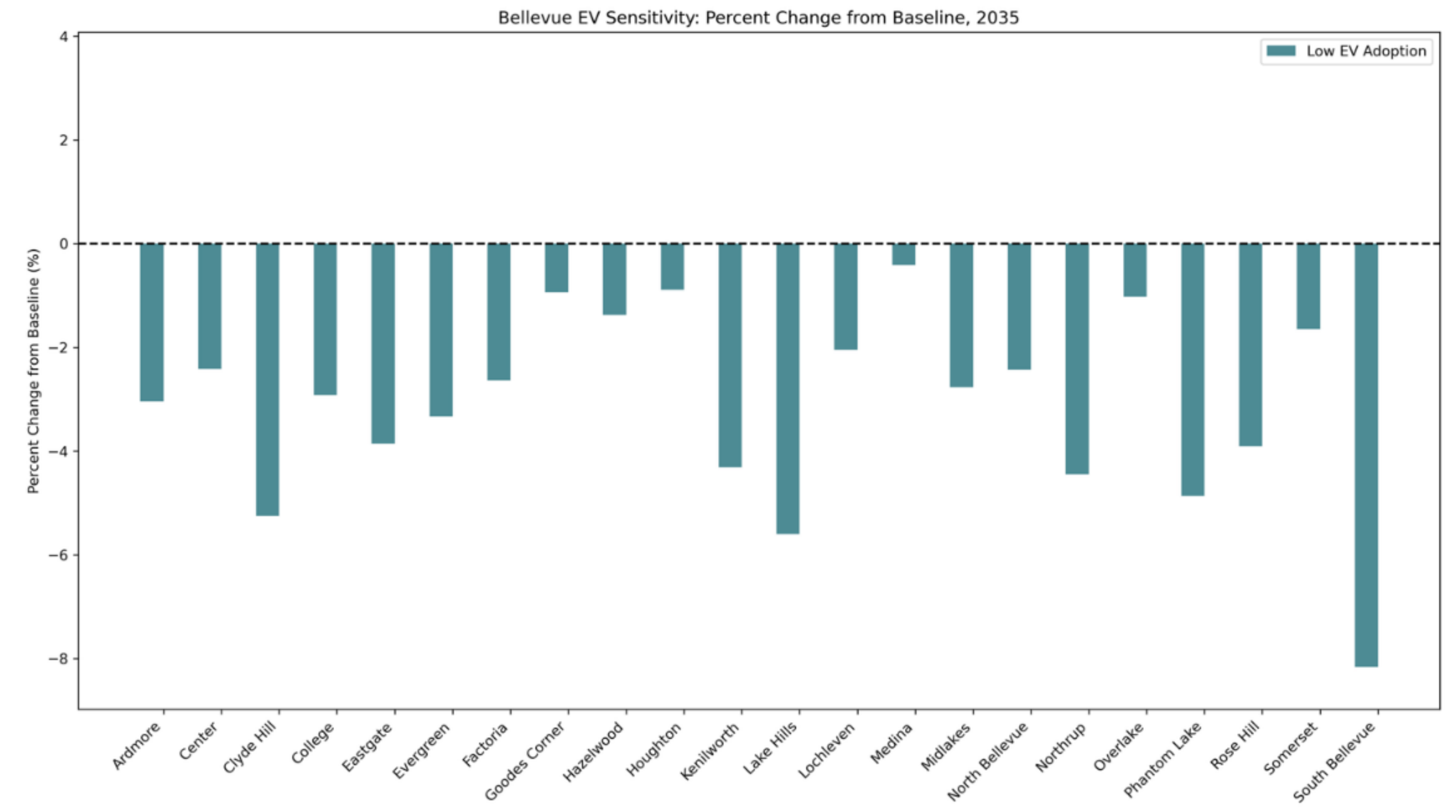


Figure B-4. Bellevue EV Sensitivity

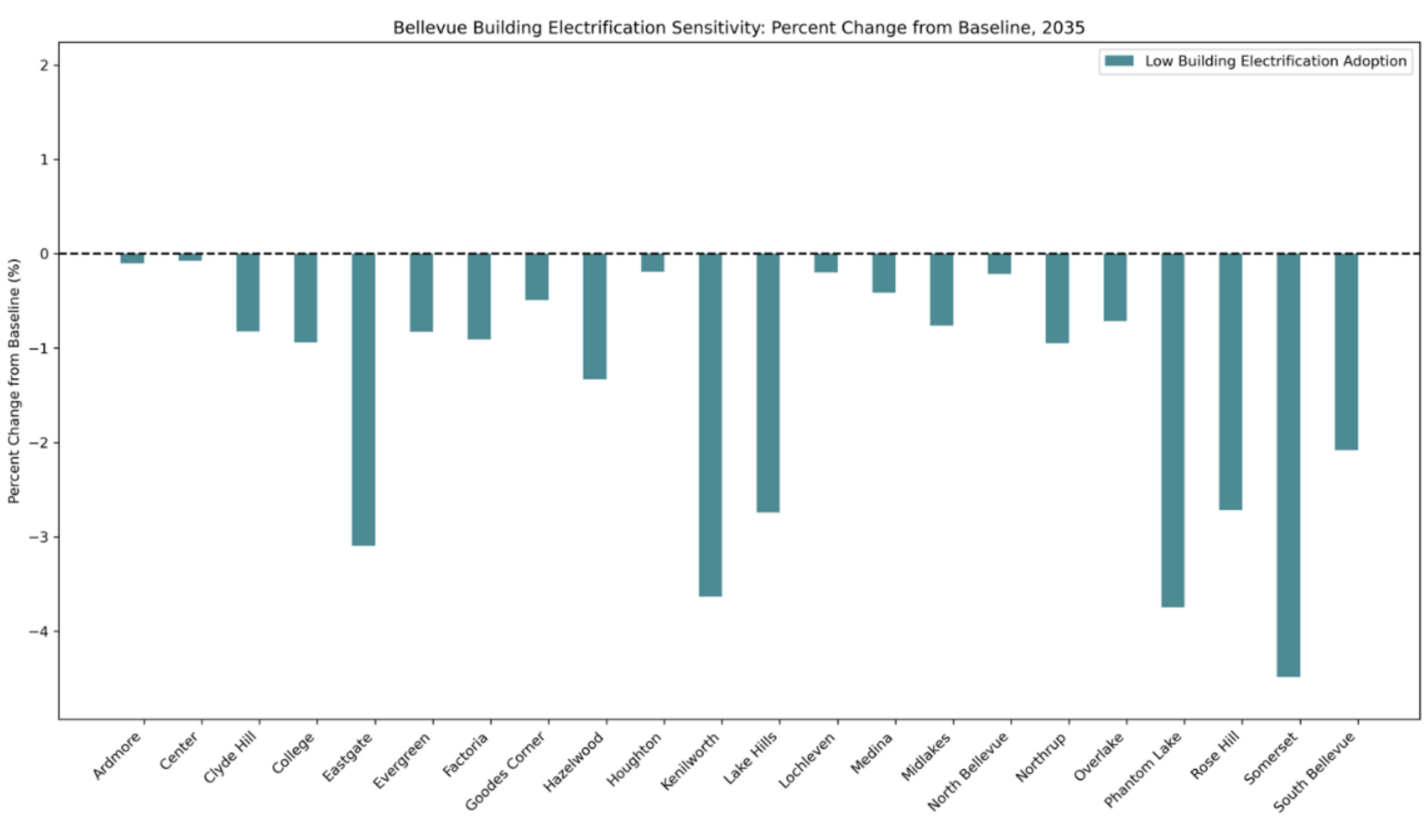


Figure B-5. Bellevue Building Electrification Sensitivity

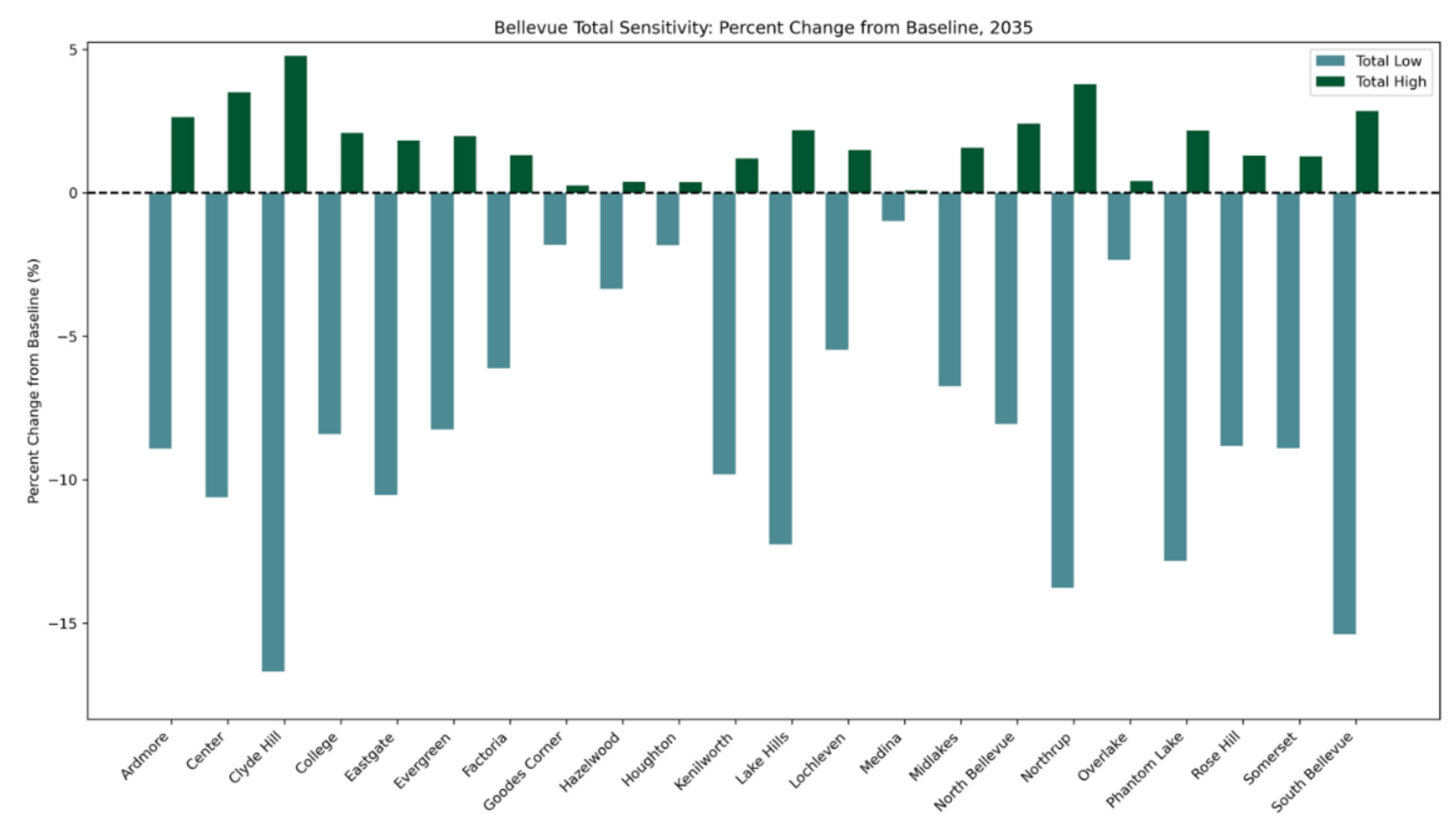


Figure B-6. Bellevue Total Sensitivities

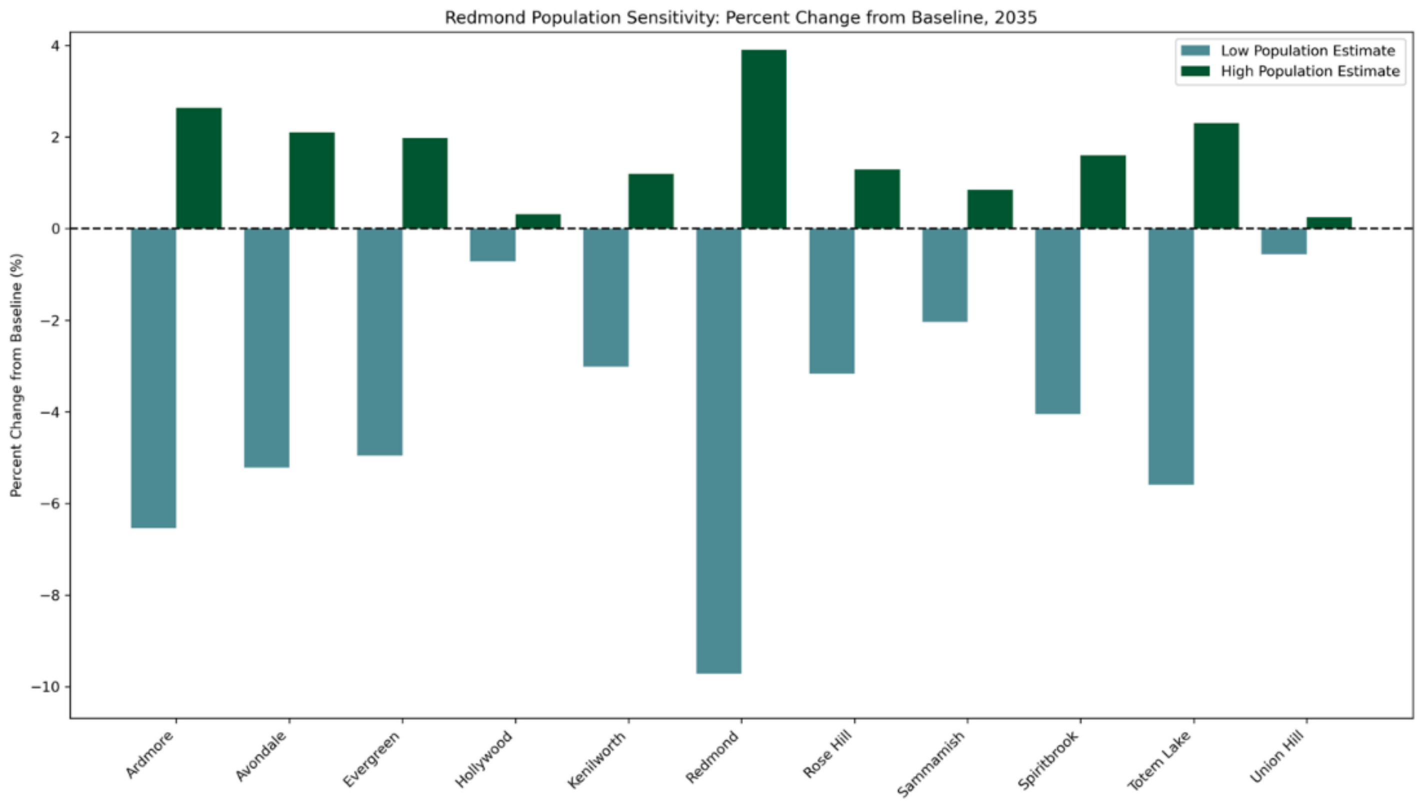


Figure B-7. Redmond Population Sensitivity

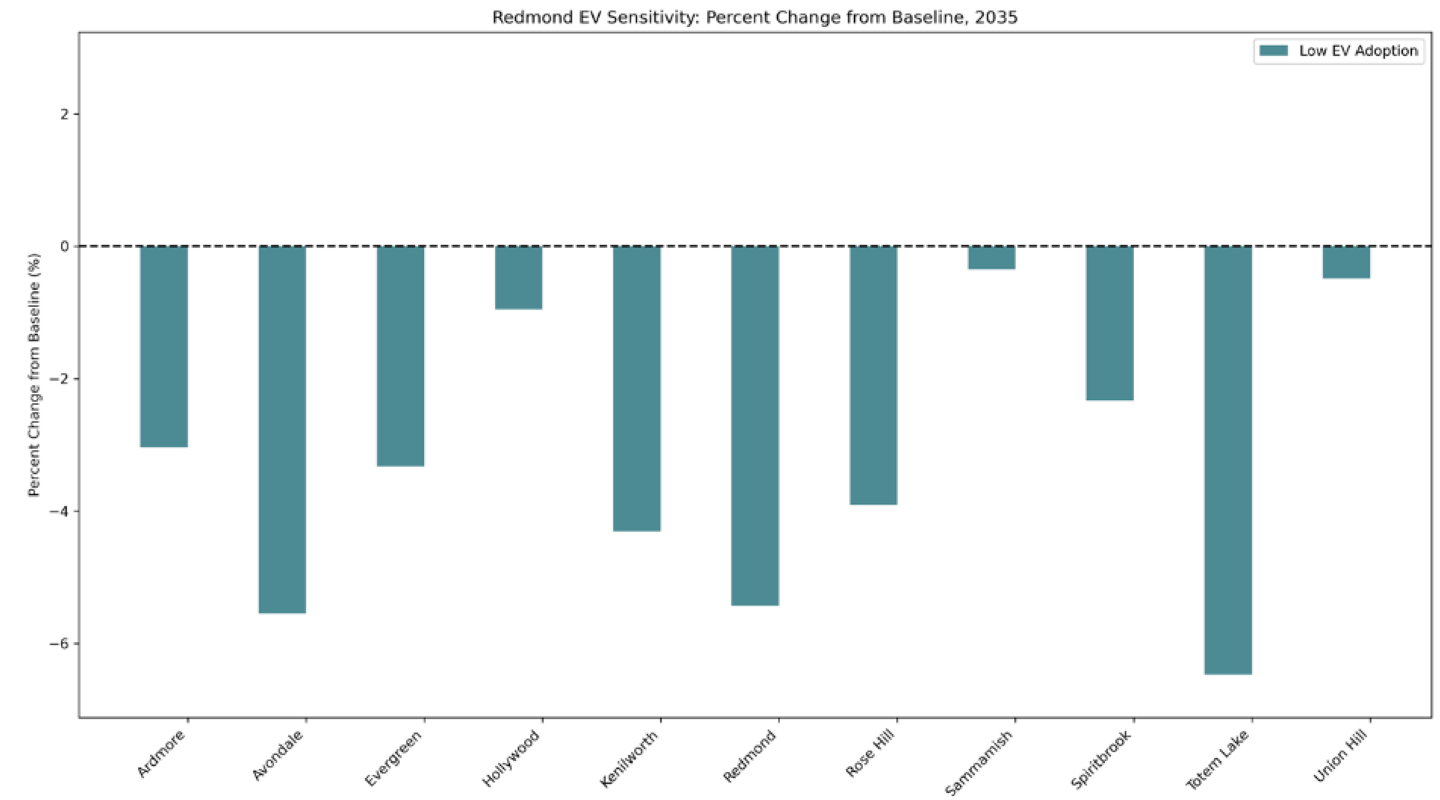


Figure B-8. Redmond EV Sensitivity

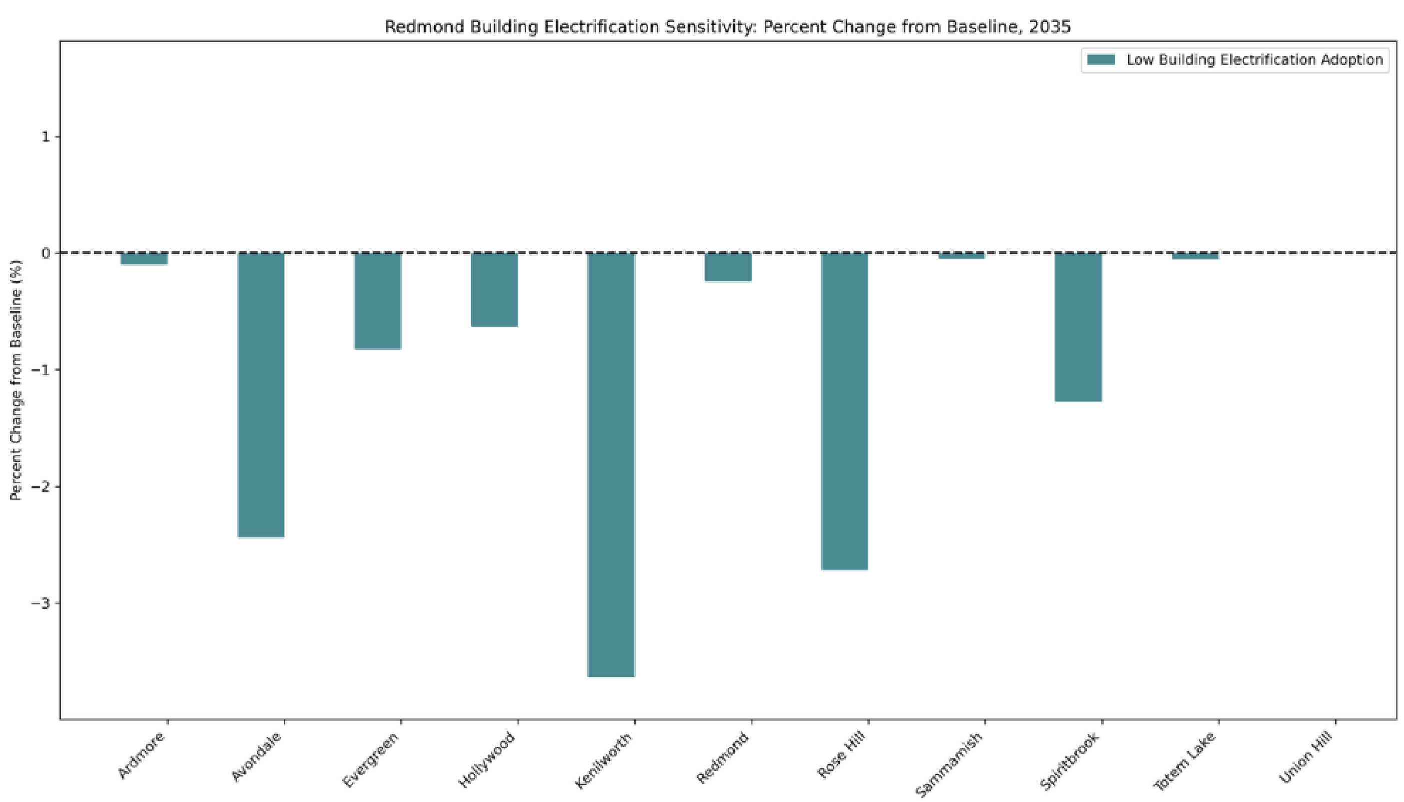


Figure B-9. Redmond Building Electrification Sensitivity

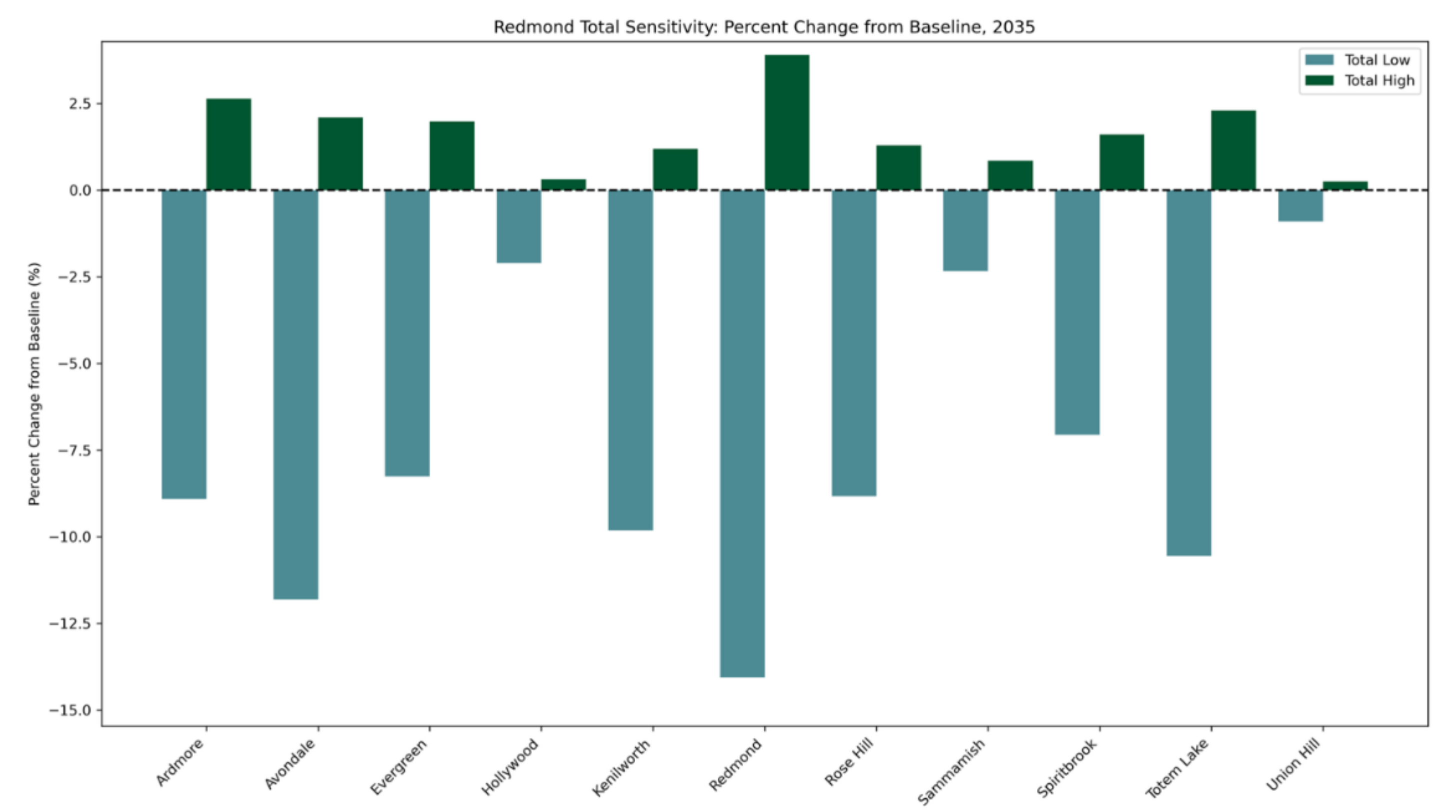


Figure B-10. Redmond Total Sensitivities

Appendix C. Emerging Grid Technologies

The electric grids serving the Cities of Bellevue and Redmond are entering a critical period of modernization driven by increasing electrification. This transition is shaped by growing adoption of EVs and charging infrastructure, as well as expanded building electrification to reduce greenhouse gas emissions and address climate change. Supporting this growth will require coordinated investments both within the electric grid itself and at the grid edge.

Figure C-1. PSE's Smart Grid Solar Battery Trailer

On-grid technologies at the distribution level focus on expanding and modernizing core utility infrastructure while adding localized intelligence, flexibility, and automation to accommodate rising electricity demand and maintain reliability. These include grid modernization technologies, such as Volt-VAR control and optimization, Advanced Distribution Management Systems (ADMS), and long-duration distribution storage. These technologies enable utilities to operate distribution assets more efficiently, improve outage detection and response, and better integrate emerging technologies across the system.

Grid-edge technologies are deployed closer to customers and influence how and when electricity is used. These include DERs such as rooftop solar, battery storage, and microgrids; grid-interactive efficient buildings that can adjust energy use in response to grid conditions; advanced heat pump systems with flexible controls; thermal energy networks (e.g. geothermal and sewer heat recovery); managed EV charging; and artificial intelligence-enabled building and localized system controls.

Together, grid and grid-edge investments work in tandem to maintain reliability as electrification grows, reduce or shift peak demand, increase system flexibility, and defer or better time major infrastructure investments.

On-Grid Technologies

Volt-VAR Control and Optimization

Volt-VAR uses advanced sensors, communications, and software to continuously monitor and adjust voltage levels on the distribution grid in real time. As electrification increases through EVs, heat pumps, and other electric technologies, Volt-VAR optimization helps maintain stable voltage and power quality under higher and more dynamic loads. By reducing energy losses on power lines and managing reactive power flows, these systems improve efficiency and ensure that distributed resources such as rooftop solar and EV chargers do not create local voltage fluctuations. This capability allows the grid to accommodate additional electrified demand more reliably and cost-effectively, helping defer the need for certain infrastructure upgrades.

Advanced Distribution Management Systems (ADMS)

ADMS serves as the central operational platform for managing the utility's distribution grid, integrating functions such as outage management, distribution automation, voltage regulation, and real-time power flow analysis. As electrification increases and demand patterns become more dynamic, ADMS provides utilities with improved situational awareness and control of on-grid assets, including substations, feeders, switches, and voltage-regulating equipment. This enhanced visibility allows utilities to identify emerging constraints, optimize power flows, and respond more quickly to system disturbances. When paired with distributed resources and grid-edge technologies, ADMS enables more precise coordination between traditional infrastructure and non-wires alternatives (NWAs). By optimizing existing grid capacity and directing operational responses before overloads occur, ADMS can help defer or reduce the scale of costly infrastructure upgrades while maintaining system reliability.

In support of this approach, PSE is advancing a suite of grid modernization initiatives, including development of an ADMS to enable real-time distribution monitoring and operational visibility, implementing smart street lighting, instituting a Living Lab to test and scale emerging technologies, and installing pole-mounted sensors to improve asset monitoring.[25]

Distributed Energy Resource Management Systems (DERMS)

Often described as the "air traffic control" system for the distribution grid, DERMS coordinates large numbers of customer-sited resources such as rooftop solar, EV chargers, and behind-the-meter batteries with utility grid operations. By providing real-time visibility and control, DERMS enables these distributed resources to be used as NWAs, helping manage local constraints and support capacity needs without immediate investment in traditional infrastructure. As electrification increases and flexible electric loads grow, DERMS can actively manage when and how distributed resources operate, particularly during peak demand periods, to prevent localized overloads on transformers and feeders. This coordinated approach supports grid reliability, enables higher levels of electrification, and helps defer or optimize the timing of more costly grid upgrades, while allowing customer-sited technologies to deliver value both to individual customers and to the broader electric system.

Long-Duration Distribution-Level Storage

Long-duration storage includes emerging technologies such as flow batteries and thermal energy storage systems (sometimes referred to as "hot brick" storage) that can deliver electricity or heating over extended periods, often ten hours or more, at the neighborhood or circuit level. Unlike standard lithium-ion batteries, which are typically designed for shorter durations, these systems can provide sustained backup power during prolonged outages or peak demand events. As electrification increases and electric loads become more weather-dependent, long-duration storage can help maintain reliability, support critical services, and reduce stress on substations and feeders. When strategically deployed, these resources can also serve as non-wires alternatives, helping defer traditional infrastructure upgrades while enhancing local resilience.

[25] PSE. *Grid Modernization Initiatives.* PSE | Grid Modernization Initiatives. https://www.pse.com/en/pages/grid-modernization/grid-modernization-initiatives

Grid-Edge Technologies

Grid-Interactive Efficient Buildings

Grid-interactive efficient buildings (GEBs) are rapidly becoming a central strategy for grid modernization, combining energy efficiency, load flexibility, smart controls, and two-way communication technologies. The U.S. Department of Energy's GEB initiative aims to transform buildings into flexible grid assets by integrating demand flexibility and advanced controls to improve affordability, comfort, and system-level performance.[26] GEBs can also blend energy efficiency, storage, renewables, and flexible load technologies to produce a more stable, resilient, and low-carbon energy system.

Customers adopting GEB-enabling technologies—such as advanced building automation systems, thermal storage, and smart load-management tools—gain the ability to shift energy use in response to real-time grid conditions, reducing utility bills and creating opportunities to earn incentives through demand response or grid-service programs. These technologies also enhance comfort and operational reliability while supporting the integration of renewable energy and reducing overall peak demand.

Vehicle-to-Grid (V2G) and Managed Charging

V2G technology uses bidirectional chargers that allow EVs to not only draw electricity from the grid but also return stored energy back to the grid or supply power to a home or building when needed. From a grid-edge perspective, V2G transforms EVs into mobile energy storage assets that can help manage peak demand, provide backup power during outages, and support grid stability as electrification grows. When coordinated through managed charging or demand response programs, V2G can reduce strain on local transformers and feeders, enable non-wires alternatives, and help defer traditional infrastructure upgrades while offering vehicle owners opportunities for resilience benefits and financial compensation for grid services.

By coordinating charging behavior through time-of-use rates, automated load controls, and utility-enabled managed charging programs, EV demand can be shifted away from peak periods and aligned with available grid capacity. Smart charging can help reduce coincident peaks at the feeder and substation levels, improve utilization of existing infrastructure, and limit the need for near-term upgrades as public, workplace, and multifamily charging expands. Integrating managed charging into EV project planning in both cities will enable electrification to scale in a way that is grid-aware, cost-effective, and supportive of long-term system reliability.

DERs

DERs including rooftop solar, battery storage, microgrids, and district energy systems enable customers to play a more active role in managing energy use and supporting grid performance. These technologies allow customers to meet a portion of their energy needs onsite, increase resilience during outages, and reduce reliance on centralized generation. When combined with energy efficiency and flexible controls, DERs can flatten and shift load profiles, and ease stress on local infrastructure.

Virtual Power Plants are groupings of resources, such as energy storage, rooftop solar and EV chargers, that can be used to balance peaks in electricity loads. PSE and AutoGrid launched a virtual power plant in 2023.

Shifting electricity use in response to grid conditions is one of the most cost-effective strategies for managing the impacts of electrification and maximizing the value of existing infrastructure.

[26] U.S. Department of Energy. Grid-Interactive Efficient Buildings. https://www.energy.gov/cmei/buildings/grid-interactive-efficient-buildings

PSE has many flexible demand programs such as PSE's Flex Programs[27] (Flex Rewards, Flex EV, Flex Batteries, etc.), Up & Go Electric Fleet EV Load Management,[28] and Enel Business Demand Response.[29]

Thermal Energy Networks

Thermal energy networks function as geothermal and sewer heat recovery systems and are typically more energy efficient than traditional heat pumps. Washington HB 2131[30] allows gas utilities to invest in thermal energy networks. Deploying this technology could be an efficient way to heat and cool new developments while avoiding or delaying major substation upgrades.

Smart Energy Management Systems and AI-Driven Analytics

Smart energy management platforms and AI-powered analytics are revolutionizing building operations by enabling real-time optimization based on granular energy and occupant data. With AI-driven automation, customers can deploy connected technologies that autonomously adjust building operations based on utility price signals, carbon intensity, or comfort requirements. These systems help reduce operating costs, improve equipment performance, and streamline compliance with emerging regulations while supporting more informed energy management decisions.

Load Flexibility and Demand Response Technologies

Load flexibility technologies enable customers to strategically shift or reduce energy use in response to grid conditions, making them a key component of a modern, electrified energy system. The U.S. Department of Energy identifies demand flexibility and smart controls as foundational elements of grid-interactive efficient buildings, allowing building operations to better align with the needs of the broader electric grid. Through connected thermostats, intelligent building management systems, and advanced load-shifting strategies, such as thermal energy storage, customers can adjust when and how they use electricity. These capabilities help avoid peak pricing, support demand response programs, and reduce emissions by increasing consumption when cleaner electricity is most abundant. Collectively, load flexibility technologies lower energy costs, improve comfort and control for customers, and enhance long-term grid reliability and resilience.

[27] PSE. PSE Flex. https://www.pse.com/en/rebates/PSE-flex
[28] PSE. Up & Go Electric for Fleet. https://www.pse.com/en/pages/electric-cars/fleet-electrification
[29] PSE. Flex C&I. https://www.pse.com/en/business-incentives/energy-management-programs/flex-c-i
[30] Washington State Legislature. HB 2131. https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/House%20Passed%20Legislature/2131-S.PL.pdf?q=20260424142933

Appendix D. Regulations and Policies

State Decarbonization Policies

Washington House Bill 1589, enacted in 2024, is particularly transformative for PSE.[31] The bill mandates integrated planning across electric and gas operations, prioritizing electrification, emissions reduction, and the equitable distribution of benefits and burdens. It also directs large combination utilities, such as PSE, to transition customers away from natural gas over time and restricts rebates for new gas appliances beginning in 2025. The law explicitly requires PSE to plan for "all cost-effective electrification", which, paired with Washington's broader decarbonization framework, will increase regional electricity demand and accelerate the need for new grid capacity and infrastructure in the Bellevue and Redmond communities.

This policy direction builds on the Washington Clean Energy Transformation Act (CETA), which requires a coal-free electricity supply by 2025, greenhouse gas–neutral electricity by 2030, and 100% clean electricity by 2045.[32] CETA compels utilities to create four-year Clean Energy Implementation Plans and integrate renewable and non-emitting resources into long-term planning. These mandates reinforce PSE's ongoing Energize Eastside investments by ensuring that future grid expansions support the transition to non-emitting energy sources while maintaining reliability for high-growth areas like Bellevue and Redmond.

The recently passed Washington Senate Bill 6355 establishes the Washington Electric Transmission Authority, which will coordinate the planning, siting, and permitting of new high-priority electric transmission infrastructure.[33] The Authority aims to support the goals set in CETA by strengthening the state's grid, improving reliability, and supporting renewable energy development.

Finally, Washington's Climate Commitment Act (CCA) defines a goal of reducing greenhouse gas emissions by 95% by 2050 and creates an overarching carbon-reduction framework that intersects with every aspect of the grid transition.[34] The CCA caps emissions from major sources, including utilities, and reinvests revenue into clean transportation, grid modernization, energy efficiency, and community resilience. The program's emphasis on environmental justice ensures that investments target overburdened communities, which can influence siting and upgrade decisions within the Eastside grid as cities pursue more equitable energy outcomes.

Clean Building Policies

At the building scale, the Washington Clean Buildings Performance Standard requires owners of large commercial and multifamily buildings to meet energy-use intensity targets or undertake cost-effective efficiency improvements.[35] Buildings are grouped into Tier 1 or Tier 2 based on their square footage and have various compliance reporting schedules based on size, with the first reporting schedule beginning in June 2026. These requirements drive extensive electrification and efficiency upgrades across Bellevue and Redmond's commercial and tech-sector building stock, which further increases electricity demand and influences PSE's substation and feeder capacity planning in the region.

[31] Washington State Legislature. HB 1589. https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/House%20Passed%20Legislature/1589-S.PL.pdf?q=20260403102644
[32] Washington State Department of Commerce. Clean Energy Transformation Act (CETA). https://www.commerce.wa.gov/energy-policy/electricity-policy/ceta/
[33] Washington State Legislature. SB 6355. https://lawfilesext.leg.wa.gov/biennium/2025-26/Pdf/Bills/Senate%20Passed%20Legislature/6355-S.PL.pdf?q=20260424143508
[34] Washington State Department of Commerce. Climate Commitment Act. https://www.commerce.wa.gov/cca/
[35] Washington State Department of Commerce. Clean Buildings Performance Standard. https://www.commerce.wa.gov/cbps/

Clean Transportation Policies

The transportation sector, a major driver of load growth, is also largely impacted by Advanced Clean Cars II (ACC II) and the Advanced Clean Trucks (ACT) rule, although they are currently paused.[36] ACC II required all new light-duty vehicles sold in Washington to be zero-emission by 2035. The ACT regulation similarly mandated rising sales of zero-emission medium- and heavy-duty vehicles. These policies are intended to accelerate EV adoption across the region, pressuring local distribution systems and requiring additional charging infrastructure deployment.

Complementing these transportation policies, the Washington Clean Fuel Standard (CFS) reduces the carbon intensity of transportation fuels by 45% by 2038, providing market incentives for electrification, renewable fuels, and EV charging infrastructure.[37] As electricity becomes an increasingly important compliance pathway, the CFS indirectly drives both transportation and building sector electrification, affecting system load profiles for PSE's Bellevue–Redmond service territory.

[36] State of Washington Department of Ecology. Vehicle Emissions Standards. https://ecology.wa.gov/air-climate/reducing-greenhouse-gas-emissions/vehicle-emissions-standards
[37] State of Washington Department of Ecology. Clean Fuel Standard. https://ecology.wa.gov/air-climate/reducing-greenhouse-gas-emissions/clean-fuel-standard

Appendix E. Auxiliary Maps and Charts

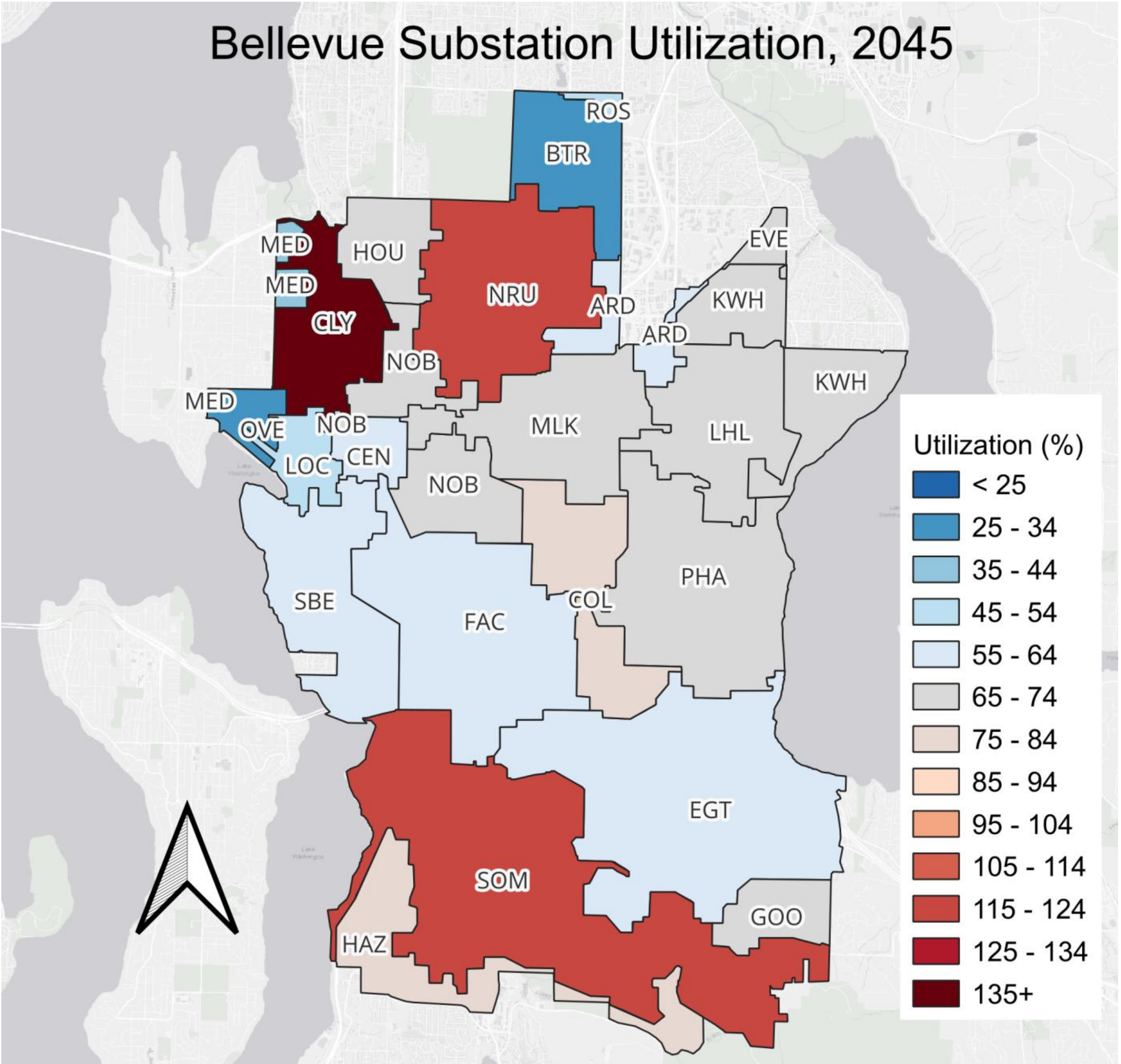


Figure E-1. Bellevue Substation Utilization, 2045

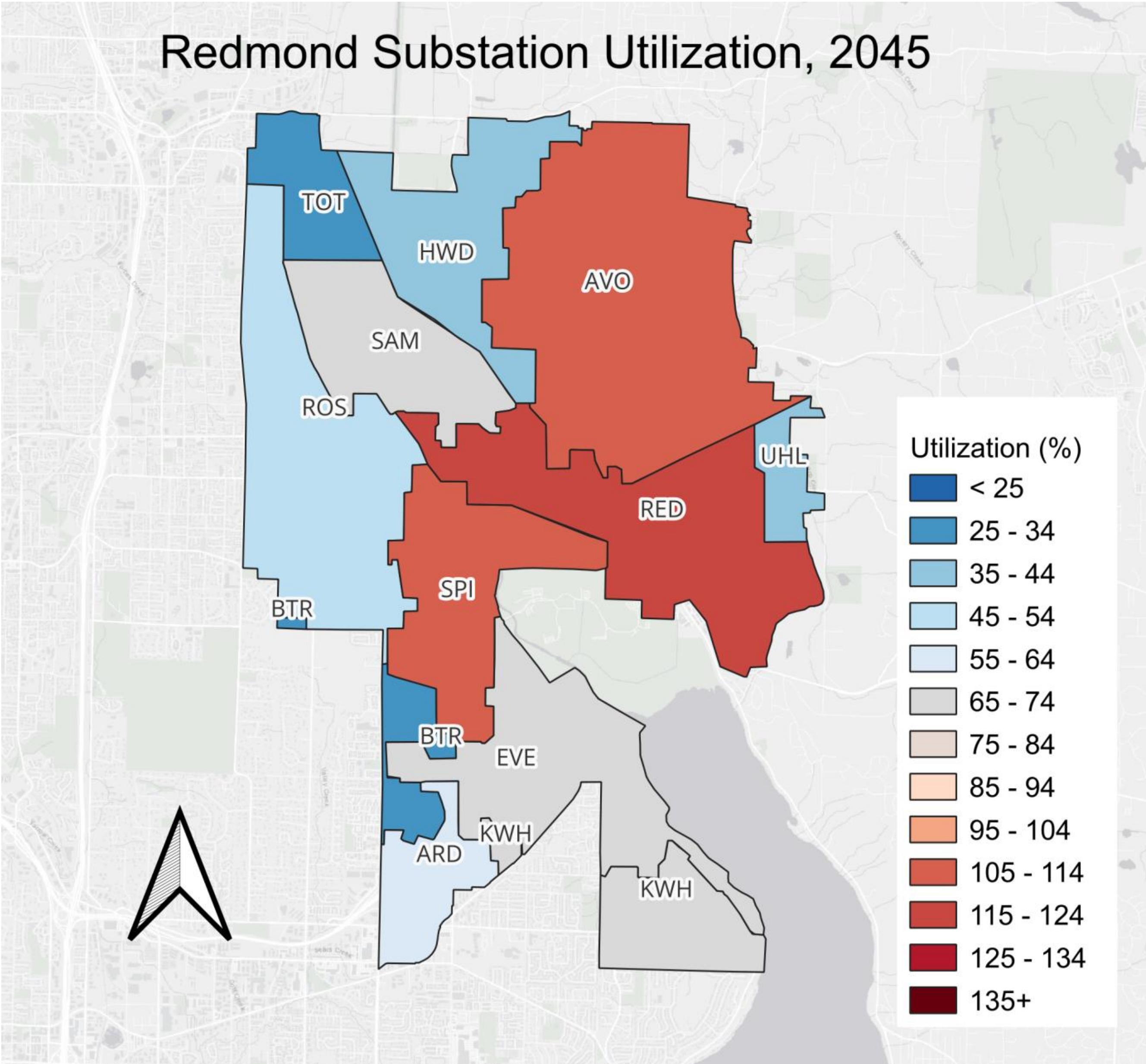


Figure E-2. Redmond Substation Utilization, 2045

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