RESOURCE PLAN

CHAPTER THREE

PUGET SOUND ENERGY

Contents

1. Introduction

This chapter presents Puget Sound Energy's preferred portfolio for the 2023 Electric Progress Report (2023 Electric Report). Our preferred portfolio is the result of robust Integrated Resource Plan (IRP) analyses developed with input from interested parties. Informed by our deterministic portfolio, risk, and portfolio benefit analyses, this portfolio meets the Clean Energy Transformation Act (CETA) requirements.

Puget Sound Energy is the Pacific Northwest's largest utility producer of renewable energy. We currently own and contract more than 10 million MWh of renewable and non-emitting energy, and we forecast this will grow to more than 30 million MWh by 2045.

Throughout the resource planning process for the 2023 Electric Report, we focused on the following key objectives, which lay the foundation for this and all future resource plans:

- Achieve the renewable energy targets under CETA — meet at least 80 percent of PSE's demand with renewable and non-emitting energy and achieve carbon neutrality by 2030, and meet 100 percent of PSE's demand with renewable and non-emitting resources by 2045.
- Build a reliable, diversified power portfolio of renewable and non-emitting resources.
- Continue to be a clean energy leader in the Pacific Northwest and beyond.
- Ensure an equitable transition to clean energy for all PSE customers.
- Ensure our resource planning aligns with PSE's Clean Energy Implementation Plan (CEIP) to meet our interim targets and CETA obligations.
- Ensure resource adequacy while transitioning to clean energy.

We used three distinct types of analysis to develop, refine, and identify the preferred portfolio:

1. The deterministic portfolio analysis solves for the least-cost solution and assumes perfect foresight about the future.
2. The risk analysis examines the preferred portfolio's performance concerning uncertainty in hydroelectric, wind and solar conditions, electric and natural gas prices, customer demand, and unplanned plant-forced outages.
3. The portfolio benefit analysis incorporates equity into the IRP process by measuring potential equity-related benefits to customers within a given portfolio. Because the IRP process is inherently forward-looking, this analysis seeks to identify portfolios containing a mix of electric resources that can enable more equitable customer outcomes in the future. It is important to note the IRP process generally lacks the detail to assess specific existing or future programs and actions that address equity. However, the IRP process can provide a pathway that ensures we acquire the electric resources necessary to implement more equitable programs and measures.

➔ See Chapter Five: Key Analytical Assumptions and Chapter Eight: Electric Analysis for details on these analyses, including methodologies and results.

We present this chapter in the following three sections. Section 2 summarizes the preferred portfolio and describes how the resource additions will meet our projected demand growth. Section 3 describes the contributors to our near-term capacity deficit and how this drives the resource additions in the preferred portfolio. Section 4 presents our process for developing and selecting a preferred portfolio and includes our portfolio benefit analysis results.

2. Preferred Portfolio

Puget Sound Energy is committed to reaching the CETA goals and achieving greenhouse gas (GHG) neutrality by 2030 and a GHG-free electric energy supply by 2045. The electric resource plan shows our current path to meet CETA commitments. Our plan prioritizes delivering cost-effective, reliable conservation and demand response and distributed and centralized renewable and non-emitting resources to our customers at the lowest reasonable cost. The plan reduces direct PSE emissions and achieves GHG neutrality by 2030 through clean energy investments.

We have made many updates and changes since PSE's 2021 IRP. The preferred portfolio resource additions for the 2023 Progress Report include significant increases in renewable resources to meet the CETA requirements and peak demand. We provide a detailed discussion of these changes in Chapter Eight: Electric Analysis and the following summary:

- Capacity Resources: We saw increased capacity resources due to increasing peak demands over the 2021 IRP and reduced market reliance. With the increased peak capacity contribution and lower resource costs, we saw more energy storage resources added to the 2023 preferred portfolio than the 2021 IRP preferred portfolio.
- Clean Energy Resources: Overall, there is an increase in renewable resource additions to meet CETA requirements due to the increase in the demand forecast. A complete discussion of changes to the demand forecast is in Chapter Six: Demand Forecasts.
- Conservation: Overall, the 2023 Progress Report CPA potential is down from the 2021 IRP by approximately 13 percent by 2045. The reduction in the CPA is due to the newly incorporated impact of climate change assumptions, which reduced savings in the later years of the study, and a new statutory provision requiring the state to adopt more efficient building energy codes to achieve a 70 percent reduction by 2031. We added the impact of this statute, which moved some of the potential from energy efficiency into codes and standards, and the updated building stock assessments, which have more efficiency penetration compared to the last stock assessment.
- Distributed Energy Resources: The 2023 progress report is consistent with the CEIP targets through 2025, and then we see an increase in net-metering solar based on the new forecast from current trends and economics, including rebates from the inflation reduction act.

This section presents the preferred portfolio, describes how the combination of resource additions will meet our projected demand growth, and explains how diversifying resource technology is paramount to reducing technology risk. The preferred portfolio further clarifies the following near-term and long-term priorities.

Near-term Priorities (2024–2029):

- Add diverse commercially available resources to meet CETA energy and resource adequacy needs
- Add utility-scale and distributed resources to achieve the renewable or non-emitting energy targets specified in PSE's 2021 CEIP
- Begin commercial activity to acquire bulk transmission to transport renewable energy from distant renewable energy zones to our customers
- Begin shifting our planning frameworks to align with WRAP requirements as more long-term information becomes available
- Continue to acquire conservation resources
- Continue to develop and refine methods to embed equity into resource decisions.
- Continue to participate in the Western Resource Adequacy Program (WRAP) on an operational basis
- Explore commercial opportunities for advanced nuclear small modular reactors (SMR) capacity and other non-emitting technologies
- Lead and actively participate in developing the region's hydrogen hub infrastructure
- Pursue demand response programs that can effectively help lower peak demand
- Reduce reliance on short-term market purchases in response to the changing western energy market

Long-term Priorities (2030–2045):

- Complete acquisition and development of additional transmission capacity (e.g., Cross Cascades, Idaho, Wyoming, Montana, B.C.) to deliver additional clean energy to our customers
- Develop and acquire generating resources that take longer to develop to meet CETA non-emitting generation obligations while maintaining resource adequacy and peak demand.
- Examine repowering or upgrading existing thermal resources and renewable generation to better position PSE to achieve the 2045 goal of an emission-free generation portfolio.
- Explore new capacity options to drive diversity in our energy supply

2.1. Resource Additions Summary

Table 3.1 describes our preferred portfolio of resource additions. With this combination of conservation, demand response, renewable resources, energy storage, and CETA-qualifying peaking capacity, PSE will reach GHG neutrality by 2030. However, given the large amounts of variable energy resources, such as wind and solar, and energy-limited resources, such as energy storage, we will need to rely on newer technologies, such as hydrogen, to reach a GHG-free energy supply by 2045 while maintaining reliability and resource adequacy. Although the high cost of advanced nuclear SMR deterred us from having it in the preferred portfolio, we will continue to monitor the technology.

Table 3.1: Electric Preferred Portfolio, Resource Additions Incremental Nameplate Capacity (MW)

Resource Type	2024–2025 Incremental	2026–2030 Incremental	2030 Cumulative	2031–2045 Incremental	2045 Cumulative
Demand Side Resources	**201**	**417**	**618**	**646**	**1,265**
Conservation[1]	65	216	281	537	818
Demand Response	136	201	337	110	446
Distributed Energy Resources	**212**	**527**	**739**	**1,652**	**2,392**
DER Solar	172	380	552	1,572	2,124
Net Metered Solar	*59*	*225*	*284*	*1,109*	*1,393*
CEIP Solar	*79*	*-*	*79*	*-*	*79*
New DER Solar	*34*	*155*	*189*	*463*	*652*
DER Storage[2]	40	147	187	80	267
Supply Side Resources	**1,337**	**4,023**	**5,360**	**5,814**	**11,174**
CETA-qualifying Peaking Capacity[3]	237	474	711	877	1,588
Wind	600	800	1400	2,250	3,650
Solar	100	600	700	1,590	2,290
Green Direct	-	100	100	-	100
Hybrid (Total Nameplate)	300	1,150	1450	298	1,748
Hybrid Wind	*100*	*500*	*600*	*200*	*800*
Hybrid Solar	*100*	*300*	*400*	*-*	*398*
Hybrid Storage	*100*	*350*	*450*	*100*	*550*
Biomass	-	-	-	-	-
Nuclear	-	-	-	-	-
Standalone Storage	100	900	1000	800	1,800
Total	**1,750**	**4,967**	**6,717**	**8,112**	**14,830**

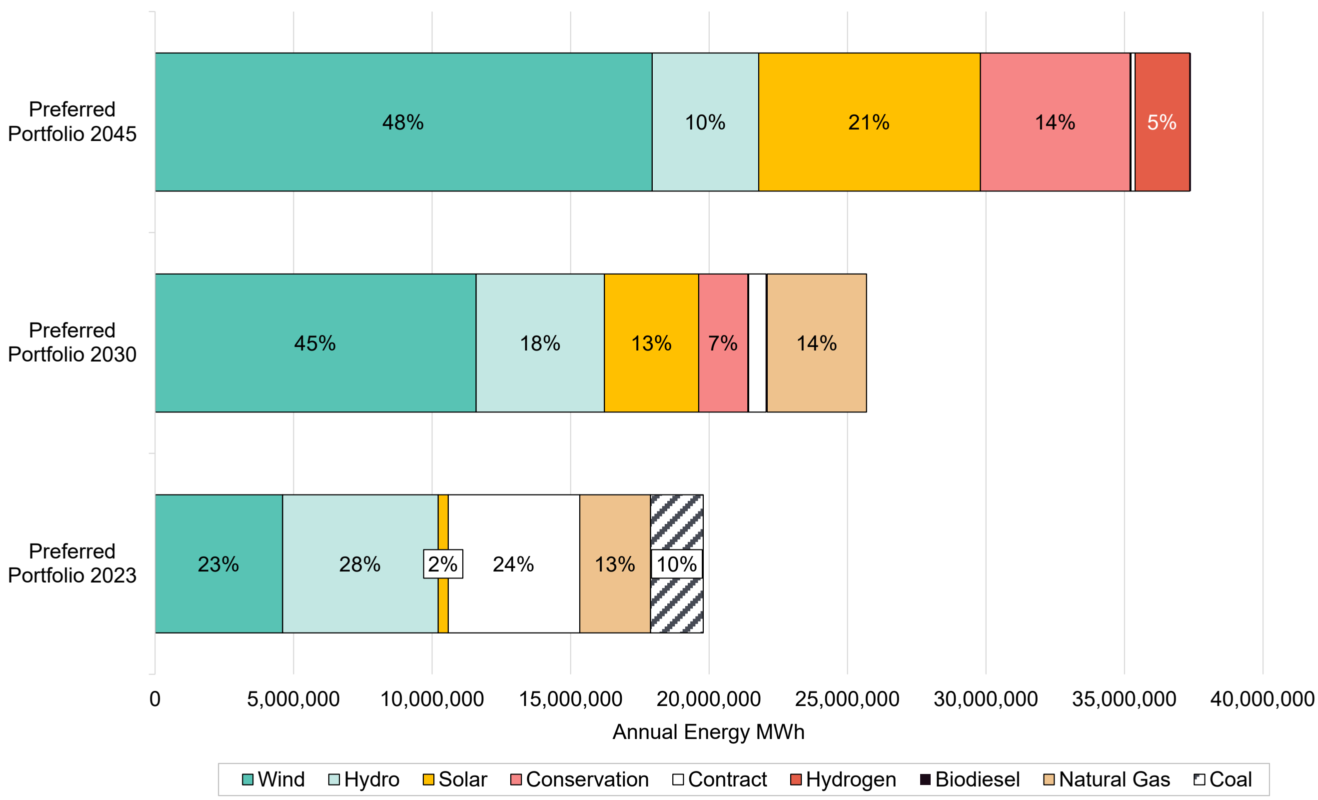
Notes:

1. Conservation in winter peak capacity includes energy efficiency, codes and standards, and distribution efficiency.
2. Distributed Energy Resources (DER) storage includes CEIP storage additions, non-wires alternatives, and distributed storage additions.
3. CETA-qualifying peaking capacity is functionally like natural gas peaking capacity but operates using non-emitting hydrogen or biodiesel fuel.

Figure 3.1 illustrates the projected annual energy production in 2023 and the future with the preferred portfolio. Wind resources are the largest share of capacity additions in the preferred portfolio, accounting for 36 percent of all energy-producing resources added to the planning horizon. However, wind resources produce 48 percent of the total annual energy in 2045, far more than its nameplate capacity indicates. Conversely, CETA-qualifying peaking capacity accounts for 13 percent of nameplate capacity (excluding storage) added by 2045 but supplies only 6 percent of the annual energy in 2045. Figure 3.1 illustrates that with the preferred portfolio, solar and wind remain the primary energy supply for meeting CETA, supplying nearly 70 percent of the portfolio's

CETA qualifying peaking capacity is functionally like natural gas peaking capacity but operates using non-emitting hydrogen or biodiesel fuel. We describe CETA qualifying peaking capacity in Chapter Five: Key Analytical Assumptions, and present alternative fuel assumptions in Appendix D: Generic Resource Alternatives. **RCW 19.405.020 (34)** annual energy in 2045. While CETA-qualifying peaking capacity resources are essential for resource adequacy, as discussed later in this chapter, they don't contribute substantially to the CETA-qualifying energy need.

Figure 3.1: Forecasted Annual Energy Production (Excluding Storage Dispatch)



2.2. Meeting Future Growth

The 2023 Electric Report shows we will meet future sales growth by combining utility-scale, demand-side (conservation), and distributed energy resources (DERs) described in Table 3.1. Distributed energy resources include storage systems, solar generation, or demand response that provides specific benefits to the transmission and distribution systems and simultaneously supports resource needs. The role of DERs in meeting system needs is changing, and the planning process is evolving to reflect that change. Distributed Energy Resources make lower peak capacity contributions and have higher costs. However, they are essential in balancing utility-scale renewable investments, transmission constraints, and local distribution system needs. The 2023 analysis also shows these resources enable larger equity benefits.

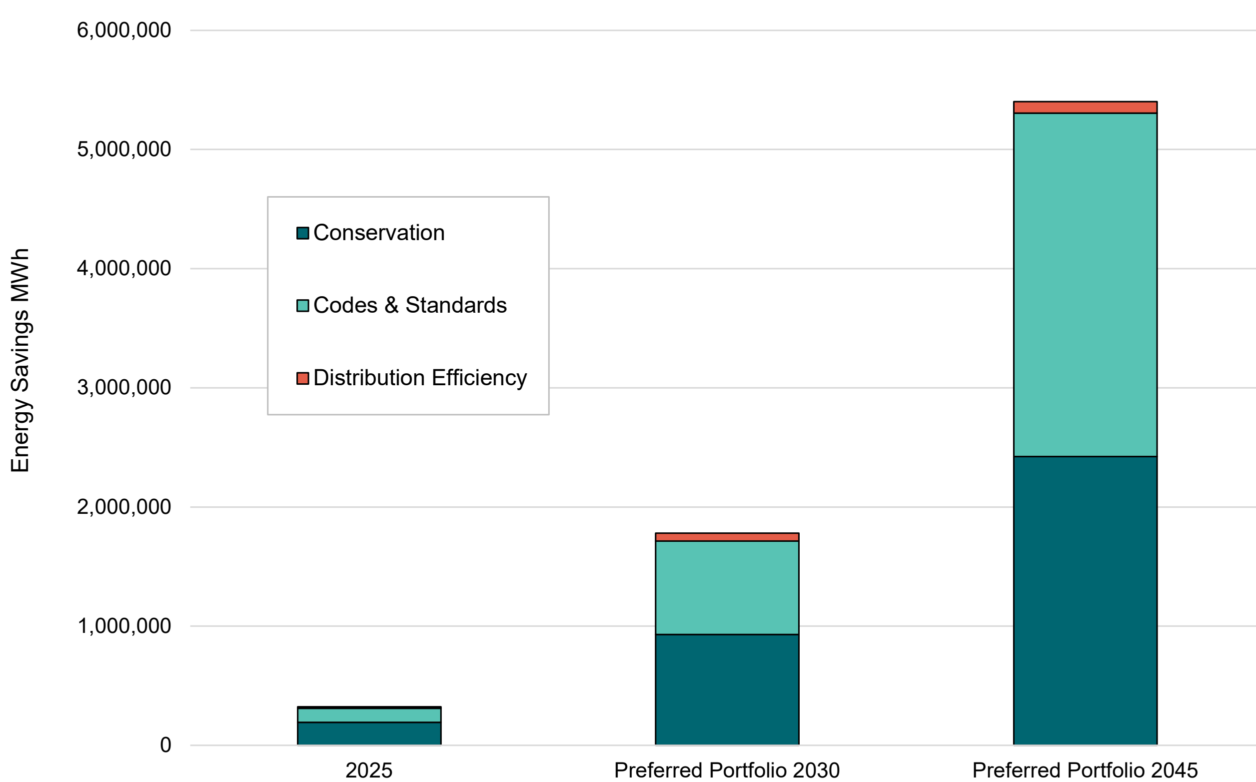
In the following section, we detail how the combination of resources in this plan will meet demand growth.

2.2.1. Conservation

For this analysis, conservation includes new energy efficiency measures, new codes and standard gains in efficiency, and distribution efficiency. Figure 3.2 describes the new energy savings from the preferred portfolio conservation measures.

➔ Appendix E: Conservation Potential Assessment contains a detailed discussion of the building codes and energy efficiency measures we modeled.

Figure 3.2: Preferred Portfolio Conservation Savings (MWh)

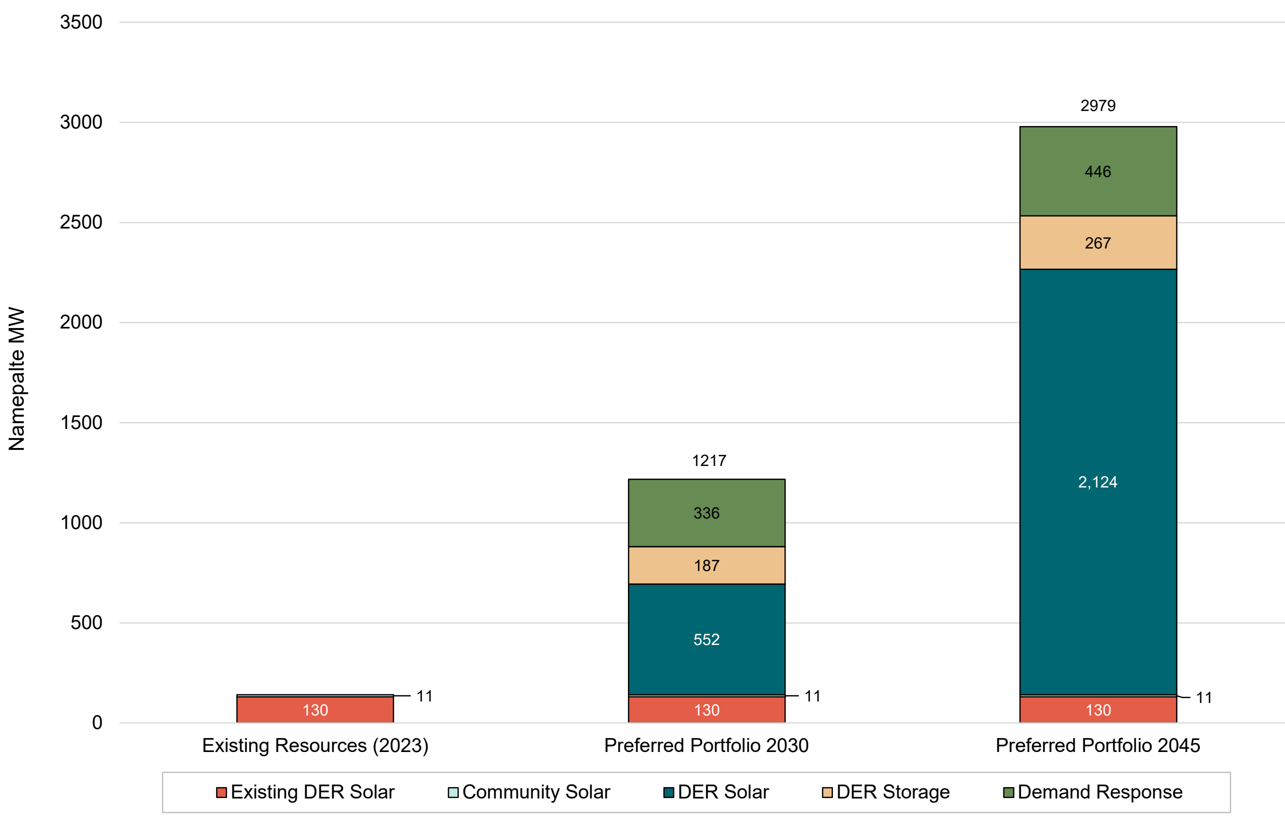


2.2.2. Distributed Energy Resources

Distributed energy resources are any resources located below the substation level. The customer or PSE can install DER. We included demand response, solar, and energy storage as distributed resources for this analysis. Our system includes 130 MW of customer-installed rooftop solar through net metering and 11 MW of community solar. We estimate we will add 552 MW of distributed solar and 187 MW of storage to the portfolio by 2030, growing to 2,124 MW of solar and 267 MW of energy storage by 2045. Demand response programs are peak savings options offered to customers, including direct load control for indoor heating and air conditioning thermostats and water heaters, managed electric vehicle charging, and critical peak pricing. Some distributed resources cost more than utility-scale programs but potentially enable larger equity benefits. Thoughtfully implemented, distributed resources can enable more equitable outcomes for customers in the clean-energy transition. We considered DERs necessary when developing our preferred resource plan, as discussed in Section 4 of this chapter.

Figure 3.3 shows the distributed resource capacity added to the preferred portfolio.

Figure 3.3: Preferred Portfolio Distributed Resource Additions (Nameplate MW)



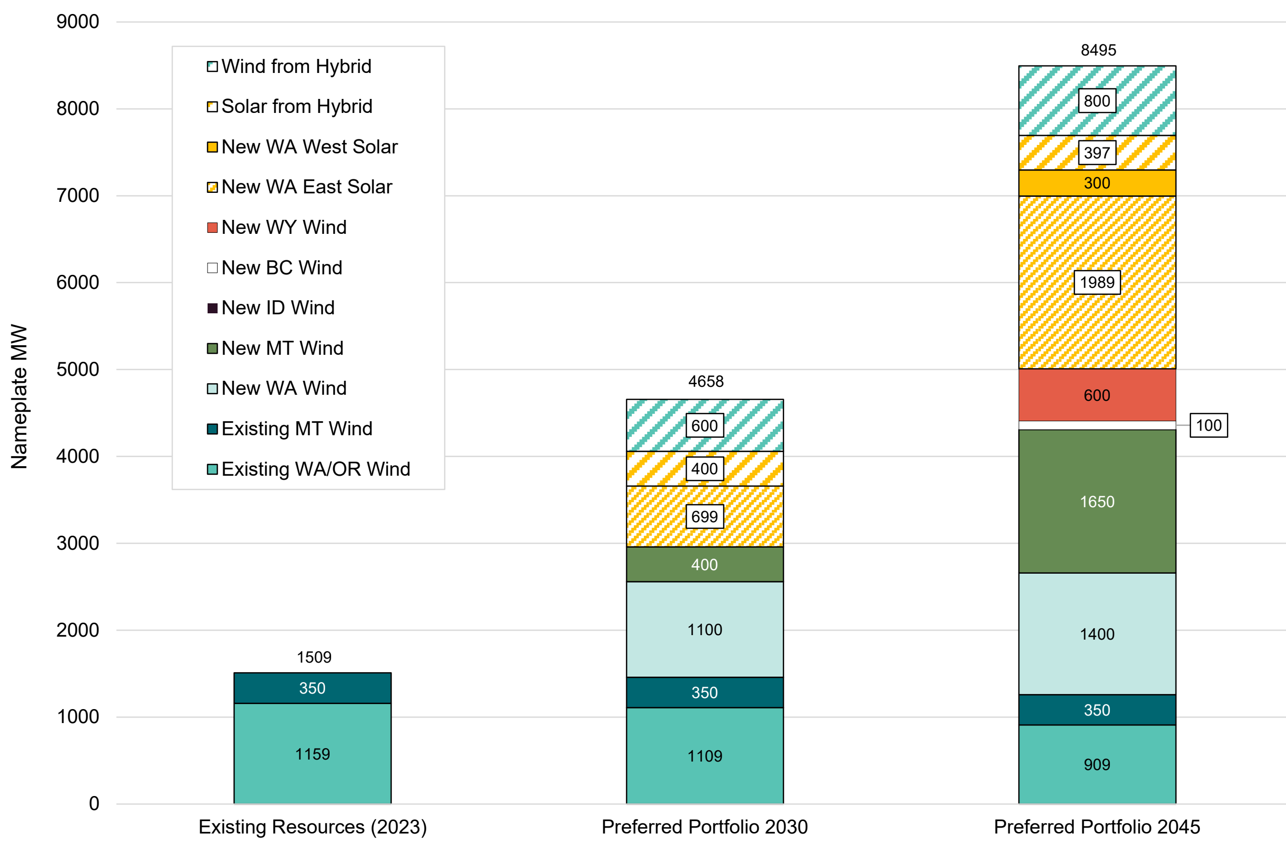
2.2.3. Clean Energy Resources

Qualifying clean energy (renewable and non-emitting) resources under CETA include wind, solar, advanced nuclear SMR, and alternative fuels such as biodiesel and hydrogen. Along with distributed energy resources, we must add many large utility-scale resources to the portfolio to meet the clean energy requirements. Figure 3.4 presents the utility-scale renewable resource additions in the preferred portfolio.

The scale and diversity of renewables PSE needs will require access to renewables outside Washington State and around the Pacific Northwest region, such as Montana, Wyoming, Idaho, and British Columbia. We will work to optimize our existing regional transmission portfolio to meet our growing need for renewable resources in the near term. However, the Pacific Northwest transmission system likely will need to be significantly expanded, optimized, and possibly upgraded to keep pace with the growing demand for clean energy. Puget Sound Energy will have to invest in the transmission system to deliver energy to customers from the edge of our territory and support the integration of distributed energy resources and demand response within the delivery grid.

The preferred portfolio adds almost 3,200 MW of new wind and solar resources to meet the CETA clean energy requirements by 2030. Of the 3,200 MW of wind and solar additions, 2,800 MW are resources in Washington State that will need cross-Cascades transmission. The remaining 400 MW are in Montana and will use Montana transmission.

Figure 3.4: Preferred Portfolio Wind and Solar Additions (MW)



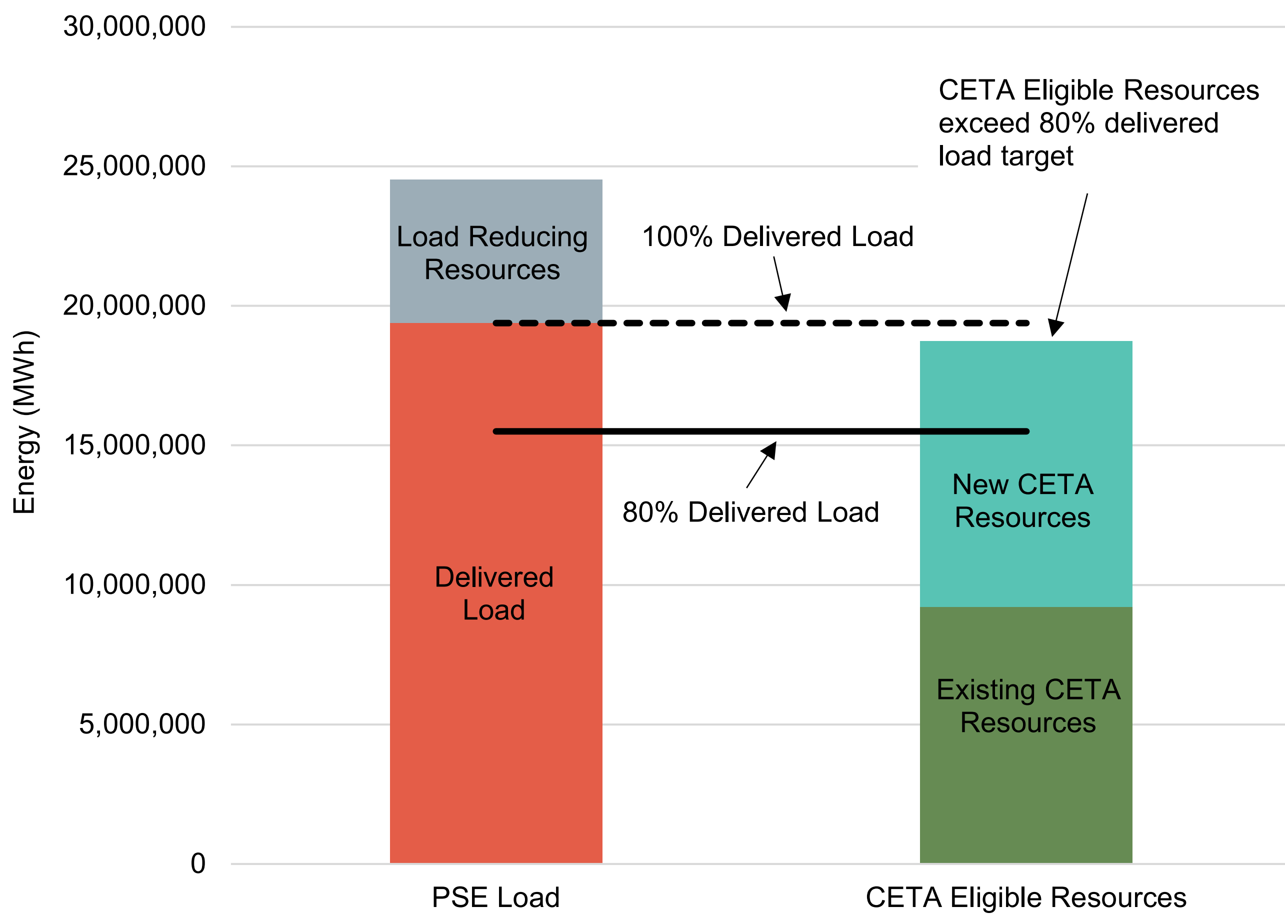
Risk of Meeting CETA Requirements

In 2030, we must meet at least 80 percent of retail sales with renewable or non-emitting resources. Figure 3.5 is the breakdown of the 2030 CETA requirement. As we can see from the chart, the preferred portfolio is well above the 80 percent requirement. For CETA compliance, we take the requirement on the adjusted retail sales after conservation, demand response, PURPA contracts[1], and voluntary renewable programs, including solar net-metering, Green Direct, and community solar. The gray bar in the chart represents the load-reducing resources, and the red bar is retail sales

[1] Public Utility Regulatory Policy Act (PURPA) qualifying facilities (QFs) are smaller generating units that use renewable resources, such as solar and wind energy, or alternative technologies, such as cogeneration.

after adjustment for load-reducing resources. The top of the red bar would be 100 percent, and the black line is 80 percent of the retail sales.

Figure 3.5: CETA Compliance in 2030 (Annual Energy MWh)



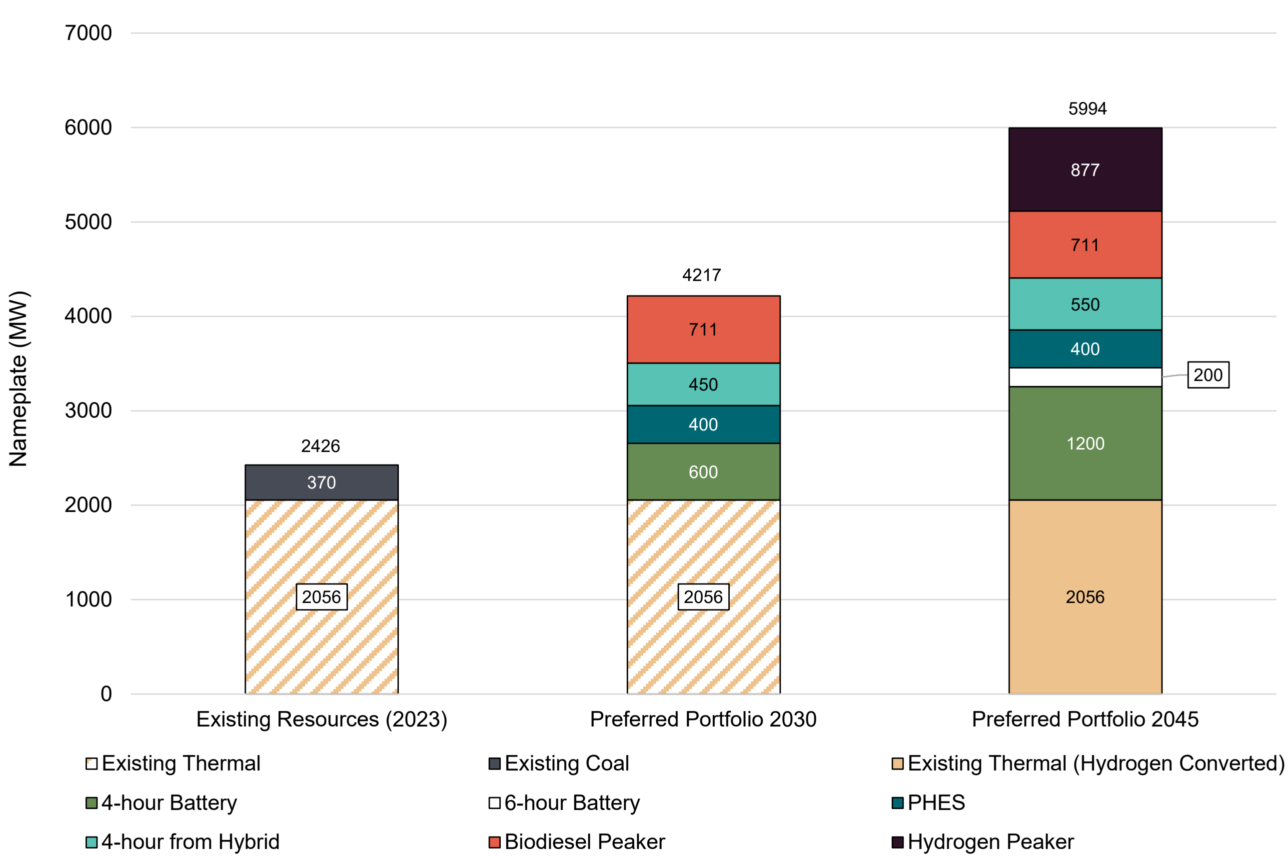
As part of the stochastic risk analysis, one of the future risks tested was whether the preferred portfolio would meet the CETA requirements under different conditions, such as changes in the demand forecast, hydroelectric generation, wind generation, and solar generation. Under all these conditions, renewable resource generation stays well above the base target for annual energy, ranging in 2030 from 80 percent at the lowest to 124 percent on the highest end, with half of the forecasted simulations in the range of 93 percent to 105 percent.

➔ Chapter Eight: Electric Analysis presents a complete discussion of the stochastic portfolio analysis.

2.2.4. Capacity Resources

Qualifying resources under CETA analyzed in this report include peaking capacity, energy storage, and advanced nuclear SMR. The peaking capacity we modeled includes CETA-qualifying fuels such as biodiesel and hydrogen, referred to herein as CETA-qualifying peaking capacity. We assumed hydrogen fuel would be available starting in 2030. We assumed natural gas to hydrogen blending would begin at 30 percent hydrogen in 2030 and increase to 100 percent by 2045. We left more than 2,000 MW of existing thermal resource capacity in the portfolio and converted it to hydrogen to maintain system reliability through resource adequacy. We modeled existing thermal resources with an option to retire them economically or convert them to hydrogen starting in 2030. As shown in Figure 3.6, the model added three additional peakers that will use biodiesel as fuel by 2030 and more than 800 MW of new hydrogen peakers by 2045. The model selected 1,450 MW of new energy storage by 2030, growing to 2,350 MW by 2045 to help meet resource adequacy and ancillary services. Energy storage resources are not energy-producing resources; they store the energy produced from other resources to be available during peak hours.

Figure 3.6: Preferred Portfolio CETA-qualifying Capacity Additions (Nameplate MW)



Hydrogen Fuel Risk

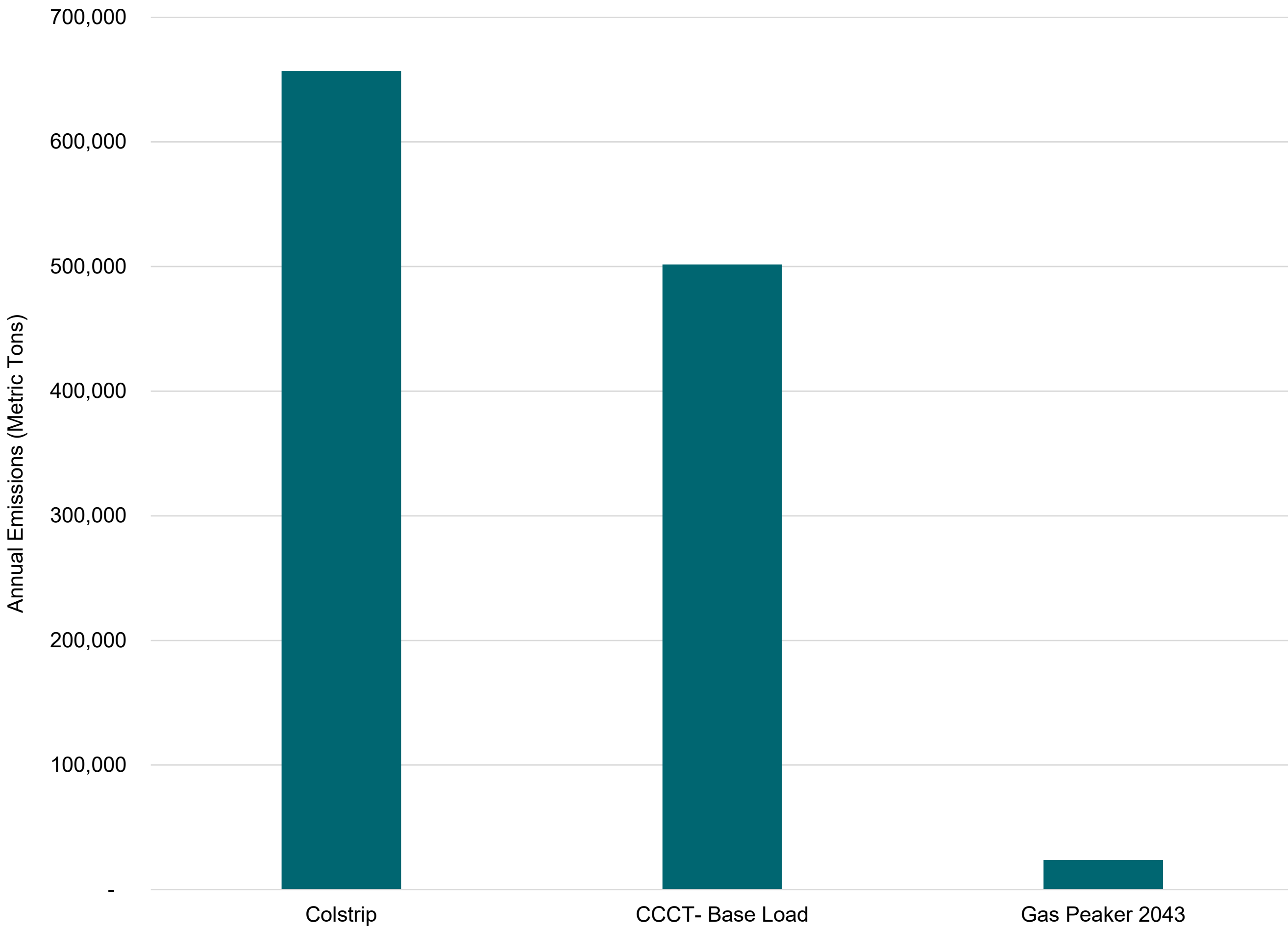
Green hydrogen has the potential to aid in the decarbonization of the electric sector without compromising reliability standards. Electrolyzers convert surplus renewable energy to hydrogen gas, which is stored for long periods until it is needed during a peak event. During a peak event, green hydrogen is combusted with either retrofitted existing equipment or at new peaking plants. Until recently, high costs have dissuaded development of hydrogen infrastructure for the energy sector, but production tax credits included in the Inflation Reduction Act have the potential to put green hydrogen in cost-parity with more conventional fuels.

In the preferred portfolio, the new hydrogen peakers start in 2039, giving us several years to understand the fuel supply before making resource acquisitions. Integrated Resource Plan meeting participants asked, "What if PSE built peakers assuming they blend to full hydrogen, but hydrogen is not available as planned?" First, we would not start building or acquiring a hydrogen peaker until 2035, which gives us more time to understand the hydrogen supply and availability. Second, we can build dual-fueled peakers using biodiesel as a backup fuel. Puget Sound Energy has eight peaking units with a backup fuel supply. We are experts in the process and requirements to set up and maintain a backup fuel supply. Like the existing peaker units, the backup is available in a tank on the property in case of primary fuel supply interruptions. Puget Sound Energy holds a place on the board of the Pacific Northwest Hydrogen Association and is working with other regional parties to explore development of a hydrogen production facility at the former Centralia coal mine in Centralia, Washington.

➔ A discussion of the work that PSE is doing on Hydrogen is in Chapter Two: Clean Energy Action Plan.

Finally, we looked at what would happen in a worst-case scenario where the frame peaker had to run on natural gas. In this event, for the limited hours the plant must run for peak contribution, the equivalent forecasted emissions would be 16,000 metric tons annually. Figure 3.7 illustrates the equivalent emissions on an equal-sized coal-fired plant (Colstrip) and a combined cycle combustion turbine (CCCT) baseload gas plant for comparison.

Figure 3.7: Annual Greenhouse Gas Emissions based on equivalent 237 MW (Metric tons CO2e)



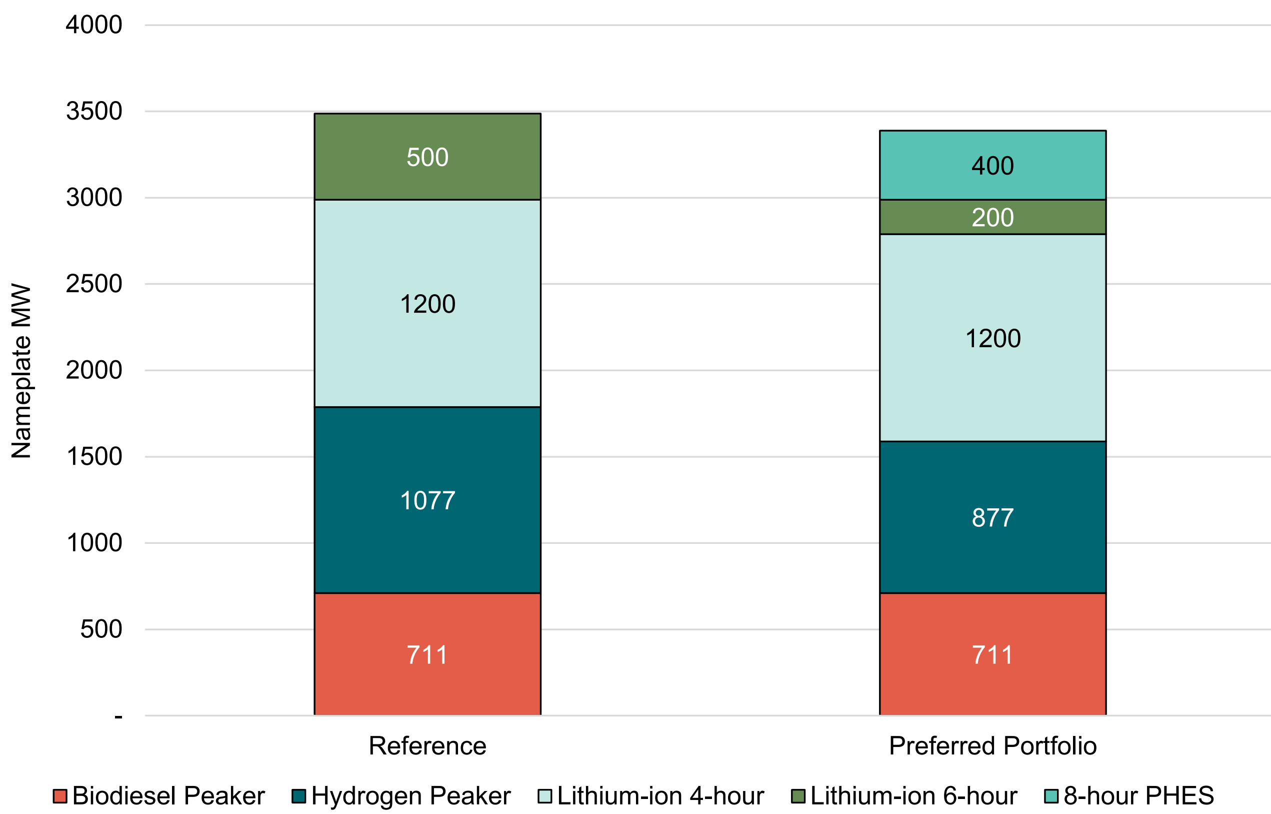
2.3. Diversifying the Portfolio

As PSE and the region seek to decarbonize systems, the future of electricity is a diverse portfolio of renewable and non-emitting resources. A diverse energy mix is essential for energy security because it is less dependent on a single fuel source, reducing vulnerabilities due to market price, supply fluctuations, and political unrest. Multiple, reliable generation sources allow a utility to provide power without disruption if one energy source fails. A diverse portfolio can reduce environmental impacts, improve reliability, and promote innovation to meet the needs of more than 1.5 million PSE customers. Resource diversity is the key to reducing emissions while preserving reliability and affordability.

The initial least-cost reference portfolio we developed for the 2023 Electric Report relies primarily on a few resources because we designed the model to select the lowest-cost resources available. However, we need to consider factors such as risk and feasibility when considering resources to include in the preferred portfolio. For example, the least-cost reference portfolio relies heavily on 4-hour batteries and hydrogen as a fuel because 4-hour batteries are the lowest-cost energy storage resource, and hydrogen is the lowest-cost, CETA-qualifying fuel source for thermal resources. To develop the preferred portfolio, we adjusted the least-cost reference portfolio to bring more diversity and lower its inherent technology and feasibility risks.

Figure 3.8 shows how we adjusted the storage resources in the preferred portfolio from the reference case to create a diverse portfolio that relies on multiple resources to meet demand. Figure 3.8 shows how diversifying storage resources results in less hydrogen peaker capacity.

Figure 3.8: New Energy Storage and Peaking Capacity Nameplate Additions by 2045 (MW)



Energy Storage

The least-cost reference portfolio will add 1,000 MW of four-hour batteries by 2030 because they are the lowest-cost energy storage resources. We adjusted the types of energy storage resources for the preferred portfolio to include more diverse technologies. For the preferred portfolio, we added 200 MW of pumped hydroelectric energy storage (PHES) in Montana and 400 MW of new Montana wind along with the existing 350 MW of wind. We added 200 MW of PHES in the Pacific Northwest to the preferred portfolio for 400 MW of PHES. The remaining energy storage is a mix of four-hour and six-hour batteries.

Advanced Nuclear Small Modular Reactors

In the least-cost reference portfolio, we modeled building more than 800 MW of new hydrogen peakers by 2045 in addition to the 2,000 MW of existing resources converted from natural gas to hydrogen. By 2045, we projected hydrogen to account for 36 percent of the peak capacity contribution. This least-cost reference portfolio relies heavily on a single fuel source with an unknown supply, creating risk. To diversify the portfolio, we can explore other technologies, such as advanced nuclear SMR, to include in future preferred portfolios. There are many unknowns around new advanced nuclear SMR technology. Although the high cost of advanced nuclear SMR deterred us from having it in the preferred portfolio, we will continue to monitor the technology. As advanced nuclear SMR technology matures, it could be a resource to help reduce the risks of relying on only a few technologies and a way to meet the CETA 100 percent requirement by 2045.

3. Resource Adequacy

The Pacific Northwest electricity industry is transitioning as governments and system planners implement major decarbonization policies. Operators and utilities are retiring significant quantities of coal-fired capacity while adding new renewable generation resources. As a result, PSE and other utilities are rethinking how we plan our systems, especially concerning resource adequacy. As we transition to 100 percent clean energy by 2045, we must ensure customers have reliable electricity and smoothly transition to a decarbonized system.

The resource adequacy analysis for this 2023 Electric Report resulted in a capacity deficit of 2,629 MW, more than double the 2021 IRP capacity deficit projected for 2029. This large deficit drives the large capacity additions in the preferred portfolio. This section describes the elements contributing to this deficit, including updates to the planning reserve margin, our reduction in market reliance, and variable resource peak capacity contributions.

3.1. Planning Reserve Margin Updates

The resource adequacy analysis for this 2023 Electric Report led us to increase the planning reserve margin to 23.8 percent in 2029, resulting in a capacity deficit of 2,629 MW. Two main elements contributed to the rise in the planning reserve margin:

- Climate change data in the load forecast and peak temperatures — when we accounted for average temperature trends, it only slightly lowered the one-in-two winter peak and increased the summer peak. Although summer peak temperatures increased, they do not come close to the winter peak level in this

2023 Electric Report's planning horizon. However, temperature volatility increased, which we accounted for in the resource adequacy and contributed to the overall increase in the planning reserve margin.

- Increase in peak demand — although the one-in-two winter peak lowered slightly, the updated electric vehicle (EV) forecast increased the demand. The increase in peak from the EV forecast was larger than the decrease from the climate change data, resulting in an overall increase to the one-in-two peak demand.

Climate change data also showed changes in the duration and frequency of loss of load events, which affected the capacity deficit. The data showed a decrease in event duration, less frequent events in the winter and more frequent events in the summer. Including climate change data increased the effective load-carrying capacity (ELCC) for solar and shorter-duration storage resources (those that discharge energy at the rated power output for less than 10 hours). Climate change data also shows the historical spring runoff is happening earlier in the year, which changes hydropower availability and the profile of hydroelectric generation and leaves less water for the summer.

3.2. Reduced Market Reliance

The western energy market has had surplus capacity for more than a decade. Given PSE's available firm transmission to the Mid-Columbia market hub, purchasing energy supply from the regional power market has been a cost-effective way to meet demand. However, the supply and demand fundamentals of the wholesale electric market have changed significantly in recent years in two important ways: supplies have tightened, and pricing volatility has increased.

In response to these changing conditions, we plan to replace short-term market supplies with firm resource adequacy qualifying capacity contracts compliant with CETA, meet our resource adequacy requirements, and align with a potential regional resource adequacy program. The preferred portfolio includes added firm capacity resources and reduced short-term market purchases.

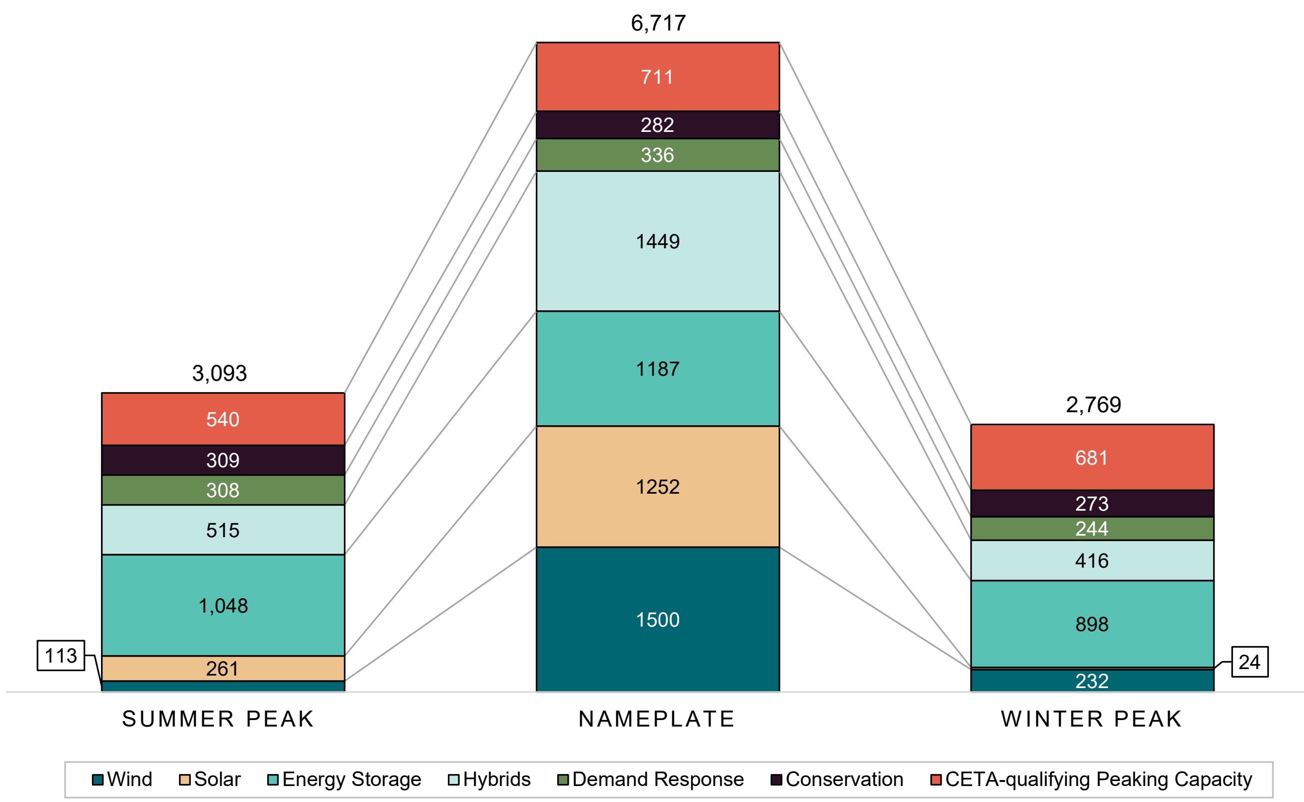
Our approach allows us to survey the market for available resource adequacy qualifying agreements and enables us to develop regional resource adequacy program requirements to help inform PSE's future needs. Given the tightening of energy markets and our preparations for possible participation in the Western Resource Adequacy Program (WRAP), we plan to reduce PSE's reliance on short-term wholesale market purchases.

This approach has challenges, such as permitting and building generating and storage resources and transmission to meet growing demands in an increasingly complex permitting landscape. Although those challenges are real, we are confident the resource plan in this 2023 Electric Report indicates a path to reach our clean energy goals and achieve the clean energy future our customers expect.

3.3. Peak Capacity Contribution

Electric resources, particularly variable resources such as solar and wind, rarely perform at nameplate capacity during peak need. Therefore, ensuring resource adequacy relies on evaluating a resource's peak capacity contribution, which is the nameplate capacity combined with the ELCC. After adjusting for the peak capacity contribution of each resource, we need more resources to meet the peak need than the nameplate capacity suggests. For example, solar's 24 MW peak capacity contribution requires over 1100 MW of installed nameplate capacity. After adjusting for peak capacity contribution, over 6,700 MW of new resources installed nameplate capacity adjusts to over 3,000 MW summer peak capacity and over 2,700 MW winter peak capacity, as detailed in Figure 3.9.

Figure 3.9: Nameplate Capacity Adjusted to Peak Capacity Contributions (MW)



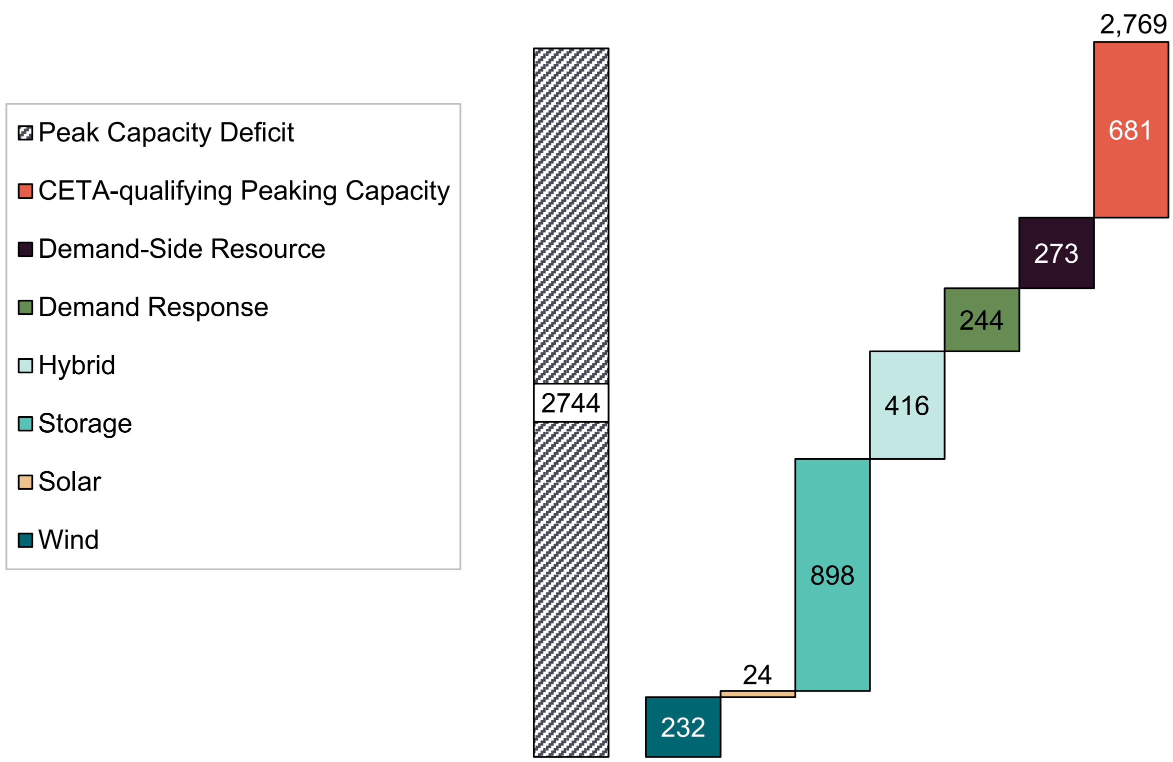
3.3.1. Winter Peak Drives Resource Capacity Additions

We analyzed summer and winter peak capacity. Consistent with prior years, the winter peak is higher than the summer peak. We noted that the increase of renewable energy and energy storage in the preferred portfolio contributed to meeting the summer peak need better than they contributed to the winter. For example, solar has a four percent peak capacity contribution in the winter but a 55 percent contribution in the summer. We added solar to the portfolio because it meets the CETA requirement and the summer peak need, but it does very little to meet the winter peak need. Given that the preferred portfolio meets the 2030 CETA target and renewable resource additions meet the summer peak capacity need, the winter peak need drives new peaking capacity in the preferred portfolio. The preferred portfolio builds 711 MW of CETA-qualifying peaking nameplate capacity by 2029 (Table 3.1), and assuming a 96 percent ELCC in winter (see Appendix D: Generic Resource Alternatives for operating assumptions), this adds 681 MW of peaking capacity. These additions balance the winter peak and create more than 250 MW summer peak surplus.

Figure 3.10 shows the breakdown of the effective winter peak capacity contribution for new resources. Note that this figure combines the nameplate capacities provided in Table 3.1 with respective ELCCs found in Appendix D: Generic Resource Alternatives.

➔ Please see Chapter Seven: Resource Adequacy Analysis for a detailed winter and summer peak needs discussion.

Figure 3.10: Meeting Winter Peak Need for 2030 — New Resource Additions Effective Capacity (MW)



4. Developing the Preferred Portfolio

This section describes how we developed candidate diversified portfolios. We also discuss the trends we observed across all candidate diversified portfolios in the near- and long-term and evaluate the costs of each candidate diversified portfolio. Finally, we present the results of our portfolio benefit analysis and summarize the selection of our preferred portfolio.

4.1. Candidate Diverse Portfolios

The first step to developing a preferred portfolio is to start with a least-cost portfolio. A least-cost portfolio meets constraints in a lowest-cost way. These constraints are:

- CETA renewable and clean-energy requirements
- Hourly customer demand for the year
- Peak capacity plus a planning reserve margin
- Reduced market reliance at peak
- Transmission access for new resources

The least-cost portfolio gave us a starting point which we then adjusted to identify a feasible portfolio of diverse resources that consider equity and create customer benefits while maintaining reliability and affordability. We refined the least-cost portfolio to maximize benefits and reduce burdens to vulnerable populations and highly impacted communities consistent with CETA. Figure 3.11 shows a progression of diversified portfolios ranging from the least diverse portfolio (11 A1) to the most diverse portfolio (11 A5), with each step adding a scheduled resource to increase the portfolio's diversity. We modeled portfolios 11 B1 and 11 B2 at the request of interested parties to exclude advanced nuclear SMR additions and are like the least and most diversified portfolios (11 A1 and 11 A5)

To create a diverse portfolio, we:

1. Start with the least cost reference portfolio,
2. Make incremental changes to the portfolio to test the sensitivity of the adjustment to resource builds and portfolio cost,
3. Create a portfolio with different options from part 2, considering equity, cost, feasibility, reliability, and diversity of energy supply.

Figure 3.11: Components of the Diverse Portfolios

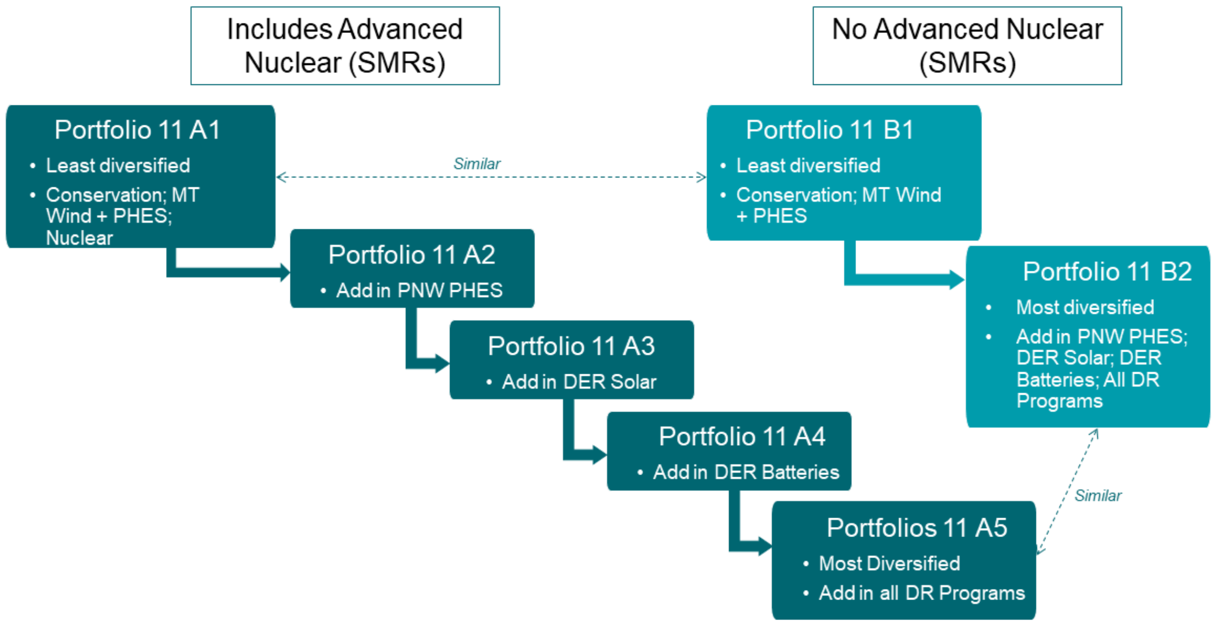
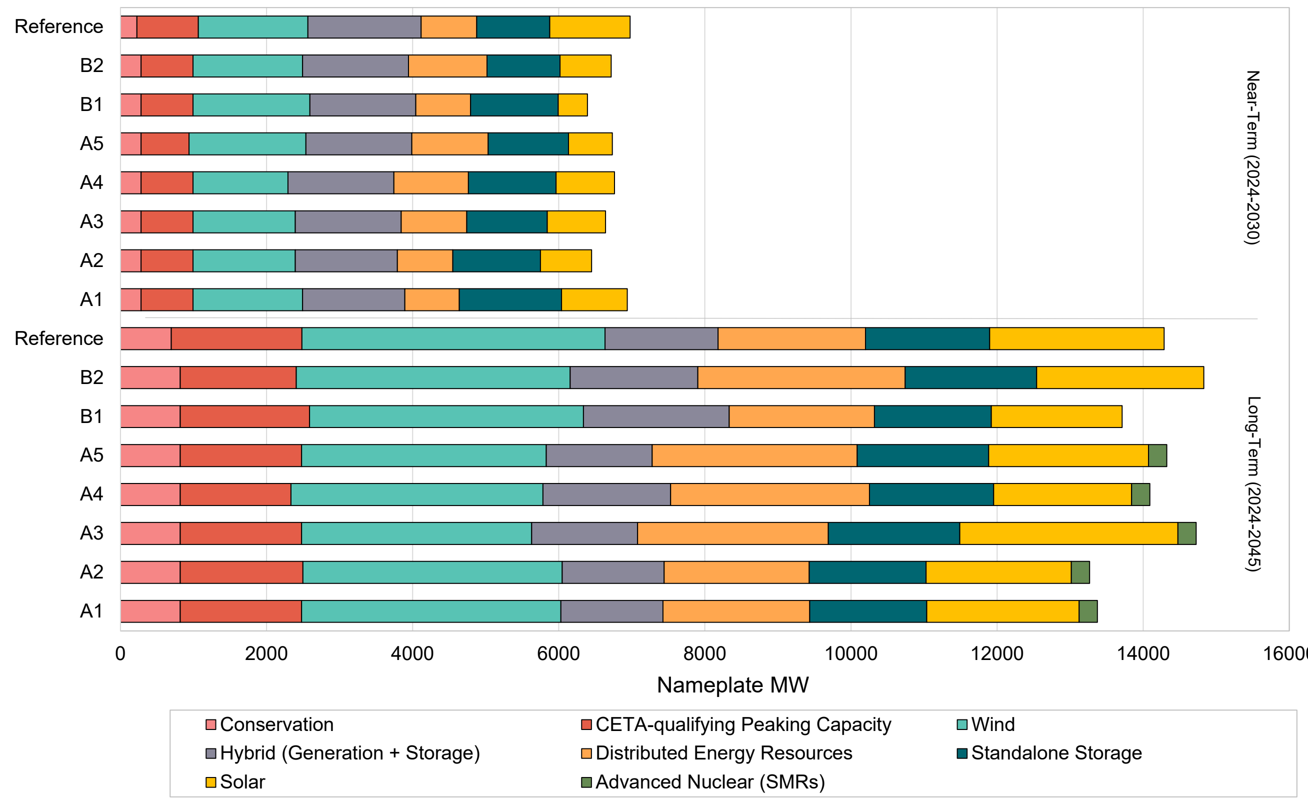


Figure 3.12 shows a breakdown of nameplate resource additions by portfolio. The portfolios are very similar in the near term (2024–2030). Puget Sound Energy needs many resources to meet CETA and resource adequacy, and there are few commercially available technologies today. All the diverse portfolios have equal amounts of conservation and CETA-qualifying peaking capacity, with the rest of the resources comprising demand response, wind, solar, energy storage, or a hybrid of renewable resources plus energy storage. For the longer term (2031–2045), the resource mix becomes more distinct between portfolios, although the need for conservation and CETA-qualifying peaking capacity is a stable addition across all portfolios.

Figure 3.12: Resource Builds (Nameplate MW)

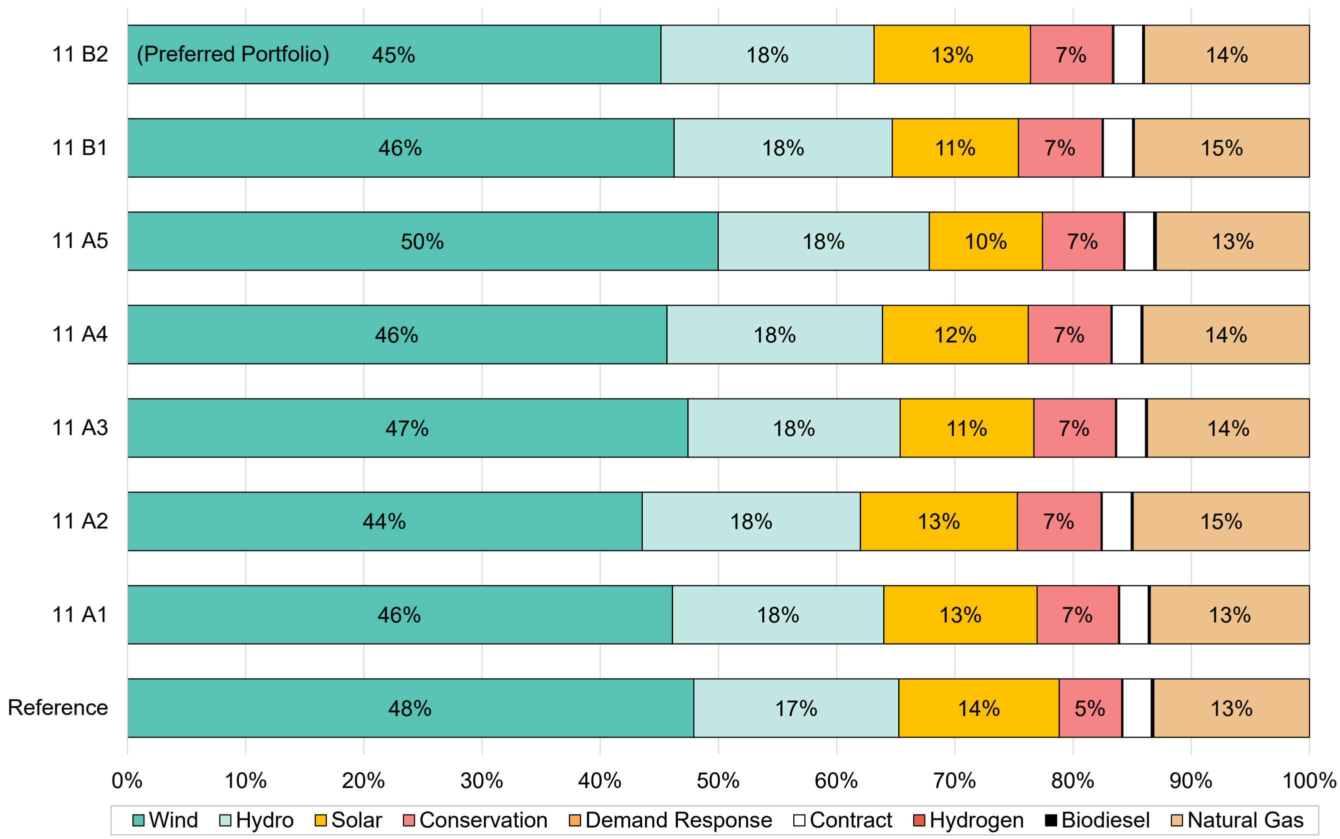


4.1.1. Near-term Resources (2024–2029)

The utility-scale and demand-side resource builds in the near term are similar across the diversified portfolios. In all the diversified portfolios, we need three peaking generation facilities by 2030 to maintain reliability as we add new variable resources. By 2030, we will add almost 1,500 MW of new energy storage to help meet resource adequacy and ancillary services. Energy storage resources are not energy-producing; they just store the energy produced from other resources, so it is available during peak hours. Given that we added more than 3,000 MW of variable energy resources by 2030 to meet the CETA requirements, we will need the energy storage resources to help store energy in low-demand hours to be used later in high-demand hours. The primary difference between the diversified portfolios is the amount of distributed energy resources. We listened to interested parties and PSE's Equity Advisory Group (EAG) and heard the importance of adding more distributed resources to the portfolio and increasing customer participation in these programs. However, no matter which portfolio we use for the preferred portfolio, the near-term resources are the same for utility-scale resources: we need to meet CETA requirements and resource adequacy, and there are limited options available to achieve these needs in the next six years.

Figure 3.13 presents each diversified portfolio's 2030 annual energy production by fuel type.

Figure 3.13: Annual Energy 2030 — Percent of Generation by Fuel Type

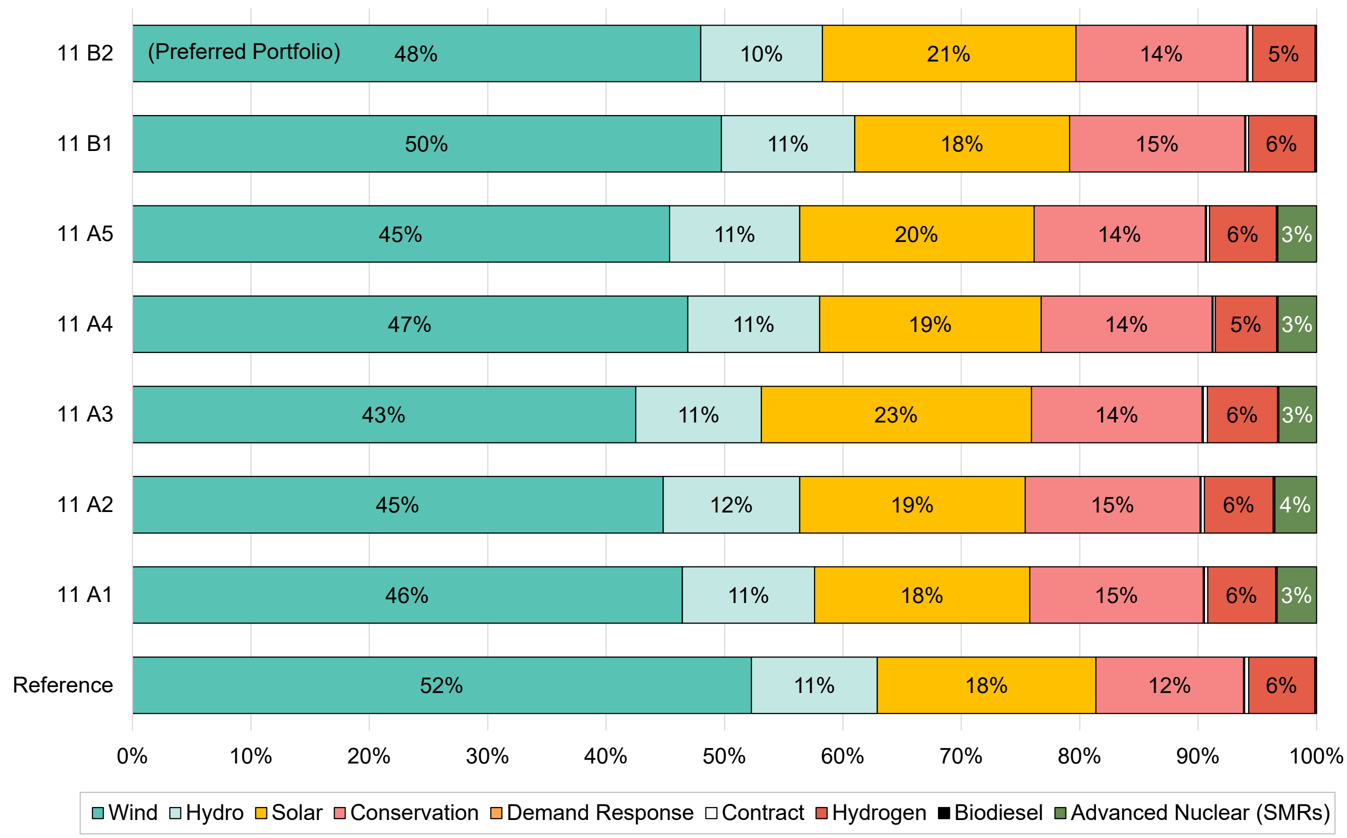


4.1.2. Long-term Resources (2030–2045)

As we look further into the future, the resources become less certain. Technological advancements are needed to achieve 100 percent clean energy by 2045. These advances could involve using alternative fuels such as hydrogen in combustion turbines or through advanced nuclear SMR technology. Both options are promising but present unique risks and costs. We will continue to explore these and other resource options in subsequent and future IRP cycles. Regardless of the technologies available long-term, it does not change near-term resources and resource options.

Figure 3.14 presents each diversified portfolio's 2045 annual energy production by fuel type.

Figure 3.14: Annual Energy 2045 – by Fuel Type (percent of generation)



4.1.3. Portfolio Costs

The portfolio costs include all those associated with construction, interconnection, transmission, fuel, and operations and maintenance of new generating resources, along with the costs to operate and maintain existing resources. We divided the portfolio costs into near-term resource additions before 2030 (Table 3.3) and longer-term, 21-year decisions for 2045 (Table 3.4). Figure 3.15 shows the annual portfolio costs for 2024–2029; annual portfolio costs for the entire planning period of 2024-2045 are in Chapter Eight: Electric Analysis.

In the near term, the combination of increasing distributed resources, conservation, demand response, and diversifying the portfolio delays adding one peaking generation facility until after 2030 but increases the cost over the reference case by $700–$880 million in the next six years.

Figure 3.15: Annual Portfolio Costs with Emissions 2024–2029 ($ Billions)

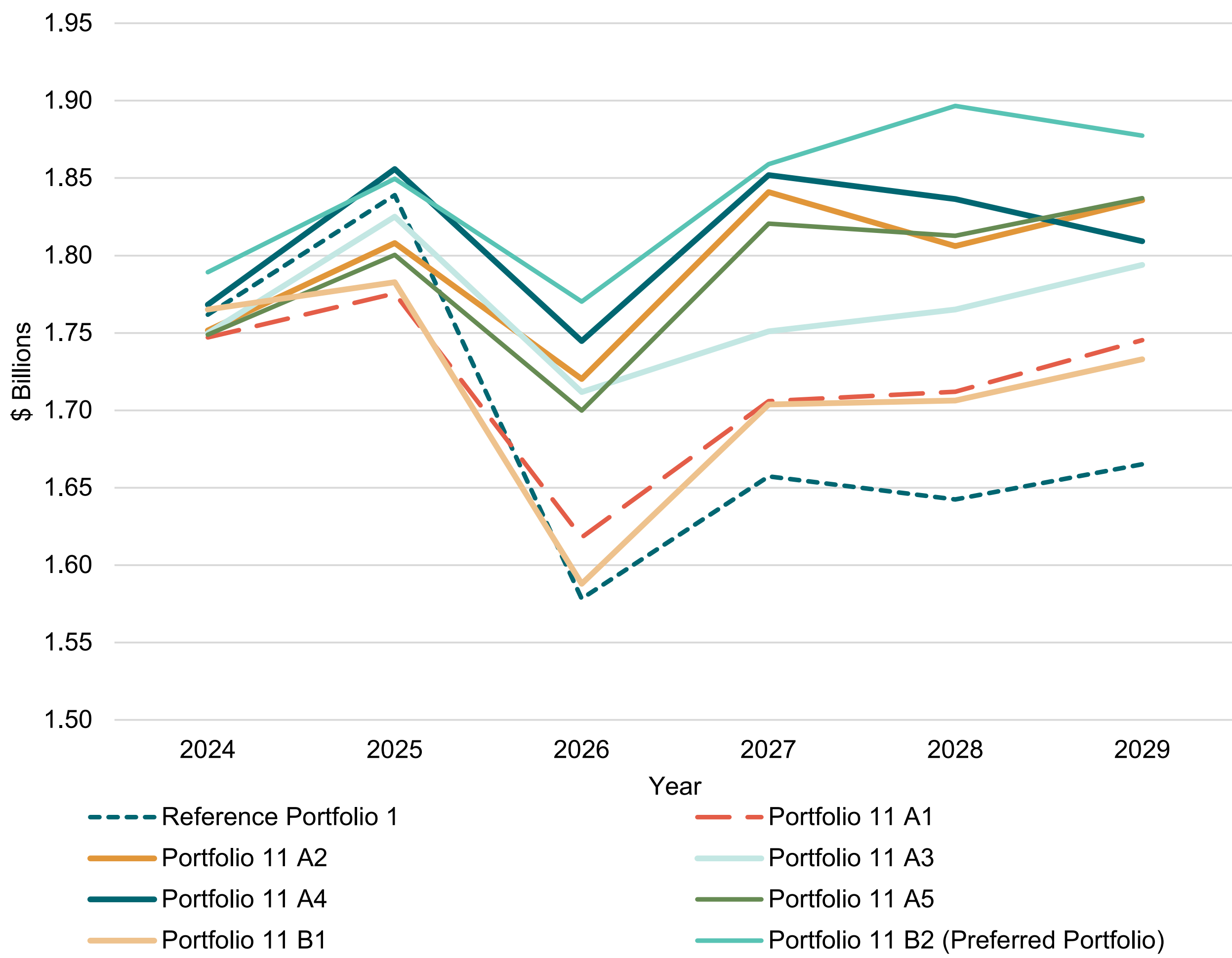


Table 3.3: Near-term (6-year) Net Present Values — 2024–2029 ($ Billions)

Portfolio	Portfolio Cost with SCGHG	Portfolio Cost without SCGHG	Social Cost of Greenhouse Gases (SCGHG)
Reference	8.14	6.05	2.08
11 A1	8.24	6.49	1.75
11 A2	8.59	6.70	1.89
11 A3	8.47	6.67	1.80
11 A4	8.68	6.75	1.93
11 A5	8.55	6.75	1.80
11 B1	8.22	6.32	1.91
11 B2 (Preferred Portfolio)	8.81	6.93	1.88

In the long-term, adding these distributed resources to the portfolio increases the cost over the reference case by $1.7 - $2.8 billion, as seen in portfolios 11 B1 and 11 A5, respectively (Table 3.4).

Diversifying the portfolio and increasing equity metrics through increased distributed resources, as described in Section 2.4.2, increases the cost of the portfolio both in the near- and long-term time horizon.

Table 3.4: Long-term (21-year) Net Present Values — 2024–2045 ($ Billions)

Portfolio	Portfolio Cost with SCGHG	Portfolio Cost without SCGHG	Social Cost of Greenhouse Gases (SCGHG)
Reference	17.61	20.85	3.24
11 A1	20.01	22.83	2.82
11 A2	20.32	23.25	2.93
11 A3	20.44	23.27	2.83
11 A4	20.74	23.64	2.90
11 A5	20.89	23.67	2.78
11 B1	18.09	21.09	3.00
11 B2 (Preferred Portfolio)	19.56	22.51	2.95

➔ Chapter Eight: Electric Analysis presents a complete discussion of portfolio sensitivity cost.

4.2. Portfolio Benefit Analysis

The Clean Energy Transformation Act requires utilities to consider equity and ensure all customers benefit from the transition to clean energy. However, AURORA, a traditional production cost model we use for portfolio modeling, only solves the least-cost solution. Therefore, we developed and used a portfolio benefit analysis tool to support our understanding of equity-related benefits and the associated costs within each portfolio and inform our work as we strive to select a portfolio best suited to enable equitable customer outcomes while also considering the cost. The preferred portfolio provides the best pathway to improve equitable outcomes of all our portfolios evaluated in this 2023 Electric Report. This outcome was driven primarily by increasing customer opportunities to participate in distributed energy and demand response programs.

The portfolio benefit analysis tool measures potential equity-related benefits to customers within a given portfolio and the tradeoff between those benefits and overall cost. We evaluated these benefits using quantitative customer benefit indicators (CBIs) and their metrics. Customer Benefit Indicators are quantitative and qualitative attributes we developed for the 2021 CEIP in collaboration with our Equity Advisory Group (EAG) and interested parties. These CBIs represent some of the focus areas in CETA related to equity, including energy and non-energy benefits, resiliency, environment, and public health.

For this 2023 Electric Report, we evaluated each portfolio using a subset of the CBIs proposed in the 2021 Clean Energy Implementation Plan, which as of this date, is still pending Washington Utilities and Transportation Commission (Commission) approval. We selected the subset of CBIs based on whether the AURORA modeling tool could quantitatively evaluate them, i.e., AURORA already had a comparable metric. The CBIs we included in the portfolio benefit analysis are:

- **Improved access to reliable, clean energy** — measured by customers with access to distributed storage resources.
- **Improved affordability of clean energy** — measured by the total portfolio cost.
- **Improved outdoor air quality** — measured by sulfur oxides, nitrogen oxides, and particulate matter generated per portfolio.
- **Increase the number of jobs** — measured by the number of estimated jobs generated for each portfolio.
- **Increases participation in Energy Efficiency, Distributed Energy Resources, and Demand Response Programs** — measured by energy efficiency capacity added and the number of customers projected to participate in distributed energy resources and demand response programs.
- **Reduced greenhouse gas emissions** — measured by the total amount of CO_2-eq[2] generated per portfolio.
- **Reduced peak demand** — measured by the decrease in peak demand achieved via demand response programs.

The portfolio benefit analysis generates a CBI index for each portfolio, an aggregate measure of these CBIs (sans the portfolio cost) normalized to the reference, least-cost portfolio. A higher CBI index indicates that a portfolio enables more equity-related benefits than the reference portfolio. The CBI index juxtaposes each portfolio's total cost (direct and externality costs). The plot (Figure 3.11) illustrates the tradeoff between increasing portfolio benefits and the associated metrics and costs. Compared to the reference portfolio, the most efficient portfolios have the highest CBI indices with minimal increase in portfolio cost and sit closest to the bottom right corner of the plot.

Figure 3.16 shows the results generated by the portfolio benefit analysis tool for all diversified portfolios analyzed in this 2023 Electric Report. We can see portfolio 11 B2 is the most efficient of the diversified portfolios because it lies furthest to the right with the highest CBI index, one of the reasons we selected portfolio 11 B2 as the preferred portfolio. It has the highest overall CBI index at 1.32 and is the most diversified portfolio without advanced nuclear SMR that we evaluated in the 2023 Electric Report.

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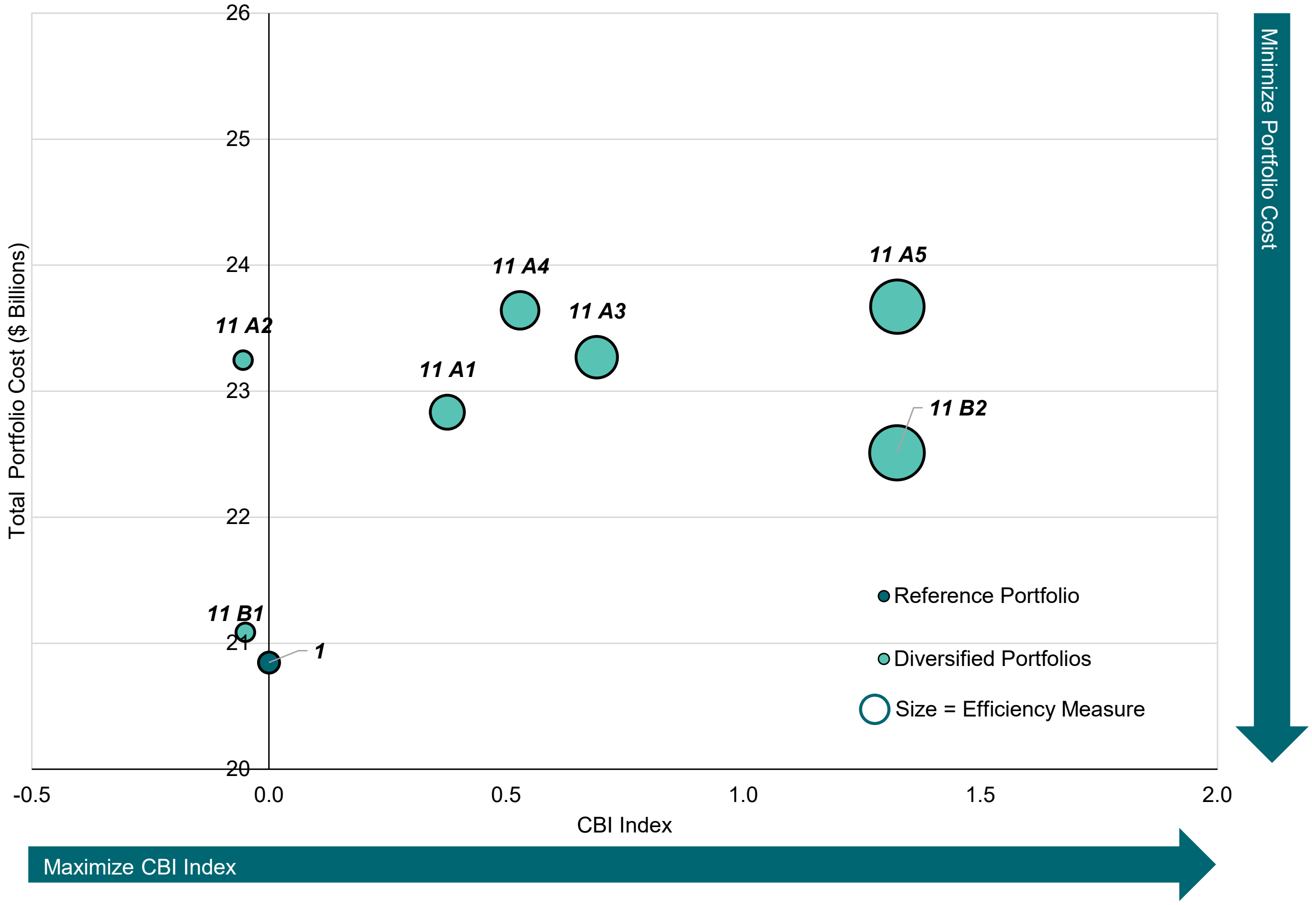
[2] CO2-eq or CO2-equivelant is a measure used to compare the emissions from various greenhouse gases based on their global-warming potential (GWP). Using the GWP, other greenhouse gases are converted to the equivalent amount of carbon dioxide.

Figure 3.16: Portfolio Benefit Analysis Tool Results



The high CBI index of portfolio 11 B2 comes from improvements in all the CBIs we considered in this analysis except for jobs, which varied slightly from the reference portfolio by less than half a standard deviation (index = -0.41). The benefits in the preferred portfolio include some of the highest potential customer participation numbers for DER solar, DER storage, and demand response programs at 87,492, 18,524, and 750,943 participants, respectively. Compared to the reference portfolio, the preferred portfolio also reduces greenhouse gas and other harmful emissions (Table 3.2).

Table 3.2: Portfolio CBI Metrics

CBI Metric	1 Reference	11 A5 Diversified Portfolio	11 B2 Diversified Portfolio
Cost ($, Billions)	20.85	23.67	22.51
GHG Emissions (Short Tons)	48,824,734	41,543,008	44,372,601
SO_2 Emissions (Short Tons)	28,841	28,836	28,759
NO_x Emissions (Short Tons)	11,426	10,307	10,805
PM Emissions (Short Tons)	9,036	8,873	8,940
Jobs (Total)	45,736	40,757	43,795
Energy Efficiency Added (MW)	695	818	818

CBI Metric	1 Reference	11 A5 Diversified Portfolio	11 B2 Diversified Portfolio
DR Peak Capacity (MW)	291	320	320
DER Solar Participation (Total New Participants)	12,115	83,903	87,492
DR Participation (Total New Participants)	513,238	750,943	750,943
DER Storage Participation (Total New Participants)	8,125	18,524	18,524

The results of the portfolio benefit analysis indicate that increasingly distributed and demand-side resources significantly increase the potential for more equitable outcomes for customers. Compared to the reference portfolio, portfolio 11 B2 has the following additions:

- **Conservation** — increases to 371 MW by 2045, 113 MW above the least-cost conservation.
- **Demand Response** — increases to 446 MW by 2045, an increase of 41 MW above the least-cost portfolio.
- **Distributed solar** — added 30 MW per year from 2026–2045, a total of 630 MW added by 2045 above the least cost portfolio.
- **Distributed storage** — added 25 MW per year from 2026–2031, a total of 150 MW added distributed storage above the least cost portfolio.

Portfolio 11 B2 achieved the highest CBI index of all portfolios evaluated in this 2023 Electric Report. In pursuing this portfolio, we will adopt a pathway forward for acquiring the resources necessary for a more equitable distribution of customer energy and non-energy burdens and benefits.

4.3. Portfolio Selection

We chose portfolio 11 B2 as the preferred portfolio because it presents a diverse mix of centralized renewable and non-emitting resources, reliable conservation, demand response, and distributed resources, and enables the most equity-related benefits of all the portfolios we evaluated. Furthermore, this portfolio reduces direct PSE emissions, achieves carbon neutrality by 2030, and is non-emitting by 2045. This portfolio is higher cost than most of the other diversified portfolios we evaluated. However, this outcome was driven primarily by increasing customer opportunities to participate in distributed energy and demand response programs, which we determined with feedback from PSE's EAG and other interested parties, were essential components of a preferred portfolio.