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February 25, 2021

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Mark Johnson,
Executive Director and Secretary
Washington Utilities and Transportation Commission
621 Woodland Square Loop SE
Lacey, WA 98503

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Re: Docket Nos UE-200304 and UG-200305 - In the Matter of Puget Sound Energy's Draft 2021 Electric Integrated Resource Plan

Dear Mr. Johnson:

Please accept the attached report on Puget Sound Energy's Draft 2021 Integrated Resource Plan. This report is submitted on behalf of Sierra Club and its more than 842,000 members, including over 32,750 members in Washington.

This report was prepared by Michael Goggin, an expert on clean energy integration and transmission at Grid Strategies, LLC. In his report, Mr. Goggin outlines a clear path for PSE to join other utilities in retiring obsolete coal and natural gas resources in favor of clean energy technologies.

Respectfully submitted on behalf of Sierra Club on the 25th day of February, 2021.

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Report on the Puget Sound Energy 2021 IRP Plan

Washington Utilities and Transportation Commission

Dockets: UE-200304 and UG-200305

Prepared for Sierra Club

February 25, 2021

By:

Michael Goggin

Grid Strategies LLC

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INTRODUCTION AND SUMMARY

Puget Sound Energy ("PSE") has a pivotal opportunity to make strategic planning decisions that can benefit and protect consumers for decades to come. PSE's exit from the Colstrip coal plant offers a once-in-a-lifetime opportunity to replace polluting resources with modern, non-emitting resources. It is critical that PSE not replace one obsolete energy source – coal – with another resource that is well on its way to obsolescence: natural gas. These comments provide a path for PSE to join other utilities in leapfrogging over obsolete technologies to the clean energy technologies of the 21st Century.

First, PSE should accelerate its deployment of renewable energy, energy storage, demand response, energy efficiency, and electrification. In particular, the recent extension federal tax credits for renewable and renewable-storage hybrid projects offers a short window in which those resources can be procured at record low costs to ratepayers. These comments also identify flaws in how PSE's Integrated Resource Plan ("IRP") models resources and the requirements of Washington Clean Energy Transition Act ("CETA").

Second, these comments explain how PSE's proposal to expand its dependence on gas generating capacity exposes its ratepayers to reliability, fuel price, and carbon price risks. The tragic events of last week, in which millions lost power across the South-Central U.S. primarily due to the loss of gas generation, are a stark reminder that gas supplies and power plants are vulnerable to interruption in all regions.

Third, our comments explain how expanding centralized power markets in the West offer an opportunity for PSE to benefit from diversity in renewable supply and electricity demand with other utilities across the West.

Fourth, we explain in detail how aggregating a diverse supply of renewable resources across a large geographic area increases the resource adequacy contribution of those resources to meeting peak electricity demand.

Finally, our comments explain that, to realize the benefits of aggregating regional diversity in renewable supply and demand, PSE must work intensively to deploy transmission that is appropriately sited to address land and wildlife concerns.

In addition, the IRP process in Washington is different than in many other states in that it lacks formal discovery. Thus, an intervenor like Sierra Club cannot access the utility's modeling and assumptions through a formal discovery process, as is the standard in most states. This analysis is more limited than it would be in other IRP proceedings due to the lack of information about PSE's modeling assumptions, methods, and results. Sierra Club respectfully requests that in future IRP proceedings, the Washington Utilities and Transportation Commission allow intervenors access to the utility's modeling and assumptions through a formal discovery process, as is standard in most states. Mr. Goggin, who assisted Sierra Club with the preparation of these comments, has testified or provided comments in IRP proceedings in Georgia, Indiana, Minnesota, Montana, and Virginia, as well as generation procurement cases in New Mexico, Ohio, Oklahoma, and Wisconsin. In all of those cases intervenors were allowed to ask questions of the utility, typically through formal discovery, and in many cases, they were provided access to the utility's modeling files including assumptions, methods, and results. Denying this access creates an inherently unlevel playing field between the utility and intervenors, and ratepayers are ultimately harmed by the lack of information and transparency. In almost all cases, access to the utility modeling revealed assumptions and methods that were not only questionable, but constituted actual errors in the utility's analysis. In cases Mr. Goggin participated in New

Mexico and Minnesota, intervenors used this access to replicate the utility's modeling and then modify assumptions to produce more optimal generation procurement choices. Having access to PSE's modeling in this case and an ability to ask questions via formal discovery, would have allowed for a more thorough evaluation of PSE's modeling and assumptions.

Many sections of the IRP, including many Appendices and results for approximately half of the modeling sensitivities, were not included in the draft IRP, depriving intervenors of the ability to comment on these important topics. For example, modeling results for PSE's stochastic analysis and market reliance analysis were not included in the draft, and sensitivities evaluating transmission expansion, more rapid deployment of energy efficiency, carbon emission requirements, gas-to-electric conversion, and the impact of climate change on demand also would have provided valuable information to inform our comments. All of the appendices for electric and gas modeling models, inputs, and results were also not provided. Unfortunately, consumers are put at risk by this lack of information and intervenors' inability to fully evaluate PSE's modeling.

I. Flaws in PSE's modeling

A. *PSE should accelerate the transition to clean energy*

PSE can reduce consumer costs and avoid the need to add fossil generating capacity by accelerating its deployment of renewable energy, energy storage, demand response, energy efficiency, and electrification. The timing of PSE's proposed resource additions in its preferred portfolio are summarized in Figure 1 copied from PSE's IRP.[1] Unfortunately, PSE's plan misses opportunities to more cost-effectively deploy non-emitting resources in the near

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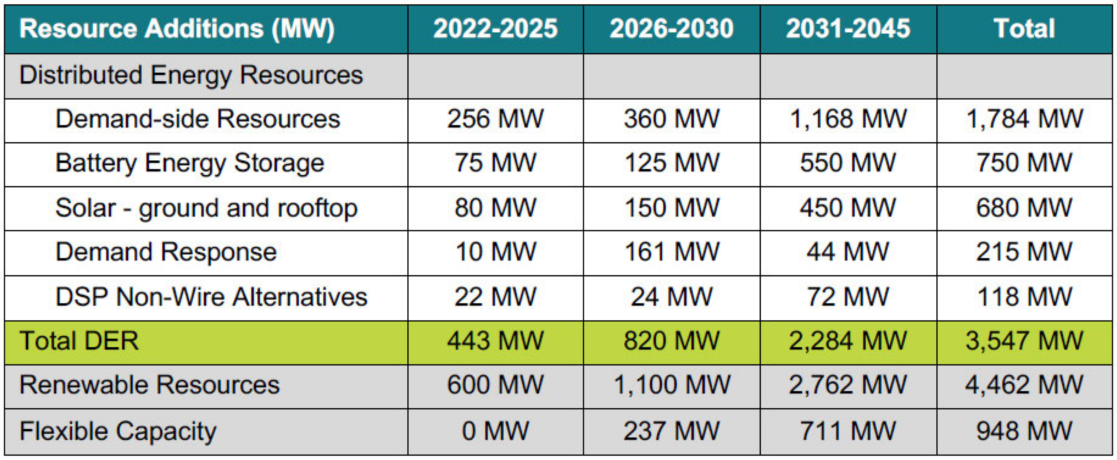
[1] Puget Sound Energy, *2021 Draft Integrated Resource Plan* at 3-4 (Jan. 2021), *available at* https://oohpseirp.blob.core.windows net/media/Default/Reports/Draft/Chapters/UE-200304-UG-200305-PSE-DRAFT-2021-IRP-Chapters-(01-04-21).pdf [hereinafter "2021 IRP"].

term that could eliminate the need to add gas capacity following PSE's exit from the Colstrip coal units in 2025.

Figure 1: Timing of PSE Preferred Portfolio capacity additions



Resource Additions (MW)	2022-2025	2026-2030	2031-2045	Total
Distributed Energy Resources				
Demand-side Resources	256 MW	360 MW	1,168 MW	1,784 MW
Battery Energy Storage	75 MW	125 MW	550 MW	750 MW
Solar - ground and rooftop	80 MW	150 MW	450 MW	680 MW
Demand Response	10 MW	161 MW	44 MW	215 MW
DSP Non-Wire Alternatives	22 MW	24 MW	72 MW	118 MW
Total DER	443 MW	820 MW	2,284 MW	3,547 MW
Renewable Resources	600 MW	1,100 MW	2,762 MW	4,462 MW
Flexible Capacity	0 MW	237 MW	711 MW	948 MW

First, recent federal tax credit extensions make it possible for PSE to add large quantities of very low-cost renewable and renewable-storage hybrid resources in the near term. Spending legislation enacted in December 2020 extended the federal renewable tax credits, allowing wind, solar, and solar-battery projects receiving higher value tax credits to come online through the end of 2025.[2] Solar and solar-battery projects received a two-year extension of the Investment Tax Credit ("ITC"), so projects that start construction before the end of 2022 can receive an ITC for 26% of up-front project costs, and 22% for projects that start construction before the end of 2023. The solar/hybrid ITC deadline for qualifying projects to be placed in service is also moved back two years, from the end of 2023 to the end of 2025.

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[2] Jeff St. John, *Congress Passes Spending Bill with Solar, Wind Tax Credit Extensions and Energy R&D Package,* (Dec. 22, 2020), *available at* https://www.greentechmedia.com/articles/read/solar-and-wind-tax-credit-extensions-energy-rd-package-in-spending-bill-before-congress.

Wind projects received a one-year extension and can now start construction through the end of 2021 and qualify for the \$15/MWh (or 60% of the full \$25/MWh value) Production Tax Credit ("PTC"). Most wind project developers qualify as "starting construction" by simply paying a deposit for turbines or other equipment. The IRS has previously allowed wind projects four years to come online after the start of construction, so wind projects placed in service through 2025 will likely be able to earn \$15/MWh PTCs for their first 10 years of operations.[3]

PSE has the opportunity to contract with many wind and solar projects currently under development that either will qualify for the extended tax credits, or have already qualified for the higher value tax credits that were available in previous years. PSE's generator interconnection queue includes 4,673 MW of proposed wind, solar, and storage projects that have applied to interconnect to PSE's system.[4] No power purchaser has been publicly announced for most of these projects, likely indicating that in most cases at least some of their capacity is still available to PSE.

This includes several large renewable and storage projects being developed near the Colstrip Transmission System ("CTS") in Montana that could be delivered to PSE. As documented by PSE and discussed at length below, Montana wind resources offer significantly higher capacity value for meeting PSE's peak demand needs, displacing the need for other capacity resources like gas. In addition to the 750 MW Clearwater wind project,[5] the

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[3] I.R.S., Notice 16-31 at 5 (May 5, 2016), *available at* https://www.irs.gov/pub/irs-drop/n-16-31.pdf.

[4] *Current Transmission Queue*, Puget Sound Energy, https://www.pse.com/pages/transmission/obtaining-services/transmission-queue (last accessed Feb. 24, 2021) .

[5] Tom Lutey, *Montana's largest wind farm will be built near Colstrip beginning in 2021*, Billings Gazette (Jan. 4, 2021), https://billingsgazette.com/news/montanas-largest-wind-farm-will-be-built-near-colstrip-beginning-in-2021/article_abcdfff8-21dc-5abe-b6d7-f5db319ca44a html.

500 MW Buffalo Trail project featuring 250 MW of wind and 250 MW of solar is also slated to come online near the CTS line in 2022.[6]

PSE can also accelerate its proposed energy efficiency and demand response programs. PSE is very conservative in its assumption for the time required to ramp up demand response programs, arguing that "[d]emand response takes a couple of years to set up before savings are achieved, so even with four programs starting in 2022, the total nameplate by 2025 is only 10 MW because of the time it takes to establish the programs and enroll customers. The total DR program size grows to 161 MW nameplate capacity by 2030."[7] This is contradicted by the experience of other utilities that have quickly ramped up demand response programs. In many cases, utilities issue solicitations for demand response programs a year or less in advance of when they are expected to be deployed.[8] PSE can also accelerate its energy efficiency programs. We expect that the modeling results for Sensitivities F and H, which respectively ramp up energy efficiency measures over 6 years instead of 10 years and use a lower discount rate for demand-side resources, will illustrate the benefits of a more rapid deployment of energy efficiency measures. Most importantly, we expect that accelerating these clean supply and demand resources would eliminate the need to add gas capacity following PSE's exit from the Colstrip coal units in 2025.

PSE's electrification efforts should also be accelerated. Early action on electrification is essential for cost-effectively reaching increasingly stringent carbon reduction requirements

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[6] Tom Lutey, *Broadview wind and solar farm gets new owner*, Billings Gazette (Dec. 17, 2020), https://billingsgazette.com/news/state-and-regional/broadview-wind-and-solar-farm-gets-new-owner/article_727b9178-dfde-55ae-a06f-912a30827503.html.

[7] 2021 IRP at 2-15.

[8] *See, e.g.,* Commercial & Industrial Demand Response Program, Pub. Serv. Comm'n of N.M, *Request for Proposals – Technology and Implementation Services* (Jan. 25, 2016), *available at* https://www.pnm.com/documents/396023/3003075/PNM+CI+DR+RFP_Jan+25+2016v2.pdf/b669c9aa-7b03-4700-8556-08751dfaccb7?t=1453768593219.

because of the slow turnover in the stock of building heating systems, water heaters, and other appliances.[9] Early action on electrification, particularly for new buildings, is also essential for reducing methane emissions from gas distribution system leaks. Electrification of building and water heating and transportation loads also adds a valuable source of controllable load that can be used for demand response, particularly during winter peak periods. It is possible to shift a large quantity of these loads earlier or later in time to reduce peak demand and coincide with periods when renewable supply is more abundant. For example, buildings and water can be preheated, or vehicle charging can be delayed. Better building envelopes also reduce building heat loss in the winter, which reduces the heating load and allows greater shifting of heating load through demand response. This reduces the amount that less efficient resistance heat strips have to run in cold weather, in addition to co-benefits such as reduced bills and improved comfort for customers.

The PSE IRP gas analysis does not adequately address building electrification and codes and standards. Appendix I and page 4-22 state that sections relevant to gas analysis, building codes and standards, and electrification will be completed for the final 2021 IRP, so we have been unable to evaluate PSE's analysis.

PSE gas demand forecasts do not seem to include codes and standards for new construction, or effects of the state building performance standard. PSE's electrification plans must be consistent with state and local requirements in Washington. For example:

- WA State Clean Energy Strategy (2021) which was recently released, identifies building electrification as a necessary strategy needed to help meet state greenhouse gas emission reduction goals.

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[9] Risky Business, *From Risk to Return – Investing in a Clean Energy Economy* at 25 (2016), *available at* http://riskybusiness.org/site/assets/uploads/sites/5/2016/10/RBP-FromRiskToReturn-WEB.pdf.

- WA state requires that new buildings will need to be net zero by 2031.
- Seattle 2018 Commercial Energy Code will prohibit gas for space heating in all buildings as well as water heating in most buildings. We expect other jurisdictions to follow with similar energy codes.
- WA State Clean Buildings Act requires existing buildings 50,000 sq feet and above to meet energy use intensity targets starting in 2026, with a voluntary incentive program starting in the fall of 2021. Given that the Clean Buildings Act requires PSE to pursue all cost-effective gas conservation, and because accounting for the social cost of carbon has pushed more measures to be cost-effective, conservation should significantly reduce energy demand.

B. *PSE's renewable cost assumptions are too high*

PSE's source for generation costs is the 2019 National Renewable Energy Laboratory ("NREL") Annual Technology Baseline ("ATB"), which is an industry standard resource. However, PSE misses continued cost reductions for renewable and storage technologies by using the 2019 version and not the current 2020 version of ATB. In particular, the cost of solar declined significantly in the 2020 version of ATB, relative to the 2019 version used by PSE.[10]

PSE's solar cost estimates are also too high because the 2019 NREL ATB cost estimate is based on a 23 MW installation size for solar.[11] Data from the Lawrence Berkeley National Laboratory show that for utility-scale solar projects installed in the U.S. in 2019, the capital costs of projects between 100 and 200 MW in size were 17 percent lower than projects between 20

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[10] *Annual Technology Baseline - 2020 v. 2019 Changes*, NREL Transforming Energy, https://atb.nrel.gov/electricity/2020/changes.php (last visited Feb. 24, 2021).

[11] *Annual Technology Baseline – 2019 Data*, NREL Transforming Energy, https://atb.nrel.gov/electricity/2019/data html (last visited Feb. 24, 2021).

and 50 MW (such as the 23 MW project assumed by PSE), and 40 percent lower than projects between 5 and 20 MW.[12]

C. Flaws in how PSE accounts for the requirements of CETA

PSE's treatment of carbon costs is inconsistent with the requirements of CETA. PSE admits that the cost of carbon is not accounted for in its modeling of the dispatch of generating resources, explaining that:

> *The SCGHG is applied as a cost adder in the development of the electric price forecast and in the portfolio modeling process when considering resource additions. The SCGHG is not included in the final dispatch of resources because it is not a direct cost paid by customers. CETA explicitly instructs utilities to use the SCGHG as a cost adder when evaluating conservation efforts, developing electric IRPs and CEAPs, and evaluating resources options. The SCGHG cost adder is included in planning decisions as part of the fixed O&M costs of that resource, but not in the actual cost and dispatch of any resource. An SCGHG adder is also added to the unspecified market purchases using the 0.437 metrics tons CO2/MWh emission rate as specified in CETA.*[13]

In reality, carbon costs are an externality associated with the production of electricity from fossil fuels, and thus are a variable cost and not a fixed cost. It is essential that the variable externality cost of fossil generation be modeled in power system dispatch to determine the efficient use of resources, using the resulting price signals to properly weigh tradeoffs between emitting resources, non-emitting resources, energy efficiency, and market purchases. By ignoring the externality cost of gas consumption, PSE's modeling greatly overestimates the capacity factors and economic value of gas power plants, and underestimates the relative value of non-emitting resources including energy efficiency and market purchases. Accurately modeling the cost of carbon in dispatch would have shown that gas capacity factors decline even more quickly and drastically than they do in PSE's modeling. With PSE's modeling already showing gas

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[12] Mark Bolinger et. al., LBNL, *Utility-Scale Solar Data Update: 2020 Edition*, (Nov. 2020), *available at* https://emp.lbl.gov/utility-scale-solar/ [hereinafter "*2020 Utility-Scale Solar Update*"].

[13] 2021 IRP at 2-22.

combined cycle capacity factors declining from 70% to 5%,[14] accounting for carbon costs in dispatch would have even more clearly shown new gas capacity to be at risk of becoming a stranded asset well within the 25-year planning horizon. Sensitivity J properly included the social cost of carbon in dispatch, which we expect will accurately show reduced reliance on gas generation and greater use of energy efficiency.[15]

The Commission should also not allow PSE to shirk its requirements under CETA by failing to make timely investments to bring cost-effective clean energy resources online. Early investments in clean energy, particularly while federal tax credits are available, reduce risks of later exceeding CETA's cap on the cost of compliance.

In particular, using transmission expansion that is appropriately sited to address land and wildlife concerns, PSE can access high capacity value renewable resources and increase ties to markets in other parts of the West, allowing PSE to operate reliably with very high levels of renewable energy at low incremental cost. PSE must take steps now that will result in that transmission, and the resources and market transactions it enables, being in place when they are needed. PSE should not be rewarded for failure by setting itself up to exceed the cap on the cost of CETA compliance.

II. Risks from increased gas dependence: correlated outages, fuel price risk, carbon price risk

A. <u>Reliability risks from gas generator correlated outages</u>

As the events of recent weeks make painfully clear, correlated failures of gas power plants are a major risk to electric reliability. Rolling blackouts in Texas and other parts of the Central U.S. were primarily caused by outages of gas generating capacity, caused by a

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[14] *Id*. at 3-8.
[15] *Id*. at 3-10.

combination of gas production wells freezing, high gas demand for heating exceeding pipeline capacity, and equipment failures at gas plants.[16]

PSE is at particular risk from this reliability threat given its significant dependence on gas generation and lack of strong access to natural gas pipelines. PSE briefly notes this risk on page 4-24 of the IRP, accurately explaining that "[n]atural gas is imported to the Pacific Northwest, primarily from British Columbia and the Rocky Mountain region. Disruptions to natural gas transportation infrastructure, therefore, present a risk to reliable gas supply in the region." The IRP also discusses the October 2018 Westcoast Pipeline explosion, correctly noting how capacity on the pipeline being limited resulted in significant curtailments and price volatility for over a year, and that "prices remain significantly more volatile compared to recent historical periods."

Other recent examples of recent pipeline supply interruption events in the Western U.S. include the 2011 Southwest outage and the Aliso Canyon outage in California. Given the long distances traversed by interstate gas pipelines, events that reduce supply or increase demand anywhere along the pipeline can result in gas shortages for all customers, even if the event did not occur in their area. Given its location near the end of only two major gas pipelines, PSE is at particular risk.

Even under normal conditions, the region frequently experiences constraints on pipeline capacity during peak demand periods. This is especially concerning given that PSE's peak electricity demand coincides with maximum demand for gas for heating. PSE's proposal to add gas power plant capacity would maintain PSE's dependence on gas for about one-third

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[16] Michael Goggin and Rob Gramlich, *Observations on winter electric reliability event in South Central U.S.*, Energy Central (Feb. 17, 2021), https://energycentral.com/c/gr/observations-winter-electric-reliability-event-south-central-us.

of its peak generating capacity for decades to come.[17] This poses both an economic and reliability risk for PSE ratepayers.

The electric reliability risk has been well-documented by many experts. Prior to last week, regions across the country had experienced similar events in which gas generators were forced offline by fuel supply limitations or interruptions.[18] The North American Electric Reliability Corporation ("NERC") has noted how correlated outages are a major risk, particularly for gas generators.[19] NERC's Winter Reliability Assessment and other NERC reports have continued to highlight this risk.[20] The PJM and New England grid operators have conducted fuel security analyses, primarily motivated by reliability close calls during the 2014 Polar Vortex and other events.[21]

Examples of widespread correlated failures of conventional generators including gas generation include the 2011 rolling blackout in ERCOT, the 2014 Polar Vortex, and the 2018 Bomb Cyclone. Notably, wind energy output was high during almost all of these events,[22] demonstrating the resilience value renewables provide by diversifying the generation mix.

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[17] 2021 IRP at 3-6.

[18] *See, e.g.*, PJM Interconnection, *Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events* (May 8, 2014), *available at* https://www.hydro.org/wp-content/uploads/2017/08/PJM-January-2014-report.pdf; FERC, *2019 FERC and NERC Staff Report: The South Central United States Cold Weather Bulk Electric System Event of January 17, 2018* (July 2019), *available at* https://www ferc.gov/legal/staff-reports/2019/07-18-19-ferc-nerc-report.pdf.

[19] NERC, *Reliability Guideline: Fuel Assurance and Fuel-Related Reliability Risk Analysis for the Bulk Power System* (Mar. 2020), *available at* https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Fuel_Assurance_and_Fuel-Related_Reliability_Risk_Analysis_for_the_Bulk_Power_System.pdf; NERC, *Special Reliability Assessment: Potential Bulk Power System Impacts Due to Severe Disruptions on the Natural Gas System* at 3, 20 (Nov. 2017), *available at* https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SPOD_11142017_Final.pdf.

[20] NERC, *Winter Reliability Assessment* at 6 (Nov. 2019), https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC%20WRA%202019_2020.pdf.

[21] PJM Interconnection, *Fuel Security Analysis: A PJM Resilience Initiative* (Dec. 17, 2018), *available at* https://www.pjm.com/-/media/library/reports-notices/fuel-security/2018-fuel-security-analysis.ashx?la=en; ISO New England, *Operational Fuel-Security Analysis* (Jan. 17, 2018), *available at* https://www.iso-ne.com/committees/key-projects/implemented/operational-fuel-security-analysis.

[22] Hannah Hunt, *How Did Wind Energy Perform During the Bomb Cyclone*, EcoWatch (Mar. 30, 2018), https://www.ecowatch.com/wind-power-bomb-cyclone-2554824592.html#toggle-gdpr.

During a cold snap in February 2011, ERCOT experienced rolling blackouts due to equipment failures at fossil generators and gas supply interruptions. In the 2014 Polar Vortex, PJM was forced to resort to voltage reductions to maintain reliability after extreme cold caused widespread conventional generator failures due to gas supply interruptions and equipment failures. Two other cold snaps that year, and a similar event in early 2015, also posed challenges for electric reliability in various regions of the country.[23] In the January 2018 Bomb Cyclone event, New England faced reliability risks as gas supplies were interrupted and fuel oil supplies dwindled during a two-week cold spell. In January 2018, many conventional generators in the South-Central U.S. experienced correlated outages due to equipment failures and gas supply interruptions.[24]

Data confirm that gas generator outages tend to be correlated events. As a recent paper co-authored by experts from NERC and Carnegie Mellon University explained:

> *Our findings highlight an important limitation of current resource adequacy modeling (RAM) practice: distilling the availability history of a generating unit to a single value (e.g. EFORd, the equivalent forced outage rate during times of high demand) discards important information about when units in a power system fail in relation to one another. Only by incorporating the full availability history of each unit into RAM can we account for correlations among generator failures when determining the capacity needs of a power system. We strongly recommend that system planners incorporate correlated failure analysis into their RAM practice.*[25]

NERC data used in the Carnegie Mellon analysis demonstrates that conventional generators experience correlated outages many times more frequently than is predicted under the

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[23] Michael Goggin, *For the Third Time in a Month, Wind Energy Protects Consumers in a Cold Snap*, Into the Wind (Feb. 10, 2014), https://cleanpower.org/blog/for-the-third-time-in-a-month-wind-energy-protects-consumers-during-cold-snap/.

[24] FERC, *2019 FERC and NERC Staff Report: The South Central United States Cold Weather Bulk Electric System Event of January 17, 2018* (July 2019), *available at* https://www ferc.gov/legal/staff-reports/2019/07-18-19-ferc-nerc-report.pdf.

[25] Sinnott Murphy et al., *Resource adequacy risks to the bulk power system in North America* at 29 (Carnegie Mellon University Feb. 15, 2018), *available at* https://www.andrew.cmu.edu/user/fs0v/papers/CEIC_17_02R1%20Resource%20adequacy%20risks%20to%20the%20bulk%20power%20system%20in%20North%20America.pdf.

assumption that individual plant outages are uncorrelated independent events. The data shows that correlated forced outages tend to occur more frequently at certain types of conventional generators, with gas generators experiencing some of the highest correlated outage rates.[26] Charts included in the analysis show that actual winter generation outages are much more common than would be expected under the assumption that generator outages are uncorrelated independent events.[27] Even when gas supply constraints are not severe enough to cause electric reliability concerns, they can impose a major cost on consumers by triggering gas prices to spike to levels dozens or even hundreds of times higher than normal.

B. Gas fuel price risk and carbon price risk

Given PSE's dependence on gas for its electric generating capacity, as well as for consumer gas supply, its ratepayers are heavily exposed to carbon price and fuel price risk. Risk-averse decision-making justifies giving added weight to high fuel price and carbon price scenarios that will result in harmful outcomes for ratepayers, even if the Commission believes another fuel and carbon price scenario is more likely. Said another way, many customers would likely prefer an outcome in which fuel prices came in lower than expected but their utility may have spent a bit more by erring on the side of a risk-averse portfolio, as opposed to an outcome in which fuel prices came in higher than expected and the utility had not built a risk-averse portfolio.

On the electric side, adding renewable and non-emitting resources diversifies PSE's generating portfolio and reduces the overall supply portfolio's fuel and carbon risk, while adding gas generation would move in the opposite direction. Generating portfolios with less new gas and more renewables provide a hedging or insurance value to ratepayers by reducing the

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[26] *Id.* at 26–27.

[27] *Id.* at S–22.

consumer impact of higher gas prices or carbon prices. Like an insurance policy or a financial hedge, this risk reduction has an economic value, separate from and in addition to the energy cost savings for those consumers.

Tools used in utility planning, and in the financial sector, can quantify the economic value of the risk reduction provided by renewable resources. Lawrence Berkeley National Laboratory ("LBNL") has developed one such tool for the utility industry to account for gas price risk.[28] Another method developed by LBNL[29] and used by utilities such as Dominion Energy, uses the cost premium for long-term gas supply contracts to calculate the cost of making a portfolio with more gas generation offer comparable risk as a portfolio with less gas generation.[30]

While the state of Washington has taken steps to regulate carbon emissions, the federal government has not. However, the U.S. EPA is required to regulate greenhouse gas emissions, and a federal rulemaking or legislation is likely in the foreseeable future. IRP modeling results for PSE's Sensitivity L, which models a federal tax on carbon, will likely show the carbon price risk of increasing reliance on gas.[31] In addition, the state is currently drafting a rule for methane emissions from upstream gas supply, which is scheduled to be complete in August 2021.[32] This will likely significantly increase the cost of gas generation. CETA's social cost of carbon of

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[28] Mark Bolinger, Lawrence Berkeley National Laboratory (LBNL), *Using Probability of Exceedence to Compare the Resource Risk of Renewable and Gas-Fired Generation* (Mar. 2017), *available at* https://emp.lbl.gov/publications/using-probability-exceedance-compare/.

[29] Mark Bolinger, et al., LBNL, *Accounting for Fuel Price Risk When Comparing Renewable to Gas-Fired Generation: The Role of Forward Natural Gas Prices*, (Jan. 2004), *available at* https://emp.lbl.gov/sites/all/files/report-lbnl-54751.pdf.

[30] Dominion, *Dominion Virginia Power's and Dominion North Carolina Power's Report of Its Integrated Resource Plan* at 144–153 (Apr. 29, 2016), *available at* https://www.nrc.gov/docs/ML1627/ML16271A535.pdf.

[31] 2021 IRP at 3-11.

[32] *See* Gov. Inslee, Directive 19-18 (Dec 19, 2019), *available at* https://www.governor.wa.gov/sites/default/files/directive/19-18%20-%20ECY%20Climate%20Rules%20%28tmp%29.pdf (to be codified as Wash. Admin. Code § 173-445).

$74/ton also applies to acquisition, so this cost should be included any gas proposals to the 2021 RFP which is expected in March or April.

C. *Assuming the feasibility of alternative fuels in PSE's preferred plan is risky*

PSE's preferred plan, Sensitivity W, assumes the use of alternative fuel for peakers. Relative to Sensitivity V, which did not assume the use of alternative fuels, this sensitivity adds significantly less battery storage. PSE's modeling assumes that case adds only $60 million in net present value revenue requirement costs relative to a case without the use of alternative fuels. While PSE has not provided enough information to determine the true cost premium it assumed for running peakers on biofuels, these costs may be a significant underestimate. Electric sector modeling by Deloitte indicates that even without accounting for continued reductions in battery costs, lithium ion batteries offer significantly lower cost carbon abatement than substituting renewable natural gas or hydrogen for natural gas consumption.[33]

At best, PSE is taking on significant risk by assuming that alternative fuel technologies will be available at sufficient scale at a reasonable cost. For example, the IRP states "this IRP does not analyze hypothetical RNG projects that would connect to NWP or to PSE's system and displace conventional natural gas that would otherwise flow on NWP pipeline capacity."[34] A number of logistical issues in fuel production, transportation, storage, and consumption would have to be addressed before it can be assumed that renewable hydrogen or biofuels could be used at gas peakers. For example, hydrogen cannot be blended into existing natural gas pipelines beyond a relatively low threshold, due to issues related to cracking and weakening pipeline steel,

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[33] Stanley Porter et al., *Utility decarbonization strategies – Renew, reshape, and refuel to zero,* Deloitte (Sept. 21, 2020), *available at* https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/utility-decarbonization-strategies html.

[34] 2021 IRP at 4-13.

leaks, and impacts on consumer appliances.[35] Therefore, converting gas generators to alternative fuels would likely require dedicated fuel delivery and storage infrastructure. Burning hydrogen in a generator could also cause concerns due to its effect on steel and other materials.

D. Reliability services from wind, solar, and storage are superior to those from gas

Thanks to technological advances, wind and solar resources are increasingly providing grid reliability services as well as or better than conventional generators.[36] For example, CAISO has shown that wind[37] and solar[38] resources that are curtailed offer dispatchable flexibility that is orders of magnitude faster than that offered by almost any conventional generator.[39] Xcel's Public Service Company of Colorado routinely uses its wind plants to provide frequency regulation by adjusting their output on a second-to-second basis, while wind plants in ERCOT provide primary frequency response that quickly and accurately stabilizes frequency following grid disturbances.[40]

Under FERC Order No. 827, inverter-based resources like solar, batteries, and wind are now also required to at least match the reactive power and voltage control provided by conventional generators.[41] Using their fast controls and inverter power electronics, batteries, wind, and solar plants are now capable of providing control of voltage and reactive power that is

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[35] M. W. Melaina et al., NREL, *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues* (Mar. 2013), *available at* https://www.energy.gov/sites/prod/files/2014/03/f11/blending_h2_nat_gas_pipeline.pdf.

[36] Michael Milligan, *Sources of Grid Reliability Services*, 31 The Electricity Journal 1 (Nov. 2018), *available at* https://www.sciencedirect.com/science/article/pii/S104061901830215X.

[37] California ISO, *ISO tests prove wind can play major role in renewable integration: Study results show wind farms' ability to supply essential grid services* (Mar. 11, 2020), *available at* http://www.caiso.com/Documents/ISOTestsProveWindCanPlayMajorRoleinRenewableIntegration.pdf.

[38] Clyde Loutan et al., NREL, *Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant* (Mar. 2017), *available at* https://www nrel.gov/docs/fy17osti/67799.pdf.

[39] E. Ela et al., NREL, *Active Power Controls from Wind Power: Bridging the Gaps* (Jan. 2014), *available at* https://www.nrel.gov/docs/fy14osti/60574.pdf.

[40] Michael Milligan et al., *Alternatives No More: Wind and Solar Power Are Mainstays of a Clean, Reliable, Affordable Grid*, 13 IEEE Power & Energy Magazine 78 (Oct. 16, 2015), *available at* http://www.consultkirby.com/files/Alternative_No_More_-_Nov_2015.pdf.

[41] Order No. 827 at 1, Docket No. RM16-1-000 (FERC June 16, 2016), *available at* https://www.ferc.gov/sites/default/files/2020-06/RM16-1-000.pdf.

faster, more accurate, and more stable than that of gas generators.[42] Wind and solar can potentially even provide reactive power and voltage support when they are not producing power, such as solar plants pulling power from the grid at night to provide reactive power and voltage support to the grid using their inverters.[43] In contrast, conventional generators must be operating and producing power to provide reactive power control and voltage support. This limits the value of fossil generators, as they are often offline and therefore unavailable to provide reactive power and voltage control. These generators could be started up to provide voltage support, but starting and operating the plant would incur significant excess costs. In contrast, a battery can precisely tailor its output or charging to meet voltage and reactive power needs with no startup or fuel cost.

Batteries are highly modular and can be deployed in the sizes and locations on the grid where they are most needed. As a result, batteries can be located near renewable generators to absorb excess that output that would have been curtailed due to transmission congestion, and then release that output later when transmission capacity is available. More importantly, batteries have the unique ability to absorb excess renewable output by charging, which gas and conventional generators cannot do.

In contrast, inflexible fossil generators tend to increase renewable curtailment, as these resources cannot change their level of output as quickly and often have high minimum output levels. Batteries can respond much more quickly, flexibly, and precisely than gas-fired units can. Batteries can ramp from full charge to full discharge output in seconds or less in response to dispatch signals.[44] Batteries do not have a minimum partial output level or a minimum shut down

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[42] *Id.* at 4.

[43] *See, e.g.*, SMA America, LLC, *Q at Night*, *available at* https://www.sma-america.com/partners/knowledgebase/q-at-night.html.

[44] *See* Jennifer E. Leisch & Ilya Chernyakhovskiy, NREL and USAID, *Grid-Scale Battery Storage: Frequently Asked Questions* at 2–3 (Sep. 2019), *available at* https://www.nrel.gov/docs/fy19osti/74426.pdf.

period. In contrast, even quick start natural gas generators typically take nearly 10 minutes to start and ramp up to full load. Batteries are faster and more accurate than gas generators in providing frequency regulation, which is used to accommodate second-to-second fluctuations in electricity supply and demand on the grid. Batteries also provide extremely fast primary frequency response, which is used to restore power system frequency in the seconds following a large disturbance on the grid, such as the loss of a large generator.

III. PSE's analysis should account for opportunities from regional markets

PSE's analysis significantly overstates the cost of reaching high renewable penetrations because it does not adequately account for increasing opportunities to use imports and regional markets. Western power markets are steadily becoming larger and more integrated, which is increasing the capacity value of renewable resources and reducing the cost of achieving high penetrations of renewable resources. Except for a few sensitivities, PSE's analysis assumes that transmission and market ties are fixed at their current levels, forcing PSE to look primarily within its current system to meet its needs.[45] This greatly inflates the cost of achieving high penetrations of renewable resources, as PSE must greatly overbuild its own renewable and storage capacity if it cannot capture the benefits of regional diversity. For example, Sensitivities N and O incur massive costs because PSE assumes it will need dozens of GigaWatts ("GW") of battery storage to meet its peak capacity needs.[46] As discussed at length below, expanding transmission to access diverse renewable resources and

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[45] In the executive summary at 1-10, PSE explicitly acknowledges that it has pivoted to looking inward for meeting its needs. However, PSE's justification for doing so is at odds with the trend through the EIM and other initiatives, discussed at length in this section, towards larger and more liquid markets in the West: "In recent years, the region has experienced periods of high price volatility and limited market liquidity. This presents a potential future risk for PSE's customers, and PSE may have to adjust its market purchase strategy going forward. PSE is evaluating the potential impacts of market purchases becoming unavailable to the portfolio." 2021 IRP at 1-10.

[46] *Id.* at 3-15 - 3-16.

increase market ties to power systems with supply and demand profiles that complement PSE's would almost certainly be a lower cost solution for reaching high renewable penetrations.

PSE's filing discusses the likely transition of the Energy Imbalance Market ("EIM") into an Extended Day Ahead Market ("EDAM") construct.[47] Greater regional coordination in operating the grid, planning and allocating the costs and transmission, and sharing resources across the region will provide large benefits and greatly reduce the amount of capacity needed to meet resource adequacy needs and provide reliability services. Regional Transmission Organizations ("RTOs") in other regions, including PJM and MISO have documented that their RTOs provide billions of dollars per year in benefits from reducing capacity needs by aggregating diverse loads and resources.[48] However, it is essential that the governance of regional markets is transparent and enables participation of public interest stakeholders, and critical that regional market rules do not disadvantage clean energy resources or impede the achievement of state clean energy policy.

Extensive regional coordination in system planning and operations is essential if the West is to cost-effectively reach the high penetrations of wind and solar resources called for under laws in Washington and other states. As a result, PSE's planning should account for the high likelihood of this evolution over the planning horizon. PSE should take particular care that it does not invest in capacity resources that will not be needed and will become stranded assets with more coordinated planning and operations in the West, particularly given the large capacity surplus in the region, as documented later in this section.

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[47] *Id.* at 4-16 - 4-17.

[48] PJM Interconnection, *PJM Value Proposition* (2019), *available at* https://www.pjm.com/about-pjm/~/media/about-pjm/pjm-value-proposition.ashx; MISO, *MISO 2020 Value Proposition*, *available at* https://cdn.misoenergy.org/20210219%202020%20MISO%20Value%20Proposition%20Presentation521885.pdf.

Large import and export ties are essential for reliable and affordable power system operations at high renewable penetrations, as these connections provide access to diverse wind and solar resources. A large body of regional[49] and national[50] analyses, including in the Pacific Northwest,[51] conclude that a diverse mix of wind, solar, and other resources is essential for economic and reliable decarbonization of the power system. As a national study published in the journal Nature Climate Change explained,[52] "the average variability of weather decreases as size increases; if wind or solar power are not available in a small area, they are more likely to be available somewhere in a larger area," so "paradoxically, the variability of the weather can provide the answer to its perceived problems." As discussed at length in the next two sections, using transmission ties that are appropriately sited to address land and wildlife concerns to build a regional portfolio significantly increases the capacity value of renewable resources by capturing diversity in their output profiles.

NREL has identified greater use of imports and exports as one of the most economical strategies for accommodating the variability observed on power systems with large amounts of wind and solar. Specifically, NREL found that in modeling case studies of California, Florida, and the Southwest Power Pool ("SPP"), increasing exports provided the largest or

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[49] Christopher T.M. Clack, Michael Goggin, Aditya Choukulkar, Brianna Cote & Sarah McKee, *Consumer, Employment, and Environmental Benefits of Electricity Transmission Expansion in the Eastern U.S.* (Americans for a Clean Energy Grid Oct. 2020), *available at* https://cleanenergygrid.org/wp-content/uploads/2020/11/Consumer-Employment-and-Environmental-Benefits-of-Transmission-Expansion-in-the-Eastern-U.S.pdf [hereinafter "*Benefits of Electricity Transmission Expansion*"].

[50] *See, e.g.,* Patrick Brown and Audun Botterud, *The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System*, 5 Joule 115 (Jan. 20, 2021), *available at* https://www.sciencedirect.com/science/article/abs/pii/S2542435120305572.

[51] *See, e.g.*, Zach Ming et al., *Resource Adequacy in the Pacific Northwest* (Energy and Environmental Economics (E3), Inc. Mar. 2019), *available at* https://www.ethree.com/wp-content/uploads/2019/03/E3_Resource_Adequacy_in_the_Pacific-Northwest_March_2019.pdf [hereinafter "*Resource Adequacy in the Pacific Northwest*"].

[52] Alexander E. MacDonald et al., *Future Cost-Competitive Electricity Systems and Their Impact on US CO2 Emissions* at 1 (Nature Climate Change Jan. 25, 2016), *available at* https://www.vibrantcleanenergy.com/wp-content/uploads/2016/09/Future_cost-competitive_electricity_syst.pdf.

second largest benefit for facilitating renewable adoption.[53] NREL's Western Wind and Solar Integration Study also showed that while large amounts of wind and solar can significantly increase power system variability in a single grid operating area, if renewable output is aggregated across the Western U.S. then power system variability actually decreases.[54]

A variety of studies have shown that large import and export ties are particularly important for power systems with high solar penetrations, like those in the Southwest. These power systems need large ties to both export high midday solar output, and import other resources, like wind and hydropower, in the evening and night when solar is unavailable.[55] The evolution to West-wide coordinated planning and operations of the electricity system will be essential for Washington, California, and other states to achieve their decarbonization requirements.

As a result, PSE should be focused on regional solutions to meeting its needs, looking not just at its current system, but across the Northwest and across the entire Western Interconnect. Solar in the Southwest and existing hydropower reservoirs in Canada can significantly complement PSE's resources, particularly during winter peak periods.

PSE can also use transmission and market ties to access load diversity, reducing its need for capacity. Generation reserve margin analysis typically accounts for the fact that power systems across a region are unlikely to experience demand peaks or supply shortfalls at the same time, so imports can be relied on to meet peak demand.[56] For example, E3's analysis indicates

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[53] Paul Denholm et al., NREL, *Impact of Flexibility Options on Grid Economic Carrying Capacity of Solar and Wind: Three Case Studies* at vii-xi, (Dec. 2016), *available at* https://www.nrel.gov/docs/fy17osti/66854.pdf.
[54] GE Energy, *Western Wind and Solar Integration Study* at 83, (NREL May 2010), *available at* https://www.nrel.gov/docs/fy10osti/47434.pdf.
[55] *Benefits of Electricity Transmission Expansion* at 21.
[56] *See, e.g.,* PJM Staff, *2019 PJM Reserve Requirement Study* at 26, (Oct. 8, 2019), *available at* https://www.pjm.com/-/media/committees-groups/subcommittees/raas/20191008/20191008-pjm-reserve-requirement-study-draft-2019.ashx.

that import ties offer 74% of their nameplate capacity as capacity value.[57] Idaho Power has documented the considerable seasonal load diversity among Pacific Northwest utilities, with combined winter and summer peaks being considerably lower than the sum of their parts because they peak during different seasons, as shown below. Idaho Power also noted that diversity not only occurs "seasonally, as illustrated in Table 6, but it also occurs sub-seasonally and daily,"[58] so the total diversity benefits during peak load hours are even greater than indicated. The diversity benefits with California and the Southwest would also be even greater than those shown below in Figure 2 (Table 6 in Idaho Power's 2019 IRP).

Figure 2

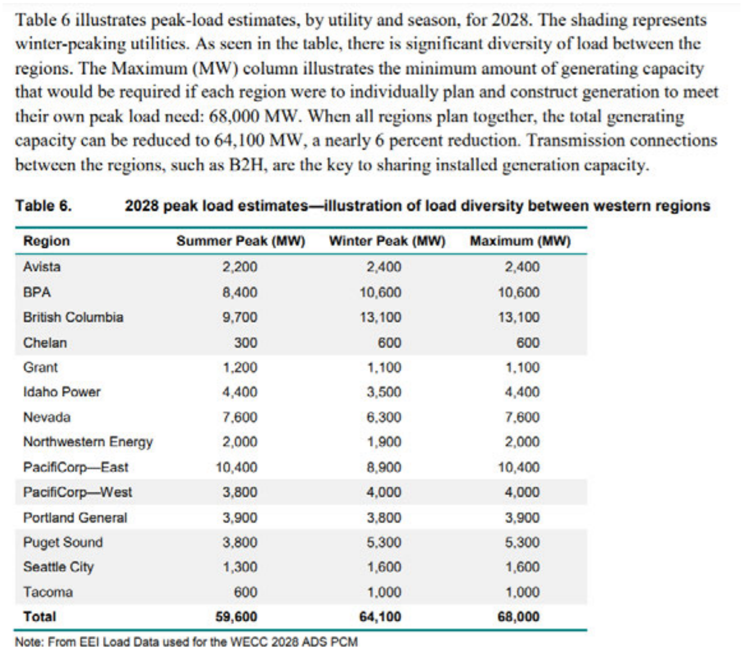

Table 6 illustrates peak-load estimates, by utility and season, for 2028. The shading represents winter-peaking utilities. As seen in the table, there is significant diversity of load between the regions. The Maximum (MW) column illustrates the minimum amount of generating capacity that would be required if each region were to individually plan and construct generation to meet their own peak load need: 68,000 MW. When all regions plan together, the total generating capacity can be reduced to 64,100 MW, a nearly 6 percent reduction. Transmission connections between the regions, such as B2H, are the key to sharing installed generation capacity.

Table 6. **2028 peak load estimates—illustration of load diversity between western regions**

Region	Summer Peak (MW)	Winter Peak (MW)	Maximum (MW)
Avista	2,200	2,400	2,400
BPA	8,400	10,600	10,600
British Columbia	9,700	13,100	13,100
Chelan	300	600	600
Grant	1,200	1,100	1,100
Idaho Power	4,400	3,500	4,400
Nevada	7,600	6,300	7,600
Northwestern Energy	2,000	1,900	2,000
PacifiCorp—East	10,400	8,900	10,400
PacifiCorp—West	3,800	4,000	4,000
Portland General	3,900	3,800	3,900
Puget Sound	3,800	5,300	5,300
Seattle City	1,300	1,600	1,600
Tacoma	600	1,000	1,000
Total	**59,600**	**64,100**	**68,000**

Note: From EEI Load Data used for the WECC 2028 ADS PCM

It should also be noted that the availability of imports is likely to be high because regional capacity surpluses are quite large. In December 2020, NERC documented that the Northwest

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[57] *Resource Adequacy in the Pacific Northwest* at 45

[58] Idaho Power Company, 2019 Integrated Resource Plan at 43 (June 2019), *available at* https://puc.idaho.gov/Fileroom/PublicFiles/ELEC/IPC/IPCE1919/CaseFiles/20190628Appendix%20D%20B2H%20Supplement.pdf.

region has a large capacity surplus well in excess of its reserve margin target through at least 2027.[59]

IV. The capacity value of wind, solar, storage, and demand response is higher than PSE indicates

PSE assumes low capacity values for wind, solar, storage, and demand response. Capacity value refers to the percent of a resource's nameplate capacity that can be counted on for meeting peak demand. For generic resource additions, PSE's current IRP assumes a capacity value of 15-18% for Eastern Washington wind, 4% for Eastern Washington solar, 1-2% for Western Washington solar and 12-44% for energy storage, and 22-46% for Montana and Wyoming wind.[60]

PSE's assumptions are low relative to those found by others, and even PSE's prior IRPs. In a prior IRP, PSE found that Montana wind offers a 53% capacity value, and a 10% capacity value for Washington solar.[61]

As shown in the chart provided below as Figure 3, modeling by industry consultant E3 shows significantly higher capacity values than PSE's assumptions. For example, E3 finds new Pacific Northwest wind offers capacity values above 25%, and that Montana or Wyoming wind provides 50-60% capacity value. Also noteworthy is that the average capacity value does not drop below 50% until nearly 20 GW of Montana and Wyoming wind is serving the region's utilities. Montana wind resources not only offer high capacity value, but a capacity value that

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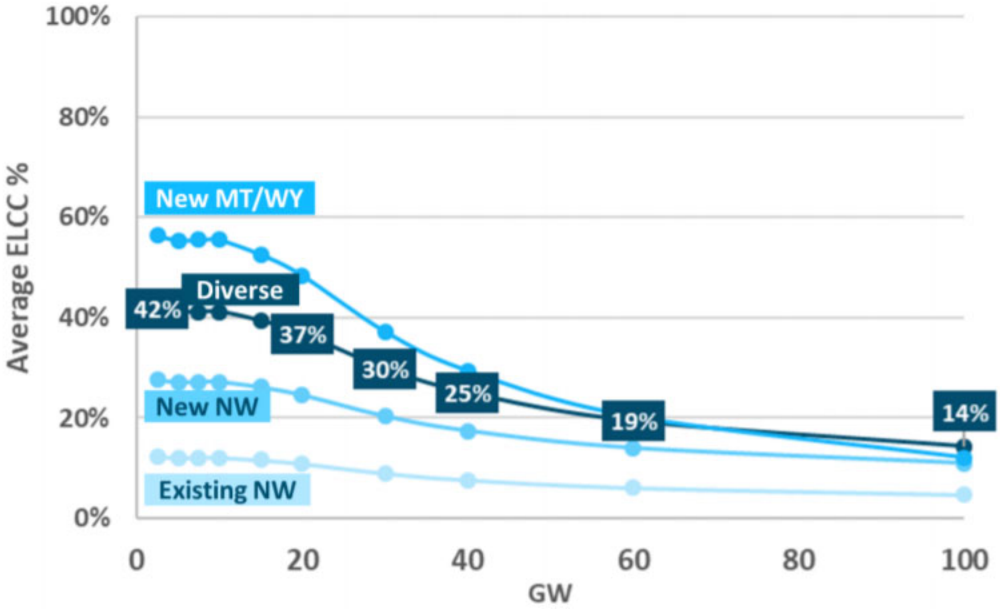
[59] NERC, *2020 Long-Term Reliability Assessment* at 150 (Dec. 2020), *available at* https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2020.pdf.

[60] 2021 IRP at 2-10 to 2-12.

[61] Puget Sound Energy, *2019 TAG Meeting #5: Resource Adequacy and Gas Planning Standard* at 43 (Feb. 7, 2019), *available at* https://pse.com/-/media/PDFs/001-Energy-Supply/001-Resource-Planning/02-IRP-02-07-19-TAG-Meeting-5-Slide-Deck-FINAL.pdf.

stays high at very high renewable penetrations. This will become increasingly important as PSE works to meet CETA targets.

Figure 3: E3 Chart: Average Capacity Value of Wind in Northwest and MT/WY



The assumed capacity values of 12-44% for energy storage in PSE's current IRP are also low too.[62] Modeling of the Pacific Northwest power system by E3 shows that several GW of storage can be added with a 73% capacity value.[63]

PSE's assumed capacity value for demand response is also too low. PSE claims a 26-37.4% capacity value at page 2-12, yet E3 says the region can procure 2 GW of demand response with a capacity value above 40%.[64] As mentioned above, electrification can increase opportunities for demand response. Electrification, and particularly building and water heating electrification, can also increase demand response's capacity value during winter peak periods. Many forms of energy efficiency, like building envelope insulation, enable longer-duration

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[62] 2021 IRP at 2-12.

[63] *Resource Adequacy in the Pacific Northwest* at 45, 58.

[64] *Id.* at 59.

demand response shifting. For example, the longer a building can maintain a comfortable temperature, the more demand response can shift energy consumption away from a peak period and to a period when resources are more abundant.

Wind plant technology improvement is expected to drive continued capacity value increases. Multiple studies have documented how taller wind turbines with longer turbines blades provide higher capacity value by increasing output during periods when older vintages of turbines had lower output.[65] Larger turbines are able to access higher quality, more consistent winds higher above the earth's surface. The increasing length of turbine blades have caused the wind energy captured by turbines to increase much more quickly than the turbines' rated capacity, also driving more consistent output by disproportionately increasing output during periods of lower wind speeds.[66] New wind turbines also have different output profiles from the existing fleet, reducing the correlation in their output and increasing capacity value. As new wind plants are built in new locations, this increases the geographic diversity of the wind fleet and increases its capacity value because the output of these new wind installations is inherently less than perfectly correlated with that of existing plants. These factors, as well as the capacity value complementarity among wind, solar, and storage discussed below, are likely to continue to outpace the decline in wind's capacity value as penetrations increase.

PSE's assumption of declining capacity value for solar also does not account for the potential benefit of technological improvement. The use of single- and dual-axis tracking at solar plants is becoming more common over time, which significantly boosts solar output in early

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[65] *See, e.g.,* Ryan H. Wiser et al., *The hidden value of large-rotor, tall-tower wind turbines in the United States,* Wind Engineering, July 7, 2020, *available at* https://emp.lbl.gov/publications/hidden-value-large-rotor-tall-tower; Lion Hirth and Simon Muller, *System-friendly wind power – How advanced wind turbine design can increase the economic value of electricity generated through wind power*, 56 Energy Economics 51 (Mar. 3, 2016), *available at* https://neon.energy/Hirth-Mueller-2016-System-Friendly-Wind-Power.pdf.

[66] Ryan Wiser et al., LBNL, *Wind Energy Technology Data Update: 2020 Edition* at 37 (Aug. 2020), *available at* https://emp.lbl.gov/sites/default/files/2020_wind_energy_technology_data_update.pdf.

morning and late afternoon hours that tend to be peak demand periods in winter and summer, respectively.[67] Solar inverter-loading ratios, or the ratio of Direct Current solar module capacity to Alternating Current plant output capacity, have steadily increased as solar modules price declines have outpaced reductions in the cost of balance-of-plant equipment. Higher inverter-loading ratios also help provide a flatter solar output profile across the day, with less decline in solar output in early morning and late afternoon hours relative to noon output, similar to the impact of larger blades on wind turbine output.

The "temperature sensitivity designed to capture climate change impacts on demand,"[68] which PSE indicates will be included in the final IRP, should capture that continued warming will increase the importance of summer peak demand periods relative to winter peak periods. This should also increase the capacity value of solar resources relative to what PSE has assumed.

Energy storage can also benefit from technological progress. New types of storage offering longer duration are being developed. In addition, continued cost reductions allow more MWh of batteries to be cost-effectively installed longer duration.

A. *Need to look holistically across a geographically and technologically diverse portfolio of wind, solar, and storage resources to capture complementarity in capacity value*

As discussed in the previous section, PSE needs to look regionally for the reliability analysis for higher penetrations of renewable resources, given trends towards markets and greater integration across the West, and the fact that regional integration becomes essential for cost-effectively achieving deep decarbonization.

PSE's IRP provides capacity values for each resource on a stand-alone basis, but it is critical that PSE's modeling and resource selection strategy account for the capacity value

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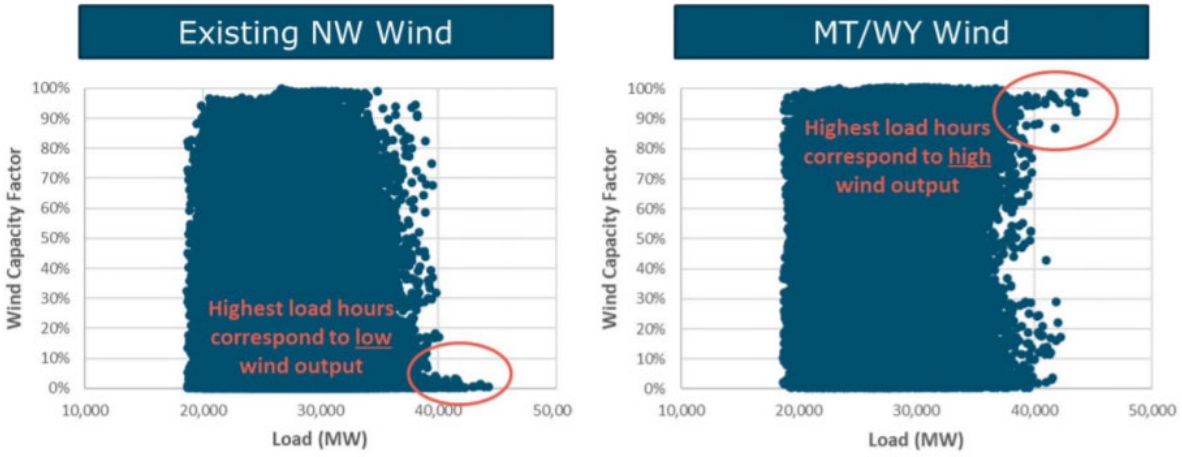
[67] *2020 Utility-Scale Solar Update* at 14 (November 2020), *available at* https://emp.lbl.gov/publications/utility-scale-solar-data-update-2020.

[68] 2021 IRP at 1-5.

diversity benefits among wind, solar, and storage, as well as among wind and solar resources located in different areas. A resource's capacity value changes based on the penetration of other resources on the power system, which requires robust analysis of a large number of potential portfolios to identify the optimal mix of resources.

As discussed earlier in this section, Montana and Wyoming wind offers PSE capacity value that is high, and stays high. In the following chart, provided as Figure 4, E3 documents how that is driven by the correlation of those resources' output with PSE's peak loads, and the diversity complementarity with existing Northwest wind resources. As E3 explains, "[e]xisting wind in the Northwest today, primarily in the Columbia River Gorge, has a strong negative correlation with peak load events that are driven by low pressures and cold temperatures. Conversely, Montana and Wyoming wind does not exhibit this same correlation and many of the highest load hours are positively correlated with high wind output."[69]

Figure 4: E3 Chart: Coincidence of Wind Output with Load



Part of the reason Montana wind provides large capacity value is because it diversifies the region's wind fleet, as can be seen in Figures 3 and 4 above. A diverse combination of

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[69] *Resource Adequacy in the Pacific Northwest* at 55-56.

Pacific Northwest and Montana or Wyoming wind retains a capacity value of 37% with 20 GW of installed wind capacity.[70] This capacity value is greater than the sum of its component parts, as indicated in the chart by the fact that the capacity value line for the diverse fleet is higher than the halfway point between the Pacific Northwest and Montana wind capacity value lines. The geographic separation between Washington, central Montana, eastern Montana, and Wyoming gives each a different output profile.

They should also be complementary because of the reduced correlation among Wyoming solar, Montana solar, and Washington solar. This includes the benefit of the sun rising earlier in Montana and Washington, providing more output during PSE's morning load ramp, and the benefit of geographic diversity canceling out local or even regional weather events like widespread cloud or snow cover.[71]

The complementarity among wind, solar, and storage is even greater than the diversity benefits among wind resources located in different areas. Due to diversity benefits among wind, solar, and storage resources, their combined capacity value is higher than the sum of their parts. The capacity value of solar increases with more wind on the power system, and vice versa, because their output patterns are negatively correlated on a daily and seasonal basis. For example, PJM's renewable integration study showed solar provided a higher capacity value when the resource mix had more wind generation, and vice versa.[72] Public Service Company of Colorado found a similar trend in a 2016 wind effective load carrying capability study.[73]

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[70] *Id.* at 55.

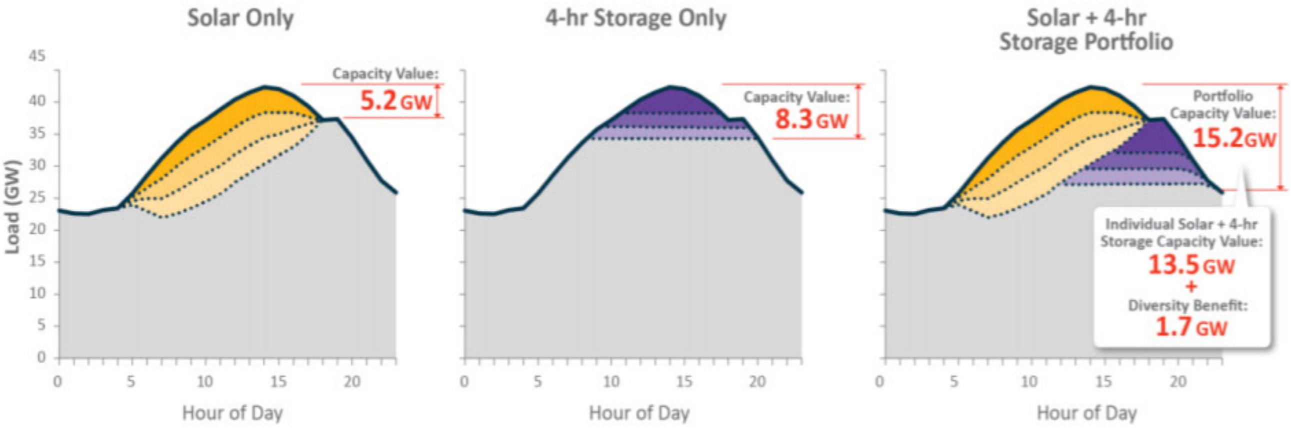
[71] Andrew D. Mills & Ryan Wiser, LBNL, *Implications of Wide-Area Geographic Diversity of Short-Term Variability of Solar Power* (Sept. 2010), *available at* https://emp.lbl.gov/sites/all/files/presentation-lbnl-3884e-ppt.pdf ["Implications of Wide-Area Geographic Diversity of Short-Term Variability of Solar Power"].

[72] General Electric International, Inc., *PJM Renewable Integration Study: Task 3A Part F, Capacity Valuation* at 29 (Mar. 31, 2014), *available at* https://www.pjm.com/-/media/committees-groups/subcommittees/irs/postings/pjm-pris-task-3a-part-f-capacity-valuation.ashx?la=en.

[73] Hearing Exhibit 103, Attach. KLS-2, An Effective Load Carrying Capability Study of Existing and Incremental Wind Generation Resources on the Public Service Company of Colorado System, Docket No. 16A-0369E (Colo.

Adding battery storage helps keep the capacity value of wind and solar high, as battery storage can absorb wind and solar output when it is less valuable and shift it later in time to peak demand periods.[74] In particular, adding storage keeps solar capacity value high by making it possible to shift midday and early afternoon solar output to later in the afternoon and evening. Similarly, battery storage can shift overnight wind output later to help meet the morning load up ramp, particularly during winter periods when morning heating demand is high and solar output is low. Less intuitively, solar also boosts the capacity value of storage. Solar output in the late afternoon and early evening helps shift peak net load later into the evening. This also shortens the duration of the peak net load period, allowing limited duration storage resources to fully meet the peak demand. As shown in the chart from E3 provided below as Figure 5, the diversity benefit between solar and storage causes their combined Effective Load Carrying Capacity ("ELCC") to be greater than the sum of their parts.[75]

Figure 5: Complementary capacity value benefit between solar and storage



Public Utility Comm'n May 27, 2016), *available at* https://www.xcelenergy.com/staticfiles//xe/PDF/Attachment%20KLS-2.pdf.

[74] Andrew Mills & Ryan Wiser, LBNL, *Strategies for Mitigating the Reduction in Economic Value of Variable Generation with Increasing Penetration Levels* (Mar. 2014), *available a*t https://emp.lbl.gov/sites/all/files/lbnl-6590e.pdf.

[75] Nick Schlag, et al., *Capacity and Reliability Planning in the Era of Decarbonization* at 6 (Energy and Environmental Economics Aug. 2020), *available at* https://www.ethree.com/wp-content/uploads/2020/08/E3-Practical-Application-of-ELCC.pdf.

Notably, the complementary diversity benefit among resources increases at higher renewable penetrations, as capacity needs shift to periods when existing resources are unable to produce. The capacity value of Montana and Wyoming wind will increase even further as PSE adds more Washington wind. As documented above, this occurs because Washington wind and Montana wind output profiles are not strongly correlated, so Montana wind tends to be available when Washington wind is not. This reduces both periods of over-generation when incremental energy has lower economic value, and periods of shortage when energy and capacity have high value.

Diversifying the type and location of PSE's renewable mix provides other benefits besides resource adequacy. Ascend Analytics,[76] LBNL,[77] and others project increasing price volatility in the Western U.S. as renewable penetrations increase, due to their correlated output patterns. Adding a diverse portfolio of wind and solar resources to the generation portfolio reduces that correlation by providing a more constant output profile, ensuring that the energy value of wind and solar resources remains high at higher penetrations and protecting against price volatility.

B. Reduced variability from a more diverse resource portfolio

PSE's IRP claims that balancing capacity will be needed to accommodate wind and solar variability.[78] A diverse portfolio of renewable resources should significantly reduce this need. Valuably, this can reduce PSE's total need for capacity, as reserves providing an upward

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[76] Ascend Analytics, *WECC Market Outlook and Modeling* at 9-13, *available at* https://www.northwesternenergy.com/docs/default-source/documents/defaultsupply/plan19/volume2/ascend-analytics-wecc-market-outlook-and-modeling-02-22-2019.pdf.

[77] Joachim Seel et al., *Impacts of High Variable Renewable Energy Futures on Wholesale Electricity Prices, and on Electric-Sector Decision Making* (LBNL May 2018), *available at* https://eta-publications.lbl.gov/sites/default/files/report_pdf_0.pdf.

[78] 2021 IRP at 1-15, 3-6.

response require capacity to be held unloaded so output can be increased if needed, and thus that capacity cannot be used to meet peak demand.

In addition, PSE currently charges variable energy resource rates that were added to Schedule 13 of its OATT in FERC case ER11-3735. In its 2018 RFP, PSE wrote that "integration costs can range between $3.02/MWh (OATT Schedule 13) and $3.15/MWh (PSE 2017 IRP, page D-43) for a wind resource."[79]

It is likely that a diverse portfolio of wind resources offers significantly lower reserve needs and integration costs than a portfolio primarily comprised of Pacific Northwest wind. BPA's Montana Renewables Development Action Plan found that Montana wind resources can be dynamically scheduled into the Pacific Northwest, which would allow the variability to be managed by BPA or the receiving Balancing Authority (i.e., PSE). This would allow PSE to pay lower rates than the ancillary services rates that were approved for NorthWestern Energy's Balancing Authority in FERC docket ER19-1756. First and most importantly, Montana wind resources are distant from and therefore are not affected by the same localized weather phenomena as PSE's existing and planned wind resources in Washington. Numerous studies show that geographic distance drastically reduces the correlation in both variability and uncertainty between two wind plants.[80] Second, higher capacity factor wind resources like those available in Montana tend to have less variability for the simple reason that they are producing at higher levels of output more of the time. Recent analysis by LBNL confirms that

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[79] Puget Sound Energy, *2018 All Resources RFP: Exhibit G. Schedule of Estimated Avoided Cost* at G-1 (2018), *available at* https://www.pse.com/-/media/PDFs/001-Energy-Supply/003-Acquiring-Energy/2018_All_Resources_RFP_Ex_G.PDF.

[80] Hannele Holttinen et al., VTT, *IEA Wind Task 25 - Design and Operation of Power Systems with Large Amounts of Wind Power* at 25-28 (IEA 2009), *available at* https://community.ieawind.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=c7a0f97c-b01c-713b-b51a-46f33d62b5db&forceDialog=0 [hereinafter "*Design and Operation of Power Systems with Large Amounts of Wind Power*"].

wind plants with consistently higher output offer greater net value from reduced variability and uncertainty, lower financing costs from reduced interannual output variability risk, and more efficient utilization of transmission capacity.[81]

As a result, other Northwest utilities have found that Montana wind offers lower integration costs. For example, PGE's 2019 IRP found that the integration costs associated with Oregon wind ($0.33/MWh) and Washington wind ($0.31/MWh) are 4-5 times larger than those for Montana wind ($0.07/MWh).[82] Given that PSE's FERC tariff identifies wind integration costs that are about 10 times higher than that, and the fact that wind integration costs significantly increase as wind penetration increases,[83] PSE's current and future integration cost savings from the use of Montana wind could be quite large.

Similar benefits could likely be attainable for solar geographic diversity if PSE deploys solar in both Washington and Montana. Geographic diversity provides an even larger reduction in the intra-hour variability of solar output than it does for wind, and the considerable distance between Montana and Washington solar should prevent localized or even regional weather phenomena from causing large or sudden fluctuations in the output of the total solar fleet, as mentioned above.[84]

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[81] Ryan H. Wiser, et al., *The hidden value of large-rotor, tall-tower wind turbines in the United States,* Wind Engineering, July 7, 2020, *available at* https://emp.lbl.gov/publications/hidden-value-large-rotor-tall-tower.

[82] Portland General Electric, *2019 Integrated Resource Plan* at 160 (July 2019), *available at* https://downloads.ctfassets net/416ywc1laqmd/6KTPcOKFlLvXpf18xKNseh/271b9b966c913703a5126b2e7bbbc37a/2019-Integrated-Resource-Plan.pdf.

[83] Ryan Wiser & Mark Bolinger, LBNL, *2016 Wind Technologies Market Report* at 70 (U.S. DOE 2016), *available at* https://eta-publications.lbl.gov/sites/default/files/2016_wind_technologies_market_report_-_corrected_back_cover.pdf.

[84] Implications of Wide-Area Geographic Diversity of Short-Term Variability of Solar Power.

C. *With diverse renewables, PSE can add more renewable resources to existing transmission capacity*

PSE could likely economically interconnect more high-quality renewable resources on existing transmission than the amount indicated in its IRP, particularly in eastern Washington and Montana. We support PSE's proposal in Appendix J for moving from requiring long-term firm ("LTF") transmission for the full nameplate capacity of resources, to instead acquiring "less than nameplate capacity of LTF transmission for renewable resources because the intermittent output of renewable resources usually leaves transmission idle, and there is often short-term transmission available (firm and non-firm) to purchase or redirect." We expect Sensitivity E, in which "[n]ew resources are acquired with firm transmission equal to a percentage of their nameplate capacity instead of their full nameplate capacity,"[85] to confirm the value of this approach for all PSE transmission to access renewable resources. We would note that the amount of nameplate renewable capacity that can be added on a line relative to the transmission capacity varies considerably depending on the diversity of the resources on the line, and is often very high.

Due to the lack of correlation in wind output patterns across even relatively short distances,[86] multiple wind plants seldom produce at their full nameplate capacity at the same time. Depending on the geographic diversity of the wind resources, it is typically economically optimal to interconnect 10-40% more wind capacity relative to available transmission capacity. For example, in its recent IRP, PacifiCorp found that in one case it could interconnect 1,100 MW of additional wind onto 800 MW of additional transmission capacity (wind capacity 37.5% higher than the available transmission capacity), while in

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[85] 2021 IRP at 3-10.

[86] *Design and Operation of Power Systems with Large Amounts of Wind Power* at 25.

another case it could add 1,920 MW of wind onto 1,700 MW of additional transmission capacity (13% more wind capacity).[87]

Given that the on-peak production of energy to meet PSE's capacity needs is increasingly more valuable than off-peak energy production, it may be economic for PSE to push the ratio of nameplate renewable capacity to transmission capacity even higher. This is particularly true when the transmission accesses resources that have high on-peak output, like Montana and Wyoming wind. While this will increase renewable curtailment, as renewable penetrations increase the opportunity cost of renewable curtailment caused by transmission congestion decreases, as during periods of high renewable output, the marginal economic value of an additional MWh can be low or even zero.

PSE could push the utilization factor of transmission capacity even higher by locating solar or storage resources along transmission that connects wind plants. Solar plants tend to have opposite output profiles as wind resources on both an hourly and seasonal basis, while storage resources located on the wind or solar plant side of a transmission constraint can charge during periods when renewable output exceeds the available transmission capacity and discharge that energy once renewable output has decreased below the available transmission capacity.

Fortunately, there are fewer constraints on where solar and storage projects can be deployed relative to wind projects, so they can often be sited in advantageous locations on the grid where they can increase the utilization factor of transmission. Some large storage and solar projects are already under development in Montana, which would allow greater

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[87] PacifiCorp, *2019 Integrated Resource Pan* at 247 (Oct. 18, 2019), *available at* https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2019_IRP_Volume_I.pdf.

utilization of CTS capacity than if it is only used for wind generation. For example, the Buffalo Trail project that is scheduled to come online near the CTS in Montana by 2022 will include 250 MW of wind and 250 MW of solar,[88] offering a steadier output profile due to the negative correlation between wind and solar output.

Similarly, PSE's interconnection queue includes a 500 MW proposed wind and storage project and a 300 MW solar and storage project in Montana.[89] In addition, a proposed 400 MW pumped storage plant located along the CTS path in Montana has received a FERC license.[90] Because this project uses a "quaternary" design in which the same equipment is used for pumping and generating, it can quickly switch between pumping and generating. As a result, it provides 800 MW of flexible capacity and can provide a range of ancillary services. This project offers at least 8.5 hours of energy storage when pumping or discharging at full capacity, which can absorb relatively long periods of high renewable output and shift that output to when transmission capacity is available. While some of these projects may be too large for PSE to contract with on its own, PSE could purchase part of their output. PSE can greatly increase the utilization of its CTS capacity by assembling a diverse portfolio of Montana wind, solar, and storage resources.

V. PSE should work to expand transmission

While PSE can add significant amounts of renewables to existing transmission, as discussed above and below, PSE should simultaneously pursue opportunities to expand

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[88] Tom Lutey, *Broadview wind and solar farm gets new owner*, Billings Gazette (Dec. 17, 2020), https://billingsgazette.com/news/state-and-regional/broadview-wind-and-solar-farm-gets-new-owner/article_727b9178-dfde-55ae-a06f-912a30827503 html. .

[89] *Current Transmission Queue*, Positions 48 and 79, Puget Sound Energy, https://www.pse.com/pages/transmission/obtaining-services/transmission-queue (last accessed Feb. 24, 2021).

[90] FERC, *Licensed Pumped Storage Projects* (Jan. 1, 2020), *available at* https://www.ferc.gov/sites/default/files/2020-04/LicensePumpedStorageProjectsMap.pdf.

transmission in Washington, regionally, and throughout the West that is appropriately sited to address land and wildlife concerns.

PSE describes options for transmission expansion in Appendix J, including proposing four strategies for regional transmission.[91] None of these strategies are mutually exclusive, and they offer different risk/reward profiles and timelines. As a result, PSE should be pursuing all of them aggressively. Specifically, PSE can implement Strategies 1 and 2 of repurposing existing transmission reservations for renewable resources in the near-term, while simultaneously pursuing additional transmission capacity through BPA's transmission service request and cluster study process (Strategy 3), and pursuing transmission projects by itself or in partnership with other utilities (Strategy 4). There is no downside to this multi-pronged approach, as significant costs are not incurred until much later in the transmission development process under Strategies 3 and 4, and considerable upside given the central importance of transmission to cost-effectively meeting CETA's requirements. For example, PSE notes "there is no commitment risk for PSE to submit [transmission service requests] in constrained areas of BPA's system since contracts are not awarded until construction is underway,"[92] so there is no downside to pursuing Strategy 3 alongside the other strategies.

A. *Opportunities to increase transfer capacity on existing transmission*

While building new transmission takes time, PSE has many opportunities to expand transmission capacity in the next several years. These opportunities can make sufficient low-cost and high-value renewable resources available PSE to meet its needs while longer-term transmission expansion is completed, avoiding the need to add emitting resources.

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[91] Puget Sound Energy, *2021 IRP – Appendices A-M* at J-15 - J-16 (Jan. 2021), *available at* https://oohpseirp.blob.core.windows net/media/Default/Reports/Draft/Appendix/UE-200304-UG-200305-PSE-DRAFT-2021-IRP-Appendices-(01-04-21).pdf [hereinafter "2021 Appendices"].
[92] *Id.* at J-9.

First, dynamic line ratings, power flow control devices, topology optimization techniques, and similar technologies can be deployed in a matter of months and allow new renewable resources to interconnect at low cost.[93] Recent analysis by the Brattle Group found that 2,670 MW of additional wind capacity could be added in SPP by adopting dynamic line ratings, power flow control devices, and topology optimization, more than doubling the amount of wind capacity that can be added while keeping curtailment at an acceptable level.[94] Brattle found a one-time investment of $85 million in these technologies would yield annual production cost savings of $175 million.

Dynamic line ratings allow more power to safely flow on transmission lines by accounting for how ambient weather conditions affect the thermal limits of those lines. Transmission line ratings are typically based on worst case weather assumptions: hot weather with full sun and no wind cooling the line. Dynamic line rating devices measure the actual thermal limit of transmission lines, which under most weather conditions are much higher than the limits based on those worst-case assumptions. Dynamic line rating devices are particularly effective for increasing transmission capacity in wind-producing areas, as high wind speeds cool transmission lines at the same time they drive high wind plant output. At a minimum, PSE could use seasonal line ratings instead of year-round ratings that are based on worst-case summer weather conditions. This would significantly increase transmission line limits during the cooler fall, winter, and spring periods when wind output is highest.

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[93] Rob Gramlich, *Bringing the Grid to Life: White Paper on the Benefits to Customers of Transmission Management Technologies* (WATT Mar. 2018), *available at* https://watttransmission.files.wordpress.com/2018/03/watt-living-grid-white-paper.pdf.

[94] Bruce Tsuchida et al.,, *Unlocking the Queue with Grid-Enhancing Technologies* at 8 (Feb. 1, 2021), *available at* https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf.

Power flow control devices, also known as Flexible Alternating Current Transmission Systems ("FACTS") devices, can also be deployed quickly to increase interconnection capacity on the existing transmission system. These are power electronics-based devices used to adjust the power transfer capabilities of the system and improve stability or controllability of the system under critical conditions. These devices have been deployed on the Bonneville Power Administration system, for example.[95] Topology optimization plays a similar role by taking specific transmission lines out of service to redirect power flow away from congestion transmission elements and onto more optimal paths.

Second, over the next several years, PSE could take steps that will add capacity to existing transmission rights-of-way. These improvements can typically be completed more quickly than new transmission lines because they do not typically require new land acquisition and permitting and regulatory proceedings. In some cases, a second circuit can be added to existing transmission towers, doubling transmission capacity on a path. Other options for increasing transmission line capacity on existing rights-of-way include reconductoring existing lines with advanced conductors that can operate at a higher capacity, replacing transmission towers with new towers that can support more circuits or higher-capacity circuits, and adding series compensation devices to increase transfer capacity and improve power flow.

In other cases, substation equipment may be a limiting factor for transfer capacity. Transformers, switches, and other substation equipment can be upgraded to overcome these

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[95] Mike Hulsee, *BPA Series Capacitors – Purpose, Design, Application, & Performance* at 6, *available at* https://na.eventscloud.com/file_uploads/d7f5c57edff3df7d19a085f064d32191_SeriesCapacitorsPresentationSPCCompatibilityMode.pdf.

constraints. Because they do not require new right-of-way, these upgrades can typically be made more quickly than building new transmission lines.

B. PSE should expand transmission within Washington

Transmission that is appropriately sited to address land and wildlife concerns will be essential for PSE to cost-effectively expand renewable resources. We expect PSE's Scenario D, which models increasing transmission limits, will show significant net benefits for ratepayers from transmission expansion. PSE's Scenario C limited transmission access to renewable resources in Eastern Washington, resulting in $900 million in additional Net Present Value ("NPV") revenue requirement cost to PSE ratepayers relative to the IRP Mid scenario which did not have this constraint.[96] The $900 million in net present value savings from accessing more Eastern Washington renewable resources represents an implicit calculation of the "budget" PSE has for building transmission to Eastern Washington. $900 million in net present value is enough to build a large amount of transmission, particularly given that the net present value cost of transmission is significantly reduced by the discount rate because it would be built later in the planning period due to the time required to plan, permit, and build transmission. The cost of Sensitivity C does not significantly increase above that of the unconstrained IRP Mid scenario until around 2040, indicating that there is sufficient time for PSE to complete the required transmission expansion.[97]

For reference, the Midcontinent Independent System Operator ("MISO") has estimated that the cost of building a new double-circuit 500-kiloVolt ("kV") transmission line, which is large enough to carry several thousand MW, is around $4.6 million per mile.[98] Based on

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[96] 2021 IRP at 3-10.

[97] *Id.* at 3-17.

[98] MISO, *Transmission Cost Estimation Guide MTEP 2019* at 46 (2019), *available at* https://cdn.misoenergy.org/20190212%20PSC%20Item%2005a%20Transmission%20Cost%20Estimation%20Guide%20for%20MTEP%202019_for%20review317692.pdf.

approximate transmission distances to eastern Washington and the discount rate reducing the net present value cost of transmission expansion, with the $900 million in net present value savings PSE could likely build multiple new double circuit 500-kV lines to Eastern Washington, or even lines with higher voltage and higher capacity, and provide large net benefits to ratepayers by accessing more cost-effective renewable resources. To mitigate land and wildlife concerns, PSE should utilize existing rights-of-way and corridors as much as possible.

C. *PSE should work to expand transmission access to Montana*

Two upgrades to the CTS system have been studied with a combined price tag of $213.7 million in 2012 dollars, which together would enable an additional 550 MW of transfer capacity from Colstrip to the BPA system. That included a cost of $87 million in 2012 dollars for the CTS upgrade,[99] and $126.7 million in 2012 dollars for upgrades to BPA's system.[100]

The CTS could be redeveloped with modern Alternating Current technology, like advanced conductors and tower designs, to achieve even higher transfer capacity across the existing right-of-way. It could even be converted to much higher capacity High-Voltage Direct Current transmission, which is increasingly the most economic option for longer-distance transmission lines like the 500-mile CTS.[101] VSC converters allow the bidirectional delivery of ancillary services, providing significant value and facilitating the operation of the

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[99] NorthWestern Energy, *Status of Montana Transmission Availability* at 2 (Aug. 2017), *available at* https://www.bpa.gov/Projects/Initiatives/Montana-Renewable-Energy/Documents%20Montana/Northwestern%20Jan%2025,%202018.pdf.

[100] Bonneville Power Admin., *MT REDAP Planning Committee: Draft Responses to Steering Committee Guidance from March 5th* at 1, (Apr. 27, 2018), *available at* https://www.bpa.gov/Projects/Initiatives/Montana-Renewable-Energy/Documents%20Montana/Planning%20Committee%20Narratives_Apr_25_Final.pdf.

[101] Liza Reed et al., *Converting Existing Transmission Corridors to HVDC is an Overlooked Option for Increasing Transmission Capacity*, 116 Proceedings of the National Academy of Sciences 13879 (July 9, 2019), *available at* https://www.pnas.org/content/116/28/13879.

power system with large amounts of inverter-based wind, solar, and battery generation. This can provide reliability services to PSE, but also allow PSE to sell services to other parts of the West. For example, the black start and inertia provided by the Pacific Northwest hydropower fleet could be sold to Montana and Wyoming as they move to a high penetration of wind generation.

D. PSE should expand transmission ties to other parts of the West

PSE should also pursue opportunities for transmission expansion to more distant parts of the West, if they are appropriately sited to address land and wildlife concerns. For example, partnering with other utilities to access low-cost and high-capacity-value Wyoming wind via Boardman to Hemingway ("B2H") and Gateway West is one potential solution. We commend PSE for its interest in 400-600 MW of capacity on B2H and corresponding capacity on Gateway West,[102] and encourage it to move expeditiously to commit to the full 600 MW of available capacity and to support prompt development of the line. PSE notes B2H has a planned 2026 in-service date,[103] so the project could deliver high-capacity-value Wyoming wind to replace PSE's exit of coal capacity at Colstrip.

SWIP-North, which would connect Idaho and Nevada, could give access to solar resources in Nevada and points south. Potential upgrades to the transmission links between California and the Pacific Northwest that could deliver solar output should also be investigated. This includes the DC Pacific intertie as well as the considerable capacity on the AC power system. Much of this transmission and substation equipment is quite old, so replacing it with state-of-the art equipment or adding new equipment could significantly increase transfer capacity. These ties offer considerable value for meeting resource adequacy

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[102] 2021 Appendices at J-12.

[103] *Ibid.*

needs because summer-peaking California and winter-peaking utilities Northwest have different load profiles daily and seasonally, and because the solar capacity in California has negatively correlated output profiles with most of the wind resources available in the Northwest and Mountain states.

Even without those upgrades, there are likely to be considerable increases in solar exports across those ties from California into the Pacific Northwest as solar capacity in California and the Southwest continues to grow. Large amounts of solar output are being exported to the Pacific Northwest during the summer now, and with growing installed solar capacities in California and the Southwest those exports will increase in the winter as well. Because this excess solar output must be curtailed if it is not exported from California, it can typically be procured at very low cost.

Winter days are significantly longer in the Southwest than the Northwest, so Southwest solar output can significantly help with meeting winter peak demands in the Northwest. These solar imports can complement resources that can shift electricity consumption a few hours in time, such as the considerable storage capacity in the existing hydropower fleet, as well as additions of storage and demand response. We encourage PSE to focus on sensitivities that examine strategies for using market purchases of increased solar imports to meet its needs.

As mentioned above, the West is transitioning to more integrated market operations. The ongoing expansion of the Energy Imbalance Market, and the likely transition to more coordinated planning and operations across the Western power system, should increase the availability of solar imports into the Pacific Northwest by reducing or eliminating market and scheduling seams between CAISO and the Pacific Northwest.

Given the long timeline needed for transmission permitting and the need to appropriately site facilities to address land and wildlife concerns, PSE should begin to pursue these opportunities now if the transmission is to be available as PSE's carbon requirements increase.

CONCLUSION

PSE should accelerate its deployment of renewable energy, energy storage, demand response, energy efficiency, and electrification. In particular, PSE can take advantage of low-cost renewable and hybrid resources due to the near-term availability of federal tax credits. By expanding access to regional renewable resources and power markets, PSE can use the powerful statistical principles behind the aggregation of diverse sources of renewable supply and electricity demand to reliably meet demand with less need for generating capacity. Accelerating the transition to clean energy will avoid the need to add gas generating capacity, reducing the economic and reliability risks of increasing dependence on gas generation.