ENERGYGPS LLC

Summary for Northwest RiverPartners

Comments on:
Northwest Energy Coalition's April 2018 Lower Snake River Dams Power Replacement Study

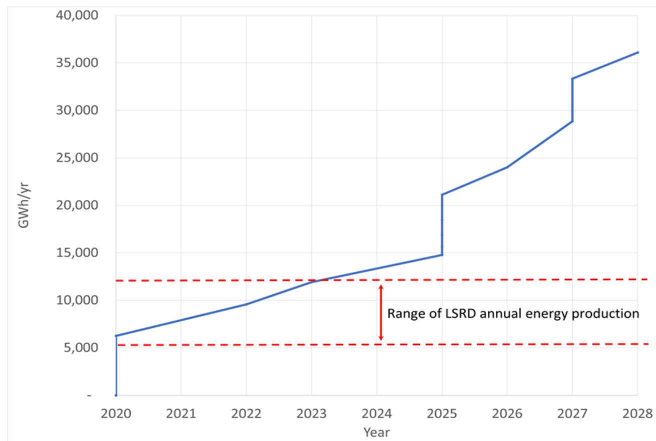
The four Lower Snake River Dams ("LSRD") dams represent a large source of relatively inexpensive, emission-free electricity, supplying over 5.5% of the Pacific Northwest ("PNW") region's electricity supply in a typical year.

The Northwest Energy Coalition ("NWEC"), in April 2018, released the Lower Snake River Dams Power Replacement Study ("NWEC Study"). The study is extensive and, among its findings, states a "portfolio of reasonably available clean energy resources, including solar, wind, energy efficiency, demand-response, and energy storage can effectively replace the most important power attributes the four LSR Dams are forecasted to contribute to the Northwest region." Although not a substitute for the detailed analysis that will be a part of the ongoing Columbia River Systems Operations EIS, as required by the National Environmental Policy Act ("NEPA"), the NWEC Study is receiving attention in the Washington Governor's LSRD Taskforce and other regional dialogs currently underway. Because of its potential to influence ongoing policy dialogs and investigations, the NWEC Study requires examination. Northwest RiverPartners contracted with the consulting firm EnergyGPS Consulting, LLC ("EGPSC") to review the NWEC Study. EGPSC made the following observations and findings:

- The NWEC Study was released over 18 months ago and relied on assumptions from the Northwest Power and Conservation Council's ("NWPCC's") 7th Regional Plan, which is now over 3 years old. As a result, many of the assumptions made by the NWEC are out-of-date and are not reflective of current state and regional energy and climate policies.
- The most significant change since the release of the NWEC Study was the enactment of new decarbonization legislation including, most notably, the passage of Washington's Clean Energy Transformation Act ("CETA"). These laws and policies significantly constrain resource options available to the PNW and larger the WECC region in response to LSRD's removal.
- This new "carbon constrained" reality is most easily measured in terms of the number of announced coal-fired power plant retirements. The most recent NWPCC resource adequacy study assumes that 4,500-6,000 MW of PNW coal-fired power plants will retire in the next 10 years. This is 1,700-3,200 MW higher than the 2,800 MW of

retirements assumed in the NWEC Study. Looking out 15 years (to 2035) at the entire WECC region, the NWPCC expects approximately 20,000 MW of retirements of coal-fired power plants. These retirements will create a large capacity and energy shortfall; one that will be significantly exacerbated by LSRD removal (Figure 1). Faced with these significant capacity and energy constraints and emerging decarbonization policies, the PNW region will have little choice but to seek replacement power from low-carbon or carbon-free resources. The NWEC Study assumptions are simply not aligned with this reality.

Figure 1. Cumulative Energy Impact of Retirements of Coal-Fired Generation Owned or Contracted by PNW Utilities (2020-2028) and Range of LSRD Annual Energy Production

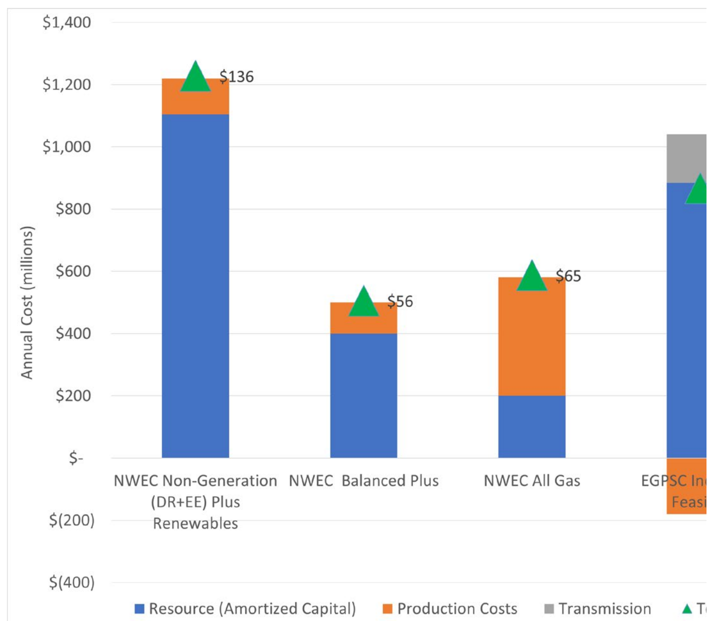


- EGSPC expects that all cost-effective demand response and energy efficiency (DR/EE) resources will be deployed by the region. However, the supply curves used by NWEC indicate that incremental DR/EE on the scale needed for LSRD's replacement will be very expensive. Until there is further development of supply curves for new, incremental DR/EE resources, EGPSC does not recommend relying on DR/EE to be the primary replacement resource for LSRD.
- All of the replacement portfolios developed by NWEC rely unduly on imports to meet energy and capacity shortfalls. NWEC's "Balanced" portfolios, which rely on a mix of DR/EE, wind, and solar resources, do not fully replace LSRD's capacity and energy value. Although new wind resources, most likely to be developed in Montana and Wyoming, can produce energy at capacity factor in excess of 40%, they will have only limited capacity value once many GWs comes online. The NWEC study should be more explicit with regard to how much it relies on imports from outside the PNW to replace LSRD's lost capacity and energy value.
- Except as provided in what it labels as "GHG Policy" sensitivity runs, NWEC does not put a value on incremental carbon emissions, which leads to an in increase in carbon emissions. These are outcomes that are likely infeasible under current and emerging carbon rules and policies. Any realistic replacement portfolio should replace all LSRD

energy with emission-free power or mitigate any incremental emissions by putting a reasonable price on residual carbon emissions.

- The NWEC Study underestimates transmission costs that will be incurred to integrate a large increment of new variable energy resources. The NWEC study effectively assumes that transmission freed up by the retirements at Colstrip 1+2 (614 MW) will free up transmission to deliver Montana wind and that the planned Boardman-to-Hemmingway line will ensure integration of new solar resources from Idaho. To integrate variable energy resources to replace LSRD will require new, incremental transmission for both new wind and solar.
- On balance, the replacement portfolios presented by the NWEC Study are either infeasible or significantly underestimate costs. As an alternative to NWEC's results, EGPSC developed a portfolio that is feasible and does not compromise regional reliability. EGPSC calls this portfolio "Indicative Feasible" (Figure 2, rightmost column). This portfolio relies on grid-scale battery storage and renewable power to supply the capacity and energy shortfall created by LSRD's removal. It also includes an adder for transmission costs so that new renewables can reach load and an adder to reflect the incremental cost of carbon emissions. With these realistic assumptions made, **EGPSC estimates a replacement cost of $860 million/year or $96/MWh.**

Figure 2. NWEC Study GHG Policy Portfolios and EGPSC Indicative Feasible Portfolio (left scale is annual cost, $millions; right scale is cost per unit of replaced energy, $/MWh)



- This cost estimate is approximate—EGPSC's analysis is not meant to be a substitute for a detailed study using more appropriate assumptions. It is significantly higher than NWEC's estimate for its balanced portfolio and, because of this, highlights the need for agreement on common assumptions and further research before any definitive conclusions are made with regard to the future operation of LSRD.

Date: January 20, 2020[1]
To: Northwest RiverPartners
From: EnergyGPS Consulting, LLC ("EGPSC")

Re: Review of the Northwest Energy Coalition's Lower Snake River Dams Power Replacement Study

Executive Summary

ES.1 Introduction

The four Lower Snake River Dams (LSRD)[2] dams represent a large source of relatively inexpensive, emission-free electricity, supplying over 5.5% of the Pacific Northwest ("PNW") region's electricity supply in a typical year.[3],[4]

The four LSRD are being evaluated as part of the Columbia River Systems Operations ("CRSO") Environmental Impact Statement ("EIS"), which, among other objectives, will comply with the requirements of the National Environmental Policy Act ("NEPA"). Breaching the four LSRD is being considered as an alternative mitigation measure in that EIS. [5] The data gathering and analysis that is being conducted as part of the CRSO EIS is the appropriate place to evaluate the impacts of this mitigation alternative. The draft CRSO EIS, including the preferred alternative, is scheduled to be available for public comment in February 2020.

Independent of the CRSO EIS study work, the Northwest Energy Coalition ("NWEC"), during April 2018 released the Lower Snake River Dams Power Replacement Study ("NWEC Study" or "Study").[6] The study is extensive and, among its many findings, states that a " portfolio of

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[1] Prior dated memo (December 19, 2020) revised to correct a typographical error.
[2] The LSRD are Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. All are located in southwest Washington and are part of the FCRPS. NWEC Study, page 19.
[3] 1,025 aMW/18,500 aMW; where 1,025 aMW represents average annual production 2007-2015 and 8,500 aMW is total regional electricity demand (NWPPC 7th Plan, 2017).
[4] The dams provide other benefits such as irrigation, transportation, flood control, and recreational benefits. These benefits are not considered in either the NWEC study or this review.
[5] US Army Corps of Engineers, Columbia River Systems Operations Update, "Introducing the Range of Alternatives," September 2019. Available at https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll8/id/4079
[6] The Study was prepared by Energy Strategies, an energy consulting firm (energystrat.com), and is billed as an independent study commissioned by the NWEC.

reasonably available clean energy resources, including solar, wind, energy efficiency, demand-response, and energy storage can effectively replace the most important power attributes the four LSR Dams are forecasted to contribute to the Northwest region." Although not a substitute for the detailed analysis that will be a part of the CRSO EIS (as required by NEPA), the NWEC Study is receiving attention in the Washington Governor's LSRD Taskforce and other regional dialogs currently underway.[7] Northwest RiverPartners ("NWRP") contracted with EGPSC to evaluate the NWEC Study.[8] EGPSC was tasked to evaluate the overall reasonableness of the Study's findings and conclusions. EGPSC did not attempt to replicate the work of the NWEC Study in detail, but instead focused on the Study's overall methodological approach, use of specific models, and key assumptions.

ES.2 EGPSC Observations and Findings

The NWEC Study uses a comprehensive suite of industry-accepted tools. Concerns over results stem from assumptions made or lack of sufficient documentation. The NWEC Study relies on industry-accepted electricity and resource planning models that are used by entities throughout the region. These include the GENESYS reliability planning model (maintained by Northwest Power and Conservation Council, or "NWPCC"), the PowerWorld model using transmission system reliability data provided by ColumbiaGrid, and ABB's GridView production cost model. These are appropriate models for use in such an analysis. Although not all data and assumptions used in the study have been made available, the NWEC Study does a reasonably good job of presenting assumptions that drive many of the results. Given that the NWEC Study relies on appropriate methodologies, EGPSC's comments focus mainly on areas where the model data or assumptions were insufficiently documented or where EGPSC found the assumption to not be reasonable or reflective of the current market or policy realities.

Key assumptions of the NWEC Study are already out-of-date and do not reflect current state policies nor the PNW's forecasted capacity shortfall. The NWEC study assumptions regarding load and available supply and demand-side resources are largely based on the NWPCC's 7th

[7] The NWEC Study appears to be relied as an input by ECONorthwest its source for estimated power replacement costs in its study, Lower Snake River Dams Economic Tradeoffs of Removal, July 29, 2019, Table 4, p. 35.

[8] Energy Strategies, Lower Snake River Dams Power Replacement Study: Assessing the technical feasibility and costs of clean energy replacement portfolios, "An independent study commissioned by the NW Energy Coalition", March 2018 (posted April 2018). Available at: https://nwenergy.org/featured/lsrdstudy/

Power Plan, which was completed nearly three years ago, in 2016.[9] Since the Study's release, significant policy changes have occurred that shift the appropriate baseline to use for any LSRD removal study. The most notable of these shifts is the passage of Washington's Clean Energy Transformation Act ("CETA") in early 2019. This legislation, along with other state and utility actions to decarbonize the electric sector, significantly constrains resource options available to the PNW and the WECC region in response to LSRD's removal.[10] Put simply, the WECC now operates in a carbon -constrained world. This constraint is most easily measured in terms of the number of announced coal-fired power plant retirements. The most recent NWPCC resource adequacy study assumes that 4,500-6,000 MW of PNW coal-fired power plants will retire in the next 10 years.[11] This is 1,700-3,200 MW higher than the 2,800 MW of retirements assumed in the NWEC Study. Looking out 15 years (to 2035) at the entire WECC region, the NWPCC expects approximately 20,000 MW of retirements of coal-fired power.[12] EGPSC estimates that the cumulative energy impact of retirements of coal-fired power plants owned or contracted by PNW utilities will exceed 35,000 GWh/year in the next decade (Figure 1). This is a large energy shortfall, one that will be significantly exacerbated by LSRD removal as its annual energy production varies from 6,500 to 12,000 GWh/year.[13] With these significant capacity and energy constraints, the PNW region will have little choice but predominantly to seek replacement power from increasingly more expensive carbon-free resources. The NWEC Study assumptions are simply not aligned with this level of resource scarcity.

[9] NWPCC, Seventh Northwest Conservation and Electric Power Plan, February 2016. Available at: nwcouncil.org/7thplan/plan

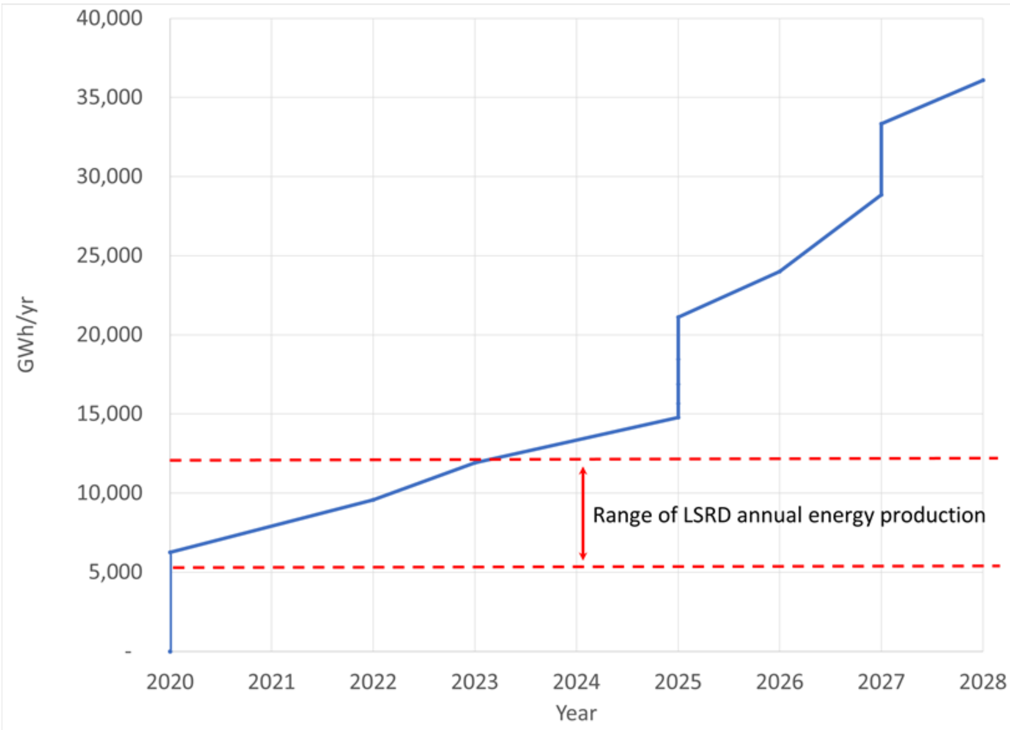
[10] An identification of key legislative/policy activities that have occurred since the NWEC Study was released is in Appendix A

[11] NWPCC, Pacific Northwest Power Supply Adequacy Assessment for 2024, October 31, 2019. Figure 2. The primary difference between the high and low end of NWPCC's range in retirements is associated with Colstrip 3 and 4. There is no announcement to retire these units although CETA will significantly constrain current owners from purchasing power from these projects.

[12] NWPPC (Kujala), Presentation at the NWPP Resource Adequacy Symposium, slide 10, October 2, 2019.

[13] NWEC Study, Figure 11. Historical average production is 9,125 GWh/year.

Figure 1. Cumulative Energy Impact of Retirements of Coal-Fired Generation Owned or Contracted by PNW Utilities (2020-2028) and Range of LSRD Annual Energy Production



The NWEC Study does not adequately discuss the appropriate priority of LSRD replacement resources relative to competing needs for new energy resources. The NWEC Study identifies several preferred replacement portfolios, all of which it describes as containing "reasonably available clean energy resources."[14] Given the multiple policy changes occurring in the region, a basic question that should be addressed is: What priority of resource selection should be given to LSRD replacement resources? Should LSRD replacement resources be selected "first," ahead of the demand created by adopted or likely decarbonization policies, or should they get resources "last"?[15] The implicit assumption of the Study appears to be the latter: that the next available resources in the region go to LSRD replacement, ahead of demand that will be created by various decarbonization policies. Given that certain decarbonization policies are now law, EGPSC generally assumes the former—that only resources reasonably expected to be available

[14] Energy Strategies, "Lower Snake River Dams Power Replacement Study Full Summary Slides", March 2018, p. 6. The NWEC Study also provides an "all gas" replacement portfolio but it is not preferred.
[15] This choice is not unlike the choice made between the common accounting rules of "last in, first out" (LIFO) and "first in, first out" (FIFO).

beyond amounts likely to be committed for the region's ongoing energy transition be associated with LSRD replacement resource. At the very least, the NWEC Study should be clearer about this important assumption.

The NWEC Study energy efficiency and demand response assumptions used in its non-generator alternatives scenarios are costly and are not feasible. EGPSC does not dispute the opportunity for demand response and energy efficiency (DR/EE) and the role it can play in the region's resource plan. However, the magnitude of incremental energy efficiency procured in the Study's two Non-Generating Alternative ("NGA") portfolios are questionable. There is already 3,000 aMW of energy efficiency embedded in the NPPPC 7th Power Plan. The NGA portfolio calls for an additional 237 aMW of energy efficiency with the marginal supply costing close to $100/MWh.[16] The "NGA Plus" portfolio includes an additional 500 aMW of DR/EE where the marginal supply costs exceed $500/MWh.[17] This level of EE is greater than the identified technical potential supply estimated by NWPCC. The high cost of DR/EE is readily apparent in the NWEC Study: Even without adjustment, the NGA Plus portfolio costs $1.2 billion/year or $136/MWh (Figure 2, leftmost column). EGPSC expects that all cost-effective DR/EE, including DR/EE promoted by utilities and regional entities, will be deployed regardless of LSRD's disposition. Until there is further development of supply curves for new, incremental DR/EE (or, econometric modeling of the demand response that will occur from higher regional electricity prices), EGPSC does not recommend relying on the DR/EE to be the primary replacement resource for LSRD.

The NWEC Study unduly relies on imports to meet energy and capacity shortfalls. All of the portfolios presented by NWEC Study rely on imports from outside the region to balance the shortfall created by LSRD removal. In the "Balanced" portfolio, approximately 30% of the shortfall created by LSRD removal is supplied by imports. Although new wind resources, most likely to be developed in Montana and Wyoming, have high annual capacity factors (in excess of 40%), they will have only limited capacity value once many GWs comes online. The prevailing regional capacity need will be for evening ramping capability and wind and solar cannot be expected to provide that to a high degree. The NWEC study appears to rely on imports to provide this capacity on the margin. There is no guarantee that the resources will be there on a firm basis, and,

[16] NWEC Study, Figure B-3. The average cost of DR and EE is $62/MWh (Table 2, below).
[17] The average cost of this block of DD/EE is $229/MWh. As a point of comparison, Energy Trust of Oregon, which implements energy efficiency programs for the majority of electricity load in the state of Oregon, has, since 2002, secured approximately 724 aMW—equivalent to a long-term acquisition rate of 45 aMW/year. Available at: https://www.energytrust.org/wp-content/uploads/2019/04/2018.Annual.Report.OPUC_.pdf

given NWEC's cost assumptions for imports, this reliance on imports leads to an underestimation of LSRD replacement costs.

Incremental carbon emissions should be mitigated or at least priced in all portfolios. Except in specific sensitivity runs, the NWEC does not put a value on carbon, which leads to an underestimate of the cost of LSRD replacement. All of the non-GHG policy portfolios increase GHG emissions. As noted above, the portfolios rely on increased production from existing fossil-fired resources within the region or outside of the region (as imports). The cost of increased GHG emissions is only reflected in the NWEC Study portfolios sensitives labeled "GHG Policy." EGPSC's view is that a realistic replacement portfolio should replace all LSRD energy with emission-free power or mitigate any incremental emissions. At a minimum, any portfolio presented should put a price on incremental carbon emissions.[18]

The NWEC Study underestimates transmission costs that will be incurred to integrate a large increment of new variable energy resources. The NWEC study effectively assumes that transmission freed up by the retirements at Colstrip 1+2 (614 MW) will free up transmission to deliver Montana wind and that the planned Boardman-to-Hemmingway line will ensure integration of new solar resources from Idaho.[19] In EGPSC's view, these identified transmission paths will be used by the region to integrate resources needed to replace retiring coal plants, not LSRD. To integrate variable energy resources to replace LSRD will require new, incremental transmission for both new regional wind and solar. For example, the Montana Renewables Development Action Plan summarized prior studies and indicates that to add substantial amounts of wind *beyond* the amount of MWs that can use transmission "freed up" by retiring Colstrip, will incur $400 million of additional transmission costs.[20] Estimating transmission costs is beyond the scope of this effort but EGPSC recommends that the NWEC study include a placeholder value of at least $35/kW-yr to reflect future incremental transmission costs.[21]

By focusing on regional bill impacts, NWEC Study misrepresents the magnitude of the cost of LSRD replacement. The NWEC Study presented total annualized costs of the replacement portfolios it developed.[22] However, when it put those costs in context, the NWEC study computed impacts on an average regional retail bill. Such a measure greatly dilutes percentage impacts because bills include many non-wholesale power cost components, such as distribution costs. A simpler and more meaningful way to show results is per-MWh-of-replaced-power.

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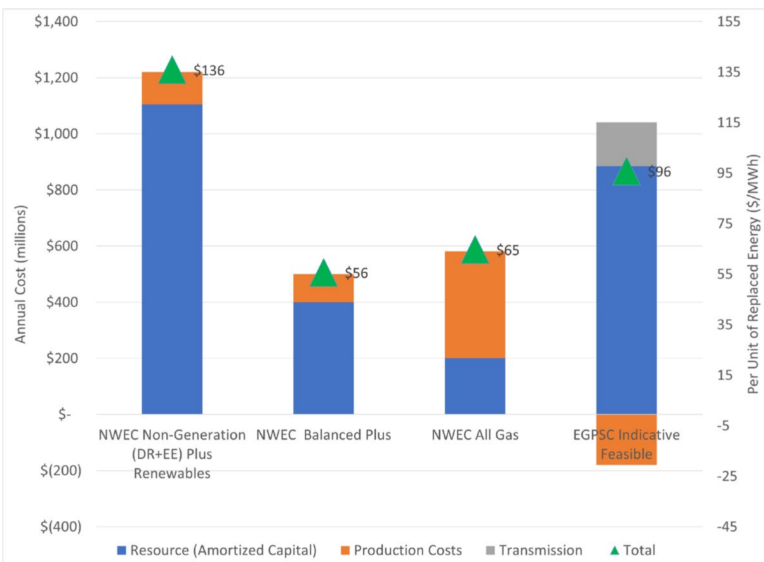
[18] In the NWEC GHG Policy portfolios a GHG adder of $14/MWh is applied.
[19] NWEC Study, p. 44
[20] Montana Renewables Development Action Plan, June 2018 identify the Colstrip Transmission Upgrade, ~$252 million, and the Montana-to-Washington Project, ~$140 million. Page 11 and Appendix A.
[21] Based on an installed cost of transmission of $220/kW and annual capital recovery factor of 16%.
[22] NWEC Study, Figure 14, page 63.

Using this straightforward measure, the NWEC Study portfolios cost between $56 - $136/MWh (Figure 2).[23]

On balance, the NWEC Study portfolios are either infeasible or significantly underestimate costs. EGPSC estimates that the cost of replacing LSRD with feasible resources is on the order of $860 million/year or $96/MWh. As an alternative to NWEC's results, EGPSC developed a portfolio that is feasible and does not compromise regional reliability. EGPSC calls this portfolio "Indicative Feasible" (Figure 2, rightmost column). This portfolio relies on grid-scale battery storage and renewable power to supply the capacity and energy shortfall created by LSRD's removal.[24] As noted above, also It includes an adder for transmission costs and includes a price on incremental carbon emissions that NWEC only included in its GHG Policy Scenarios. In EGPSC's view, this Indicative Feasible portfolio is more representative of the cost of replacing LSRD than the NWEC Study balanced portfolio. This cost estimate is approximate and EGPSC's analysis is not meant to be a substitute for more detailed modeling that should be performed in the future.

Figure 2. NWEC Study GHG Policy Portfolios and EGPSC Indicative Feasible Portfolio (left scale is annual cost, $millions; right scale is cost per unit of replaced energy, $/MWh)



[23] The NWEC portfolio costs are unaltered although only the GHG Policy cost values are shown.
[24] Resource cost assumptions for wind and solar are the same as NWEC's except that wind, on average, was assumed to have a 40% capacity factor (instead of 44%). The effective capacity value of wind and solar was estimated both to be 15%. 350 MW of 12-hour storage was included using per-unit costs of approximately 85% of NWEC's costs. Revenues from excess energy (before inclusion of carbon price) was assumed to be $20/MWh.

ES.3 Conclusion

While the NWEC Study is an ambitious project using industry-accepted models, it fails to present a feasible scenario where LSRD's capacity and energy are replaced with sufficient quantities of carbon-free resources. Instead, the "balanced" portfolios presented have higher emissions and rely on higher imports. Neither assumption is realistic. The study should have addressed the following question: If the LSRD dams are removed and replaced by physical resources with comparable energy and capacity attributes, what would those resources be and how much would they cost? EGPSC endeavored to estimate this value using carbon-free resources (wind, solar, and batteries) more likely to be available in response to LSRD's replacement. Because of the large demand for wind and solar in the region driven by ongoing decarbonization policies, any increment of new wind and solar will also require additional transmission. When factoring in these changes—adequate and feasible replacement resources, new transmission, and carbon costs, EGPGSC estimates that a more realistic estimate of replacement cost will be $860 million/year or $96/MWh. This is a significant cost—one that indicates the need for agreement on common assumptions and further research before any definitive conclusions are made with regard to the future operation of LSRD.

1. Introduction

The four LSRD[25] have a combined nameplate capacity of over 3,000 MW and have an annual median year production of approximately 1,000 aMW. Northwest Energy Coalition, during April 2018 released the Lower Snake River Dams Power Replacement Study ("NWEC Study" or "Study"). The Study was prepared by Energy Strategies, an energy consulting firm, and is billed as an independent study commissioned by the NWEC.

The LSR dams represent a large source of relatively inexpensive, emission-free electricity, supplying over 5.5% of the regions electricity supply in a typical year.[26],[27] The Pacific Northwest, primarily through state legislative action, has adopted ambitious decarbonization targets in the electric power sector. Collectively these polices set ambitious decarbonization targets for the region's power system. Considering this policy backdrop, along with LSR's size and low operating costs, any proposal to remove LSRD should undergo careful study before irrevocable decisions are made to remove them from service.

NWRP engaged EPGSC to review of the NWEC Study.[28] This review is necessarily a high level one—there is no attempt to fully replicate NWEC's study or produce an alternative study at a similar level of precision or detail. Instead this review identifies what it sees as strengths and weakness of the NWEC study. Where significant deficiencies are identified, EGPSC presents alternative assumptions and results that it believes are more supportable. EGPSC also identifies areas for which further documentation by NWEC or further study would be fruitful for analyzing this important question. The following provides a high-level critical review of the April 2018 study.

This balance of this memo is arranged as follows. Key findings are first presented. A few key issues are addressed; namely, regional coal plant retirements and LSRD reliability contributions. The memo then presents an alternative replacement portfolio. An appendix is included that summarizes policy changes made in the region since the NWEC Study was released. To efficiently use available budget, the repeating of NWEC study methods, assumptions, and results is kept to a minimum. Instead, references are provided.

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[25] The LSRD are Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. All are located in southwest Washington and are part of the FCRPS. NWEC Study, page 19.
[26] 1,025 aMW/18,500 aMW. Total regional electricity demand from the NWPPC 7th Plan, 2017.
[27] The dams provide other benefits such as irrigation, flood control, and recreational benefits. These benefits are not considered in either the NWEC study or this review.
[28] Scope of Work Contract C-0318.

2. Overview of the NWEC Study

At the outset, the NWEC study should be recognized as a significant study that relies on industry-accepted electricity and resource planning models. The study uses the following complementary models:

1. GENESYS reliability planning model. This is a model maintained by the NWPCC. More generally, the NWEC study aligns key assumptions to the NWPCC's 7th Power Plan which was released in 2016.
2. ColumbiaGrid's transmission system reliability power flow model, which uses scenarios developed by ColumbiaGrid that run on the PowerWorld model.
3. GridView production cost model. Maintained by ABB, GridView is one of a handful of production cost models widely used in the U.S.

The study is also clearly written and does a reasonably good job of presenting key assumptions used in the model. This said, there are assumptions for which documentation was insufficient and, when significant, EGPSC identifies them in this memo.

The heart of any resource planning study is not its analytical tools or the quality of explication, but the reasonableness of the assumptions used. Accordingly, EGPSC's review focuses on the NWEC's assumptions. For ease of understanding and presentation, the NWEC Study arranges its assumptions in the form of multiple scenarios or "replacement portfolios" that satisfy the replacement of LSR. The portfolios include a mix of resources potentially available to the region. Five portfolios of three general types are presented:

- All Gas. In this portfolio, a mix of combined cycle and reciprocating engines is procured.
- Non-Generating Alternative ("NGA") and NGA Plus. These portfolios rely on an increased level of programmatically secures demand response ("DR") and energy efficiency ("EE"). The two NGA portfolios assume ~ 1 GW of DR and between 320-880 aMW of EE. Specifically, the NGA Plus portfolio increases EE by a factor of 2.75x relative to the NGA portfolio. Both NGA portfolios include a modest amount of battery storage.
- Balanced and Balanced Plus. The balanced portfolios include about half of the DR and EE included in the NGA portfolio. To that level of DR and EE, 750 MW of wind and utility-scale

solar is added. In the Balance Plus portfolio, the level of DR and EE is unchanged but wind and solar is further increased.[29]

Table A of the NWEC study shows the specific MW levels of the replacement resources selected in each portfolio. Furthermore, three of the NWEC study portfolios are modified to include additional carbon pricing in placed on power produced from fossil fuels. Thus, a total of 8 portfolios presented consistently throughout the report.

3. Important Developments in PNW Resource Planning

As a result of technological change and the need to address carbon dioxide and other pollutants created by traditional sources of electric power production, the electric power grid in the west ("WECC")[30] is undergoing significant transformation. Put simply, the WECC now operates in a carbon constrained world. Mostly led by legislation at the state level, the WECC now operates under mandates to significantly reduce the carbon intensity of its power sector. An identification of key legislative/policy activities that have occurred since the NWEC Study was released is in Appendix A. Renewable energy resources are an increasingly large source of electric power. The PNW region continues to progress deploying demand response programs and energy efficiency. The PNW remains a decentralized market consisting of multiple balancing authorities; however, the introduction of the Western Energy Imbalance Market ("EIM") is changing the landscape somewhat. A full review of these changes is beyond the scope of this effort but EGPSC calls out these larger trends to underscore how fast things are changing and how it should come as no surprise that the NWEC study, now over 18 months old, is out of date with respect to certain assumptions. The balance of this section focuses on a key assumption, the retirement of existing fossil fired power plants.

In the WECC, nearly 20,000 MW of coal plants are expected to retire by 2030, approximately 10% of the dependable capacity in the region.[31] A significant fraction of coal plants in the west are contracted or owned by load serving utilities in the PNW. Table 1 indicates that PNW utilities will retire 6,700 MW of coal plants during the period 2020-2030. The recent NWPCC 2024 Resource Adequacy study reports a similar range, between 4,500-6,000 MW—the range mostly depends on assumptions regarding Colstrip 3+4. Across the entire WECC, the NWPCC

29 Importantly, the Balanced Plus portfolio is used by ECONorthwest its source for estimated power replacement costs in its study, Lower Snake River Dams Economic Tradeoffs of Removal, July 29, 2019, Table 4, p. 35.

30 Western Electric Coordinating Council or WECC is commonly used to refer to the synchronized power grid connecting all western US states, western Canadian provinces, and a portion Mexico's Baja Del Norte region.

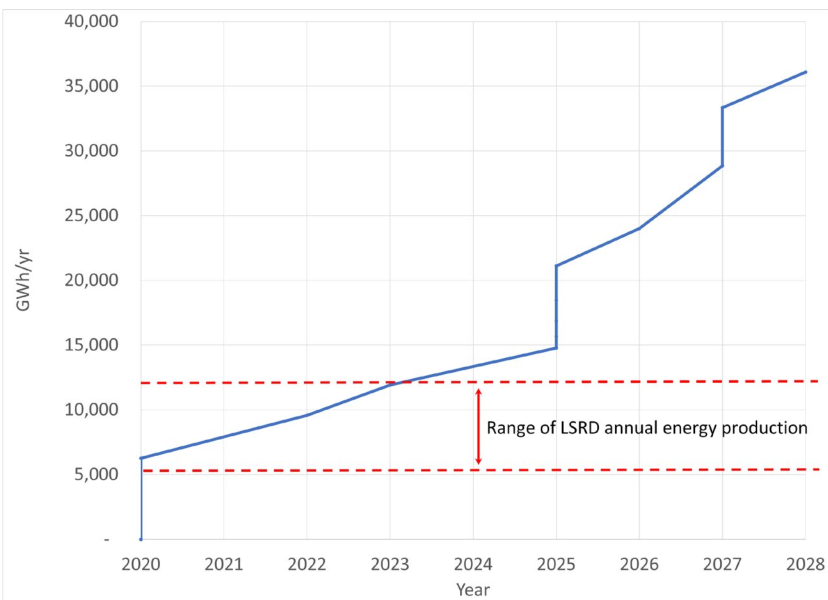
31 As reported by the NWPCC at a recent Power Pool Conference. Available at: www.nwpp.org/resources/

expects approximately 20,000 MW of retirements of coal-fired power. Based on this data, EGPSC estimates that the cumulative energy impact of retirements of coal-fired power plants owned or contracted by PNW utilities will exceed 35,000 GWh/year in the next decade (Figure 3). This is a large energy shortfall; one that will be significantly exacerbated by LSRD removal as its annual energy production varies from 6,500 to 12,000 GWh/year.[32] Whether it is from coal or LSRD retirement, all of this energy will require substitution from other resources (Figure 3).

Table 1. PNW Utilities: Generation of Electricity from Coal from Units Where Retirement is Announced or At-Risk

	Total MW	Total MWh		Boardman	Centralia 1	Centralia 2	North Valmy 1	North Valmy 2	Colstrip 1+2	Colstrip 3	Colstrip 4	Jim Bridger 1	Jim Bridger 2	Naughton 1	Naughton 2	Cholla 4	Craig Unit 1	Craig Unit 2
State				OR	WA	WA	NV	NV	MT	MT	MT	WY	WY	WY	WY	AZ	CO	CO
Capacity (MW) (approx)				522	670	670	277	285	614	740	740	600	600	192	256	414	428	428
Annual Generation (MWh) (2018)				1,285,500	2,495,903	2,871,480	571,729	878,195	3,309,915	4,842,055	4,504,712	2,336,327	2,739,466	1,224,135	1,579,434	1,916,020	2,656,155	2,877,335
Current Reitrement Date				2020	2020	2025	2020	2025	2022	2027	2027	2023	2028	2025	2025	2020	2025	2026
Owner:				**Ownership Shares (%)**														
PSE	677	3,991,649							50%	25%	25%							
PGE	818	3,154,853		100%						20%	20%							
Pacificorp/NV Energy	2,329	11,290,583					50%	50%		15%	15%	67%	67%	100%	100%	100%	19%	19%
Avista	148	934,677								10%	10%							
Northwestern	222	1,452,617								30%								
Talen	529	3,006,371							50%		30%							
Idaho Power	681	2,416,876					50%	50%				33%	33%					
Transalta	1,340	5,367,383			100%	100%												
Total	6,744	31,615,009																

Figure 3. Cumulative Energy Impact of Retirements of Coal-Fired Generation Owned or Contracted by PNW Utilities (2020-2028) and Indicative Range of LSRD Annual Energy



[32] NWEC Study, Figure 11. Historical average production is 9,125 GWh/year.

By contrast, the NWEC study identifies only 2,800 MW of coal plant retirements. This is 1,700-3,200 MW lower than the values presented in the recent NWPCC study.[33] The reality of coal plant retirements has put the region into a significant capacity deficiency in the upcoming planning horizon. The NWPP has undertaken a significant effort to address resource adequacy in the region.[34]

4. NWEC Study Key Issues Identified

The following are the most important findings made by EGPSC. Additional notes on EGPSC's review may be found in Appendix B.

1. None of the identified portfolios fully replace LSRD in terms of capacity and energy. This is a significant result that is not adequately highlighted in the NWEC study. As a result, *all* NWEC Study portfolios increase GHG emissions as they effectively rely on increase production from existing dispatchable resources with available capacity (nearly all fossil-fired thermal) within the region or outside of the region; the latter identified as increased "net exports". The NWEC study acknowledges the increased emissions but states that incremental emissions may be addressed with emerging policies that effectively put a price on the incremental emissions. The cost of increased emissions is only reflected in the NWEC Study portfolios sensitives labeled "GHG Policy." A more reasonable replacement portfolio would replace all LSRD energy with emission-free power or fully mitigate any incremental emissions.[35]

2. The Study's preferred portfolio contains an unrealistic amount of DR and EE. The NWEC NGA and so-called "Balanced" portfolios rely on large amounts of incremental DR, and EE. EGPSC believes all of these portfolios are infeasible, even the "balanced" ones. As noted above, the PNW is now in a carbon-constrained era and coal power retirements loom at a level much higher than what was assumed in the NWEC study. To the extent that incremental DR and EE is available, it will be procured by utilities and customers as a matter of course and will not be a discretionary resource available to replace LSRD.

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33 NWPCC, Pacific Northwest Power Supply Adequacy Assessment for 2024, October 31, 2019
34 NWPP, Exploring a Resource Adequacy Program for the Pacific Northwest, October 2019
35 A GHG adder of $14/MWh is very modest. In EGSPC's view, the GHG Policy sensitives should become the "primary" cases of the NWEC study and future research should explore new sensitivities with even higher marginal GHG value.

3. The Study appears to underestimate transmission costs from integrating large increment of new variable energy resource additions, effectively assuming that transmission freed up by the retirements at Colstrip will make available transmission for Montana wind and that the presumed committed Boardman to Hemmingway line will allow for integration of new solar resources from Idaho.[36] Similar to the NWEC assumptions regarding DR/EE, such freed up transmission will be used by the region to integrate resources needed to replace retiring coal plants, not LSRD. To integrate variable energy resources to replace LSRD will undoubtably require new, incremental transmission for both new regional wind and solar. And such transmission is not cheap. The Montana Renewables Development Action Plan summarized prior studies and indicates that to add substantial amounts of wind *beyond* the amount of MWs freed up by retiring Colstrip, will incur $400 million of additional transmission costs.[37]

5. Focus on Reliability Needs Created by LSRD Removal

The NWEC study uses the GENESYS reliability planning model developed by the NWPCC. This model is the de-facto standard for long-term reliability planning in the region. The NWEC study claims that it ensured that replacement portfolios adequately replace on a monthly basis the effective capacity decrease created by LSRD removal.

Although EGPSC found no significant methodological gaps in the NWEC Study it, nonetheless, has concerns regarding the is assumptions and results related to reliability. The NWEC study indicates the capacity value of LSRD is approximately 1,500 MW.[38] EGPSC was able to verify the hydro data used by NWEC and performed its own computation of effective capacity value (Figure 4). In this figure, regional load is netted against all hydro and wind.[39] The net load is a reasonable measure of hourly resource need. Seven years of NWPP data were available and used in the analysis, so the variable nature of PNW hydro resources (including LSRD) is

[36] NWEC Study, p. 44

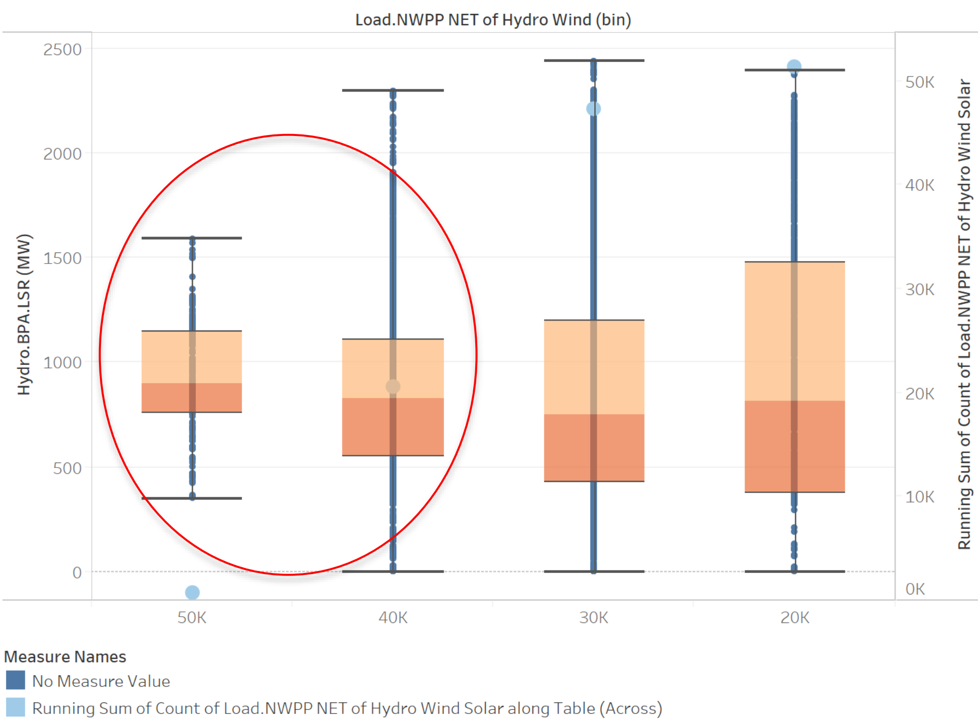
[37] Montana Renewables Development Action Plan, June 2018 identify the Colstrip Transmission Upgrade, ~$252 million, and the Montana-to-Washington Project, ~$140 million. Page 11 and Appendix A.

[38] NWEC Study, Figure A-1.

[39] NWPP load is used as the measure of regional load. An analysis looking at BPA control area loads produced a similar result.

reasonably represented.[40] LSRD hourly production is shown in each net load bin. The highest load bins (circled column on left-hand side) represents ~20% of the highest net load hours in the most critical reliability months (Nov-Feb). Under these conditions, LSRD generates mostly between 600-1200 MW. That's a significant amount and indicates that LSRD has at least some ability to dispatch power when need is high as water resource levels are generally low during these winter months. On balance, EGPSC believes it is appropriate for any replacement portfolio to provide at least 1,000 MW of effective winter season capacity.

Figure 4. LSRD Hourly Production Under Varying Levels of Net Regional Load (Nov-Feb for Years 2013- present)



NWEC appears to make a similar assumption in that it relies on approximately ~1,400 MW of incremental gas capacity and imports in its All Gas portfolio. Less clear is the capacity value it ascribes to wind and solar in its balanced portfolios. It is widely recognized that the capacity value of wind and solar are low. The NWEC Study also shows that the Balanced portfolio significantly increases winter on-peak power imports.[41] The reliance on increased imports

[40] EGPSC also performed a similar analysis using over a decade of BPA data (BPA control area load [including export] and wind) and found a similar result.
[41] NWEC Study, Table C-1 and Figure C-2 show peak flows in the summer and winter

during peak hours is troubling. On balance, EGPSC believes that a more realistic accounting of replacement power capacity values is warranted

6. Indicative Alternative Replacement Portfolio

Although not a substitute for a detailed modeling, it is possible to adjust NWEC's results to reflect a portfolio that is feasible and not compromise regional reliability. EGPSC calls this portfolio "Indicative Feasible". This portfolio has the following characteristics:

7. No reliance on incremental natural gas. Although technically feasible, it is highly speculative to assume that more gas-fired generation will be permitted and procured to replace LSR. Gas-fired generation may very well be part of the mix that will be used to replace coal and other generation retiring in the region. To say, however, that the region will intentionally procure carbon-emitting thermal resources to replace LSRD is speculative. For this reason, the Indicative Feasible portfolio does not include any new gas generation.
8. No reliance on incremental DD and EE. All portfolios considered by NWEC assume that economically achievable DR and EE is pursued. To replace LSRD in the NGA and balanced portfolios, NWEC relies on "technically achievable" DR and EE at levels above what is already procured in the NWPCC's 7th Plan. Such resources are subject to market barriers. Such resources are highly speculative given that, since the NWEC study was issued, ~4,000 MW of *additional* coal plant retirements have been announced in the study period. An examination of the supply curves shown in the NWEC study indicate that the curves are steeply rising in the area that would need to be procured to replace LSR.[42] More generally EGPSC expects that all cost-effective DR and EE will be pursued in the region given its commitment to these resources and the programmatic capabilities of utilities, NGOs, and state agencies. In this context, to assume that there is additional DR /EE to replace LSRD is highly speculative.[43]

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[42] EGPSC reduced the capacity factors of new wind and solar slightly to reflect values used for new PNW resources used in other IRPs. DR EE supply curves are shown in the NWEC study at p. 67. New curves are being prepared for the 8th (2020) NWPPC Plan. Although these curves can be examined and may include new, lower-cost DR and EE, EGPSC's view is that all cost-effective DR/EE will be captured before LSRD replacement resources are sought.

[43] EGPSC believes it would be reasonable to factor in the negative demand response that will come from higher prices resulting from replacement. Neither NWEC study nor the Indicative Alternative Portfolio include estimates of such normal price response, but a study update could.

9. Reliance on new in-region wind, solar, and storage resources. Although wind and solar are resources available “at scale” for the region, they are intermittent and require careful modelling to successfully replace a large hydro resource. As noted above, the NWEC Study includes wind and solar in its “balanced” portfolios and, with limited adjustments, EGPSC uses the NWEC Study assumptions for solar and wind resource costs.[44] The Indicative Feasible portfolios use a balance of wind, solar, and storage to a level that replaces the capacity lost by the LSRD.[45] By using higher amounts of wind, solar, and batteries (again, missing from the NWEC Study balanced portfolios), adequate effective replacement capacity is attained, and the portfolio creates an incremental energy surplus which can be sold in the wholesale market. EGPSC assumes a marginal wholesale power revenue of $35 / MWh, which represents a long run value of the excess power from variable energy resources sold into the market of approximately $21/MWh and a carbon adder of $14/MWh.[46] By including carbon in the value of incremental energy, the Indicative Feasible portfolio appropriately reflects the value of carbon emissions, a value that is missing the NWEC Study portfolios except in its “GHG Policy sensitivities”
10. Recognition of incremental transmission costs. As described above, the NWEC Study assumed almost no incremental transmission costs. The cost of integrating Montana wind (at levels above the amounts that can be integrates as a result of Colstrip power plant retirements) is about $363/kW. Assuming this cost is probably too high as there are multiple locations in the region where variable energy resources can be integrated. A resource interconnection cost study is beyond the scope of this analysis, but an order-of-magnitude cost adder of $220/kW, or $35/kW-year, is, in EGPSC’s view, a reasonable transmission adder.

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44 The NWEC Study Costs do not include an explicit adder for variable energy resource integration costs. Although EGPSC did not change this assumption, further research into whether integration costs have been sufficiently covered is recommended.
45 EGPSC assumed that wind and solar’s effective capacity value was 15%. For storage, EGPSC assumed that costs would be ~15% lower than NWEC’s estimated costs (on a per MWh basis) but that the duration of the battery would need to be 12 hours, rather than 4 hours.
46 EGPSC used the same carbon adder assumed by NWEC: $34/MTOE which translates into $14/MWh assuming it substitutes for electricity produced by fossil resources at the “unspecified” rate.

Details of the Indicative Alternative portfolio in comparison to the NWEC portfolios are shown in Table 2.[47] Figure 5 shows the overall portfolio costs using a presentation form similar to the one made in Figure 14 of the NWEC Study. All the NWEC GHG Policy Portfolios are shown and the Indicative Alternative portfolio is added in the rightmost column. With Figure 5, few key things become readily apparent:

- None of the portfolios are cheap. When it came to cots, the NWEC study focused on indicative bill impacts. Such a measure, however, greatly dilutes percentage impacts because bills include many non-wholesale power cost components, such as distribution costs. EGPSC believes a simpler and more meaningful way to show results is per-MWh-of-replaced-power. By this straightforward measure, all of the portfolios have a cost of replacement power of $55/MWh or greater.
- The Indicative Alternative portfolio cost is $860 million/year or approximately $96/MWh for the replacement power. This is approximately 80% greater than the cost of NWEC Study "balanced" portfolio. The Indicative Alternative scenario does not increase reliance on imports. In fact, it produces an increment of excess energy which can be sold in the regional market. (This revenues from sale of portfolio excess energy is shown in the figure as the "negative" orange bar.) This cost estimate is approximate and EGPSC's analysis is not meant to be a substitute for more detailed modeling that should be performed in the future.

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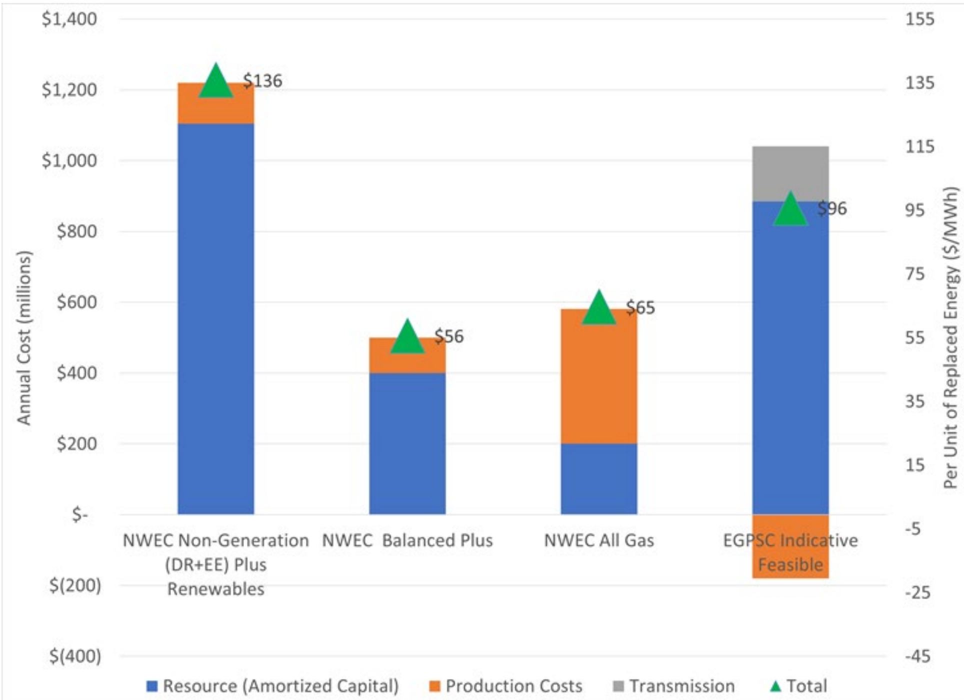
47 As noted earlier in this memo, EGPSC's view is that all portfolios should price carbon on the margin. For that reason, only the NWEC "GHG Policy" portfolios are shown in comparison to the Indicative Feasible portfolio.

Figure 5 NWEC Study GHG Policy Portfolios and EGPSC Indicative Feasible Portfolio (left scale is annual cost, $millions; right scale is cost per unit of replaced energy, $/MWh)



ENERGYGPS LLC

Table 2. Portfolio Resources (MW and aMW) and Total Costs

	ELCC		ELCC					CF	Scalar MW	Scalar Cost (from 4- to 12-hour less technological change)		ELCC		Scalar					ELCC		Scalar					ELCC		CF		ELCC										$35	35		
	34%		100%					-2%	3.5	2.5		15%		2.0					15%		2.6					100%		32%		100%									Annualized Costs $e6 (Fig.				
Resource Type -->	LSR	LSR	DR+EE	DR+EE SubT2		DR+EE	Storage	Storage	Storage	Storage	Storage	Wind	Wind	Wind	Wind	Wind	Wind	Wind	Solar	Solar	Solar	Solar	Solar	Solar	Solar	New Gas SubTotal	New Gas	New Gas	New Gas	Imports	Imports	PNW Incrmntl Thrml	total Imp+ PNW Incr Thermal	total Imp+Other Thermal		Total Nameplate excluding Imports	Total Effective	Total Energy	Resource (Amortized Capital)	Production Costs	Transmission	Total	Per MWh
Case	MW	aMW	MW	aMW	$e6	$/MWh	MW	aMW	$e6	$/kW	Implied CRF	MW	aMW	$e6	$/kW	Implied CF	Implied CRF	$/MWh	MW	aMW	$e6	$/kW	Implied CF	Implied CRF	$/MWh	MW	$e6	aMW	$/MWh	MW	aMW	aMW	aMW	$/MWh	Total Nameplate MW	MW	MW	aMW	$million	$million	$million	$million	$/MWh
Reference	3,000	1,025																								-							-		3,000	3,000	1,020	1,025					
Non-Generation (DR+EE)			1,464	273	148	61.90	100	(0)	14	1,200	12%																			103	286	466	752	34.17	1,667	1,564	1,667	1,025	$ 162	$ 225		$ 387	$ 43
Non-Generation (DR+EE) Plus Renewab			1,464	743	1,090	167.49	100	(0)	14	1,200	12%																			116	75	207	282	34.03	1,680	1,564	1,680	1,025	$ 1,104	$ 84		$ 1,188	$ 132
Non-Generation (DR+EE) Plus Renewab			1,464	743	1,090	167.49	100	(0)	14	1,200	12%																			116	846	(564)	282	47.00	1,680	1,564	1,680	1,025	$ 1,104	$ 116		$ 1,220	$ 136
Balanced			732	136	49	41.11		-				500	219	103	1,725	44%	12%	54	250	65	32	1,600	26%	8%	56	-				215	213	391	604	40.04	1,697	1,482	1,059	1,025	$ 184	$ 212	$ 1	$ 397	$ 44
Balanced Plus			732	136	49	41.11		-				1,250	547	256	1,725	44%	12%	53	750	198	95	1,600	26%	8%	55	-				273	40	104	144	50.08	3,005	2,732	1,305	1,025	$ 400	$ 63		$ 463	$ 52
Balanced Plus + GHG Policy			732	136	49	41.11						1,250	547	256					750	198	95									273	759	(616)	144	79.49	3,005	2,732	1,305	1,025	$ 400	$ 100		$ 500	$ 56
All Gas																										950	200	300	76	432	267	458	725	52.74	1,382	950	1,382	1,025	$ 200	$ 335		$ 535	$ 60
All Gas + GHG Policy																										950	200	151	151	$ 432	1,164	(290)	874	49.77	1,382	950	1,382	1,025	$ 200	$ 381		$ 581	$ 65
Indicative Alternative + GHG Policy			-				350	(0)	126	3,000	12%	2,500	1,093	512	1,725	40%	12%	53	1,950	516	247	1,600	26%	8%	55	-					(400)	(184)	(584)	35.25	4,800	4,800	1,018	1,025	$ 885	$ (180)	$ 156	$ 860	$ 96

Appendix A. Recent State Level Legislation and Policies Impacting the PNW Power Sector

The following briefly identifies recent state-level policy changes that press for further decarbonization of the western grid. Many of these developments were not factored in by the NWEC Study as they occurred after 1Q2018.

- **California**. SB 100 was enacted into law on September 10, 2018, after the issuance of the NWEC study. SB 100 moved California to a 60% RPS by 2030 and a 100% carbon-free goal by 2045. California's RPS "bucket" rules which encourage in-state resources over out-of-state (discussed above) remain with respect to the 2030/60% RPS target. However, incremental procurement needs beyond the 60%--i.e., procurement driven by the 2045 100% carbon free goal--do not specific any geographic preferences. The 2024 policy guidelines are only now beginning to take shape with state regulatory activities beginning in 2020. It is reasonable to assume incremental project procurement from out-of-state energy resources, including renewable energy projects in the PNW, will occur as a result of SB 100.
- **Washington**. Although a ballot initiative that would have implemented a carbon tax was defeated in 2018, the Washington State legislature in early 2019 passed the Clean Energy Transformation Act ("CETA", or SB 5116). CETA includes three major mandates on both IOUs and POUs. First, CETA mandates that all coal-fired resources must be eliminated from the portfolio of generation resources used to serve Washington consumers by December 31, 2025. Second, all electricity sold at retail in Washington must be GHG "neutral" by January 1, 2030. As part of the this GHG neutrality requirement, 80% of electricity delivered to Washington customers must be from non-emitting or renewable resources. The remaining 20% may come from unbundled RECs, investments in energy transformation projects, or approved alternative compliance plans. Existing hydro and nuclear resources may count toward this neutrality target but, with respect to new hydro, it can only count if it is constructed on irrigation canals or other artificial waterways. Third, CETA requires that by 2045, 100% of electricity sold in Washington state be produced either from renewable resources or non-emitting generators. CETA also includes cost caps and off-ramps. Generally, a utility may seek exemption if the cost of compliance can be shown to exceed 2% of the utilities' revenues.

- **Oregon**. Oregon's current RPS was passed in 2016 (SB 1547, the Clean Electricity & Coal Transition Act), which expanded the RPS targets to 50% by 2040 for large investor owned utilities and 25% by 2025 for large consumer-owned utilities. The law also includes a 2030 "no coal" requirement on the state's electricity supply. The NWEC Study presumably factors in these RPS requirements.[48]

  During 2018 and 2019, the Oregon Legislature attempted to pass HB 2020, a cap-and-trade bill similar to California's. The program was to be implemented by 2021 and included target carbon emission reduction goals of 45% below 1990 levels by 2035 and 80% below 1990 levels by 2050. Although HB 2020 did not pass during the 2019 legislative session, the bill still has wide support and it, or another similarly aggressive decarbonization bill, is likely to pass in Oregon's 2020 short session or the 2021 regular legislative session. For purposes of any LSRD replacement study, it is reasonable to consider that the demands of Oregon HB 2020, or similarly effective policy, should be considered as part of the reference case.

  Other states and utilities in the West have also enacted stronger decarbonization or RPS laws. These laws all have put upward pressure for the demand for carbon free electricity and increase pressures for coal plant retirements.

[48] NWEC Study, p. 38: "The Reference Case … reflects: (1) achievement of existing state policy for renewable portfolio standards …"