Northwest RIVERPARTNERS
Hydropower for a better Northwest

AN EXAMINATION OF NORTHWEST ENERGY COALITION FEBRUARY 2022 WHITE PAPER ON REPLACING THE LOWER SNAKE RIVER DAMS

EXECUTIVE SUMMARY

Northwest RiverPartners has prepared the following analysis of the Northwest Energy Coalition (NWEC) February 2022 white paper, *Smart Planning Will Drive Replacing the Power from Lower Snake River Dams*.

We want to begin by affirming Northwest RiverPartners' agreement with NWEC about the importance of maintaining reliable, affordable, and carbon free electricity and the need to recover salmon and steelhead populations. We also agree both objectives are simultaneously possible—*and necessary*. However, solutions must be science-based and minimize societal harm in order to qualify as good public policy.

Unfortunately, the assumptions, methodology, and statements embedded in the NWEC paper include significant errors, allowing NWEC to conclude, "…the lower Snake River dams can be replaced with a diverse set of clean energy technologies that will perform better and are rapidly declining in costs." The implication is that this path would be routine, inexpensive, and safe.

As our analysis—and almost every other recent power planning report—demonstrates, nothing could be further from reality.

THE FOLLOWING ARE FIVE KEY ERRORS WITHIN THE NWEC PAPER:

NWEC ERROR #1: REPLACING THE DAMS WOULD BE A "ROUTINE" UNDERTAKING

- The NWEC paper fails to recognize the context of major challenges facing the Western electric grid. In doing so, it ignores the warnings of a myriad of authorities, rolling blackouts across three US states in the past two years, and numerous expert analyses.

NWEC ERROR #2: THE REGION HAS AMPLE CLEAN GENERATION "UNDER DEVELOPMENT"

- The NWEC paper wrongly counts proposed generation, which lacks transmission, permitting, and financing, as a reliable indicator of generation under development. In doing so, it ignores the historical record and prudent utility practices.

NWEC ERROR #3: POWER REPLACEMENT COSTS ARE LOW

- The NWEC paper greatly underestimates the cost of the resource mix necessary to fully replace the zero-carbon benefits of the lower Snake River dams and ignores the implications for vulnerable communities across the region.

NWEC ERROR #4: GRID RELIABILITY IS NOT AFFECTED

- The NWEC paper incorrectly states the NPCC 2021 Power Plan concluded that replacing the lower Snake River dams would not harm grid reliability. That scenario was not studied in the Power Plan.

NWEC ERROR #5: CLIMATE CHANGE MEANS SNAKE RIVER DAMS SHOULD BE BREACHED

- NWEC's paper ignores the fact that only 4 of the 76 listed at-risk salmon and steelhead populations along the Pacific Coast come from the Snake River. All 76 populations are threatened by climate change, especially during their years in the ocean. NWEC's recommended path would add to the climate problem by increasing CO_2 emissions.

INTRODUCTION

About Northwest RiverPartners

In an effort to combat climate change, the Pacific Northwest has established some of the nation's most aggressive decarbonization goals. This effort is not surprising, because the region is well known for its environmental ethic and love of nature and the outdoors.

As part of this ethic, Northwesterners are very tied to our iconic salmon species. For Native American Tribes, the connection is even more dear and critical.

Northwest RiverPartners represents community-owned, not-for-profit electric utilities across the region, as well as other supporters of clean energy and transportation. Our mission is to lead the charge for the Northwest to realize its clean energy potential with hydroelectricity as the cornerstone.

Our member organizations are leaders in the climate change fight. Their support of clean energy and transportation sets a very high standard for the rest of the nation. Our members also realize the impacts dams have on salmon must be mitigated, and they fund the nation's largest fish and wildlife mitigation program.

As a result of these efforts, approximately one million acres of salmon habitat have been protected, treated, or maintained, and major fish passage upgrades have been applied at the lower Columbia, mid-Columbia, and lower Snake River dams. Juvenile salmon now survive the downstream journey through the hydropower system at approximately the same rate as a free-flowing river.[1]

Northwest RiverPartners and its members are committed to being part of the solution for clean energy and healthy salmon populations, and we will continue to provide leadership in these areas. **In terms of salmon recovery, we note several important solutions** in the section entitled, "NWEC Error #5: Climate Change Means Snake River Dams Should Be Breached."

Background of NWEC White Paper

Northwest Energy Coalition (NWEC) is an advocacy organization with the stated mission of leading the Northwest's broadest alliance of energy interests in designing, promoting, and implementing clean, affordable, and equitable energy policy grounded in analytical expertise. NWEC is also an active plaintiff in litigation over the operation of the Federal Columbia River Power System.

As part of its advocacy, NWEC has asserted for decades that the lower Snake River dams (LSRD) need to be removed/breached to protect salmon. NWEC also states the LSRD can be

[1] https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.0060265

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affordably and reliably replaced by a carbon-free portfolio of wind, solar, batteries, energy efficiency, and demand response resources.

However, NWEC's February 2022 paper includes significant incorrect assumptions or ignored considerations that lead to erroneous conclusions.

Our critique identifies five overarching shortcomings in the NWEC paper's arguments, which result in incorrect or misleading conclusions regarding the region's need and ability to replace the power generation provided by the LSRD.

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NWEC ERROR #1: REPLACING THE DAMS WOULD BE A "ROUTINE" UNDERTAKING

A major shortcoming in NWEC's paper is the assumption that the current state of the Western power grid is routine, so replacing the generating capabilities of the LSRD can be handled by basic utility planning.

NWEC's paper states, "Planning for changes in power system generation resources is a routine and well-defined task for the utility sector. There are many examples of generation resource closures with no reliability issues."[2]

In actuality, the level of change forecasted for the Western grid is unprecedented. Washington, Oregon, California, and Nevada have all passed 100% clean energy legislation in an effort to combat the serious threat of climate change. (See graphic below.)

Clean Energy Mandates for Western States

Washington 100% Clean Energy
- 2045

Oregon 100% Clean Energy (IOUs)
- 2040

California 100% Clean Energy
- 2045

Nevada 100% Clean Energy
- 2050

Over 14,000 megawatts (MW) of fossil-fueled generating resources are planned to be retired over the next decade,[3] and a large portion of those retirements will occur in the Pacific Northwest.[4]

[2] Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 1.
[3] WARA 2021.pdf (wecc.org)
[4] Draft 2021 Northwest Power Plan (nwcouncil.org)

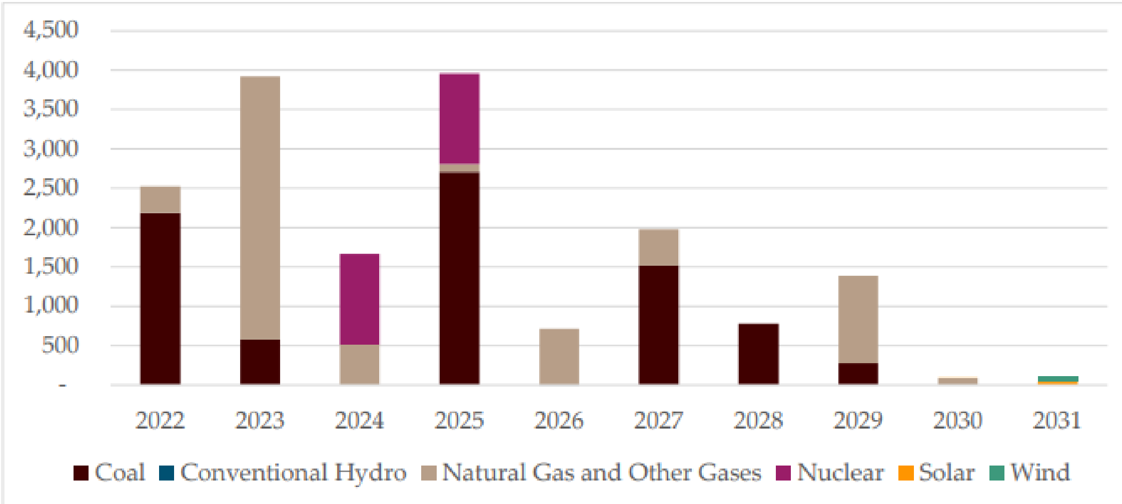


Figure 1: Western Interconnection Capacity Retired by Resource Type 2022–2031

Source: Western Electric Coordinating Council 2021 Western Assessment of Resource Adequacy Appendix B

To put that amount of energy into perspective, **it has taken the Pacific Northwest nearly 44 years to achieve 7,000 average megawatts of savings from its extensive energy efficiency programs.**[5]

Maintaining Grid Reliability

To understand the nature of the challenge ahead, one has to understand the physics of the electric grid. "Load" (i.e., demand for electricity) must, at all times, be in near-perfect balance with the amount of energy supplied to the grid.

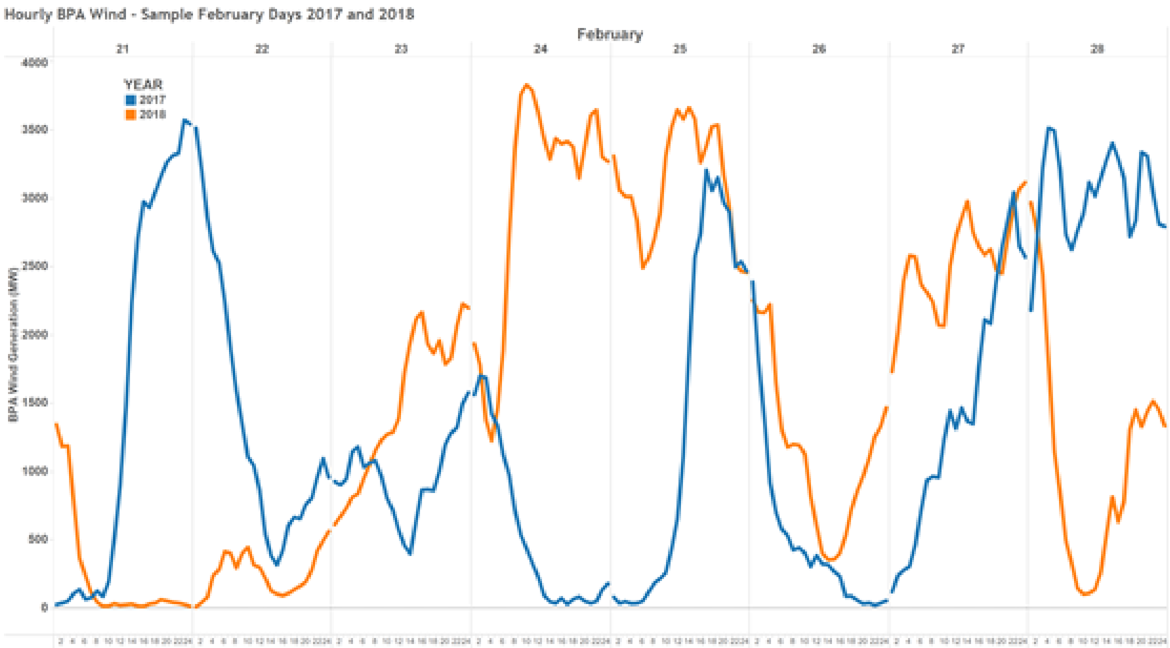
If demand and supply fail to balance, the grid can collapse, causing *uncontrolled* blackouts, such as the 2003 Northeast Blackout.[6] These types of blackouts are very difficult to recover from and can last days or longer. They represent a significant threat to public health and safety.

Wind and solar power, the most popular replacements for coal and natural gas, are important resources in the fight against climate change, however they introduce an inherently high moment-to-moment, hour-to-hour, and day-to-day variability to the grid. As a result, they tend to complicate the grid's ability to perfectly balance supply and demand.

They must be paired with or backed up by energy storage resources, like utility-scale batteries, pumped storage, or on-demand generating resources like hydropower, nuclear, natural gas, or coal-fired generation.

The graph below shows an example of extreme wind generation volatility that can occur within the Bonneville Power Administration's Balancing Authority Area over an eight-day period.

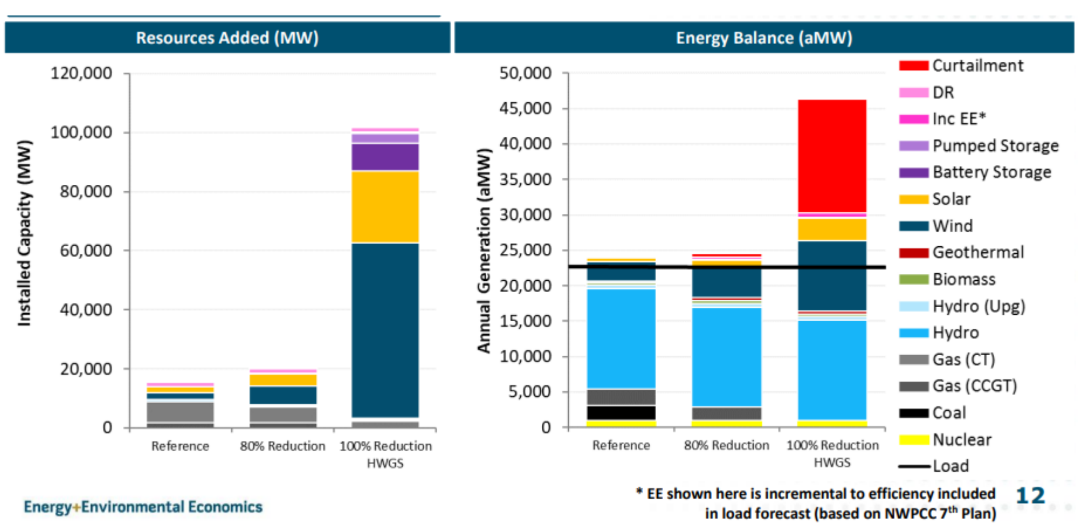
[5] Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 8.
[6] More recent blackouts in California, Texas, and Oklahoma have been "controlled" or "rolling" blackouts, where the grid operator purposely shuts down segments of the grid on a rotating basis in order to avoid an uncontrolled blackout.



Source: Energy GPS

Some of this variability can be mitigated by enlarging the geographic footprint of the intermittent resources or "over-building" the amount of variable energy resources to ensure sufficient generation. But, enlarging the footprint often requires building new transmission lines, which are highly difficult to permit and very expensive to construct. Resource over-builds are costly as well.

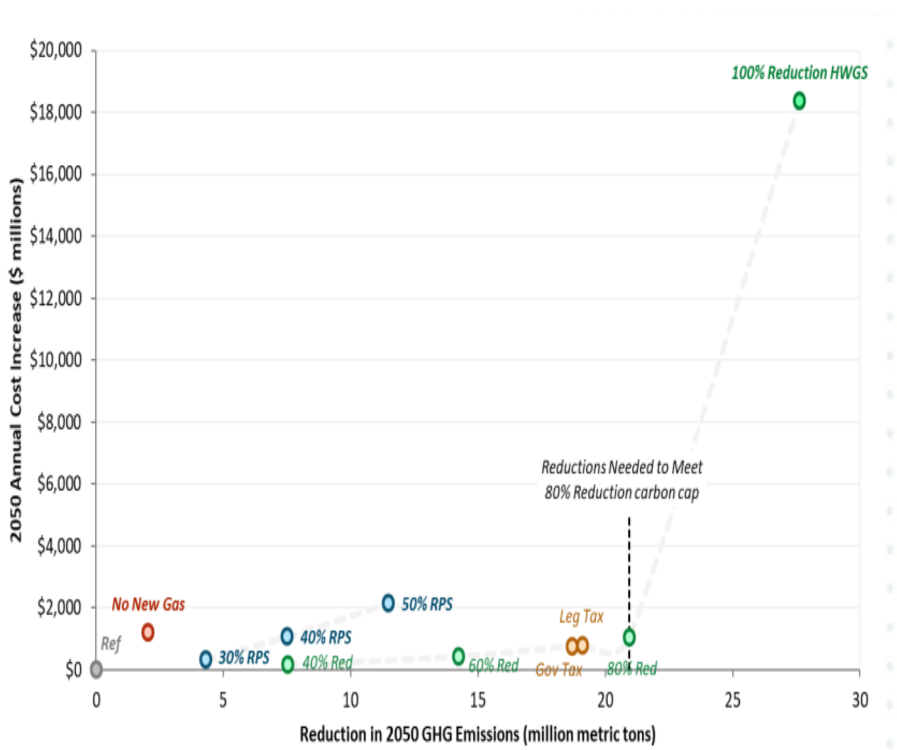
Unprecedented Generation Buildout Required



Source: E3

The magnitude of the challenge is shown by a 2018 study by energy consulting firm E3. In this study, which examined electric grid decarbonization scenarios for the Pacific Northwest, E3 projected **84,000 MW of new renewable capacity** and **10,000 MW of new storage** (e.g., batteries, pumped storage, etc.) would be required to achieve a carbon-free electric grid for Oregon and Washington by 2050. **Notably, these numbers assumed the lower Snake River dams remain in place.**[7]

Because optimal sites[8] for new generating plants are typically the first to be developed, costs can increase significantly once those sites are spoken for. This principle of an upward sloping supply cost curve is demonstrated by the E3 forecast below. E3 shows an almost exponential increase in costs between an 80% carbon reduction goal and a 100% carbon reduction goal, jumping from roughly $1 billion annually to approximately $18 billion annually.[9]



("HWGS" is Hydro, Wind, Geothermal, Solar)
Source: E3

LSRD CAPABILITIES

The LSRD generate approximately 1,000 average megawatts (aMW) of energy. For intermittent renewables to provide that amount of average energy, it would take roughly 2,500 MW of wind generation or 3,000 MW of solar generation.

The LSRD can increase their output to 2,500 megawatt-hours (MWh) per hour to meet peak demand for multiple days during the winter. To put that magnitude into perspective, the combined winter peaking capability of the LSRD is roughly equivalent to that of two large nuclear power plants or four large coal-fired plants. (See Appendix A for details)

[7] Pacific Northwest Low Carbon Scenario Analysis 2018 Scenarios & Sensitives - E3
[8] "Optimal" implies sites that are easy to permit, with access to existing transmission and to "fuel." For wind or solar power, the fuel is wind and sunshine, respectively.
[9] Pacific Northwest Low Carbon Scenario Analysis 2018 Scenarios & Sensitives - E3

More Demand Coming

The estimates above do not account for the potential electrification of large portions of our economy. As an example, Washington's legislature just passed an initiative to end gasoline-powered car sale in the state by 2030.[10] Meanwhile, different governmental bodies across the Northwest have limited or banned natural gas as a heating source for new homes and commercial buildings. These changes, by design, will greatly increase the demand for zero-carbon electricity.

A 2021 Princeton University study, entitled "Net-Zero America: Potential Pathways, Infrastructure, and Impacts," estimates that to achieve a net-zero economy, electricity generation will need to "double to quadruple" by 2050 and that "clean electricity is the linchpin."[11]

Even without that added demand for clean energy, the challenge of reaching a carbon-free grid is daunting.

Calls for Concern

Organizations authorized to maintain grid reliability and those trusted to provide neutral, unbiased analyses, recognize the unprecedented challenge grid operators are facing.

The following agencies are on record as noting the severity of the challenge ahead:

- Western Electricity Coordinating Council[12]
- California Independent System Operator[13]
- Western Power Pool[14]
- Pacific Northwest National Laboratory[15]
- Northwest Power Planning and Conservation Council[16]

WECC Statement

The Western Electricity Coordinating Council (WECC) came to the following conclusion regarding the difficulty of achieving a carbon-free Western grid:[17]

> *Using an energy-based probabilistic approach, WECC's analysis of resource adequacy over the next 10 years reveals the following takeaways:*

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[10] ctH-2991.3.pdf (wa.gov)
[11] PowerPoint Presentation (princeton.edu)

[12] WECC is one of eight regional entities with delegated authority from the North American Electric Reliability Corporation (NERC) and Federal Energy Regulatory Commission (FERC) to promote Bulk Electric System reliability across North America.
[13] The California Independent System Operator is a non-profit Independent System Operator serving California. It also operates the Western Energy Imbalance Market and is a Reliability Coordinator.
[14] Western Power Pool (formerly Northwest Power Pool) is a member driven organization dedicated to help maintain electric reliability through coordinated grid operations.
[15] PNNL is a National Laboratory under the US Department of Energy.
[16] The Northwest Power and Conservation Council develops regional power plans and oversees fish and wildlife program expenditures per the requirements of the 1980 Northwest Power Act.
[17] WARA 2021.pdf (wecc.org)

- *Both demand and resource availability variability are increasing, and the challenges they present appear worse now than they did in the 2020 Western Assessment.*
- *Under current PRMs [planning reserve margins],all subregions in the West show many hours at risk of load loss over the next 10 years.*
- *To mitigate resource adequacy risks over the near-term (1–4 years) and long-term (5–10 years), PRMs need to be increased—in some cases significantly—or other actions taken to reduce the probability that demand exceeds resource availability.*
- *Subregions rely heavily on imports to remain resource adequate. In no case can a subregion be resource adequate on its own.*
- *As early as 2025, all subregions will be unable to maintain 99.98% reliability because they will not be able to reduce the hours at risk for loss of load enough, even if they build all planned resource additions and import power.*

Weather creates variability, and weather is growing more erratic and extreme—a pattern that is expected to continue over the next decade. Based on data reported by Balancing Authorities (BA), demand and resource variability have increased and will continue to increase over the next decade. In addition, predictions about more extreme weather and changing climate patterns portend increases in variability, likely beyond what entities currently predict.

CAISO Statement

The California Independent Operator came to the following conclusion in its 2021 Sumer Loads and Resources Assessment:

> *In recent years, significant amounts of new renewable generation, especially solar, have reached commercial operation to meet the 60 percent requirement by 2030. To successfully meet the state's Renewables Portfolio Standard goals, increasing amounts of flexible and fast responding resources must be available to integrate the growing amounts of variable resources. These increasing amounts of variable resources integrated with the ISO grid pose unique challenges for ISO operations and for the analytical tools used by the ISO to assess near-term reliability.*[18]

WPP Statement

The Western Power Pool (formerly the Northwest Power Pool) included the following statement in its July 2021 Resource Adequacy Program – Detailed Design memo:

> *The integrated regional power system is in transition. The impending retirement of several thermal generators within and outside the region (the Western US and Canada) mixed with increasing variable energy resources (VERs), has led to questions about whether the region will continue to have an adequate supply of electricity during critical hours. In the past four years, several studies have identified an urgent and immediate challenge to the regional electricity system's ability to provide reliable electric service during high demand conditions. These developments threaten to upset the balance of loads and resources within the region and, if not properly addressed, will increase the risk of supply disruptions during Winter and Summer, increase financial risk for utility*

[18] 2021-Summer-Loads-and-Resources-Assessment.pdf (caiso.com) p 36

customers, and hinder the ability of the system to meet environmental goals and legal requirements.[19]

PNNL Statement

Pacific Northwest National Laboratory includes the following statement on its website:

> *But in its current state, the grid is not ready to meet the growing electricity needs of our digital economy, nor is it ready to meet the complex challenges brought on by widespread adoption of distributed energy resources, the electrification of transportation, and increased customer choice. Our grid must also be made more resilient. We must protect the nation's power delivery system from cyber and physical attacks and from extreme weather events and natural disasters. We also must address load volatility and power quality issues caused by the intermittency of renewable energy resources such as solar and wind. Achieving this resilience is essential, even as we attain higher standards of performance in reliability, cost of service, efficiency, environmental impact, and safety.*[20]

NPCC Statement

The Northwest Power Planning & Conservation Council included this synopsis in its recently completed 2021 Power Plan:

> *The combination of increased competitive pressure and clean energy policies has resulted in the early retirement of less efficient thermal generators, and also increased thermal generator planned retirements during the initial five-year "action period" of this plan. This indicates that the capacity of coal-fired power plants in the region will be reduced by more than 60 percent over the next decade. Furthermore, uncertainty remains over the role of existing natural gas-fired power plants beyond this decade, and also the future development of new gas-fired generators within the region…Combined, these actions signal a major paradigm shift for the electricity sector in the region (and elsewhere), presenting challenges to maintaining and enhancing an adequate, efficient, economical, and reliable power supply.*

Other Experts

Numerous additional studies, including peer-reviewed research have identified the difficulty. As an example, a 2017 peer-reviewed study in the Proceedings of the National Academy of Sciences included the following conclusion:

> *With all available technologies at our disposal, achieving an 80% reduction in GHG emissions from the electricity sector at reasonable costs is extremely challenging, even using a new continental-scale high-voltage transmission grid. Decarbonizing the last 20% of the electricity sector as well as decarbonizing the rest of the economy that is difficult to electrify (e.g., cement manufacture and aviation) are even more challenging. These challenges are deepened by placing constraints on technological options.*

[19] 2021-08-30_NWPP_RA_2B_Design_v4_final.pdf (westernpowerpool.org) p 8
[20] Electric Grid Modernization | PNNL

Recent Grid Emergencies

The above warnings do not come without reason. Keeping the grid sufficiently supplied is especially challenging in an era of climate change. In the last two years, three different states have used rotating blackouts to ration electricity. California did so in the summer of 2020.[21] Texas and Oklahoma did so in the winter of 2021.[22,23] Also, while it was much less publicized, multiple Pacific Northwest utilities declared emergencies in 2020, which meant that the next step would have been to purposely blackout customers.

In the case of Texas, lives were lost as people weren't able to heat their homes. In all three cases of rolling blackouts, extreme weather played the major role, which brings up an important point—due to climate change, these types of extreme weather events are likely to become more frequent, which means our grid will be tested as never before.

Implications

These warnings are not to imply a zero-carbon grid is unachievable, but the context of these challenges and the need to fight climate change are important factors in the LSRD discussion.

At the very least, we can say, from a grid reliability perspective, removing the LSRD represents a high degree of risk, as we head towards an uncertain future.

From a climate change perspective, removing the LSRD before the last coal and natural gas plants are shuttered essentially prolongs the lives of fossil-fueled generation and significantly adds to the region's carbon footprint.

This latter point was demonstrated by a 2020 the federal study. The study found that even with a zero-carbon replacement portfolio, removing the LSRD would increase regional the grid's CO_2 emissions by roughly 1.3 million metric tons per year, as we're forced to rely more on existing fossil-fueled generation.[24]

[21] California Expresses Frustration as Blackouts Enter 4th Day - The New York Times (nytimes.com)
[22] UTAustin_(2021)_EventsFebruary2021TexasBlackout_(002)FINAL_07_12_21.pdf
[23] More rolling blackouts possible across Oklahoma (oklahoman.com)
[24] Executive Summary: 2020 Columbia River System Operations Environmental Impact Statement

NWEC ERROR #2: THE REGION HAS AMPLE CLEAN GENERATION "UNDER DEVELOPMENT"

Requests for Proposals

The NWEC study states, "Significant new clean resource potential exists, and the current pipeline of projects under development exceeds the region's need." It then goes on to quote the total bids into the Request for Proposals (RFP) for PaciCorp and Puget Sound Energy.

According to NWEC's paper, in the case of PacifiCorp, over 36,000 MW of proposals were received. For Puget Sound Energy (PSE), 18,000 MW of proposals were received. The NWEC paper concludes, "The bids received show that there are considerably *more* resources available to be developed in the region than there is need."[25] (original emphasis)

This conclusion is erroneous. **The use of RFP submissions as a gauge for resources available to be developed represents a distortion of the nature of RFP responses and is an unreliable means for calculating the region's actual energy portfolio.**

Initial RPF submissions are typically non-binding. As a result, proposals routinely suffer from a lack of financing, permitting, and firm transmission availability, and they may be submitted simultaneously to numerous utilities.

An example of the non-binding nature of RFP's can be seen in PSE's 2021 All-Source RFP for Renewable and Peak Capacity Resources guidelines. Below is the schedule of fees that bidders must pay for the initial round of proposals:[26]

- Bid fees will be assessed per proposal based on the total (aggregated) nameplate of the project:

Proposal Size	Bid Fee
≥5 – 10 MW	$2,500
10 – 20 MW	$5,000
≥20 MW	$10,000

Keep in mind, large generating resources can cost into the hundreds of millions of dollars or more, so a $10,000 submission fee does very little to ensure only practical bids are submitted.

PSE acknowledged the unreliable nature of the initial round RFP bids when it included the following statement in its RFP guidelines:

[25] Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 7.
[26] https://apiproxy.utc.wa.gov/cases/GetDocument?docID=110&year=2021&docketNumber=210220

> *PSE reserves the right to negotiate only with those bidders and other parties who propose transactions that PSE believes, in its sole opinion, to have a reasonable likelihood of being executed substantially as proposed.*[27]

Transmission Queues

Using RFP initial bids as a proxy for available generation is a risky idea. However, an even more alarming suggestion is to use utility transmission queues for this purpose. However, NWEC's paper suggests doing just that:

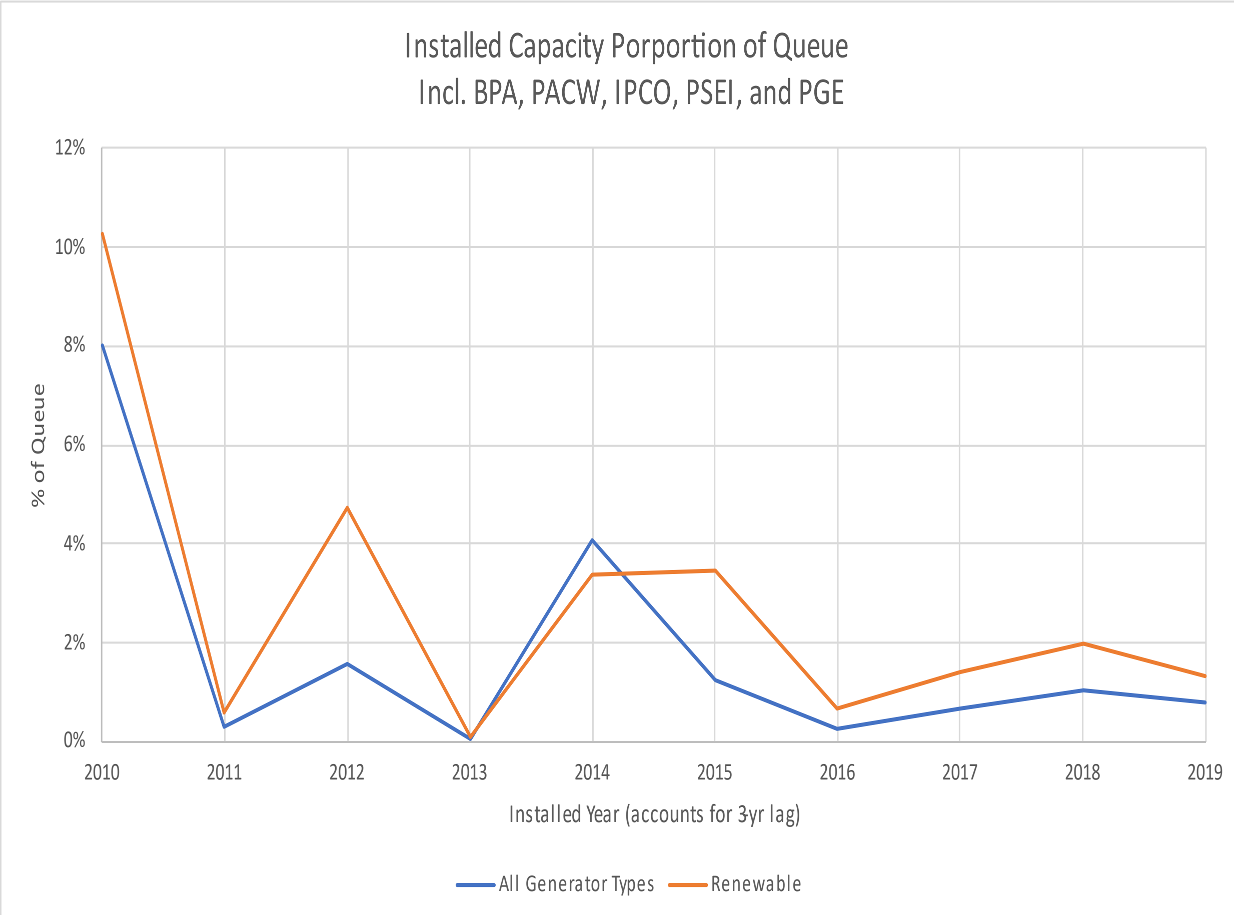
> *Another measure of the magnitude of potential resource development is the requests made by resource developers for transmission service (often called a transmission queue) for BPA, PacifiCorp, and other investor-owned utilities. These requests include over 100,000 MW of wind, solar and storage projects that are seeking access to the federal and regional transmission system.*[28]

NWEC neglects to mention that submitting resources into transmission queue requires almost no upfront costs, and the project sponsors are not required to pass a certification that their projects have permitting, financing, etc. Accordingly, transmission queues are better viewed as a wish list. They are notoriously bad predictors of realistic projects.

The NWEC paper later acknowledges, "…only a fraction of these projects will get built due to a variety of reasons…" However, NWEC still concludes, "…the queue reflects the potential and the financial interests that are circling the region." [29]

NWEC's paper fails to provide the size of the fraction we can count on, however. One way to do so is to look at the history of the queue versus the amount of generation built. (See chart below)

[27] https://apiproxy.utc.wa.gov/cases/GetDocument?docID=110&year=2021&docketNumber=210220
[28] Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 7.
[29] Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 7.



Source: Energy GPS

If one compares the number of megawatts that have come on-line each year as a percentage of the queue at the time, it equates to **roughly 1.8% per year**, allowing for a three-year construction lag.[30,31] The 1.8% figure is inflated by 2010, when approximately 21,000 MW of total generation were in the queue.

The comparison below does not include a construction lag. In this comparison, one can see each year's combined queue compared to the total number of megawatts that came on-line. This methodology results in a percentage well below 1.0% per year, as recent construction has failed to keep up with the pace of the queue's expansion.[32]

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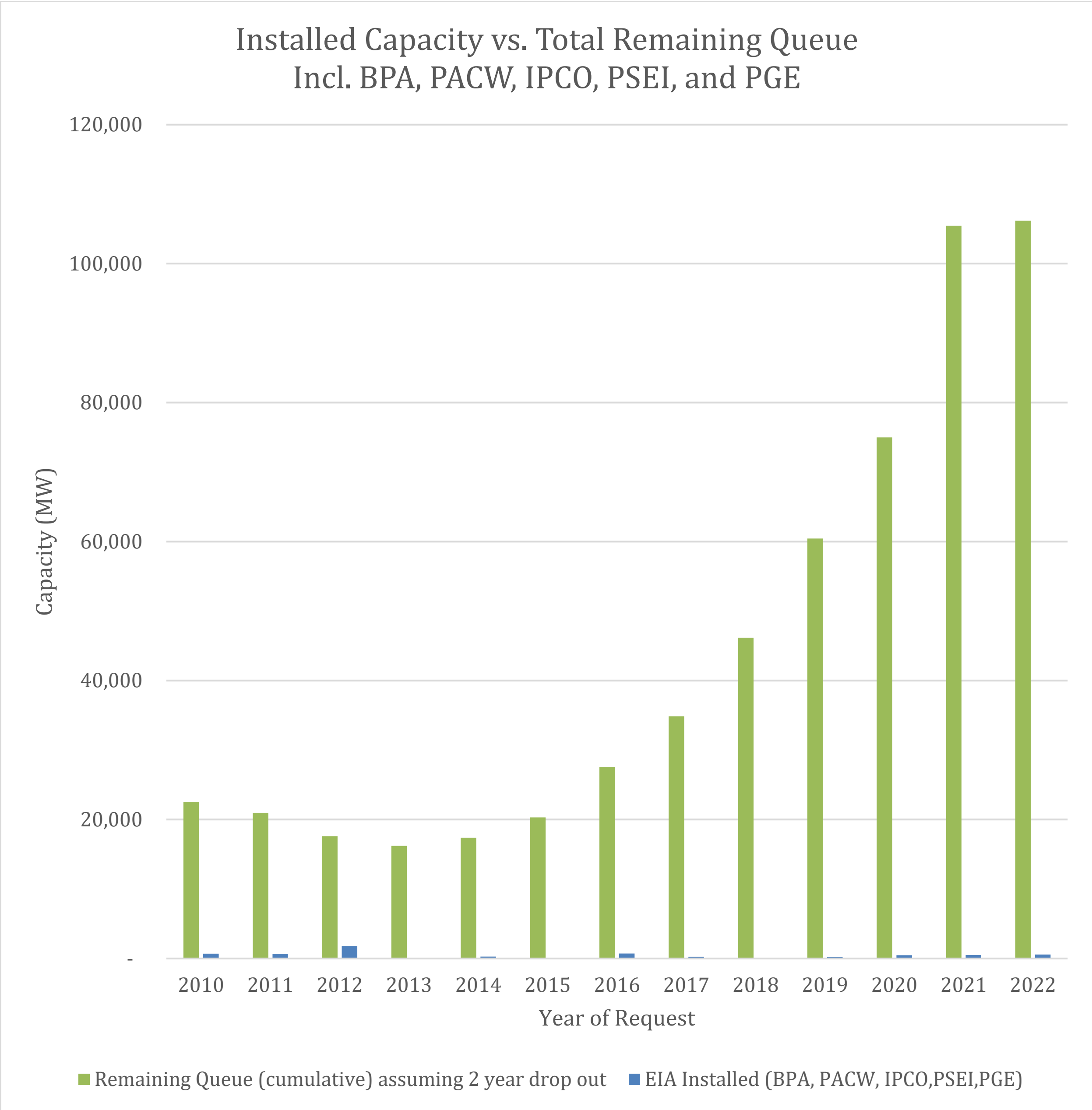
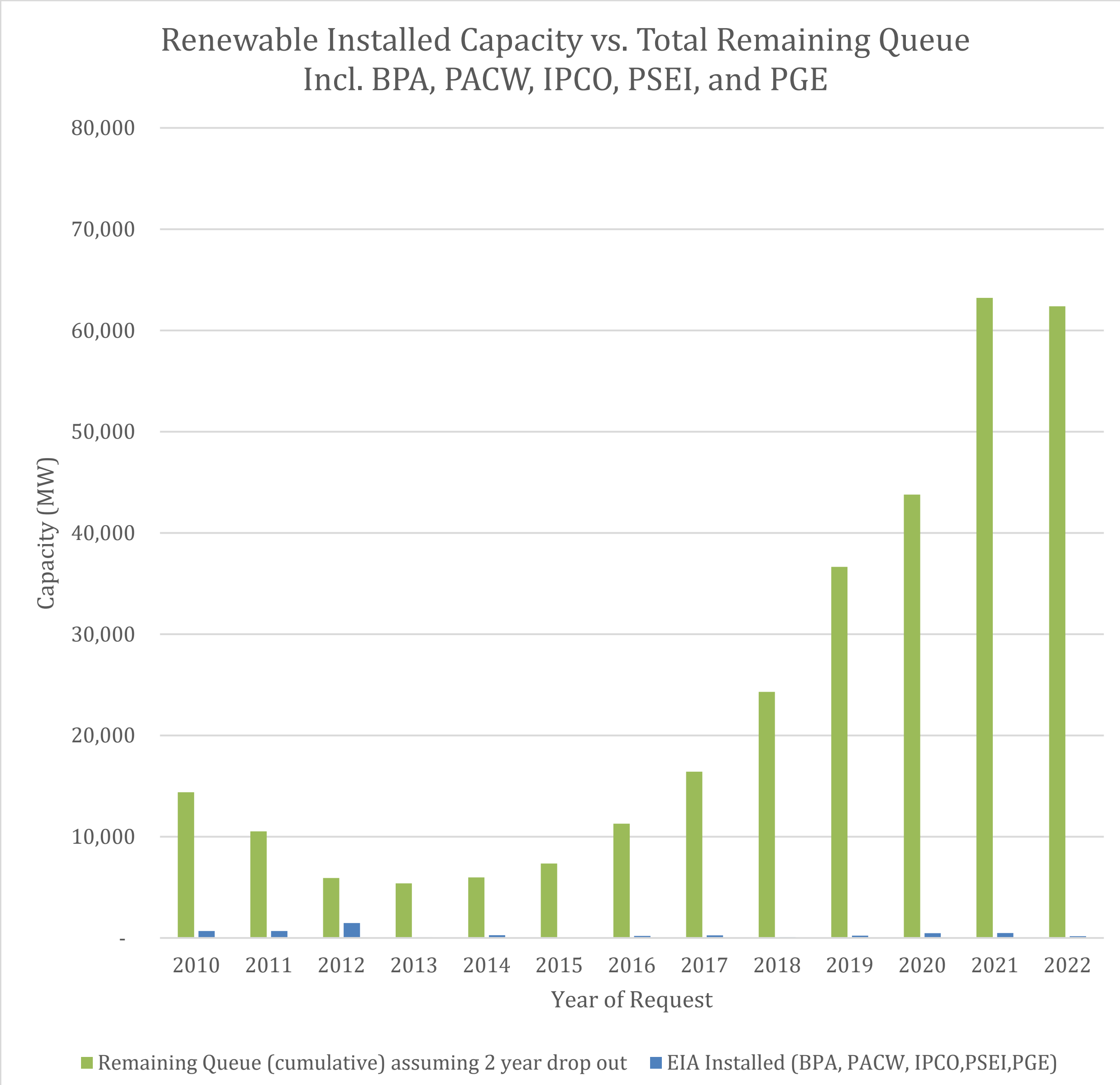
[30] A conservative approach yields an estimate of roughly 106,000 MW of "nameplate" generation are in the transmission queues of BPA, PacifiCorp West, Idaho Power Company, Portland General Electric, and Puget Sound Energy as of 3/1/2022. It is possible the number is larger, depending on one's assumptions around resources that have dropped out.

[31] Due to the lag, only figures through 2019 can be shown.

[32] The two-year dropout assumes projects either are withdrawn from the queue or come on-line after two years, so as not to overstate the size of the remaining queue.



Source: Energy GPS



Source: Energy GPS

Either of these methods result in the same basic conclusion—the fraction of resources in various transmission queues that are actually constructed is exceedingly small (i.e., 2% or less on average each year). As a result, one cannot reasonably rely on transmission queues as dependable indications of resources that will be developed. To do so would be very unwise, as electric utilities are responsible for public safety and cannot risk an unreliable power supply.

NWEC ERROR #3: POWER REPLACEMENT COSTS ARE LOW

The NWEC paper compares the cost assumptions from its 2018 commissioned study[33] to prices from PacifiCorp's 2021 RFP. The comparison shows a significant drop in the prices of wholesale solar, wind, and batteries since 2018.[34]

However, the original 2018 NWEC-commissioned study had several deficiencies which makes carrying that analysis forward problematic. Northwest RiverPartners commissioned Energy GPS to perform a review of the 2018 NWEC study.[35] The Energy GPS critique noted the following shortcomings:

1) The 2018 NWEC study didn't account for Washington's Clean Energy Transformation Act (CETA). As a result, the NWEC study assumes an energy surplus that is no longer available with the early retirement of thousands of megawatts of coal and natural gas generating plants.
2) The 2018 NWEC study was overly reliant on demand response and energy efficiency programs, which were not justified by the cost curves associated with those resources.
3) The 2018 NWEC study underestimated the need for new transmission buildouts to accommodate additional energy production and storage.
4) The 2018 NWEC study undercounted the value of the carbon-free energy and capacity provided by the LSRD, in light of the region's aggressive decarbonization policies established in 2019.

As part of its review, Energy GPS also provided its own cost estimate for a viable zero-carbon replacement portfolio for the LSRD. The forecasted replacement cost was $860 million per year for 20 years.

Similarly, the Bonneville Power Administration, the US Army Corps of Engineers, and the US Bureau of Reclamation performed an LSRD replacement analysis for the 2020 Columbia River System Operations Environmental Impact Statement (CRSO EIS). The federal agencies found replacing the full capabilities of the LSRD with a zero-carbon portfolio of solar plus batteries would cost roughly $16 billion over a 20-year period.[36] This figure is on par with the Energy GPS estimation.

BPA estimates this cost would increase the wholesale energy rate by 50%, which would have a devasting effect on vulnerable communities across the Pacific Northwest. Millions of utility customers would see increases in their electric bills of 25% or more.[37]

In terms of energy equity, many community-owned utilities that receive their power supply from BPA have disproportionately high senior, Hispanic, and Native American populations compared to the rest of the region. The increased costs have to be understood in the larger context of already high housing costs and strong inflationary pressures that have contributed to a homelessness crisis across the Pacific Northwest.

[33] The Lower Snake River Dams Power Replacement Study – NW Energy Coalition
[34] Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 4.
[35] Energy GPS Review of 2018 NWEC-Commissioned Study
[36] Executive Summary: 2020 Columbia River System Operations Environmental Impact Statement
[37] For many public power utilities, power supply costs represent roughly half of their total costs.

An additional shortcoming of NWEC's paper is the assumption that the price of wind, solar, and batteries will continually decline. Lazard's Levelized Cost of Storage Comparison for Energy shows that assumption is risky. In 2020, the Lazard survey showed an unsubsidized levelized cost of utility-scale solar plus four-hour batteries ranging from $81-$140/MWh.[38] Lazard revised its price upward, however, in 2021, the price increased to $85-$158/megawatt-hour.[39]

Given multiple supply chain challenges, instability in global trade, and limited availability of key materials, like lithium, it is risky to depend on perpetually declining prices.

Costs

BPA Utility Rate (shaped and firmed): 3.5 c/kWh

New Solar + Batteries (four-hour storage): 8.5 to 15.8 c/kWh*

*Source: 10/28/2021 *Lazard Levelized Cost Of Storage, and Levelized Cost Of Hydrogen*

The Lazard figures also demonstrate that, even at the low end, the price for unsubsidized solar[40] paired with batteries compares very *unfavorably* to the shaped and firm energy provided under the Bonneville Power Administration. BPA's Priority Firm rate is $35/MWh or 3.5 cents/kWh.

Importantly, as noted previously, the Lazard price only includes four-hour battery storage, whereas the hydropower system provides multi-day, and in some cases, even multi-season storage.

Finally, NWEC claims that the cost of refurbishing the LSRD turbines will be prohibitive in the context of falling wind and solar prices:

> *Meanwhile, each of the four lower Snake River dams has six generators, all of which have now been in service for 45 to 60 years. Only the three oldest generators have been rebuilt so far. The cost of updating and operating these dams will only increase as they continue to age. For example, replacing two turbines at Ice Harbor dam cost $58 million. Straight multiplication would put the cost of replacing all the remaining turbines at just*

[38] https://www.lazard.com/perspective/lcoe2020
[39] https://www.lazard.com/perspective/levelized-cost-of-energy-levelized-cost-of-storage-and-levelized-cost-of-hydrogen/
[40] The levelized cost for wind is higher than the levelized cost for solar.

over $600 million. Whereas the cost of replacement clean energy resources will continue to fall throughout this decade as shown in the NREL data in Figure 2.[41]

However, the $600 million figure needs to be taken into the context of the expected total amount of energy produced.

Assuming the useful life of a hydropower turbine is 45 - 60 years, an estimated cost per year throughout the useful life can be calculated.[42] On the low end of 45 years, $609 million will cost roughly $44.3 million per year[43]. The LSRD have an average output of 1000 megawatt-hours (MWh) per hour. Using the fact that there are 8760 hours in a year, this breaks down to $5.06 per MWh throughout a 45-year lifespan (assuming a 7 percent discount rate).

Similarly, using the high end of 60 years as the lifespan, the cost would be an estimated $43.2 million per year[44]. This breaks down to be $4.93/MWh over the 60-year lifespan (assuming a 7 percent discount rate).

$5/MWh converts to 0.5 cents/kWh. Looking again at Lazard's levelized cost of energy, an additional 0.5 cents per kWh would place BPA's rate at 4.0 cents/kWh compared to roughly 8.5 to 15.8 cents/kWh for solar + batteries.[45]

Note, wind turbines, solar panels, and especially batteries, have much shorter useful lives. The useful life is typically 20 years for wind turbines and 25 to 40 years for solar PV.[46] Thus, they will have to be replaced numerous times during the same 45 to 60-year lifespan of a hydropower turbine.

It is also important to note that the new hydropower turbines may provide the ability to increase power generation. Small-scale model testing of the new fixed-blade runner design included in the current replacements at Ice Harbor dam indicate it may increase power generation by 3 to 4 percent.[47] If increased power generation were to occur, the costs per kW and MWh would be even lower.

This is not an argument against wind, solar, and batteries, but it does indicate the LSRD are more than cost competitive. The NWEC report misrepresents these facts.

[41] Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 4.
[42] Using NWEC's own numbers, the capital cost per kilowatt can be determined. Using a total replacement cost of $609 million for the remaining 21 turbines. Since the cost of two of the six turbines at Ice Harbor Dam is already covered, there are four remaining turbines to replace. At the other three LSRD, the combined maximum output is 2430 MW, with each having an individual maximum output of 810 MW. Assuming proportionate output by each turbine, the maximum output of the 21 turbines needing replacement is 2757 MW. Therefore, the capital cost is $221/ kW . Lazard's Levelized Cost of Energy Analysis published in October of 2021 included a comparison of unsubsidized capital costs between renewable energy resources. Utility scale solar PV had capital costs between $800 - $950. Wind resources had capital costs between $1025 - $1350 . These figures do not include the cost of batteries. Compared to these values, the capital cost of replacing the remaining 21 turbines is quite favorable.
[43] Calculated using a 45-year annuity-due, with present value $609 million and discount rate 7%
[44] Calculated using a 60-year annuity-due, with present value $609 million and discount rate 7%
[45] The levelized cost of wind is higher than solar.
[46] https://www.nrel.gov/analysis/tech-footprint.html
[47] https://www.nww.usace.army.mil/Portals/28/siteimages/Missions/Ice%20Harbor%20Turbine%20Event/FS_160511NewTurbinesFINAL.pdf

NWEC ERROR #4: GRID RELIABILITY IS NOT AFFECTED

The Northwest Power and Conservation Council ("the Council") recently completed its 2021 Power Plan. The Power Plan represents what the Council believes is the most economic means of achieving official policies while maintaining a reliable power grid.

NWEC, in its paper's description of the 2021 Power Plan, misstates the conclusion of the Power Plan in the following excerpt:

> *In light of these and other changes, the Northwest Power and Conservation Council 2021 Plan does not anticipate any new investments in natural gas generation to meet regional reliability needs or planned coal plant retirements and, with appropriate advance planning, replacing the power and ancillary services of the Snake River dams will not change this picture.*[1] (NWEC footnote references the 2021 Draft Power Plan) [48]

NWEC's statement implies the Council performed an analysis around LSRD replacement, which it has not.[49] If NWEC is inserting its own conclusion, it is doing so without sharing its analysis.[50] NWEC's assertion also ignores analyses performed by the federal agencies most responsible for keeping the lights on in the region.[51]

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48 Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 10.
49 Draft 2021 Northwest Power Plan (nwcouncil.org)
50 Planning-for-Energy-Replacement-Feb-2022-1.pdf (nwenergy.org) p 10.
51 Executive Summary: 2020 Columbia River System Operations Environmental Impact Statement

NWEC ERROR #5: CLIMATE CHANGE MEANS SNAKE RIVER DAMS SHOULD BE BREACHED

The NWEC paper misses the context of climate change and salmon survival and thereby makes a recommendation that would place more salmon populations at risk by increasing CO_2 emissions. The paper includes the following statement:

> *At the center of the clean energy and salmon recovery debate is the fact that climate change is increasing the near-term extinction risk for Snake River salmon and steelhead stocks and that it is impossible to recover them to healthy, fishable levels without restoring a free-flowing lower Snake River. The scientific evidence is overwhelming that removal of the four federal dams on the lower Snake River is necessary to avoid extinction and recover Snake River salmon and steelhead.*

Notably, while the NWEC paper refers to "overwhelming" scientific evidence that the LSRD need to be removed, it fails to include a single reference to a peer-reviewed study to bolster its assertion.

That said, NWEC's paper zeroed in on the key survival issue for salmon—climate change. But, by focusing too narrowly on a single river, the paper draws the wrong inferences.

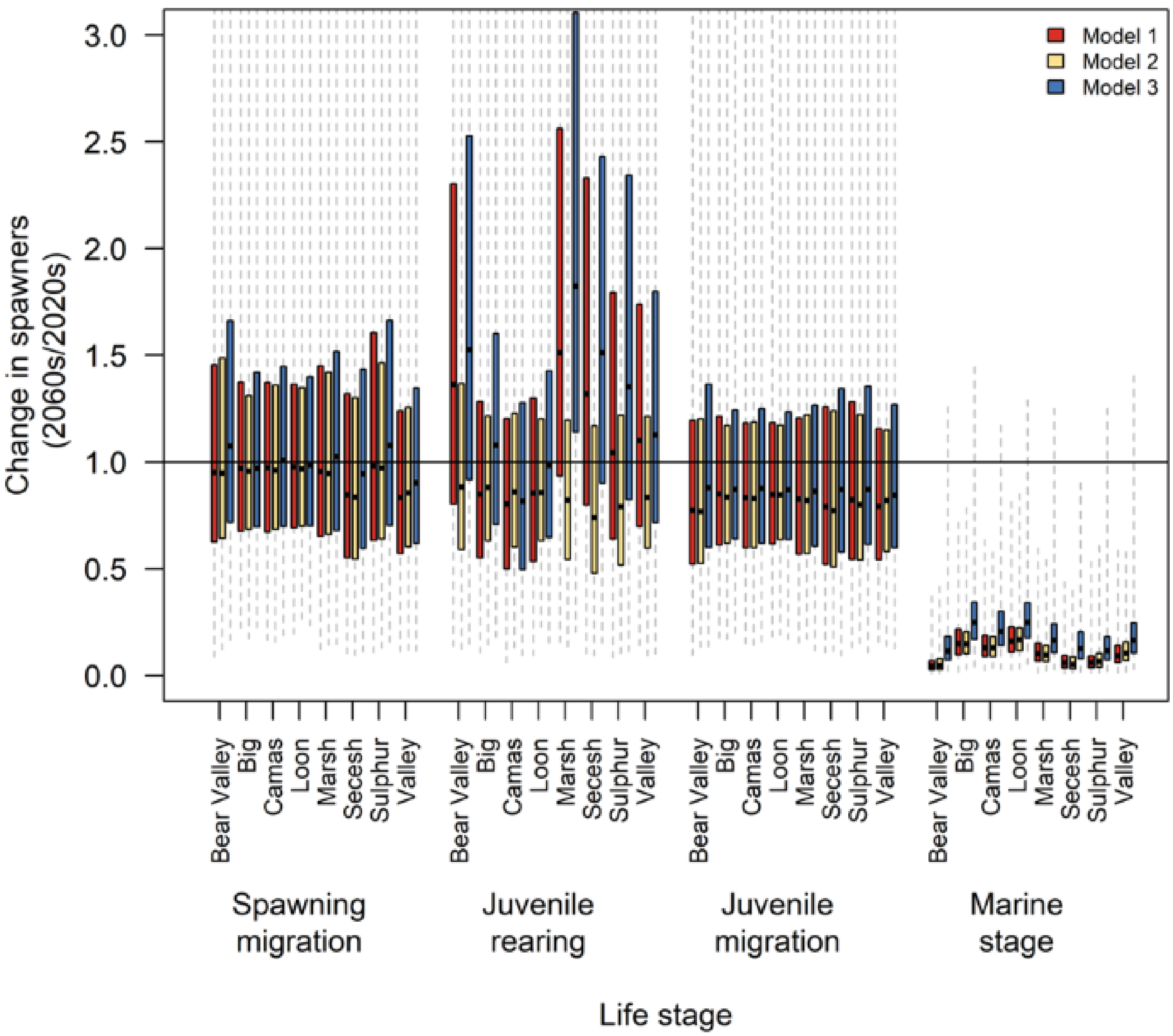
The Snake River is home to four endangered or threatened salmon and steelhead populations, but they are 4 of 31 endangered or threatened populations on the US West Coast.[52] The Canadian Pacific Coast has 45 salmon and steelhead populations listed as officially at risk.[53]

Therefore, **we know that *at least* 72 of the 76 of the US and Canadian-listed salmonid populations are not at risk due to the LSRD, but all 76 are threatened by climate change.**

The magnitude of the climate change threat is also important. In 2021, NOAA Fisheries issued a peer-reviewed study which predicted key Chinook populations may go functionally extinct by 2060 if the ocean continues to warm at its current rate.[54] This study also identified the threat salmon face from ocean warming is much greater than the threat from warming rivers. The paper includes the following summary:

> *Climate impacts were most dramatic in the marine stage, where survival was reduced by 83–90% (Fig. 7). This occurred despite the fact that smolts arrived at Bonneville Dam about 6.5 days earlier, indicating an earlier initiation of the marine stage, which generally improves marine survival.*[55] (Chart below is Fig.7 from NOAA paper)

[52] https://www.fisheries.noaa.gov/species-directory/threatened-endangered
[53] Pacific Region - aquatic species at risk (dfo-mpo.gc.ca)
[54] https://www.nature.com/articles/s42003-021-01734-w
[55] https://www.nature.com/articles/s42003-021-01734-w



Consistent with the previously mentioned NOAA study, a 2020 peer-reviewed study concluded that Chinook salmon survival has declined on average by 65% over the last 50 years, whether salmon were returning to rivers with dams or to free-flowing rivers. This figure applies to rivers from Northern California to Southeast Alaska.[56] The region's Independent Scientific Advisory Board confirmed this finding.[57]

The 50-year period examined in the study coincides precisely with the same period noted by the Intergovernmental Panel on Climate Science as, "50 years of unabated ocean warming."[58]

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[56] https://onlinelibrary.wiley.com/doi/10.1111/faf.12514
[57] https://www.nwcouncil.org/sites/default/files/ISAB 2021-3 ReviewOfWelchEtAl2020CoastWideSARs_29June.pdf
[58] https://www.ipcc.ch/srocc/

CHINOOK SALMON SURVIVAL

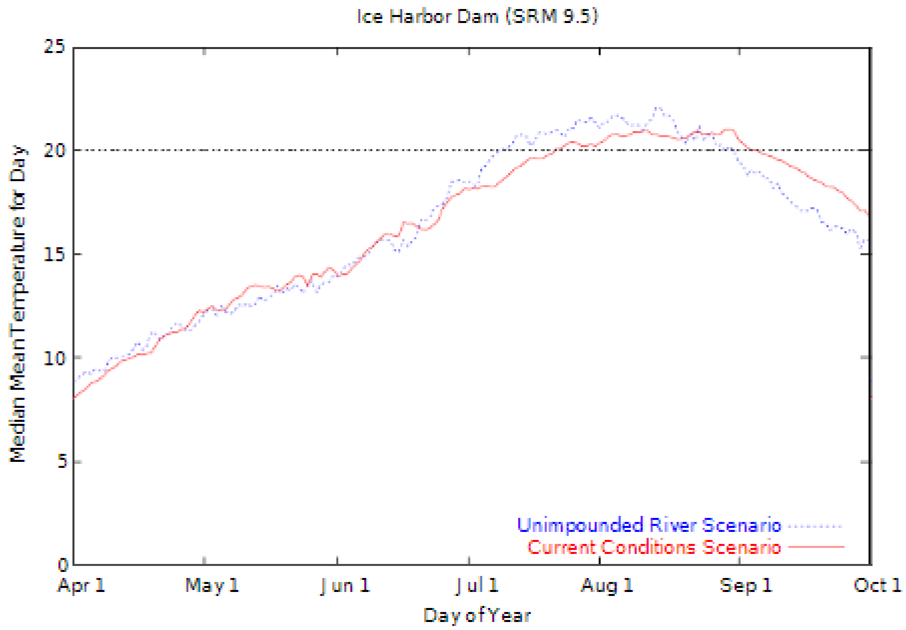
From California to Alaska, coastwide Chinook salmon survival has dropped 65% since the 1970s as the ocean has warmed from climate change.

While the magnitude of the threat of river warming may not be nearly as large, scientists agree river warming still represents a serious problem for salmon in an era of climate change. However, what is much less clear is the role the LSRD have on river temperatures.

The EPA's RBM10 model indicates the LSRD cause river temperatures to be warmer in the summer months because they slow the flow of water. The Pacific Northwest National Laboratory's MASS 1 model, on the other hand, shows a much different result.

The MASS 1 model indicates the larger body of water created by the LSRD reservoirs takes more energy to warm, and therefore provides a buffer against the most dangerous temperatures compared to an undammed river.[59] (see chart below)

[59] Richmond, Marshall C. "Regional Scale Simulation of Water Temperature and Dissolved Gas Variations in the Columbia River Basin", July 2002.



Comparison of the simulated median mean temperature at Ice Harbor Dam location for current impounded and unimpounded conditions.

In terms of historical data comparing river temperatures before and after the LSRD were constructed, records are sparse. However, a team of researchers conducted a water temperature study on behalf of the US Army Corps of Engineers in 2002, which compared pre-lower Snake River dam temperatures from 1955 to 1958 to measurements after the lower Snake River dams were constructed. (The Snake River dams were built in the 1960s and early 1970s.[60])

The researchers found no evidence that river temperatures had increased following construction of the dams, although the data set was quite limited. The team identified air temperature and flow levels as the biggest influencers on temperatures in the river.[61]

Given that there is missing data and different collection methods, this analysis should not be employed by itself, but it is fair to say that between the modeling disagreements and the lack of clear historical records, the science on the impact of the LSRD on river temperatures is mixed.

The primary scientific case made for breaching the LSRD is the theory of delayed mortality, which posits that salmon which pass more dams as juveniles, return in fewer numbers as adults. However, the West Coast-wide study results seem to refute that conclusion.

There are some exceptions to those coastwide declines, including spring Chinook from the John Day and Yakima rivers, which are still returning in strong numbers. As a result, those two rivers are often pointed to by delayed mortality believers. However, this variation can potentially be

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[60] USACE. "Lower Snake River Dams".

[61] Peery, C. and Bjornn, T. "Water Temperatures and Passage of Adult Salmon and Steelhead in the Lower Snake River", 2002, p.49. https://www.webpages.uidaho.edu/uiferl/pdf reports/UItempreport2002.pdf

explained by the fact that different salmon populations migrate to different parts of the ocean, some of which may be more protected from the impacts of changing ocean conditions.

Meanwhile, the fact that fall Chinook from the Snake River return in higher percentages as adults than fall Chinook from the John Day and Yakima rivers, runs contrary to the delayed mortality theory.[62]

Finally, in 2007, the Independent Scientific Advisory Board studied the issue and found no measurable evidence of a cause-and-effect relationship between the number of dams by juvenile salmon and adult returns ratios.[63]

In short, there is a lack of peer-reviewed scientific evidence to demonstrate the lower Snake River dams are the limiting factor for salmon or steelhead health. The context of a near-synchronous decline of salmon populations along the Pacific Coast of North America and even across the world—whether or not dams are present—provides sufficient reason for us to pause to consider what other factors may be at play.

If the NOAA Fisheries' study is correct, and the threat is directly linked to ocean temperatures, then removing productive, zero-carbon hydropower projects is a step in the wrong direction for salmon.

Recall that breaching the dams, according to the 2020 CRSO EIS, would increase the grid's CO_2 output by a minimum of 1.3 million metric tons per year, even if replacement was with a 100% renewable portfolio plus storage. A portfolio that relied on new natural gas generation would result in a 3.3 million metric ton increase per year.[64]

Neither figure includes the impact of the elimination of barging capabilities from the river if the dams are breached. Commodity flows would shift to truck and rail, resulting in a likely increase of roughly 1 million tons of CO_2 each year.[65]

Northwest RiverPartners Suggested Alternatives to Dam Breaching

Northwest RiverPartners believes salmon do need the region's help. We also firmly believe there are productive ways to help salmon which don't require dam breaching.

The following are areas where government and private funding could greatly help with salmon restoration:

MARINE STUDIES

NOAA Fisheries recently announced four vessels and more than 60 scientists are setting out as part of the *largest expedition ever* to study salmon in the North Pacific Ocean.[66] The

[62] https://www.nwcouncil.org/sites/default/files/ISAB 2021-3 ReviewOfWelchEtAl2020CoastWideSARs_29June.pdf
[63] http://www.nwcouncil.org/sites/default/files/isab2007_1.pdf
[64] Executive Summary: 2020 Columbia River System Operations Environmental Impact Statement
[65] NATIONAL TRANSPORTATION IMPACTS & REGIONAL
[66] 2022 Pan-Pacific Expedition | International Year of the Salmon

expedition's goal is to better understand extreme climate variability in the ocean and its impact on Pacific salmon.

Notably, this expedition has only *$10 million in funding*. Compare that to the *billions* of dollars invested in freshwater habitat projects and research over the years. The fact is, even though salmon spend most of their lives in the ocean, very little is known about where they go during the marine phase or where the highest degrees of mortality are occurring.

If we really want a solution to restoring salmon to abundance, it will likely involve developing a better understanding of the marine environment.

The insights gained could impact how we operate our river systems. For example, right now BPA loses well over $100 million per year and millions of megawatt-hours of renewable energy each year from fish spill (sending water over the top of dams rather than through turbines). Fish spill is implemented, in part, to push juvenile salmon more quickly to the ocean.

The assumption behind the operation is juvenile salmon survive at a higher rate in the ocean than in the river. However, that assumption has never been studied in the Columbia River Basin. If studied, we may find spill is not a productive means of aiding salmon, which could lead to lower spill levels and an increase in the region's CO_2-free generation.

ESTUARY REPAIRS

A 2019 peer-reviewed study showed estuaries along the West Coast of the United States have lost 85% of their historcial vegetated wetlands over the past 100 years.[67] These wetlands represent key nurseries for juvenile salmon and steelhead as they make the transition from freshwater to the ocean.

Estuary vegetation is highly important, because it helps hide salmon from bird predators, and estuary channels help shelter salmon from larger fish and other predators. Restoring estuary wetlands and vegetation could be a major step in salmon recovery across the Pacific Northwest and beyond.

HATCHERY REFURBISHMENT

Northwest RiverPartners has partnered with the Columbia River Inter-Tribal Fish Commission (CRITFC) to call attention to the plight of the region's Mitchell Act hatcheries. These hatcheries don't get their funding through BPA, but rely on the Department of Commerce.

[67] Insights into estuary habitat loss in the western United States using a new method for mapping maximum extent of tidal wetlands (plos.org)

Their funding has been inadequate to keep up with modernization requirements, and so these hatcheries are only able to produce salmon at a fraction of their intended levels. Securing adequate funding for these hatcheries would represent a big step forward for salmon in the region.

DECARBONIZATION

President Biden's aggressive plan to decarbonize the US Electricity Sector by 2035 speaks to the importance of fighting climate change for our nation and our planet. While climate change represents a serious threat to humanity, as noted above, it represents an even more critical and immediate threat to salmon.

Hydropower represents close to 90% of the Pacific Northwest's renewable energy and half of its total electricity generation. As a result, the Pacific Northwest has the least carbon-intensive grid in the United States and the most affordable clean energy in the nation.

We also have much lower levels of unhealthy plant emissions, such as sulfur and nitrogen oxides, than areas of the country that are more reliant on fossil fuels.

By preserving our existing hydropower and nuclear generation and adding new renewable resources, we can improve conditions for our planet and its salmon.

CONCLUSION

Northwest RiverPartners, our members, and partners are committed to restoring healthy salmon populations in the Pacific Northwest and beyond. We believe in the sanctity of the treaties between the United States and Native American Tribes, which were signed with the expectation of a healthy salmon economy for generations of Native Americans to come.

We also believe that dams, especially dams which have been upgraded with highly advanced fish passage capabilities, should not become a symbol or scapegoat for a problem that is much more pervasive and widespread. These dams, and the benefits they provide, are too important to the region and its many communities to be sacrificed when there are other reasonable explanations for salmon declines and other recovery options to explore.

In the context of climate change, we believe NWEC's February 2022 paper has flipped logic upside down when it states,

> *At the center of the clean energy and salmon recovery debate is the fact that climate change is increasing the near-term extinction risk for Snake River salmon and steelhead stocks and that it is impossible to recover them to healthy, fishable levels without restoring a free-flowing lower Snake River.*

As we've demonstrated in this rebuttal paper, it is highly unlikely, if not impossible, for the region to achieve its clean energy goals without the lower Snake River dams in place.

Breaching the lower Snake River dams will lead to additional 1.3 - 3.3 metric tons of CO_2 *annually*, according to the most recent federal study.[68] This figure doesn't include the impact of the elimination of barging capabilities from the river if the dams are breached. Commodity flows would shift to truck and rail, resulting in a likely increase of roughly 1 million tons of CO_2 each year.[69]

Given the threat of climate change to salmon, we as a region and nation cannot afford to backslide on our carbon reduction efforts. Hydropower will remain a critical part of that effort."[70]

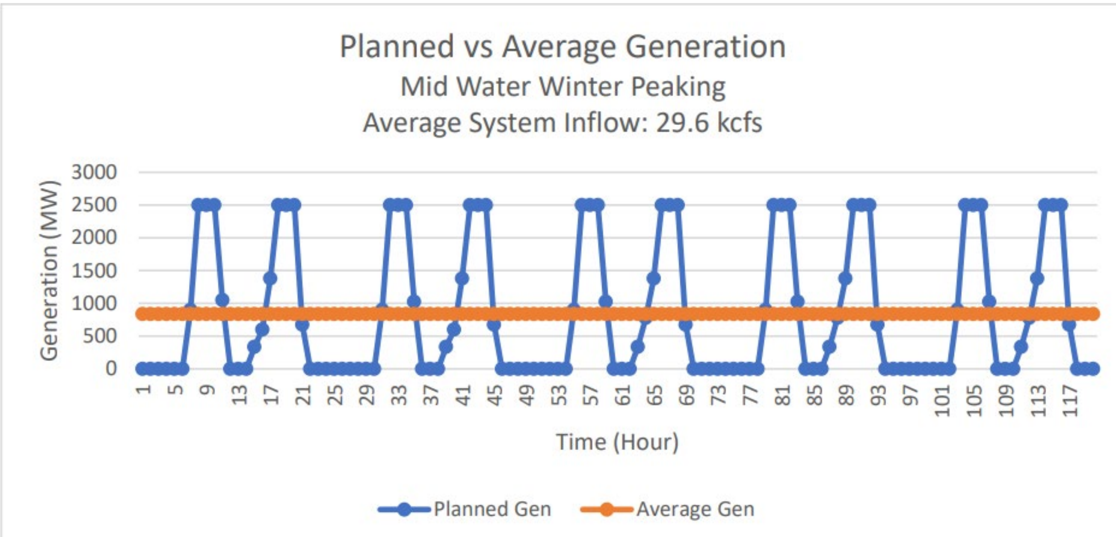
Learn more at nwriverpartners.org

[68] Executive Summary: 2020 Columbia River System Operations Environmental Impact Statement
[69] NATIONAL TRANSPORTATION IMPACTS & REGIONAL
[70] Accelerating Decarbonization of the U.S. Energy System | The National Academies Press (nap.edu)

APPENDIX A

The peaking output of the LSRD is made possible because they come with a huge built-in "battery" in the form of the reservoirs behind each of the four dams. They can hold back water during low demand hours and then release it past hydropower turbines during high demand hours.[71]

This storage capability allows them to reliably provide power during hours and days of greatest need, such as a multi-day cold snap.[72] (See graph below.)



Source: NWRP: Dollars & Sense (Appendix A)[73]

As real-life examples, the Bonneville Power Administration issued two separate press statements in 2021, pointing to the criticality of the LSRD helping to provide reliable service during two historic weather events, one in the winter and one in the summer. [74,75]

The press statement following the winter ice storm included the following quote from BPA Administrator, John Hairston:

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[71] It would take much more than 2,500 MW of four-hour battery storage to replace the multi-day peaking capabilities of the LSRD. The entire 2,500 MW or 10,000 MWh of batteries would be completely depleted in less than one day of trying to replace the capabilities of the LSRD. To recharge the batteries for a second day of operation would mean depleting the grid of additional electricity, which likely wouldn't be a good option during extreme weather.

[72] Dollars & Sense: (nwriverpartners.org)

[73] Dollars & Sense: (nwriverpartners.org) Appendix A

[74] https://www.bpa.gov/-/media/Aep/about/publications/news-releases/20210616-pr-08-21-lower-snake-river-dams-provided-crucial-energy-and-reserves-in-winter-2021.pdf

[75] https://www.bpa.gov/-/media/Aep/about/publications/news-releases/20210722-pr-10-21-lower-snake-river-dams-help-region-power-through-recent-heatwave.pdf

> *"Year after year, the Pacific Northwest can count on service from these projects [the four LSRD] in the winter when electricity consumption is highest," said BPA Administrator John Hairston. "As we feel the impacts of climate change and the region builds more intermittent energy resources like wind and solar, we're seeing more evidence that these dispatchable hydroelectric facilities are vital to public safety and electric reliability for the region."*

The press statement following the June heat dome event included the following statement:

> *During the late June heatwave, the four dams on the lower Snake River provided much-needed energy, balancing and contingency reserves, and Ice Harbor dam on the lower Snake River played a key role in keeping the lights on in the Tri-Cities area in eastern Washington. Without these four dams, powering through the heatwave could have been much more expensive and operationally challenging.*

Calls to breach the LSRD also ignore the role the dams play in helping the region add solar and wind power to the grid. The LSRD storage capabilities mean they can also quickly increase or decrease their generation to help fill in the gaps created by wind and solar power.[76] Due to this role, eliminating the dams has a secondary effect of making it more difficult to add new renewable resources to the grid and to achieve additional decarbonization goals, such as electrifying transportation.

[76] https://www.bpa.gov/-/media/Aep/about/publications/news-releases/20210722-pr-10-21-lower-snake-river-dams-help-region-power-through-recent-heatwave.pdf