Lower Snake River Hydropower Dams

A Resilience Assessment of Regional Impacts with Proposed Dam Removal

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Executive Summary

This study explores whether the Lower Snake River dams including Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams should be removed for harming fish populations while not providing competitive energy prices. We review previous Lower Snake River dams' studies that approach this problem from an economic, energy security, and environmental lens. This study primarily took an energy resilience approach; however, the environment was also considered in our analysis.

Both Washington and Idaho are both heavily dependent on hydropower for electricity production. The Lower Snake River dams produces 1,024 average MW, which is equivalent to 16% of all of Bonneville Power Administration's average hydropower production. Bonneville Power Administration currently generates more electricity than their customer's demand. It is true that the Lower Snake River Dams could be removed, and Bonneville Power Administration can still meet its electricity demand; however, future energy projections should be considered. When looking at population growth, we project that the energy equivalence of over 3 Lower Snake River dams power production will be needed by 2040 assuming no new energy efficiency and demand response measures. This is a worst-case scenario to show the scale of potential electricity demand in the region. If all this new electricity demand is filled with natural gas, there would be an increase in carbon emissions by approximately 12 metric tons of CO_2.

Along with new electricity demand, the region is continuing to develop transmission that would help Bonneville Power Administration export more of its clean energy to other places. This energy could help other states, which do not have the same access to clean energy, reach greenhouse gas emission goals. The Boardman to Hemingway transmission project is one specific example that connects Pacific Power, Bonneville Power Administration, and Idaho Power together. This connection is crucial for Idaho Power to reach its own goal to become 100% carbon-free by 2045.

According to our All Hazards Analysis, when any of the Lower Snake River dams are removed there are hospitals in both Lewiston, Idaho and Kennewick, Washington that are impacted. These hospitals would need additional energy supplies if these dams were removed. The Lower Monumental dam is one of three electricity inputs into the Columbia Generating Station nuclear facility. We can qualitatively say that the Columbia Generating Station would need to invest in another energy source to ensure the reliability of this nuclear facility.

Given the information covered in this report, we suggest the Lower Snake River dams continue to operate while BPA, Corps, and Reclamation continue to implement fish projects on the Lower Snake River dams. It is our opinion, efficiency and demand response measures along with clean hydropower can be implemented together to reach Washington's clean energy goals. To help the fish populations, the mitigation strategies that have been proven in other BPA and Corps facilities can be applied to the Lower Snake River dams. We have shown that if proper fish mitigation can be performed with the current dam infrastructure, these dams could be run at a higher capacity to produce more energy.

As with any research, results are dependent on the current data available. The value of these dams should continually be assessed, and once the dams reach a point where they are not serving their original intended purpose, removal should be reconsidered.

1.0 Introduction

The states of Idaho and Washington are both heavily dependent on the use of hydropower for electricity generation. While hydropower is a green, low-carbon option for generating electricity, some of Bonneville Power Administration's (BPA), Army Corps of Engineers (Corps), and Bureau of Reclamation (Reclamation) hydropower facilities have been criticized for damaging salmon populations while not providing competitive energy prices. Specifically, the four Lower Snake River dams including Ice Harbor, Lower Monumental, Little Goose, and Lower Granite have been identified by the economic consulting firm ECONorthwest to be economically incapable of providing necessary salmon rehabilitation while providing low-cost energy (ECONorthwest, 2019). The critics of the Lower Snake River dams suggest that the dams be closed in order to save the salmon population; however, there was no analysis done on the energy infrastructure resilience in the case that the dams were closed (Malarkey, 2019). This report will take an all hazards approach to see how the region would need to respond in the case of a disruption of power production from the Lower Snake River dams. The following study will explore the results and assumptions of previous studies about the Lower Snake River dams, outline the current energy profile of the Washington-Idaho region, and give a suggestion for future of the Lower Snake River dams based on analysis of future energy projections. While the fish population is an important consideration and is covered in this paper, the main focus for this report is on the region's energy resilience, which is defined as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (NRC, 2012, pg. 16).

BPA projects that in 2020 their annual average for power generation will be 81% (6,396 aMW) hydropower (BPA, 2019). The total region's projected resources for 2020 are 28,832 aMW with the next closest energy resource behind hydropower being natural gas, but even this only comes in at 20% (5,869 aMW) of the region's total projected energy generation resources (BPA, 2019). With over 80% of BPA's projected generation capacity coming from hydropower and 40% of the generation capacity in the whole Pacific Northwest being hydropower it's important that discussions around possibly losing power generation includes a look at resilience of the power market in the Pacific Northwest region.

The Snake River has been deemed critical habitat for salmon (ECONorthwest, 2019). Sockeye salmon were the first salmon that were listed on the endangered species list which triggered the need for an environmental statement (ECONorthwest, 2019). All four of the lower Snake River dams were built from 1962-1975 and Sockeye were listed as an endangered species in 1991 (ECONorthwest, 2019). This meant that the dams were constructed and put online before the salmon were listed as an endangered species. This resulted in the environmental impact statement being required after the dam construction and the beneficial uses already being utilized.

2.0 Previous Studies

In the last 3 years, there have been multiple studies giving suggestions for the future of the Lower Snake River dams. This paper will cover the main points of three reports that each have their own set of assumptions and conclusions. It is important to consider the writers assumptions when analyzing data as this can drastically change the conclusions of the authors.

2.1 Northwest Energy Coalition Strategies (2018)

The Northwest (NW) Energy Coalition was the most recent study that has addressed whether the Lower Snake River Dams (LSRD) could be replaced without compromising reliability while minimizing greenhouse gas (GHG) emissions. This study used a variety of energy simulation tools including the GENESYS Model for hourly simulations, PowerWorld Modeling Software for transmission reliability, and the ABB GridView Model for production cost modeling. The following study looked at alternative scenarios including breaching the Lower Snake River Dams without replacement resources, a non-generating alternative that focused on a demand response as the solution, a balanced replacement, and an all gas alternative. All alternatives with some power replacement included had a lower loss-of-load probability (LOLP). A LOLP is related to how often customers would be left without power. Many of the alternatives focused on increasing demand response, improving energy efficiency, battery storage, wind, and solar. All proposed alternatives had increases in GHG emissions and prices; however, the authors state that it is possible for the LSR dams to be replaced while keeping reliability. We will see that the LOLP results from this study conflicts with the Environmental Impact Statement that was produced by the LSRD operators.

2.2 ECONorthwest (2019)

After a thorough review of the ECONorthwest economic study of the Lower Snake River Dams, we find the study to be thorough in scope and depth as far as it is possible. We take issue, however with certain models and assumptions used in the conclusion for the removal of the dams. As our examination adds resiliency into the equation, we find that the rationales for closure of the dams do not hold water.

First, is the question of the Steelhead population and damage to the populations due to the dams. While the ECONorthwest openly states that they are not experts in determining all the factors to the reasons for the decreases in the populations they also use the assumption that closure of the dams would directly affect the fish population. They claim that this makes economic sense with a survey to find the willingness-to-pay (WTP) by each consumer where they claim that each would have a WTP of $39.40 extra in energy expenses each year. This allows for the summation of all consumers with a WTP of $39.40 to justify the costly removal of the dams. This method of measuring a WTP for simple survey is highly debated for its validity. This model known as Non-Use-Value is one not utilized in most reports for the LSRD's and we believe should be reexamined. Compared with other surveys concerning the same issue we find greatly different numbers. Furthermore, we believe that if other options were included in the survey questions, namely fish passage projects, flow mitigation, and reduction of resilience; we believe the results would have been much different.

Secondly, the study assumes that the production of energy to make up for the hydropower loss will be sourced by clean energy over time and adds the cost to society of the added CO_2 brought on by the immediate alternative energy source. However, without considering the added risks of disruption due to energy sourcing instead of local energy production is what allows for such conclusions to be made. By including other economic models to account for the risks to regional resiliency such as the value-of-a-statistical-life (VSL), even by the most conservative approach, we see more economic sense in keeping the dams.

2.3 Columbia River System Operations Environmental Impact Statement (EIS) (2020)

The environmental impact statement was released by the Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation), and Bonneville Power Administration (BPA) to investigate multiple different options for the LSR Dams to meet the following objectives:

1. Improve Juvenile Salmon,
2. Improve Adult Salmon,
3. Improve Resident Fish,
4. Provide a Reliable and Economic Power Supply,
5. Minimize greenhouse Gas (GHG) Emissions,
6. Maximize Adaptable Water Management,
7. Provide Water Supply, and
8. Improve Lamprey

(Corps, Reclamation, & BPA, 2020). While the plan suggested five unique alternatives, this report will only cover the plans that include the Preferred Alternative, the plan that the agencies would like to follow, and Multiple Objective Alternative 3, a plan that includes removal of the LSRDs (CRSO, 2020). The preferred alternative includes a flexible spilling operation that will increase or decrease water spill over the dams depending on how valuable the power generation is at the time (Corps, Reclamation, & BPA, 2020). This plan also includes investment in additional Lamprey passage (Corps, Reclamation, & BPA, 2020). Lamprey cannot utilize the same form of passage that fish use because they must suction up passages instead of climbing them. The preferred alternative meets all objectives; however, electricity production would fall from 1100 aMW to between 800-940 aMW depending on the water conditions (Corps, Reclamation, & BPA, 2020). The reduction in power production would lead to an increase in electricity rates and carbon emissions when compared to current operation (Corps, Reclamation, & BPA, 2020). The breaching of the LSRDs was not chosen as the preferred alternative in this study because of the decrease in reliable power production, increase in GHG emissions, and impact on the transportation industry (Corps, Reclamation, & BPA, 2020). Rate increases were found to be between 8.2-19.3 % depending on what power source was implemented (Corps, Reclamation, & BPA, 2020). Unlike the NW Energy Coalition Study, this study found that the loss-of-load probability would increase if the LSR dams were removed. They found that the likelihood of power outage would increase from 6.6% (one outage every 15 years) to 13.9% (one outage every 7 years) (Corps, Reclamation, & BPA, 2020). The EIS also considers the fact that if barge transportation was eliminated, there would be an increase in trucking and rail prices to meet the shipping demand increase (Corps, Reclamation, & BPA, 2020).

3.0 Regional Energy Profile

When looking at resiliency in Washington and Idaho the energy profiles for each state must be considered. Washington generated 9,995 thousand MWh through October 2019 (EIA, 2020). This is across five sources of electricity generation (EIA, 2020). The five sources of electricity generation in Washington are natural gas-fired, coal-fired, nuclear, hydropower, and nonhydroelectric renewables (EIA, 2020). Hydropower generates 4,000 MWh which is 40% of Washington’s net electricity generation (EIA, 2020). Idaho has a similar power mixture when looking at energy profiles.

Through October 2019 Idaho generated 1,660 thousand MWh across three sources of electricity generation (EIA, 2020). The three sources of electricity generation in Idaho are natural gas-fired, hydroelectric, and nonhydroelectric renewables. Hydroelectric generation was 887 thousand MWh which is 53% of Idaho's electricity generation. This means that both states rely heavily on hydroelectric generation for their electricity generation.

Figure 1 illustrates the relevance of hydropower generation for both Idaho and Washington. The circle size is relative to the amount of power that the plant generates. The largest circles are hydropower facilities and the red circles are the Lower Snake River dams. Their size is still much larger than other sources of generation like solar, biomass, and wind.

There are four relevant power providers near the Lower Snake River dams: 1) Benton PUD, 2) Pacific Power, 3) Clearwater Power Company, and 4) Avista Corporation. Benton PUD provides services in Kennewick, WA. Hydropower makes up 79.6% of Benton's fuel mix (Benton PUD, 2018). Pacific Power provides services to Walla Walla and Dayton amongst other areas. Hydropower makes up 26.7% of Pacific Power's fuel mix (Pacific Power, 2017). Clearwater Power Company provides services to Benewah county, Clearwater county, Idaho county, Latah county, Lewis county, Nez Perce county, Shoshone county, Asotin county, Garfield county, and Whitman county. Clearwater Power Company utilizes electricity from Bonneville Power Administration, and hydropower makes up 85.82% of their fuel mix (Clearwater, 2020). Avista Corporation provides services to Pullman, Clarkston, Moscow, Lewiston, and Coeur d'Alene among other cities in Washington and Idaho. Hydropower makes up 49% of the fuel mix for Avista Corporation (Avista, 2020). Almost all these service providers rely on a fuel mix where hydropower is about forty percent of the fuel mix. Overall, hydropower is an important part of the fuel mix in both Washington and Idaho.

4.0 Analysis Methods

4.1 Resilience Analysis Methods

Idaho National Lab's (INL) All Hazards Analysis (AHA) program was used to determine the impacts of different dam failures/closures on the south-eastern Washington's and north-western Idaho's energy infrastructure. The AHA model was built using open source data from the Homeland Infrastructure Foundation-Level Data (Department of Homeland Security, 2020) and the National Pipeline Mapping System (United State Department of Transportation, 2020). Data for power plants, electrical substations, natural gas pipelines, college campuses, and hospitals were all added to the AHA model. The AHA tool can run "simple simulations" that account for a single point of failure in the system. The AHA tool then reports back what systems are impacted as a result of the point failure. As a result, this report will focus on the failure of individual dams to see if there are any insights on what could be done to make the region more resilient. In addition to the AHA tool, this study also considered the impacts of future developments that have already been planned in the region including coal plant closures and new transmission additions when evaluating the resilience of the region.

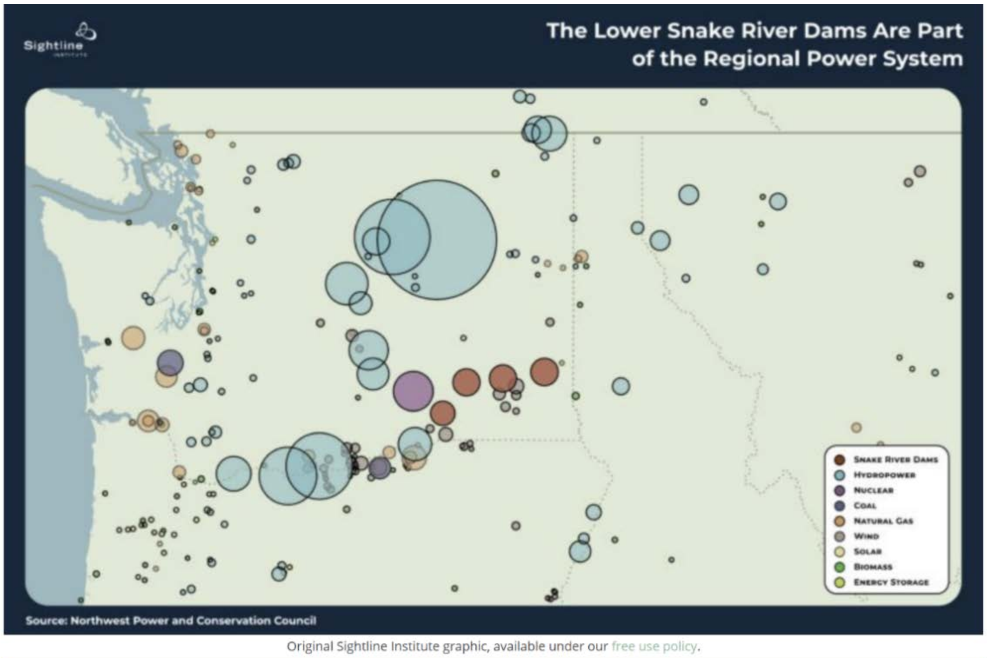

Figure 1: Power generation by generation type. From Snake River Dams Hydropower is no Longer Particularly Cheap, by Daniel Malarkey, Copyright 2019 Sightline Institution; used with permission

4.2 Environmental Analysis

4.2.1 Greenhouse Gas Emissions

GHG emissions were qualitatively and quantitatively calculated in this analysis. To estimate the new power demand in the region due to population growth, this study assumed the same population growth rates as seen from 2010-2020 (13.2% Washington and 14% Idaho). We also assumed that every resident would use 10.972 MWh/year (EIA, 2019). We then compared how many LSR Dams that would need to be added to the region to make up for this energy consumption without any improvements in efficiency and demand response measures. Tables 1 & 2 show the results for Washington and Idaho, respectively. This shows that the capacity of over 3 LSR Dams will be needed to keep up with energy demand in the region. This is a worst-case scenario however because there certainly will be advancements in efficiency and demand response that will make the resources we currently have better utilized. If the region requires all the new energy, Table 3 shows the added carbon emissions to the region given different natural gas strategies. By adding a 100% natural gas strategy, the region would add over 12 metric tons on CO_2 to the region. This level of emissions is approximately equivalent to the emissions of 6 – 518 MW Boardman Coal Power Plants. Equation 1 shows the calculations used determine new carbon emissions by adding natural gas power.

$$D_{NG} = 0.417312(E_{added}) \quad (1)$$

Where D_{NG} is the metric tons of CO_2 added to the atmosphere, and E_{added} is the energy capacity added in MWh (EIA, 2020).

Table 1. New power requirements assuming same 10-year growth as seen from 2010-2020.

Washington

Year	Population (million)	Energy Added Annually (MWh/year)	Energy Added Per Day (MWh/day)	# of LSRD Needed (24,500 MWh/day)
2020	7.61	0	0	0
2030	8.62	10,964,068.63	30,038.54	1.23
2040	9.76	12,411,325.69	34,003.63	1.39

Table 2. New power requirements assuming same 10-year growth as seen from 2010-2020.

Idaho

Year	Population (Million)	Energy Added Annually (MWh/year)	Energy Added Per Day (MWh/day)	# of LSRD Needed (24,500 MWh/day)
2020	1.79	0	0	0
2030	2.04	2,729,213.62	7,477.30	0.31
2040	2.32	3,111,303.53	8,524.12	0.35

Table 3. New carbon emissions for different energy profile implementations assuming same 10-year growth as seen from 2010-2020.

Million Metric Tons CO_2 Emissions Added Per Year

Strategy	Washington	Idaho
25% Natural Gas	2.439	0.609
50% Natural Gas	4.877	1.219
75% Natural Gas	7.316	1.828
100% Natural Gas	9.755	2.437

4.2.2 Fish Population

We looked at the fish data published from the Corps (Figure 2) over the last few years along with water temperature at the Pasco, WA bridge past the Columbia River Generating Station and before the Ice Harbor Lock and Dam (Figure 3). This shows that the fish population within the last 10 years has seen a decline. The decline in fish number has led Bonneville Power Administration to implement fish mitigation projects such as protecting tributary flows, adding fish screens, opening access to fish habitat, improving riparian habitat and more (BPA , 2019). The water temperatures are concerning given that the Columbia River System Operator's Environmental Protection Statement stated that "Elevated water temperature, above state water quality criteria of 20℃ (68℉), within much of the Columbia and Snake Rivers is a concern" (Corps, Reclamation, & BPA, 2020). It should be noted that the years of 2015, 2016, and 2017 were the hottest years on record (may have helped cause decrease in salmon population) (Army Corps of Engineers, 2020).

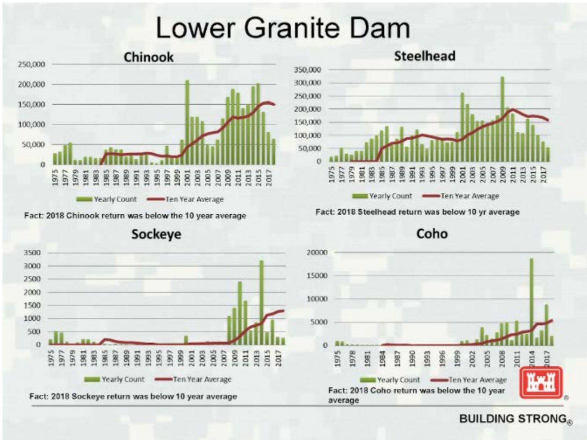

Figure 2: Fish populations recorded at the Lower Granite River Dam.

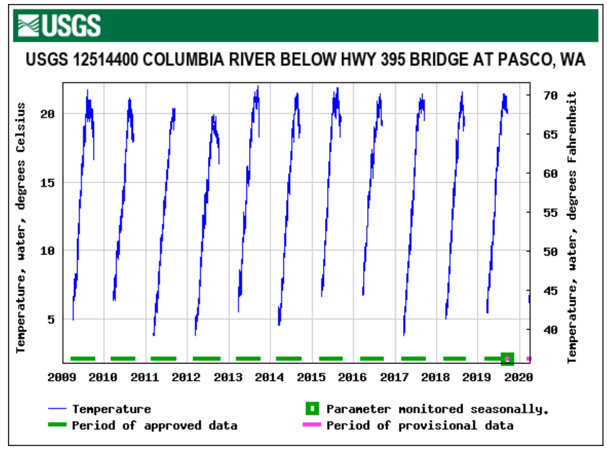

Figure 3. Water temperatures in the past the Columbia Generation Station.

Currently, the Bureau of Reclamation has a large fish passage project at the Cle Elum Dam. This project could be considered as a potential fish passage solution. When the project is finished there will be juvenile passage at the dam as well as trap and haul procedures established (BOR, 2018). Reintroduction of fish will also take place in order to boost the rate at which the fish will reproduce (BOR, 2018). This could be a project to look to in the future once it is completed. Even though, this is not the focus of this paper it is still valuable to mention the possibility of fish passage and subject matter experts can look to these other projects that have been implemented for effective and efficient implementation at the four Lower Snake River Dams.

5.0 Regional Preparedness to Disruptions

5.1 2028 Energy Contract

One of the largest and most commonly discussed issues with resiliency in the energy sector in Washington and Idaho is the discussion of Bonneville Power Administration's (BPA) contract with their buyers. This contract is set to expire in 2028 and with that the current buyers can decide to not renew their contracts with BPA (Karier, 2019). They might decide to not renew their contract if the wholesale power costs from BPA are more expensive than the cost of other electricity sources (Karier, 2019).

There are multiple reasons for why the wholesale rates for BPA would be more expensive than other sources of electricity. BPA currently has a high ratio of debt that needs to be paid down by 2028 to help reduce the cost of their electricity (Karier, 2019). BPA must also invest in the environmental component of hydropower generation (Karier, 2019). This costs BPA a lot of money to implement and they have spent $8.5 billion over the last 30 years for their salmon program (Karier, 2019).

Another critique of these dams is the cost of operations and maintenance of the dams. In fiscal year 2020 the Army of Corps of Engineers requested a total of $17,704,000 for the operation and maintenance of the four Lower Snake River dams (USACE, 2019). A majority of this, $10,314,000 or about 58%, of the request is for maintenance of the dams (USACE, 2019). Ice Harbor Lock and Dam has the largest budget request at a total of $7,003,000 (USACE, 2019).

If BPA is unable to reduce their costs or they are unable to reduce their debt to asset ratio it is thought that their customers may not want to renew their contracts (Kearier, 2019). This would create a situation where BPA would have to look for new customers to sign contracts. This could be difficult if the costs for BPA's wholesale power is not less than the competitors' prices.

5.2 Case I: Dam Failure

5.2.1 AHA Analysis:

Each of the four Lower Snake River dams have been listed as significant hazard dams (USACE, 2018). The Army Corps of Engineers defines significant hazard as "no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns" (USACE, 2018). These dams are close to cities such as Walla Walla, Pasco, and could affect Lewiston as well. If Ice Harbor would fail then it would have the greatest effect on Walla Walla, WA as evident in figure 4. Looking at the AHA results in figure 4 this failure would affect Lewiston as well. Figure 5 shows the hospitals that would be affected by a failure of Ice Harbor. Failure of Lower Monumental dam (Figure 6) would result in the Columbia Generating Station being affected. This is one of the main generating stations in the Pacific Northwest. If one of the dams were to fail there would need to be an additional 280 average MW come online if the dam's generation was being utilized at the time of the failure (EcoNorthwest, 2019). If there was a total failure of this dam, there would need to be a more permanent solution for the additional 280 average MW to come online. AHA results are not shown for Lower Granite and Little Goose because AHA gave the same results as shown in Figure 6 for the Lower Monumental Dam.

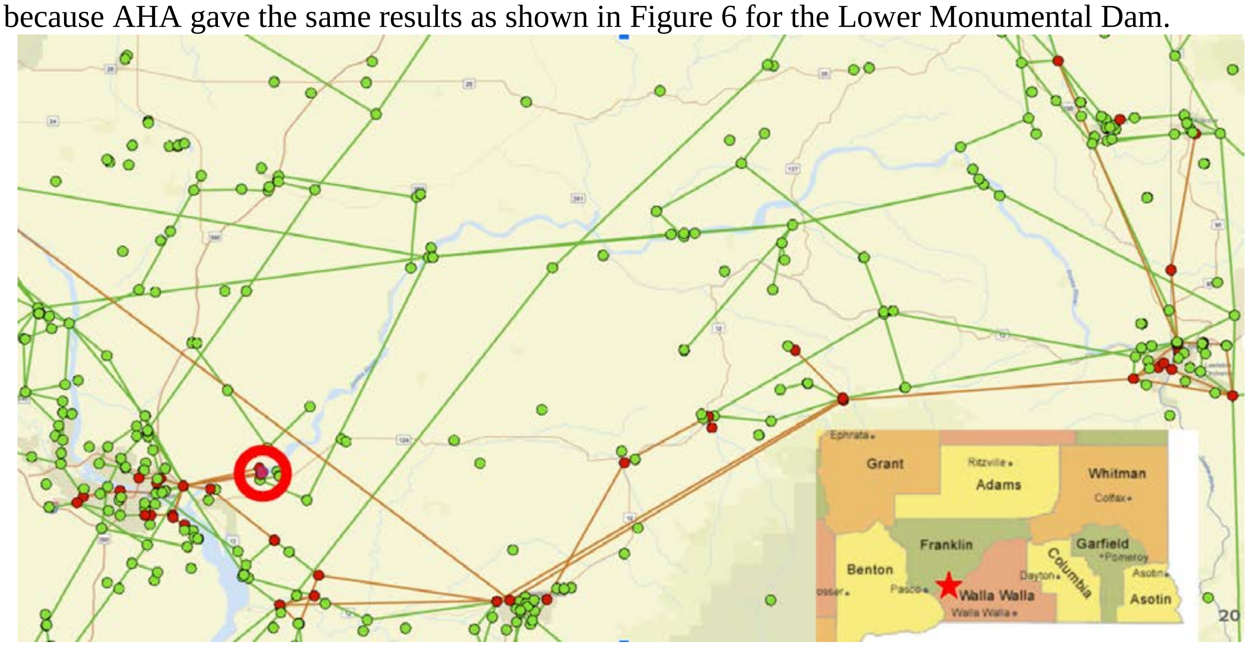

Figure 4: Ice Harbor Dam Failure

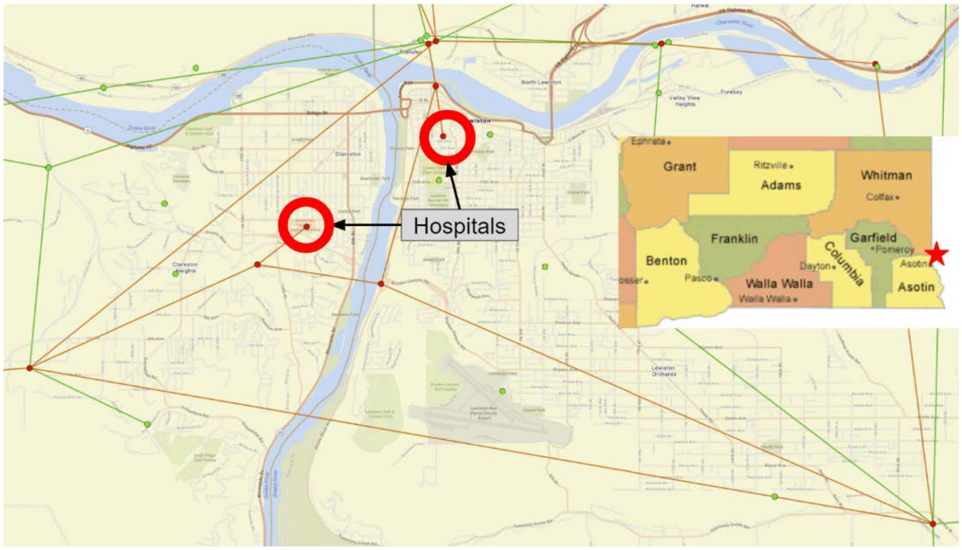

Figure 5: Ice Harbor Failure Effect on Hospitals in Lewiston

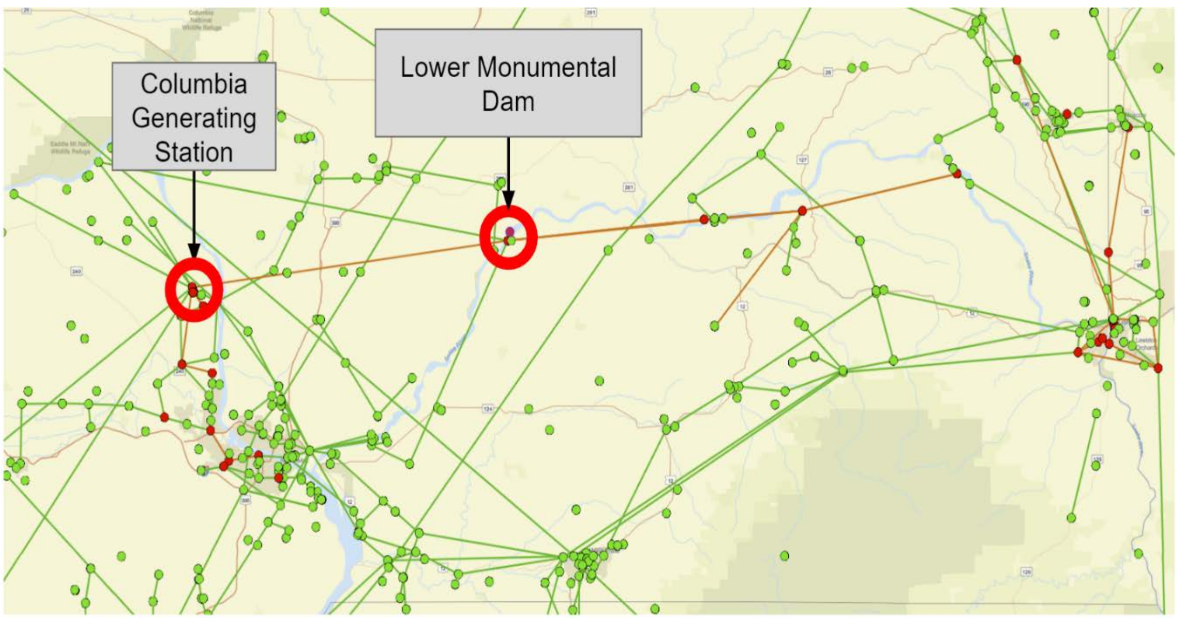

Figure 6: Lower Monumental Dam Failure

<u>5.3 Case II: Lower Snake River Dam Closures</u>

5.3.1 Energy System Resilience Analysis:

If all four of the Lower Snake River dams were removed there would need to be an equivalent 1,024 average MW generated by another fuel source (EcoNorthwest, 2019). The fuel source that would likely be turned to is natural gas (EcoNorthwest, 2019). If this was fully replaced with natural gas this could result in up to 12 million metric tons of carbon-dioxide being released into the atmosphere (EPA, 2020). Approximately four million metric tons of carbon-dioxide emissions is equivalent to about one coal powerplant.

The eight largest hydroelectric plants in Washington have a higher capacity than what they generate, which also leaves room for increased generation, instead of having to replace generation with natural gas (EIA, 2018). If the plants were to generate 24/7 throughout the whole year, the largest hydropower plants could generate 136,699,800 MWh (EIA, 2018). Currently the plants generate 60,852,493 MWh (EIA, 2018). Even if the plants were only able to generate fifty percent of the year, the largest hydropower plants would generate 68,349,900 MWh which is still almost 7.5 million MWh more than the current generation. This is only plants that could generate more electricity in Washington, Idaho also has four plants that have additional capacity.

Idaho's four plants have a total capacity of 14,366,400 MWh (EIA, 2018). Currently these four plants generate 6,003,818 MWh (EIA, 2018). This leaves an additional capacity of 8,362,582 MWh if the plants were able to generate 24/7 all year long (EIA, 2018). These are just some of the hydropower facilities in Idaho. They have some of the highest available capacity.

Removal of the plants is also something to consider on top of the additional carbon-dioxide that would be emitted from the possible generation replacement. Blachly and Uchida did a study in 2017 finding that the average cost of dam removal is $22,331 to $30,620 per vertical foot. Between all four dams there is a total of 692.5 vertical feet (USACE, 2020). This would cost between $15,464,217.50 and $21,204,350.00 for removal of the dams. This would be a one-time cost for the Army Corps of Engineers and the Bonneville Power Administration but results in the loss of their generation.

Another consideration that should be included in the discussion of closing the dams is that the Lower Monumental Dam is one of three power lines that have been connected to the Columbia Generating Station Nuclear facility (See Figure 6). While this study includes no quantitative data on how this would impact the resilience of the nuclear facility, it should be assumed that the nuclear facility would need to upgrade its power options to keep the same amount of reliability.

5.3.2 Special Case – Columbia Generating Station Refueling:

While BPA meets customer demand on most normal days, resilience analysis should include special cases when the grid is not running at full capacity. We will consider when the Columbia Generating Station (CGS) nuclear power plant is being refueled as one special case in this report. The CGS does its refueling every two years during the spring time because that is when river flows are highest, so any lost energy from the nuclear power plant can be accommodated by increased hydropower. Figure 7 shows when the power plant was refueling during spring 2019. Figure 8 illustrates the fact that BPAT has enough energy during the nuclear refuel to offset the generation lost during refuel. The interchange line represents the amount of electricity flowing over the lines during that point in time. This figure also illustrates the fact that BPA can generate enough electricity to meet their demand without the Lower Snake River Dams.

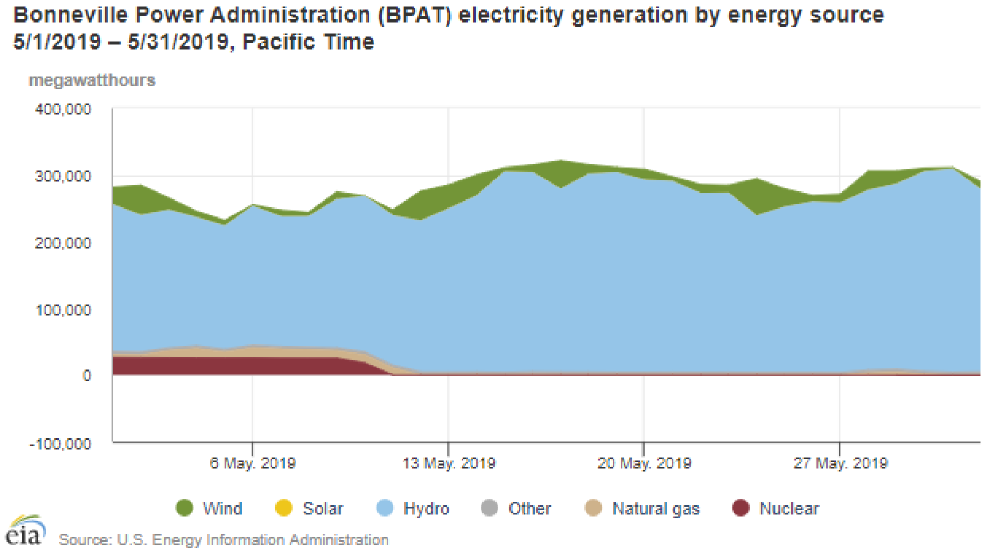

Figure 7. BPA spring power generation during nuclear refuel

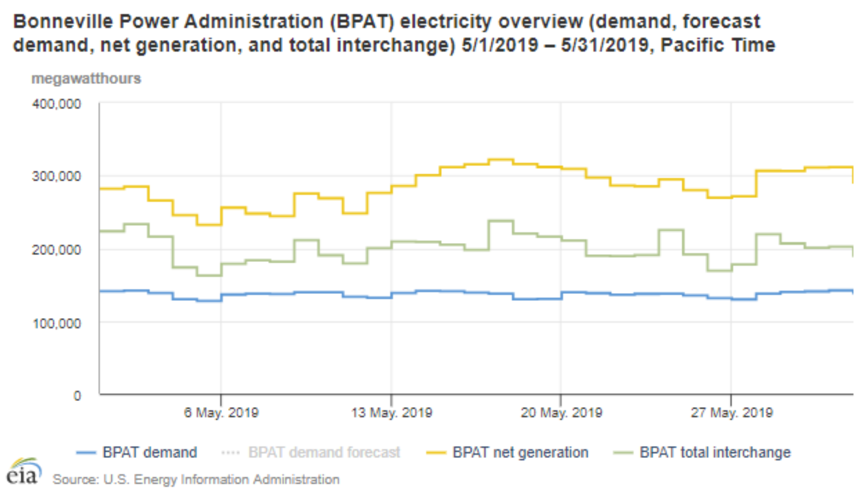

Figure 8. BPA net generation, interchange, and demand during spring 2019 Columbia Generation Station nuclear refuel.

5.4 Future Regional Energy Projects

In order to get a holistic view of whether the dams should be closed, all current and future energy projects should be considered. Some examples include new power transmission lines projects that could give the Washington region more chances to sell clean hydropower energy to other customers across the region. The Washington-Idaho region have many new transmission projects being built in the next few years: 1) Boardman to Hemingway, 2) Gateway West and South, 3) Wallula-McNary, and 4) West of McNary Reinforcement (Big Eddy – Knight). The Boardman to Hemingway project specifically will connect Idaho Power to ~1,000 MW of clean electricity during peak summer loads (B2H, 2020). This project is split between Idaho Power, BPA, and Pacific Power. This new transmission will help Idaho Power's goal to become carbon neutral by

2045 while it also will give BPA more customers for its power. A picture describing the transmission project is shown in Figure 9.

Along with new power transmission, there will be future coal power-plant closures in the region. Table 4 shows a few coal powerplants that have or will close within the next five years. Washington's carbon goals have caused many of these plants to schedule closing. The power provided by these plants will need to be supplements with clean/green energy in the coming years.

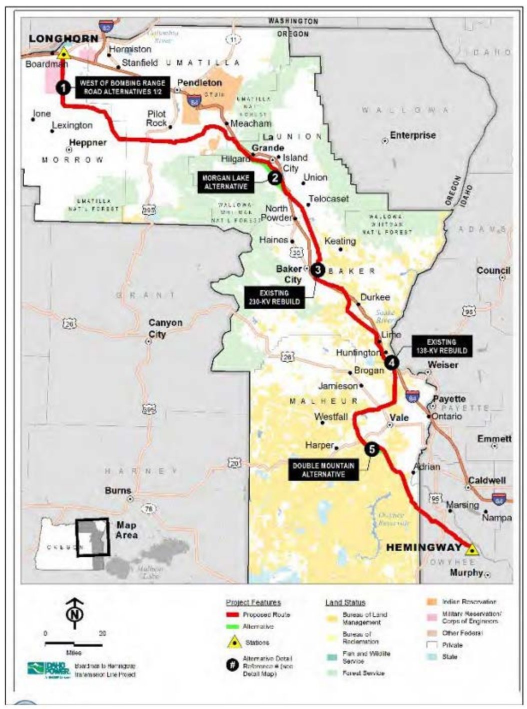

Figure 2: B2H Route Submitted in 2017 EFSC Application for Site Certificate
Source: 2017 Idaho Power Integrated Resource Plan

Figure 9. Broadman to Hemingway Transmission project.

Table 4. Future regional coal power plant closures in the next five years.

Location	Power Generation (MW)	Year
Boardman (OR)	585	2020
Colstrip 1 & 2 (MO)	614	January 5th, 2020
Centralia 1 & 2 (WA)	1,340	2020 & 2024

6.0 Main Players and Others Who Should be Engaged

6.1 Bonneville Power Administration:

Bonneville Power Administration (BPA) is a non-profit federal power marketing administration based in the Pacific Northwest. Figure 10 shows that a majority BPA's power production comes from hydro and nuclear power. Currently, BPA produces more power than their customer base's demand for electricity. As a result, BPA can sell excess power to other states such as California. The prices that BPA receives can be as much as double what they receive for selling power in Washington and Idaho (\$0.16/kWh vs. \$0.08/kWh, respectively). Since Bonneville overproduces some have said that the LSR Dams can be removed and Bonneville can still meet its customer's demands; however, there are more considerations that should be considered including population growth and potential future carbon taxes.

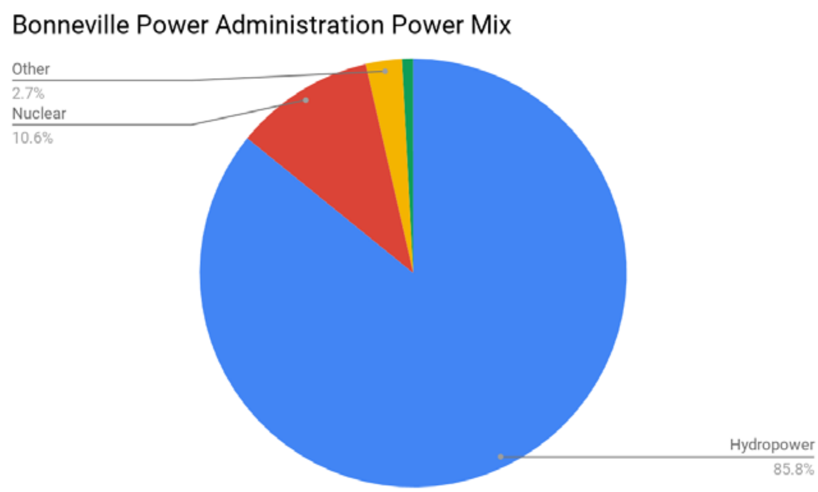

Fig 10. Bonneville Power Administration power mix.

6.2 Army Corp. of Engineers:

The Army Corp. of Engineers own and operate the Lower Snake River Dams. In addition to producing energy for the region, the LSRD transports 40% of the nation's wheat (Army Corps of Engineers, 2020). Approximately 260 people work across the LSR Dam's according to the Corps' website (Army Corps of Engineers, 2020). The ice harbor dam alone transported 2.3 million tons of grains, petroleum products, fertilizer, wood products, and miscellaneous cargo across the dam in 2015 (Army Corps of Engineers, 2020).

7.0 Limits and Remaining Questions

Even though some of the financial figures for BPA and the Army Corps of Engineers are made public, it is difficult to find final expenditures broken out by each facility. Overall figures for operations and maintenance can be found but finding financial information for each specific facility is difficult for the public.

The other limit that we had was finding information about what the wholesale rate for BPA is and who they are selling the electricity to. There are some reports available, but it is jargon laden and difficult to understand when a member of the public is trying to access this information.

8.0 Recommendation

Given the information covered in this report, we suggest the Lower Snake River dams continue to operate while BPA, Corps, and Reclamation continue to implement fish projects on the Lower Snake River dams. Our suggestions come from a resilience perspective that considers not only future energy demand from population growth, but also future regional power plant closures that will occur in the coming years. Additionally, with Washington's goal to produce 100% carbon-free electricity by 2045, it is hard to see the increase in energy demand be met solely by non-hydro renewables and demand response measures. It is our opinion that efficiency and demand response measures along with clean hydropower can be implemented together to reach Washington's clean energy goals.

The Lower Snake River dams may be under-utilized currently; however, increased transmission infrastructure outside of the Washington-Idaho region would allow any excess clean energy to be sold to other areas of the country that do not have access to the same clean energy sources. Removing the dams now may be feasible for the state of Washington, but if California must build a new gas power plant because Washington does not have excess clean energy to sell, is Washington really promoting clean energy? To help the fish populations, the mitigation strategies that have been proven in other BPA and Corps facilities can be applied to the Lower Snake River dams. We have shown that if proper fish mitigation can be performed with the current dam infrastructure, these dams could be run at a higher capacity to produce more energy.

As with any research, results are dependent on the current data available. The value of these dams should continually be assessed, and once the dams reach a point where they are not serving their original intended purpose, removal should be reconsidered.

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