Assessing the Power System Contributions of the Lower Snake River Dams Under Different Potential Future Conditions and Analyzing Options for Replacing these Contributions

This is not intended to be a study of removal of the Lower Snake River Dams, rather it is a study looking at what it would take to replace the power system services provided by these projects. To the extent removal is referenced in this workplan, it is referencing studies done by other entities and is using the language chosen by those studies.

Objective

To analyze the power system impacts of any potential decision that could remove the power system services provided by the Lower Snake River dams (LSRDs) and the requirement for replacement resources that would achieve a similar level of reliability.

That is, this workplan explores the power system with and without the power system outputs of the LSRDs. This is a narrow focus and a small part of the information that would need to be considered by any decision makers determining the future of these dams.

There are two important inherent assumptions in pursuing this study:

1. **It is feasible to operate the power system without the output of the LSRDs.** There are many different power systems throughout the globe. It is not necessary to do detailed modeling to understand it is feasible to replace the output of the LSRDs. That is, it is possible to find a set of replacement resources that would make the system as reliable or more reliable, cost considerations aside. This study would be intended to add insight on different strategies for replacing these power system services and estimate their cost and impact under different future conditions.
2. **As an isolated action, removing the output of the LSRDs from the power system makes it less reliable.** The underlying theory on evaluating reliability on power system implies that when you remove generation from a power system holding all other elements static, the power system becomes less reliable. The only way to offset this is to add new resources back to the power system that would not have otherwise been built. The magnitude of the impact can vary greatly depending on the details of the power system being evaluated, but the direction of the impact is well established by both academic and industry literature. Detailed modeling is not needed to establish this.

The narrow focus requires being careful and clear about where we expect to limit the scope of the analysis:

- **The intent of this analysis is not to determine the outcomes for fish and wildlife**. Understanding the potential for future generation from the dams and the impacts of a system without the dams included requires some level of analysis on likely future considerations to protect fish & wildlife. However, we will not be attempting to identify the biologically best operation nor analyzing the survival conditions for fish under different potential future operations. We will have to make some choices, based on inputs from others, about what fish operations and fish mitigation might look like in the future, with or without the dams, to formulate reasonable non-power constraints for the model.
- **This is not an analysis of the economic viability of the LSRDs.** In looking at the regional power system excluding the LSRDs, we are analyzing what resource strategies get back to a reliable system. The work might provide some incidental insights on the power system value of the LSRDs themselves, but that's not the point and not the analysis.
- **This is not an analysis of the other project/system purposes of the LSRDs**, such as navigation, irrigation, and flood control, and not aimed at providing any information or insights on what it might take to get those back to status quo to the extent those are affected. We will have to make some choices, based on inputs from others, to formulate reasonable non-power constraints for the model, but the intent is again to focus on the impact on power generation.
- **This is not an analysis of different potential retirement schedules.** All analyses will be done with or without all the LSRDs.

Background

The four Lower Snake River dams are Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. Lower Granite, Little Goose and Lower Monumental dams each have a maximum capacity of about 930 megawatts. Ice Harbor's maximum capacity is lower, at about 700 megawatts. The combined maximum capacity of the four dams is about 3,500 megawatts.

In an average water year, the four projects will produce about 931 average megawatts of energy. Lower Granite produces 220 average megawatts; Little Goose produces 244 average megawatts; Lower Monumental produces 265 average megawatts; Ice Harbor produces 202 average megawatts.

These four projects contribute to providing all of the attributes required for the federal system to function as a full-service electrical provider. One of the most important characteristics of the hydroelectric system in the Northwest is its ability to provide large amounts of power for relatively short periods of time. The four dams are connected to the automatic generation control system that regulates electricity generation at each dam, second by second, to keep the system's operating frequency as close to 60 cycles per second as possible. Generation at these dams is also varied, hour by hour, to accommodate the morning and evening swings in demand. During parts of the year, when these projects are not running at full capacity, idle generators are counted as part of the federal system's reserve requirement that provides backup for emergency situations. And, during extremely cold weather conditions, these dams are used in conjunction with water releases from upstream reservoirs to provide additional electrical energy.

There are two recent studies that provide important background information and context. In September of 2020, the U.S. Army Corp of Engineers, Bureau of Reclamation, and Bonneville Power Administration signed a Joint Record of Decision on the Columbia River System Operations

Environmental Impact Statement (CRSO EIS). The CRSO EIS is a broad study, but one element of that study looked at removal of the LSRDs and examined replacement resources. The other recent study that was referenced in the CRSO EIS as well was the Northwest Energy Coalitions Lower Snake River Dam Power Replacement Study (NWEC LSRDPRS).

Study Phases

Phase 1 – Estimate operations of the LSRDs under uncertain future conditions

Previous Study Considerations

- The NWEC LSRDRPS included an appendix examining historic energy and capacity contributions of the LSRDs. The impact of holding reserves was estimated by adding constraints to the hydropower system using the Council's TRAP model for adequacy and using assumptions from the WECC Common Case as implemented in the GridView™ production cost model.
- The CRSO EIS looked at three scenario alternatives based on different levels of coal retirement in the region for the No-Action-Alternative, all the multiple-objection scenarios, and the Preferred Alternative scenario.
- The CRSO EIS includes an appendix that examines hydropower from the federal system under the all the examined alternatives (Appendix J).

Critical Stakeholder Expertise

This phase will depend on feedback from stakeholders who understand the current operational restrictions and potential future operational restriction on the LSRDs. It will also need feedback on the implementation of different potential future conditions in the Council's AURORA and GENESYS models.

Workplan for Phase 1

The 2021 Plan used a transitional setup for GENESYS taking restrictions from HYDSIM. Part of the work needed is to update stakeholders on the model setup that would be more appropriate for analysis on the LSRDs. Looking at characteristics of individual projects is a different proposition than understanding broad regional trends in adequacy. The Council did substantial work exploring the comments and feedback provided on our GENESYS model for the 2021 Plan. While this work did not rise to a level to show meaningful divergence from the regional adequacy outcomes documented in the draft of the 2021 Plan, it can be leveraged for the purposes of this study which require a more granular level of detail. Further vetting of the inputs to the GENESYS model and the associated outputs will be pursued in this phase.

Part of the vetting of the model will be to describe the characteristics of how the Lower Snake River Dams operate in our model under different future conditions/markets. Considerations for this work will be:

- Use the 2021 Plan market price forecast assumptions updated to capture hydro generation's value for meeting clean requirements – while there is no current market mechanism for "clean credits" like renewable energy credits, the plan shows this will be an important constraint for the future power system;
- Run at least 3 operating years with one in the 2020s, one in the 2030s, and one in the 2040s;

- Use select scenarios from the plan – Limited Markets, Early Coal Retirement, Partial Decarbonization, etc.;
- Identify key outputs – generation, spill, reserves, etc. and provide these outputs publicly for vetting.

To close this phase, we will summarize the results in a memo, brief report, and presentation to the Council and provide any supporting Excel workbooks on the website.

Phase 2 – Examine hydro-system impacts at remaining projects after removal of the LSRDs

Previous Study Considerations

- The CRSO EIS in Multiple-Objective 3 (MO3) considered breach of the four LSRDs. In MO3, there were additional operations described at the four Lower Columbia dams, Libby, Grand Coulee, Hungry Horse, and Chief Joseph. Since MO3 was for multiple objectives, it's possible that some of these operations are not related to the breach assumptions and driven by other considerations.
- The CRSO EIS looked at changes in spill priority as a result of breach of the four LSRDs based on a spill priority list excluding the LSRDs for lack-of-market spill. It also had assumptions about changes to the upper-rule curve storage for flood risk management at Grand Coulee and Libby.

Critical Stakeholder Expertise

This phase will depend on feedback from stakeholders that understand comprehensive operational restrictions and fish and wildlife considerations of the hydro system and how they may change in a power system excluding the LSRDs.

Workplan for Phase 2

We will estimate impacts of a system without the LSRDs that could change operational restrictions and thus affect power generation at the remaining hydro projects. This includes consideration of what operations for fish and wildlife would apply to the dams in the system without the LSRDs assessing whether that would be substantially similar or different from the expected operations at those dams with the LSRDs included in the system. For example:

- Will there be changes to operations required on the Lower Columbia dams? Can we still assume that we can meet elevation targets at the lower Columbia dams if the hydrology changes due to removal of the Snake dams?
- Will operations at Grand Coulee need to change? What about rule curves at other storage projects? Will there be impacts from the Columbia River Treaty that changes operations on the Canadian projects that might need to be considered?
- Will there be different operational requirements at the Hells Canyon Complex? It seems possible that alternative operations at some projects will be needed to support the conditions in the section of the Snake River where the dams have been removed. What are likely flow requirements for this reach?

- Will there be different operational requirements at Dworshak? E.g. currently there are releases from Dworshak to provide cold water to Lower Granite Dam – what happens if that requirement changes?
- Is there any potential to increase hydro generation at the remaining project to offset losses from removal of the LSRDs? How will that affect fish constraints?
- Do all these changes work given climate-change-based flows as well as flows based on historic precipitation?
- Any other hydro system changes.

To close this phase, we will summarize the parameter and methodology changes implemented in the models in a memo, brief report, and presentation to the Council and provide supporting Excel workbooks if needed on the website.

Phase 3 – Estimate the incremental reliability needs of a system excluding the LSRDs

Previous Study Considerations

- In the NWEC LSRDPRS, there is an estimate of the impact on adequacy from removing the LSRDs. This is based on a study year 2026 but the study generally was intended to look at replacement of the power within 10 years. This study looked at annual loss-of-load probability (LOLP), annual expected unserved energy (EUE), monthly LOLP, and monthly EUE. The need was estimated by the change in these four metrics when looking at a system with and without the power output of the LSRDs.
- The CRSO EIS included a sensitivity based on MO3 that looked solely at LSRDs breach. It includes the anticipated reduction in generation based on federal average generation and based on generation from the 1937 water year (critical water).
- In the CRSO EIS there was a qualitative assessment of the changes in flexibility to the hydropower system based on the various alternatives.

Critical Stakeholder Expertise

This phase will depend on feedback from stakeholders who understand power system models and different measures of adequacy and reliability. It will be important to get feedback on the change in dispatch of the regional resources in a system excluding the power output of the LSRDs compared to a system that includes the power output of the LSRDs.

Workplan for Phase 3

We will describe incremental need of a system excluding the power system outputs of the LSRDs compared to a system with the LSRDs. This will include consideration of the changed hydro constraints for other projects under different markets/conditions. All other assumptions will align with plan assumptions as described in Phase 1.

To close this phase, we will summarize the results in a memo, brief report, and presentation to the Council and provide any supporting Excel workbooks on the website.

Phase 4 – Identify different resources or combinations of resources to test as strategies for returning the power system to a similar level of reliability

Previous Study Considerations:

- In the NWEC LSRDPRS a range of replacement portfolios were examined. These included a Non-Generating Alternative (NGA) portfolio which used EE, DR, market purchases, and batteries. An NGA plus portfolio which increased the EE in the NGA portfolio. A Balanced Portfolio which included EE, DR, wind generation, and solar generation. A Balanced Portfolio Plus which added more wind and solar to the balanced portfolio. Finally, an All-Gas Portfolio which had combined cycle and reciprocating engines run on natural gas. These portfolios were examined for both cost and greenhouse gas emissions.
- The CRSO EIS looked at replacement based on two portfolios. One included addition of 1120 MW of combustion turbines fired by natural gas. The other looked at adding 1960 MW of solar generation, 980 MW of batteries, and 600 MW of demand response.

Critical Stakeholder Expertise:

This phase will depend on feedback from stakeholders that understand the potential for different generating technologies to provide similar services as the power system services provided by the LSRDs. It will help to feedback from stakeholders that understand power system models and how adding different generating technologies to a modeled system impacts measures of adequacy and reliability.

Workplan for Phase 4

We will, using stakeholder feedback, scope out reasonable portfolios that could augment a system without the LSRDs to get back to a similar level of reliability. To accomplish this, we will need to identify different augmenting portfolios using traditional and emerging generation resources, demand side management options, storage, etc. Some modeling and exploration will likely be needed to create reasonable initial portfolio acquisitions for testing and refining in subsequent phases.

These portfolios should also be constructed with some projection on the impact on system costs from the required capital investment for new resource construction. We would expect options for resources and assumptions regarding resource costs will align or be very similar to the 2021 Plan assumptions.

In addition, it will be important to construct portfolios that are likely to explore a range of outcomes for greenhouse gas emissions.

To close this phase, we will summarize the composition of the portfolios identified and anticipated impacts on system cost and greenhouse gas emissions in a memo, brief report, and presentation to the Council and provide supporting Excel workbooks if needed on the website.

Phase 5 – Estimate the impacts or range of impacts of the region's total power system cost

Previous Study Considerations

- The CRSO EIS estimated a reinforcement project would be needed to maintain reliable load service to the Tri-Cities area if there was a loss of hydropower generation at Ice Harbor Dam.

The estimated cost of reinforcement was approximately $94 million. There were ranges of costs for the EIS alternatives included in the appendix on power and transmission (Appendix H)

- The NWEC LSRDRPS examined the single-year change in system operating costs based on replacement portfolios for business and usual conditions and estimated the impact on residential electric bills.
- The NWEC LSRDRPS included power flow studies looking at stead-state reliability and transient reliability. These studies were completed using heavy-summer and heavy-winter flows for a 2027 power flow case.
- The CRSO EIS included power flow studies based on the WECC 2028 Anchor Data Set (ADS). GridView™ was used for studying transmission congestion under the different alternatives. Powerflow studies were performed for summer conditions using a WECC 2023 summer powerflow case.

Critical Stakeholder Expertise

This phase will depend on feedback from stakeholders who understand changes to the transmission system required by removal of large generating resources and the transmission path rating process. It will also depend on stakeholder feedback on the cost of removal of large generating resources, and the current and future operating and maintenance costs for the LSRDs.

Workplan for Phase 5

We will estimate impacts on the region's total system costs from adding the portfolios identified in phase 4 to a power system excluding the power-related outputs of the LSRDs including:

- Resource costs based on power plan data
- Transmission reinforcement costs (work with Bonneville, Northern Grid, and others)
- Reduction in power-based O&M needed to support the projects
- Etc.

We will also estimate the impacts on power system operations from adding the portfolios identified in phase 4 to a power system excluding the power-related outputs of the LSRDs, for example potential transmission path rating changes.

To close this phase, we will summarize the parameter and methodology changes implemented in the models and provide a synopsis of the total system cost impacts identified in a memo, brief report, and presentation to the Council and provide supporting Excel workbooks if needed on the website.

Phase 6 – Examine the reliability outcomes

Previous Study Considerations

- The NWEC LSRDPRS included annual LOLP, annual EUE, monthly LOLP, and monthly EUE for the portfolios examined.
- The CRSO EIS included annual LOLP under each alternative for different scenarios based on coal retirement and the portfolios examined.

Critical Stakeholder Expertise

This phase will depend on feedback from stakeholders who understand power system models and different measures of adequacy and reliability.

Workplan for Phase 6

We will run analysis with different market scenarios / conditions and different portfolios augmenting a system without the power system outputs of the LSRDs and report on resource adequacy outcomes. The assumptions in the models would generally align with the assumptions used for the 2021 Plan except for the changes identified in phases 1 through 5.

To close this phase, we will summarize the results in a memo and presentation to the Council. We will also review the analytical work from phases 1 to 6 with the Council and get Council member feedback to prepare for phase 7.

Phase 7 – Collect analytical findings into a white paper

Workplan for Phase 7

We will create a consolidated report and capture other considerations as needed. The whitepaper will be sent to the Council for review and release as a draft for public comment. We will consider public comment and consider any revisions needed for finalizing the white paper. The release of the final white paper will conclude the study.