Pacific Northwest Zero-Emitting Resources Study

Executive Summary

January 29, 2020

Energy+Environmental Economics

1.1 Study purpose

The Northwest energy system is undergoing a transition. In 2019, Washington state adopted the Clean Energy Transformation Act, which sets the state on a path to serve 100 percent of retail electric loads with carbon-free electricity. In that context, Energy Northwest retained E3 to investigate the role of zero-emitting resources in meeting the region's future energy needs in a carbon constrained future.

Energy Northwest is a public power joint operating agency created by the Washington state legislature in 1957 and its membership includes 27 public utility districts and municipalities. Energy Northwest's portfolio is comprised solely of carbon-free generating resources, including wind, solar, hydropower and nuclear. The agency owns and operates the Columbia Generating Station (CGS), the only nuclear generator in the Northwest and third largest generating resource in the state of Washington. CGS is licensed to operate through 2043, with the potential for a second 20-year license extension through 2063. Energy Northwest, leveraging its expertise in the nuclear industry, is also exploring a potential role developing small modular nuclear reactors (SMRs) in the region. SMRs are an emerging, technology – with domestic commercial operation planned for the mid-to-late 2020s – that offer potential cost, performance and safety advantages over conventional nuclear generation.

This research focuses on two key questions of interest to Energy Northwest:

- What are optimal electricity resource portfolios to achieve deep carbon emissions reductions in the Pacific Northwest?

- How does the availability of firm zero-emitting generation, including both CGS and SMRs, affect the cost of achieving carbon reduction goals while maintaining a reliable electric system?

The study builds on previous analyses done by E3 in the Northwest, including:

- *Pacific Northwest Low Carbon Scenario Analysis (2017):* This study found that a portfolio of hydro, renewables and natural gas is the least cost strategy to achieve an 80% reduction in electricity sector emissions in the Northwest and that policies that directly target GHG reductions are lower cost than those that rely on renewable-only mandates or bans on gas generation.
- *Pacific Northwest Low Carbon Scenario Analysis: 2018 Scenarios and Sensitivities (2018)*: This study found that the cost of achieving 100% decarbonized electricity in the Northwest is greatly reduced if firm-zero GHG resources like SMRs or biomethane powered gas generators are available.
- *Resource Adequacy in the Pacific Northwest (2019):* This study found that firm generation is required to ensure a reliable system under deep decarbonization. That generation is needed because the marginal capacity contributions of wind, solar and storage decline as their penetrations increase. The study also found that gas is the least cost option to provide firm capacity given existing technologies.

1.2 Approach

This study uses E3's RESOLVE model to optimize the portfolio of resources serving loads in the "Core NW" region (Figure 1). RESOLVE co-optimizes investments and

operations to minimize total NPV of electric system costs over the study time horizon.

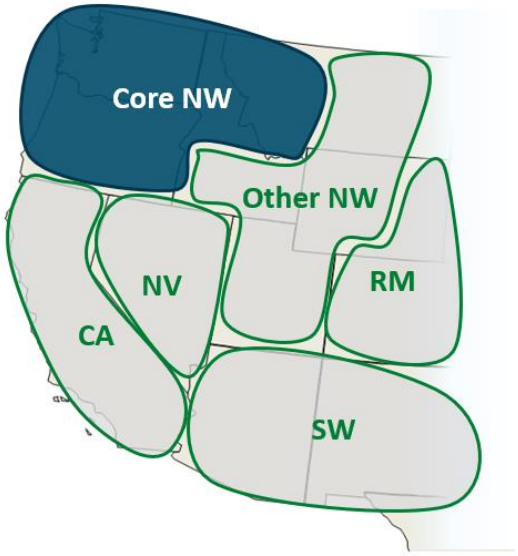

Figure 1: The Core NW Region. RESOLVE simulates electric sector operations across the west and optimizes investments in the Core NW region.

Scenarios in this study are designed to evaluate the implications of resource options for the cost and infrastructure requirements of achieving deep electricity emissions reductions in the Northwest. These resources include energy limited, variable and "firm" zero-emitting resources (Figure 2). Past work by E3 suggests that deep electric sector emissions reductions are possible using largely energy limited or variable resources, provided those resources are backed by firm capacity.

Key resource option scenarios include:

+ Renewables and Gas Available
+ Renewables, CGS Relicensing and Gas Available
+ Renewables, CGS, Gas and Zero-Emitting Firm Available
+ Renewables, CGS and Zero-Emitting Firm Available (No New Gas)

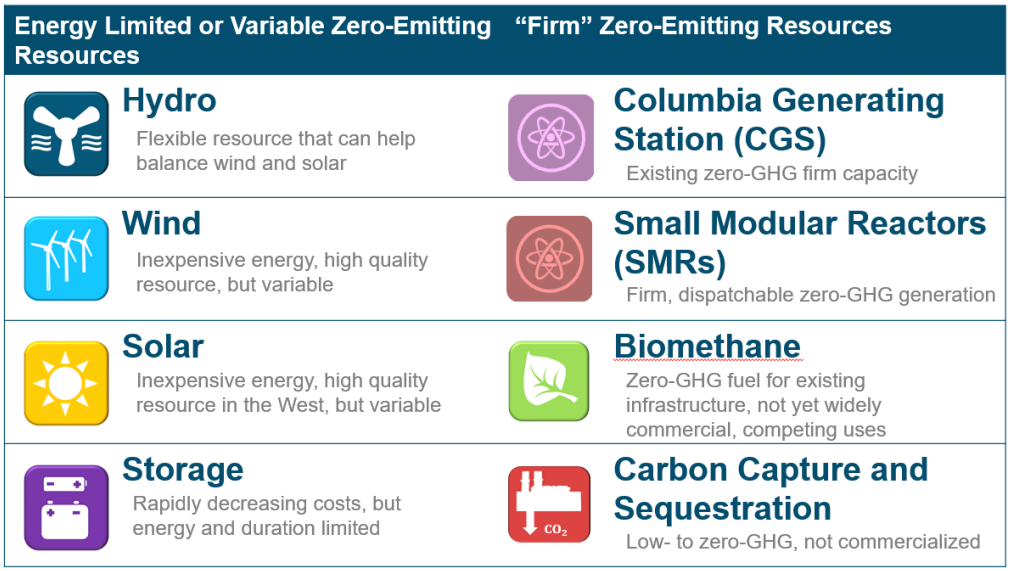

Figure 2: Zero-Emitting Resources in available RESOLVE. RESOLVE also has the option to select fossil generation.

Resource option scenarios are compared against different electric sector emissions reduction scenarios, including 80%, 90%, 95% and 100% below 1990 levels (Figure 3). These scenarios represent different levels of GHG emissions policy ambition for the NW electricity system.

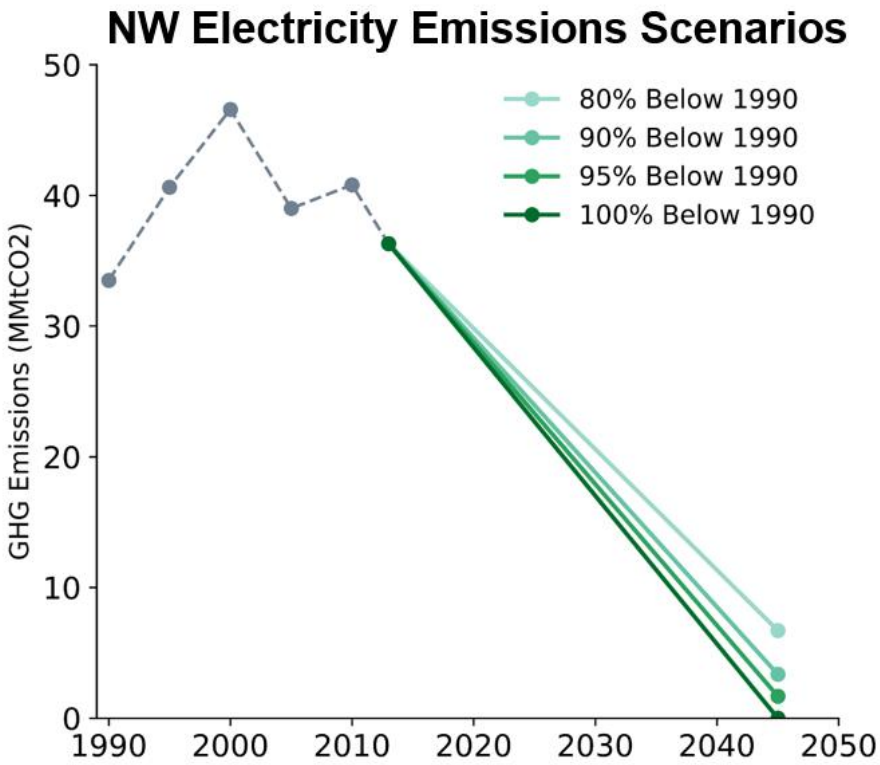

Figure 3: Electric GHG Emissions Scenarios. Past work by E3 suggests that a GHG cap of between 3 and 5 MMtCO2 is needed to achieve an 80% economy-wide emission reduction in Washington and Oregon.

1.3 Key Assumptions

This study updates several resource cost assumptions incorporated in past NW RESOLVE analyses.

1.3.1 RENEWABLES AND STORAGE COSTS

Wind and solar resource costs have been updated to NREL 2019 ATB Mid case assumptions. Battery storage costs are derived from the Lazard LCOS 4.0 report[1].

1.3.2 NUCLEAR COSTS

E3 worked with Energy Northwest to develop resource costs for both the cost of relicensing CGS and building SMRs. E3 used two sources for SMR costs, the NREL ATB Nuclear resource and "nth of a kind" estimates from NuScale, a vendor that designs and markets SMR technologies.

E3 also considered the cost of SMRs after receiving a production tax credit (PTC) as an additional cost sensitivity. Today, an $18/MWh PTC is available for up to 6,000 MW of new nuclear capacity. After accounting for nuclear projects that are under construction or announced, E3 assumed that 3,000 MW of PTC capacity is available to the Northwest region.

1.4 Findings

A key finding of this analysis is that very deep electric emissions reductions in the region can be achieved at manageable costs, provided firm capacity is available. However, the costs of achieving 100% GHG reductions exhibit a marked increase when new firm capacity cannot be built in the region (Figure 4).

[1] The bulk of the analysis done in this report was completed before LCOS 5.0 was released.

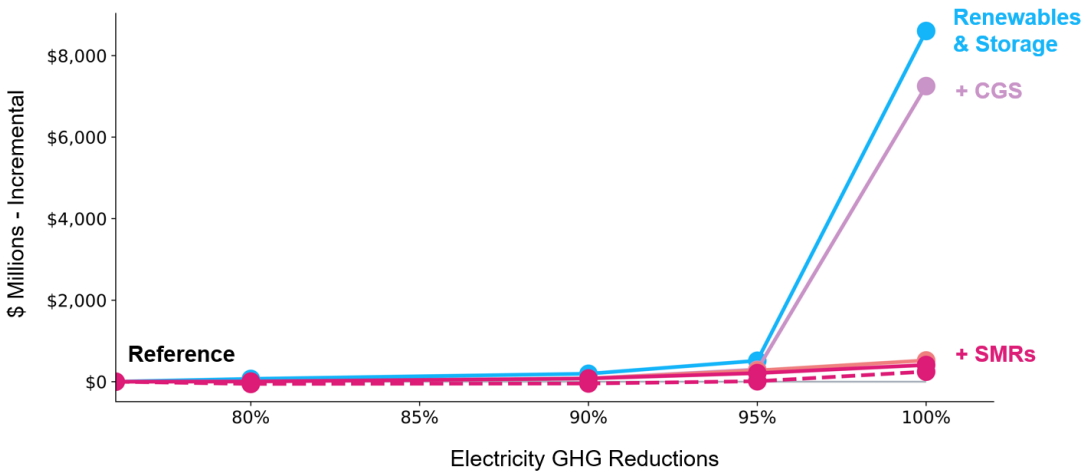

Figure 4: GHG abatement costs. The y-axis represents the incremental cost of each scenario compared to a Reference case that does not apply an emissions constraint.

1.4.1 COLUMBIA GENERATING STATION

CGS is relicensed in all the resource and emissions target scenarios in which it is available. The value of CGS stems from its ability to provide both energy and firm capacity without emitting carbon. The value of CGS ranges from $75 million per year in the 80% GHG reduction scenario to $1.35 billion in the 100% GHG reduction scenario.

1.4.2 SMALL MODULAR REACTORS

The role of SMRs in the Northwest's future electricity system depends on their cost, the stringency of regional emissions limits and the availability of gas generators to provide firm capacity.

- **Base Costs:** At NREL ATB and NuScale costs, SMRs are selected in the 95% and 100% emissions reduction scenarios. In all but one case, the first

SMRs are built in 2045. By 2045, the amount of SMR generation selected by the model under the NuScale cost scenario is about twice that of the amount selected under the NREL cost scenario due to the lower costs projected by NuScale.

- **Production Tax Credit:** When a nuclear production tax credit is available, SMRs are selected in all emissions reduction scenarios and are built earlier, with the first units coming online in 2040.
- **No New Gas**: SMRs have their largest build out in cases where gas generators—powered by either natural gas or biomethane—cannot be built. In these cases, the first SMRs are built by 2030, with at least 6.3 GW of SMRs built by 2045.
- **100% GHG Reduction:** At NuScale costs, SMRs reduce the cost of achieving a 100% electric sector GHG reduction by nearly $8 billion per year). That value stems from those resources' ability to provide firm capacity, thereby avoiding a large overbuild of renewables.

1.5 Scenario Cost Comparison

Scenario costs are summarized in terms of average retail rates in Figure 5. The cost of the scenarios considered in this analysis are similar when natural gas generation capacity can be built. Those scenarios exhibit similar portfolio builds, largely relying on renewables that are backed by rarely used gas generation. If new gas capacity is not available, the costs of decarbonizing the Northwest electricity system increase markedly when only renewables, hydro and storage are available. If zero-GHG firm resources—including CGS, SMRs and biomethane—are available then the services provided by gas generators can be

replaced at reasonable cost. That same finding holds in cases where zero-GHG emissions are allowed in the Northwest electricity system.

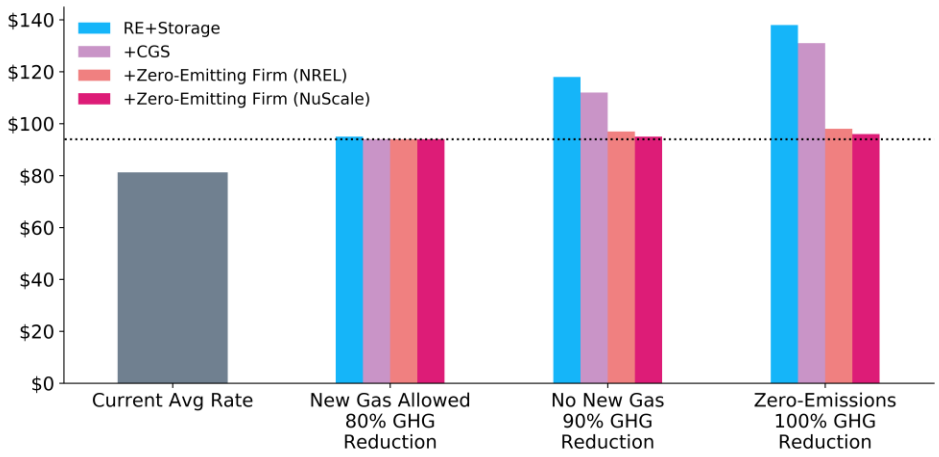

Figure 5: 2045 electricity rates under different scenarios. The y-axis shows the average retail rates for different resource and emissions scenarios. The x-axis shows the current average retail rate in the Northwest and the future rates under scenarios where new gas is allowed, where no new gas is allowed, and where the region achieves 0 GHG emissions.

1.6 Conclusions

Achieving deep decarbonization of the Northwest electricity system can be accomplished at reasonable cost if firm capacity can be built in the region. Columbia Generating Station is relicensed in all scenarios while zero-emitting firm resources like SMRs are most valuable under very tight emissions reductions regimes. In those cases, zero-emitting firm resources provide important reliability services that reduce the cost of achieving deep emissions reductions relative to

scenarios that only rely on renewables and storage. SMRs have their largest role when new gas generators cannot be built or when they are able to receive a nuclear production tax credit. In those cases, SMRs are built in all emissions reduction scenarios.