Rainbow over the Rocky Reach Dam in Washington State. *Photo from Katelynn English, U.S. Department of Energy*

The Role of Hydropower in the Next-Generation Grid

Hydropower can provide a low-carbon source of energy, capacity, and flexibility to the grid. The National Renewable Energy Laboratory's (NREL's) hydropower research covers multiple aspects of grid integration, including hydropower's role in grid planning, operations modeling, and reliability and resilience research.

NREL has the unique ability to assess hydropower's value over a wide variety of industry-vetted scenarios, providing critical predictions about the evolution of the power sector (for example, how much carbon emissions various combinations of energy sources, including hydropower, can cut).

North American Renewable Integration Study

NREL's North American Renewable Integration Study (NARIS) evaluated four scenarios for North American power systems through 2050, focusing on the effects of various renewable technology cost trajectories, emission constraints, demand growth, and outcomes. The multiyear study revealed multiple combinations of electricity generation, transmission, and demand that can result in 80% carbon reduction by 2050.

The NARIS team's hydropower research compared similar scenarios with and without the ability to adjust power output from U.S. and Canadian hydropower generators, showing that annual system costs are $2.3 billion (or 3%) higher without this flexibility. These results help improve the water power industry's understanding of the value of hydropower and pumped storage hydropower in an evolving North American grid.

In 2021, NREL released a U.S. perspective report in coordination with the U.S. Department of Energy and a companion report describing a Canadian perspective in coordination with Natural Resources Canada.

For more information about this research, contact:
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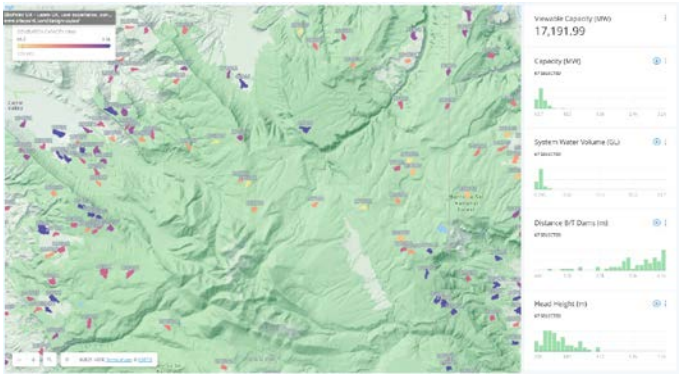
The multiyear North American Renewable Integration Study found that multiple combinations of electricity generation (including by hydropower), transmission, and demand can result in 80% carbon emissions reduction by 2050. *Data visualization courtesy of NREL*

Pumped Storage Hydropower Research

Pumped storage hydropower (PSH) is the largest source of energy storage on the grid today. Its flexibility to respond to various power system demands makes PSH well suited to provide grid reliability and resilience.

PSH systems use two large pools (or reservoirs) of water, one at a higher elevation than the other. When water is released from the upper reservoir and flows down to the lower, it spins a turbine that creates electricity. That electricity is then sent to the grid and on to consumers. When the grid receives excess energy from other sources, like wind and solar, that process is reversed. The excess energy pumps water uphill, where it's stored for later use. NREL's research focuses on closed-loop PSH, which uses reservoirs separated from natural bodies of water. These systems are more environmentally friendly than earlier, open-loop PSH systems, which connected to natural waterways.

In 2021, NREL developed an interactive map and geospatial data that show the quantity, quality, and cost of closed-loop PSH resources in the United States, including Alaska, Hawaii, and Puerto Rico. For this initial dataset, the research team assumed a 10-hour storage duration with dam heights of 40 meters, minimum head height of 300 meters, and maximum distance between upper and lower reservoirs of 4.5 kilometers.



NREL researchers developed an interactive map and geospatial data showing the quantity, quality, and cost of U.S. closed-loop pumped storage hydropower resources. Pumped storage hydropower currently accounts for 95% of U.S. utility-scale energy storage. *Data visualization courtesy of NREL*

The supply curves capture a range of drivers that influence PSH potential and serve as the basis for analysis and modeling applications. Future work will expand the data to include other specifications.

Through this and other research, NREL is helping to optimize both existing and new hydropower facilities by lowering costs, shortening commissioning times, and reducing PSH's environmental footprint.

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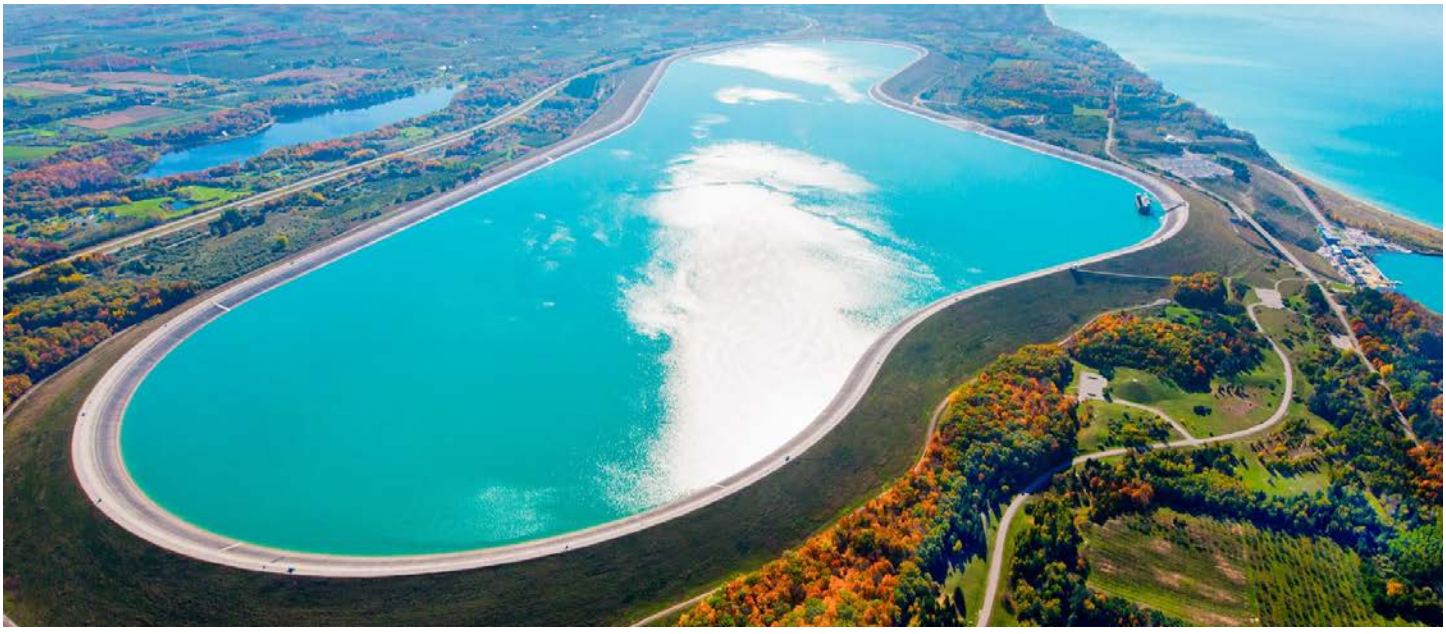

Pumped storage hydropower systems, like the one shown here, provide the largest source of energy storage on the U.S. grid. NREL research is helping to maximize both existing and new hydropower facilities by lowering costs, shortening commissioning times, and reducing environmental impacts. *Photo courtesy of the National Hydropower Association*

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