Refining hydroelectric power for grid resilience with Idaho Falls Power

How a field demonstration with Idaho Falls Power can lead to breakthroughs in hydropower research

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The United States has hundreds of hydroelectric plants on rivers and streams. These hydropower plants house turbines that produce electricity, supplying the nation's grid with roughly 7% of its energy and 22% of its renewable energy. Ideally, power plant outputs can be adjusted to meet the needs of the grid as people use appliances. However, only 3% of dams in the U.S. are equipped for energy production and run-of-river hydropower plants' energy output is dictated by the natural variance in water flow. To mitigate this, Idaho National Laboratory researchers developed a hybrid system that harnesses the power of water and energy storage.

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In the event of a local or regional blackout, "islanding," or supplying power to an area that has been disconnected from the grid, allows hospitals, police and fire stations, and emergency shelters to continue operations. In normal conditions, if a plant's main generators are shut down, they can be restarted by drawing power from the grid. During a wide outage when off-site power is not available, a "black start" can jump-start the local power grid into islanding mode. Until now, small hydroelectric plants provided little support in these events. Instead, many power stations relied on diesel generators for quick startup.

Batteries and ultracapacitors

Looking for a green alternative, INL researchers began studying ultracapacitors – large industrial storage devices that can quickly release electricity on demand. While conventional batteries use chemicals to store larger amounts of power

Idaho National Laboratory

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for extended durations, ultracapacitors store power as static electricity, using insulators to keep positive and negative charges separated. With their higher power density, ultracapacitors can deliver quick bursts of energy and capture excess charge.

Field tests in Idaho

In 2017, INL began working with Idaho Falls Power – a municipal utility that owns five small hydropower plants on the Snake River – on a project for the U.S. Department of Energy's Water Power Technologies Office. Idaho Falls approached INL after a December 2013 blackout left thousands without electricity in subzero cold. To investigate the hydropower plants' capacities for islanding and black starting, Idaho Falls Power and INL used INL's Digital Real-Time Simulation laboratory, with advanced modeling and simulation capabilities that enabled the team to design and validate a system in a controlled environment before testing it in the real world.

With results from the modeling and simulation tests in hand, engineers connected Idaho Falls Power's turbines in different configurations with ultracapacitors at one of its substations in April 2021. For the test, researchers rented two 4-megawatt load banks, external devices that mimic the spikes and dips in operational load during islanded conditions.

The 2021 field demonstration tested three different options for meeting Idaho Falls Power's requirements:

- Innovating small hydropower controls in islanded mode
- Synchronizing multiple power plants on the islanded system
- Integrating an ultracapacitor energy storage system

Two of the city's bulb turbine plants running together were able to carry 8 MW of load, the maximum capacity that could be taken from the rented load bank. A single ultracapacitor energy storage system was able to arrest frequency deviation within the island mode protection settings, allowing the single and multiple hydropower units to support electrical loading at a higher level.

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy.

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