Development and Demonstration of Advanced Tools for Hydropower Plant Optimization

A team from four national laboratories, led by the Environmental Science (EVS) Division at Argonne National Laboratory, will develop and demonstrate a suite of advanced, integrated analytical tools to improve hydropower operational efficiency and environmental performance.

Problem/Opportunity

Environmental and resource constraints have increased the demand for renewable energy supplies; hydropower represents one such energy source that has already been used extensively and offers the benefits of that experience. The major challenge facing hydropower suppliers today is how to operate conventional hydropower plants more efficiently – increasing electricity generation and power sales while dealing with an increasingly uncertain water-constrained operating environment and complex electricity markets.

Approach

Under an award from the U.S. Department of Energy (DOE), Energy Efficiency and Renewable Energy Office's Water Power Program, a team of National Laboratories, led by Argonne National Laboratory, and including Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories will develop and demonstrate a practical suite of advanced integrated analytical tools to (1) improve hydropower operational efficiency and (2) inform environmental performance decisions. The team consists of experts in hydropower systems, grid operations, electricity markets, engineering, computer modeling and simulation, and environmental analysis. The tool set will supplement and enhance currently available tools by providing an evaluation of "best hydropower practices" and integrating water forecasting, reservoir and power system modeling, stream flow routing, ecological simulation algorithms, and hydropower unit performance metrics. Tool set components will be designed to operate individually or as an integrated suite. In addition, the tool set will address a continuum of time horizons — from long-term planning to real-time operations — and will apply to a wide range of hydropower operations and environmental conditions. The team will be guided by a Technical Review Committee, consisting of representatives from key hydropower stakeholders, during all phases of the project — from development through demonstration.

Tool Set Components

Day-ahead Scheduling and Real-time Operations: This component will consist of several algorithms that help day-ahead schedulers and real-time operators increase hydropower efficiency and enhance the value of both power generation and ancillary services. The tool will be capable of simulating a wide range of scheduling and dispatch guidelines at unit, plant, and system levels to meet specific business objectives and practices.

Hydrologic Forecasting: This component will comprise a spatially distributed modeling system that provides sub-daily to seasonal ensemble inflow forecasts to the environmental performance, day-ahead scheduling and real-time operations, and seasonal hydrosystems analysis tools. The

component will reduce forecast uncertainty through the use of remotely sensed spatial data, high-resolution meteorological forecasts, and real-time stream flow updating — allowing for improved system operations by eliminating the need for overly conservative projections of water availability.

Environmental Performance: An environmental performance modeling component will facilitate incorporation of ecological parameters and performance objectives into the day-ahead scheduling and real-time operations and the seasonal hydrosystems analysis tools. Such a component will allow explicit consideration of the effects of operations on sensitive environmental components during scheduling and will allow users to evaluate differences in the environmental performance of various operating scenarios.

Unit and Plant Efficiency: This component will include analytical tools to assess and improve unit performance characteristics for the scheduling and dispatch of hydropower units. It will also assist operators in developing unit performance and system performance metrics that will measure the degree of improvement that results from investment in and implementation of the advanced tools developed for this project.

Seasonal Hydrosystems Analysis: This systems-level simulation and optimization tool will be used to perform tradeoff and scenario analysis of medium- to long-term operations. The tool will allow users to balance seasonal and multi-seasonal forecasts of energy demand and water availability/water demand against power generation capacities, operational constraints, competing water users, and environmental performance. Model outputs will help users ensure that short-term operations are optimal in terms of both power generation and long-term environmental goals. The tool will also identify and prioritize improvements to reservoir operations, physical plant or dam structures, and/or environmental activities that would provide the greatest return on investment.

Goals

The long-term goal is that the tool set will be deployed to assist hydropower operators in market, schedule, dispatch, and operational decisions. The tool set will be demonstrated using data from hydropower sites that are representative of different operational and environmental conditions across the United States. Performance will be assessed and evaluated against baseline operational performance characteristics. Modifications and refinements will be made as necessary to help ensure that the tool set is practical and useful in helping hydropower planners and operators (1) manage the risks associated with hydrological uncertainty and adverse environmental impacts, (2) reduce costs, (3) increase unit availability and plant capacity factors, and (4) enhance the economic value of hydropower resources. The most important goal is to develop tools that end users can — and will — use.

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