Pacific Northwest
NATIONAL LABORATORY

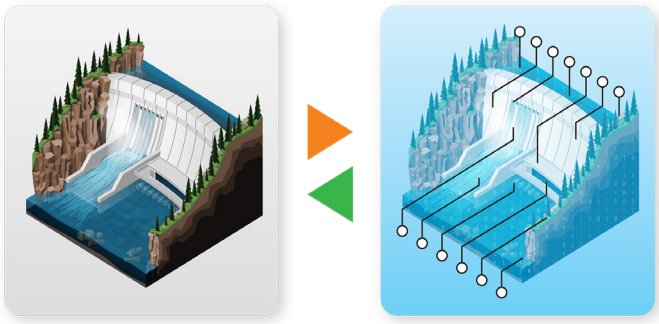
Digital Twins

OPTIMIZING THE PERFORMANCE OF HYDROPOWER FACILITIES

THE CHALLENGE

With an average age of 64 years, the United States hydropower fleet requires smart modernization to reduce costs and enhance the overall reliability and value of the nation's longest-serving renewable energy technology.

As the electric power grid prioritizes reliability and resiliency while valuing an evolving mix of variable renewable energy sources, hydropower technology requires integrating control systems, analytics, simulation, and optimization to remain competitive.



Digital Twins address challenges by creating digital profiles of historical and current hydropower plants based on virtual and real-time data and feedback to optimize hydropower operations. (Graphic by Chris DeGraaf | Pacific Northwest National Laboratory)

THE SOLUTION

A Digital Twin (DT) is a virtual representation of a physical entity created using various data sources like sensors, simulations, and data.

Sponsored by the Water Power Technologies Office, Pacific Northwest National Laboratory (PNNL), and Oak Ridge National Laboratory (ORNL), the launch of DTs for hydropower will affordably modernize the nation's hydropower plant fleet.

- **Digital Representation:** A virtual model of a hydropower facility is created using data collected from sensors, devices, historical data, maintenance records, and other sources.
- **Data Integration:** Data from sensors, devices, and other sources are used to update and maintain a DT's accuracy and relevance.
- **Analytics and Simulation:** A DT can run simulations and perform analytics to predict behavior, test changes, and optimize performance.
- **Communication:** Information flows between a DT and the physical object it models through sensors and other data connections.

NEXT-GENERATION HYDROPOWER

DTs play a significant role in optimizing hydropower facilities' operation, maintenance, and overall performance.

- **Performance Monitoring and Analysis:** Analyzing real-time data allows operators to monitor a facility's performance and identify deviations from optimal operating conditions.
- **Predictive Maintenance:** DTs predict equipment failures and maintenance needs by analyzing historical and real-time sensor data, enabling maintenance activities at the right time, reducing downtime, and avoiding costly unplanned outages.
- **Optimizing Energy Production:** By analyzing data and simulating different operating conditions, operators can identify ways to optimize energy production, such as adjusting turbine settings, managing water reservoir levels, and coordinating energy generation with demand fluctuations.
- **Resource Management and Environmental Impact Assessment:** DTs manage water resources more efficiently by modeling water inflows, reservoir levels, and environmental factors. This aids in minimizing water usage and the potential effects of different operational strategies on the environment, helping operators make informed decisions that minimize negative impacts.

CASE STUDY

The Alder Hydroelectric Development is a part of the Nisqually Hydroelectric Project located on the Nisqually River in Washington State. It is owned and operated by the City of Tacoma's Public Utilities Department and is a significant component of the Nisqually River Hydroelectric Project.

The Alder Dam was completed in 1945. It rises 330 ft above bedrock, stretching 1,600 feet. The two 25,000-kilowatt turbine generators in its powerhouse produce clean renewable hydroelectric energy to serve approximately 18,000 homes per year.

The DT project led by PNNL and ORNL worked with Tacoma Power to collect data about water levels, flow rates, and other important parameters to train a DT, which was then trained, modeled, and validated against real data.

The goal of this project is for operators to monitor the performance of the facility and identify any deviations from the optimal operating conditions. DTs are capable of simulating events and conditions, predicting maintenance and repairs, and reviewing outcomes using the DT dashboard.

To learn more and access the Digital Twin dashboard, scan the QR code or visit hydro.digitaltwin.labworks.org

For more information, email the team at digitaltwinhydro@pnnl.gov

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