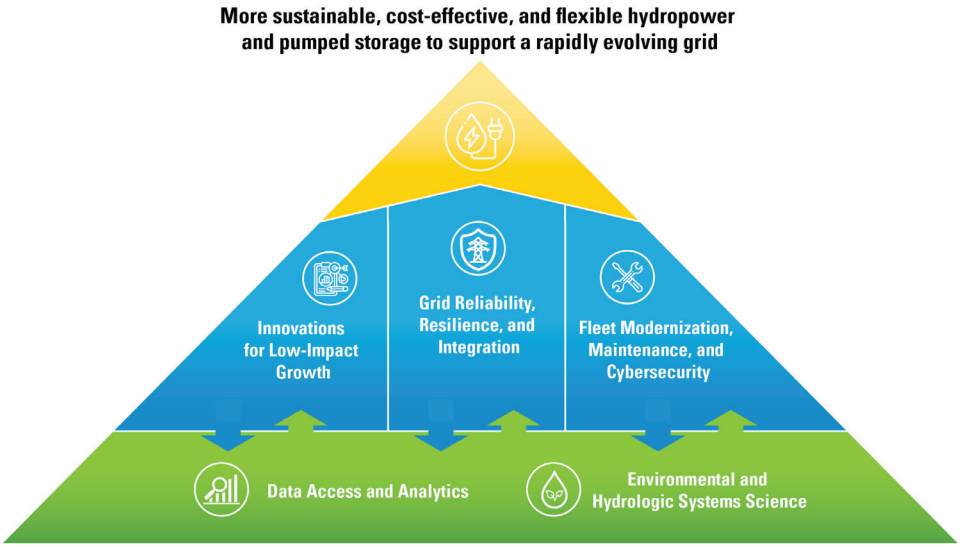
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Hydropower Program's 2019–2020 Accomplishments Overview



WPTO Hydropower Program Strategic Organization. *Source: Water Power Technologies Office*

The Water Power Technologies Office's (WPTO) Hydropower Program conducts early-stage research and development (R&D) and applied science to advance transformative, cost-effective, reliable, and environmentally sustainable hydropower and pumped-storage hydropower (PSH) technologies; better understand and capitalize upon opportunities for these technologies to support the nation's rapidly evolving grid; and improve energy-water infrastructure and security. The vision of the Hydropower Program is a U.S. hydropower and PSH industry that modernizes and safely maintains existing assets; responsibly develops new low-impact hydropower; promotes environmental sustainability; and supports grid reliability, integration of other energy resources, and energy-water systems resilience.

This document highlights recent Hydropower Program successes, organized by activity area, from 2019–2020. To learn more about these projects and their accomplishments, please see the full WPTO 2019–2020 Accomplishments report[1]. For more information on WPTO's Hydropower Program, visit the WPTO website[2] and subscribe to the office's Water Wire newsletter[3].

Activity Areas Overview

The Hydropower Program comprises five R&D activity areas that represent the program's strategic approaches to addressing the challenges faced by U.S. hydropower stakeholders.

Grid Reliability, Resilience, and Integration (HydroWIRES): Understand, enable, and improve hydropower and PSH's contributions to reliability, resilience, and integration in a rapidly evolving electricity system.

Environmental and Hydrologic Systems Science: Research and develop new technologies to better characterize river systems and evaluate potential impacts; avoid, minimize, or mitigate environmental impacts; and improve understanding of various hydrologic risks and uncertainty.

Fleet Modernization, Maintenance, and Cybersecurity: Develop digitalization, maintenance, and cybersecurity tools and capabilities to enable data-driven decision making, improve system reliability, and reduce costs; enhance infrastructure security.

Data Access and Analytics: Improve access to relevant hydropower, river, and water information—including hydropower educational and training materials—and develop analytical tools to explore opportunities and weigh potential trade-offs across multiple objectives at basin-scales.

Innovations for Low-Impact Hydropower Growth: Support new, low-impact hydropower development by advancing design and testing of standard modular hydropower technologies for both existing water infrastructure and new stream-reach developments, while also leveraging advancements in manufacturing and materials for reduced costs.

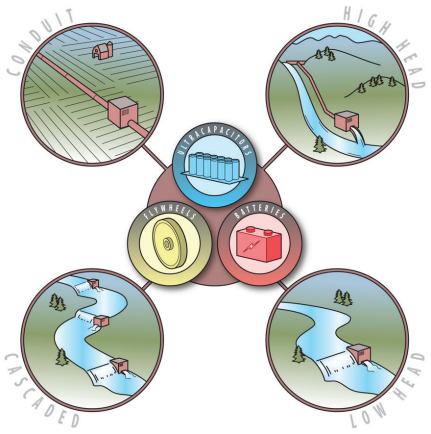
[1]https://www.energy.gov/eere/water/water-power-technologies-office-accomplishments-2020
[2]https://www.energy.gov/eere/water/hydropower-program
[3]https://www.energy.gov/eere/water/water-wire

PROJECT HIGHLIGHTS

Grid Reliability, Resilience, and Integration

Integration of Run-of-River Hydropower with Energy Storage Creates Additional Grid Value, New Market Participation Opportunities:

Throughout 2019–2020, Idaho National Laboratory collaborated with Argonne National Laboratory and the National Renewable Energy Laboratory (NREL) to demonstrate the technical potential and economic benefit of integrating multiple run-of-river plants with energy storage. These hybrid systems utilize new hardware, software, and communication approaches, and function similarly to conventional reservoir-based hydropower plants, opening the door for new markets for run-of-river participation.



Concept design of INL's Integrated project. *Source: Idaho National Laboratory*

Halving the Commissioning Timeline for PSH Development, FAST Prize Successfully Produces Promising Technical Solutions:

In October 2019, WPTO selected four grand prize winners for the Furthering Advancements to Shorten Time (FAST) Commissioning for PSH Prize. Winning ideas ranged from modular steel dam concepts that could cut down on construction schedules, to tunnel-boring machines for more affordable underground excavation, and closed-loop, scalable PSH systems adaptable to sites without natural bodies of water. Winners received cash prizes and vouchers to work with national labs to further advance their concepts and prepare them for market.

HydroWIRES—New Hydropower and Grid-Focused Initiative Produces New System Designs, Prize Results, Analyses, and Specialized Technical Assistance:

Rapid changes in the U.S. electricity system, including changes in the generation mix as well as markets and policy, have created new needs for grid services that hydropower and PSH are inherently well-suited to provide. In response to these opportunities, WPTO recently launched HydroWIRES (Water Innovation for a Resilient Electricity System)—a comprehensive new initiative designed to investigate evolving value streams, operational strategies, and innovative technology solutions that could enable new roles and uses for hydropower and PSH—and is supporting this endeavor with a variety of funding mechanisms.

Low-Cost, Modular Pumped-Storage That Can Be Installed Anywhere—ORNL GLIDES Project Nears Commercial Readiness:

The Ground-Level Integrated Diverse Energy Storage (GLIDES) project, led by Oak Ridge National Laboratory (ORNL), concluded initial phases of R&D on a new form of PSH with promising estimated returns on investment for future commercial projects. Designed to fill the gap between small-scale battery and large grid-scale PSH options, the system stores electricity mechanically in the form of compressed gas that displaces water in high-pressure vessels. ORNL completed simulation and initial physical testing of the GLIDES system to verify its viability as a storage option in both utility and behind-the-meter applications, and analyzed the technology's ability to provide essential reliability services across diverse U.S. electricity markets.

New Pumped-Storage System Could Significantly Reduce Geologic Risk and Increase Market Viability:

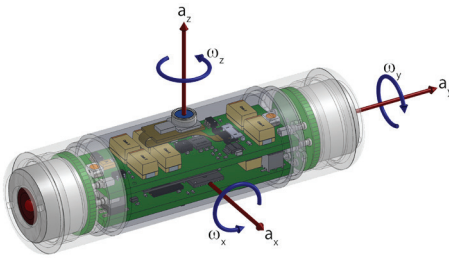
Obermeyer Hydro's novel PSH configuration eliminates the need for an underground powerhouse, one of the more costly, risky, and environmentally impactful aspects of PSH construction. Obermeyer and project partners NREL, Microtunneling, Inc., and Small Hydro Consulting demonstrated that this system would reduce construction costs, decrease environmental impacts, and increase the number of potentially viable sites for PSH.

Lower Environmental Impacts for Closed-Loop Pumped-Storage—New National Lab Study Published:

While PSH constitutes approximately 95% of existing U.S. utility-scale energy storage and there are dozens of new projects being considered, lack of clarity around environmental impacts of new developments remains a challenge. Newer closed-loop configurations, which are not connected to natural water bodies, offer the potential for new projects to have significantly lower impacts than traditional open-loop configurations. A newly published research study from Pacific Northwest National Laboratory (PNNL) comprehensively reviews the wide range of potential issues, while also describing how impacts can be avoided, minimized, or mitigated.

Environmental and Hydrologic Systems Science

National Labs Commercialize Proven Environmental Evaluation Tools for Industry Use: WPTO's HydroPASSAGE project, a multiyear R&D collaboration between PNNL and ORNL, successfully tested, licensed, and commercialized toolsets that can be used to reduce fish injury and mortality, as well as lower the costs of licensing and operations. A key output under the HydroPASSAGE portfolio was the application of the Sensor Fish, a small, autonomous instrument filled with sensors that analyze the physical stresses fish may experience when passing through or around dams. New and improved Sensor Fish were successfully deployed during two separate field tests and licensed to the wildlife radio telemetry company Advanced Telemetry Systems.



Three-dimensional (3D) model of the Sensor Fish device. *Source: PNNL*

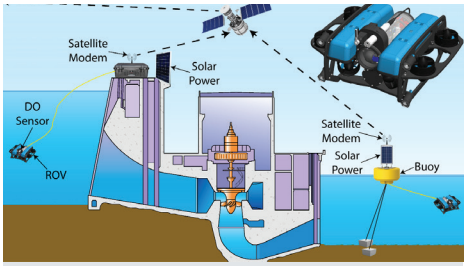
Industry-Led Research Provides Accurate, Artificial Intelligence-Based Approach for Analysis of Sensitive Species Passing Through or Around Dams: The Electric Power Research Institute (EPRI) has successfully automated identification processes for young American eel tracked with multi-beam sonar. This breakthrough may help solve a key industry-wide barrier to improving fish passage outcomes for this important species. Applying artificial intelligence techniques, EPRI was able to automate time-consuming processes for eel identification with greater than 98% accuracy in laboratory-based testing and almost 90% in field testing, results that are comparable to the classification accuracy achieved by human analysts.

Smallest-Ever Acoustic Transmitter with Advanced Battery Improves Juvenile Fish Tracking and Analysis: PNNL has completed development of new, miniaturized fish tags, which are able to be quickly injected, even into tiny juvenile eel and lamprey. The tags are based on the Juvenile Salmon Acoustic Telemetry System technology, originally developed a decade ago with funding from both the U.S. Department of Energy (DOE) and the U.S. Army Corps of Engineers. Field tests for the new tags show almost a 100% detection rate. Once commercialized, they can be critical tools for tracking the upstream and downstream movements of a broad range of small species or the juvenile life stages for larger species that were not able to be tracked previously.

Innovators Offer New Solutions for Protecting Fish via Collaborative Interagency Prize: In 2020, WPTO and the U.S. Bureau of Reclamation selected three winners for the Fish Protection Prize, a competition designed to inspire innovators to help keep fish away from water diversions and intakes. Winning competitors were awarded funds to continue developing their technologies, which included an efficient new bar shape for fish exclusion screens inspired by filter-feeding fish; the use of acoustically sensitive materials in fish diversion systems to facilitate easier inspection; and a physical or combined physical/electrical device designed to guide fish to the safest path through a hydropower intake or water diversion.

The Fish Protection Prize inspired innovators to develop solutions to improve fish protection, or exclusion, technologies, like the fish guidance netting system designed for cost-effective maintenance and sustainability. *Source: Nicholas LaBry's Team, 2nd place grand prize winners, Fish Protection Prize*

Public-Private Partnership, New Autonomous Dissolved Oxygen Sensor Enables Hydro Plant's Improved Energy Generation and Water Quality: In late 2019, PNNL's new autonomous, mobile, water quality sensor platform was field-tested for the first time. This new sensor package enables safer, timelier, and more comprehensive water-quality data collection around hydropower plants—meeting the practical monitoring needs of dam owners and operators, while the critical data it collects supports the development of more accurate, predictive, real-time modeling. The technology was put into practice at a hydro facility in North Carolina, where the system monitored the performance of a newly installed aerating turbine.



The autonomous water quality monitoring system increases the reliability of water quality data collection around hydropower facilities. The data are collected via a robot, to be retrieved anywhere with an internet connection. *Source: PNNL*

Fleet Modernization, Maintenance, and Cyber Security

New Techniques Demonstrate Significant Reductions in Cavitation, Critical for Extending the Service Life of Hydropower Components: In 2019, PNNL completed a series of lab tests and successfully identified techniques to reduce cavitation erosion, a critical step toward enhancing the performance and service life of new and repaired hydropower components. The project's next stage focuses on advancing cold spray technologies, identified as the best method for on-site cavitation repair, while lowering operation and maintenance costs and reducing the duration and frequency of outages.

Data Access and Analytics

Constructing a Complete Picture: DOE Publishes Timely and Valuable Data on U.S. and Global Hydropower and Pumped-Storage: In 2021, WPTO published the third edition of the U.S. Hydropower Market Report, which compiled data from public and commercial sources, as well as DOE R&D projects, into a publicly available document that provides a comprehensive picture of developments, industry trends, and projections for U.S. and global hydropower. For example, the report outlines that almost as much PSH capacity was added in the United States from 2010 to 2019 (1,400 MW) as the combined installed capacity of all other forms of U.S. energy storage. The researchers also found that interest in PSH around the world is rapidly growing, with 50 projects (53 GW of capacity) under construction as of 2019 and an additional 226 GW of PSH in development, which would more than double the global fleet.

Innovations for Low-Impact Hydropower Growth

Hydropower Manufacturing Prize Winners Conceive Strategies To Lower Costs and Improve Performance of Hydropower Components: In December 2020, WPTO announced 11 winners for the I AM Hydro Prize, a competition designed to identify opportunities for advanced manufacturing to reduce the costs of hydropower technologies. Each winner was awarded cash prizes to further develop their concepts, which range from 3D-printed turbine components and anti-fouling coatings to composite magnets for hydropower generators and retrofitting non-powered dams using 3D concrete printing.

Penn State Demonstrates Modular, Scalable, and Rapidly Deployable Hydropower Turbine and Generator System Appropriate for a Variety of Sites: After years of analysis and testing, Pennsylvania State University has manufactured and tested a hydropower turbine-generator that can be deployed at a variety of low-head sites, scaled across a spectrum of operating ranges, and has the potential to significantly reduce levelized cost of energy. Initial capital costs were found to be competitive with existing commercial solutions, while water tunnel testing at Penn State's Applied Research Lab demonstrated hydraulic efficiencies approaching 90% with the ability to operate efficiently over a broad range of flows.

The 21st Century Archimedes Screw: New Materials and Manufacturing Techniques Enable the Turbine's Highest-Ever Measured Efficiency: Percheron Power, with support from PNNL and Utah State University, developed and tested a next-generation Archimedes Hydrodynamic Screw (AHS) turbine that was constructed using composite materials and advanced manufacturing methods—offering lower costs and the best efficiency ever measured for such a system. These AHS turbines are technically very simple, requiring significantly lower costs to install and operate than competing low-head turbines, and are also highly tolerant of debris, equating to higher levels of reliability over an expected lifetime of 40 years or more.

Percheron Power's composite Archimedes hydrodynamic screw.
Source: Utah State University

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