OAK RIDGE NATIONAL LABORATORY

# Modernizing US Hydropower with Advanced Manufacturing

For over 100 years, hydropower has contributed reliable energy to the US power grid. However, its longevity is also its challenge. Problems arising from aging infrastructure, supply chain issues, and new technological requirements have been exacerbated by a conventional manufacturing process that has been slow to evolve over the years.

A new report released by the US Department of Energy's Oak Ridge National Laboratory assesses how advanced manufacturing and materials, such as 3D printing and novel component coatings, could offer solutions to modernizing the existing fleet and designing new approaches to hydropower.



*Redesigned boom anchor (right) for Nimbus Dam. Additive manufacturing reduced cost from $1,800 for one anchor to $1,570 for six.*

*Credit: Jonathan Rogado US Bureau of Reclamation*

## Broad Stakeholder Input

In 2022, hydropower supplied nearly 6 percent of the total utility-scale electricity generation in the US. Given hydropower's impact on grid reliability, local economies, and the environment, the DOE Water Power Technologies Office and ORNL hosted a two-day workshop in August 2022 to discuss manufacturing roadblocks and how to move hydropower forward.

Hydropower developers and operators, representatives from the advanced manufacturing industries, researchers, and environmentalists discussed rising costs and shrinking material supplies, as well as the benefits of manufacturing alternatives that could more quickly increase the scale of needed production—often at a lower cost and in a shorter timeframe.

**EXPECTED VALUE OF ADVANCED MANUFACTURING**

- Expand new design capabilities
- Improve system and component performance
- Reduce time to build parts
- Reduce reliance on foreign manufacturing
- Reduce operations and maintenance costs
- Enhance predictive maintenance through sensors
- Enable environmental mitigations

**Scan to review the project profile**



OAK RIDGE National Laboratory | U.S. DEPARTMENT of ENERGY

25-G01726

# Current Hydropower Challenges




- **Aging infrastructure**—As the average age US hydropower dam is 64 years old, repairs are often needed on four main systems: turbines and generators, pressurized conduits and gates, structures and foundations, and electrical systems and controls. In addition to maintenance and repair costs, facilities lose revenue during required outages.
- **Supply chain issues**—Manufacturing high-quality large metal components (e.g., turbine runners) is not currently possible in the United States. Because of this, along with shortages in crucial materials and electronics, hydropower operators have to procure critical parts and equipment from foreign vendors, resulting in long lead times that range from months to years.
- **Environmental mitigations**—The continued viability of the nation's hydropower industry requires the adoption of new environmental mitigation technologies such as fish ladders, fish-friendly turbines, and environmentally safe lubricants. Costs associated with these measures are typically high and can curb their development.
- **Evolving operational standards**—Increasing energy demands necessitate hydropower innovations that reduce cost and increase flexibility for new projects, like pumped storage hydropower, non-powered dam retrofits, conduit hydropower, and new stream reach development. While project costs and benefits are site specific, new projects can struggle to achieve cost parity with existing hydropower, largely because of economies of scale and regulatory hurdles.

# Advanced Manufacturing Capabilities

**Additive Manufacturing**—Components can be more easily built onsite, with greater durability and reliability, at a lower cost and more quickly.
metal parts | fiber-reinforced polymers | concrete structures | sand castings | magnetic materials

---

**Novel Machining and Casting**—New processes can return production of large parts to the United States. Advanced manufacturing can also apply textured coatings to reduce friction of components operating in water. Already employed in:
automotive | aerospace | electronics | medical industries

---

**Innovative Materials**—These materials are often lighter, stronger, more resistant to corrosion, easier to repair, and more environmentally friendly, such as novel lubricants. Can decrease wear and tear in high-stress areas:
motors | composite bearings | pipelines and conduits | wicket gates

---

**Novel Coating Process**—Component damage from electrical and mechanical failures and other complications can be mitigated by providing a range of protective coatings that can enhance:
corrosion/wear resistance | surface hardness and texture | thermal/electrical insulation | resistance to bacterial damage

# Continued Collaboration

To support a more reliable, affordable and secure energy future, continued collaboration is critical. Understanding key stakeholder issues and priorities, as well as conducting valuable research at user facilities such as DOE's Manufacturing Demonstration Facility at ORNL, are expected to pave the way toward (1) identifying and prioritizing investments in advanced manufacturing and material solutions and (2) developing an R&D roadmap and supporting technical collaborations for advanced manufacturing in hydropower.


**CONTACT**
Scott DeNeale
Water Resources Engineer
Environmental Sciences Division
Oak Ridge National Laboratory
denealest@ornl.gov
865-241-7368


ornl.gov/waterpower