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Federal Energy RD&D: Water Power

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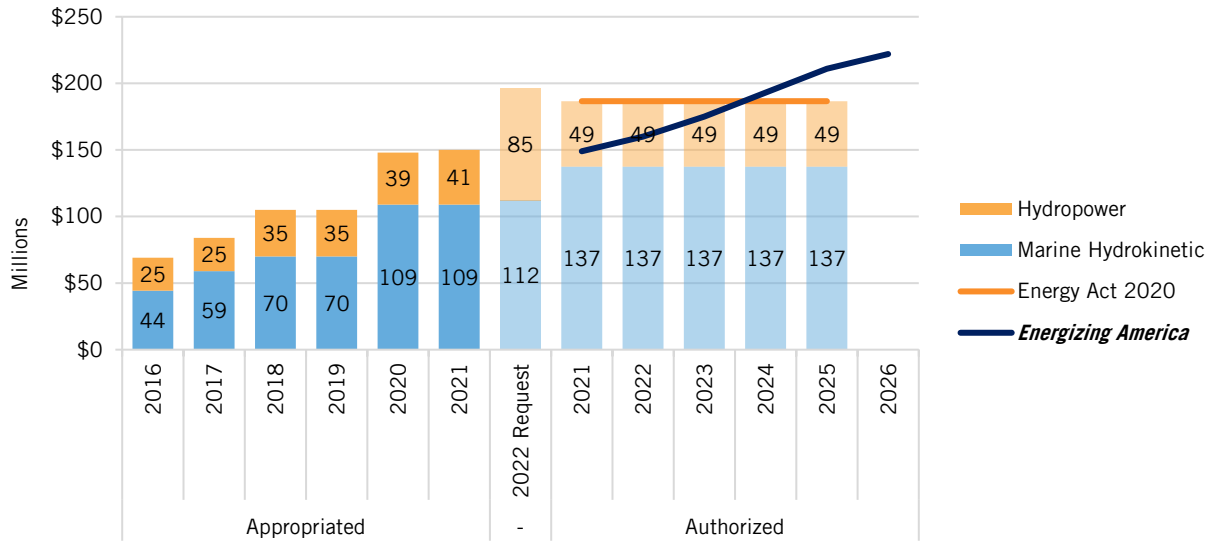
The Department of Energy's (DOE) Water Power program supports research, development, and demonstration (RD&D) of two types of technologies: conventional hydropower (including pumped storage) and marine and hydrokinetic (MHK) energy. Conventional hydropower uses a dam or other structure to convert the kinetic energy of flowing water into electricity, while MHK technologies convert the energy of waves, tides, and currents.[1]

Figure 1: *Energizing America* recommends ramping up funding for water power RD&D by nearly 50 percent by FY 2026. [2]



What's at Stake

Hydropower is the second-largest source of renewable energy, providing nearly 7 percent of the nation's electricity (and 18 percent of its carbon-free electricity) for the first 11 months of 2020.[3] And pumped-storage hydropower accounts for more than 90 percent of U.S. grid-scale electricity storage, far more than lithium-ion batteries.[4] However, installed capacity of conventional hydropower and pumped-storage hydropower has stalled at about 100 gigawatts (GW), and innovation is needed to jump-start growth. DOE's 2016 *Hydropower Vision* report identifies up to 50 GW of new hydropower capacity that could be gained from upgrading and modernizing the existing fleet, installing generation on non-powered dams, and developing new, small hydropower and pumped-storage technologies. Near-term growth potential of hydropower generation through 2030 is estimated at 9.4 GW, while approximately 16.2 GW in new pumped-storage hydropower could also become available by 2030.[5] DOE recently launched the Hydropower and Water Innovation for a Resilient Electricity System (HydroWIRES) to improve both conventional and pumped-storage hydropower contributions to the grid, and to roadmap future research directions.[6]

National resource assessments have found 1.25–1.85 terawatt-hours per year (TWh/yr) of untapped, technically extractable MHK potential, or the equivalent of 30 percent of the total electricity generated in the United States.[7] MHK technologies are at an early stage of

development due to the fundamental scientific and engineering challenges of generating power from complex low-velocity/high-density dynamics in a corrosive ocean environment. Although they could potentially provide a low-carbon energy alternative for the 28 coastal and Great Lakes states, additional cost reductions are needed to make them cost competitive with other sources of electricity.

Additionally, marine energy can provide new capabilities, such as onboard energy generation and remote recharging, in areas far from land-based power grids. In April 2019, DOE released a new report, *Powering the Blue Economy*, that identifies non-grid applications and opportunities for marine renewable energy to tap into new markets and provide new energy services.[8] However, the United States lags behind nations that have invested more heavily in developing marine energy technologies. For example, the EU established a European Marine Energy Centre that enables prototypes up to 1 MW to be tested in open waters. The United States has no test beds that are comparable in scale.[9]

The Energy Act of 2020 provides the first reauthorization of DOE's Water Power program in more than a decade. The law authorizes activities that support the development of new technologies for pumped storage, constructed waterways, new stream-reach development, and modular and small dams. Moreover, the law authorizes projects that advance new pumped storage hydropower technologies, including systems with adjustable speed, modular systems, and alternative closed-loop systems. To accelerate innovation in marine technologies, DOE will continue supporting existing National Marine Energy Centers and create new centers that focus on in-water testing and demonstration. The bill authorizes $186.6 million annually for FY 2021 through FY 2025, including $137 million for marine energy and $49 million for hydropower RD&D activities.[10]

Figure 1 shows historical DOE investment in water power RD&D by subprogram, for FY 2016 through FY 2021, and the FY 2022 budget request. The orange line shows authorized funding levels from the Energy Act of 2020. The blue line shows recommended funding levels from the *Energizing America* report, which envisions a ramp-up to a 50 percent increase in water power technologies RD&D by FY 2026 (see box 1).

Box 1: An Innovation Agenda for Water Power

The *Energizing America* report co-authored by the Information Technology and Innovation Foundation (ITIF) and Columbia University's Center on Global Energy Policy offers several recommendations to accelerate innovation in water power. Similarly, ITIF's December 2020 report "An Innovation Agenda for Advanced Renewable Energy Technologies" makes recommendations to DOE and Congress:

- Congress should ramp up funding for MHK and advanced hydropower technologies by 50 percent over the next five years to address RD&D needs and meet the innovation targets outlined in the *Hydropower Vision* and *Powering the Blue Economy* roadmaps.[11]

- DOE should establish a modeling and computational program to explore the integration of new components to hydropower infrastructure, develop cheaper and more durable components, and improve fleet performance to increase generation capacity and offer flexibility to complement intermittent renewable energy sources.[12]
- DOE should support the demonstration of innovative and sustainable hydropower designs and establish hydropower RD&D test facilities that demonstrate environmental protection technologies to minimize impacts to marine ecosystems.[13]
- DOE should support RD&D programs that reduce costs for marine energy technologies. Programs that involve prize competitions could be well suited for marine energy, given its technological immaturity and uncertainties in design.[14]

Water Power RD&D Subprograms

RD&D in the Water Power program is spread across two subprograms:[15]

- **Hydropower R&D** seeks to reduce the site-specific costs of construction, powerhouse design/installation, and environmental mitigation of new hydropower at non-powered dams; develop turbine designs that generate more power at given water flows or increase operational ranges with reduced impacts for existing hydropower facilities; optimize modes of operation for grid stabilization; and develop novel closed-loop pumped-storage designs that can be deployed at a wider range of sites.
- **Marine and Hydrokinetic Technologies** focuses on researching controls to maximize power production over a range of ocean conditions; improving and validating modeling tools and methodologies to optimize device and array performance and reliability across operational and extreme conditions; and investigating new approaches to safe and cost-efficient installation, grid integration, operations, maintenance, and decommissioning of MHK projects. An MHK open-water wave-energy test facility currently being developing—to be begin operation between 2021 and 2022—will allow testing and validation of industry-developed MHK energy-conversion components and systems.[16] The subprogram is also exploring the ability of marine energy to provide non-grid energy services in areas where access to an electric grid is limited.[17]

Key Elements of the FY 2022 Budget Proposal[18]

The budget proposal seeks $196.56 million for the Water Power program, a 31 percent boost from FY 2021 enacted levels. Some highlights include:

- **A 3 percent increase in the Marine Energy Technologies subprogram,** including increased funding for advanced materials and manufacturing; increased funding to advance technologies from the Waves to Water and Ocean Obs prize competitions; continued funding for the development and testing of marine hydro-kinetic systems and components, as well as wave-powered desalination systems; and continued support of the Testing Expertise and Access for Marine Energy Research (TEAMER) initiative, a

campaign to provide developers with access to marine energy testing facilities across the nation.

- **A 106 percent increase in the Hydropower Technologies subprogram,** including increased funding for the HydroWIRES initiative to support the development and testing of innovative pumped-storage hydropower technologies; funding to support a hydropower-specific program at Oak Ridge National Laboratory's Manufacturing Demonstration Facility to reduce the manufacturing costs of new hydropower technologies; and new funding for research into novel water infrastructure sensors to detect leakage and evaporative losses to promote water conservation.

Further Reading

- Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), http://www2.itif.org/2020-energizing-america.pdf.
- Robert Rozansky, "An Innovation Agenda for Advanced Renewable Energy Technologies" (ITIF, 2020), http://www2.itif.org/2020-advanced-renewables-energy.pdf.

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ENDNOTES

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11. Varun Sivaram et al., *Energizing America*, 58.
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