Water Power

Overview

The Water Power Program supports research, development, demonstration, and deployment (RDD&D) in two distinct renewable power domains: (1) Hydropower and (2) Marine and Hydrokinetic (MHK) energy.

With 78 gigawatts (GW) of installed capacity, hydropower currently provides approximately 50 percent of all U.S. renewable electricity generation and 7 percent (213 terawatt hours, or TWh, in 2013) of annual total U.S. electricity production. The Water Power Program's Hydropower RDD&D activities support critical efforts in technology development, market acceleration and grid integration across three important hydropower resource classes: (1) Existing Water Infrastructure, (2) Undeveloped Streams, and (3) Pumped-Storage Hydropower. The existing water infrastructure resource class represents up to 12 GW (31 TWh/year) of technical hydropower resource potential, of which a portion may be economically feasible to add to the U.S. electrical grid from the development of non-powered dams,[1] after considering environmental limitations, dam integrity and safety issues, and existing non-energy uses such as flood control, water supply, navigation, environmental restoration, or recreation. In addition, restoring and upgrading existing hydropower facilities represents up to an additional 5 GW (approximately 13 TWh/year) of potential capacity.[2] The Water Power Program's assessment of this existing water infrastructure resource class calls for technology advancements that reduce environmental footprints, lower replacement and production costs, and enable more robust management of increasingly complex and competitive water resource demands. Developing hydropower technology from undeveloped streams represents another opportunity to increase the generation of renewable electricity throughout the country. Undeveloped streams resource class – those segments of natural waterways outside the physical footprint of existing water infrastructure – represents over 60 GW (340 TWh/year) of technical hydropower resource potential, of which a portion may be economically feasible to develop after factoring other uses and environmental considerations including threatened and endangered species. The third resource class, pumped storage hydropower (PSH), represents an opportunity for hydropower to enable the integration of variable renewable generation, such as wind and solar power, into the U.S. electrical grid. The Water Power Program's focused approach to hydropower RDD&D, known hereafter as the "HydroNEXT Initiative," is a comprehensive strategy that addresses the entire technology RDD&D pipeline across each of the resource classes noted above. Initially, HydroNEXT will focus on new and innovative generation technology development, including performance testing and environmental validation. Promising hydropower technologies identified in the initial phase will be considered for demonstration and ultimately deployment by industry.

With more than 50 percent of the U.S. population living within 50 miles of the Nation's coasts, MHK technologies, such as those that capture energy from ocean currents, river currents, and waves, hold significant potential to supply renewable electricity to consumers in coastal load centers, particularly in areas with high costs of electricity. The Water Power Program has determined that cost-effective MHK technologies could provide a substantial amount of valuable renewable electricity for the Nation due to the MHK technical resource potential, as well as its proximity to major coastal load centers, predictability, and forecastability. This potential (technically extractable) resource includes 1170 TWh/year of wave energy[3], 250 TWh/year of tidal energy[4], and 283 TWh/year of combined ocean and river current energy located throughout diverse regions of the continental U.S., Hawaii, and Alaska of which a portion may be economically feasible to develop.[5,6] For

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[1] An Assessment of Energy Potential at Non-Powered Dams in the U.S. Prepared for the U.S. Department of Energy, Wind and Water Power Program by Oak Ridge National Laboratory, April 2012.

[2] Zhang, Q. and B. T. Smith. 2014. Final Report: Demonstration Assessments of the Hydropower Advancement Project. ORNL/TM-2014. Oak Ridge, TN: Oak Ridge National Laboratory. 2014.

[3] P. Jacobson, G. Hagerman, and G. Scott, (2011). "Mapping and Assessment of the U.S. Ocean Wave Energy Resource," Electric Power Research Institute, Report Number 1024637, 2011.

[4] K. Haas, H. Fritz, S. French, B. Smith, and V. Neary, (2011). "Assessment of Energy Production Potential from Tidal Streams in the U.S.," Georgia Tech Research Corporation, 2011.

[5] K. Haas, H. Fritz, S. French, and V. Neary, (2013). "Assessment of Energy Production Potential from Ocean Currents Along the U.S. Coastlines," Georgia Tech Research Corporation, 2013.

[6] T. Ravens, K. Cunningham, and G. Scott, (2012). "Assessment and Mapping of the Riverine Hydrokinetic Resource in the Continental U.S.," Electrical Power Research Institute, Report Number 1026880, 2012.

example, based on other energy industries' recovery of technically available energy, extracting just five percent of the technical resource potential for the U.S. could result in MHK powering seven million American homes with clean energy.

DOE investments in high-risk, early-stage MHK technology development, and key supporting design tools used broadly by this emerging sector, currently fill a critical gap that the private sector is unable to address sufficiently on its own. DOE's MHK portfolio focuses on funding innovation to drive down the cost of electricity through significant performance improvements and reductions in initial investment costs. Cost-competitiveness of MHK energy will require that individual devices can capture more than double the amount of energy than is technically feasible by current prototypes. The Water Power Program is committed to a multi-pronged effort that will allow the MHK sector to rapidly advance and achieve cost-competitiveness with local hurdle rates in major coastal load centers by 2030. Based on the quantitative estimates of resource and deployment potential resulting from these assessments, the MHK subprogram will place priority focus on technology development for wave energy devices while continuing to support key tidal and ocean current energy developments.

Highlights of the FY 2016 Budget Request

Existing U.S. hydropower assets and water infrastructure provide opportunities to recover, optimize, and add new capacity with advanced and sustainable hydropower technologies. Specifically, FY 2016 activities in this area are the first step in a multi-year HydroNEXT program that supports enabling technology that allows for growth in hydropower from currently non-powered dams (NPD). The initial focus of research and development (R&D) will be on modular powertrain technologies with the potential to minimize the need for costly, customized, site-specific engineering at existing NPD sites. NPD's represent up to 12 GW (31 TWh/year) of technical hydropower resource potential, of which a portion may be economically feasible to develop. After considering environmental limitations, dam integrity and safety issues, and existing non-energy uses, a portion of this technical potential may be economically feasible to develop to expand the amount of reliable base-load low-carbon electricity in the U.S. The Hydropower Technologies subprogram is seeking to unlock this resource through investments in modular technology R&D and standardized site engineering templates and environmental evaluations, and through continued collaborations with relevant Federal agencies to improve regulatory efficiencies.

The Hydropower Technologies subprogram has determined through a comprehensive technical resource assessment, released in FY 2014, that undeveloped streams in the U.S. represent more than 60 GW of potential hydropower capacity of which a portion may be economically feasible to develop after factoring other uses and environmental considerations including threatened and endangered species. New hydropower facilities with less than 30 megawatts (MW) of capacity represent the majority of development opportunities. However, the expansive and expensive civil works typically required by conventional technology and development designs overwhelm the cost-benefit feasibility of new projects. As a result, advances in technology to promote low-impact new development by reducing civil and environmental impact mitigation costs are required to improve the cost-benefit ratio of these new projects. Building on FY 2015 investments, FY 2016 activities in this area will focus on continued advances in high efficiency modular powertrains.

In FY 2016, small-scale standardized modular PSH technology R&D will target reduction of powertrain costs, and costs associated with civil works, typically 40 to 50% of total project costs, to achieve feasibility in distributed (<1 MW), municipal-industrial-commercial (1 to 20 MW), and utility (20 to 100 MW) scale contexts for PSH deployment. Specific R&D activities will initiate PSH research and development by investing in innovation in two areas: (1) scalable PSH facility designs using commercial off-the-shelf (COTS) pumps, turbines, piping, tanks, and valves to achieve reductions in PSH deployment costs, and (2) hybrid PSH technology designs combining water storage with other forms of energy storage within energy and water delivery and collection systems.

Shared test facilities provide industry with a cost-effective means by which to test and validate their as-built designs and are critical to demonstrate the risk reduction required to enable follow-on private sector financing. In FY 2016, the MHK subprogram will complete front end engineering and design for a potential full-scale grid-connected open water wave test facility capable of testing and demonstrating Wave Energy Converter (WEC) components and systems under operating and survival conditions. The results of this completed engineering and design phase will be used to support a programmatic go/no-go decision on further facility construction funding. To support the emerging industry, the facility would have four test berths at depths greater than 50 meters, with an annual average power density greater than 30 kilowatts per meter (kW/m) to allow for survivability tests. This project will leverage the results from the MHK subprogram's FY 2013 awards that are evaluating site locations and delivering preliminary designs and cost estimates.

In FY 2016, the MHK subprogram will support projects that integrate innovative WEC components into prototype systems and test and validate these innovative prototype systems through open water demonstrations and testing. Significant improvements in system performance are necessary to achieve a doubling of the absorbed power of MHK devices, a key element of MHK device cost-competitiveness in early entry markets. This effort builds on previous program technology research and development efforts, such as the Systems Performance Advancement projects. Components targeted for systems integration and testing within this area include Advanced Controls; Advanced Power Take-Off (PTO); and Optimized Structures.

Having accurate and cost-effective monitoring instrumentation will be a key element in acquiring MHK environmental permits in a predictable and timely manner and reducing overall project costs. Existing instruments are challenged by the high energy, often low light conditions of MHK settings, as well as by the limited availability of automated data processing tools for the large amounts of information collected. In FY 2016, the MHK subprogram will build upon its work initiated in FY 2015 to develop and test new environmental monitoring instrumentation. Successful tests and demonstrations in laboratory and controlled environments will be followed by open-water tests in conjunction with the deployment of MHK devices, where possible.

A Water Technology Program "Incubator" funding opportunity will invest 5 percent of Water Technology Program funding toward new off-roadmap innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so they may be "on-ramped" to future program roadmaps and the program portfolio.

Within the FY 2016 Budget Request, the Water Power Program supports one Departmental Crosscut: Energy-Water Nexus. The Energy-Water Nexus crosscut is an integrated set of investments and cross-program collaborations that: (1) support a national data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; (2) strategically target crosscutting technology opportunities within the system of water and energy flows that offer the greatest opportunity for positive impact; and 3) are informed, supported, and strengthened by focused policy analysis and stakeholder engagement. These investments position DOE to contribute strongly to the Nation's transition to more resilient energy and coupled energy-water systems.

FY 2016 Crosscuts ($K)

	Energy-Water Nexus	Total
Water Power	**1,000**	**1,000**

Water Power
Funding ($K)

	FY 2014 Enacted[1]	FY 2014 Current[2]	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Water Power					
Hydropower Technologies	17,290	16,973	19,200	25,500	+6,300
Marine and Hydrokinetic Technologies	41,275	40,861	41,100	40,800	-300
NREL Site-Wide Facility Support	0	0	700	700	0
Total, Water Power	**58,565**	**57,834**	**61,000**	**67,000**	**+6,000**

SBIR/STTR:

- FY 2014 Transferred: SBIR $640,000; STTR $91,000
- FY 2015 Enacted: SBIR $880,000; STTR $121,000
- FY 2016 Request: SBIR $1,071,000; STTR $161,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $34,956.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

Water Power
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
Hydropower Technologies: The increase is due to an expanded focus of the new HydroNEXT Initiative to leverage existing water infrastructure (Non-Powered Dams) and undeveloped steams for increased hydropower generation. Specifically for non-powered dams, investments will focus on: (a) standardized modular powertrain technologies; and (b) standardized site engineering designs and approaches. Regarding undeveloped streams, the key focus will be on innovations in structural materials and construction methodologies that reduce costs and environmental disturbance.	**+6,300**
Marine and Hydrokinetic Technologies: No significant change in funding.	**-300**
Total, Water Power	**+ 6,000**