Water Power for a Clean Energy Future

Water power is the nation's largest source of clean, domestic, renewable energy. Water power technologies harness energy from rivers and oceans to generate electricity for the nation's homes and businesses, and can help the United States meet its pressing energy, environmental, and economic challenges. Water power technologies fall into two broad categories: conventional hydropower and marine and hydrokinetic technologies. Conventional hydropower uses dams or impoundments to store river water in a reservoir. The water is released through a turbine to generate electricity. Marine and hydrokinetic technologies capture energy from waves, tides, ocean currents, free-flowing rivers, streams, and ocean thermal gradients.

The United States has abundant water power resources, enough to meet a large portion of the nation's electricity demand. In 2009, conventional hydropower generated 272 million megawatt-hours (MWh) of electricity, almost 7% of all U.S. electricity production. According to preliminary estimates from the Electric Power Resource Institute, the U.S. had additional water power resource potential of more than 85,000 megawatts (MW).[1] This includes efficiency upgrades at existing hydroelectric facilities and development of new low-impact facilities, as well as abundant marine and hydrokinetic energy resources.

The Department of Energy's (DOE's) Water Power Program works with industry, universities, other federal agencies, and DOE's national laboratories to promote the development and deployment of technologies capable of generating environmentally sustainable and cost-effective electricity from the nation's water resources.

[1] *Assessment of Waterpower Potential and Development Needs.* EPRI, Palo Alto, CA: 2007. Page 3-2. *http://www.aaas.org/spp/cstc/docs/07_06_1ERPI_report.pdf*

The Bonneville Dam on the Columbia River between Washington and Oregon has 20 turbines with a total capacity rating of more than 1,000 megawatts. Courtesy of the U.S. Army Corps of Engineers

Industry Overview

Conventional hydropower has been used since the 1880s to generate electricity, and it provided more than one-third of the nation's electricity during the 1940s. Although non-federal entities own the majority of the nation's individual hydropower plants, around half of the nation's hydroelectric generation capacity is owned and operated by federal agencies, most notably the U.S. Army Corps of Engineers and the Department of the Interior's Bureau of Reclamation. The Department of Energy works with these agencies, as well as with commercial owners and operators of hydropower dams, to modernize the nation's hydropower facilities through the deployment of advanced technologies.

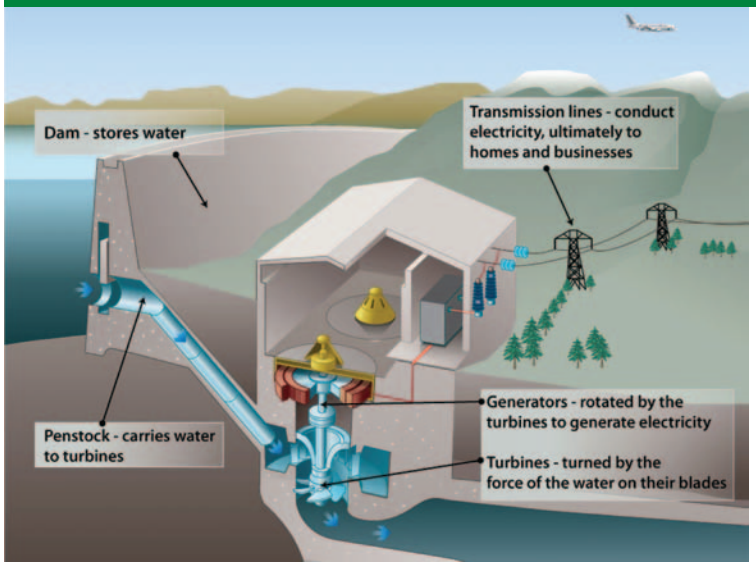
The marine and hydrokinetic energy industry is at an early stage of development, with only a handful of demonstration projects operating in U.S. waters. Installing these demonstration devices in open-water settings allows technology developers to gather crucial operational data that are used to refine device designs and establish baseline cost and performance projections. Technology developers have investigated numerous device design approaches to harness different water power resources, and these approaches are beginning to coalesce around a smaller number of designs as the industry matures. Descriptions of some different marine and hydrokinetic technology types can be found in the Water Power Program's Marine and Hydrokinetic Technology Glossary: *www.windandhydro.energy.gov/hydrokinetic/techtutorial.aspx*.

Water Program Activities

The Water Power Program works to develop advanced water power technologies and to accelerate market adoption of these technologies.

Conventional Hydropower

The program conducts applied research, testing, and demonstration of advanced conventional hydropower technologies to improve generating capacity and reduce potential environmental effects. For example, in 2009, the Water Power Program awarded $30.6 million in American Recovery and Reinvestment Act funds to modernize infrastructure at seven facilities. These upgrades will increase generating efficiency and reduce adverse environmental effects at the hydropower facilities. The program also undertakes technology development and testing activities to prove advanced concepts and to support future full-scale projects. For example, the program funds the Electric Power Research Institute (EPRI) to finalize the engineering and construction of a fish-friendly hydropower turbine that will compete with existing designs.



Cross section of conventional hydropower facility that uses an impoundment dam.

Finally, the program undertakes a range of research and testing activities that provide the scientific basis for improving hydropower technologies, from the development of hardware to software and analytical methods. Hydropower plant operators can use these products and studies to improve their facilities' generation capacity and environmental performance.

The Water Power Program works to reduce the time and costs associated with permitting hydropower projects, to better quantify the potential magnitude, costs, and benefits of hydropower generation, and to identify and address other barriers to hydropower deployment. One key aspect of this work is assessing the nation's hydropower resources, including the potential for increased generation and capacity at existing hydropower facilities and non-powered dams as well as the potential for new low-impact and small hydropower generation. Another aspect of the program's work is the design, development, and testing of new ways to reduce potential adverse environmental effects of hydropower generation. These include effects on fish populations, water quality, and river habitats. Finally, the program works to quantify the benefits of effective and cost-competitive conventional hydropower technologies and to communicate those benefits to policymakers and key stakeholders.

Marine and Hydrokinetic Technologies

The Water Power Program supports the development and testing of a wide variety of marine and hydrokinetic systems and components, from proof-of-concept studies through full-scale demonstration projects. Program funding has supported the research and development of devices such as wave power buoys, tidal power turbines, oscillating water column wave energy converters, and ocean thermal energy conversion components. The program also develops tools and models that support the design, development, and optimization of marine and hydrokinetic devices. These projects will help maximize efficient electricity generation at marine and hydrokinetic power plants while mitigating potential environmental effects. In addition, the program has established university-led National Marine Renewable Energy Centers to facilitate in-water testing of marine and hydrokinetic devices and components. These centers will have open-water test berths as well as laboratory facilities that will allow researchers to investigate marine and hydrokinetic devices in real-world conditions.

To accelerate the market development of marine and hydrokinetic technologies, the program works to reduce the time and costs of siting marine and hydrokinetic power projects and to identify and address barriers to their deployment. For example, the program is funding studies on the potential effects of marine and hydrokinetic technologies on specific species as well as aquatic ecosystems. The program is also assessing the potential extractable energy contained in the nation's waves, tides, ocean currents, rivers, streams, and ocean thermal gradients. Finally, the program is conducting economic analyses to quantify the benefits of the widespread deployment of effective and cost-competitive marine and hydrokinetic systems. These activities include assessing industry research and development needs, identifying policy mechanisms and market designs that will support accelerated deployment, and providing information and training to potential members of the marine and hydrokinetic industry and other stakeholders.

Hydrokinetic technology devices extract energy from domestic rivers, estuaries, and coastal waters. Courtesy of Oceanlinx/PIX17208; OpenHydro/PIX17243; Ocean Power Technologies/PIX17114; Kris Unger, Verdant Power Inc./PIX17209; Hydro Green Energy/PIX 17211.

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