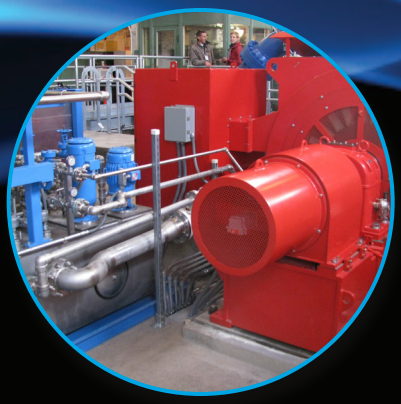
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

WIND AND WATER POWER TECHNOLOGIES OFFICE

U.S. Department of Energy Wind and Water Power Technologies Office Funding in the United States:

HYDROPOWER PROJECTS

Fiscal Years 2008 - 2014



Hydropower Projects

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Introduction

Wind and Water Power Technologies Office

The Wind and Water Power Technologies Office (WWPTO), within the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE), supports the development, deployment, and commercialization of wind and water power technologies. WWPTO works with a variety of stakeholders to identify and support research and development (R&D) efforts that improve technology performance, lower costs, and—ultimately—deploy technologies that efficiently capture the abundant wind and water energy resources in the United States. WWPTO is one office that contains two distinct focus programs: wind and water. The Wind Program and the Water Power Program operate as integrated, but separate entities within WWPTO.

The Water Power Program is committed to developing and deploying a portfolio of innovative technologies for clean, domestic power generation to support of a clean energy future.

The Water Power Program provides R&D funding in two major areas:

1. Hydropower Projects
2. Marine and Hydrokinetic Projects

The breakdown of Water Power Program funding is presented in a pair of reports that showcase the projects funded in each of the abovementioned areas.

Hydropower

Moving water is a powerful source of energy that is harnessed to provide clean, fast, and flexible electricity generation. Hydropower is currently the largest source of renewable electricity worldwide and represents a reliable and domestic resource that can power millions of American homes and businesses. Hydroelectric energy has been used in the United States since the 1880s and currently produces 6%–7% of the nation's total electricity.[1] DOE estimates that the United States possesses significant additional hydroelectric generating capacity at existing dams and manmade waterways, and at new, undeveloped low-impact sites.

The Water Power Program helps industry harness this renewable, emissions-free resource to generate environmentally sustainable and cost-effective electricity. Through support for public, private, and nonprofit efforts, the Water Power Program promotes the development, demonstration, and deployment of advanced hydropower devices and pumped storage hydropower applications. These technologies help capture energy stored by diversionary structures, increase the efficiency of hydroelectric generation, and use excess grid energy to replenish storage reserves for use during periods of peak electricity demand. In addition, the Water Power Program works to assess the potential extractable energy from domestic water resources to assist industry and government in planning for our nation's energy future. From FY 2008 to FY 2014, DOE's Water Power Program announced awards totaling approximately $62.5 million to 33 projects focused on hydropower. Table 1 provides a brief description of these projects.

There are three sources of funding for WWPTO hydropower projects covered in this report: Congressional Appropriations for Funding Opportunity Announcements (FOAs), Congressionally Directed Projects (CDPs), and the American Recovery and Reinvestment Act of 2009 (Recovery Act).

The Water Power Program has rapidly expanded since it was established in 2008. From Fiscal Year (FY) 2008 to FY 2014, Congress increased the Water Power Program budget from nearly $10 million in FY 2008 to $59 million in FY 2014.

Types of Funding Sources

WWPTO's research and development (R&D) projects are financed through two primary sources of funding: Congressional Appropriations and Congressionally Directed Projects (CDPs). Congressional Appropriations determine the operating budgets for each EERE office. WWPTO-funded R&D projects are typically awarded to recipients as grants through competitive Funding Opportunity Announcements (FOAs) that are dedicated to specific topic areas. CDPs are also funded by Congress, but are outside of the annual federal budget process. Frequently, there is a cost-share requirement for recipients of both competitive FOA grants and CDPs.

In addition to these two primary funding sources, WWPTO may be financed directly through specific legislation passed by Congress. In Fiscal Year 2009, for example, Congress passed the American Recovery and Reinvestment Act of 2009 (Recovery Act). A portion of Recovery Act funding was dedicated to WWPTO's R&D projects.

WWPTO also funds research projects at DOE's national laboratories through the laboratories' annual operating plans. This funding is not detailed in this report. However, a national laboratory may be a lead or a partner on a competitively awarded project covered in this report. In these cases, the national laboratory is identified as the lead or partner in the appropriate project descriptions.

The Small Business Innovation Research (SBIR) program, in DOE's Office of Science, provides competitive awards-based funding for domestic small businesses engaging in R&D of innovative technology. SBIR has funded hydropower R&D projects; however, these projects are not covered in this report.

Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Advanced Energy Conversion, LLC	Hydropower from Wastewater	$475,750	FY 2009 CDP	New York
Project Description				
Advanced Energy Conversion, LLC (AEC) designed a turbine that captures the kinetic energy of processed wastewater to generate electricity. Since electricity is often one of the largest operating costs at a wastewater treatment plant, generating onsite electricity at wastewater treatment plants has the potential to reduce energy costs. AEC has patented National Aeronautics and Space Administration award-winning technology that it utilized to develop an integrated hydroelectric turbine generator to convert kinetic energy in an effluent stream (or any other low-pressure flow) into electricity. The turbine technology helps to reduce energy costs associated with wastewater treatment by generating onsite renewable electricity. The project examined the turbine design in both small facilities that process less than 1 million gallons of water per day and large facilities that process more than 75 million gallons of water per day.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Alabama Power Company	Upgrades to Alabama Power Hydroelectric Developments	$6,000,000	Recovery Act Hydroelectric Facility Modernization FOA	Alabama
Project Description				
Alabama Power Company upgraded four units at three of its hydropower facilities located on the Coosa River System. The upgrades included the installation of high-efficiency turbines to increase the efficiency and reliability of the individual units and the Coosa River System as a whole. The Coosa upgrades provide additional low-cost renewable energy generation to meet demand and are expected to increase annual generation by over 7%. In addition, the new units are expected to increase reliability and reduce maintenance costs.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Alcoa, Inc.	Tapoco Project: Cheoah Upgrade	$12,174,956	Recovery Act Hydroelectric Facility Modernization FOA	Multi-State (North Carolina, Pennsylvania)
Project Description				
Alcoa Power Generating Incorporated, a fully owned subsidiary of Alcoa Incorporated, implemented major upgrades at its Cheoah hydroelectric facility near Robbinsville, North Carolina. The upgrades included the installation of two new high-efficiency turbines, generators, and transformers, as well as improvements to the balance-of-plant equipment and preparation work for the installation of two additional units. The two-year project increased site-wide generation by 47,200 megawatt hours annually. Completion of the full five-unit modification resulted in a nearly 50% increase in generating capacity—from 88 megawatts (MW) to 110 MW—and added 40 to 50 years to the facility's expected lifespan without requiring modifications to the dam.				

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[a] DOE Funding Amounts identified in this table reflect the total DOE funding planned for award to each project for the total period of project performance that may span multiple years. DOE Funding Amounts shown in this table may be subject to change.

Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Argonne National Laboratory (operated by UChicago Argonne, LLC)	Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States	$1,875,000	Advanced Hydropower Technology Development FOA	Illinois
Project Description				
Argonne National Laboratory, in partnership with Siemens Energy, MWH Americas, Energy Exemplar, and National Renewable Energy Laboratory, is conducting a study to analyze the value of advanced pumped storage technologies in the United States. The project includes development of detailed dynamic simulation models of advanced pumped storage technologies, such as adjustable speed and ternary unit arrangements. Modeling and simulation studies will be conducted to quantify various energy and capacity services that can be provided by pumped storage plants to the power system, as well as to estimate the value of these services under different market structures and for different levels of variable renewable generation in the system.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
City of Boulder	Modernization of the Boulder Canyon Hydroelectric Project	$1,180,000	Recovery Act Hydroelectric Facility Modernization FOA	Colorado
Project Description				
The City of Boulder in Colorado modernized the 100-year-old Boulder Canyon Hydroelectric Project, originally constructed in 1910. With significant redirection of the historic water flow to meet the city's current municipal and minimum instream flow uses, the two existing 10 megawatt (MW) Boulder Canyon Hydroelectric turbines/generators were too large to operate efficiently and were at the end of their useful lifetime. With this funding, the city installed a single new turbine/generator unit that is appropriately sized (approximately 5 MW) for the available water flow. This unit increased generation by as much as 30% and turbine efficiency by 18% to 48%, depending on flow. Over its 50-year life, the new unit will generate approximately 500,000 megawatt hours that would not otherwise be produced. The project increased generation and efficiency; improved safety for personnel and equipment; improved environmental protection; modernized and integrated control equipment into the city's municipal water supply system; preserved significant historic engineering data; and contributed to economic recovery through the creation or preservation of 19 full-time jobs for one year.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
City of North Little Rock	Hydroelectric Facility Improvement Automated Intake Clearing Equipment and Materials Management	$450,000	Recovery Act Hydroelectric Facility Modernization FOA	Arkansas
Project Description				
The City of North Little Rock in Arkansas upgraded a hydroelectric generation facility located at the Murray Hydroelectric plant on the Arkansas River. The facility experienced significant costs to collect debris that obstructed the intake on a regular basis and limited plant operation. The project acquired and implemented automated industrial equipment, including an intake maintenance device and wood grinder. The intake maintenance device improved the plant's flow characteristics by continuously clearing the intake channel of the often heavy volume of debris that comes downstream. The wood grinder received the tree limbs, tree trunks, and other organic debris removed by the intake maintenance device, minimizing the need for burning debris, and thus reducing air pollution.				

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Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
City of Pleasant Grove	Project Blue Energy	$337,936	FY 2010 CDP	Utah
Project Description				
The City of Pleasant Grove in Utah will utilize existing municipal infrastructure and resources to generate power. Project Blue Energy will be positioned at the mouth of Battle Creek Canyon where the city's potable water supply is stored and distributed, providing a secure location with a continuous water source at a suitable pressure for hydropower generation. The project aims to provide a facility to be used for the generation of micro-hydropower with access and exhibits available to students at local universities, municipalities, agencies, and the general public for micro-hydropower generation research. The City of Pleasant Grove will demonstrate the value of harnessing clean and renewable energy sources through the use of innovative micro-hydropower generation.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
City of Quincy	Quincy Area Hydropower Project	$475,750	FY 2009 CDP	Illinois
Project Description				
The City of Quincy in Illinois is conducting feasibility studies to assess the viability of developing hydropower generation facilities by installing new Very Low Head (VLH) hydropower technology turbines within existing lock and dams on the upper Mississippi River near Quincy, Illinois. Based on initial studies in France, the VLH units meet all "fish-friendly" criteria, exceeding current U.S. technology. Upon completion of the project, the energy generated is expected to exceed the amount of electricity currently consumed by the city's facilities, water, wastewater, and street lighting. Excess capacity will be sold on the grid to provide the city with additional revenue. If the funded studies prove VLH is feasible at the suggested sites, the City of Quincy could be the first VLH installation in the United States.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
City of Tacoma	North Fork Skokomish Powerhouse at Cushman No. 2 Dam	$4,671,304	Recovery Act Hydroelectric Facility Modernization FOA	Washington
Project Description				
The City of Tacoma Department of Public Utilities in Washington installed two Francis turbine/generator units, adding approximately 3.6 megawatts of capacity, increasing annual generation by 13%. The project is located at an existing dam, Cushman No. 2, which is part of the Cushman Hydroelectric Project owned by Tacoma Power. The installation of the new powerhouse generated additional clean, renewable energy using currently diverted, but unutilized water flow. Because fish passage has been blocked since the construction of the two Cushman dams in the late 1920s, the project developed an innovative fish collection and passage system that supports the reintroduction of Washington's endangered steelhead and salmon populations upstream of the Cushman Hydroelectric Project.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Earth by Design	45 Mile Hydroelectric Project	$1,200,000	Advanced Hydropower Technology Development FOA	Oregon
Project Description				
Earth by Design developed and tested a new low-head modular hydropower technology in a canal in Oregon's North Unit Irrigation District to produce cost-competitive electricity. This project has successfully identified and evaluated an innovative technology solution with strong performance results that will make low-head hydro development more viable. In addition, a second site was evaluated and determined to be a better location for improving the overall performance of this project.				

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Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Eaton Corporation	Advanced Manufacturing Techniques for Efficient Turbine and Generator System	$2,200,000	Water Power Manufacturing FOA	Michigan
Project Description				
Eaton Corporation will develop an innovative small hydropower turbine and generator system that use lightweight advanced materials and advanced manufacturing techniques such as laser-assisted welding, surface treatments, and processing. The turbine will be designed to operate constantly at high efficiencies across a wide range of "heads," or changes in elevation, and water flow rates. Eaton Corporation will design, fabricate, and test its turbine at 1/10th scale.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Electric Power Research Institute	"Fish-Friendly" Hydropower Turbine Development & Deployment: Phase II Preliminary Engineering & Model Testing	$1,113,361	Advanced Water Power FOA	California
Project Description				
Electric Power Research Institute is completing the remaining developmental engineering required for a new hydropower turbine concept. A key aspect that differentiates the new turbine and advanced runner from existing turbines is the technology's "fish-friendly" design. Upon completion of the project, Electric Power Research Institute will possess a robust, fish-friendly design that is ready for field demonstration and is commercially viable.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Electric Power Research Institute	Quantifying the Full Value of Hydropower in the Transmission Grid	$2,577,975	Advanced Water Power FOA	Multi-State (California, Tennessee)
Project Description				
Electric Power Research Institute, in partnership with Oak Ridge National Laboratory and Sandia National Laboratories, is developing and demonstrating an innovative approach for quantifying and maximizing the benefits provided by hydroelectric and pumped storage projects to transmission grids. The project will establish a wide-area modeling approach, build a database, and develop and simulate scenarios in support of defining a new methodology for planning and applying hydropower assets to support the integration of variable renewables to the transmission grid.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Hydro Green Energy	Laboratory Demonstration of a New American Low-Head Hydropower Turbine	$300,000	Advanced Hydropower Technology Development FOA	Illinois
Project Description				
Hydro Green Energy designed, built, tested, and validated a scale model of a stackable, modular low-head hydropower turbine. Based on the success of lab test results, a full-scale model could be used for low-head water projects at existing locks and dams that aren't currently equipped to produce hydropower.				

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Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Hydro Green Energy	Real World Demonstration of a New American Low-Head Unit	$1,500,000	Advanced Hydropower Technology Development FOA	Multi-State (Illinois, Pennsylvania)
Project Description				
Hydro Green Energy will further develop, install, and evaluate the stackable low-head modular hydropower turbines at a constructed waterway in Braddock, Pennsylvania.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Hydro Research Foundation	Hydro Fellowship Program	$3,747,025	Advanced Water Power FOA	Multi-State
Project Description				
Hydro Research Foundation established a competitive Hydro Fellowship Program designed to stimulate new student and academic interest in conventional or pumped-storage hydropower research and careers. Since 2010, the Hydro Fellowship Program has awarded 43 fellowships to graduate-level students at more than 20 universities for two-year periods of study in the fields of hydropower- related engineering and environmental sciences.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Hydro Research Foundation	Hydro Research Award Program	$999,997	University Research Awards and Workforce Development for Hydropower FOA	Multi-State
Project Description				
The Hydro Research Foundation is implementing a University Research Award Program by building on its successful Hydro Fellowship Program. Twelve research award projects have been selected for funding at universities across the nation, with a second round of projects to be selected in 2015.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Los Alamos County	Installation of a Low-Flow Unit at the Abiquiu Hydroelectric Facility	$4,558,344	Recovery Act Hydroelectric Facility Modernization FOA	New Mexico
Project Description				
The County of Los Alamos Department of Public Utilities (DPU) owns and operates the Abiquiu Hydroelectric Plant located in Rio Arriba County, New Mexico. DPU constructed a powerhouse addition and installed a new 3 megawatt (MW) low-flow turbine generator to the existing hydroelectric plant. The project increased total plant power generation by 22% from 13.8 MW to 16.9 MW. The addition of this equipment allows for year-round generation of power during the Rio Chama low-flow winter season, as well as increased power generation throughout the remainder of the year. The project is one aspect of Los Alamos County's commitment to sustainable public utility systems (electric, water, gas, and wastewater) through its Los Alamos Green utilities initiative and resource conservation programs.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Minnesota Power	Fond du Lac Hydroelectric Facility Modernization	$815,995	Recovery Act Hydroelectric Facility Modernization FOA	Minnesota
Project Description				
Minnesota Power upgraded a 12 megawatt Francis turbine/generator unit at the Fond du Lac hydroelectric facility, constructed in 1924. The project returned the existing hydroelectric generator to its original nameplate capacity by overhauling the unit to increase annual generation by 3,000 megawatt hours (MWh). The original cast iron runner and wicket gates were also replaced with a new state-of-the-art steel runner and steel gates, improving annual generation by an additional 3,000 MWh based on 10-year averaged data, bringing the total increase in generation to 6,000 MWh or a 12% increase in annual generation over the present.				

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Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Natel Energy	Development and Endurance Testing of SLH Timing Belt Powertrain in Hydraulic Laboratory Environment	$300,000	Advanced Hydropower Technology Development FOA	California
Project Description				
Natel Energy, in consultation with Alden Research Laboratory, designed, built, and commissioned a reliable powertrain for the Schneider Linear hydroEngine™. This powertrain enables the development of new low-head hydropower capacity by reducing capital and maintenance costs, achieving levelized-cost-of-energy savings of around $2 per megawatt hour.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Natel Energy	North Unit Irrigation District Monroe Drop Low-Head Hydropower Technology Demonstration	$746,042	Advanced Hydropower Technology Development FOA	Multi-State (California, Oregon)
Project Description				
Natel Energy plans to deploy and test a scaled-up version of the modular Schneider Linear hydroEngine at a Bureau of Reclamation facility in Oregon, validating the commercial performance and economic feasibility of the device in a low-head constructed waterway. This project is also funded by the Department of the Interior.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Navigant Consulting	Workforce Development for Hydropower	$350,000	University Research Awards and Workforce Development for Hydropower FOA	Illinois
Project Description				
Navigant is conducting a workforce development study of the U.S. hydropower industry over the next 20 years. The study will investigate potential educational and training needs of the hydropower industry under different scenarios, map required skill sets, evaluate existing training programs, and identify any possible gaps that could prevent the industry from meeting future needs.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Near Space Systems	Small Hydropower Research and Development Technology Project	$300,000	Advanced Hydropower Technology Development FOA	Colorado
Project Description				
Near Space Systems developed modular designs for new hydropower turbines to harness energy from outlet pipes, incorporating a novel generator design.				

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Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
New Mexico State University	Hydropower Energy Resource (Hyper) Harvester	$299,312	Advanced Hydropower Technology Development FOA	New Mexico
Project Description				
New Mexico State University designed, built, tested, and validated two modular Hydropower Energy Resource (HyPER) devices to harvest energy from unused low-head and low-flow dams and drops in waterways with minimal impact to existing infrastructure. Built entirely of carbon composite material and fiberglass, the small turbine generator modular device is lightweight, easy to assemble, transport, install, and service, helping to keep costs low. The technology uses highly durable plastic moldings for the turbine and a fully submersible submarine-type of generator reinforced by fiberglass, which adds strength to the self-standing structure, allowing it to withstand the harsh environment of irrigation water. Fabrication led to several novel additive manufacturing techniques that promise to enable low-cost and rapid manufacturing processes.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Pacific Northwest National Laboratory (operated by Battelle)	Sensor Fish Redesign to Support Advance Hydropower Development	$299,906	Advanced Hydropower Technology Development FOA	Washington
Project Description				
Pacific Northwest National Laboratory is redesigning the sensor fish to accommodate a wide range of users and provide critical in situ measurements over the majority of the range of turbine designs. It will directly support the development of hydropower technologies that feature enhanced environmental performance designs to increase electricity generation while reducing impacts to sensitive fish species.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Pennsylvania State University	DOE/PSU Graduate Student Fellowship Program for Hydropower Research	$3,000,000	Advanced Water Power FOA	Pennsylvania
Project Description				
The Pennsylvania State University (PSU) and American Hydro Corporation (AHC) established a competitive DOE/PSU Fellowship Program to support graduate student research directly related to the hydropower industry. Fellows in the program received a highly competitive stipend package and a faculty mentor/advisor that helped identify and support the fellow's pertinent and challenging area of hydropower research. PSU faculty and representatives from AHC, DOE, and an electric utility company reviewed fellowship applications and awarded a minimum of 10 fellows with approximately $100,000 per year per project. The program provided the hydropower industry with new research and experts that support the development of a more efficient use of our nation's hydroelectric power facilities, thereby reducing air pollution and greenhouse gas emissions.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Pennsylvania State University	Low-head Hydropower Turbine and Generator System Prototype	$2,200,000	Water Power Manufacturing FOA	Pennsylvania
Project Description				
Pennsylvania State University will develop and demonstrate a low-head hydropower turbine and generator system prototype that combines lightweight, corrosion-resistant metallic components that can be produced through an additive manufacturing process. A monitoring tool that determines the health of the system and indicates when maintenance is necessary will also facilitate improved operation.				

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Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Percheron Power	Harnessing the Hydroelectric Potential of Engineered Drops	$1,495,427	Advanced Hydropower Technology Development FOA	Washington, Colorado
Project Description				
Percheron Power will install the nation's first Archimedes Hydrodynamic Screw hydropower system for demonstration and evaluation. The system may eventually be deployed at other low-head sites and manmade waterways like irrigation and wastewater channels. This project is also funded by the Department of the Interior.				
Project Recipient	**Project Title**	**DOE Funding Amount**	**Funding Source**	**Project Location**
Regents of the University of Minnesota	Turbine Aeration Physical Modeling and Software Design	$250,000	Advanced Hydropower Technology Development FOA	Minnesota
Project Description				
This project will develop a modeling tool to advance the development and implementation of aerating turbines at hydropower facilities to improve water quality. The project will combine a physical test bed with new analytical models for investigating how hydropower turbine blade shape and operation affect oxygen transfer and aeration.				
Project Recipient	**Project Title**	**DOE Funding Amount**	**Funding Source**	**Project Location**
Sacramento Municipal Utility District	Design and Construction Support for New Slab Creek Power House Project	$1,494,750	Advanced Hydropower Technology Development FOA	California
Project Description				
Sacramento Municipal Utility District plans to use power tunnels in a novel siting approach to develop a new small powerhouse downstream from the Slab Creek dam in order to utilize the increased minimum flows required during relicensing to support environmental quality and recreational boating.				
Project Recipient	**Project Title**	**DOE Funding Amount**	**Funding Source**	**Project Location**
Sacramento Municipal Utility District	Iowa Hill Pumped Storage Development	$4,961,138	Advanced Hydropower Technology Development FOA	California
Project Description				
This project is reducing risk and subsequent costs by conducting geotechnical investigations of the mountain where the Iowa Hill Pumped Storage project's water conveyance and powerhouse will be located. The project will also analyze the value of energy and ancillary services it will provide to better understand the value of advanced pumped storage for renewables integration. Both tasks are critical in reducing financial uncertainty of the 400 megawatt pumped storage project that will support integration of variable renewable energy resources, such as wind and solar in California.				
Project Recipient	**Project Title**	**DOE Funding Amount**	**Funding Source**	**Project Location**
Walker Wellington	W4E Hydropower Turbine Generator System Validation	$93,000	Advanced Hydropower Technology Development FOA	Maine, Massachusetts
Project Description				
Walker Wellington tested a direct-drive, modular turbine-generator for its applicability in manmade water structures with various head and flow conditions.				

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Table 1: FY 2008 – FY 2014 Hydropower Project Descriptions[a]

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Weisenberger Mills	Demonstration of Variable Speed Permanent Magnet Generator at Small, Low-Head Hydro Site	$56,000	Advanced Hydropower Technology Development FOA	Kentucky
Project Description				
Weisenberger Mills evaluated a variable-speed, permanent magnet generator for small low-head hydropower. The new technology increased efficiency by more than 50% by allowing the generator to respond to variations in water flow.				

Hydropower Funding Distribution

DOE funded 33 hydropower projects through the Water Power Program from FY 2008 to FY 2014. These projects are categorized in the following sections by activity area, topic area, geographic region and division, state, recipient type, and funding source.

Funding by Activity Area and Topic Area

The Water Power Program's R&D efforts fall under six major activity areas (see Table 2). The majority of the projects funded under these areas are aimed at reducing the technical barriers to hydropower device development, improving device reliability and performance, and enhancing the understanding and evaluation of various technology types. A smaller portion of Water Power Program funding is focused on reducing the time and costs associated with siting water power projects; better quantifying the potential magnitude, costs, and benefits of water power generation; and identifying and addressing other barriers to deployment.

Nearly 50% of WWPTO's hydropower funding for projects announced in FY 2008 to FY 2014 was directed at hydroelectric facility modernization through the American Recovery and Reinvestment Act of 2009 (Recovery Act). Modernization efforts are dominated by projects that increase hydropower facilities' generating capacity and improve plant and equipment efficiency. Alcoa, Incorporated was awarded more than $12 million for the modernization of the Cheoah Hydroelectric Facility—the largest hydropower award resulting from the Recovery Act.

Capacity and Efficiency Equipment Upgrades represents the largest activity area in terms of total funding, largely due to the FY 2009 Recovery Act FOA, "Hydroelectric Facility Modernization." Many of those projects have finished, however, so look for the Water Power Program to increase funding in the other five activity areas moving forward.

Table 2: FY 2008 – FY 2014 Hydropower Funding Distribution by Activity Area

Activity Area	Total Funding	Percent of Total
Capacity and Efficiency Upgrades	$29,850,599	47.8%
Advanced Generating Equipment	$11,415,531	18.3%
Grid Integration and Support	$9,414,113	15.1%
Workforce Development	$8,097,022	13.0%
Environmental Mitigation Technologies	$1,413,267	2.3%
New Generating Capacity	$2,308,436	3.7%
Total	**$62,498,968**	

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Funding by Geographic Region & Division

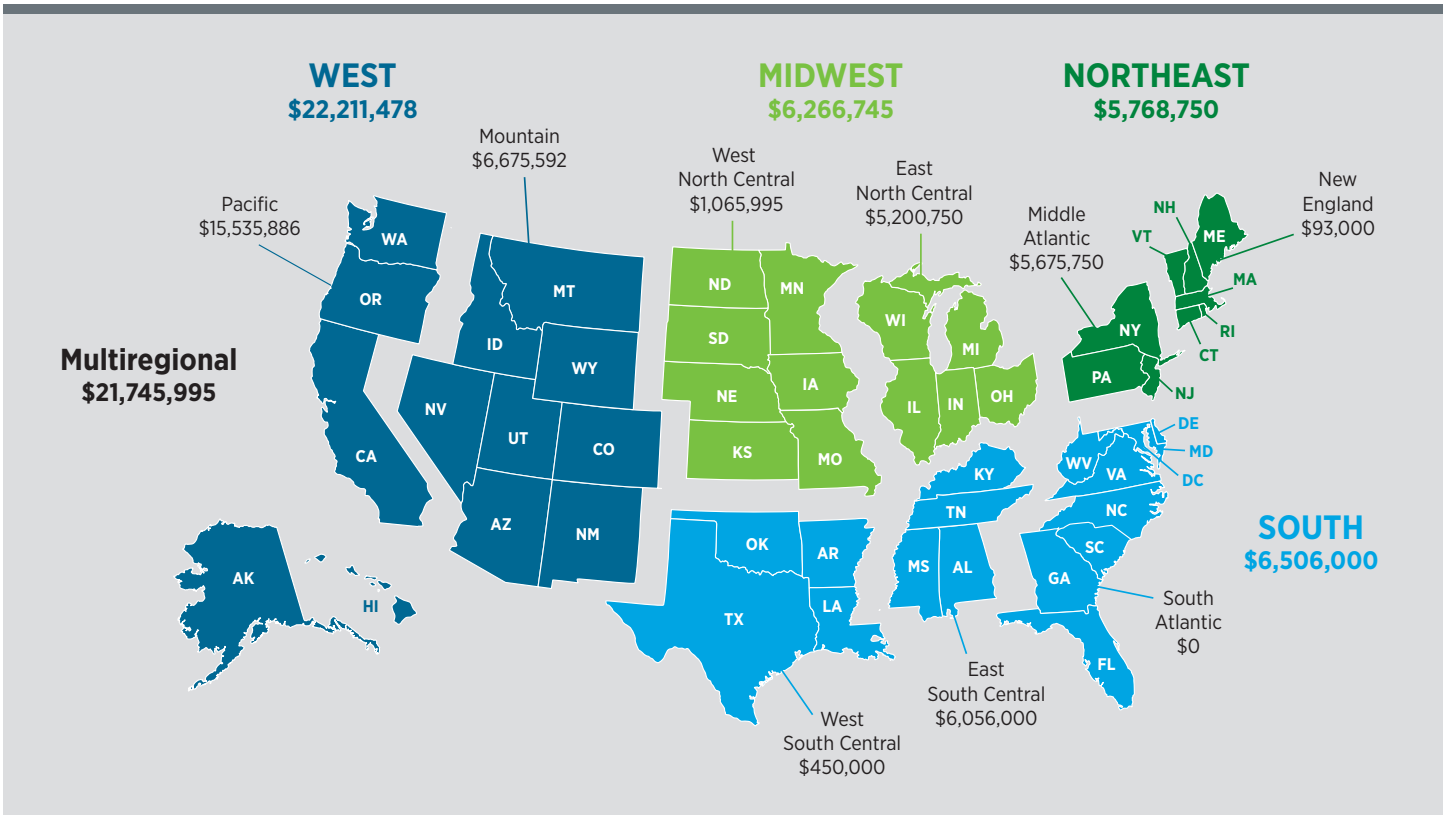
Hydropower projects were awarded in each of the country's four geographic regions. Table 3 provides details on how the Water Power Program's funding was distributed within regions and divisions. The geographic regions and divisions used to present the distribution of WWPTO's funding are based on the U.S. Census Regions and Divisions.[2] Six projects spanned several regions and divisions and are thus categorized as multiregional.

Exhibit 1 provides a map that shows how the Water Power Program's hydropower project funding was distributed throughout the United States.

Table 3: FY 2008 – FY 2014 Hydropower Funding by Geographic Region & Division

Region	Region Total Funding	Division	Division Total Funding
West	$22,211,478	Pacific	$15,535,886
		Mountain	$6,675,592
South	$6,506,000	East South Central	$6,056,000
		South Atlantic	$0
		West South Central	$450,000
Northeast	$5,768,750	Middle Atlantic	$5,675,750
		New England	$93,000
Midwest	$6,266,745	East North Central	$5,200,750
		West North Central	$1,065,995
Multi[b]	$21,745,995	Multi	$21,745,995
		Total	**$62,498,968**

Exhibit 1: FY 2008 – FY 2014 Hydropower Funding by Geographic Region & Division



[b] The multiregional category is not used in the U.S. Census Regions and Divisions. The multiregional category reflects WWPTO funding awarded to projects occurring across multiple divisions and regions.

Funding by State

Water Power Program funding for the 33 hydropower projects was distributed to projects in 15 states, with six projects listed as multi-state.

Two of the states with the largest individual shares were Pennsylvania and Washington, receiving a combined total of $13.1 million (or approximately 19% of total funding). Both had large projects funded by the Recovery Act and FOAs and are working to modernize hydroelectric facilities and develop advanced hydropower technologies. California was the state with the most funding not awarded a Recovery Act project, receiving nearly $8 million. The six projects that spanned multiple states account for 35% of total funding for hydropower projects. Table 4 outlines funding by state.

Table 4: FY 2008 – FY 2014 Hydropower Funding Distribution by State

State	Total Funding
Alabama	$6,000,000
Arkansas	$450,000
California	$7,869,249
Colorado	$1,480,000
Illinois	$3,000,750
Kentucky	$56,000
Maine	$93,000
Michigan	$2,200,000
Minnesota	$1,065,995
New Mexico	$4,857,656
New York	$475,750
Oregon	$1,200,000
Pennsylvania	$5,200,000
Utah	$337,936
Washington	$6,466,637
Multi[c]	$21,745,995
Total	**$62,498,968**

[c] The multi-state category reflects WWPTO funding awarded to projects occurring across multiple states.

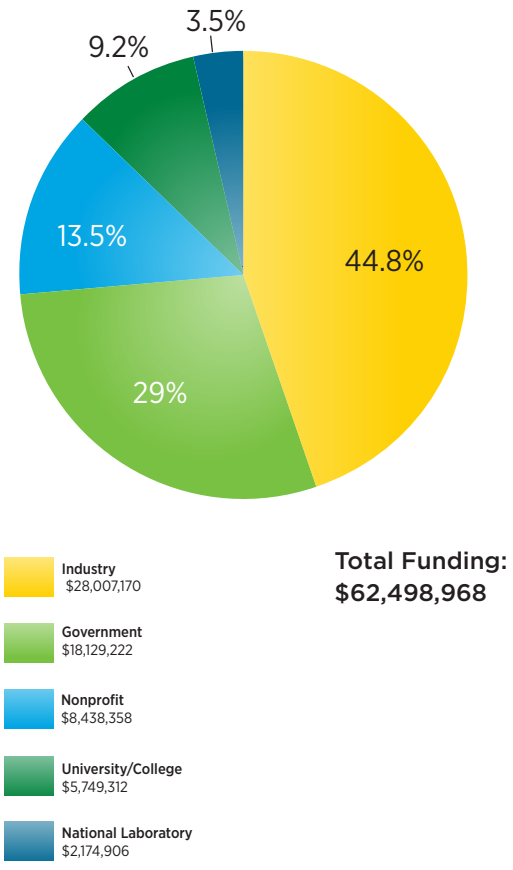
Funding by Recipient Type

DOE funds a variety of recipient types, including private industry, nonprofit organizations, universities and community colleges, investor-owned utilities and public utilities, local and state governments, as well as DOE national laboratories, other federal agencies, and interstate government agencies.

Nearly half of the total funding was awarded to private industry and nearly one-third to local governments or municipalities. The remaining funds were awarded to four nonprofit organizations, four universities, and two national laboratories. Exhibit 2 provides these details by recipient type.

The Recovery Act funding was split between private industry and local governments and/or municipalities. Private industry-led projects received nearly $19 million of the total $29.9 million, and local governments and/or municipalities received roughly $11 million in funding.

Exhibit 2: FY 2008 – FY 2014 Hydropower Funding Distribution by Recipient Type



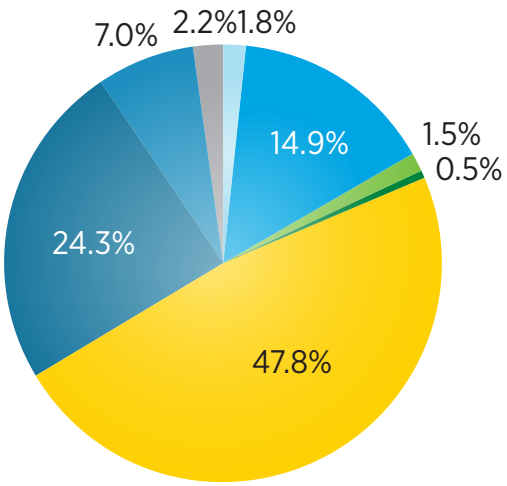
Industry projects awarded to private-sector companies dominate the Water Power Program's hydropower investment portfolio, representing 44.8%—$28 million of total funding.

Funding Sources

Exhibit 3 below provides details on the sources of funding for the Water Power Program's 33 hydropower projects awarded from FY 2008 to FY 2014.

Between FY 2008 and FY 2014, $31.4 million was awarded to 23 hydropower projects from Congressional Appropriations through five Water Power Program FOAs. An additional $1.3 million was awarded to three hydropower projects through Congressionally Directed funds, and $29.9 million was awarded to seven projects from the Recovery Act through one FOA.

Exhibit 3: FY 2008 – FY 2014 Funding Sources for Hydropower R&D Projects



FOA 50.2%

- **Advanced Water Power Projects FOA**
  $1,113,361
  Number of Projects: 1
- **Advanced Water Power FOA**
  $9,325,000
  Number of Projects: 3
- **Advanced Hydropower Technology Development FOA**
  $15,170,575
  Number of Projects: 15
- **Water Power Manufacturing FOA**
  $4,400,00
  Number of Projects: 2
- **University Research Awards and Workforce Development for Hydropower FOA**
  $1,349,997
  Number of Projects: 2

CDP 2.1%

- **FY09 CDP**
  $951,500
  Number of Projects: 2
- **FY10 CDP**
  $337,936
  Number of Projects: 1

Recovery Act 47.8%

- **Hydroelectric Facility Modernization**
  $29,850,599
  Number of Projects: 7

Total Funding: $62,498,968
Total Number of Projects: 33

Accomplishments

The Water Power Program provided approximately $62.5 million in funding for hydropower projects from FY 2008 to FY 2014, with numerous projects operating over multiple years. The Water Power Program made significant key accomplishments in increased hydroelectric generation and equipment efficiency; advanced turbine development; support for hydropower research fellowships and professional opportunities; environmental benefits for fish populations; and research to support hydropower integration with the transmission grid.

Highlighted accomplishments include the following:

- Two innovative, cost-reducing low-head hydropower projects went online for start-up testing in April 2015, with power production operations to follow. Natel Energy of California and Earth by Design of Oregon used advanced materials and manufacturing techniques in the development of these projects, which operate with a change in elevation between 2 and 20 meters. According to Energy Department assessments, there is a technical resource potential of more than 50 gigawatts of capacity at low-head sites. These projects will demonstrate the ability to develop low-head hydropower across the United States at an affordable rate. The Natel Energy project is co-funded by the Department of Interior.
- With DOE support, Weisenberger Mills, a century-old operational gristmall in Kentucky, performed system testing of an innovative generator technology that promises to improve the power generating efficiency of small low-head hydropower sites. These sites tend to have low overall efficiencies as most turbines and generators are unable to respond well to significant water level variations caused by stream flows. Weisenberger Mills tested and evaluated a variable-speed generator technology for small low-head hydropower, and found that it increased efficiency by more than 50 percent. This generator technology may help make the development of thousands of small low-head hydropower sites feasible with its higher efficiency levels and simpler installations. The new generator will also allow water from the mill's creek to provide all of the mill's power needs.
- The Electric Power Research Institute designed the Alden Fish-Friendly Turbine to support the development of more efficient and environmentally friendly hydropower turbines that can compete with traditional designs. The turbine was designed to reduce fish mortality while generating at efficiencies equal to or better than conventional Francis turbines. After extensive modeling and testing, the Alden turbine is now ready for installation and testing at a hydroelectric plant, and efforts are under way to find an industry partner to accomplish this next step.

End Notes

[1] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind and Water Power Program, Water Power for a Clean Future, DOE/GO-102011-3287. June 2011. http://water.energy.gov/pdfs/51315.pdf

[2] Energy Information Administration, U.S. Census Regions and Divisions. June 14, 2000. http://www.eia.gov/emeu/recs/census_map.html

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