U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# Water Power Technologies Office 2017 Marine Energy Accomplishments

*Photo courtesy of Northwest Energy Innovations*

## What We Do

The Water Power Program funds early-stage research and development to advance the state of the art within hydropower and marine energy, enabling industry to develop and deploy new technologies for commercial applications. The office's goal is to deliver low-cost, reliable power and resiliency to the nation's electricity grids—which will benefit Americans from coast to coast.

WPTO invests in early-stage research to accelerate development of innovative water power technologies while ensuring that long-term sustainability and environmental issues are addressed.

WPTO supports efforts to validate performance and grid reliability for new technologies, develop and increase accessibility to necessary testing infrastructure, and evaluate systems-level opportunities and risks.

WPTO aggregates, analyzes, and disseminates relevant, objective, technical information on water power technologies and related issues to stakeholders and decision makers.

The U.S. Department of Energy's (DOE's) Water Power Technologies Office's (WPTO's) marine and hydrokinetic (MHK) portfolio has numerous projects that support industry advancement in wave, tidal, and ocean and river current technologies. In order to strengthen state-of-the-art technologies in these fields and bring them closer to commercialization, WTPO funds industry, academia, and the national laboratories. A U.S. chapter on marine and hydrokinetic energy research and development was included in the Ocean Energy Systems' Technology Programme—an intergovernmental collaboration between countries, which operates under a framework established by the International Energy Agency. This brochure is an overview of the U.S. accomplishments and updates from that report.

## Who We Work With

WPTO works with industry and national laboratories to advance water power development and deployment. Three laboratories support the majority of our marine renewable energy research: the National Renewable Energy Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories.

DOE also supports three university-led National Marine Renewable Energy Centers (NMRECs) in the Pacific Northwest, the Southeast, and Hawaii, each with unique research and testing capabilities for supporting the development of new marine energy technologies.

NREL National Renewable Energy Laboratory

Pacific Northwest National Laboratory

Sandia National Laboratories

FAU SNMREC Southeast National Marine Renewable Energy Center Florida Atlantic University

NNMREC Northwest National Marine Renewable Energy Center

HNEI Hawai'i Natural Energy Institute University of Hawai'i at Mānoa

# 2017 MHK Program Updates

### FUNDING MARINE ENERGY TECHNOLOGIES

In June 2017, WPTO announced up to $12 million to support the development of novel technologies capable of generating reliable and cost-effective electricity from U.S. water resources. This Funding Opportunity Announcement supported research in Wave Energy Converters (WECs) System Advancement and Marine Renewable Energy Technology Development.

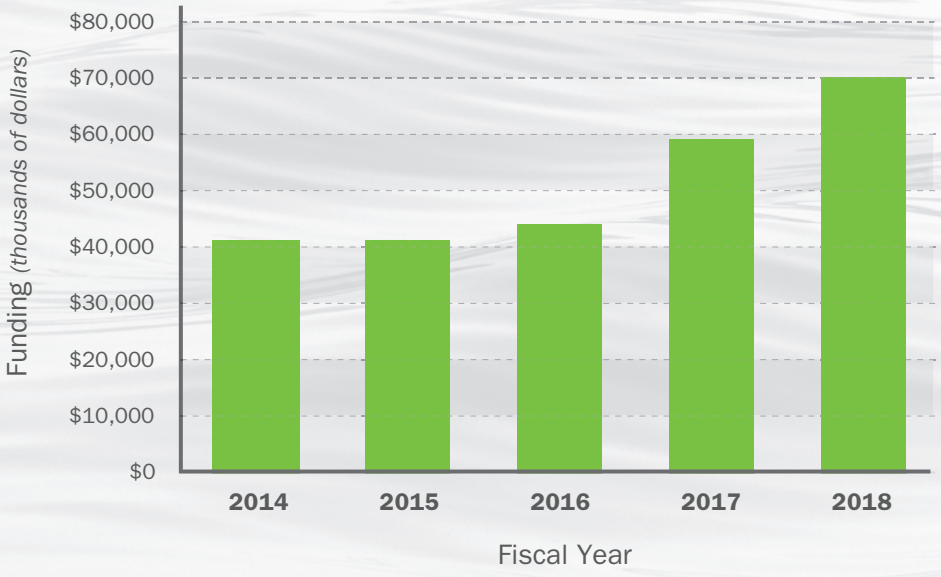
There were four awards in total. **AquaHarmonics** and **California Wave Power Technologies** were each awarded funding to advance their designs and conduct open-water testing. **Portland State University** was awarded funding to develop a multistage, magnetically geared generator specific to marine renewable energy devices. **ReVision Consulting** will be researching accurate wave-prediction technology for WEC device controllers, which will help WECs more efficiently convert wave energy into electricity.

The National Renewable Energy Laboratory deployed two buoys off the coasts of Oregon and Maine in 2017.
*Photo courtesy of the National Renewable Energy Laboratory, 25664*

### SUPPORTING FOUNDATIONAL MARINE RENEWABLE ENERGY RESEARCH

WPTO supports national laboratories and university partners to conduct early-stage, high-risk R&D to broadly benefit multiple device developers and technology types. This includes research at three National Marine Renewable Energy Centers (NMRECs) that have unique capabilities to address the most pressing marine energy technology development questions.

As an example of recent research, the **Northwest National Marine Renewable Energy Center** (NNMREC), a joint program between Oregon State University, the University of Washington, and the University of Alaska Fairbanks, conducted several laboratory experiments in 2017 with cross-flow turbines. These experiments revealed a potential 58% increase in generation efficiency for a single turbine when machine learning was applied to the control strategy for multiple cross-flow turbines in a dense array configuration. Also in 2017, NNMREC environmental researchers used machine learning paired with an integrated instrumentation system to detect and classify marine animals in imagery data, in real time, and at wave and current energy sites. This allowed researchers to record and study only those moments of interest when wildlife are present at the sites, drastically reducing the amount of low-value data they would have otherwise collected.




*Water Power Technologies Office–MHK Program funding from 2014-2018*

In May 2017, the **National Renewable Energy Laboratory** completed deployment of two buoys outfitted with high-accuracy sensors to record wave and tidal movement off the coasts of Oregon and Maine, areas known to be potential hot spots for marine energy development. The work is part of a larger project that will analyze wave and tidal energy sites with great development potential and gather data to validate the computer modeling tools that industry uses to design devices. The project is funded by DOE and implemented with **Sandia National Laboratories** and **Pacific Northwest National Laboratory.**

### DEVELOPING A NEW STRATEGY

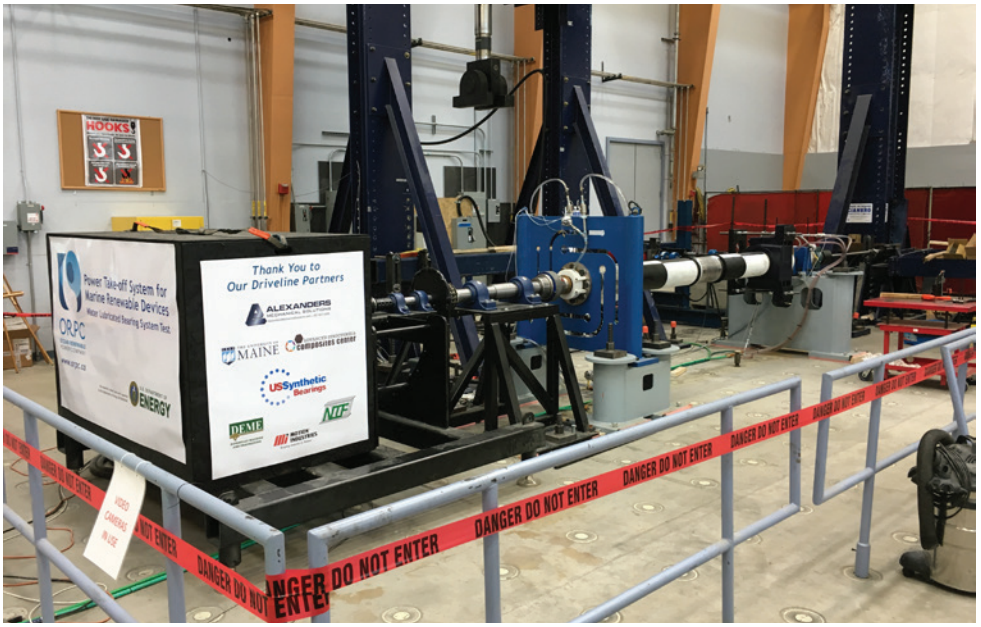
In 2017, WPTO's MHK Program solicited a second request for information from stakeholders in its effort to develop, update,

and publish a new Program Strategy for Marine and Hydrokinetics R&D. This Strategy has been developed through multiple rounds of feedback and discussion with industry, academia, government staff, and other stakeholders. The WPTO Strategy would cover the time period from present to 2035, but would also be updated every 4–5 years to reflect changes in research needs, priorities, and challenges faced by the industry.

### EXPLORING NEW APPLICATIONS FOR MARINE ENERGY TECHNOLOGIES

Many existing marine energy applications focus on supplying power to the nation's grid. However, WPTO has increased its attention on potential applications for marine energy technologies in other maritime markets, such as powering ocean observation networks or offshore aquaculture farms, recharging underwater vehicles, or desalinating seawater. Generating reliable, cost-effective energy for these maritime markets can open up new scientific, military, and commercial opportunities while providing critical revenue and in-water experience to advance marine energy technologies.

In December 2017, WPTO organized and hosted a three-day **Distributed and Alternate Applications for Marine Renewables Forum** in Washington, D.C., to investigate alternate applications and markets for marine energy beyond grid-scale power. The forum attracted a broad range of stakeholders from the marine renewable energy industry, academia, defense, and the national labs in addition to market-specific subject-matter experts. The information collected during this forum will help guide WPTO's activities and strategy. The report will be open for public comments during 2018.




A specialized bearing system and driveline components underwent full-scale testing in 2017.
*Photo courtesy of ORPC, Inc.*

## 2017 Project Updates and Select Results

### DEVELOPING A NATIONAL WAVE ENERGY TEST FACILITY

WPTO awarded **Oregon State University** and its partners $35 million to design, permit, and construct a new wave energy test facility off the coast of Newport, Oregon. In July 2017, detailed negotiations for the development and operation of the site concluded, paving the way for a detailed design of the site and eventual construction.

Following construction, this site will serve as the national test facility for evaluating full-scale WEC device performance, environmental interactions, and survivability, complementing the test capabilities of the nearby Pacific Marine Energy Center. The test facility site plans to host a utility-scale grid connection from shore to four separate ocean test berths located in water 65 to 78 meters deep. The National Wave Energy Testing Facility will be permitted for concurrently testing up to 20 WECs, which will be useful for array validation testing.

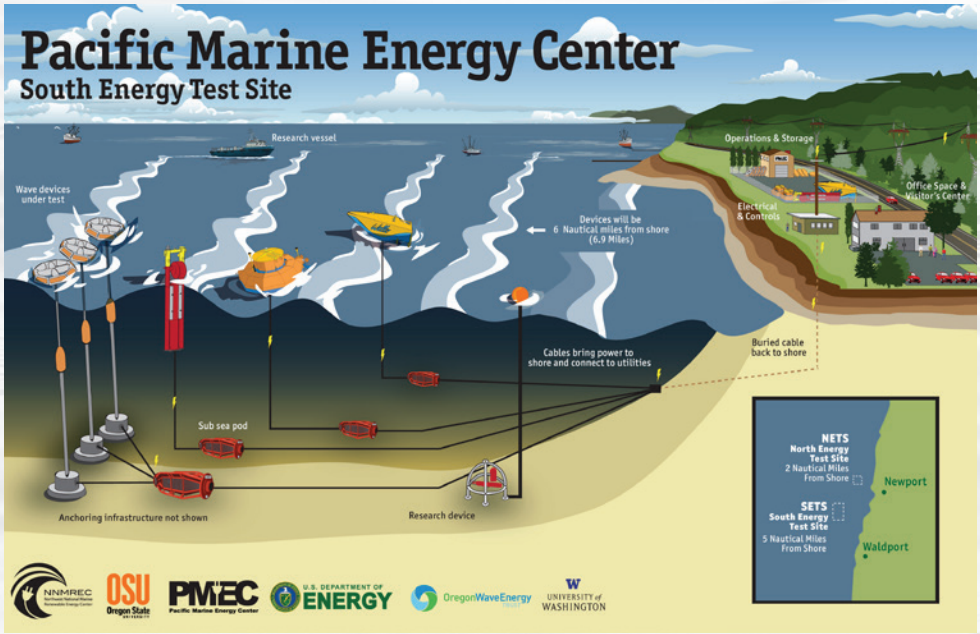


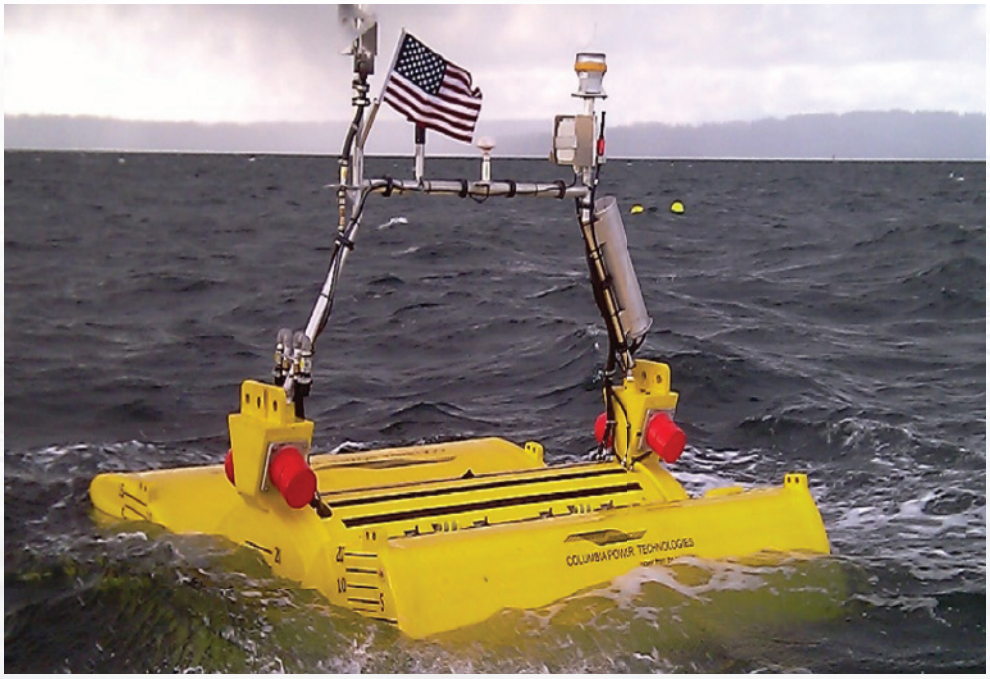

Illustration of the new Pacific Marine Energy Center test facility off the Oregon coast.
*Illustration courtesy of Oregon State University*

### IMPROVING POWER TAKE-OFF SYSTEMS

In summer 2017, **ABB Group**, **Texas A&M's Advanced Electrical Machines Lab**, and **Resolute Marine Energy** developed and tested an integrated magnetic-gear generator. This advanced design improves power take-off systems for wave energy converters. After testing a 10-kW prototype, results indicated that the generator could be ideal for low-speed, high-torque applications like wave energy, or even tidal and wind. The prototype was part of a DOE-funded project to research direct-drive generators that could eliminate hydraulic components in some wave energy power take-off systems.

### REDUCING WEC FAILURE RATES

In June 2017, **Ocean Renewable Power Company** completed full-scale testing of a specialized bearing system and associated driveline components. The research was funded by WPTO and was completed in collaboration with the University of Maine. This is the first phase of the project, and future phases will focus on developing a more robust electrical generator to reduce failure rates.




Shown here is an example of a direct-drive wave energy system.
*Photo courtesy of Columbia Power Technologies*

## PARTNERING WITH THE NAVY TO TEST ADVANCED WAVE ENERGY CONTROLS

In August 2017, Sandia National Laboratories tested advanced controls on a WEC at the **U.S. Navy's Maneuvering and Seakeeping (MASK) Basin** in Bethesda, Maryland, in conjunction with the U.S. Navy. This testing supports Sandia's research into control algorithm development, numerical simulation, and future model testing to increase the power output of WEC devices. The Navy's MASK Basin, used in the finals of the Wave Energy Prize, has a state-of-the-art wave-maker that can generate precise waves for hours. This allows researchers to quickly test and see the response of the converter's control systems under numerous wave conditions.

## GUIDING INTERNATIONAL OCEAN ENERGY STANDARDS

WPTO is a supporting body of the U.S. Technical Advisory Group (TAG) to the International Electrotechnical Commission (IEC) Technical Committee (TC) 114. The **IEC TC 114**, through the collaboration of 26 member countries, is developing engineering and design standards that will define the international requirements for all ocean energy devices in the future, helping to streamline device certification and commercialization. The TC has published eight Technical Specifications since its inception in 2008, which are now beginning to be used by industry in project and device development. In 2017, the U.S. TAG held its annual meeting in Honolulu, Hawaii, where members discussed the status on the committee's specifications. More information can be found at: http://www.tc114.us/

## ASSESSING ENVIRONMENTAL EFFECTS

During 2017, the United States continued its lead role on Annex IV of the International Energy Agency—Ocean Energy System's **Assessment of Environmental Effects and Monitoring of Marine Renewable Energy Technologies** project. Annex IV is a 10-year, multiphase project that was established in 2010 to examine the environmental effects of marine energy development and is currently in its third and final phase. The Pacific Northwest National Laboratory (PNNL) is the implementing body for the United States' involvement in Annex IV and coordinates the online knowledge management system Tethys (*http://tethys.pnnl.gov/*). In 2017, PNNL focused on public outreach and data dissemination and in support of this, hosted four webinars and two workshops that attracted several hundred stakeholders.

This information is a summary of the U.S. chapter in the 2017 International Energy Agency—Ocean Energy Systems Report (https://report2017.ocean-energy-systems.org/).


The OE Buoy is designed around the oscillating water column principle. Its turbine captures the energy of the wave and the generator converts this energy to electrical power. A full-scale commercial prototype will have a capacity rating of 1.75 MW.
*Photo by Ocean Energy Limited*

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For more information, visit: energy.gov/eere/water

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