

2.1.4.420 – Waves to Water: A Desalination Prize



Scott Jenne

National Renewable Energy Laboratory

Dale.Jenne@nrel.gov

July 21, 2022

NREL/PR-5700-83359

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08G028308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Water Power Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

Project Overview

Project Summary

The Waves to Water Prize was launched in 2019 with the purpose of creating solutions to pair wave energy power with desalination, with a specific focus on remote and islanded communities. The Waves to Water Prize administered \$3.3 million in prizes over five stages to accelerate the development of small, modular, wave-powered desalination systems capable of providing potable drinking water in disaster relief scenarios and remote coastal locations. The prize supported the integration of existing and novel wave energy generation technologies with water technologies that can deliver effective, consistent, durable, and low-maintenance water delivery systems.

Intended Outcomes

[As part of the Water Power Technologies Office's \(WPTO's\) Powering the Blue Economy initiative, the Waves to Water Prize contributes to building resiliency in coastal locations](#) by accelerating technological advancement in small, modular, wave energy-powered desalination systems. The prize emphasized early-stage marine energy research and produced some of the first wave-powered desalination prototypes ever to be deployed.

Project Information

Principal Investigator

- Scott Jenne

Project Partners/Subs

- Coastal Studies Institute (CSI)
- Engineering for Change
- Army Corps of Engineers
- International Desalination Association (IDA)
- Janicki Industries
- Chromosphere Studios
- Greater Houston Community Foundation

Project Status

Sunsetting

Project Duration

- January 2019
- September 2022

Total Costed (FY 2019–FY 2021)

\$4,048,000

Project Objectives: Relevance

Relevance to Program Goals:

- The Waves to Water (W2W) Prize touches on all three of the marine energy program's R&D priorities:
 - Foundational R&D:
 - The W2W Prize incentivized the development of small, modular, wave-powered desalination systems. This project required applicants to leverage numerical modeling tools; look at advanced materials that can be easily packaged, transported, and assembled; and evaluate performance metrics that can quantify the performance of electricity-producing and non-electricity-producing systems.
 - Technology-specific system design and validation:
 - Throughout the prize, contestants were required to prototype components and subsystems prior to performing in-water testing at a scale that is beneficial for coastal community applications.
 - Reducing barriers to testing:
 - The final stage of the prize was an in-water test, and all four contestants that made it to the final event were teams that had not received WPTO funding before, and only one of the teams had prior in-water experience outside of the prize.

Project Objectives: Relevance

Relevance to PBE Goals:

Powering the Blue Economy

- To understand end-user needs and quantify the value of marine energy in emerging ocean markets uniquely suited to marine renewable energy technology
 - Throughout the prize we continued discussions with end users as well as developed a sub-contract with Engineering for Change (E4C) to quantify near-term, small-scale, desalination opportunities.
- To accelerate marine energy technology readiness through near-term opportunities, supporting WPTO's marine renewable energy strategy and mission
 - Primary objective was to accelerate the development of smaller scale WEC technologies that are aligned with a near-term opportunity.
- To enable broader blue economy goals by developing solutions to meet energy challenges facing private and public sector blue economy partners, including unlocking the potential of new ocean-enabled technologies; enhancing scientific capabilities in the ocean; and developing resilience in remote, coastal, and island communities.
 - 4 industry developed prototypes and 1 lab developed prototype were designed and built to expand on this goal.

Project Objectives: Approach

Approach:

- When planning the prize, the team leveraged lessons learned from the Wave Energy Prize as well as desalination R&D performed at NREL to inform the technical challenges this prize could address. A couple key takeaways informing the prize were:
 - Prizes tend to focus teams on winning and competition often to the detriment of taking big technology risks that may more effectively advance the technology area or provide non-incremental innovation.
 - Prizes are highly effective at public engagement and building a community around an issue: Making a prize publicly-facing provides a great opportunity to draw interest and attract new solutions.
 - Single metrics are easily gamed: The team developed a series of competing metrics and category prizes to encourage a diversity of technology and market approaches.
- The structure of the prize incentivized the development of systems that met a series of technology development goals: (1) flexibility in varied wave conditions; (2) easily deployed; (3) ship in a standard container; (4) operate without environmental degradation; and (5) deliver minimum water quality and;
- These systems could be evaluated at a publicly-accessible event where teams had to compete for metrics directly related to the technology development goals and the eventual demonstration of wave powered desalination systems, such as most water production, cleanest water, lightest weight, fastest assembly/installation, and a grand prize consisting of a combined water volume, water cleanliness, and a commercialization pitch.

Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- 65 concept designs were submitted, 10 lab/water prototypes were evaluated in the CREATE stage, and 4 prototypes were successfully installed at Jennette's pier on April 3rd
 - All 4 devices produced drinkable water.
- Additionally, the prize saw 66 design submission designs through 10 validated prototypes prior to the Drink Stage.
- NREL designed, built, and tested an open-source WEC to validate installation techniques and serve as an R&D platform for future R&D efforts.
- Developed a network of partners for the competitors to support commercialization after the prize.
- Several other products were developed for community outreach:
 - Comic book aimed at elementary students
 - Public facing events to engage the public in the device designs and deployments
 - Numerous partnerships (Coastal Studies Institute, International Desalination Association, Janicki Industries, Engineering for Change, Army Corps, WoodNext Foundation)



Outcomes:

- Desalination provides a near-term learning opportunity without the necessity of multi-MW installations allowing for significantly smaller dollar investments.
 - Specific R&D focal points:
 - Power quality (i.e. mitigating fluctuations) required by desal systems
 - Smaller units (< 10kW) can still produce meaningful value for water stressed regions when producing water
 - Accelerated learning for marine ops and installation, including design for installation and commissioning
 - As the technology matures there are opportunities to both scale up the technology as well as transfer learning to other markets (e.g. Grid, Municipal Water, etc.)
- The primary objective of a public facing event was to provide community engagement to demonstrate that wave energy can be used for other applications outside of grid tied electricity production.
 - Numerous news outside news articles picked up the story
 - 100+ people registered/ ~200 attended the W2W open house in Nags Head
- The personal connection to drinking water was regularly stated as an area of interest throughout the prize planning process.

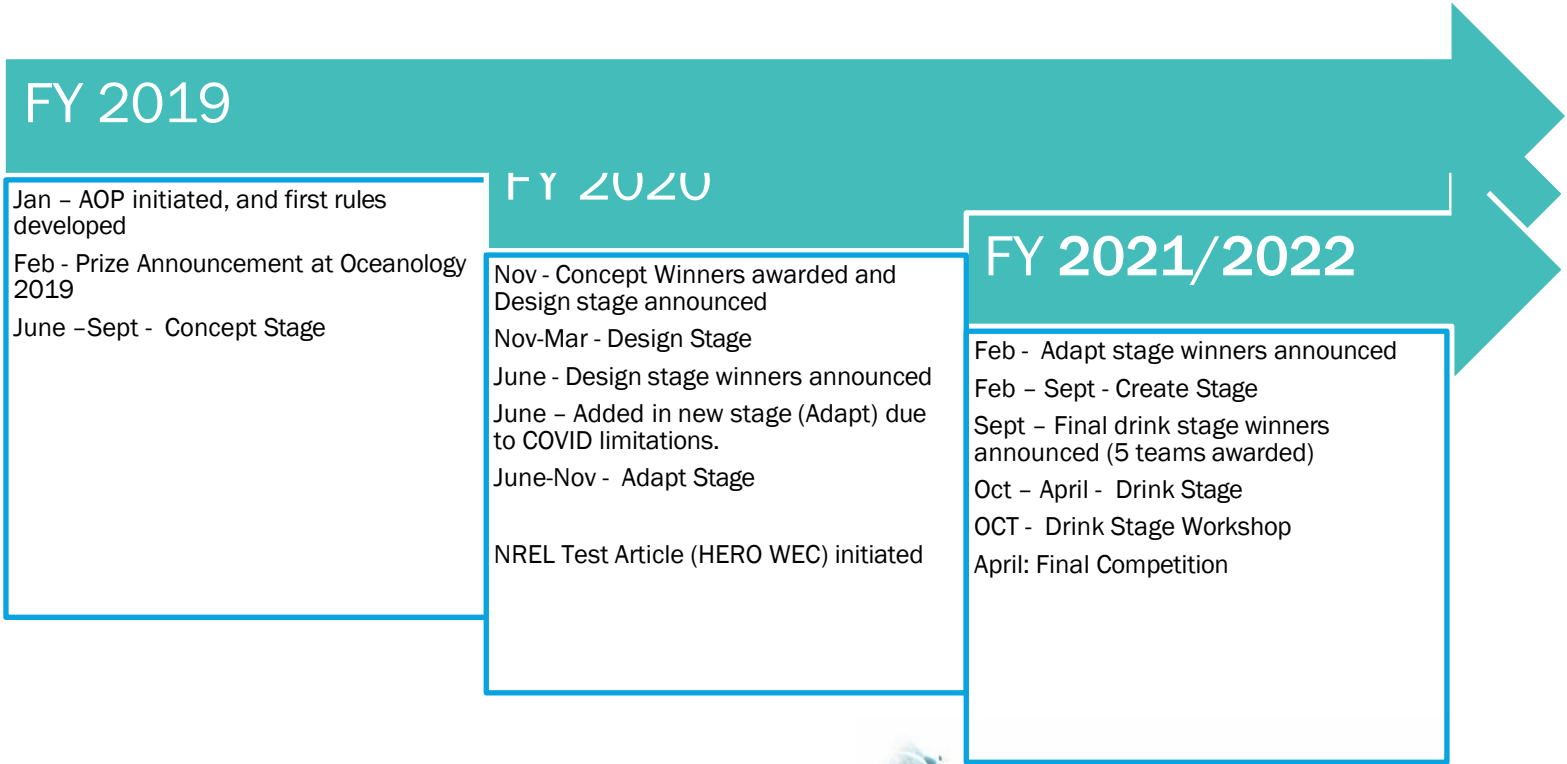
Project Timeline

Critical Milestones:

- 3/31/2019 – Team held an in-person workshop with key stakeholders in the desalination, wave energy, and coastal resiliency communities to shape rules document.
- 7/31/2019 – Go/No-Go after close of first phase to determine if the prize should continue based on initial applications.
- 6/30/2020 – Testing site identified, and CSI team established as key partner.
- Numerous Awards distributed – 5 milestones reflecting award distribution, another 5 for release of new stages and rules documents.
- Final Design Review: January 2022

Additional Notes on Project Management approach

- Throughout the project the prize team held regular weekly meetings (NREL/WPTO) along with several working meetings for rules document refinement, judge determination, assessment of reviews, etc.
- NREL brought on additional project management support throughout the project as additional scope was added
- Numerous tasks added to the life of the project
 - Comic book
 - HERO WEC design, fabrication, and testing
 - Partnerships for outreach, team support, etc.



Project Budget

Total Project Budget – Award Information		
DOE	Cost-Share	Total
\$7,250,000 (including FY 2022)	\$0	\$7,250,000 (including FY 2022)

FY 2019	FY 2020	FY 2021	Total Actual Costs FY 2019–FY 2021
Costed	Costed	Costed	Total Costed
\$184,000	\$1,644,000	\$2,222,000	\$4,048,000

- Scope was added to the project to include the Spark Squad comic book, addition of an X-band radar installation on the pier through the Army Corps, and team support with Engineering for Change.
- The most notable change was the addition of the ADAPT stage in response to the COVID-19 pandemic. This added an additional year to the prize to ensure teams had the adequate resources to stay engaged and provide opportunities to design site-specific changes into their submissions.

End-User Engagement and Dissemination

- Intentionally designed to attract innovators new to marine energy as well as existing marine energy and desalination researchers
 - Concept stage – 60 eligible submissions representing 9 from academia, 21 from industry, and 30 individual applicants.
 - 14/20 of the Concept Stage teams that received funding had not received funding from WPTO prior to W2W.
- W2W targeted entrepreneurs bridging both wave energy and desalination. Teams developed strategic partnerships to bring these skillsets together (example team : Univ of Hawaii, Indian Institute of Technology, Uppsala University)
- The team developed partnerships with a range of organizations that provided direct support to teams (financial and in-kind) and prize outreach.
- All the prize stages were publicly announced through WPTO and NREL press releases, HeroX, and direct communication with teams.
- The near-term deployment opportunities from this prize have provided new learnings for future marine energy deployments and critical areas for future R&D, aiming to improve the long-term cost reduction pathways for marine energy.
- Prize has been instrumental to ongoing focus on end-users, specifically government missions and procurement at FEMA, Navy, and USAID – aiming to build direct R&D partnerships



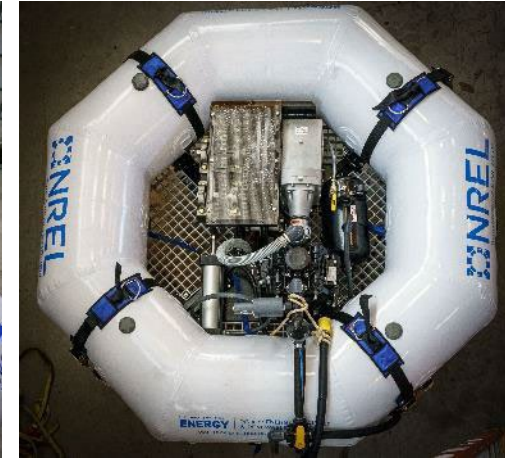
Performance: Accomplishments and Progress

- 4 WECs successfully deployed in one day, all produced drinkable water
 - No other WPTO funded project has achieved multiple WEC deployments in a single deployment day, regardless of size/scale.
 - No other WPTO funded project has produced desalinated water from seawater using only wave energy.
- 2 of the 4 competitors leveraging inflatable materials, a first for WPTO
 - 13 of the 20 that made it to DESIGN leveraged inflatables.
- Numerous R&D priorities highlighted:
 - Shallow water wave dynamics
 - Limitations of off-the-shelf power electronics and hydraulic equipment
 - Lack of marine grade off-the-shelf components necessary for early-stage prototyping.
- First of its kind comic book in partnership with Chromosphere
- Development of the sponsorship mechanism to accept financial and in-kind support from external organizations
- First major PBE investment and strongly influenced DOE's Water Security Grand Challenge



Performance: Accomplishments and Progress (cont.)

- NREL designed, built, and tested HERO WEC (Hydraulic and Electric Reverse Osmosis Wave Energy Converter)
 - Open-source WEC design will reduce barrier to entry for subcomponent and WEC R&D.
 - First-of-its-kind modular WEC quickly adapts to produce electricity or pump water.
 - HERO WEC will serve as an additional research asset for WPTO.
- Numerous media outlets picked up the W2W story (not a comprehensive list):
 - *CleanTechnica* – [Link](#)
 - *Coastal Review* – [Link](#)
 - *Hydro Review* – [Link](#)
 - *Offshore Energy* – [Link](#)
 - *Scientific American* – [Link](#)
 - *The Virginian-Pilot* – [Link](#)



Future Work

- Follow on HERO-WEC deployment (August 2022)
- Prize outputs are currently being used to determine future R&D opportunities.
- Prize Lessons Learned to inform future prize planning.
- Developing HSE standard for future marine deployments

Q&A