Hawai‘i Natural Energy Institute Research Highlights

Ocean Energy

The Hawai‘i Wave Surge Energy Converter (HAWSEC)

OBJECTIVE AND SIGNIFICANCE: The objective of the Hawai‘i Wave Surge Energy Converter (HAWSEC) project, funded primarily by the U.S. Department of Energy (DOE), is to mature a wave energy converter (WEC) concept developed by the HNEI-led team, that could ultimately produce cost-effective renewably generated electricity for coastal communities. The project is expected to make important advances in the emerging wave energy field and has the potential to mature a technology with realizable commercial potential in the future for Hawai‘i, the U.S., and beyond.

BACKGROUND: HNEI has been involved in supporting research and testing objectives at the U.S. Navy's Wave Energy Test Site (WETS), off Marine Corps Base Hawai‘i, since 2010 with funds from both DOE and the U.S. Navy (Naval Facilities Engineering Systems Command, NAVFAC). Through this involvement, HNEI has gained valuable practical experience associated with real-world deployment and operation of WECs in this first-of-its-kind in the U.S. grid-connected test site. Additionally, through numerical modeling of WEC dynamics and mooring systems in support of WETS test objectives and WEC developers, HNEI has accumulated key design insights and numerical modeling expertise related to WEC design.

The HAWSEC concept is based on the oscillating wave surge converter (OWSC), or flap-type WEC. Such systems rely on the surge motion of the waves close to shorelines, where wave direction becomes more consistent than offshore. The flap moves back and forth in the waves and drives hydraulic cylinders to pump water through a hydro turbine to generate electricity. Its inherent scalability could support smaller-scale generation for isolated communities or islands, or larger-scale devices (likely deployed in arrays) to generate power to feed into coastal power grids. The small-scale version of the flap is shown in Figure 1.

We are exploring both a high-head/low-flow and a low-head/high-flow hydraulic system – utilizing the same flap in the first half of the project – ultimately settling on an optimized configuration with a hydro turbine selected to best align with the optimized head and flow before scaling up for additional testing in the latter stages of the project.

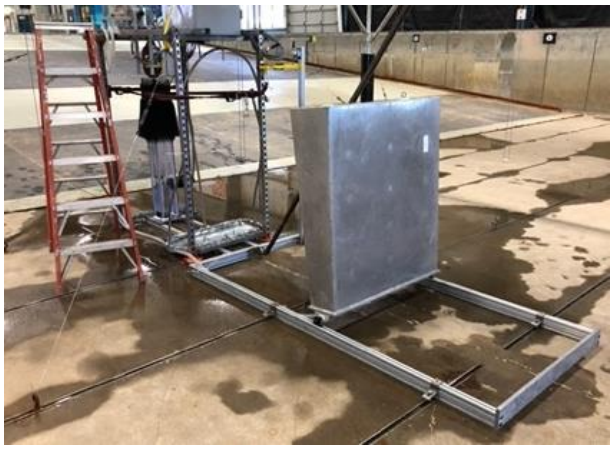

Figure 1. HNEI's HAWSEC system in Oregon State University's wave basin for testing.

PROJECT STATUS/RESULTS: This project was initated in August 2020. HAWSEC development is proceeding along the following broad set of tasks:

1. Numerical modeling of small-scale version, nominally a 1m x 1m flap, to optimize design;
2. Fabrication and local testing of the small-scale system, both the hydraulic system and the flap itself, in nearshore waters on O‘ahu;
3. Controlled tank testing of the small-scale system at Oregon State University's (OSU) Hinsdale wave basin;
4. Validation of numerical modeling with test results from OSU;
5. Numerically scaling up to medium scale, nominally a 3m x 3m flap, and completing a buildable design of the HAWSEC at this scale;
6. Undergoing a Go/No-Go decision with DOE;
7. Fabrication of the power takeoff (PTO) for a medium scale system;
8. Laboratory testing of the medium-scale PTO; and
9. Validation of medium-scale numerical models with test data, and modeling and performance prediction for a full-scale version of HAWSEC.

A hydraulic bench test setup was completed in our lab on the UH campus in early 2022, including a linear actuation system that is capable of simulating realistic wave forcing. Lab testing was carried out between January and May 2022, resulting in readiness to ship the full system to Oregon for wave basin testing at OSU.

Nearshore testing of the flap in local waters at Makai Research Pier was conducted in May 2022 (Figure 2), with encouraging results that further de-risked the upcoming basin tests.

Figure 2. Flap testing at the Makai Research Pier.

Controlled wave basin testing at OSU was completed in two phases, without and with a power takeoff (hydraulic) system, in June and October/November 2022 (Figure 3). Excellent results were obtained, particularly for the high-head PTO, where the power produced exceeded expectations. Due to this, the high-head PTO – in which a hydraulic cylinder pumps water at high pressure through a nozzle to rotate a Pelton wheel turbine – is the selected approach for the second phase of the project, where the device will be scaled up in size with the goal of conducting subsequent testing and validation.

Figure 3. Controlled wave basin testing at OSU.

In February 2024, we successfully got through the Go/No-go decision from DOE. While there have been some administrative and process delays, the work under the second budget period has begun, with the project expect to wrap up in early 2026.

This extended timeline stems from substantial procurement challenges in Budget Period 1 and a shipping-related setback, which cost the project several months. Despite these delays, the project is meeting its technical objectives and has resulted in a WEC concept that is of high interest to DOE and to our partners at the National Renewable Energy Lab, who are now working with us on a new project that is utilizing our small-scale flap for a PTO development of their own and subsequent deployment at Makai Pier, which is expected to begin in summer 2025.

Funding Source: U.S. Department of Energy; Energy Systems Development Special Fund

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Last Updated: November 2024