Hawai‘i Natural Energy Institute Research Highlights

Ocean Energy

Hawai‘i Marine Energy Center (HMEC)

OBJECTIVE AND SIGNIFICANCE: The objective of the Hawai‘i Marine Energy Center (HMEC) is to advance and promote marine energy solutions for Hawai‘i and the islands of the Pacific. The team’s intent is to develop HMEC as a regional hub for marine energy expertise in the National Marine Energy Center (NMEC) framework that the U.S. Department of Energy (DOE) has established.

These efforts include expanding HNEI’s earlier wave energy research efforts, establishing new research tasks, enhancing testing capabilities, strengthening communications and outreach related to marine energy, and establishing new marine energy test facilities and infrastructure to complement the existing U.S. Navy Wave Energy Test Site (WETS).

BACKGROUND: In 2008, DOE established the Hawai‘i National Marine Renewable Energy Center (HINMREC) at HNEI. This was one of four university-based NMECs focused on various forms of marine energy advancement. HINMREC’s unique focus was research on ocean thermal energy conversion (OTEC) technologies and assisting the Navy with the establishment of WETS. HNEI has been involved in supporting research and testing objectives at WETS, the nation’s first grid-connected open water wave energy conversion test facility located off Marine Corps Base Hawai‘i, since 2010 with funds from both DOE and the U.S. Navy (Naval Facilities Engineering Systems Command, NAVFAC) (Appendix G1).

Funding for HINMREC ended in 2019. However, new funding from DOE in 2024 allowed the four NMECs to expand ongoing operations, make improvements to infrastructure, and build relationships to advance marine energy in their regions. As part of this new impetus, HINMREC was rebranded to HMEC.

In a complementary dual effort, in 2024, DOE awarded HNEI two grants to fund operations and activities at HMEC. If fully funded, these award would fund the HMEC activities for a five-year period.

PROJECT STATUS/RESULTS: Work under these awards began in late 2024 and their overall goals are to:

1. Establish communications and educational outreach at multiple levels, including developing and delivering a series of short courses ranging from introductory to deeper dive topics;
2. Establish and expand local and regional relationships with governmental entities and industry in Hawai‘i and the Pacific Islands and national laboratories;
3. Maintain and expand marine energy-relevant test facilities, including pursuing the addition of the Kilo Nalu Observatory (KNO) and Makai Research Pier (MRP) into DOE’s Testing and Expertise for Marine Energy (TEAMER) network;
4. Advance marine energy-relevant research and development to address several demonstrated industry needs;
5. Enhance marine energy-relevant test infrastructure and laboratory test equipment to enhance HMEC’s capabilities; and
6. Coordinate with DOE, the other NMECs, and the University Marine Energy Research Community (UMERC) on various forms of marine energy research collaboration.

Over the past year, HMEC has made important progress on each of these objectives.

Under #1, in order to provide the short courses, HNEI had extensive discussions with potential content providers, developed a survey to help us shape content, and selected topics for our first year. Our initial offerings will be a 1-week course on ocean thermal energy conversion (OTEC) and a 1-week marine energy introductory course. These will be offered during UH’s Summer 2026 semester and held in person. During subsequent years, we plan to offer courses that take a deep dive into the modeling, design, and deployment of oscillating water column (OWC) and oscillating wave surge-type wave energy converters (WECs).

HMEC also established a robust STEM outreach effort, including:

- A marine energy focused partnership with UH's STEM Pre-Academy, which offers learning opportunities for Hawai‘i educators at the middle school level. This effort resulted in two workshops and the creation of new demonstration capabilities related to waves and wave energy conversion;
- Instruction of a wave energy class at Kapiolani Community College;
- Participation in two UH Mānoa open houses; and
- Provision of three wave energy internships during Summer 2025 to one UH undergraduate and two local high school students.

In pursuit of #2, we have solidified pre-existing relationships with Sandia National Laboratories, Pacific Northwest National Laboratory, and the National Renewable Energy Laboratory (NREL) to enhance our research outcomes. HNEI conducted outreach with our federal Congressional delegation and familiarized ourselves with the Hawai‘i State Energy Office to increase their awareness of our work in marine energy. We also strengthened existing relationships and developed new ones with industry, having participated in multiple collaborative proposals. Local companies Sea Engineering, Oceanit, Makai Ocean Engineering, and PacMar all represent current and/or potential future partners in our work.

Additionally, we placed an early emphasis on establishing relationships with potential research and demonstration partners in Guam, due in part to the potential to expand these relationships to other Pacific Islands. In 2025, this included participation in the University of Guam's Conference on Island Sustainability in April, which included a well-received discussion on HMEC's marine energy initiatives, which could ultimately address the power and freshwater needs of islands.

To achieve #3, we developed a catalog of existing marine energy test infrastructure that may be of interest to researchers within the NMEC framework. We are also currently in the early stages of discussions regarding the environmental permitting that will be necessary for the establishment of KNO and MRP into the TEAMER open water test facilities network. If added, this would allow those facilities to be utilized by researchers around the world by applying for funding through the TEAMER program. This utilization might include testing or demonstration of small-scale wave energy converters, environmental sensors of relevance to marine energy projects, or other marine energy-relevant ocean deployment projects. Moreover, this would result in additional funding to UH to support test objectives.

Advancing R&D efforts towards #4 are specifically focused in the following five projects:

a. Advance WEC control strategies, with an emphasis on both OWC and oscillating wave surge converter (OWSC) concepts, including numerical modeling, laboratory testing, and an ocean test in the latter stages of the project. To date, control strategies with the most promise for WEC performance improvement have been identified for the OWC WEC type, in collaboration with Sandia National Laboratories. This task supports a PhD candidate who is making great progress with the task lead and her advisor. The candidate presented a paper on this work at the European Wave and Tidal Energy Conference in Madeira, Portugal in September 2025. The second portion of this task will focus on a flap-type WEC and will begin at a later date in the overall award.
b. Conduct fully coupled numerical fluid-soil-structure interaction (FSSI) analyses as applied to marine energy converter anchoring—leading toward more cost-effective designs and lower energy costs associated with marine energy. This project has focused on the validation of a numerical model using pre-existing data from wave flume tests and has produced a versatile model that can next be used to examine a number of test cases.
c. Extend existing 7-14-day wave forecast models to longer time scales—from monthly to interannual—by examining wave conditions as they relate to dominant climate cycles, such as El Nino/La Nina. Efforts on this project have generated a statistical analysis which shows that a focus on the El Nino/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) will account for a large majority of the seasonal and interannual variability in the wave forecast.

These two climate cycles are now being studied as they relate to the longer-term wave forecast. This work promises to produce a tool that will be valuable in terms of long-range forecasts for operational planning and WEC/mooring design.

d. Numerically study the downrange effects of WEC arrays on the wave field as it impacts nearby coastlines and coastal infrastructure—utilizing advanced non-hydrostatic methods. This project has yet to begin as it is scheduled for a later date in the overall award.
e. Develop a "high-flow" power takeoff (PTO) system for an OWSC-type WEC (flap), utilizing numerical modeling, design, and laboratory testing to validate performance. This complements the "high-head" approach undertaken in another HNEI DOE project—the Hawai'i Wave Surge Energy Converter (HAWSEC) (Appendix G2). This study is producing encouraging results in numerical space related to ultimate device power performance. Laboratory testing is the next step, and efforts to procure, fabricate, or 3D print the necessary test components are now underway.

Objective #5 deals with the procurement of various equipment that will enhance HMEC's testing capabilities. HNEI's first identified upgrade was a hydraulic test bench and a data acquisition system (MODAQ2), developed to our needs by NREL, which has been approved by DOE. Several other items were identified and we are currently in the process of requesting DOE approval. We hope to have all identified items procured during the first half of the coming calendar year.

In order to fulfill #6, HMEC has become thoroughly integrated into the DOE NMEC community. Regular meetings occur with DOE's Water Power Technologies Office (WPTO) and the other NMECs on a wide variety of topics of relevance to enhancing academic and industry partnerships aimed at advancing marine energy solutions toward commercial readiness, with the long-term aim of ensuring that these solutions contribute to the renewable energy mix of the future. This collaboration allowed us to refine our key strategic goals for the next five years. We are currently in the process of building those goals into a Strategic Vision Report for submission to DOE as a deliverable. Our overarching goal is to identify marine energy solutions of relevance to the Pacific Islands, with an emphasis primarily on wave energy, with a growing emphasis on OTEC, both of which are highly relevant in the tropical Pacific.

Additionally, in August, HNEI's participation in UMERC's annual conference included presentations on **high-flow hydraulic pump characteristics for OWSC applications**, HMEC's marine energy curriculum enhancements, and developments of relevance to the advancement of **two OWC wave energy converter concepts**—a fixed breakwater with integrated OWC generation and a floating OWC for autonomous vehicle recharge.

Funding Source: U.S. Department of Energy

Contact: Patrick Cross, pscross@hawaii.edu

Last Updated: November 2025