

UNIVERSITY OF HAWAI‘I SYSTEM ANNUAL REPORT



**REPORT TO THE 2016
LEGISLATURE**

**ANNUAL REPORT FROM THE HAWAI'I
NATURAL ENERGY INSTITUTE**

HRS 304A-1891

December 2015

Report to the 2016 Legislature

Annual Report on
The Hawai'i Natural Energy Institute

HRS 304A-1891

**Hawai'i Natural Energy Institute (HNEI) School of Ocean
and Earth Science and Technology
UH Mānoa**

SUBJECT: Annual Report on Activities, Expenditures, Contracts Developed, Advances in Technologies, Work in Coordination with State Agencies and Programs, and Recommendations for Proposed Legislation, required in accordance with HRS 304A-1891 (Act 253, SLH 2007).

HIGHLIGHTS:

The following key achievements were made possible in whole or part by contributions from the State's barrel tax:

- **Wave Energy Test Site** – In June, the country's first grid-connected wave energy test site offshore from the Marine Corps Base in Kaneohe became fully operational with the deployment of the first wave energy conversion device. The sites three berths will soon be occupied, with others in a queue to take advantage of this unique facility.
- **Hydrogen Fueling Station** – The State's first unattended fast-fill hydrogen fueling station on the Marine Corps Base in Kaneohe allows drivers to self-fill their cars just like they would at a gas station, and serves to demonstrate the capability of the technology to be user friendly.
- **Grid Modeling – RPS Study** – Independent electric utility system analyses were conducted to identify cost-effective solutions and practical strategies for increasing renewable energy generation; providing valuable information to the Public Utilities Commission and other stakeholders as we move toward the State's RPS targets.

- **Smart Inverter Deployment and Testing** – Smart inverters were deployed in a Maui neighborhood to test and demonstrate their ability to manage rooftop PV generation and provide support to the distribution grid to enable higher penetrations of renewable energy on the system. Testing and data collection is ongoing.
- **Final Hawaii Clean Energy Programmatic Environmental Impact Statement -** Provides federal and local agencies, policymakers, energy developers, and the public with information and guidance on adhering to all laws and permitting requirements, implementing well-planned best management practices and mitigation measures, and consideration of community and cultural concerns that can be used to make decisions about renewable energy and energy efficiency deployment.

All of these projects are described more fully later in this report.

SUMMARY:

The Hawai'i Natural Energy Institute (HNEI) conducts essential energy research relevant to Hawai'i and the world. Programs focus on identifying technically sound, cost effective solutions and practical strategies that can be implemented to deliver commercially viable renewable energy. The ultimate goal is to achieve a stable and cost-effective energy mix for Hawai'i, while reducing our dependence on oil and other fossil fuel resources.

HNEI brings together people from a wide range of disciplines and different types of organizations to tackle the urgent and complex sustainable energy needs of the state and the nation. Analysis, research, engineering, economics, and policy are integrated to develop technology, strategies and policies that will have significant positive impact on the energy mix.

HNEI is committed to supporting the State, Federal agencies and industry in planning and implementing clean energy initiatives. HNEI's activities can be grouped into five core functions:

- Research & Development
- Technical Validation & Implementation
- Analysis & Modeling

- Education & Training
- State Energy & Policy Support

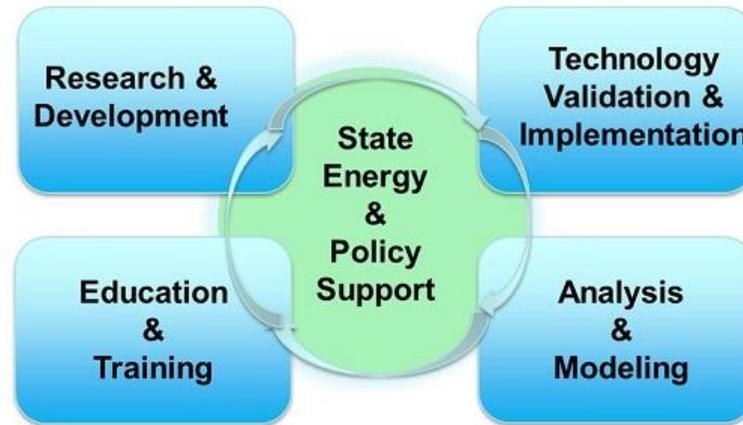


Figure 1. The schematic shows how these functions are inter-related and overlap by design to maximize collaboration and leverage resources.

State Energy & Policy Support

HNEI was established in 1974 to coordinate and undertake the development of natural energy sources for Hawai'i. In 2005, HNEI faculty developed a strategic plan which called for HNEI to be the UH and State focal point for multidisciplinary research and education on the energy supply for Hawai'i. In this plan, HNEI proposed to take a leadership role in the development of public-private partnerships for sustainable energy deployment and demonstration projects in Hawai'i.

The significance of HNEI's contributions to the State was recognized by the Hawai'i State Legislature which, in 2007, established HNEI in statute (ACT 253) and expanded its mandate to explicitly include coordination with state and federal agencies; and the demonstration and deployment of efficient end use technologies including those that address peak electric demand issues.

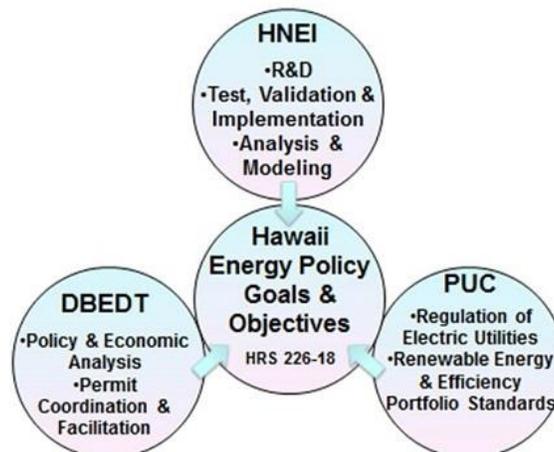
Act 253 also established the Energy Systems Development Special Fund (ESDSF) and directed that it be managed by HNEI. It went unfunded until 2010, when ACT 73 established a barrel tax and authorized that 10 cents of the tax on each barrel be deposited into the ESDSF. HNEI, in collaboration with the State Energy Coordinator, develops expenditure plans for the ESDSF to maximize the value of these funds to meet needs and opportunities within the state, and to maximize matching funds from federal and private sources.

HNEI Mission (from ACT 253)

To coordinate and undertake the development of Hawai'i's abundant natural energy sources, in order to:

- Diminish Hawai'i's dependence on imported fossil fuels;
- Meet the state's increasing energy demands with little or no environmental degradation;
- Contribute to the technology base for finding solutions to the national and global energy shortage;
- Coordinate with state and federal agencies; and,
- Demonstrate and deploy efficient end use technologies, including those that address peak electric demand issues.

In executing this mandate, HNEI has assumed an important role within the state to reduce Hawai'i's dependence on fossil fuels, serving as the implementing organization for several large, public-private partnerships to develop, deploy and demonstrate renewable energy systems. HNEI continues to forge strong partnerships with industry, state and national organizations creating a thriving synergy that expands resources and accomplishments for all involved. HNEI works closely with federal funding agencies, industry, the State Energy Office, our State legislators, Public Utilities Commission and our Congressional delegation, providing stability and enhancing the benefits afforded to residents of Hawai'i and beyond.



HNEI has become recognized as an independent organization providing trustworthy and practical information to support the safe, reliable, and economically viable development

of renewable energy technologies and systems. The foundation of HNEI's strength lies in its people and partners. The diversity of talents, education, experience, and the entrepreneurial spirit of this team creates flexibility in performing a range of renewable energy development responsibilities. HNEI also serves as a critical bridge between State and Federal initiatives, supporting for example the "Hawai'i Clean Energy Initiative, to achieve the goal of 70 percent clean energy by 2030, and the State's more recent 100% renewable portfolio standard. In summary, HNEI's responsibilities go beyond traditional academic research, playing a significant role in public-private partnerships and supporting analysis for state energy policy.

Research & Development (R&D)

As an Organized Research Unit within the University of Hawai'i at Mānoa (UH), HNEI has maintained a strong core research effort. HNEI's faculty and staff are truly multidisciplinary, with a wide diversity of backgrounds. For efforts requiring additional expertise, HNEI also works closely with other units on campus, including the School of Ocean & Earth Science & Technology (SOEST), College of Engineering, College of Tropical Agriculture and Human Resources, and College of Social Sciences. This critical mass allows HNEI to conduct increasingly comprehensive and complex research. With a strategic focus on remaining flexible to support the dynamic needs of renewable energy development, HNEI's direction continues to evolve.

Technology Validation & Implementation (TV&I)

Moving R&D discovery from UH labs to market is an important aspect of HNEI's TV&I mission. HNEI faculty and staff have been successful in transferring patented HNEI technology in a variety of areas to demonstration scale, and even commercial implementation.

Additionally, there are many emerging technologies of potential significance to Hawai'i's energy needs developed elsewhere. Under our TV&I efforts, we identify and bring to Hawai'i technologies of interest, for validation and assessment for use in Hawai'i. These activities are frequently guided by our analysis and modeling efforts and supported by our R&D activities. HNEI's TV&I projects usually involve industrial partnerships and often include cost share. A good example is the ongoing effort to evaluate emerging grid scale battery energy storage technology as a solution to both transmission and distribution level issues associated with high penetration of intermittent renewable energy technologies.

Analysis & Modeling

HNEI conducts and supports analysis and modeling to analyze important forward looking scenarios for Hawai'i's energy mix. This analysis is critical to identifying optimal and realistic paths forward to meet Hawai'i's clean energy goals. Results from these studies are used as to guide state policy and help identify important validation projects in areas such as biofuels, grid integration, and hydrogen.

Education & Training

As a research institute, HNEI does not have its own academic program but has active partnerships throughout the university. Faculty members develop and present courses for academic units in SOEST, the College of Engineering, and the College of Tropical Agriculture and Human Resources. HNEI faculty support and supervise graduate students and post docs across these departments. Additionally, HNEI's state-of-the-art research facilities are used by UH research collaborators. HNEI also currently provides funding to Maui Community College, Kauai Community College and the College of Engineering (UH Mānoa) to support curricula and workforce development. Other funded projects include the Pacific Asian Center for Entrepreneurship and E-Business (PACE), which supports several fellowships at the UH College of Business to develop a workforce cross-trained in the business, legal and technical aspects of future energy systems. HNEI also supports the Asia-Pacific Technology and Education Partnership (APTEP), funded by the Office of Navy Research (ONR).

The attached report summarizes HNEI's current research activities for the past fiscal year and provides a summary of the expenditure for the funds provided by the barrel tax to the ESDSF.

Summary of Activities, 2015
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and
Technology
University of Hawai'i at Mānoa

Director: Richard E. Rocheleau

Staffing:	Permanent Faculty (FTE)	8
	Other permanent staff (APT)	3
	Temporary Faculty	26
	Other temporary staff (APT, RCUH)	21
	Training (a)	24

(a) Includes post-doctoral fellows, graduate and undergraduate students, and visiting scientists.

SUMMARY OF CONTRACTS AND ACTIVITIES: Due to new or expanded programs in ocean energy, hydrogen, smart grids, and interest by the Office of Naval Research (ONR) to utilize Hawai'i as a site for alternative energy testing in the Pacific region, HNEI has consistently been able to capture significant extramural funding (over \$9.6 million for FY 2015 based on a 3 year rolling average).

HNEI is a nationally acknowledged research leader with major activities in areas such as hydrogen and fuel cells, biofuels, ocean resources, and grid integration. While continuing to conduct basic and applied research, HNEI has, in accordance with HRS 304A-1891, also undertaken a pivotal role within the state including identification, evaluation, and testing of advanced energy technologies and systems aimed at reducing Hawai'i's dependence on fossil fuels. HNEI serves as the implementing and/or managing partner for several major public/private partnerships to deploy and demonstrate renewable energy systems to meet Hawai'i's energy needs. These efforts support both the goals of the State of Hawai'i and our project partners.

A brief synopsis of select HNEI activities follows:

Hawai'i Energy Sustainability Program (HESP): HESP is a continuation of the United States Department of Energy's (USDOE) Distributed Energy Resource Technologies for Energy Security program initiated in 2006. Under this program, managed by HNEI and conducted in partnership with GE Global Research, the Hawaiian Electric Company (HECO), Maui Electric Company (MECO) and the Hawai'i Electric Light Company (HELCO), HNEI has established a research and assessment program in integrated energy and systems analysis of electricity technologies. Through this program, HNEI conducts essential research in areas of relevance to Hawai'i and abroad including analysis and modeling of isolated grid systems with high amounts of renewable energy resources, power distribution and microgrid systems, and advanced power system monitoring, intelligent control, communications and enabling technologies. HNEI's program is focused on identifying technically-sound cost effective solutions and practical strategies that energy generators and grid operators can implement to deliver commercially viable renewable energy to achieve reduced dependence on oil and other fossil fuel resources. Major activities under this program have included:

RENEWABLE ENERGY GRID INTEGRATION STUDIES

HNEI is developing ground-breaking analytic tools to allow higher penetration of renewables on island grid systems.

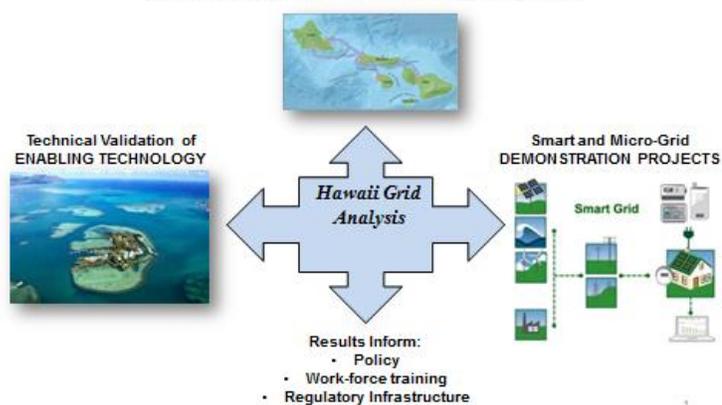


Figure 2. Renewable grid integration studies.

- *O'ahu Wind Integration Study (2008 - 2010)*
- *Hawai'i Solar Integration Study (2010 - 2012)*
- *O'ahu – Maui County Grid Interconnection (Stage 2) Study (2012 – 2013)*
- *O'ahu EV Charging Study (2012 – 2013)*
- *Renewable Portfolio Standards Study (2013-2015)*
- *Liquefied Natural Gas Study (2012)*

* Descriptions and detailed reports of these studies can be found on the HNEI website.

- *RPS II Study (2015 -)* This new phase of system modeling and analyses, is looking at even higher penetrations of renewable energy under the State's new 100% RPS law. It will evaluate likely system challenges, mitigations, and the costs and benefits associated with new equipment or modifications to operating practices including a more comprehensive review of energy storage.

HNEI has also committed resources from the Energy Systems Development Special Fund to support these efforts. This work is closely coordinated with the State Energy Office and the USDOE, and is cofunded by the ESDSF. This is described further in the section below on the ESDSF.

GridSTART: Building on its systems analysis experience and growing technical expertise in the area, HNEI established its Grid Systems Technologies Advanced Research Team (**GridSTART**) to develop, test and evaluate advanced grid architectures, enabling policies, and new technologies and methods for effective integration of renewable energy resources and power system optimization. **GridSTART** serves to integrate HNEI efforts across all its technology areas and has developed strong partnerships with state, federal, and international agencies, organizations and businesses, especially in the Asia-Pacific region. Its funding sources include the Office of Naval Research, NavFAC (via the Applied Research Laboratory at the University of Hawai'i – ARL-UH), USDOE, Hitachi, Nissan, and the State of Hawai'i. The following four sections briefly describe a few of the projects **GridSTART** is managing and/or supporting.

Hawai'i Naval Base Grid Modernization: In September, 2014, the Office of Naval Research, through a \$2.5 million contract with ARL-UH, funded HNEI to develop a power grid modernization strategy and action plan to meet the future needs of the Navy in Hawai'i, with a special focus on the reliability and power quality demands of electrical service to the shipyard. As part of this task, a renewable energy integration action sub-plan will be developed to help the Navy meet its renewable energy goals in a manner that maintains electrical service reliability and stability, ensuring continuity of mission critical activities.

Maui Smart Grid: This very significant HNEI-led USDOE demonstration project was formally started on October 17, 2008, with partners that include General Electric, MECO, HECO, Sentech, and First Wind, among others. This \$15 million project was intended to demonstrate reduction of peak electricity demand by at least 15% through the use of advanced smart grid and demand-side-management technologies, and to assist MECO in providing reliable and stable electricity with increasing

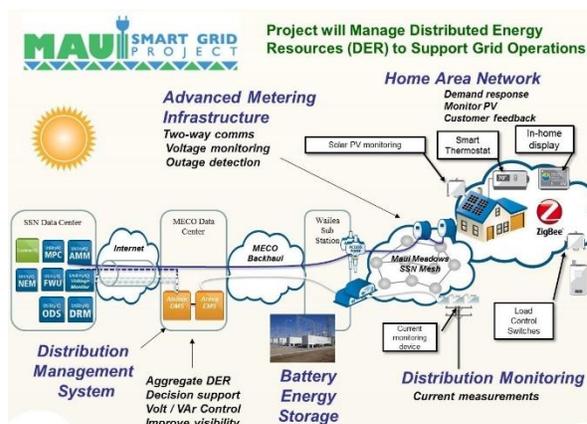


Figure 3. Maui Smart Grid Demonstration Project.

percentages of as-available renewable resources. The equipment was installed, and the demonstration was conducted through 2014. A final report on this work was completed in December 2014. HNEI is also serving as one of the Hawai'i implementing organizations for the NEDO Smart Grid Initiative, also located on the south side of Maui.

DOE Smart PV Inverter Project: In a project that closely supported the Maui Smart Grid efforts, an HNEI-led team won a new project under the USDOE Sunshine Program to develop and demonstrate new “smart grid-enabled” PV inverters. This project, announced in September 2011, was intended to facilitate higher penetrations of solar PV systems by mitigating the utility operations issues resulting from variability of PV systems. HNEI used \$400,000 from the Energy Systems Development Special Fund to meet a critical funding shortfall and to insure efforts to secure the federal funding. Project partners include Fronius, which supplied the advanced PV inverters, and Silver Spring Networks, which integrated them into the smart grid network they developed. Maui Electric Company, Hawaiian Electric Company, and Pepco Holdings Inc. are the utility partners supporting the live demonstrations on their utility grids.

Under the USDOE funding the HNEI team completed development of the technology and purchased hardware for deployment and testing. Due to changes in the DOE program, continued testing of this hardware on the Maui grid is now supported by the Office of Naval Research.

Asia-Pacific Research Initiative for Sustainable Energy Systems: The APRISES initiative, formerly named the Hawai'i Energy and Environmental Technologies Initiative (HEET) was initiated in 2001 with funding from the Office of Naval Research (ONR), focused on the development and testing of fuel cells and seabed methane hydrates has been expanded to include biofuels and to support testing of critical heat exchanger technology in support of Ocean Thermal Energy Conversion (OTEC). The program was expanded to include deployment and testing of net energy neutral buildings, testing of grid scale Li-ion high power batteries for grid support, and support of various hydrogen infrastructure projects on the islands. In 2013 HNEI was awarded an additional \$15 million to continue the current activities and further expand to include testing and evaluation of renewable generation and power system controls for smart and micro-grid applications. This program has provided substantial support for various smart and microgrid research activities with ongoing efforts on Moloka'i, Coconut Island, at the UH Manoa campus, and various projects on Maui.

Hawai'i Hydrogen Program: Since 2003, HNEI has developed funding from various federal, state, and private sources to deploy hydrogen infrastructure at multiple sites on O'ahu and Hawai'i Island in support of both DOD and civilian transportation projects. These efforts, summarized in the following subsections, are budgeted at over \$8 million including approximately \$1,000,000 from the Energy Systems Development Special Fund to support a local bus service in the Hilo-Puna area on Hawai'i Island.

Hydrogen Energy System as a Grid Management Tool: This joint USDOE-DOD-HNEI project is intended to test and evaluate the dynamic operation of an electrolyzer to demonstrate its potential to provide frequency control in support of additional renewable generation, and to provide fuel for two transportation demonstration projects. The intended site at Puna Geothermal Ventures has been delayed due to continuing delays in executing a Memorandum of Agreement with PGV, and most recently the lava flow threatening Pahoia and the main access road. Due to the continuing delays the project is conducting initial system dynamic testing at the Powertech Labs facilities in Vancouver, Canada, after which the system will be delivered to Hawai'i and installed at the NELHA facility in Kona. It is expected to be fully operational by May 2016. The total budget is approximately \$5 million.

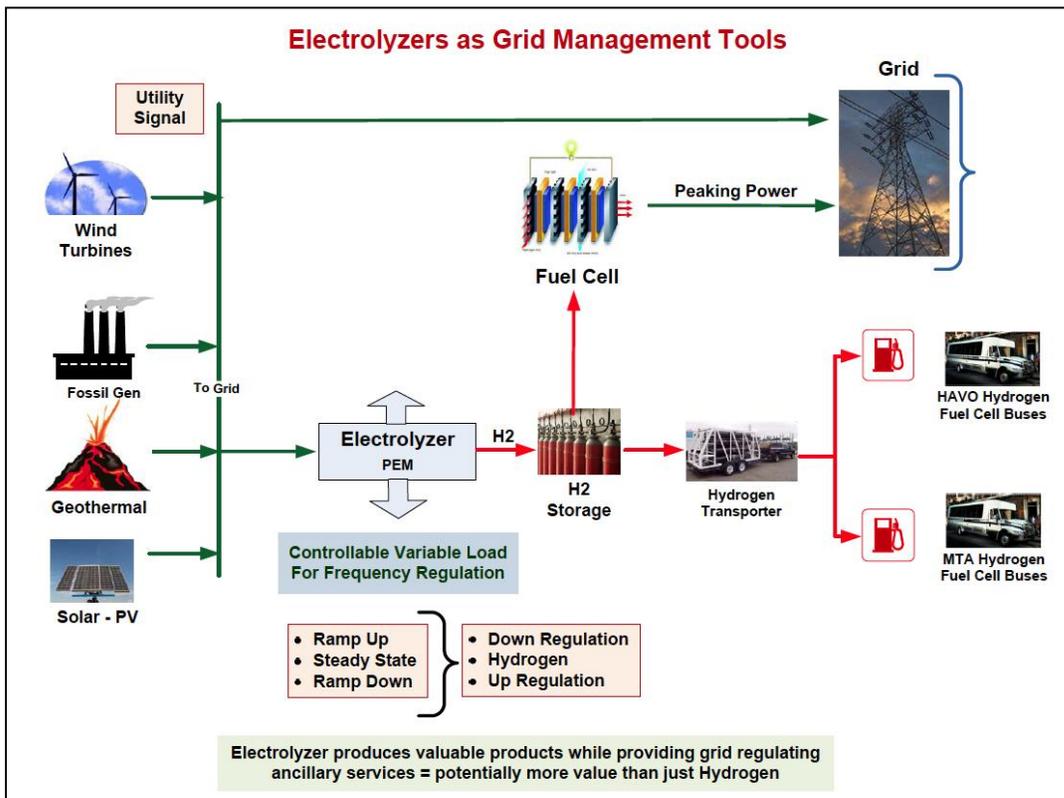


Figure 4: Batteries & Electrolyzers as Grid Management Tools

Hydrogen Fueling Tube Trailers: HNEI is also assisting with the purchase of two (2) hydrogen transport trailers to support multiple fueling sites from one production site. Current plans are to support refueling at Hawai'i Volcanoes National Park and the Island of Hawai'i Mass Transportation Agency. The trailers carry over 100 kilograms of hydrogen at a pressure of 450 bar (6,600 psi). The trailers support the development of critical hydrogen delivery infrastructure on Hawai'i Island. The trailers were completed in May 2014 and are projected to be delivered in May 2015 with the hydrogen energy system equipment.

Marine Corps Base (MCB) Hawai'i Hydrogen Fueling Station at Kaneohe Bay: The Office of Naval Research (ONR) has leased and deployed five General Motors (GM) Equinox Fuel Cell Electric Vehicles (FCEVs) at MCB to enable the US Navy/Marine Corps to conduct technical evaluations and gain experience in the operation of FCEVs utilizing direct hydrogen fuel. HNEI has signed an MOA with MCB Hawai'i to provide rapid high-pressure refueling infrastructure in support of this work. The station has been commissioned and has been successfully fueling vehicles since November 2014. Vehicle fill times are under 5 minutes.

Hawai'i National Marine Renewable Energy Center (HINMREC): In March 2009, USDOE executed a five-year agreement with UH - HNEI to establish a new Center to facilitate the development and implementation of commercial wave energy converters (WECs) and to assist the private sector in developing Ocean Thermal Energy Conversion (OTEC) systems for use in Hawai'i and around the world. The HINMREC has established industry-driven partnerships between WECs and OTEC developers, utility companies, engineering and environmental support companies, university researchers, federal and state government agencies, and other non-government organizations (NGOs). The HINMREC coordinates engineering and science efforts to address industry needs and leverage U.S. Department of Defense (DOD) interest in Hawai'i energy projects. The USDOE awarded multiple year funding (2008-2015) to HINMREC of approximately \$8 million.

This USDOE funding and an additional \$9 million contributed by the Naval Facilities Engineering Command (NAVFAC) in 2014, through the University of Hawai'i's Applied Research Laboratory, is being used to support testing activities at the United States' first grid-connected wave energy test site (WETS) at Marine Corps Base Hawai'i. The site is now fully permitted with three berths at different depths. Northwest Energy Innovations deployed its Azura in June of 2015. A second WEC device will be deployed as soon as the weather permits, and a third is scheduled for deployment next year. HNEI is working with NAVFAC and USDOE to support the WETS efforts in

three key areas: 1) independent WEC device performance analysis; 2) environmental impact monitoring; and 3) ongoing measurements and analyses of device acoustic signature, device and cabling electromagnetic fields (EMF) and changes in device/mooring-induced sediment transport, seawater chemistry, and ecological environment.



Figure 5. Azura wave energy converter (WEC) deployed off of Marine Corps Base Hawai'i.

Solar Initiatives: HNEI is also working with USDOE and ONR to conduct high-fidelity resource assessments and testing of emerging solar technologies. The objectives are to characterize emerging photovoltaic (PV) technologies, to understand the performance of PV in differing environments, and to collect information to evaluate the effects of high PV generation on the grid. Multiple test sites became operational in 2012. Additional test sites are being developed.

Fuel Cell and Battery Testing: HNEI researchers conduct testing and modeling to develop advanced battery system diagnostic and prognostic technology to further understanding of the performance of advanced fuel cells and batteries for use in electric vehicles and renewable energy storage applications. Funding sources include the US Department of Energy EERE Office and the Office of Naval Research. HNEI has recently initiated a major effort to conduct testing to better predict the lifetime of grid-scale battery energy storage technologies.

EXPENDITURES: General Funds \$ 1,118,248
Tuition and Fees S Funds \$ 69,750
Research and Training Revolving \$ 390,842
Extramural Awards \$ 9,638,743

All of these funds support the research and training activities described above. We anticipate 2016 extramural funding levels to be comparable to those from 2015. The rate of expenditure is expected to be similar to that of 2015.

CONTRACTS DEVELOPED: HNEI has developed many subcontracts under its existing extramural federal funding. Contracts using the Energy Systems Development Special Fund are described in the section below on the specific projects funded by ESDSF. HNEI coordinated and planned for ESDSF expenditures with the State Energy Coordinator.

ADVANCES IN TECHNOLOGY: HNEI continues to conduct research to advance renewable energy technologies and system integration. HNEI has patent applications and/or patents in the areas of battery charging, conversion of biomass to charcoal, solar production of hydrogen, novel filtration for operation of fuel cells in harsh environments, and conversion of waste streams to valuable bioplastics in the processing of ethanol. Licensing discussions are ongoing in all of these areas.

COORDINATION WITH STATE AGENCIES: HNEI works closely with DBEDT and other agencies on a variety of renewable energy projects and continues to seek new opportunities and means to do so. Projects initiated or ongoing in 2014 which involve strong collaboration/coordination with DBEDT include the following:

- o ***Hawai'i Hydrogen Power Park:*** The hydrogen power park is funded in part by USDOE and in part by the Hydrogen Investment Capital Special Fund through DBEDT. HNEI is the implementing partner and works closely with DBEDT in the execution of this project.
- o ***Hawai'i Hydrogen Plan:*** HNEI, via Kolohala Ventures developed the State Hydrogen Plan as called for as part of the Hydrogen Investment Capital Special Fund.
- o ***Marine Corps Base (MCB) Hawai'i Hydrogen Fueling Station at Kaneohe Bay:*** HNEI leveraged the State of Hawai'i investment in the Hawai'i Hydrogen Power Project to develop the fast-fill high pressure fueling station at MCB Hawai'i, in support of the deployment of the ONR/GM Equinox fuel cell vehicles. HNEI continues to work closely with HCATT, DBEDT and the state

legislature to attract national and international partners to support the roll-out of fuel cell electric vehicles in Hawai'i.



Figure 6. Fast-fill H2 fueling station at MCBH in Kaneohe.

- o **National Marine Renewable Energy Center:** HNEI is working closely with DBEDT to attract technology providers to the state to participate in this project and to provide assistance in the permitting process.
- o **Hawai'i Clean Energy Programmatic Environmental Impact Statement (PEIS):** HNEI closely coordinated the PEIS effort with the Hawai'i State Energy Office and the USDOE. The recently completed PEIS will provide federal and local agencies, policymakers, and developers with information and guidance they can use to make decisions about actions that will support achieving HCEI goals.
- o **Hawai'i Public Utilities Commission support:** HNEI has been coordinating with the PUC on developing assumptions and scenarios for the RPS Study (described in the ESDSF section below) to support their need for independent modeling and analysis of utility systems and their capabilities, constraints and planning needs.

- o ***Hawai'i State Energy Office Support:*** HNEI is working with the Hawai'i State Energy Office in DBEDT to support programs in energy efficiency, renewable energy, test bed development, and energy education and outreach.

RECOMMENDATIONS FOR PROPOSED LEGISLATION: Generally, HNEI does not initiate legislation, but is a member of the Hawai'i Energy Policy Forum and works closely with this group to review legislative initiatives in the energy area. Via federal funds and the ESDSF, HNEI also financially supports the University of Hawai'i's Hawai'i Energy Policy Forum for outreach and analysis efforts.

ENERGY SYSTEMS DEVELOPMENT SPECIAL FUND

As described above, the Energy Systems Development Special Fund (ESDSF) was established in 2007, but went unfunded until 2010, when the Hawai'i Legislature established a barrel tax and authorized that 10 cents of the tax on each barrel of oil be deposited into the Fund. This has amounted to approximately \$2,300,000 per year of barrel tax funding for the ESDSF. HNEI works in collaboration with the State Energy Coordinator to develop an expenditure plan to maximize value of these funds to meet near term needs and opportunities within the state; and maximize leveraging of federal and private dollars.

The ESDSF statute (Sections 304A-1893, 1894, and 2169, HRS) was repealed (through a sunset provision) on June 30, 2013, and re-established on July 1, 2014. Thus, the ESDSF did not exist and thus received no barrel tax funding for fiscal year 2014.

Below is a description of projects that were supported by money committed from the Fund prior to its repeal and that continued or were completed in FY 2015, and projects newly initiated after the ESDSF was re-established.

Continuing/Completed Projects

Smart Inverter Deployment: (\$400,000) This US DOE funded project led by the University of Hawai'i, was intended to develop and commercialize smart grid-enabled PV inverters to mitigate grid reliability impacts of high penetrations of PV systems. This project was part of the ongoing smart grid demonstration projects on Maui. HNEI obligated \$400,000 from the Fund to match partner cost share. This cost share from the Fund resulted in an initial federal award of \$1.5 million with an additional \$4.5 million that was awarded upon successful demonstration of the go/no-go deliverables in early 2013. Due to changes to the DOE program, continued testing of this hardware on the Maui grid is now supported by the Office of Naval Research.

Hydrogen for Grid Management: (\$500,000) In 2011 HNEI was awarded \$ 1.7 million by the Naval Research Laboratory (funds provided to NRL by US DOE) to demonstrate the use of electrolyzer technology to simultaneously produce hydrogen for fuel and for grid management. This program leveraged other investment from the US Department of Energy, the Hawai'i Hydrogen Capital investment Fund, and in-kind cost share from Puna Geothermal Venture and County of Hawai'i Mass Transit Agency. The hydrogen system, originally intended to be located near PGV, has been delayed due to continuing delays in executing a Memorandum of Agreement with PGV, and most

recently the lava flow threatening Pahoehoe and the main access road. Due to the continuing delays the project is conducting initial system dynamic testing at the Powertech Labs facilities in Vancouver, Canada, after which the system will be delivered to Hawai'i and installed at the NELHA facility in Kona. It is expected to be fully operational by May 2016. HNEI also contracted with the Hawai'i Center for Advanced Transportation Technologies (HCATT) to procure a bus and convert it to operate on advanced fuel cells to for use in the county. Approximately \$500,000 from the ESDSF was committed for this work.

Hydrogen Fueling Tube Trailers (\$555,000) ESDSF money was used to purchase two (2) hydrogen transport trailers to support multiple fueling sites from one production site. Current plans are to support refueling at Hawai'i Volcanoes National Park and the Island of Hawai'i Mass Transportation Agency. The trailers carry over 100 kilograms of hydrogen at a pressure of 450 bar (6,600 psi). The trailers support the development of critical hydrogen delivery infrastructure on the Island of Hawai'i. The trailers were completed in May 2014 and are projected to be delivered in May 2016 with the hydrogen energy system equipment.

Hawai'i Clean Energy Programmatic Environmental Impact Statement:

(\$2,100,000) In 2010, DOE announced its intent to prepare a programmatic environmental impact statement (pursuant to the National Environmental Policy Act, or NEPA) with the State as a joint lead for wind energy development under the Hawai'i Interisland Renewable Energy Program. In response to public comments, as well as regulatory and policy developments, DOE broadened the scope of the analysis. In July 2012, in coordination with the USDOE and DBEDT, HNEI contracted New West Technologies to conduct a Programmatic Environmental Impact Study (PEIS). The PEIS analyzes, at a programmatic level, the potential environmental impacts of clean energy activities and technologies in the following clean energy categories: (1) Energy Efficiency, (2) Distributed Renewables, (3) Utility-Scale Renewables, (4) Alternative Transportation Fuels and Modes, and (5) Electrical Transmission and Distribution (including undersea cables). The draft PEIS was published in April, 2014, eight public hearings were held on the six major Hawaiian Islands, and the comment period closed in July 2014. The Final PEIS (completed in September 2015) considers and/or address all comments received on the draft.

The PEIS provides federal and local agencies and policymakers and energy developers with information and guidance on adhering to all laws and permitting requirements, implementing well-planned best management practices and mitigation measures, and consideration of community and cultural concerns they can use to make decisions about actions that support achieving HCEI goals. The PEIS also includes website references

of information that is routinely updated to ensure readers get the most up-to-date material.

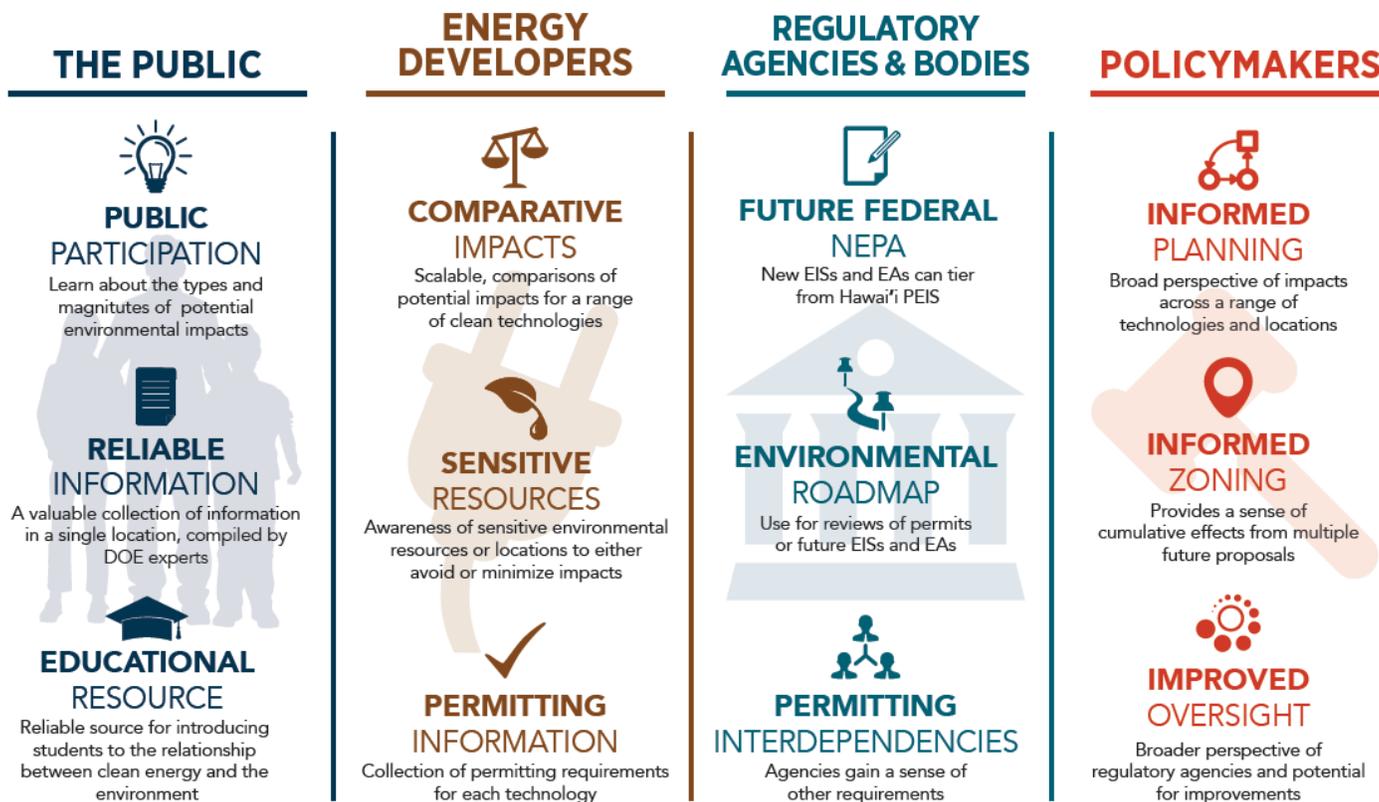


Figure 7. The Hawai'i Clean Energy PEIS -- Benefits to stakeholder groups

Hawai'i Energy Policy Forum Support, HCEI Metrics (\$350,000). HNEI continues to support the Hawai'i Energy Policy Forum and the Social Science Research Institute at the UH in their efforts to seek smart energy solutions for a clean and sustainable energy future through advocating policies and initiatives and promoting civic action. HNEI also specifically supported the Forum's effort to develop a set of metrics to measure the State's progress toward meeting the Hawai'i Clean Energy Initiative's requirements.

Wave Energy Test Site (\$500,000). UH/HNEI through the Hawai'i National Marine Renewable Energy Center was awarded a total of \$8 million by USDOE to support wave energy testing at the recently completed Wave Energy Test Site (WETS) at MCBH. This \$500,000 cost-share from the fund was critical to receipt of this award. These funds will support environmental and resource studies supporting the Navy sponsored plug-and-play facility. The Navy has committed approximately \$11 million for infrastructure at the WETS. Combined resources of the Navy, USDOE and the Fund

have resulted the country's first grid-connected site where developers can test their wave energy conversion technology for proof of seaworthiness, functionality, system integrity, and technology viability.

Renewable Portfolio Standards Study (\$850,000) In May 2015 HNEI and partner General Electric Energy Consulting (GE) completed this study that built upon the modeling work done in several earlier studies and evaluated various mixes of renewable energy generation (primarily wind and solar), different island-interconnection strategies, and changes to utility operations to identify cost-effective pathways to meet the state's Renewable Portfolio Standards (RPS) targets. The U.S. DOE also provided funding for the Study. A variety of utility operational changes including reduced minimums on thermal units, thermal unit cycling, demand response, alternate fuels (e.g. Liquefied Natural Gas) and adjustments to ancillary service procurement were evaluated in the analysis.

The study showed that Hawai'i can cost-effectively achieve and even exceed the 30% goal for 2020 mandated by recent legislation. It provides a valuable tool to assess potential pathways to meet the State's goals while also maintaining a reliable system.

This type of modeling provides an independent look at the utility system and how changes to it and its operations can affect its costs and its ability to accept additional renewables. The report and additional analyses that build upon it will provide regulators and other stakeholders with valuable information as we continue reducing our dependence on fossil fuels.

Key findings of the study include:

- High levels of intermittent renewable energy generation with minimal curtailment can be achieved with modifications to electric system operations and infrastructure expected by 2020. With these changes, the islands of O'ahu and Maui can surpass the 2020 RPS goal while lowering electricity costs and increasing the reliability of the grid with or without island interconnection.
- Balanced growth of wind and utility-scale and distributed solar was shown to help reduce the aggregate variability and intermittency and the need for ancillary services on the grid relative to continued expansion of a single resource type.
- The use of natural gas as a transition fuel has the potential to substantially lower the cost of electricity, depending on cost projections for LNG and oil. The price

will be dependent on the volume of LNG consumed, hence any cost benefit decreases as renewable penetration increases.

- Increased use of energy efficiency, demand response, and storage will be needed to maintain grid reliability with fewer thermal generators on the system, as is projected by the utility.
- Inter-island transmission can facilitate more efficient use of resources, contribute to increased grid reliability, and enable increased renewable penetration by providing expanded siting options.

Hawai'i State Energy Office Support (\$1,125,000) HNEI continues working with the Hawai'i State Energy Office in DBEDT to support programs for:

- Hawai'i Test Bed Development and Energy Education and Outreach
 - Design Planning for Innovation Center for energy system commercialization testing, innovation, advancement, and energy venture acceleration
 - Energy Education and Outreach to generate awareness of Hawai'i's clean energy goals and their contribution to economic growth
- Energy Efficiency – Technical Assistance for High Performance Buildings
- Renewable Energy
 - Enhance EnerGIS Renewable Energy Resource Tool
 - Online Self-Help Investor Development Tools
 - Energy Systems Infrastructure Development – infrastructure planning may include LNG, fuels and/or smart grid.

Energy Efficiency Natural Ventilation Research (\$356,000) HNEI is conducting research and demonstration of three areas of energy efficient, emerging technology research that will enable natural ventilation to be integrated into building operation without sacrificing modern expectations of comfort. These technologies will be of interest to public facilities such as schools that are increasingly concerned about educational environments as they relate to student performance. Four areas using technologies being researched for Hawai'i-specific application are:

- 1) **Natural Ventilation and Comfort Mitigation:** HNEI is conducting research in collaboration with the UH School of Architecture Environmental Research and Design Laboratory on increasing comfort in extreme conditions in naturally ventilated spaces. Night flushing, ceiling fans and controls, and the use of

individual comfort devices are being assessed for applicability in non-air-conditioned environments in Hawai'i.

- 2) **Radiant Cooled Surfaces:** Radiant panels that can be retrofitted into standard T-bar ceiling grids, wall surfaces or work space cubicles can be used in conjunction with natural ventilation to provide a cooling effect at a much lower energy cost than conventional air conditioning. These are particularly applicable in buildings where natural ventilation provides sufficient airflow for much of the year, but where comfort is desired or required for the hotter, more humid portions of the year. The cooling benefits derive from an air conditioning compressor sized at a fraction of a standard compressor.
- 3) **Building Modeling and Simulation:** HNEI is conducting predictive modeling research using computational fluid dynamics (CFD) models to understand and validate heat transfer and comfort conditions within naturally ventilated spaces. In combination with building energy simulation tools, CFD can be used to predict the impact of external variables (adjacent structures, orientation, topography) on air movement into a building. Internal CFD models are being used to evaluate air flow within a space, including the effect of ceiling fans and radiant cooling surfaces. Modeling can be used as a predictive tool to determine the impact of comfort mitigating measures being considered by the State for schools and other unconditioned spaces.
- 4) **Energy Performance Dashboard:** HNEI is developing a classroom-based energy dashboard to provide real-time feedback to occupants as to how energy is being used in the facility, serving both as an energy management and an educational tool. The dashboard disaggregates energy consumption by end-use as well as the total load. The dashboard also displays energy generation (e.g., solar PV) in both real time, and year to date. The dashboard also integrates predictive modeling algorithms that compare annual usage-to-date with the predicted usage, providing feedback to users as to whether specific energy targets are being met. Based on the targets, recommendations are provided on-screen to help shape energy consuming behavior from day to day in order to meet annual energy targets. This dashboard is being designed specifically for Net Zero Energy facilities, but can also be used for conventional facilities as well.

New Projects

Renewable Portfolio Standards Study II (\$550,000) HNEI is continuing its modeling efforts with GE to provide independent assessments of issues critical to policy development and infrastructure investment. The analyses will build upon the recently completed RPS Study and further evaluate impacts of increasing renewables, system challenges, mitigations and the costs and benefits of various solutions. The study will also evaluate distribution level challenges and mitigations including distributed PV growth, frequency response, ride through capabilities and the ability of distributed resources (e.g. smart inverters, battery systems) to address these challenges.

The study is structured to be conducted in smaller pieces to provide results and findings on a more regular basis, and to allow enough flexibility to meet rapidly evolving state energy analysis needs in a timely way.

Economic Study of Hawai'i's Renewable Portfolio Standard (\$186,000)

In an effort related to the RPS Study II, HNEI is supporting the University of Hawai'i Economic Research Organization (UHERO) to assess the economic implications for the State of achieving high penetration levels of renewable energy focusing on policy mechanisms and economic outcomes. UHERO will identify load profiles based on changes to factors such as rate design and storage capacity that may be used as inputs to GE modeling analyses, and will use results from GE modeling analyses to assess the broader economic impacts to the State under various scenarios.

Assessment of the Variability of the Energy Resource for Solar and Wind Power on Oahu (\$222,000) Also related to the RPS Study II, this assessment by the UH Department of Meteorology will analyze the variability of the solar and wind energy resource on the Island of Oahu over periods of seconds, minutes, hours, days, months, years, and decades. Current models are based on wind and solar resource data from only one or two years. A clearer understanding of the actual variability of these resources over multiple timescales is critical for both accurate forecasting and planning.

Electric Vehicle Transportation Center Partnership (\$150,000)

HNEI is a partner in the Electric Vehicle Transportation Center (EVTC), a four-year, \$9 million research effort to help create the nation's electric-vehicle transportation network, which is operated by the University of Central Florida's Florida Solar Energy Center (FSEC). The vision for the EVTC is to transform the country's transportation network into a fully integrated 'smart' electric vehicle deployment coupled with a 'smart' electric grid, achieved with maximum efficiency and minimum time and disruption. HNEI is

conducting research targeting the integration of electric vehicles into power grids characterized by high penetration of intermittent renewable energy.

Federal Aviation Administration Alternative Jet Fuel Supply Chain Tropical Region Analysis (\$75,000) HNEI is partnering with other University of Hawaii departments and the FAA to develop information on regional supply chains for use in creating scenarios of future alternative jet fuel production in tropical regions, including the identification of the key barriers that must be overcome to produce significant quantities of alternative jet fuel in Hawaii and similar tropical regions.