

# UNIVERSITY OF HAWAI'I SYSTEM ANNUAL REPORT



**REPORT TO THE 2015  
LEGISLATURE**

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

**HRS 304A-1891**

**November 2014**

## Report to the 2015 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).

**NOTE:** Sections 304A-1893, 1894, and 2169, HRS, were repealed on June 30, 2013. While, the Energy Systems Development Special Fund (ESDSF) was not in place during the period this report covers (July 1, 2013 – June 30, 2014), activities already initiated or contracted did continue. The ESDSF was re-established by Act 107, Session Laws Hawaii 2014, effective July 1, 2014.

**SUMMARY:**

The Hawaii Natural Energy Institute (HNEI) was established in 1974 to coordinate and undertake the development of natural energy sources for Hawaii. In the past decade, HNEI has substantially increased its funding base. During this time, HNEI has also developed significant partnerships with local and national industry addressing integration of renewable energy technologies onto the grid, an issue of critical importance to the State. In 2007, the State Legislature 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.

**HNEI Mission (from ACT 253)**

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

- Diminish Hawaii'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 its mission, HNEI has assumed a pivotal role within the state to reduce Hawaii's dependence on fossil fuels, serving as the implementing organization for several large, high-visibility public-private partnerships to develop, deploy and demonstrate renewable energy systems. HNEI works closely with federal funding agencies, industry, the State Energy Office, our State legislators, and our Congressional delegation; regularly participating in high level coordination meetings.

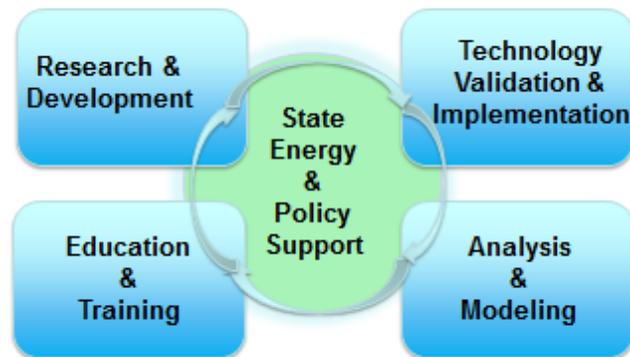
HNEI supports the State's "Hawaii Clean Energy Initiative" (HCEI), to achieve the goal of 70 percent clean energy by 2030, serving as a critical bridge between State and Federal initiatives. For example, HNEI serves as the implementing research partner for the Asia Pacific Technology and Education Program funded by the Office of Naval Research ("ONR"). HNEI also manages the USDOE Hawaii National Marine Renewable Energy Center to facilitate the advancement of ocean energy technologies, and leads many technology development/validation efforts as described below.

While HNEI's plays a significant role in the development and management of public-private partnerships and supporting analysis for state energy policy, we have also maintained our strong core research effort. Today, HNEI conducts programs in the areas of Alternative Fuels; Renewable Power Generation Technologies; Energy Efficiency; Electrochemical Power Systems; and Grid Integrated Energy Systems.

HNEI staff are predominantly non-tenure track faculty and full time research staff, allowing greater flexibility in realigning research efforts. Along with the multidisciplinary education and extensive experience of HNEI's staff, HNEI can consistently align its efforts with the changing objectives of the State of Hawaii, the US DOE and DOD. For example, Grid Integrated Energy Systems, the area with the most significant amounts of federal and state funding today were not part of HNEI's portfolio just a few years ago. HNEI's sustainability activities remain well aligned with the State's energy goals and with the University's Strategic Plan.

The energy needs of the state and the nation are both urgent and complex. Solutions are often capital intensive with long lead times and have the risk of unintended consequences. Development of technology, strategies and policies that will have significant positive impact on the state energy mix requires the integration of analysis, research, engineering, economics, and policy.... and more. It requires people from a wide range of disciplines and from different types of organizations to work together. HNEI operates in this manner.

HNEI's activities can be grouped into five core functions; Research & Development, Technical Validation & Implementation, Analysis & Modeling, Education & Training, and State Energy & Policy Support. As illustrated in the schematic, these functions are inter-related, and overlap by design, in order to maximize collaboration and leverage resources.



Act 253 also established the Energy Systems Development Special Fund (ESDSF) and directed that it be managed by HNEI, but 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. UH/HNEI access to those funds was delayed until June 2011. That fall, in collaboration with the State Energy Coordinator, HNEI developed an expenditure plan to maximize the value of these funds to meet near term needs and opportunities within the state. HNEI initiated actions on all but one of the original items. In 2012 and 2013, HNEI, again in collaboration with DBEDT, expanded the project portfolio to include additional high priority projects. The attached report summarizes HNEI's current research activities for the past year and provides a summary of the expenditure for the remaining funds provided under ACT 73, before the repeal of the ESDSF.

**Summary of Activities, 2014**  
**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	24
	Other temporary staff (APT, RCUH)	17
	Training (a)	40

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

**SUMMARY OF CONTRACTS AND ACTIVITIES:** Between 2001 and 2007, the Hawai'i Natural Energy Institute (HNEI) experienced substantial growth in its extramural funding from under \$2 million per year to over \$5 million per year. 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 seen a dramatic increase in extramural funding since then from \$5.7 million in 2007, to over \$17 million for 2013 and 2014 (based on 3 year rolling averages).

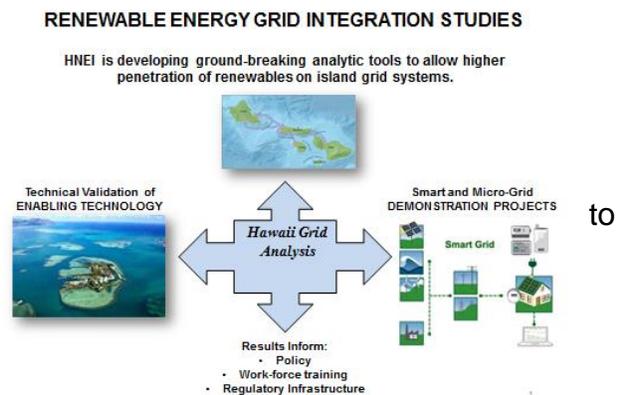
HNEI is a nationally acknowledged research leader with major activities in areas such as hydrogen and fuel cells, biofuels, ocean resources, and grid integration. While continuing to conduct basic and applied research, HNEI has, in accordance with HRS 304A-1891, also undertaken a pivotal role within the state to reduce dependence on fossil fuels 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 the goals of the Hawai'i Clean Energy Initiative (HCEI).

A brief synopsis of select HNEI activities follows:

***Hawai'i Energy Sustainability Program (HESP):*** HESP is a continuation of the 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 Hawaii 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 and its predecessor, the Hawai'i Distributed Energy Resource Technologies for Energy Security program have included:

*Oahu Wind Integration Study (2008 - 2010)* – Utilizing a variety of modeling and grid simulation tools, this study evaluated the technical feasibility and economic viability of operational strategies, improvements to existing infrastructure, and new technologies to enable high penetrations of renewable energy in Hawaii. A viable strategy was developed integrate up to 500 MW of wind and 100 MW of solar energy on the isolated Oahu power grid.



*Hawaii Solar Integration Study (2010 - 2012)*: The Hawaii Solar Integration Study (HSIS) built upon the knowledge gained in the Oahu Wind Integration Study (OWIS). The study examined very high penetration scenarios of solar and wind energy – up to 760 MW of distributed and utility scale solar PV and 300 MW of wind resources for Oahu, and up to 45 MW of distributed and utility scale solar PV and 72 MW of wind on Maui. Focused on the operational impact on the Oahu and Maui bulk power systems, the HSIS evaluated reserve strategies, impacts on thermal unit commitment and dispatch, utilization of energy storage, renewable energy curtailment, and other aspects of grid reliability, operations and costs.

*Oahu – Maui County Grid Interconnection (Stage 2) Study (2012 – 2013)*: In partnership with Hawaiian Electric Company, HNEI managed the Stage 2 Study, which built upon the work of both the OWIS and HSIS to examine the value proposition of prospective grid interconnection of the power systems on Oahu to those in Maui county (Maui, Lanai and Molokai) via submarine power cables, advanced control systems and operational strategies. The study, completed in May 2013, found a variety of benefits that grid interconnections could potentially provide, and recommended further research to compare the incremental value of potential interconnections with modified utility

operating practices. This work is being performed in the Renewable Portfolio Standards Study described below.

*Oahu EV Charging Study (2012 – 2013):* Leveraging the validated models of the Oahu power grid refined in the OWIS and HSIS, this study's primary objectives were to quantify the impact of electric vehicle charging on Oahu grid operations and to explore how different control techniques to manage EV charging profiles might further enhance the integration of wind and solar resources (e.g., by reducing curtailment and/or providing a new source of reserves). This study was prepared for DBEDT's Strategic Industries Division and was published as part of DBEDT's larger Hawaii Renewable Energy Grid Project Report for the USDOE that was delivered in 2014.

*Renewable Portfolio Standards Study (2013-present):* For this study, HNEI has contracted with GE to build upon the work done in the OWIS, HSIS, and Stage-2 studies to evaluate and assess the likelihood of compliance with the State RPS requirements. The study has modeled costs and economics as well as the technical implications of various scenarios to help identify promising approaches to meeting the 2020 RPS mandate. The analyses compare the value of grid-tied, and generation-tied undersea island interconnections with island independent systems. The analyses also include the impacts of using liquefied natural gas for electricity production, of modified utility operating practices and reserve requirements, and the use of ancillary services such as demand response and battery energy storage systems. The goal of the study is to provide insight on the economic and technical implications of the approaches analyzed to inform decision makers that need to implement plans to achieve the RPS objectives. The final report will be delivered by the first quarter of 2015.

*Liquefied Natural Gas Study (2012):* In response to a request from the state, HNEI retained FACTs Inc. to evaluate the potential importation of liquefied natural gas (LNG) to Hawaii. The study (1) assessed the potential demand for LNG in Hawaii, (2) evaluated the costs and benefits of LNG compared to other fossil fuels, (3) identified the potential impacts of LNG on Hawaii's economy and Hawaii's energy future, and (4) identified and assessed regulatory policies and practices that may be necessary or appropriate for Hawaii to consider for the importation of LNG. The final report was delivered in December, 2012 and HNEI used approximately \$150,000 from this program to fund the study. In a separate body of work, HECO contracted for studies to assess the technical feasibility of various import facility options and infrastructure requirements, and to assess different LNG supply options, including potential sources, pricing, security, and contracting options. Together the HNEI and HECO studies should begin to provide a foundation to assist in planning and decision making as the importation and use of LNG in Hawaii is considered.

In addition to the technical studies, HNEI has committed resources from the Energy Systems Development Special Fund to support the Hawaii Clean Energy Programmatic EIS efforts. This work is closely coordinated with the State Energy Office and the USDOE, and is cofunded by the the Energy Systems Development Special Fund. This project is described in the section on the ESDSF.

***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 the Big 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 the Big 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 will conduct initial system dynamic testing at the Powertech Labs facilities in Vancouver, Canada. This is planned for six months completing in mid-2015. At that time the system will be delivered to Hawaii and installed at another site. Negotiations are ongoing to site it at the NELHA facility in Kona. It is expected to be fully operational by the end of 2015. The total budget is approximately \$5 million.

*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 Hawaii Volcanoes National Park and the Island of Hawaii 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 Hawaii. The trailers were completed in May 2014 and will be delivered in mid-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 Hawaii to provide rapid high-pressure refueling infrastructure in support of this work. The station has been commissioned and successfully fueled its first vehicle on November 19<sup>th</sup>, 2014. Vehicle fill times are under 5 minutes.

***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 is 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 percentages of as-available renewable resources. The equipment was installed, and the demonstration is being conducted through 2014. A final report on this work will be completed by December 2014. HNEI is also serving as one of the Hawai'i implementing organizations for the recently announced 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 is supplying the advanced PV inverters, and Silver Spring Networks, which will integrate 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, 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). More recently the program was again 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 Molokai, Coconut Island, at the UH Manoa campus, and various projects on Maui.

***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 Hawaii'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 Hawaii. The site is now fully permitted with three births at different depths, expected to be functional by February 2015. 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.

#### ***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.

***The Flash Carbonization™ process:*** Under this technology development effort, HNEI is scaling-up a UH patented process invented at the Institute for the rapid and efficient production of charcoal from biomass. Charcoal is the renewable replacement for coal that is burned in Hawai'i for power generation and is the biggest contributor to global warming. To assist licensees of our patents, HNEI is now developing emissions control technology that will facilitate the permitting process so that the technology can be operated in Hawai'i and on the Mainland. HNEI also is exploring the use of this technology to produce charcoal from Honolulu sewage sludge, and the production of charcoal to replace coke used to reduce silica to silicon for the manufacture of photovoltaic cells. The latter work is funded by the National Science Foundation and involves collaboration with the Dow Corning Corporation.

***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 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 \$ 1,234,022  
Tuition and Fees S Funds \$ 41,948  
Research and Training Revolving \$ 388,235  
Extramural Awards \$ 17,338,181

All of these funds support the research and training activities described above. We anticipate 2015 extramural funding levels to be comparable to those from 2014. The rate of expenditure is expected to be similar to that of 2014.

**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 Hawaii.

- o **Utility Scale Clean Energy Capacity Project:** HNEI provided substantive assistance to DBEDT in the development of this award from the USDOE and recently assisted DBEDT in evaluating the impact of electric vehicles on the O'ahu grid system.
- 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 **Hawaii Clean Energy Programmatic Environmental Impact Statement (PEIS):** HNEI is closely coordinating the PEIS effort with the Hawaii State Energy Office and the USDOE. The 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 **Hawaii 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 **Hawaii State Energy Office Support:** HNEI is working with the Hawaii 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 was established in 2007 under ACT 273 but went unfunded until 2010, when, under ACT 73, 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. Due to account issues, UH/HNEI was unable to access these funds until June 2011. Between June 2011 and June 30, 2013, HNEI received a total of \$7,173,639 in funding. HNEI worked 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 dollars. As noted previously, Sections 304A-1893, 1894, and 2169, HRS, were repealed on June 30, 2013, and re-established on July 1, 2014. Thus, the Energy Systems Development Special Fund (ESDSF) did not exist and received no barrel tax funding for fiscal year 2014. HNEI is currently coordinating with DBEDT to plan the expenditure of new funds which have begun to accrue.

Below is a description and update of the programs and projects supported by money committed from the Fund prior to its repeal, totaling approximately \$7,000,000.

***Geothermal Resource Assessment: (\$400,000)*** The US DOE has funded a project led by the University of Hawai'i to validate a new geophysical inversion and analysis procedure to map the subsurface structure of the geothermal resource and lower exploration costs. DOE funding was approximately \$1 million over two years with additional cost share from industry partners. HNEI committed \$400,000 from the Fund to purchase the relevant equipment and support one scientist to conduct the analysis to insure that the equipment and know-how developed under this effort will be available for additional resource studies with near-term target areas on both the Big Island and Maui. This work, initiated in Spring 2012 will also allow site exploration on the Island of Maui.

***Geothermal Strategic Development Study (\$115,000 )*** HNEI contracted with the Pacific International Center for High Technology Research (PICHTR) to assess the current environment for geothermal development in the state, including the level of industry interest, and the identification of state and county agency needs to adequately perform the functions necessary for anticipated geothermal development. From this information PICHTR prepared a geothermal strategic development plan that will help agencies be prepared for the complex planning, assessment, regulatory, and permitting activities required. This plan, which can serve as a guide to DBEDT and other state agencies (e.g. DOH and DLNR) involved in geothermal development, was completed in December 2012.

***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 recent changes to the DOE program, deployment and demonstration of this technology will be funded via a grant to HNEI from ONR.

***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 will conduct initial system dynamic testing at the Powertech Labs facilities in Vancouver, Canada, after which it will be delivered to Hawaii and installed on the Big Island. Negotiations are underway for siting at the NELHA facility in Kona. It is expected to be fully operational by the end of 2015. HNEI also contracted with the Hawaii 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 Hawaii Volcanoes National Park and the Island of Hawaii 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 Hawaii. The trailers were completed in May 2014 and will be delivered in mid-2015 with the hydrogen energy system equipment.

***Hawai'i Clean Energy Programmatic Environmental Impact Statement:***

***(\$1,700,000)*** A Programmatic EIS for the undersea cable was identified by USDOE and DBEDT as the next critical step in planning for the interconnection of the Hawaiian Islands via undersea cable - a critical step to meet HCEI goals. In July 2012, in coordination with the USDOE and DBEDT, HNEI contracted New West Technologies to conduct a Programmatic Environmental Impact Study for alternative scenarios for deployment of undersea electrical cables for interconnection of O'ahu, Maui, and Hawai'i Counties electrical grids. The PEIS is analyzing, 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 State of Hawai'i and the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) are cooperating agencies in preparing this PEIS. The PEIS will provide 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 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. The Final PEIS, which will consider and/or address comments received on the draft, is currently being drafted, and is due out in the first quarter of 2015.

***The Pacific Asian Center for Entrepreneurship and E-Business: (\$50,000)*** PACE consists of an integrated set of leading-edge entrepreneurship programs at the

University of Hawaii Shidler College of Business with an innovative curriculum, research projects, and community outreach and involvement with Pacific and Asian entrepreneurs and entrepreneurial ventures. HNEI expended \$50,000 of the Fund to support several PACE fellowships to conduct technical and business analyses of critical energy issues. Support of this program was intended to develop a workforce cross-trained in the business, legal and technical aspects of future energy systems. This effort stopped with the ESDSF sunset and has not been reinitiated.

***Hawaii Energy Policy Forum Support, HCEI Metrics (\$350,000)***. HNEI supports the Hawaii 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 Hawaii Clean Energy Initiative's requirements.

***Wave Energy Test Site (\$500,000)***. UH/HNEI through the Hawaii National Marine Renewable Energy Center has been awarded a total of \$ 8 million by USDOE to support wave energy testing at the soon to be 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 will result in a grid-connected site where developers can test their technology for proof of seaworthiness, functionality, system integrity and technology viability.

***Sea Water Air Conditioning Monitoring (\$160,000)*** Seawater air conditioning has the potential to contribute significantly to the state's energy efficiency goals. HNEI has procured federal funding to develop high-fidelity plume models to assess the impacts of cold water return depth, a factor which has major impact on the capital cost of these projects. HNEI has also procured funding to initiate on-site monitoring before and during operation of the Honolulu SWAC system to assess impacts and validate models. HNEI is using \$160,000 from the barrel tax to conduct the long-term monitoring necessary to validate performance. Depth of discharge has major impact on the overall cost of the SWAC project. This work has the potential to save millions from future projects substantially increasing the likelihood of future SWAC development and resulting fuels savings.

***Renewable Portfolio Standards Study (\$850,000)*** HNEI has contracted with GE to build upon the modeling work done in the OWIS, HSIS, and Stage-2 studies to evaluate and assess the likelihood of compliance with the State RPS requirements. The study, cost shared by US DOE has modeled costs and economics as well as the technical implications of various scenarios to help identify promising approaches to meeting the 2020 RPS mandate. The analyses compare the value of grid-tied, and generation-tied undersea island interconnections with island independent systems. The analyses also include the impacts of using liquefied natural gas for electricity production, of modified

utility operating practices and reserve requirements, and the use of ancillary services such as demand response and battery energy storage systems. The goal of the study is to provide insight on the economic and technical implications of the approaches analyzed to inform decision makers that need to implement plans to achieve the RPS objectives. A final report will be available in the first quarter of 2015.

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

- Hawaii 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 Hawaii'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. Three areas of research using technologies to be researched for Hawaii-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 mitigating 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-conditioned environments in Hawaii.
- 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.