

UNIVERSITY OF HAWAI‘I SYSTEM ANNUAL REPORT



REPORT TO THE 2012 LEGISLATURE

ANNUAL REPORT FROM THE HAWAI‘I
NATURAL ENERGY INSTITUTE

HRS 304A-1891

November 2011

Report to the 2012 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, Its Work in Coordination with State Agencies and Programs, and Recommendations for Proposed Legislation, required in accordance with HRS 304A-1891 (Act 253, SLH 2007).

SUMMARY: Section 304A-1891 passed by the Hawai‘i State Legislature in 2007 established the Hawai‘i Natural Energy Institute (HNEI) in statute, defined duties of the institute and its director, and required an annual report to the legislature on its activities, expenditures, contracts developed, advances in technologies, coordination with State agencies and programs, and recommendations for proposed legislation. It also established the Energy Systems Development Special Fund and directed that it be managed by HNEI, but no funding was provided. In 2010, ACT 73 established a barrel tax and authorized that 10 cents of the tax on each barrel be deposited into the Energy Systems Development Special Fund. As reported last year, the authorization to access those funds was included in the Budget Worksheets under Program ID#BED120, under the Department of Business, Economic Development and Tourism (DBEDT) delaying UH/HNEI access to those funds.

In June 2011, UH was able to access these funds. Although none of these funds have been expended, HNEI did, in collaboration with the State Energy Coordinator, develop a detailed expenditure plan to maximize value of these funds to meet near term needs and opportunities within the state. The attached report summarizes HNEI’s current research activities and provides a detailed summary of the proposed expenditure for the available funds provided under ACT 73.

Summary of Activities, 2011
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

Director: Richard E. Rocheleau
Phone: 808-956-8346
rochelea@hawaii.edu

Staffing:	Permanent Faculty (FTE)	7
	Other permanent staff (APT)	3
	Temporary Faculty	18
	Other temporary staff (APT, RCUH)	19
	Training (a)	45

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

SUMMARY OF CONTRACTS AND ACTIVITIES: Between 2001 and 2008, 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. This growth accelerated in 2009, 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 in using Hawai'i as a site for alternative energy testing in the Pacific region. As a result, extramural funding to HNEI increased to over \$14 million in 2009, to over \$24 million in 2010, and reached \$31 million in 2011.

HNEI is a nationally acknowledged research leader with major activities in areas such as hydrogen, fuel cells, biofuels and ocean resources. 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: A continuation of the Distributed Energy Resource Technologies for Energy Security program initiated in 2006, 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), addresses technical issues associated with increased penetration of intermittent renewable and distributed energy technologies in the electrical grid. To date, models have been developed and validated for the Big Island, Maui, and O'ahu and for various interconnection scenarios. These models are being used to examine utility practices to manage grid stability and reliability in the face of increased as-

available renewable energy systems and to evaluate operational and technology changes that would allow reliable operation with increased intermittent renewables energy from sources such as wind and photovoltaics, including detailed studies of the proposed interisland connection in support of HCEI. The models are also being used to identify the impact of near-term energy-transforming projects such as grid storage, hydrogen infrastructure, and electric vehicles.

In early 2011, HNEI published the results of the O‘ahu Wind Integration Study (OWITS), a major two-year study analyzing the potential impacts of integrating large amounts of wind power from Neighbor Islands (Molokai and Lanai) into the O‘ahu grid through an undersea cable (known as the “Big Wind” project). The report was the first in-depth technical analysis of the potential project and the report was covered fairly extensively in the news media. This analysis provided direct support to the state’s efforts to develop strategies for the interisland undersea cable and planning for the EIS.

As follow on to this work, under HESP, HNEI is continuing the work with HECO, MECO, and GE to perform a detailed analysis of the impact of including Maui in the interconnection efforts. These studies will begin first quarter 2012. In addition to the technical studies, HNEI proposes to use up to \$1million from the Energy Systems Development Special Fund to support additional EIS efforts. This is being closely coordinated with the State Energy Office.

Other follow on studies, this time with HECO, MECO, and NREL include the Hawai‘i Solar Integration Study, which will analyze scenarios of large increases in solar PV power on O‘ahu and Maui. This study started in 2011 and will continue through 3rd quarter 2012. In addition, under separate funding from the US DOE (via DBEDT), HNEI is examining the impact of a large numbers of battery powered electric vehicles (BEV) or fuel cell powered vehicles on O‘ahu . The analysis will also be completed in 2012.

Hawai‘i Hydrogen Program: A culmination of an effort first started in 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 next three subsections, are budgeted at over \$ 8 million including approximately \$500,000 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: In a joint USDOE-DOD project (funding from the US DOE and project technical program management from the Naval Research Laboratory (NRL)), HNEI is developing hydrogen production infrastructure at the Puna Geothermal Venture (PGV) electricity production plant on the Island of Hawai‘i. The project objectives include 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 hydrogen produced at the geothermal plant will be used to fuel fuel-cell-powered shuttle buses operated by the County of Hawai‘i Mass

Transportation Agency as a feeder service to the main Hele-on bus line in the Puna district, and in support of fuel cell buses at Hawai'i Volcanoes National Park (HAVO). The PGV hydrogen system is planned to be operational by the end of August 2012. The total budget is approximately \$5 million.

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. The first five vehicles were delivered in October 2010. HNEI has been approved to relocate the HAVO 350 bar (5,000 psi) fast-fill station, funded by the USDOE and State of Hawai'i, to MCB Hawai'i. Additional funding (approximately \$ 1.25 million) to upgrade the 350 bar station to 700 bar capacity has been received from ONR. An MOA under negotiation with MCB Hawai'i is nearly completed. Once executed, the hydrogen fueling station system is expected to be operational two months later.

Hawai'i Hydrogen Power Park: With funding from the USDOE and from the State's Hydrogen Investment Capital Special Fund through the Department of Business, Economic Development and Tourism (DBEDT), HNEI is the implementing partner for the installation of a hydrogen fueling station on the Big Island at Hawai'i Volcanoes National Park (HAVO). In support of this effort, HNEI worked with HAVO to secure separate funding in the amount of \$1 million from the U.S. Department of Transportation to convert two conventional diesel shuttle buses into hydrogen-fueled FCEV shuttle buses to transport tourists at the park. The Hawai'i Center for Advanced Transportation Technology (HCATT), a sub-agency of DBEDT, will execute the conversion leverage of their considerable expertise in managing the Hickam Air Force Base hydrogen program. Fuel for this effort will be provided by the newly funded PGV Hydrogen Infrastructure (see above).

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 four-year, \$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. In 2011, HNEI completed the detailed engineering for this project, initiated a community outreach effort to recruit volunteers and educate the public on smart grid technology, and began the initial installations of smart grid equipment in volunteer homes. We will finish installing equipment in 2012 and conduct the demonstration through 2013. 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. In addition to general advice, HNEI is leading efforts to coordinate between the two smart grid projects. HNEI has also developed a new PV-Smart Inverter project (see below) that will become an integral part of the Maui Smart Grid efforts.

DOE Smart PV Inverter Project: In a project that closely supports the Maui Smart Grid efforts, an HNEI-led team won a new project to develop and demonstrate new “smart grid-enabled” PV inverters. This project, announced in September 2011, is intended to higher penetrations of solar PV systems by mitigating the utility operations issues resulting from variability of PV systems.

These new PV inverters will be tested as a part of the ongoing smart grid demonstration projects on Maui and another smart grid pilot project in Oklahoma. Partners in the project include Fronius and Silver Spring Networks to integrate advanced PV inverters supplied by Fronius into the smart grid network developed by Silver Spring Networks. Maui Electric Company, Hawaiian Electric Company, and Oklahoma Gas and Electric are the utility partners supporting the live demonstrations on their utility grids.

Funding for the project includes approximately \$6.1 million in DOE funding and almost \$ 6million cost share from the industry partners. Funding limitation from the DOE, in year one, has jeopardized timely completion of the technology portion of this work. Due to its critical contribution to the smart grid efforts, HNEI is proposing to use up to \$400,000 from the Energy Systems Development Special Fund to insure timely and successful completion of this effort.

Asia-Pacific Energy Technology Initiative: The APET 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. A key focus under HEET was the development of the Hawai‘i Fuel Cell Test Facility (HFCTF) located on HECO property on Cooke Street. Today this facility has, in addition to ONR funding, several awards active or pending from the USDOE, the National Renewable Energy Laboratory, and various companies. HNEI is currently under discussion with HECO to rename this facility to highlight the renewed interest by HECO and new activities in the testing of advanced battery technology.

In 2009/2010, HEET was expanded to include biofuels and to support testing of critical heat exchanger technology in support of Ocean Thermal Energy Conversion (OTEC). In 2011 these efforts were expanded more to include deployment and testing of net energy neutral buildings, testing of grid scale Li-ion high power batteries for grid support, and, as described above, support of various hydrogen infrastructure projects on the islands. In 2012 we will continue the current activities and anticipate further expansion to include testing and evaluation of renewable generation and power system controls for smart and micro-grid applications.

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. USDOE recently awarded \$2,333,379 for the second and third years of funding (September 2010 to September 2012). This is in addition to the first-year federal funding of \$978,048. The state’s utilities, industrial partners and the University of Hawai‘i are providing in-kind cost-share matching.

Solar Initiatives: HNEI is the primary subcontractor to MVSystems, a mainland solar energy company, for development of technology for the solar production of hydrogen. HNEI has critical patents in this field and is currently negotiating with industry for licensing and further development. HNEI is also providing technical support, data acquisition, and analysis services to the Hawai‘i Department of Education for the installation of \$5 million in solar systems on selected schools.

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. In support of this effort, HNEI has developed a high-data-rate Data Acquisition System (DAS) to collect time-stamped data of weather and PV performance at a variety of sites. The high-data-rate time-stamped data provide the raw data to support analysis of the transient response characteristics due to the environmental conditions. The initial test site, at Pu‘u Wa‘a Wa‘a Ranch on the Big Island of Hawai‘i was put into operation in 2010 with data collected through 2011. Multiple sites and technologies are expected to become operational in 2012.

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 a collaboration with the Dow Corning Corporation.

Algal Bio-Oils for Biodiesel Production: Under this technology development effort, HNEI is working with various industry partners to contribute to the development of technology for the production and extraction of oils from biomass. The UH Office of Technology Transfer and Economic Development (OTTED) has filed for a U.S. patent on technology developed by HNEI faculty on this topic. Two external funding streams have been secured. The first is with a start-up mainland company that is seeking to

evaluate this HNEI technology to extract bio-oil from jatropha biomass. The second, funded through the Center for Biomass Engineering Research and Development, is aimed at fundamentally modeling the HNEI technology. Combined, these efforts focus on the production of biodiesel from waste streams and downstream separation processes which will be essential for cost-effective production of algal oils.

Microalgal Oil for Jet Fuel Production: HNEI is the subcontractor on a Navy Small Business Technology Transfer project for producing jet fuel. We are involved in wastewater treatment, reuse and management for microalgae cultures as well as production of value-added co-products from biomass.

Electrochemical Power Systems R&D: Researchers in HNEI's Electrochemical Power Systems Laboratory 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 through the Idaho National Laboratory, the Air Force Research Laboratory through the Hawai'i Center for Advanced Transportation Technologies, and Hawai'i Renewable Energy Development Venture funds through Better Place. Two patents have been filed for a novel sugar-air battery, which will be supported by the US Navy Space and Warfare Systems Command (SPAWAR) for various potential applications as sustainable power sources.

EXPENDITURES: General Funds \$ 1,116,078
Tuition and Fees S Funds \$ 44,249
Research and Training Revolving \$ 253,565
Extramural Awards \$ 30,917,128

All funds were expended in support of research and training activities described above. We anticipate 2012 extramural funding levels to be comparable to those from 2010, somewhat lower than in 2011. This is primarily due to the continuation of several multiyear efforts funded in 2011. The actual rate of expenditure is expected to be similar to that of 2011.

CONTRACTS DEVELOPED: HNEI has developed many subcontracts under its existing extramural federal funding but due to the delayed access to the Energy Systems Development Special Fund (June 2011), no contracts specific to HB1003 HD3 SD1 CD1, SLH 2007, were developed. However, as summarized below, HNEI has coordinated with the State Energy Coordinator and anticipates development of several contracts under the Special Funds during first quarter 2012.

ADVANCES IN TECHNOLOGY: HNEI continues to conduct research to advance renewable energy technologies. HNEI has patents in the areas of battery charging, conversion of biomass to charcoal, solar production of hydrogen, and conversion of waste streams to valuable bio plastics in the processing of ethanol. Licensing discussions are

ongoing in all of these areas. On behalf of HNEI faculty, OTTED has submitted a patent application on extraction of bio-oils from biomass to the U.S. Patent Office, and HNEI faculty has responded to patent reviewer questions. This patent is now pending further review.

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 2010 which involve strong collaboration/coordination with DBEDT include the following:

- ***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.
- ***Hawai'i Hydrogen Plan:*** HNEI, via Kolohala Ventures, is developing the State Hydrogen Plan as called for as part of the Hydrogen Investment Capital Special Fund. HNEI is working closely with DBEDT to insure that this plan is consistent with State objectives in this area.
- ***Marine Corps Base (MCB) Hawai'i Hydrogen Fueling Station at Kaneohe Bay:*** HNEI is leveraging the State of Hawai'i investment in the Hawai'i Hydrogen Power Project by reallocating the hydrogen production and fueling station from the Hawai'i Volcanoes National Park to MCB Hawai'i, in support of the deployment of the ONR/GM Equinox fuel cell vehicles. HNEI has worked closely with DBEDT in coordinating this evolving project. This project is receiving global interest as a result of GM's commitment to target Hawai'i for the first commercial rollout of its FCEV program.
- ***Utility Scale Clean Energy Capacity Project:*** HNEI provided substantive assistance to DBEDT in the development of this award from the USDOE and was recently awarded funding from DBEDT to evaluate the impact of electric vehicles on the O'ahu grid system.
- ***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.
- ***Hawai'i-Okinawa Partnership on Clean and Efficient Energy Development and Deployment:*** HNEI has worked closely with DBEDT, HECO, and MECO staff in scoping demonstration projects in Hawai'i under this partnership between the U.S. and Japanese governments in the areas of smart grid, ocean energy, and energy efficiency technologies. In February 2011, the New Energy and Industrial Technology Development Organization (NEDO) announced their plans for a smart grid demonstration project as a part of this partnership. HNEI staff travelled with HECO staff to Japan to brief NEDO officials and Japanese industry as a part of their project scoping efforts, which continued through most of 2011. In November 2011, NEDO and the State of Hawai'i held the formal signing ceremony to begin the project officially. HNEI has supported this effort from the preliminary stages through to the official kickoff. We will be coordinating several of the technology demonstrations in the DOE-funded smart grid demonstration

projects with NEDO and Hitachi, which is NEDO's industry lead on the project. As the projects continue, HNEI will also be looking for additional opportunities to support this effort by applying for new proposals from DOE or other funding opportunities.

RECOMMENDATIONS FOR PROPOSED LEGISLATION: Generally, HNEI does not initiate legislation, but HNEI does recommend funding the Energy Systems Development Special Fund. As high oil prices continue to pressure the consumer and energy providers, this fund would accelerate the acceptance and deployment of pre-commercial energy and energy-efficiency technologies expected to have near-term impact on Hawai'i's energy infrastructure. HNEI 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, HNEI also financially supports the University of Hawai'i's Hawai'i Energy Policy Forum for outreach and analysis efforts.

ENERGY SYSTEMS DEVELOPMENT SPECIAL FUNDS: As described in the summary, the Energy Systems Development Special Fund was established in 2007 but was 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 be deposited into the Fund. Due to account issues, UH/HNEI was unable to access these funds until June 2011. As a result no expenditures have been made. However, HNEI has, in collaboration with the State Energy Coordinator, developed a detailed expenditure plan to maximize value of these funds to meet near term needs and opportunities within the state. Some of the planned expenditures were identified in the sections above under the relevant programs. Below is a full accounting of the plans for expenditure of up to \$2.7 million from the Fund.

Geothermal Resource Assessment: (\$400,000) On September 8, 2011 the US DOE announced plans to fund 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 is approximately \$1 million over two years with additional cost share from industry partners. We are proposing to use \$400,000 from the Fund to purchase the relevant equipment and support one scientist to conduct the analysis to insure that 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. .

Smart Inverter Deployment: (\$400,000) On Sept 2, 2011, the US DOE announced plans to fund a project led by the University of Hawai'i to develop and commercialize smart grid-enabled PV inverters to mitigate grid reliability impacts of high penetrations of PV systems, and demonstrate these systems at two sites, one on Maui and one on the mainland. This program was described above. In spite of the substantial budget, the DOE award for year one was reduced by \$800,000 relative to that needed to meet deliverables for critical go-no go decisions at the end of year one. HNEI proposed to use \$400,000 from the Fund to match additional partner cost share to maximize likelihood of meeting the critical go/no-go deliverables.

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. As described above, this program leverages other investment under the Hawai‘i Hydrogen Power Park and supporting funds from the US Department of Energy and Hawai‘i Hydrogen Capital investment Fund and in-kind cost share from Puna Geothermal Venture and County of Hawai‘i Mass Transit Agency. This project has been identified by US DOE and Office of Naval Research as an outstanding example of inter-agency cooperation. However, initial capital cost and site preparation for this project exceeds the currently available budget. Supplemental support in the amount shown will insure that this high visibility project remains on schedule. HNEI proposed to use \$500,000 from the Fund to support this project with these funds used primarily to support development of the fuel cell bus conversion for operation in the underserved Puna area.

Hawai‘i Undersea Cable Project: (\$600,000 to \$1,000,000) The State Department of Business and Economic continues planning and environmental studies to examine alternative scenarios for deployment of undersea electrical cables for interconnection of O‘ahu and Maui County electrical grids. HNEI proposed to expend up to \$1,000,000, in coordination with DBEDT efforts in this area to provide critically needed resources for the next phase of these studies. These funds are expected expended via sub award to industry.

Energy Storage: (\$300,000) Grid scale energy storage has the potential to significantly impact the ability of the utility to integrate intermittent renewable energy generation into the grid. There are multiple projects underway on all islands using a variety of funds including US Department of Energy, Office of Naval Research, DBEDT ARRA funds, and private investment. To date there has not been a systematic analysis of the commercial value of these technologies on the Hawai‘i electric grid systems. HNEI proposes using up to \$300,000 from the Fund to support development of the business case. These funds leverage ongoing battery storage technology projects funded by DBEDT ARRA funding, and several HNEI projects funded by USDOE and ONR. The analysis proposed to be conducted with these funds also supports the very critical efforts of the PUC and the Renewable Standards Working Group to develop PV interconnections standards, in which battery storage may play a key role.

The Pacific Asian Center for Entrepreneurship and E-Business: (\$100,000) The Pacific Asian Center for Entrepreneurship and E-Business (PACE) is the home for an integrated set of leading-edge entrepreneurship programs at the University of Hawai‘i . Based in the Shidler College of Business, PACE is dedicated to fostering the entrepreneurial spirit among all members of the University and local community. Programs are organized into three areas:

1. An innovative graduate and undergraduate curriculum reflecting an Asian Pacific theme
2. Research projects that facilitate entrepreneurial practice and the advancement of our understanding of entrepreneurship in the Pacific Rim, and
3. An active agenda of community outreach and involvement with Pacific Asian entrepreneurs and entrepreneurial ventures

HNEI proposed to expend up to \$100,000 to support a limited number of PACE

fellowships annually, to conduct technical/business analysis of critical energy issues. Project considered under this program will be developed in close collaboration with DBEDT. Ongoing support of this activity is intended to provide future workforce cross-trained in both the business, legal, and technical aspect of future energy systems.