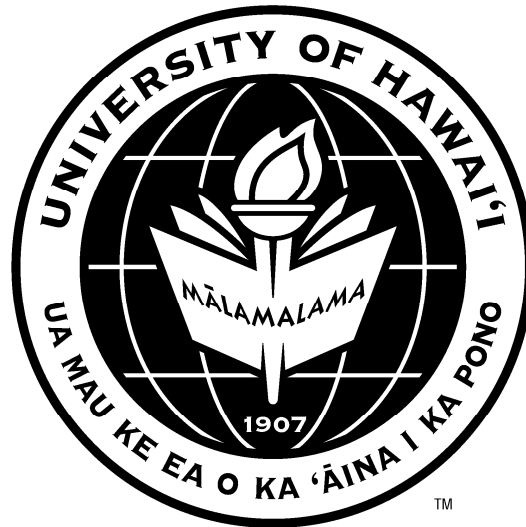


UNIVERSITY OF HAWAI‘I SYSTEM REPORT



REPORT TO THE 2018 LEGISLATURE

Report on the
Evaluation of Energy Efficient Technology Projects

ACT 15, SLH 2017
(revision of ACT 234, SLH 2007, and HRS 304A-1893.1)

December 2017

Report on the Evaluation of Energy Efficient Technology Projects

Act 15, SLH 2017, amended Act 234, SLH 2007, by revising the reporting requirement of the greenhouse gas emissions reduction task force (dissolved in 2010) by deleting the “every fifth year reporting” requirement to the Legislature. Also, Act 15 amended HRS 304A-1893.1 by redirecting the appointment of a two-person independent panel of independent energy and environmental technical experts from DBEDT to the University of Hawai'i Office of the Vice President for Research and Innovation (OVPRI). The panel is required to submit an initial evaluation beginning July 1, 2017 to the 2018 Legislature and every three years thereafter.

In compliance with the legislation, OVPRI appointed the following individuals to serve on the panel and to provide their expertise in evaluating the projects and activities funded by the energy systems development special fund:

Kyle Datta is currently the general partner of Ulupono Initiative, a Hawai'i-focused impact investing firm founded by Pierre Omidyar that uses for-profit, non-profit and social investments to improve the quality of life for island residents in three areas: locally produced food; clean, renewable energy; and waste reduction. Previously, he was the CEO of U.S. Biodiesel Group, a national biodiesel firm funded by private equity; managing director of research and consulting at the Rocky Mountain Institute; and a vice president of Booz, Allen & Hamilton, where he was the managing partner of the firm's Asia Energy Practice and later led the U.S. Utilities practice. Mr. Datta holds bachelor of science, master in environmental science in resource economics, and master in public and private management degrees from Yale University. He was CEO of New Energy Partners, an energy consulting and renewable development firm located in Hawai'i. He has co-authored several books including *Winning the Oil Endgame* (2005), and *Small is Profitable* (2002).

Dr. Terry Surles received his PhD in Analytical Chemistry from Michigan State. He has more than 250 publications, technical reports, and presentations to his credit. He has served on a number of committees, including five appointments with the National Academy of Sciences and continues that service for government agencies, including the US Department of Energy and the National Renewable Energy Laboratory. He has recently consulted for a number of organizations, including the Economic Development Alliance for Hawai'i, Booz, Allen, Hamilton, the East-West Center, the United Kingdom Energy Research Centre, and the State of Victoria. From 2000 to 2004, he was on loan to the California Energy Commission as the Public Interest Energy Research Program Director from Lawrence Livermore National Laboratory (LLNL) where he had been Associate Laboratory Director for Energy Programs. Emphasis in these programs was

on energy efficiency, demand side management and response and climate change science and analysis. Subsequent positions included President and Chief Executive Officer of the Pacific International Center for High Technology Research (2003-2005), Technology Integration and Policy Analysis Program Manager at the Hawai'i Natural Energy Institute (2006-2010), and Vice President for R&D (2010 to 2012) at the Desert Research Institute.

Their reports are attached.

Review of the Hawai‘i Natural Energy Institute (HNEI) Work Related to the Energy Systems Development Special Fund (ESDSF) Program Activities

The University of Hawai‘i Office of the Vice President for Research and Innovation (OVPRI) requested Terry Surles be a member of the independent panel to evaluate the 2017 activities of HNEI at the University of Hawai‘i at Mānoa as they relate to the performance of their activities under ESDSF as well as their more extensive programmatic activities. My extensive energy and environmental background has recently included serving as Interim Administrator for the Hawai‘i State Energy Office and, currently, I am Senior Advisor at the California Institute for Energy and Environment.

While HNEI had been created in 1974, it was only in 2007, that the Hawai‘i State Legislature passed legislation that established HNEI in statute. In addition to placing HNEI in statute, ESDSF was created for the purpose of developing an integrated approach for the portfolio management of renewable energy and energy efficiency projects that would lead to a reduction of Hawai‘i’s dependence on fossil fuel and imported oil and other imported energy resources. This mandate would allow Hawai‘i to be in a better position in moving toward energy self-sufficiency. As part of that legislation, and follow-on legislation enacted in 2017 (ACT 15), OVPRI is tasked with assembling a panel of independent experts to assess HNEI project activities that were conducted under HRS 304A-1893.1.

Key aspects of the 2007 legislation included a charge to HNEI to, in part (as I have paraphrased the legislative language):

1. Perform research, development, and deployment (RD&D) activities for renewable energy sources for electricity and transportation in coordination with state and federal agencies and the private sector
2. Demonstrate and deploy energy efficient technologies that address peak periods of electricity demand
3. Aggressively seek matching funds from federal agencies and the private sector for its RD&D activities

As part of this legislation HNEI was charged to administer ESDSF. Thus, HNEI was charged to award contracts to develop and deploy technologies that will reduce Hawai‘i’s dependence on important energy resources. This charge was not only for previously mentioned aspects, but also focused on nearer term development and deployment of technologies that could better utilize indigenous resources.

Given the requirements established under the Act and to be consistent with Kyle Datta’s report structure, I have chosen to use the criteria that he developed for the review:

- 1) To what degree were Hawai‘i Special Funds matched by external sources?

- 2) Do contracts and grants HNEI awarded focus on critically important technologies that reduce oil dependence and comply with criteria enumerated in the Act?
- 3) Is the portfolio well managed, as defined by on time deliverables and staying within the budget?
- 4) Is HNEI's policy input influential to energy sector decision-making?
- 5) To what degree is HNEI's portfolio of efforts shifting to entire energy system in Hawai'i to be more sustainable, affordable and resilient?

I. To what degree were Hawai'i Special Funds matched by external sources?

HNEI provided information to the reviewers that – in summary – was impressive in terms of the amount of federal funding that was obtained by utilizing matching ESDSF funds. Approximately \$38M was received from federal agencies – primarily the Department of Defense (DoD) and the Department of Energy (DOE). An additional \$250K came from the private sector. These matched approximately \$9M provided under ESDSF – a 4:1 ratio that is quite substantive. It should also be noted that a number of these projects built off of existing projects that had been developed working with federally funded activities prior to the authorization of ESDSF funding in the State legislature in 2010. In summary, the overall approach should be commended, as it has been important to build from existing work to continue technology development to a stage where it can be deployed by the private sector.

II. Do contracts and grants HNEI awarded focus on critically important technologies to reduce oil dependence and comply with criteria enumerated in the Act?

The funds being utilized are consistent with the goal of reducing oil dependence in the state. In particular, the new emphasis on energy efficiency is critical for meeting Hawai'i Clean Energy Initiative (HCEI) goals that include 100% renewable electricity by 2045. This extremely ambitious goal can only be reasonably reached on Oahu with highly aggressive approaches to energy efficiency, demand side management, and new demand response technologies. Generally, a more cost-effective approach is to utilize “negawatts” in meeting energy needs. As part of this effort, HNEI's work with state agencies, such as the Advanced Energy Efficiency and Renewable Energy Workshops, to promote energy education will be important in encouraging energy efficient behavior.

Other nearer-term work that is of importance to the state includes:

- a. Supporting the HCEI environmental review process
- b. Assessment of resource variability
- c. Grid services for high penetration renewables (While this may appear to be more in the future, analyses to better understand impacts and benefits will be critical for

- assisting the regulatory agencies and the utilities to better understand best practices.)
- d. Smart grid inverters
 - e. Electric vehicle transportation center
 - f. Department of Education heat abatement program
 - g. Analysis of battery energy storage on O‘ahu
 - h. Renewable Moloka‘i

A substantive amount of funding is directed towards the development of longer-term technology research and development activities. This research approach is appropriate as it will always be difficult to predict “winners” in the deployment of future technologies for both electricity and transportation. Thus, the three project areas that are grouped here are reasonable ones to be pursuing, given the need to better develop indigenous state energy resources. These are also major federally-funded projects in which the funding – as focused on Hawai‘i – is consistent and appropriate for federal programs. Specifically, these are:

- a. The Wave Energy Navy Test Site – originally funded primarily by USDOE as part of UH/HNEI being designated as one of the two national leads for ocean energy projects in 2008.
- b. Two hydrogen energy programs – one focused on electricity and one focused on transportation
- c. Aviation Sustainability Center – was much more modestly funded. The reason that this is important for the future is because HNEI is obtaining funds from a new agency (the Federation Aviation Authority) and allows HNEI to be involved early in an area that will grow in importance.

III. Is the portfolio well managed, as defined by deliverables meeting or exceeding study objectives in a timely manner and staying within the budget?

There are no reasonable accessible data to inform the reviewers as to how well the portfolio is being managed. Qualitatively, I am not aware of any significant negative issues related to HNEI project portfolio. Based on my recent position as Interim Administrator in the State Energy Office, all commentary I received pertaining to HNEI’s ESDSF work was positive.

IV. Is HNEI’s policy input influential to energy sector decision-making?

HNEI efforts have been extremely valuable to various state agencies and to the utilities. HNEI has expended over \$2M on support for the Hawai‘i State Energy Office (HSEO), the Hawai‘i Energy Policy Forum, and the Public Utility Commission (PUC). These efforts have included work on the 2014 projections for the Renewable Portfolio Standards (RPS) through 2020, assessment of variability, grid stability, grid services for high renewable penetration, open grid studies, and battery storage assessment. A key component of any analysis is that HNEI is a key stakeholder in the public policy process

by providing objective analysis on critically important issues. Recently, this objectivity became more important as HSEO had taken a more active role as an intervener in various PUC dockets, thus removing itself from being a facilitator and objective observer in its own right. The State of Hawai'i needs objective analyses to balance grid stability, utility economic well-being, and the need for the state to reach mandated RPS goals.

These efforts have included a variety of grid analyses that were based on utilizing General Electric (GE) energy systems models. This has been another example of building upon earlier efforts. Funding for these activities stems from federal funding that was available to HNEI that started in 2006. By keeping a focus on what the state and the utilities needed, this funded activity has now spanned over eleven years in which valuable analyses were performed to support both state regulatory processes and private sector decision-making.

A newer focus has moved to the incorporation of new grid services. Specifically, how do new technologies related to demand response and distributed generation utilization impact the electricity grid? As new technologies emerge, the need to address demand response in terms of moving load into peak afternoon generation will become more important. As this is not, historically, how demand response is used, this work will be of extreme importance. Analyses of grid services – ancillary services – will assist the PUC in determining how to support both consumers and the utility in determining how to best meet their respective needs of reliability, stability, and cost control.

Based on my recent time at HSEO, it is clear that HNEI's efforts in 2017 were very influential to the regulatory process and broader policy support for the State. Based on my on-going conversations with HSEO, HNEI activities may be even more important in 2018, as the PUC will need to address the complexity of grid modernization based on HECO's recent submission. HSEO will also need their support as the State moves into the next ten years of HCEI.

V. To what degree is HNEI's portfolio of efforts shifting the entire energy system in Hawai'i to be more sustainable, affordable, and resilient?

This question is a bit redundant to the answer in the previous question. Briefly, the State has moved more rapidly than previously anticipated towards a more distributed systems and a more renewable energy construct. In many instances, the decrease in technology prices (for example, solar cells) and the insertion of new technologies to support greater percentages of renewable resources have driven change faster than anticipated. To this end, HNEI analytical work has shown that Hawai'i's grid can support greater percentage penetration of distributed renewable resources that had been supposed. It should be pointed out that these analyses also impact decisions made in other states, particularly California.

It has been critical that an in-state cadre of experts – such as those in HNEI – remain cognizant of these changes and also remain sufficiently nimble in its analysis and research projects to stay ahead of the curve instead of solving yesterday's problems. This

approach is somewhat antithetical to traditional university research. That is, much academic work may be done on “what if” analyses, which are not useful in the near term. Other academic work may simply use antiquated modeling systems that have not been modified to address new paradigms associated with the changing nature of energy system integration.

Thus, HNEI has been successful in developing analyses and models that can better address change, but does so in a manner that is extremely useful to state-based decision-makers. HNEI is effective in looking forward to future opportunities and challenges and - in that context - providing cutting edge analysis that frames the debate for emerging – and in some cases unanticipated - issues. In this final area, it is important to reiterate that analytical support to key state agencies is critical in moving the state forward in meeting their renewable energy and energy efficiency goals. As an aside, it may become more important in the future for HNEI to work closely with the state Department of Transportation as decisions related to fuel cell vehicles and electric vehicles become more important – particularly as these decisions relate to vehicle/grid interactions and the proper use of demand response technologies. That said, my observation is that the analytical support provided to the PUC and the HSEO has been invaluable over the years in providing information for informed decision-making.



December 14, 2017

To: University of Hawai'i Office of the Vice President for Research and Innovation (OVPRI)

The University of Hawai'i Office of the Vice President for Research and Innovation requested that Kyle Datta be a member of the independent panel to evaluate the recent 2017 activities of the Hawai'i Natural Energy Institute (HNEI) at the University of Hawai'i at Mānoa (UH Mānoa). As General Partner of Ulupono, with over 25 years of global experience in the energy sector, I have the qualifications to review the Institute's activities, and am honored to be part of this panel.

In 2007, the Hawai'i State Legislature passed groundbreaking energy legislation that included establishing HNEI at UH Mānoa. Under that legislation, and follow-on legislation enacted in 2017 (ACT 15), OVPRI is tasked with assembling a panel of independent experts to assess the activities HNEI conducted under HRS 304A-1893.1.

Under the original ACT, there was established the Energy Systems Development Special Fund (ESDSF) for the purpose of developing an integrated approach and portfolio management of renewable energy and energy efficiency technology projects that will reduce Hawai'i's dependence on fossil fuel and imported oil and other imported energy resources and move Hawai'i toward energy self-sufficiency.

As described in the original ACT, the Institute was tasked to administer the special fund for the following activities:

- 1) Obtaining matching funds from federal and private sources for research, development, and demonstration of renewable energy sources.
- 2) Awarding contracts or grants to develop and deploy technologies that will reduce Hawai'i's dependence on imported energy resources and imported oil and,
- 3) Managing the portfolio of projects commissioned under this subsection.

The criteria for which projects can be commissioned are attached in Appendix A. Given the requirements under the Act, I have organized my review under the following four questions:

- 1) To what degree were Hawai'i Special Funds matched by external sources?
- 2) Do the contracts and grants HNEI awarded focus on critically important technologies to reduce oil dependence and comply with criteria enumerated in the ACT?
- 3) Is the portfolio well managed, as defined by on time deliverables and staying within the budget?
- 4) Is HNEI's policy input influential to energy sector decision making?

Investing in a Sustainable Hawai'i



- 5) To what degree is HNEI's portfolio of efforts shifting to entire energy system in Hawaii to be more sustainable, affordable and resilient?

To what degree were Hawai'i Special Funds matched by external sources?

In 2007, Act 253 established the Energy Systems Development Special Fund (ESDSF). In 2010, Act 73 authorized 10 cents of the \$1.05 tax imposed on each barrel of petroleum products imported to Hawai'i to be deposited into the ESDSF. This has amounted to approximately \$2.3 MM per year of barrel tax funding for the ESDSF. HNEI provided the reviewer panel with information from 2013 to present of external funds, and a thorough discussion of 2017 new projects.

The ESDSF barrel tax funding from 2013 to present would amount to approximately \$9.2 MM. In total, the Federal government funds applied to HNEI projects was \$37.7MM. This is a 4:1 ratio, which is indeed impressive. It should be noted that three major projects represent the preponderance of the match.

- US Navy Wave Energy test site, where \$500,000 EDSF investment helped leverage \$22.3 MM of US Navy, DOE, and ONR funds
- Smart Grid inverters where \$400,000 of EDSF investment helped leverage \$3.1 MM of DOE funds and \$3.1 MM of private industry
- Hydrogen Fueling Infrastructure where \$1.1 MM of EDSF plus \$2.5 MM in State of Hawai'i Hydrogen Fund helped leverage \$6.5 MM from DOE and ONR.

In addition, HNEI has gotten the private sector to contribute another \$0.25MM in funds and in kind services. There were some additional University of Hawai'i funds and in-kind services provided as well.

In summary, HNEI has played a critically important role in being the leading stakeholder in working with the Federal DOE, ONR, and the Navy in bringing in federal funds to the state. They have further played critical roles in attracting private sector funds, particularly from Japan, and in 2017 Korea.

Do the contracts and grants HNEI awarded focus on critically important technologies to reduce oil dependence and comply with criteria enumerated in the ACT?

This section of the evaluation focuses on HNEI's technology research activities and their major studies. The technology research activities fall into the following categories:

- 1) Near term applied research on technology characteristics with the objective of more rapid deployment of these technologies to accelerate conventional (variable) renewable generation technologies (e.g. wind and photovoltaic).



- 2) Long term research on technologies that have the potential to be transformative if once they are proven

While ESDSF funds were deployed in a 27%/73% ratio between near and long term, the vast majority of external funds were attracted to long term projects. This is an prudent financing approach to technology research— attract external federal funds to long term technology development which has high failure risk, and use local ESDSF funds to apply more proven technologies so they can leverage even greater capital deployment within our state of conventional renewable technologies.

Smart Inverters, Grid Scale battery energy storage, and microgrid projects are all directed at accelerating deployment of variable renewable technologies. These have already had a major impact on HEI's willing to accept these technological approaches as viable solutions for the grid in high renewable penetration scenarios. The electric transportation center studies on batteries and grid integration are providing valuable data on the limits of how much EVs can reduce curtailment, in a high variable renewable scenario, as well as the implication to the batteries of using them in V2G applications. This is very important work (subject the caveat that future renewables may be firm and not variable), to help all stakeholders understand the best approaches for integration of EVs.

The hydrogen energy systems, hydrogen trailer and wave energy test site are could lead to transformative technologies that, at scale, could shift Hawai'i's energy system. However, currently, there are not at the level of economics (in the case of hydrogen) or technology readiness (in the case of wave energy), that they will make an impact today, or even in the next 5 or more years. Nonetheless, since other parties are willing to fund the majority of these efforts, they are clearly justified under the Act.

HNEI also has a long term jet fuel pathways study for the FAA that will be helping on understanding what is practical, given the current state of biomass to jet fuel technologies.

HNEI has a major project for SEO to support the Programmatic Environmental Impact statement (PEIS) for HCEI. This is a sweeping, system-wide document that can be used by all renewable developers when preparing project specific EIS. Therefore, it was a wide scale approach to reducing the permit time for new renewables, and thereby advancing the state's goals.

Finally, HNEI has some smaller projects related to energy efficiency and education. Energy efficiency is always the least expensive approach to achieving our renewable goals, and all of these projects help support other parties understanding of how to leverage energy efficiency approaches.



Is the portfolio well managed, as defined by the deliverables meeting or exceeding the study objectives in a timely manner and staying within the budget?

The assessment portfolio management ultimately requires program evaluation approaches, and it is the recommendation of this reviewer that HNEI use some EDSL funds to conduct such an evaluation in the 10th year after barrel tax funds were provided (e.g. 2023).

In the interim, the general metrics of research and development management, meeting or exceeding deliverables in a timely manner and staying within budget, can usually only be seen in the negative (e.g. a project was rejected by the federal agency, or was significantly behind schedule or over budget). There was no data provided to the reviewer panel to evaluate this quantitatively. Qualitatively, this reviewer is not aware of any significant negative outcomes in the portfolio of HNEI projects, though some have been delayed to uncontrollable circumstances (e.g. volcano eruption changing site for hydrogen transportation demo, ocean environment challenges for the wave energy center), while others may be slower than expected due to challenges with the speed of utility actions or government regulatory requirements (e.g. Navy prerequisite actions before technology can be demonstrated).

Is HNEI's policy input influential to energy sector decision making?

Since 2013, HNEI has expended over \$2 MM on support for the Hawai'i State Energy Office, the Hawai'i Energy Policy forum, and several important studies for the PUC (Renewable Portfolio Standard study Phase I-III, assessment of variability, grid stability, grid services for high renewable penetration, open grid studies and battery storage assessment). HNEI's plays a very important role as an objective stakeholder (no commercial or advocacy interest) in the public policy process by providing objective analysis on critically important issues.

In 2017, HNEI studies were particularly important in two major areas:

Generation Supply

In 2017, after nearly 5 years of effort, the PUC decided which direction the State of Hawai'i should take in terms of generation supply. HNEI's studies with GE played an important supporting role in determining through dynamic simulations the extent to which variable renewables can enter the O'ahu grid, and the overall effect on reliability. While these were not the only studies looking at this questions, and it was the totality of the analytic efforts by both the utility, external consultants, and other UH researchers (Dr. Fripp) that ultimately led the PUC to support accelerating renewables, the HNEI studies were helping in framing certain issues.

A caveat on the GE studies. The Phase I work was important at the time, but was based on a generation plant configuration that is no longer applicable. The Phase II effort is valuable as a foil for what would happen if a large amount of variable renewables were placed on the grid, but as we can see in KIUC, the future of renewables is firm renewables (e.g. integrated with storage at



both the utility and distributed scale). A challenge that HNEI and GE face is that the underlying technology configuration is changing faster than their modeling approach. Before HNEI embarks on Phase III, it should consider changing the underlying technologies to reflect the type of next generation technology that will be providing power to the grid.

Grid Services

The PUC is in the midst of two important dockets on Demand Response and Distributed Energy resources that will ultimately determine the future of distributed energy in Hawai'i. HNEI is spearheading several important studies on grid services, accessibility of power flow information, grid stability and storage. Collectively, this is an important body of work that will objectively inform the regulators of what is possible and practical.

Pathways to an open grid with Kevala are groundbreaking because it democratizes the accessibility of power flow information of the grid that would otherwise be opaque. The transparency for customers, suppliers and regulators will help the distributed energy markets develop efficiently. The grid services (also known as ancillary services) review will help the PUC determine what services are needed for reliability as high renewable penetration is reached, which will provide objective input to the open dockets mentioned above. Similarly, the grid stability study algorithms were adopted by HECO for planning in the power supply improvement plans. HNEI has done both technical demonstration and analytic work to understand how batteries can be economically deployed on O'ahu.

Collectively, HNEI's efforts in 2017 were very influential to the regulatory process and their work will be equally important in 2018, as the PUC delves more deeply into the complexity of grid modernization.

To what degree is HNEI's portfolio of efforts shifting to entire energy system in Hawaii to be more sustainable, affordable, and resilient?

The purpose of Act 253 was to shift Hawai'i's entire energy system away from fossil fuel dependence and towards a more sustainable, affordable, and resilient. Over the last decade, our understanding of Hawai'i's electrical energy system challenges and needs has evolved with accelerating renewable and distributed technology. Similarly, the convergence of the electricity sector and the ground transportation sector has occurred far earlier than expected. The rapid advance of technology requires HNEI to be nimble in its analysis and research projects to stay ahead of the curve instead of solving yesterday's problems. This suggests a "learn fast, fail fast" approach, which is often at odds with traditional university research.

Overall, HNEI has been successful in looking forward at the future challenges and providing cutting edge analysis and research that helps shape decision maker thinking by framing the issues that need to be addressed. There are some exceptions as mentioned above that we hope that



HNEI will address going forward. There neutral objectivity is extremely important since even government agencies can have a political agenda that can limit their objectivity.

HNEI's most important contributions to date have been in the following areas:

- 1) Confirming the ability of Hawai'i's energy system to maintain reliability with a high degree of variable renewable penetration.
- 2) Providing important research on the technical characteristics of battery storage and smart inverters that is proving instrumental to the rapid deployment next generation of distributed and renewable power
- 3) Building technical and business partners with Asia Pacific partners in Japan and Korea
- 4) Providing analytic support to the PUC and SEO



APPENDIX A

Projects to be commissioned under the Act 253 may include:

- A) Balance the risk, benefits, and time horizons of the investment to ensure tangible benefits to the Hawai'i consumer, with priority given to short-term technology development
- B) Emphasize innovation and renewable energy supply and energy efficient and end use technologies focusing on environmental attributes, reliability, and affordability
- C) Enhance transmission and distribution capabilities of renewable energy supply for electricity
- D) Enhance reliability and storage capabilities of renewable energy for electricity
- E) Ensure that research, deployment, and demonstration efforts build on existing programs and resources and are not duplicated
- F) Address critical technical and scientific barriers to achieving energy self-sufficiency by reducing dependence on imported oil and imported energy resources
- G) Ensure that technology used and developed for renewable energy production and distribution will be commercially viable and,
- H) Give priority to resources that are indigenous and unique to Hawai'i.