

UNIVERSITY OF HAWAI‘I SYSTEM REPORT



REPORT TO THE 2024 LEGISLATURE

Report on the Evaluation of Energy Efficient Technology Projects

HRS 304A-1893.1

December 2023

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 this year's panel and to provide their expertise in evaluating the projects and activities funded by the energy systems development special fund for the 2024 Legislative Session.

Charles Hanley

Mr. Hanley is Senior Manager of the Grid Modernization and Energy Storage Group at Sandia National Laboratories. His group conducts research on enhancing the resilience of our critical energy infrastructures, including grid-scale optimization, controls, and microgrids; energy storage technologies; renewable energy integration; power electronics; cyber security; and advanced analytics for complex systems. He joined Sandia in 1988 and has been working in Sandia's renewable energy and electric grid programs since 1994. From 2005 through 2014, Mr. Hanley managed Sandia's Photovoltaics and Distributed Systems Integration Program. Prior to that, he managed Sandia's international renewable energy programs, through which he oversaw the implementation of more than 400 photovoltaic and wind energy systems in Latin America. He received his B.S. in Engineering Science from Trinity University in San Antonio, Texas, and his M.S. in Electrical Engineering from Rensselaer Polytechnic Institute, in Troy, New York.

Jennifer Potter

Ms. Potter is Director of Regulatory Innovation at Strategen and primarily focuses on regulatory innovation and demand-side management strategies. Her expertise includes strategies for distributed energy resources, energy efficiency and demand response, performance-based regulation, advanced rate design, and customer equity. Prior to joining Strategen, Ms. Potter served as Commissioner with the Hawaii Public Utilities Commission. Ms. Potter was previously a faculty member at the Hawaii Natural Energy Institute (HNEI). Prior to her time with HNEI, Ms. Potter was a Senior Scientific Engineering Associate at Lawrence Berkeley National Laboratory. Preceding her stint in academia, Ms. Potter worked for Sacramento Municipal Utility District and Roseville

Electric as a Principal Forecaster, Project Manager, and Enterprise Performance Manager.

Ms. Potter has a Master of Science in Public Policy and Management from Carnegie Mellon University and a Bachelor of Arts in Economics and International Studies from Southern Oregon University.

Gerald A. Sumida

Mr. Sumida is a Partner in Carlsmith Ball LLP's Honolulu office and a member of the firm's Business, Corporate & Finance practice group. He concentrates on business structuring and operations, including corporate, limited liability company, joint venture and partnership matters; business acquisitions; sales and mergers; securities law; start-up company and venture capital financing; administrative and public utilities law; energy law, including energy project development and project finance; antitrust and trade regulation law; federal, state and county legislative and administrative matters; and international legal matters.

Mr. Sumida has represented firms in developing energy, including renewable energy projects and facilities that sell power to electric utilities, including structuring organizational arrangements, negotiating power purchase arrangements, completing site acquisition, undertaking permitting and land use matters, negotiating financing, including project finance arrangements, engaging in public utilities commission proceedings relating to energy projects. Current clients include Kalaeloa Partners (cogeneration), Puna Geothermal Venture (geothermal), Ulupono Initiative (PUC proceedings involving microgrids, community based energy projects, protected agriculture, integrated grid planning), landowners hosting renewable energy projects, and financing groups for energy projects. Former clients include First Wind (wind), Sea Solar International (OTEC), Oceanlinx (wave energy), Green Energy Team (biomass), and other solar photovoltaic, energy service, waste-to-energy and clean technology firms. He is also a member of the Stakeholder Council and Stakeholder Technical Working Group of Hawaiian Electric's Integrated Grid Planning process.

Mr. Sumida rejoined Carlsmith Ball LLP after serving from October 1999 to December 2002 as the General Counsel of the Asian Development Bank, a multilateral development bank established in 1966 to promote the economic and social development of the Asian and Pacific Region (ADB). ADB, based in Manila, Philippines, currently has 67 member countries, and provides development assistance to over 40 countries in this region. He led a group of 28 international lawyers, drawn from 25 countries, who handle ADB's international legal, financing, lending, borrowing, investment and development work, as well as ADB's institutional matters, and undertake their own law and policy reform projects in various countries, and he advised ADB's senior management and board of directors.

Charles J. Hanley
Sr. Manager, Grid Modernization and Energy Storage

7 December, 2023

Dr. Eric Matsunaga
University of Hawaii

Dear Dr. Matsunaga,

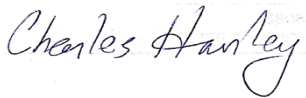
Subject: *Evaluation of HNEI Triannual Report to the State of Hawai'i, dated December 2023*

It is my pleasure to provide this review of the Hawai'i Natural Energy Institute (HNEI) Energy Systems Development Special Fund (ESDSF) report for the operating years 2021-2023. It has been a number of years since I last visited HNEI. It is wonderful to see that their activities have continued to grow into an impactful program that serves Hawai'i's clean energy objectives while addressing related concerns associated with grid stability, resource adequacy, climate resilience, equity, and technology readiness. As I state below, the State of Hawai'i – and HNEI in particular – is a leader in the transition to a clean energy infrastructure, learning valuable lessons that regulators, policymakers, and utility operators across the country are applying in their similar efforts.

I offer my assessment in relation to a few key questions below, based on suggestions and wording I pulled from the original ACT 253, HRS 304A-189 and the subsequent ACT 15.

Feel free to contact me if you need any further information or have a need for any clarification.

Sincerely,



Charles Hanley
Cell: 505-506-6399

Review of HNEI ESDSF Triannual Report, Dated December 2023
Submitted by: Charles Hanley, Sandia National Laboratories
7 December 2023

Do the contracts and grants awarded focus on critically important technologies to reduce oil dependence?

The state of Hawai'i has been a national and global leader in the transition to clean renewable energy technologies for some time. While the rest of the world is rushing to address climate change via clean energy adoption, the residents of Hawai'i have already been utilizing local renewable resources to reduce high energy costs. As a result, Hawai'i has had to deal with issues related to renewable integration and high penetration that the rest of the country is now starting to face. The project portfolio of the Hawai'i Natural Energy Institute (HNEI) addresses several of these issues from perspectives of technology development, integration, and adoption.

Across the spectrum of the projects described in the three appendices, the broad portfolio of 28 activities provides several valuable policy and technology analyses, as well as technology development and demonstration opportunities, and some forward-looking research activities that leverage HNEI technology strengths. This portfolio indeed focuses on critical technologies, as well as policy and market factors needed for effective adoption of renewable and associated energy technologies, thereby reducing dependence on oil. These activities showcase specific capabilities at the University of Hawai'i as well as conditions particular to Hawai'i.

Examples include:

- Grid studies related to decommissioning of oil-based power plants on Oahu and Maui. As constituents, we all want clean energy now. As customers, we all demand reliability and availability of electricity. These two demands can clash, and it's necessary to study the impacts of retirement of large centralized plants in terms of meeting demand and providing overall system reliability. HNEI's studies on these topics help to directly inform utility decisions such that both these demands can adequately be balanced.
- Exploring adoption of hydrogen as a long-duration energy storage solution. HNEI research on materials for fuel cells and hydrogen storage, as well policy analyses regarding firm renewable needs and the associated role of hydrogen and the Hawai'i Hydrogen integration study offer insights into possible pathways for hydrogen adoption to help enhance resilience of the Hawai'i grid.
- Exploring wave energy, in partnership with the U.S. Navy's Wave Energy Test Site and utilizing HNEI-developed technology.
- Analyzing pathways to meet RPS targets. Exploring impacts of Time-of-Use rates, impacts of oil plant retirements, and firm renewable needs are the types of analyses that mainland utilities are starting to recognize they need to meet their IRP targets in the face of aggressive renewable standards.
- Addressing equity and community-focused concerns in the face of an energy transition. The Moloka'i Community Energy Resilience Action Plan and the Energy Transition Partnership Program are examples of how growing concerns regarding energy equity are being addressed on a local basis.
- Worthy of note is the attention paid to maintaining capabilities to carry out these projects. For instance, the project focused on Stochastic Modeling of High Renewable Grids provides HNEI

with the modeling capability needed to analyze impacts of plant retirements and such topics as climate effects and reliability impacts of high renewable penetration. Maintaining such modeling capability is key to HNEI's ability to deliver on several projects.

Is the portfolio well managed?

Speaking broadly, the Triannual ESDSF Report submitted by HNEI describes a breadth and depth of activities that address policy, utility planning, technology adoption, and related technology R&D. It is a well-developed portfolio. The organization of the report and its appendices illustrate clear management of funds and emphasis on deliverables, stakeholders, reporting, and sponsors. Certainly, the portfolio appears to be well managed.

For further emphasis, I'll offer detail pertaining to two points in the original ACT 253, HRS 304A-1891. While I could choose other points to address, these two seem well aligned with the question posed.

- A. Obtaining matching funds from federal and private sources for research, development, and demonstration of renewable energy sources.
- B. Ensure that research, deployment, and demonstration efforts build on existing programs and resources and are not duplicated.

(A) Given that a stated objective for the use of state funds is to leverage private and federal investments, clearly HNEI has been quite successful in this regard. In the prior 3-year period, outside funding was on the order of \$10M/year. During the 2021-2023 period, this has grown to an average of nearly \$15M/year. Additionally, funding sources vary across principally federal sources in DOD, DOE, and DOS, as well as some private sector funding. It is a strong and diverse portfolio that brings significant resources to address the clean energy needs of Hawai'i.

(B) The cost-shared research efforts in Appendix C clearly leverage specific HNEI capabilities associated with PGM-free catalysts for fuel cells, materials related to hydrogen storage and liquid hydrogen carriers, encapsulants for solar cells, and a wave energy converter. These research areas directly support well-established future-looking energy concerns in Hawai'i. Similarly, analytical work on converting oil plants to biomass address questions of land use, importation costs, and operations specific to the Hawai'ian islands. More broadly, the suite of analytical research conducted throughout utilizes HNEI capabilities uniquely and builds on existing or past work in the field. I see no reason for concern that HNEI is creating redundancy or irrelevance in its research, nor that they are venturing afield of their expertise and prior experience.

Is the policy input influential to decision making?

The policy input described in the report is broad and covers numerous aspects of grid modernization and transition to a clean infrastructure, including adoption of hydrogen and electric vehicles, scenarios related to high penetrations of renewables, retirement of current oil plants, energy efficiency and controls for buildings, and feasibility of state and utility targets. From my experience, the Hawai'i situation – a relatively small grid with high energy costs – is one that attracts much attention from the mainland, mainly because Hawai'i has been more aggressive regarding renewable energy adoption. Thus, from a research, policy, and regulatory perspective, partners on the mainland often refer to studies, research, and reports from HNEI and other Hawai'ian research organizations.

All this is to say that I believe the output of these HNEI efforts are indeed influential; however, I do not have the direct experience of seeing the impact of these policy-related analyses. That could be a

consideration for future reports – a section on impacts and adoption by target stakeholders and decision makers based on the input they've received from these HNEI efforts. That said, I will restate that I do know that researchers, regulators, and policy-makers across the US utilize the publications that HNEI and its partners produce.

Summary Statements

In my view, the HNEI portfolio portrayed in this Triannual ESDFS Report is forward-looking, strategically oriented, focused on Hawai'i's incumbent strengths and resources, and provides crucial aspects of a path toward a clean, equitable, and resilient energy system. It has been both an education and a pleasure reading through it.

I offer a final consideration: from my perspective as a program manager at a national laboratory, I know of a growing number of collaborative activities among several national labs that should be strengthened over time with a greater role of HNEI. I offer my assistance in helping to turn these discussions into real efforts with impactful results. As an example, my team participates as part of the UNIFI consortium led by the National Renewable Energy Laboratory, in which we're exploring a large-scale demonstration on Kuai. Additionally, we've worked with HNEI, University of Alaska Fairbanks, University of Puerto Rico Mayaguez, and other national labs on the development of microgrid implementation tools for remote and rural communities. It would be wonderful to see that collaboration take root. As a final example, the burgeoning field of long-duration energy storage for the electric grid needs real-world problems to address, and Hawai'i yet again stands as an excellent early adopter environment. The national labs are exploring related RD&D projects; we should be engaging HNEI more integrally. I know there are more good examples and that HNEI is deeply engaged with the national labs. Nonetheless, I urge further collaboration.

**Evaluation of Hawai'i Natural Energy Institute Activities
For the Period 2021– 2023
Provided by Jennifer Potter
Director of Regulatory Innovation
Strategen Consulting**

The Hawai'i Natural Energy Institute (HNEI), a research arm within the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawai'i at Mānoa (UHM), was established in 1974. HNEI was formally recognized in statute in 2007, with a mission to address critical energy needs within the State. The institute develops, tests, and evaluates innovative renewable energy technologies. By combining internal research efforts with collaborations in public-private partnerships, HNEI showcases practical applications and facilitates the integration of emerging technologies into the energy landscape.

The following review comments reflect my assessment of the Hawai'i Natural Energy Institute (HNEI) research portfolio and results reflected in the Summary Report prepared by the HNEI in November 2023. I provide my comments according to the HNEI charter as reflected in the following legislation from the State of Hawai'i:

- ACT 253, Session Laws of Hawai'i (SLH) 2007;
- HRS 304A-1891; and
- ACT 15, SLH 2017.

Specifically, ACT 253 states that HNEI shall administer the Special Fund to fulfill the purposes described above by using Special Fund revenues for the following activities (codified at HRS § 304A-2169.1):

- Obtaining matching federal and private funding for research, development, and demonstration of renewable energy sources.
- Awarding contracts or grants to develop and deploy technologies to reduce Hawai'i's dependence on imported energy resources and oil.
- Managing the portfolio of projects funded by HNEI.

As such, my review addresses the following questions:

1. To what extent did federal and private sector funding align with Special Funds in supporting the research, development, and demonstration of renewable energy resources?
2. Do the contracts and grants awarded by HNEI for developing and deploying technologies aimed at reducing Hawai'i's reliance on imported energy resources and oil prioritize critical technologies necessary for achieving these goals?
3. Is the management of projects initiated and funded by the Special Fund effective in terms of implementation and adherence to relevant budgetary constraints?
4. To what extent does HNEI and its programs and activities contribute to and shape Hawai'i's initiatives in transitioning its energy system towards a more sustainable, resilient, and cost-effective energy ecosystem?

5. How impactful and influential are HNEI's research, technical analyses, and policy evaluations on agencies and organizations involved in policy-making and decision-making processes?

The content featured in the Special Fund report is both inspiring and enlightening. It is strongly advised that the Institute disseminate comprehensive reports detailing the research and findings it successfully concludes. Currently, there is a scarcity of publications covering HNEI's diverse array of projects, and making these research findings publicly accessible would be advantageous for both the state of Hawaii and the country. The majority of the research undertaken by HNEI stands at the forefront of the industry, contributing cutting-edge and distinctive insights. As HNEI continues to embark on pioneering and significant initiatives, it becomes increasingly imperative to share these valuable insights with the broader academic community and the energy industry at large.

- 1. To what extent did federal and private sector funding align with Special Funds in supporting the research, development, and demonstration of renewable energy resources?**

For the period 2021-2023, the HNEI attracted \$44,260,983 of extramural awards from federal and private funding sources. HNEI brought in approximately \$15 million per year over the three-year review period, indicating a notably robust ratio of partner funding. The awards and external funds obtained were highly congruent with the renewable energy resources Research, Development, and Demonstration (RD&D) field, showcasing a focused commitment to advancing renewable energy.

The funding allocated for initiatives like the PGM-Free Catalysts for PEM Fuel Cell Applications and the Magnesium Boride Etherates for Hydrogen Storage projects serves as exemplary instances of collaborative cost-sharing arrangements with the Department of Energy and the Office of Naval Research. HNEI's report highlights five such cost-share projects, showcasing cutting-edge research into emerging and experimental technologies. These endeavors play a pivotal role in advancing our understanding of technologies that have the potential to facilitate a transition towards clean and renewable energy sources.

- 2. Are the contracts and grants awarded by HNEI for developing and deploying technologies aimed at reducing Hawai'i's reliance on imported energy resources and oil?**

The Hawai'i Natural Energy Institute stands as a beacon of progress in fostering sustainable energy solutions for the beautiful islands of Hawai'i. With a steadfast commitment to reducing the state's reliance on imported energy resources and oil, HNEI diligently awards contracts for developing and deploying cutting-edge technologies and conducting analyses. These contracts not only signify a proactive approach to addressing the pressing issues of energy security and environmental sustainability but also highlight HNEI's pivotal role in driving innovation within the region. By fostering collaboration and supporting projects that aim to harness indigenous, renewable resources, HNEI is instrumental in shaping a resilient and self-sufficient energy landscape for Hawai'i, ensuring a brighter and cleaner future for generations to come.

3. Is the management of projects initiated and funded by the Special Fund effective in terms of implementation and adherence to relevant budgetary constraints?

As the custodian of projects instigated and financially supported by the Special Fund, HNEI demonstrates a commitment to accountability and efficiency in the realm of sustainable energy development. HNEI not only initiates these projects but also meticulously oversees their management, ensuring effective implementation while adhering strictly to pertinent budgetary constraints. The institute's research endeavors encompass demonstration projects, such as the NELHA and MTA Hydrogen Stations and Fuel Cell Electric Buses project, which utilized Special Fund resources, complemented by federal and state funding, for applied research in clean energy initiatives. The allocation of funds from the Special Fund for this project exemplifies prudent financial management, a practice consistently upheld across HNEI's entire project portfolio.

Through strategic oversight and robust project management practices, HNEI ensures that each initiative aligns with its intended goals while staying within the allocated financial parameters. This dedicated approach not only underscores HNEI's commitment to fiscal responsibility but also enhances the organization's reputation as a reliable custodian of resources, thereby contributing significantly to the success and impact of sustainable energy projects within the region.

4. To what extent does HNEI and its programs and activities contribute to and shape Hawai'i's initiatives in transitioning its energy system towards a more sustainable, resilient, and cost-effective energy ecosystem?

HNEI, with its visionary programs and activities, stands at the forefront of shaping Hawai'i's transformative journey towards a sustainable, resilient, and cost-effective energy ecosystem. Through innovative research, strategic partnerships, and proactive initiatives, HNEI plays a pivotal role in advancing the state's energy transition objectives. By pioneering technologies, conducting impactful studies, and fostering collaborations with key stakeholders, HNEI contributes valuable insights that inform and guide Hawai'i's policies and strategies. The institute's multifaceted approach addresses the immediate challenges of energy security and lays the foundation for a long-term, sustainable future. HNEI's commitment to harnessing renewable resources, reducing dependence on imported fuels, and promoting cutting-edge solutions resonates deeply with Hawai'i's vision for a clean and resilient energy landscape, making it an indispensable force in shaping the state's energy initiatives.

HNEI has undertaken studies aimed at informing ongoing procurement efforts and proposed legislation, focusing on both variable and firm renewable energy sources. The objective is to ascertain the minimum level of firm power required for O'ahu under varying scenarios of wind, solar, and storage additions. Building on this foundation, in 2023, HNEI expanded its analysis to explore specific resources capable of meeting firm renewable energy needs. This includes an examination of biodiesel, hydrogen, and multi-day energy storage solutions. As projects are identified through the Stage 3 Firm Renewable RFP (Docket #20170352), HNEI remains poised to meticulously review proposals and provide comprehensive recommendations and analyses to the Commission upon request.

Furthermore, HNEI has conducted reliability studies for the island of Maui, evaluating capacity needs in light of the Kahului Power Plant. This analysis has informed the utility, the Commission, and the State

Energy Office about the capacity shortfalls and energy insecurity occurring on the island of Maui, hopefully inspiring swift action to address the capacity needs.

5. How impactful and influential are HNEI's research, technical analyses, and policy evaluations on agencies and organizations involved in policy-making and decision-making processes?

HNEI's research, technical analyses, and policy evaluations wield significant influence and impact on the agencies and organizations involved in policy-making and decision-making processes within Hawai'i. The institute's rigorous and innovative approach to sustainable energy solutions has positioned it as a thought leader in the field, providing crucial insights that shape the trajectory of policy initiatives. HNEI's research outcomes not only contribute to a deeper understanding of energy challenges but also offer pragmatic and data-driven recommendations. By fostering collaboration and sharing expertise with government agencies and key stakeholders, HNEI ensures that its findings directly inform policy decisions. The institute's work resonates not only for its scientific rigor but also for its practical applicability, making it an invaluable resource for those steering the course of energy policies in Hawai'i, ultimately contributing to the state's journey towards a more sustainable and resilient energy future.

Over the timeframe spanning 2021 to 2023, HNEI has undertaken a series of comprehensive studies commissioned by the PUC and HSEO. HNEI has been a reliable resource for modeling and technical analyses for the Commission for over a decade, and much of this work has been funded by the Special Fund. As a former commissioner over this timeframe, HNEI's analyses and support were invaluable to the organization.

In fulfilling its mandated role, HNEI routinely reviews the achievability and effectiveness of the Renewable Portfolio Standards (RPS) every five years, reporting the outcomes to the PUC. For example, responding to a specific request from the PUC, HNEI is conducting a thorough assessment of life-cycle greenhouse gas (GHG) emissions associated with various energy resources and production technologies applicable to Hawai'i. This endeavor aimed to furnish Hawai'i-specific quantitative life-cycle carbon dioxide analysis (LCA) of GHG emissions, providing crucial insights to inform PUC decision-making as stipulated by HRS Sec. 269-6(b). This analysis is still underway, but the research has far-reaching impacts on Hawaii's regulatory and policymaking bodies, and the ambitious goal is to reach 100% carbon neutrality by 2045.

Notably, the institute spearheaded community energy planning for Molokai, collaborating with residents to envision energy infrastructure options aligned with capacity needs and community sustainability priorities.

Additionally, HNEI supported the PUC and State Energy Office with an analysis that included an evaluation of the impact of the AES coal plant retirement on O'ahu, with results disseminated through engagements with the Governor's Power Past Coal Task Force and public meetings tied to PUC Docket 2021-0024 on the transition plans for retiring fossil fuel power plants.

This concludes my review of the Special Fund Summary Report. Thank you for the opportunity to review.

**Review of the Hawai‘i Natural Energy Institute’s Projects and Activities
Funded by the Energy System Development Special Fund
For the Period 2021 through 2023**

Provided by
Gerald A. Sumida
Partner, Carlsmith Ball LLP
Honolulu, Hawai‘i

December 8, 2023

The Hawai‘i Natural Energy Institute (HNEI) was originally created in 1974 but was formally established as a part of the University of Hawai‘i (UH) by Act 253 (2007). Act 253 also established the Special Fund to develop an integrated approach to, and portfolio management of, renewable energy and energy efficiency technology projects that will reduce Hawai‘i’s dependence on imported fossil fuel and other imported energy resources and move Hawai‘i toward energy self-sufficiency. It provided that the projects and activities funded by the Special Fund shall be evaluated every three years by an independent panel of two experts in accordance with Hawai‘i Revised Statutes (HRS) § 304A-1893.1. Subsequently, Act 73 (2010) provided that 10 cents of the \$1.05 tax on each barrel of petroleum products (excluding aviation fuel) imported into Hawai‘i shall be deposited into the Special Fund. Act 253 was later amended by Act 15 (2017) to designate the UH Office of the Vice President for Research and Innovation (OVPRI) as the appointing authority of the independent panel to evaluate the projects and activities funded by the Special Fund.

HNEI’s purposes, as stated in Act 253 (codified as HRS §§ 304A-1891 *et seq.* (2022)), are basically to:

- Develop renewable sources of energy for power generation and transportations fuels by working in coordination with state agencies, federal agencies, and private entities;
- Conduct research, development, demonstration and deployment activities for renewable energy sources for power generation and transportation in coordination with state and federal agencies and the private sector;
- Demonstrate and deploy energy efficient technologies, including those that address peak electricity demands; and
- Aggressively seek matching funding from federal agencies and the private sector for its research, development and demonstration activities.

HNEI shall administer the Special Fund to fulfill the purposes described above by using Special Fund revenues for the following activities (codified at HRS § 304A-2169.1 (2019)):

- Obtaining matching federal and private funding for research, development and demonstration of renewable energy sources;

- Awarding contracts or grants to develop and deploy technologies that will reduce Hawai‘i’s dependence on imported energy resources and imported oil (the types of projects that HNEI might fund are listed in Annex A to this Review); and
- Managing the portfolio of projects commissioned by HNEI.

Act 253 sets forth the general criteria to assess the degree to which the projects and activities conducted by HNEI comport with and achieve the stated objectives of the Special Fund. *See* HRS §§ 304A-1893.1 (2019) and 304A--2169.1(c) (2022). On this basis, this Review addresses the following questions:

1. To what degree were the Special Funds matched by federal and private sector funding to support research, development and demonstration of renewable energy resources?
2. Do the contracts and grants awarded by HNEI to develop and deploy technologies that will reduce Hawai‘i’s dependence on imported energy resources and oil focus on critical technologies to achieve these purposes?
3. Is the portfolio of projects commissioned and funded by the Special Fund well-managed in terms of implementation and within applicable budgetary limits?
4. To what extent are HNEI’s research and technical and policy analyses useful and influential to policy-making and decision-making agencies and organizations?
5. To what degree does the existence of HNEI and its programs and activities support and influence generally Hawai‘i’s efforts to transform its energy system toward a more sustainable, resilient and affordable energy ecosystem?

Within the past several decades, Hawai‘i’s energy ecosystem, on a State-wide basis, continues to undergo extensive and intensive transformations, which provide a significant backdrop for reviewing HNEI’s programs and activities supported by the Special Fund. In August 2014, the Hawai‘i Public Utilities Commission (PUC) set forth a fundamental vision for Hawai‘i’s energy future in its seminal *Commission’s Inclinations on the Future of Hawaii’s Electric Utilities - Aligning the Utility’s Business Model with Customer Interests and Public Policy Goals*. That document outlines a vision of Hawai‘i’s energy future, the transformed role of the electric utilities in that future, and the specific pathways that the PUC would explore to effectuate that vision. Since then, PUC policies and decisions, complemented by legislative mandates and executive initiatives have vigorously pursued the reduction of Hawai‘i’s dependence on imported fossil fuels, the development of Hawai‘i’s own indigenous renewable energy resources, the reduction of greenhouse gas (GHG) emissions, and exploration of mitigation and adaptation measures to deal with climate change. These include the 100% clean energy goal for electricity generation by 2045 and the attainment of a net zero carbon emissions goal by 2045.

Under the PUC's new performance based regulatory framework, the Hawaiian Electric Companies, under PUC oversight, have issued a successive series of major requests for proposals (RFPs) for renewable energy generation (primarily solar and energy storage) resulting in numerous utility-scale solar projects, as well as other RFPs for a broad array of grid services

(including distributed energy resources, grid services, and community-based renewable energy projects). The Hawaiian Electric Companies, under its integrated grid planning (IGP) process which the PUC has accepted, has sought to transform its resource planning and implementation processes to incorporate significant stakeholder participation and community outreach in pursuing its renewable energy and related clean energy initiatives.

At the same time, rapid and extensive technological changes are occurring in how energy is generated, distributed, regulated, used, and stored, all of which are supporting the integration of greater amounts of renewable energy into the utilities' grid system, increasing the spread and use of distributed energy resources, and enhancing the use of energy efficient technologies. Complementing, and supporting, all of these developments are important regulatory measures, as well as research and development and technological advances, affecting the greater use of alternative fuels for ground, marine and air transportation.

Many of these transformative changes are the result of legislative and regulatory actions in response to the policy goals of reducing the use of fossil fuels for energy generation and transportation, increasing the integration of renewable energy and storage into the islands' grid systems, and reducing greenhouse gas (GHG) emissions and seeking to mitigate adverse consequences of climate change. Other sources of change are the continuing plethora of technological advances in the generation, transmission and distribution, use, regulation, and storage of energy, and the dynamic interaction between policy mandates and supporting technological infrastructures and advances. This is the transformational energy ecosystem and context within which HNEI operates and helps to support and fashion.

This Review addresses the criteria stated above in fulfillment of the review requirements of Act 253.

I. To what degree were the Special Funds matched by federal and private sector funding to support research, development and demonstration of renewable energy resources?

HNEI provided information to the reviewer that clearly evidenced HNEI's very effective leverage of Special Fund amounts to obtain extramural funding - primarily from the U.S. Government, including the Office of Naval Research (ONR), and the U.S. Department of Energy (DOE). During the Review period from 2021 to 2023, HNEI leveraged Special Funds in the amount of some \$2.31 million to obtain approximately \$44.26 million, for an almost 19 to 1 ratio, which is exceptional. In Fiscal Year 2023 alone, some \$887,000 of Special Funds leveraged almost \$13.9 million funds from extramural awards, for an almost 16 to 1 ratio. It should be noted that some of these projects were continuations of projects that had been developed working with federally-funded activities prior to this reporting period, and that some of the funding covers multiple years during this reporting period. In addition, it should also be mentioned that during this review period HNEI also leveraged some \$450,000 in UH cost share for several projects identified below.

Several impressive examples of the effective leveraging of Special Fund amounts are the following:

- DOE Wave Surge Energy Converter, where some \$143,390 of Special Funds helped leverage some \$1.322 million of DOE funding and \$165,760 as a UH cost share.
- NELHA and Hawai‘i Mass Transit Authority Hydrogen Station and Fuel Cell Electric Buses project - although most of this project was completed in the prior reporting period, \$50,000 of Special Funds leveraged an additional \$600,000 from ONR supported the final installation and operation of this station during this reporting period. Overall for this project, some \$1.1 million of Special Funds helped to leverage a total of some \$7.5 million from ONR, DOE and the Federal Transit Authority, plus \$2.5 million from the State’s H2 Capital Investment Fund.
- Federal Aviation Administration's Aviation Sustainability Center (ASCENT) program, where \$450,000 of Special Funds leveraged \$700,000 of FAA funds for research on the development of supply chains for alternative, renewable, sustainable jet fuel production in Hawai‘i.
- DOE's Magnesium Boride Etherates for hydrogen Storage, where \$57,000 of Special Funds leveraged some \$746,000 of DOE funds to develop magnesium Brodie materials to meet DOE's hydrogen storage targets, supplemented by some \$129,000 as a UH cost share.
- Molokai Community Energy Resilience Action Plan and Energy Transition Initiative Partnership Program (ETIPP), where \$90,000 of Special Funds was used to leverage \$335,000 in DOE funds to assist the Molokai community to develop an islandwide, community-led and expert-informed collaborative planning process for increased renewable energy on Molokai, and with ETIPP to explore cost, reliability, and infrastructure challenges for small and isolated communities, both projects as part of HNEI's deployment of energy efficient technologies in Hawai‘i.

HNEI was clearly successful in working with especially DOE, ONR, the U.S. Navy and other federal departments and agencies in bring federal funds into the State to support Hawai‘i’s renewable energy programs and initiatives. In addition, it has obtained funding from other sources, as well as in-kind services, for several projects.

II. Do the contracts and grants awarded by HNEI to develop and deploy technologies that will reduce Hawai‘i’s dependence on imported energy resources and oil focus on critical technologies to achieve these purposes?

The projects funded by HNEI are fully consistent with the goal of reducing Hawai‘i’s dependence on imported energy resources, including fossil fuels, and conversely increasing the use of indigenous renewable energy resources in Hawai‘i and reducing greenhouse gas (GHG) emissions. These contracts and grants focus on several areas that are of critical importance in the immediate term as well as longer term.

An increasingly urgent matter that emerged several years ago and has become a focus of concern centers on how best to ensure the continuing integration of significant amounts of utility-scale solar-plus storage projects, as well as other grid services projects, on all major islands in a manner that maintains safe, reliable and stable utility grid operations. These resources are variable or intermittent energy sources (solar energy is available only when the sun shines, and wind speeds vary) and energy storage is still limited to 4, or possibly 6, hours. HNEI has continued its projects that explore, often with the use of modeling, how to maintain grid stability and integrity in the face of increased integration of especially solar plus storage projects. For Oahu, and also for Maui, a key issue is how to ensure grid stability on Oahu when existing utility-scale fossil-fuel baseload power generation ceases operation. This involved AES' coal-fire baseload facility that ceased operations in September 2022, and planned retirements of HECO's fossil-fuel generation units within the next few years. For Maui, this involves the cessation of MECO's Kahului fossil-fuel generation unit in 2027, a matter made more complex by the recent withdrawals of four utility scale solar and energy storage projects due to cost and supply chain issues.

Part of these integration analyses involves what grid services can effectively be provided by distributed energy resources. HNEI continues its work on battery storage scheduling issues, maintaining grid stability especially in “low grid strength” conditions (with decreased use of conventional power plants), and determining how effectively to use “grid-forming inverters” without the need for conventional power plants or synchronous condensers. These are all key factors for the effective integration of variable renewable energy sources.

HNEI participates in exploring the potential for the development of supply chains for alternative, renewable sustainable aviation fuel production in Hawai‘i, through the UH’s participation in the Federal Aviation Administration’s Aviation Sustainability Center (ASCENT) team of U.S. universities. This work has also reviewed the fuel properties of construction and demolition waste (CDW) as well as biomass feedstock crops. In light of international as well as national initiatives to reduce the use of petroleum-based aviation fuels to reduce GHG emissions, these activities are important preparatory work for potential future regulation of available fuel content.

HNEI continues to support research and testing of a wave energy conversion (WEC) concept to generate cost-effective renewable generated electricity for coastal communities, which is funded by the DOE and uses the U.S. Navy’s wave energy test site on Oahu.

Interest in the use of hydrogen, especially “green” hydrogen, for electricity generation but also for transportation has recently greatly increased, and HNEI’s hydrogen production dispensing station on the Island of Hawai‘i at the Natural Energy Laboratory Hawai‘i Authority (NELHA) continues to be an important demonstration of hydrogen-fueled transportation. This project evaluates the technical and financial performance and durability of the equipment to support a fleet of three hydrogen fuel cell electric buses operated by the County of Hawai‘i’s Mass Transit Authority. This knowledge can be used to evaluate the deployment of zero emissions buses for public transportation. Other hydrogen fuel projects include development of platinum group metal-free catalysts for hydrogen fuel cell applications, liquid hydrogen carriers, and modified magnesium boride materials to improve hydrogen storage capacities that meet DOE targets.

Finally, HNEI is continuing its collaboration with the UH School of Architecture's Environmental Research Design Lab and the Department of Hawaiian Home Lands (DHHL) to help develop residential housing designs to improve comfort and energy efficacy. HNEI is also helping to develop and demonstrate a building energy analysis process that can be used during early design phases at multiple transit-oriented development sites located along Oahu's light rail line. This will help to reduce energy use in buildings, increase energy security and resiliency, and enable a better quality of life for residents. It is also working with the UH School of Architecture's Environmental Research and Design Lab and the UH Community Design Center.

III. Is the portfolio of projects commissioned and funded by the Special Fund well-managed in terms of implementation and within applicable budgetary limits?

Normally this question would be assessed in terms of, for each funded project, the projected duration of the project, any interim timelines or deadlines, the nature (and quantity, if applicable) of the deliverable(s), the project budget, the staff allocations, and possibly additional criteria or special conditions attributed to that specific project. To the extent that performance under each of these criteria was accomplished satisfactorily or not, and if not, what were the causes for any such failures (e.g., force majeure, change of circumstances, unanticipated acceleration of deadlines, etc.), each project could be so assessed, and the portfolio of projects, on that basis, could be similarly assessed. No data or information was presented to the reviewer to conduct such an assessment; however, the reviewer is not aware of any significant negative issues or outcomes related to HNEI's project portfolio, and the continuing high level of funding from the various funding sources strongly suggests that such funders find HNEI's performance and results to be quite satisfactory.

IV. To what extent are HNEI's research and technical and policy analyses useful and influential to policy-making and decision-making agencies and organizations?

As briefly described above, HNEI's work, based on its statutory mandates, focus on reducing Hawai'i's continued dependence on imported fossil fuels, increasing Hawai'i's use of renewable technologies (including its own indigenous renewable energy resources), reducing GHG emissions, dealing with adverse consequences of climate change, and enhancing Hawai'i's energy reliability and resiliency in anticipation of extreme weather and other events that have caused major disruption, havoc and loss both in Hawai'i and elsewhere.

HNEI continues to play a critical and increasingly significant and unique role in assisting various policy bodies, including especially the PUC, the Hawai'i State Energy Office (SEO), Hawaiian Electric Companies, the County of Honolulu Climate Change Commission, among others, in providing targeted research and analyses to be used in decision-making. HNEI has also supported the Hawai'i Energy Policy Forum in its programs, studies and outreach efforts, as well as more recently the Institute of Science for Global Policy to explore specific hydrogen issues in the Pacific island community.

The PUC is conducting numerous proceedings involving fundamental and significant energy issues, many of which have involved studies requested by the PUC to aid it in its proceedings. These encompass performance based regulation of the Hawaiian Electric Companies, distributed energy resources (including demand response and aggregated power supplies), competitive

bidding framework for grid services (including new generation and diverse forms of grid services), community based renewable energy, microgrid tariff, integrated grid planning, evaluation of renewable portfolio standards, and RFPs for renewable energy resources and grid services, among others. The PUC has called on HNEI, and its contractor Telos Energy, to provide independent third-party technical expertise to augment analyses conducted by the PUC, for both near-term as well as long-term questions.

HNEI is also a key participant in the Hawaiian Electric Companies Integrated Grid Planning (IGP) process, which is overseen by the PUC. The IGP seeks to integrate forecasting, resource adequacy requirements, grid services (including generation), transmission and distribution, and procurement into an comprehensive process with significant stakeholder involvement through the Stakeholder Council and IGP working groups. The IGP also includes a Technical Advisory Panel (TAP) comprised of experts to provide an independent review of the utilities' modeling and planning (which HNEI chaired from 2018 to 2021 and remains a TAP member).

The PUC is conducting an Electrification of Transportation (EoT) proceeding aimed at significant reductions in GHG emissions from the transportation sector. HNEI has conducted an analyses of the net GHG benefits on Oahu of electric vehicles compared to the current fleet and other vehicle options.

The Hawai'i Energy Policy Forum (HEPF), founded in 2002 as a collaborate energy planning and policy group, seeks to enable informed decisions to advance Hawai'i's Clean Energy Goals. HNEI supports HEPF's various programs, including its Hawai'i Clean Energy Day, an annual Legislative Briefing, peer exchange program, another activities.

HNEI's activities thus range from directly providing the PUC and SEO with research, technical expertise, and analytical support, assisting the Hawaiian Electric Companies in the IGP process (including chairing the TAP and also working with others in the IGP Stakeholders Council and the various IGP working groups), and assisting HEPF to reach both energy and transportation community companies and members but also to facilitate outreach into the broader community. All of these activities and programs are in furtherance of HNEI's purposes.

Finally, in a very innovative program, HNEI assisted stakeholders in Molokai to develop the Community Energy Resilience Action Plan (CERAP), a unique community initiative representing an independent, island-wide, community-led and expert-informed collaborative planning process to increase renewable energy on Molokai. HNEI assisted by providing technical expertise, data, modeling capabilities, and technical reviews of the project. In July 2023, the CERAP was presented to the PUC in collaboration with the Molokai community and HNEI as the lead technical partner. This model has been characterized as an effective way to involve the broader community in fashioning its renewable energy future.

V. To what degree does the existence of HNEI and its programs and activities support and influence generally Hawai'i's efforts to transform its energy system toward a more sustainable, resilient and affordable energy ecosystem?

Within the context of the profound transformations occurring in Hawai'i's energy ecosystem, HNEI, over a relatively short time, has become a unique resource and an integral part of

Hawai‘i’s intellectual and knowledge resource base that is capable to providing relatively rapid, focused, deployable responses and products to address, and contribute to the solution of, fundamental challenges and barriers to the achievement of Hawai‘i’s Clean Energy Goals. This has already been demonstrated in, among other areas, HNEI’s contributions in analyzing the pace and extensiveness of the integration of renewable energy resources and energy storage into Hawai‘i’s grid systems on all islands. The pace of this particular transformation has been adversely impacted by the COVID-19 pandemic, resultant supply chain disruptions and cost increases, and the Russian invasion of Ukraine and even further cost increases, and one significant negative result is the withdrawal of at least four utility-scale solar and energy storage projects within the past two or so years. These aggravate, to an extent, projected plans for retirements of electric utilities’ fossil fuel generation units. These changes further underscore value the continuing work that HNEI is doing in these areas.

Beyond undertaking studies, analyses, projects, and institutional capabilities in support of its statutory mandates and Hawai‘i’s Clean Energy Goals, HNEI also represents a critical human intellectual resource, both in its highly educated, trained and skilled core faculty and staff as well as in its network of temporary faculty, staff and other professionals, and its network of similar resources throughout the State, and also nationally and internationally. Its program for interns and students significantly adds to the growing group of developing professionals who are already contributing to furthering the goals of HNEI. As a State comprised of several islands, each island must have its own electric grid and system, and this poses unique challenges for each island as it seeks to integrate greater amounts of variable renewable resources, plus storage, supplemented by energy efficiency and conservation measures. Issues of grid stability and how effectively to meet these issues have pushed Hawai‘i to the forefront of dealing with these challenges and devising effective solutions. Hawai‘i, and Hawaiian Electric Companies, have become nationally and internationally recognized for their pioneering work in dealing with this aspect, which generally has not occurred in most U.S. mainland electric grids. As a result, HNEI’s work, in collaboration with the Hawaiian Electric Companies, among others, has contributed to dealing with these issues from a utility operational standpoint, as opposed to primarily academically oriented research. Similarly, HNEI’s research and analytical contributions to organizations such as the PUC have provided timely, focused and critical support to the PUC and other organizations.

In summary, HNEI has become an integral partner with the State, the Counties, the electric utilities, and the private sector in contributing to the State’s pursuit of its clean energy goals. In the course of its operations, it has administered the Special Fund in a manner consistent with its purposes as set forth in Act 253, and the projects and activities that HNEI has funded using Special Funds as well as additional funds that it has obtained through leverage of the Special Fund are in furtherance of the purposes set forth in Act 253.

* * *

ANNEX A

CRITERIA FOR PROJECTS FUNDED BY THE SPECIAL FUND

Act 253 (codified at HRS § 304A--2169.1(c)(2) (2019)) states that projects may be commissioned by HNEI and funded by the Special Fund that:

- (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 innovative and renewable energy supply and energy efficiency 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 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.