Hawai'i Natural Energy Institute Research Highlights

International Support

Asia Pacific Regional Energy System Assessment (APRESA)

OBJECTIVE AND SIGNIFICANCE: In August 2017, HNEI was awarded a grant from the Office of Naval Research (ONR) to support energy system transitions in select locations throughout the Asia-Pacific region under the Asia Pacific Regional Energy System Assessment (APRESA) program. The objective of APRESA is to develop comprehensive energy system assessments in the Asia-Pacific region regarding energy transition strategy, policy, regulation, technology options, demonstrations, implementation plans, and training based on the specific requirements or needs of the targeted jurisdictions and strategic alliances.

BACKGROUND: During the seven years of APRESA activities, HNEI established substantive strategic partnerships with national, regional, and local jurisdictions, as well as private and public stakeholders including numerous utilities, universities, and other research and international aid and development entities, such as the World Bank (WB), Asian Development Bank (ADB), Australian Infrastructure Financing Facility for the Pacific (AIFFP), The Asia Foundation (TAF), The Maureen and Mike Mansfield Foundation (TMF), U.S. Agency for International Development (USAID), and U.S. Department of Defense (DOD) organizations in the areas of interest. Based on the programmatic success of these strategic partnerships, ONR has extended the APRESA program for an additional two years through 2024.

Nations with ongoing active engagement and support activities include Vietnam, Thailand, Philippines, Indonesia, Laos, Cambodia, the Republic of Palau, the Cook Islands, the Federated States of Micronesia (FSM), Papua New Guinea, the Republic of Fiji, and the Republic of the Marshall Islands (RMI). The criteria for selection of jurisdictions include: 1) those with significant rates of projected demand growth requiring rapid energy system expansion and transformation; 2) strategic trade and geopolitical opportunities to the United States; 3) potential to integrate renewable energy technologies; and 4) a collaborative environment to conduct the work.

In addition to the deep local partnerships formed in these jurisdictions, this program has led to a highly successful collaborative relationship with the U.S. Agency for International Development (USAID) and its implementation of prime contractors throughout the region (e.g., Deloitte, Tetra Tech, Abt Associates, RTI, Chemonics, and Delphos International).

USAID partner country governments need high-quality technical expertise to guide their decision-making and can learn from the experience of more developed countries using their best practices and case studies. With significant experience providing technical expertise in the renewable energy space, HNEI is uniquely positioned to partner with USAID and provide energy intelligence in identifying tailored solutions for jurisdictions in need. This collaborative approach, leveraging the capabilities, resources, and know-how of HNEI and USAID implementing contractors in the Asia-Pacific region is consistent with the U.S.' whole-of-government strategy to grow sustainable and secure energy markets across the region. Achieving self-reliance enables emerging economies to rely less on external aid in times of crisis, promotes more transparent markets that incentivize private investment, and redirects resources from inefficient energy subsidies toward more productive utilization. Low-cost renewable energy has the potential to improve the financial viability of energy sectors, reduce vulnerabilities to malign and climate change influences, and improve a country's overall ability to finance its self-reliance. HNEI's collaborations and interventions under this grant help deliver technical expertise to policymakers in emerging economies that can aid in achieving lower-cost, cleaner energy solutions that catalyze competitive markets and reduce carbon emissions – ultimately enabling their populations to enjoy universal, reliable, and cleaner electricity services.

HNEI is using the remaining APRESA funding to complete the efforts in the current countries and to expand this work to select other locations with particular focus on Pacific Island countries (PICs). These efforts are supported by several HNEI faculty and staff, including those of the HNEI's Grid System Technologies Advanced Research Team (Grid*START*). Relative to its recent engagements in PICs, HNEI Grid*START* has launched a new partnering arrangement with the Japan International Cooperation Agency (JICA) and its prime contractor, Okinawa Enetech, in joint Pacific region energy transition technical support to PICs. In 2024, HNEI is jointly delivering with Enetech technical support to

Palau on a range of issues. Discussions are underway with JICA and Enetech to expand on the collaborative successes in Palau and jointly deliver further support to other PICs in 2025.

PROJECT STATUS/RESULTS: A number of select projects initiated under the APRESA award are summarized below. Many of these are also described in more detail in separate project summaries in the **International Support section**.

Vietnam

Innovation System Mapping Project in the Renewable Energy Sector

Under this effort, HNEI provided financial support and guidance, to the National Institute for Science and Technology Policy and Strategy Studies (NISTPASS) to map the innovation opportunities associated with renewable energy (RE) sector development in Vietnam. While the development of renewable energy resources in Vietnam is a government priority, there has been a lack of clarity about the role of many organizations in Vietnam impacting energy development, the relationship between them, and the policies required to foster energy innovation. An objective of this work was to identify which Vietnamese stakeholders in the RE sector would benefit from further policy and institutional support. To meet the aggressive government goals associated with RE innovation, the project is also focused on identifying relevant organizations in the sector and understanding how they interact with each other and as a system.

In April 2023, NISTPASS held a workshop with various Vietnamese groups titled "Mapping Sector Innovation System of Renewable Energy in Vietnam," which was attended by HNEI and ONR personnel. Incorporating inputs from this workshop, NISTPASS produced a final deliverable book titled "Sectoral Innovation System in Renewable Energy: Case of Solar and Wind in Vietnam," along with a SIS stakeholders' analysis report. This project was largely completed at the end of 2023. Final reporting and payments are being completed.

Saigon Energy Hub (SEHub) Support

HNEI is collaborating with Ho Chi Minh City's Institute for Regional and Urban Studies (IRUS) to develop a public renewable demonstration and technology center to raise the community awareness of the needs, the feasibility, and the benefits of energy efficiency and renewable energy. Originally planned for an outdoor public park venue, the project now consists of a number of energy efficiency and renewable energy themed workshops being conducted at new facilities located at Ho Chi Minh City Union of Science and Technology Association's Headquarters.

To date, six workshops covering carbon credits, offshore wind power, legal framework regarding energy savings, energy management, integrated infrastructure and transit-oriented development, and GIS as an effective urban management tool have been conducted. Eleven speakers have contributed, and 260 stakeholders (online and in-person) have participated. Participation has ranged from researchers, technology associations, and business owners to policy makers. The last two workshops are planned for early 2025. This work is described in more detail in "***Saigon Energy Hub (SEHub) Support***."

Institute of Energy (IoE) and HNEI MOU

Collaborations originally planned under an existing HNEI and EREA (Electricity and Renewable Energy Agency) MOU continue, but via collaboration with a different group within the Ministry of Industry and Trade – the Institute of Energy (IoE). HNEI met with IoE in April 2023 and again in September 2024 to finalize discussions of an MOU and to define the near-term scope of the research collaboration. Consistent with previous discussions, it was also agreed that HNEI would support training of the IoE staff to facilitate development of a high-fidelity dispatch model of the Vietnamese grid system. A detailed scope of work and schedule has been agreed to with training to be initiated in December 2024.

Thailand

Provincial Electricity Authority of Thailand (PEA) Collaboration

HNEI has developed a capacity-building program focused on topics of renewable energy grid integration, smart grid technologies, microgrid assessment and design, and the development of advanced EV charging applications for engineers from the Provincial Electricity Authority of Thailand (PEA). PEA is a large Thai distribution grid operator with a service territory spanning all of Thailand,

except for the Bangkok metropolis and two adjoining provinces (Thailand has 77 total provinces).

Since Spring 2020, HNEI Grid*START* has delivered a training program for PEA select engineers. The program accommodates two classes of up to six engineering interns each year. The program lasts for twelve weeks and includes 40 hours of lectures and team-oriented deep immersion in custom "hands-on mini project" research, development, and test endeavors tailored to the learning needs of working utility engineers focused on energy distribution systems. While the program was paused due to Thailand's political climate following the 2023 elections, the program is poised to resume in February 2025 with HNEI welcoming a new group of engineering interns from PEA.

Despite the temporary hold on the internship training program in 2024, collaboration with PEA remained active in other areas. In December 2023, Grid*START* supported PEA's successful commissioning of a microgrid system on Koh Phaluai, an island in the southern Gulf of Thailand featuring 1 MW of photovoltaic capacity, a 750 kW/1,500 kWh battery energy storage system, and two 300 kW diesel generators, all managed with a centralized microgrid controller. This innovative system is designed to operate solely on renewable energy when conditions permit, providing reliable electrical service to island residents. This work is described in more detail in "***Provincial Electricity Authority of Thailand (PEA) Collaboration***."

Waste-to-Bioenergy Conversion for Community PV-BioGrid
With APRESA funding, HNEI contracted Chiang Mai Rajabhat University, Thailand to conduct an assessment of small biomass systems as a firm power option in islanded settings. The study included a resource assessment of potential biomass feedstocks in Thailand, including urban solid wastes and agricultural residues and a technology assessment of available conversion systems. Based on the results, an anaerobic digestion system was selected to integrate into a grid-isolated community dependent largely on PV for electricity. The system has been installed at the University and after shake down testing, was integrated with the direct current microgrid system. Reports are being prepared to close out this effort.

OptiGrid
HNEI met with and planned a project with SGTech, Naresuan University focused on machine learning-driven optimization of battery energy storage systems (BESS) for Thai grid operations. Objectives include identifying effective use of BESS through design, installation, operation, and maintenance to ensure long life under Thai tropical conditions. Use cases for use of BESS to support and stabilize the Thai grid will be identified and studied. Based on the preliminary meetings under this award, SGTech was included in HNEI's APRISES 2023 proposal to ONR to fund the OptiGrid effort.

Philippines
Support to the USAID Energy Secure Philippines (ESP) Program
HNEI Grid*START*'s engagement with the Philippines power sector began in 2019 through collaboration with USAID Clean Power Asia by providing support to the Philippines Department of Energy (PDOE) for net energy metering (NEM) program development. This partnership expanded through APRESA and USAID Energy Secure Philippines (ESP) program funding, delivering technical support to the Philippines Energy Regulatory Commission (ERC), distribution utilities (DUs), and other relevant agencies. Key focus areas included developing "off-grid" NEM rules for rural areas and establishing a battery energy storage system (BESS) regulatory framework.

Throughout 2022 and 2023, HNEI delivered comprehensive off-grid NEM rules, BESS regulations, and capacity building for key stakeholders. In November 2023, Grid*START* delivered energy storage systems (ESS) training to PDOE, focusing on ESS costs and benefits in relation to the country's renewable energy goals of 35% by 2030 and 50% by 2040. The training addressed policy frameworks and institutional approaches for BESS implementation, while ensuring reliable and cost-effective electricity for both on- and off-grid systems.

In 2024, HNEI's scope expanded significantly to include an all-electric fishing boat design review, provincial utility capacity building, and an energy resiliency assessment for Camp Aguinaldo, the headquarters for the Armed Forces of the Philippines. The team conducted extensive site and stakeholder

engagement across Manila, Bohol, Iloilo, and Siargao with local officials, provincial utilities, and key energy stakeholders to develop targeted solutions for provincial energy needs. This work is described in more detail in "***Support to the USAID Energy Secure Philippines (ESP) Program***."

Indonesia

USAID Sustainable Energy for Indonesia's Advancing Resilience (SINAR) Program

HNEI Grid*START* is providing technical support to USAID's Sustainable Energy for Indonesia's Advancing Resilience (SINAR) program, a five-year initiative supporting Indonesia's clean energy transition. The support encompasses capacity building in advanced energy systems including financing, procurement, planning, and operations. A key focus is improving the performance of energy utilities, particularly PT Perusahaan Listrik Negara (PLN), while strengthening the energy sector's institutional framework through enhanced procurement standards, cost recovery mechanisms, and modernized planning and operating practices.

In February 2022, HNEI delivered a three-day webinar on Hawai'i's renewable energy transformation to Indonesia's Directorate General of Electricity and Ministry of Energy and Mineral Resources. Building on this initial exchange, we conducted a three-day workshop on small island grid planning for PLN in Bali and a one-day webinar for the National Energy Council of Indonesia (Setjen DEN) in Jakarta in May 2023.

In February 2024, HNEI Grid*START* organized an extensive Smart Grid Benchmarking Study Tour in Hawai'i for Indonesian utility executives and stakeholders. The delegation visited both O'ahu and Kaua'i, participating in classroom training and field trips. The program included meetings with the Hawai'i Public Utilities Commission, State Energy Office, and Hawaiian Electric Company. On Kaua'i, participants visited Kaua'i Island Utility Cooperative (KIUC) facilities, examining hybrid PV and battery storage systems while learning about advanced metering infrastructure and operational technologies. This work is described in more detail in "***USAID Sustainable Energy for Indonesia's Advancing Resilience (SINAR) Program***."

Laos

Électricité du Laos (EDL) and Ministry of Energy and Mines (MEM) Support

HNEI has agreed, pursuant to an October 25, 2021 Letter of Engagement with EDL, to deliver needed technical capacity building support at EDL's request on the following topics: 1) practical guidance for interconnection of distributed solar PV systems to the distribution grid; 2) training curriculum on topics such as voltage regulation and variation, frequency limits, voltage dips, voltage unbalance, voltage flicker and harmonics; and 3) standards of practice for installing and operating underground distribution cables. With team resources limited due to other active support engagements across the Asia-Pacific region, HNEI Grid*START* plans to deliver in-person and remote training to EDL on these topics starting in 2025.

USAID Southeast Asia's Smart Power Program (SPP) – Laos

HNEI entered into a collaboration with Deloitte Consulting on October 27, 2022, as part of the USAID Southeast Asia Smart Power Program (SPP). This $40 million, five-year initiative aims to mobilize $2 billion in blended financing for clean energy infrastructure, supporting Southeast Asia's goal of achieving net-zero greenhouse gas emissions by 2050. HNEI's initial tasks centered on assisting Électricité du Laos (EDL) and the Lao Ministry of Energy and Mines (MEM) in three key areas: 1) enhancing power system resilience, 2) implementing demand-side management/demand response (DSM/DR) strategies, and 3) integrating variable renewable energy (VRE) resources into their transmission and distribution systems.

In 2023, HNEI Grid*START* delivered updated Feasibility Study Guidelines for wind, solar, and biomass energy projects in Laos, as well as an updated Grid Code incorporating interconnection standards for Inverter-Based Resources (IBRs). The team also conducted capacity building sessions for EDL and MEM staff on these topics. Continuing this support, in May 2024, HNEI virtually presented on IBR grid connection requirements at a workshop in Vientiane, Laos. The session, attended by approximately 30 key representatives from various organizations, highlighted applications and practices from the U.S., particularly Hawai'i. HNEI

Grid*START* is currently working with SPP to identify additional support needs for EDL and MEM, including strategy development and capacity building on hybrid (VRE and BESS) projects for cross-border energy trade with Cambodia and Thailand. This work is described in more detail in "***USAID Southeast Asia's Smart Power Program (SPP) – Laos***."

Cambodia

USAID Southeast Asia's Smart Power Program (SPP) – Cambodia

As a subcontractor to Deloitte Consulting for the USAID Southeast Asia Smart Power Program (SPP), HNEI is working to enhance grid resilience and renewable energy integration in Southeast Asia. This initiative involves long-term collaboration with Cambodia's Electricite de Cambodge (EdC) to manage high levels of variable renewable energy (VRE) and conducting regional capacity-building workshops for ASEAN Power System Operators (APSO). By sharing U.S. best practices, especially from Hawai'i, we aim to strengthen utility capacity and promote renewable electricity trading.

In May 2024, HNEI Grid*START* conducted a workshop at EdC's headquarters in Phnom Penh, Cambodia, organized with USAID SPP and the Australian Department of Foreign Trade and Investment. This workshop enhanced Cambodian energy practitioners' understanding of VRE integration. In August 2024, another workshop was held during the APSO Annual Meeting in Manila, Philippines, focusing on improving VRE integration capabilities among ASEAN Member States. This work is described in more detail in "***USAID Southeast Asia's Smart Power Program (SPP) – Cambodia***."

Pacific Island Countries (PICs)

Renewable Energy Regulatory and Technical Support for Palau

HNEI is providing wide-ranging technical and regulatory/policy support to Palau's Energy and Water Administration (PEWA) and the Palau Public Utilities Corporation (PPUC) in three key areas: 1) energy regulatory frameworks, 2) grid modeling, and 3) renewable generation interconnection requirements and streamlined interconnection processing. Following a technical and financial analysis of PPUC's grid operations in October 2023, Grid*START* delivered new distributed generation interconnection requirements (i.e. a grid code), which PEWA adopted in February 2024. The team also delivered a three-day renewable energy integration training in Koror in June 2024.

To enhance support for Palau, HNEI met with the Asian Development Bank (ADB) in Manila during June and August 2024 to define collaborative opportunities. Additionally, Grid*START* launched a partnering arrangement with Okinawa Enetech and the Japan International Cooperation Agency (JICA) to coordinate and jointly deliver elements of their respective technical support for renewable energy integration in Palau. This work is described in more detail in "***Renewable Energy Regulatory and Technical Support for Palau***."

Renewable Energy Regulatory and Technical Support for the Cook Islands

HNEI Grid*START* is providing technical and regulatory support to Te Aponga Uira (TAU), the government-owned electric utility of the Cook Islands. This collaboration began in September 2023 with a one-day training program in Honolulu for TAU's senior management and a board member, sharing Hawai'i's energy transition experiences.

In July 2024, we conducted extensive capacity building sessions on Rarotonga, meeting with TAU management, board members, and Prime Minister Mark Brown. The presentations covered Hawai'i's energy transitions, battery storage implementation case studies from Pacific Island Countries and Kaua'i, and potential clean energy scenarios for Rarotonga.

Building on these engagements, HNEI continues to support the Cook Islands' clean energy transition through distribution feeder analysis, customer program development, utility financial planning, and renewable energy project procurement. Following the July 2024 visit, Grid*START* has continued to support TAU on key needs, such as distribution feeder analysis to determine the "hosting capacity" for distributed PV, and strategic measures to support and improve utility financial integrity. This work is described in more detail in "***Renewable Energy Regulatory and Technical Support for the Cook Islands***."

Renewable Energy Regulatory and Technical Support for Yap State, Micronesia
HNEI Grid*START*, through APRESA funding and in partnership with the Pacific Power Association (PPA), is providing technical and regulatory support to the Yap State Public Service Corporation (YSPSC) in the Federated States of Micronesia. This collaboration builds on our involvement with PPA since 2023, when the team delivered invited presentations at PPA's 30th annual conference in Saipan.

In October 2024, HNEI conducted its first training at YSPSC's offices, delivering a two-day program covering Hawai'i's clean energy transition, variable renewable energy (VRE) management, grid interconnection standards, energy storage, electric vehicles, climate adaptation, and renewable energy procurement. The team provided hands-on training with its internally developed *Generation Mix Resource Modeling Tool* and conducted facility site visits to identify further support needs. Grid*START* plans to continue its support to YSPSC in 2025 and expand similar training programs to other Pacific region utilities under its partnership with PPA. This work is described in more detail in "***Renewable Energy Regulatory and Technical Support for Yap State, Micronesia***."

Southeast Asia
Sustainable Aviation Fuel (SAF) Production
APRESA funds have supported HNEI's participation in a research program evaluating sustainable aviation fuel production systems for tropical environments. Current activities include evaluation of biomass resources derived from urban solid waste and their suitability as feedstocks for thermochemical gasification systems. The synthesis gas product can be subsequently converted with Fischer-Tropsch synthesis to sustainable aviation fuel. The aviation industry (civilian and military) faces significant greenhouse gas challenges due to dependence on petroleum jet fuels and limited opportunity for electrification.

Additionally, APRESA funding contributed to a sustainable aviation fuel workshop in Bangkok, Thailand in May 2023, which was organized by the Federal Aviation Administration (FAA), the U.S. Trade Development Agency, the National Energy Technology Center of Thailand, and HNEI. A second workshop was held in Bali, Indonesia in July 2024 co-organized by the FAA through their Aviation Sustainability Center (ASCENT), the Indonesian Directorate General for Civil Aviation, the National Energy Technology Center of Thailand, and HNEI. The workshops' goals were to share information on SAF developments in the region and to identify barriers to implementing SAF value chains spanning feedstock production to end use. Participants from various Asia-Pacific countries attended, representing civil aviation authorities, government policymakers, airlines, SAF feedstock producers, consumers, and technology providers, university researchers, and airport operators.

Oil Seed Production Analysis
Millettia pinnata, also called karanja or pongamia, is indigenous to the Indian subcontinent and Southeast Asia. This leguminous tree bears seed rich in fatty acids (27 to 39 wt%) that when harvested can be processed into oil, nitrogen-rich meal, and lignocellulosic pod fractions that all can play roles in improving the resiliency in both food and energy for island communities in tropics. APRESA funds support an initial cost of production analysis to determine farm gate prices for harvested seed pods based on costs to establishment, maintenance, and harvesting costs for pongamia orchards in Hawai'i. This analysis framework can be extended to other locations in the tropical Pacific.

Hawai'i's state tree, kukui (*Aleurites moluccannus*, or candlenut), bears nuts that are roughly 40% shell and 60% fleshy seed, the latter containing ~60% oil. Although commonly found in Hawai'i and across the Indo-Pacific region, little work has been done to understand kukui productivity and management. Utilizing APRESA funding, a review of the scientific literature is underway to provide a summary of the current knowledge and identify opportunities of exploration.

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