# Hawai‘i Natural Energy Institute Research Highlights

*International Support*

## *Asia Pacific Regional Energy System Assessment (APRESA)*

**BACKGROUND**: In August 2017, HNEI initiated efforts under a five–year grant from the Office of Naval Research (ONR) for the Asia Pacific Regional Energy System Assessment (APRESA). The objective of this five-year grant is to develop comprehensive energy system assessments that include strategy, policy, regulation, technology options, demonstrations, implementation plans, and training for energy system transitions in select locations throughout the Asia-Pacific region, based on the specific requirements or needs of the targeted jurisdictions and strategic alliances. The first three years of this program has laid a firm foundation for continued success built upon the development of solid partnerships with national, regional or local jurisdictions, private and public stakeholders including utilities, universities, and other research and international aid and development entities such as the World Bank (WB), Asian Development Bank (ADB), U.S. Agency for International Development (USAID), and U.S. Department of Defense (DOD) organizations in the areas of interest.

Active engagement and support activities are currently ongoing in Vietnam, Thailand, Laos, Indonesia, Papua New Guinea and the Philippines, with new engagements under development in various Pacific Island countries. Jurisdictions were selected based on projected demand growth and need for rapid energy system expansion and transformation, the potential to integrate renewable energy technologies, and collaborative environment in which to conduct the work.

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

USAID partner country governments are in need of 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, promote 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 their 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 proposes to utilize continued APRESA funding to extend the efforts in the current countries and to expand this work to other countries, regions, and DOD facilities of interest. Included in this planned effort is support for Hawai‘i Green Growth to assist the regional attainment of the UN Sustainability Goals.

**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 included in the **International Support** section.

*Thailand: Biomass Gasification Demonstration*
With APRESA funding, HNEI contracted Chiang Mai Rajabhat University, Thailand, to conduct an assessment of small gasification systems as a firm power option in islanded settings. The study will include 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 these results, a conversion system will be selected and evaluated in an existing micro-grid operated at

Chiang Mai Rajabhat University. These extended tests will evaluate feedstocks and their preparation, identify maintenance requirements and practices, and develop gasifier system control strategies for interfacing with the intermittency of other micro-grid components.

*Biochar Production from Rice Husk and Plastics*
An evaluation of mixed waste pyrolysis concluded with the publication of the manuscript: "**Investigation of Biochar Production from Copyrolysis of Rice Husk and Plastic**" in the journal ACS Omega. APRESA supported the exchange visit of Dr. Ketwalee Kositkanawuth from the King Mongkut's University of Thailand, Thonbury at HNEI and the evaluation of the biocarbon products detailed in the journal article.

*Postdoctoral Training in Sustainable Aviation Fuel*
APRESA funds have supported Dr. Quang Vu Bach'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.

*EGAT Renewable Integration Study (Thailand)*
On February 28, 2018, the Electricity Generating Authority of Thailand (EGAT) held a ceremony to sign a multi-year Memorandum of Understanding (MOU) with HNEI. The MOU terms of reference include education, training, workshops, and exchange programs (study tours or site visits) under topics, such as *Strengthening the Operation Capacity to Support Renewable Energy Integration into the Power System*. Under this MOU, HNEI's Grid***START*** team and EGAT built and calibrated a high-fidelity production cost model of the Thai power grid in PLEXOS. In March 2021, a multi-day remote workshop was held for EGAT, focusing on model updates, tuning and calibration. Time series photovoltaic (PV) and wind data sets for all existing RE and future high penetration RE cases were developed and analyzed with multiple distributed PV scenario cases. Application of this Thai power grid model continues including analysis of the need for more flexible grid assets and measures to meet this need. This work, described in more detail in the "**EGAT Renewable Integration Study**" project summary, extends and expands the collaborative work amongst HNEI and EGAT.

*Provincial Electricity Authority of Thailand (PEA) Collaboration*
HNEI's Grid***START*** team developed a capacity building program focused on renewable energy integration and smart grid technologies development and application for engineers from the Provincial Electricity Authority of Thailand (PEA), the Thai distribution grid operator responsible for electricity supply to the entirety of Thailand, except for the Bangkok metropolis and two adjoining provinces (Thailand has 77 total provinces). Initiated in Spring 2020, the internship program was designed to accept two classes of six PEA engineers annually, participating in an eight-week curriculum of combined lectures (40 hours) and team oriented deep emersion in custom "mini-project" research, development, and test endeavors tailored to the learning needs of working utility engineers. A renewable energy integration and smart grid technologies series of lectures with emphasis on energy distribution system applications was developed and delivered to the PEA engineers. The first PEA intern class was received at HNEI from March to May 2020. However, due to COVID-19 travel restrictions, the second intern class was postponed and bifurcated into: (1) a five-day online lecture component conducted remotely in May 2021; and (2) an in-person lecture and mini-project component from October to December 2021. For the in-person component currently underway at HNEI in Honolulu, Hawai'i, the intern class was split into two teams, each focused on one of two mini-project topics: (1) ARGEMS application development: Distribution Secondary Fault Detection and Location; and (2) Bidirectional EV Charging Control Optimization. This work is described in more detail in the "**Provincial Electric Authority of Thailand (PEA) Collaboration**" project summary.

*Technical Support for Development of BESS Technical Standards for Thailand*
The support objective of this project was to provide technical assistance to Thailand's Office of Energy Regulatory Commission (OERC) in its ultimate adoption of codes and regulations for battery energy storage system (BESS) applications in Thailand. Through leveraged partial funding by USAID Clean Power Asia (CPA), HNEI has provided expert advice to OERC and Thai stakeholders, culminating in the delivery of a comprehensive guide and roadmap for developing BESS technical codes and standards for Thai regulatory action. Following the first Stakeholder Focus Group held in August 2020, a Final Stakeholder Consultation Workshop was held in Bangkok on February 18, 2021. HNEI presented online the final draft of the BESS technical standards report to OERC, with Thai electric utilities and numerous energy sector stakeholders in attendance. Stakeholder feedback was incorporated into the final deliverable "*Guidelines for Developing BESS Technical Standards in Thailand*," which was submitted to USAID CPA on March 29, 2021, for delivery to OERC. This work is described in more detail in the "**Development of BESS Technical Standards for Thailand**" project summary.

*MOU between HNEI and Chulalongkorn University, Faculty of Engineering, Smart Grid Research Unit (Chula)*
The MOU establishes a framework for multi-year collaboration amongst HNEI and Chula engineering faculty on a range of activities exploring approaches, methodologies, tools, techniques, systems, and policies that lead to enhanced resilience and energy reliability while enabling a clean energy transition through grid modernization and smart grid initiatives. Collaborative endeavors include the following two projects.

Thailand Regional Solar PV Forecasting Project: The HNEI solar forecasting system combines information derived from numerical weather prediction (NWP), satellite images, and ground based instruments to monitor current regional irradiance conditions in near real-time and predict upcoming irradiance conditions and resulting PV power production, from minutes to days ahead. HNEI's Grid***START*** team setup a new test domain for its solar forecasting system to evaluate its application in Thailand. Utilizing archived Himawari-8 satelite images, a month of 6-hour ahead irradiance forecasts were generated for over 30 test sites in Thailand. At each site, ground-based observations of hourly insolation were provided. To visualize the results, a regional aggregate dashbord was built using web-based tools, which can be found at: http://128.171.156.27:5100/sitesforecast/. This work is described in more detail in the "**Thailand Regional Solar PV Forecasting**" project summary.

Chulalongkorn Smart Campus Project – ARGEMS: To build joint research and development capacity in the area of grid modernization and smart grid initiatives, HNEI is field deploying multiple devices of its Advanced Real-time Grid Energy Monitor System for integration with other smart grid technologies in Chula's Smart Campus Project. Two ARGEMS devices have been shipped to Chula. The first device has been operating in a lab setting for over a year, and the second device is ready for installation on a building transformer. Other devices have been prepared for final configuration and shipment. This work is described in more detail in the "**Chulalongkorn University Smart Campus Project – ARGEMS**" project summary.

*Vietnam: Mapping of Renewable Energy Sector Innovation System*
Under this project, HNEI is providing financial support and guidance, to the National Institute for Science and Technology Policy and Strategy Studies (NISTPASS) to map the innovation system in the renewable energy (RE) sector in Vietnam. While the development of renewable energy resources in Vietnam is a government priority, there is lack of clarity in regard to the role of many organizations in Vietnam impacting energy development and the relationship between them. With rapidly growing industrialization and modernization of the economy, energy demand is predicted to increase by over 10 percent annually during 2016-2020 and by eight percent per annum during 2021-2030 resulting in a four-fold increase in total electricity demand by 2030 compared to 2014. Under Vietnam's Revised National Power Development Master Plan for the 2011-2020 Period, the share of RE is anticipated to significantly accelerate beyond the 10 percent goal previously set for 2030. To meet the aggressive government goals associated with RE innovation, the project is focused on identifying all the relevant

organizations in the sector and understanding how they interact with each other and as a system. The analysis will involve an exhaustive review of energy producers; energy consumers; business systems; educational and research systems; policies, regulations and statutes; and infrastructure developers. By May of 2020, NISTPASS completed its initial assessment of the innovation and RE sector innovation system (SIS) in Vietnam. This mapping, based on the National Systems of Innovation Concept, included the functions and challenges of the SIS, stakeholders and linkages and mutual learning between stakeholders, and preliminary concepts on policy to promote the SIS. The next step is to identify what government support is currently available for energy innovation and where support is most needed to promote future energy innovation growth in Vietnam. This work is described in more detail in the "**Vietnam: Mapping of Renewable Energy Sector Innovation System**" project summary.

*Renewable Energy Integration Support in Vietnam*

The USAID Vietnam Low Emission Energy Programme (V-LEEP) under the leadership of Deloitte has been working closely with relevant agencies in Vietnam's Ministry of Industry and Trade (MOIT), the Electricity and Renewable Energy Authority (EREA), Electricity Regulatory Authority of Vietnam (ERAV), and the Institute of Energy (IEVN) to study and enable a functional and competitive regulatory framework and conditions which support an increase of renewable energy generation and consumption. HNEI partnered with the National Renewable Energy Laboratory (NREL) to support V-LEEP with expertise in variable renewable energy integration modeling and advanced power system planning for Vietnam's Power Development Plan (PDP-8) efforts.

HNEI's Grid***START*** team contributed to V-LEEP's report to MOIT/EREA on a new methodology roadmap to update the historical PDP process and to incorporate international best practices for planning for higher levels of variable renewable energy. Based on the results of this assessment, MOIT/EREA adopted V-LEEP's recommendations on a new process and methods, including the use of advanced grid simulation tools for PDP-8 analyses. To implement this shift in PDP-8 analytical approach and methodology, MOIT/EREA established a Modeling Working Group (MWG) to conduct production cost analysis for the development of PDP-8. V-LEEP, together with HNEI and NREL, delivered two technical trainings in Hanoi for the MWG and other relevant stakeholders on the application of advanced modeling tools and analytics in long-term planning. In March 2021, Deloitte delivered to MOIT/EREA a technical report, *Impact Analysis of Integrating Significant Renewable Energy in Vietnam's Power Sector: A PLEXOS-based Analysis of Long-Term Power Development Planning*, that provides feedback for MWG generation and transmission planners to optimize the PDP-8 using the least-regret approach. This work is described in more detail in the "**Recommendations on Methodology for Vietnam Power Development Plan (PDP)**" project summary.

*Technical Interconnection Requirements for Solar and Wind Projects in Laos*

Starting in 2018, HNEI, in a partnership with USAID Clean Power Asia (CPA), drafted interconnection grid codes and supported power purchase agreement (PPA) structure and terms development for Laos' first market-based competitive solar pilot auction. Based on this work, Électricité du Laos (EDL), the Laos grid operator, requested extended support from HNEI to develop interconnection grid codes for distributed PV and utility-scale solar and wind projects, a foundational need to enable uptake of solar and wind resources into the Laos power grid. HNEI's Grid***START*** team commenced work in 2020 on the development of two key deliverables: (1) *Électricité du Laos Distributed Solar Photovoltaic Generating Facility Interconnection Standards* (Dec 2020); and (2) *Électricité du Laos Inverter-based Generating Facility Transmission Interconnection Standards* (Jan 2021). These deliverables were submitted and presented jointly by HNEI and USAID CPA to EDL and the Lao Ministry of Energy and Mines (MEM) in March 2021. This work is described in more detail in the "**Technical Interconnection Requirements for Solar and Wind Projects in Laos**" project summary.

*Energy Secure Philippines (ESP) – Philippines' Net-Metering Framework; Regulatory Framework for BESS*

In 2019, HNEI's Grid***START*** team provided technical and capacity building support in collaboration with USAID Clean Power Asia to assist the Philippines Department of Energy (PDOE) to

prepare and present its Department Circular (DC) for "*Promulgating Policies to Enhance Customers' Participation in the Philippines' Net-Metering Framework*." In 2020, PDOE issued a new Net-Metering Policy which, while maintaining the 100 kW limit on system capacity, removed the Distribution Impact Study fee imposed by distribution utilities on Net-Metering applicants. HNEI Grid***START*** continued throughout 2020 to provide online capacity building webinars offering in-depth training to Philippine energy regulators, administrators, energy stakeholders, and particularly the implementing staff of the numerous Philippine distribution utilities charged with Net-Metering program execution and PV system interconnections. Following the new policy enactment, the participation rate in the Net-Metering Program has increased by almost 15%.

In 2021, HNEI is supporting the activities of the new USAID Energy Secure Philippines (ESP) Program and the Philippines Energy Regulatory Commission (ERC) to advance inclusive economic growth and resilient energy sector development through the following two project endeavors: (1) the enactment of new net energy metering (NEM) rules tailored for their numerous small island grid systems; and (2) the establishment of a regulatory framework for battery energy storage systems (BESS) adoption in the Philippines. This work will be described in more detail in a subsequent report.

*ASEAN Interconnection Masterplan Study (AIMS) III Support*

As a basis for assessment, regional planning, and development of a prospective integrated ASEAN Power Grid, the ASEAN countries have conducted three AIMS studies to date. The latest development in the study, AIMS III, began in 2019 and builds upon the foundational work of the previous two studies. It aims to evaluate ASEAN power market integration through the grid connection of renewable energy and power trade. HNEI's Grid***START*** team is providing technical assistance as a core member of the Technical Review Group (TRG) for the AIMS III effort. The TRG, comprised of a core and secondary group of international experts, is tasked with performing reviews and providing guidance on the scope, data needs, assumptions, analyses and results of AIMS III. The AIMS III work is divided into three phases. Phase 1, Capacity Expansion Planning, and Phase 2, Grid Performance Analysis, are both complete. HNEI is presently engaged in scoping discussions at the request of the ASEAN Center for Energy (ACE), an intergovernmental organization within the ASEAN structure representing the 10 ASEAN Member States' (AMS) interests in the energy sector, for continued technical support of Phase 3, Multilateral Market Analysis, which is yet to start. This work is described in more detail in the "**ASEAN Interconnection Masterplan Study (AIMS) III Support**" project summary.

*ASEAN Centre for Energy (ACE) Capacity Building*

HNEI's Grid***START*** team is delivering training at the request of the Jakarta, Indonesia based ASEAN Centre for Energy (ACE), an intergovernmental organization representing energy sector interests of the ten ASEAN Member States (AMS). The capacity building initiative endeavors to build the knowledge base and capability of ACE planning/engineering staff in the advanced analytics needed for effective renewable energy integration analysis, and ultimate power grid modernization and optimization in ASEAN countries. In February 2020, in-person training was provided at ACE headquarters in Jakarta on the need for, value, tools, and methodologies of production cost modeling and analytics. Follow-on extended training for ACE personnel at HNEI in Honolulu was scheduled, but postponed due to COVID-19 travel restrictions. This training will enhance ACE's close work with energy authorities/ministries/utilities in the AMS in implementing the ASEAN Plan of Action for Energy Cooperation which serves as a blueprint for AMS cooperation to enhance energy development, while shaping the region's sustainable and environmentally friendly growth. In anticipation of reduced restrictions on travel, discussions are again underway with ACE to resume hands-on capacity building endeavors in Jakarta and/or Hawai'i.

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*Contact*: Richard Rocheleau, rochelea@hawaii.edu;
Leon Roose, lroose@hawaii.edu;
Scott Turn, sturn@hawaii.edu;
Mark Glick, mbglick@hawaii.edu;
Jim Maskrey, maskrey2@hawaii.edu

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