OBJECTIVE AND SIGNIFICANCE: In August 2017, HNEI was awarded a five-year 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 select locations throughout 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. During the first five years of APRESA, HNEI established substantive strategic partnerships with national, regional, and local jurisdictions, as well as 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), 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 through 2024.

Nations with ongoing active engagement and support activities include Vietnam, Thailand, Laos, Indonesia, Papua New Guinea, and the Philippines. New engagements with Pacific Island countries include Fiji, Kiribati, Republic of Marshall Islands, Federated States of Micronesia, Nauru, Palau, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu under WB funding, with these partnerships initially made possible through APRESA regional support activities. The criteria for selection of jurisdictions include those with significant rates of projected demand growth requiring rapid energy system expansion and transformation; strategic trade and geopolitical opportunities to the United States; potential to integrate renewable energy technologies; and a collaborative environment 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 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 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. These efforts are supported by a number of HNEI faculty and staff including those of the HNEI’s GridSTART team focused on advanced grid technologies.

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 under the International Support section.
**Biomass Energy Demonstration (Thailand)**

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 and is being installed and evaluated in an existing micro-grid operated at Chiang Mai Rajabhat University. Extended tests will evaluate feedstocks and their preparation, identify maintenance requirements and practices, and develop system control strategies for interfacing with the intermittency of other micro-grid components.

**Production Cost Estimates for Millettia pinnata**

*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 can be converted to renewable diesel and sustainable aviation fuel. Seed meal and pod fiber are processing coproducts with potential value as animal feeds and energy/bioproduct feedstocks, respectively. Under this project, cost estimates for pongamia production are being developed for farm gate prices of harvested seed-in-pod to inform design of pongamia based value chains.

**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 System Technologies Advanced Research Team (GridSTART) built upon its prior work with EGAT, developing and calibrating a high-fidelity production cost model of the Thai power grid in PLEXOS, and applied the model to assess the impact on the Thai power grid of alternative high penetration distributed PV scenarios over the next five- to ten- year horizon. With COVID-19 travel restrictions to Thailand now lifted, HNEI is engaged with EGAT to scope follow-on analysis using the PLEXOS Thai power grid model, such as evaluation of carbon reduction pathways for the country, given recent targets set by the Thai government. EGAT recently purchased a license for the PLEXOS software which enables an opportunity for deeper collaboration in grid analytics ahead. This working relationship is described in more detail in the “EGAT Renewable Integration Study” project summary.

**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 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 the Spring of 2020, staff from HNEI’s GridSTART have taken the lead in delivering this training program designed to accept two classes of PEA interns annually. Each class of six engineering interns participates at HNEI in an eight-week curriculum of combined lectures (40 hours) and team-oriented deep immersion in custom “mini-project” research, development, and test endeavors tailored to the learning needs of working utility engineers. COVID-19 travel restrictions resulted in class postponements and a partial transition to online learning in the 2020-2021 timeframe. However, with the recent lifting of travel restrictions, the first and second 2022 class of PEA interns were trained at HNEI from June to August and
August to October, respectively. Each class of interns was split into two sub-groups working simultaneously on different mini-project topics: 1) optimization of virtual power plant (VPP) dispatch and demand response (DR) applications; 2) improvement of electric vehicle (EV) energy consumption estimation approach for use in EV charge/discharge optimization algorithm; 3) PV hosting capacity methodology and assessment; and 4) optimized microgrid system design. Overall, the training program provided PEA engineers with enhanced technical knowledge of distributed energy resource (DER) technologies, EV applications and microgrids. This work is described in more detail in the “Provincial Electricity Authority of Thailand (PEA) Collaboration” project summary.

**Technical Support for Development of BESS Technical Standards for Thailand**

The objective of this effort was to deliver 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 GridSTART provided expert advice to OERC and Thai stakeholders, culminating in the delivery of a comprehensive guide and roadmap to develop 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. Based on this work, HNEI was engaged in 2022 to develop a regulatory framework for adoption of BESS applications for the Philippines’ Energy Regulatory Commission under funding from USAID.

**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 and graduate students 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. Active collaborative endeavors included continuing work on the Chulalongkorn Smart Campus Project. This collaboration, established to build joint research and development capacity in grid modernization technologies, centers on field deployment of HNEI GridSTART’s Advanced Real-time Grid Energy Monitor System (ARGEMS), integrated with other intelligent grid-edge technologies in Chulalongkorn’s Smart Campus Project. To date, two ARGEMS devices were shipped to Chulalongkorn University. The first device has been operating in a lab setting for over a year, and the second device is now installed on a campus building transformer. Additional devices were prepared for final configuration and shipment. In advance of deployment at Chulalongkorn University, HNEI improved the ARGEMS documentation and developed software to enable remote firmware updates, device configuration, and testing to support the use of a new type of current transducer (Rogowski coil) needed for the Smart Campus Project field installation.

**Mapping of Renewable Energy Sector Innovation System (Vietnam)**

Under this effort, 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 about the role of many organizations in Vietnam impacting energy development and the relationship between them. An objective of this work is to identify which Vietnamese stakeholders in the RE sector can benefit from further policy and institutional support.
With the rapidly growing industrialization and modernization of the economy, energy demand in Vietnam has increased rapidly between 2016-2020 and is predicted to increase by eight percent per annum through 2030, resulting in a four-fold increase in total electricity demand compared to 2014. To meet the aggressive government goals associated with RE innovation, the project is focused on identifying 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.

In 2022, NISTPASS completed interviews with key players in the four groups of stakeholders in the renewable energy sector in Vietnam, focusing on solar and wind energies. The interviews have yielded 21 overall trends and findings ranging from opportunities in the supply side of the sector innovation system to the impacts of environmental factors and the COVID-19 pandemic. NISTPASS is currently preparing a final report summarizing results of RE innovation mapping for Vietnam and will announce plans for an international workshop/conference in Honolulu during the Spring of 2023 to review the results and explore next steps. A summary report of the outcome of the international workshop and the issuance of two publications containing research results in both the Vietnamese and English language will conclude the project. The work is described in more detail in the “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 Consulting 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. This initiative, which was extended an additional year, allowed HNEI to continue its partnership with NREL to support V-LEEP with further grid modeling and stakeholder training, building capacity in the use of advanced tools and methodologies in the Vietnam Power Development Plan-8 process. HNEI GridSTART’s support and partnership with Deloitte Consulting is continuing with the recent launch of the V-LEEP II program, which Deloitte again leads and builds upon its preceding V-LEEP program success.

Saigon Energy Hub (SEHub) Support
HNEI is supporting the Center for Urban Studies (CRUS) in the development of an online and offline energy-efficiency and renewable energy education platform to offer energy themed workshops on energy technologies and platforms. Ten public workshops will be presented live and online to the community of Ho Chi Minh City to advance public understanding and drive energy policy. The project will continue through July 2024. This work is described in more detail in the “Saigon Energy Hub (SEHub) Support” project summary.

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 the recent lifting of COVID-19 travel restrictions by the Laos government, plans are underway for HNEI to deliver in-person and remote training on these topics starting in 2023.
USAID South East Asia’s Smart Power Program (SPP) Regional Collaborative Support
A Letter of Collaboration initiated by Deloitte Consulting, the prime contractor for the new USAID South East Asia’s Smart Power Program (SPP), was signed with HNEI on October 27, 2022. The SPP is USAID’s regional successor program to its earlier Clean Power Asia (CPA) program in which HNEI’s GridSTART delivered both collaborative (APRESA funded) and CPA funded support over the prior four years. SPP is a five-year program intended to expand energy capacity through deployment of advanced energy systems, increase clean energy investment across the region’s energy sector, and improve regional energy trade to ensure secure and market-driven energy sectors that sustain economic growth.

The program will leverage bilateral and multilateral partnerships, support regional initiatives, accelerate cross-border interconnection and power trade, and create centers for training of energy practitioners to develop solutions that will help Southeast Asian countries become self-reliant and achieve their sustainable development aspirations. USAID SPP plans to implement numerous activities, including by example establishing a Center for Competitive Procurement (CCP), conducting a resiliency assessment of ASEAN power utilities, and other capacity development undertakings to support ASEAN utilities. Deloitte Consulting and HNEI GridSTART anticipate collaboration where there are opportunities for leveraging comparative advantages of USAID SPP and HNEI across all of SPP’s task areas, including utility modernization, demand-side management/demand response (“DSM/DR”), energy innovation and emerging trends, competitive procurement, power trade, and grid integration. Initial tasks for collaborative work are being scoped, with work activities to be launched first in Laos and Thailand in January 2023.

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. Staff from HNEI’s GridSTART commenced work in 2020 on 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. As these proposed technical standards are now being applied in Laos, the new USAID Southeast Asia’s Smart Power Program (SPP) has requested collaborative support from HNEI GridSTART to deliver further training on these standards to EDL, Laos MEM, and energy project developers. Activity scoping is underway, with a launch meeting for this initiative with USAID SPP, EDL, and MEM planned for January 2023.

Support to the USAID Energy Secure Philippines (ESP) Program
In 2019, HNEI GridSTART delivered technical and capacity building support in collaboration with USAID CPA 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 a 100 kW limit on system capacity, removed the Distribution Impact Study fee imposed by distribution utilities on Net-Metering applicants.

HNEI is continuing its support of the Philippines’ power sector by delivering both collaborative (APRESA funded) and USAID Energy Secure Philippines (ESP) program funded technical support to the Philippines Energy Regulatory Commission (ERC), distribution utilities (DUs), and other relevant agencies. Specifically, HNEI has been asked to develop a set of rules for an “off-grid” net energy metering (NEM) program tailored to small, rural area grid systems in the Philippines, that allows customers to sell excess distributed generation to the DUs of these small island systems that are not connected to the country’s transmission network. HNEI is also collaborating with USAID ESP and the ERC to
establish a battery energy storage system (BESS) regulatory framework for the Philippines, including: 1) streamlined rules for BESS interconnection; 2) guidelines for BESS technical codes and standards; 3) cost recovery mechanisms for utility-owned BESS; and 4) third-party-owned BESS for ancillary services. With the loosening of travel restrictions, HNEI conducted in-person presentations and regulation drafting workshops to the ERC in Manila during the second half of 2022 on: 1) HNEI’s draft NEM report; 2) HNEI’s draft BESS report; and 3) the ERC’s draft BESS regulation for the Philippines. This work is assisting the ERC in fulfilling the mandate set by the PDOE. This work is described in more detail in the “Support to the USAID Energy Secure Philippines (ESP) Program” project summary.

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 – led by the Head of ASEAN Power Utilities/Authorities (HAPUA) – have conducted the ASEAN Interconnection Master Plan Study (AIMS). Building upon this foundational work, the latest AIMS III analysis has evaluated ASEAN power market integration through the grid connection of renewable energy and power trade. HNEI’s GridSTART served as a core member of the technical review group (TRG) comprised of international experts (including NREL and IEA), which reviews and provides guidance on the scope, data collection, assumptions, and execution of the AIMS III study. The AIMS III project concluded in September 2021 with the end of the USAID CPA program. HNEI may support follow-on work in ASEAN countries that builds upon the AIMS III results as part of its newly formed collaboration with USAID’s SPP described above.

ASEAN Centre for Energy (ACE) Capacity Building
HNEI’s GridSTART delivered 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 enhanced the knowledge base and capability of ACE planning/engineering staff in the advanced analytics needed for effective renewable energy integration analysis to support 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 to implement the ASEAN Plan of Action for Energy Cooperation, 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 Hawaiʻi.

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