FINAL TECHNICAL REPORT

Executive Summary

Asia Pacific Research Initiative for Sustainable Energy Systems

Office of Naval Research

Grant Award Number N00014-14-1-0054

November 1, 2013 to December 31, 2017

HNEI
Hawai'i Natural Energy Institute
University of Hawai'i at Mānoa

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EXECUTIVE SUMMARY

This report summarizes work conducted under Grant Award Number N00014-14-1-0054, the Asia Pacific Research Initiative for Sustainable Energy Systems 2013 (APRISES13), funded by the Office of Naval Research (ONR) to the Hawaii Natural Energy Institute (HNEI) of the University of Hawaii at Manoa (UH). The overall objective of APRISES13 was to develop, test, and evaluate distributed energy systems, emerging technologies and power grid integration using Hawaii as a model for applicability throughout the Pacific Region. APRISES13 encompassed fuel cell research, evaluation and contaminant mitigation; battery cell testing; seabed methane hydrates extraction and stability; synthetic fuels processing and production to accelerate the use of liquid biofuels for Navy needs; alternative energy systems for electric power generation, and integration into secure-smart microgrids, and; energy efficient building technologies and platforms. Testing and evaluation of alternative energy systems includes Ocean Thermal Energy Conversion (OTEC), grid-scale battery energy storage, and development of several microgrid test projects.

Under Task 1, Program Management, HNEI provided overall program management and coordination, developed and monitored partner and subcontract agreements, and developed outreach materials for both technical and non-technical audiences. Additionally, HNEI continued to collaborate closely with ONR and NRL to identify high-priority areas requiring further detailed evaluation and analysis.

Under Task 2, Fuel Cell Systems, HNEI conducted testing and evaluation of single cells and balance of plant components to: support NRL efforts to develop fuel cell powered unmanned aerial vehicles (UAVs); continue the development of advanced diagnostics suitable for the design of low cost and high power density fuel cells, and; develop contaminant mitigation techniques by testing and evaluating filtration materials. Support to NRL included design and validation of a hydrogen gas management system. As well, work was done to minimize the cost of vanadium flow batteries by selecting salts of lower purity. HNEI also built a battery-testing laboratory and investigated key performance limiting aspects of battery modules.

Efforts under Task 3, Alternative Fuels, focused on the development, testing and evaluation of alternative fuels and technologies, and included activities in the areas of Methane Hydrates, Technology for Synthetic Fuels Production, and Low-cost Material for Solar Fuels Production.

Methane hydrate destabilization was examined using non-toxic aqueous glycerol solutions, and the Raman calorimeter facility was modified to study hydrate self-preservation phenomena. Several advanced technologies for synthetic fuels production were investigated. Fundamental properties of synthetic waste stream components were characterized and analyzed to predict fuel characteristics and reactivity of the composite heterogeneous waste. The properties and oxidation stabilities of biodiesel derived from catfish oil generated by processing plants in Vietnam was investigated. Biomass activity in a high-rate anaerobic digestion process was advanced through development of hybrid supports by further improving the design to eliminate gas hold up. To produce liquid fuels from synthesis gas, a solid phosphoric acid catalyst was investigated to derive hydrocarbon oils. The metabolic pathways associated with the degradation of fuels were further characterized to expand the database of genetic information to serve as the basis for rapid-detection, fuel-test capabilities and design of inhibitors. Corrosion inhibitors were investigated to attenuate corrosion in HRD fuel/seawater mixtures. A reproducibility study was conducted on the novel carbonization process along with exploration of the effects of heat-treatment to produce near-theoretical fixed-carbon yields. For solar fuels production, low-cost and environmentally friendly materials were investigated.

Task 4, Ocean Energy work included development of Ocean Thermal Energy Conversion (OTEC), Wave Energy Testing and Seawater Air Conditioning. Continued development and testing of new OTEC fabrication methods and designs focused on laser welded heat exchanger development, along with corrosion testing under a subaward to Makai Ocean Engineering. Wave energy testing research objectives and plans were further developed in collaboration with NAVFAC at the Navy's Wave Energy Test Site (WETS) off Marine Corps Base Hawaii (MCBH). In addition, numerical hydrodynamic modeling was also conducted on wave energy conversion devices and their performance. Seawater Air Conditioning (SWAC) pre-impact conditions were characterized with further deployments of long-term oceanographic mooring, water column profiling and sampling.

Funding for the Geothermal Resource Assessment planned for task 5 was reallocated to other areas of the program as approved by ONR.

Task 6, Microgrids/Grid Integration included a range of projects to develop, test and integrate secure microgrid technology including distributed energy resources. An analysis tool was developed to analyze PV performance as a function of environmental conditions. A low-cost real-time power monitor was developed with wireless communications for distribution system operations, controls, and analysis. Methods were developed to synthesize realistic PV inverter and distribution service transformer data by extrapolating results in a simulation environment using data collected in the field. The Hawaii Virtual Power Plant Demonstration Project with combined PV and battery energy storage systems (BESS) was initiated, with development of the project scope, partner roles and responsibilities identified, and utility approval secured. A series of problems with the Oahu BESS were analyzed and addressed, and testing initiated. Algorithms

for the Molokai BESS were further modified to improve responses to grid conditions. For the Coconut Island DC microgrid, an electric boat and electric utility vehicle were procured, along with a swappable battery system. Additionally, a request for proposals was developed to procure the PV, stationary battery, and integrator for the whole Coconut Island DC microgrid. Two projects were conducted for the Molokai electric grid, to address the impact of PV generation on voltage at the circuit level, and to compare two tools for system-level analysis. Development was continued on solar forecasting methods and systems, including deployment in an operational framework.

Projects completed under Task 7, Energy Efficiency included installation of PV systems on two Project FROG net zero energy platforms, expansion of the classroom comfort and energy utilization studies, as well as design of a desiccant dehumidification pilot and assessment of the applicability of ceiling fans to low energy, thermal comfort.

This report describes the work that has been accomplished under each of these tasks, along with summaries of task efforts that are detailed in journal and other publications, including reports, conference proceedings and presentations. Publications produced through these efforts are listed and available, or linked, on HNEI's website at https://www.hnei.hawaii.edu/publications/project-reports#APRISES13.