Hawaiʻi Natural Energy Institute Research Highlights

Grid Integration

Coconut Island DC Microgrid

<u>OBJECTIVE AND SIGNIFICANCE</u>: HNEI's Grid System Technologies Advanced Research Team (Grid***START***) developed a DC-based microgrid test bed on Coconut Island. The project demonstrated the reliability, resilience, and efficiency of a DC microgrid serving two buildings by comparing lighting, cooling, and plug load performance with conventional AC operation. Results advanced understanding of DC system applications for remote and islanded environments.

<u>BACKGROUND</u>: Coconut Island is home to the University of Hawaiʻi's Hawaiʻi Institute of Marine Biology (HIMB). HIMB's remote location and commitment to sustainable infrastructure made it an ideal location for testing microgrid technologies and off-the-shelf energy system components.

Project goals included deploying innovative energy systems, establishing a research platform for resilient DC microgrid technologies in tropical marine conditions, and developing solar-powered transport solutions.

<u>PROJECT STATUS/RESULTS</u>: Grid***START*** collaborated with the University of Indonesia to design a DC-DC converter (DCON) converting 48 V from the photovoltaic (PV) and battery energy storage system (BESS) to 200-350 V for DC loads. The microgrid powered DC lighting, air conditioning, and refrigeration with minimal grid dependence.

All DC microgrid components were installed and commissioned in a dedicated electrical control room housing switches, breakers, controls, converters, wiring, and the BESS. The 6.2 kW rooftop PV array and 8 kWh BESS were fully integrated, enabling autonomous operation and islanded-mode testing of critical loads.

Figure 1. DC microgrid components in the electrical room (left) and system's controller box (right).

The microgrid's stand-alone capability for maintaining critical loads during grid outages was also developed with enhanced advanced control and safety upgrades. A new OPTO22 controller with Node-RED and Node JS programming enabled automated scheduling between AC, DC, and hybrid modes. A microgrid dashboard provided real-time monitoring, performance visualization, and system alerts. Efficiency testing indicated a 3.3% improvement in air conditioner performance and a 5% reduction in lighting power consumption under DC operation relative to AC mode.

Additionally, solar-powered maritime transportation was enabled through an electric boat (E-boat). The E-boat's energy system was upgraded with 18.2 kWh fixed batteries, consolidated PV arrays to one system, and a NEMA-enclosed charge controller with emergency disconnects for improved safety and heat management. The boat's propulsion system used four battery units with independent management, allowing partial functionality during faults and enabling bidirectional energy flow with the microgrid. Initial vehicle-to-grid trials confirmed two-way operation, supporting future integration via dedicated shore power controls. The 24-foot E-boat platform provides a unique opportunity for near-shore research, offering a quiet, liquid fuel free vessel for daily operations and a replicable model for sustainable marine logistics.

Future research could identify improvements in BESS control, load balancing, and marine PV designs that could raise solar output to 3 kW. The project was terminated following loss of APRISES funding halted these advancements but key design, control and operational benchmarks were validated for DC microgrids and electric maritime systems.

Figure 2. The E-boat's powertrain fixed battery system (left) and shade structure PV system (right).

Funding Source: Office of Naval Research

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Last Updated: November 2025

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