The Hawai‘i Natural Energy Institute (HNEI) is leading a team to deploy and assess the performance of grid-scale battery energy storage systems (BESS) for system control and power quality support at both the transmission and distribution levels. The objective of the program is to identify high-value grid-scale BESS applications, and to develop control algorithms that optimize the benefit to the grid/customer while also maximizing the lifetime of the BESS under real world operating conditions. A 1MW BESS used for frequency regulation has been operating on the Island of Hawai‘i since December 2012. A second system intended for voltage and power quality support is scheduled for an industrial substation on O‘ahu before the end of 2015 and a third 2MW system for spinning reserve and grid support on the island of Moloka‘i in the first quarter of 2016.

**Challenges & Significance**

Integrating renewable energy resources into the electricity grid poses a variety of challenges due to the intermittent nature of renewable energy and the reduction of system inertia via displacement of traditional generation. These effects can manifest in such ways as increased frequency variability, voltage transients, and power quality reduction. Fast-acting BESS units have the potential to mitigate these adverse effects, enabling mandated increases in energy generation from renewable sources. Hawai‘i is at the forefront of tackling the problem of renewable energy integration. The geographic isolation of the islands’ electricity grids and the exponential growth of renewable generation make Hawai‘i’s electricity grids particularly susceptible to the adverse effects of intermittent renewable energy sources, but also an ideal test bed for energy storage solutions. HNEI’s research into energy storage will have direct benefit to Hawai‘i’s electricity grid, allowing for increased integration of renewable energy sources, and will provide insight into the design of future storage systems worldwide, particularly for systems designed to operate on islanded microgrids.

**Status & Accomplishments**

- Grid integration studies for the systems of Hawai‘i Island, Maui, and O‘ahu have been completed.
- A grid tied 1 MW/250kWh BESS system has been operating on the Island of Hawai‘i since Dec 2012.
- Control algorithms for wind smoothing and primary frequency response have been validated.
- The Hawai‘i Island BESS reduces overall grid frequency variability and reduces the variability of wind farm power output.

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**Period of Performance:**  
2009-2015

**Partner(s):**

- Hawaiian Electric Co.
- Hawaiian Electric Light Co.
- Maui Electric Co.
- Altairnano
- Integrated Dynamics, Inc
- Hawi Renewable Development

**Funding:**

Office of Naval Research
Project Details

The Office of Naval Research (ONR) is funding HNEI to identify technologies that have the potential to mitigate the adverse impacts of integrating intermittent renewable energy resources onto the electricity grid. HNEI selected Altair Nanotechnologies Inc (Altairnano) to manufacture three BESS units and collaborated with Altairnano and Integrated Dynamics Inc. to develop control algorithms for wind smoothing, frequency response, voltage (VAR) support, power smoothing, and spinning reserve for the various deployment strategies of the three BESS units.

The first BESS system funded under this program, a 1 MW/250kWh system running wind smoothing and frequency response algorithms, is grid-tied to the Hawai‘i Electric Light Co. (HELCO) electricity grid at a Point of Common Coupling (PCC) to a 10.6 MW wind farm owned and operated by Hawi Renewable Development (HRD) LLC (Figure 2). Experiments are underway to assess the impact of BESS system size and the strength of BESS response to frequency deviations on its ability to reduce frequency variability. The Hawai‘i Island BESS reduces overall grid frequency variability by 30-50% (compared to operation without the BESS, Figure 3), and when operated in the wind smoothing mode, reduces the variability of wind farm power output over 1 min periods by 60%. The experiments will also provide data on the impact of these factors on BESS usage. Battery cell testing protocols are being developed to relate BESS usage to system health, performance, and lifetime.

A second 1MW/250kWh BESS running integrated power smoothing, frequency regulation, and voltage (VAR) support control algorithms is scheduled to be installed at an industrial substation on O‘ahu in fall 2015. A third 2MW/375kWh BESS designed to provide fault management, operating reserve, power smoothing, and peak shifting in support of the Moloka‘i Secure Renewable Microgrid will be deployed in spring of 2016.

Figure 2. Aerial view of the HRD Wind Farm

Figure 3. BESS power output (top) HELCO grid frequency (mid) and frequency variability (bottom) on 3/15/13. Black/red lines indicate BESS inactive/active periods.