The Hawai’i Natural Energy Institute (HNEI) is leading a team engaged in the research, development, deployment, and analysis of grid-scale battery energy storage systems (BESS) that are designed for system control and power quality support at the generation, transmission, and distribution levels. The program aims to identify high value BESS applications at various system levels, develop control algorithms that maximize the benefit to the grid/customer and the lifetime of the BESS, and evaluate and optimize those algorithms under real world operating conditions.

**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 because of the geographic isolation of the islands’ electricity grids and the exponential growth of renewable generation. These factors 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.
- Performance of control algorithms developed for wind smoothing and primary frequency response have been validated based on the BESS commanded versus actual power output in the field.
- Preliminary analysis indicates the frequency response algorithm reduces overall grid frequency variability over 20 minute periods by 30-50% (Figure 2), and the wind smoothing algorithm reduces the variability of wind farm power output over 1 min periods by 60%.

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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. ONR supports the premise that fast-response BESS solutions are an integral part of a comprehensive solution to support US Navy interests in the Asia-Pacific Area of Operations. 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, and power smoothing 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 Hawai'i Renewable Development (HRD) LLC (Figure 3). 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 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 spring 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 is currently being developed.