

# Use of a Fast Response Battery System for Frequency Regulation

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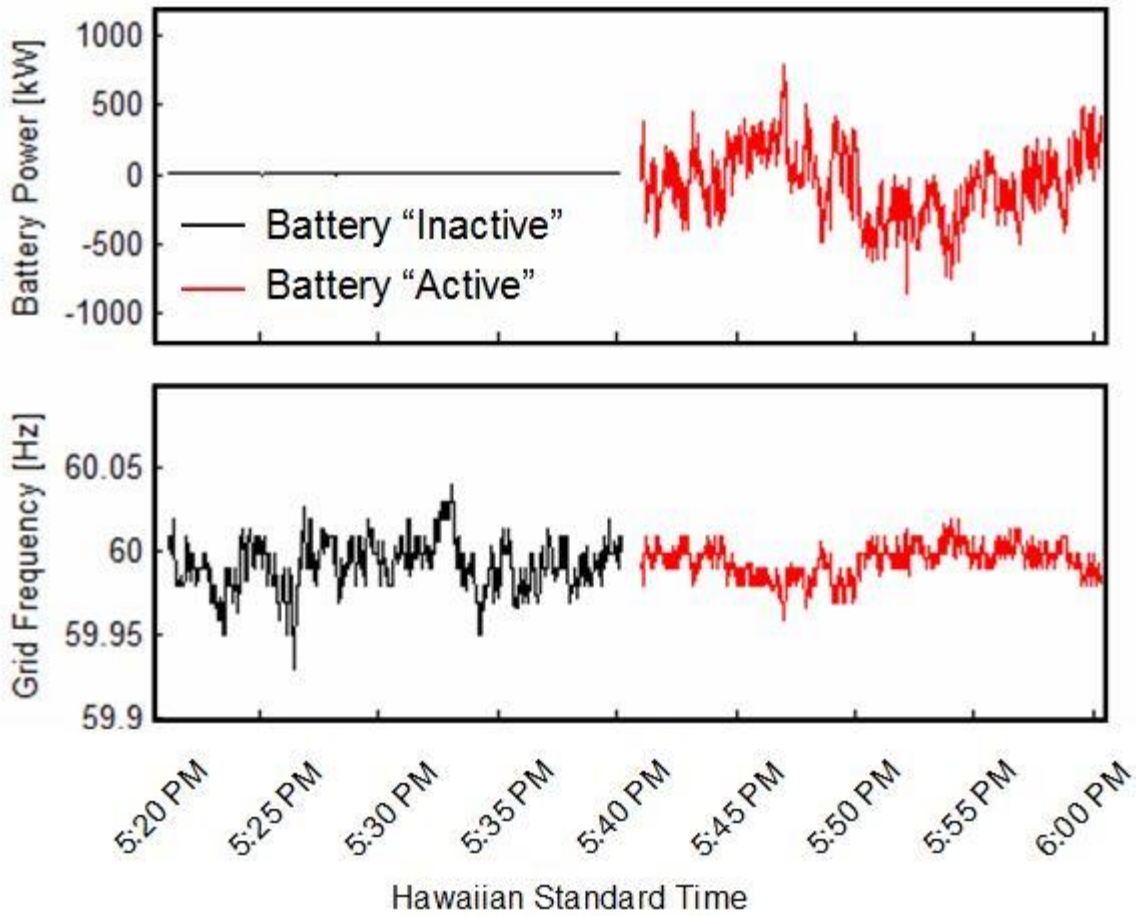


Electricity costs in Hawaii are some of the highest in the nation due to our small isolated grids, difficult transmission issues, and use of oil for over 70% of our generation. As a result, several islands are experiencing high penetrations of wind and photovoltaics (PV). On the Hawaii Electric Light Company (HELCO) grid on the Island of Hawaii, wind and distributed PV systems account for approximately 15% and 3% respectively of total electricity generation. It is well documented that the variability of this wind and PV power can cause imbalances between generation and load that are manifested as variability in grid frequency.

In 2007, models of the Island of Hawaii grid indicated that a relatively small (1 MW) fast acting Battery Energy Storage System (BESS) could significantly reduce grid frequency variability on the HELCO grid. In 2010, the Hawaii Natural Energy Institute at the University of Hawaii initiated a joint project with HELCO to experimentally validate the impact of a fast acting BESS on the HELCO grid.

In 2012, with funding from the Office of Naval Research and cost share from HELCO, a 1 MW BESS was installed at the point of common connection between the Hawi Renewable Development wind farm and the HELCO grid. This system includes a 1 MW, 250 kW-Hr battery power module from Altairnano Inc. comprised of 2,688 50A-Hr Lithium-ion Titanate cells and a 1.2 MVar inverter developed by Parker Hannifin Corporation. In partnership with HELCO and Altairnano, two real-time algorithms were developed allowing the BESS to respond to either system frequency (frequency regulation) or wind power (wind smoothing). The frequency regulation algorithm is capable of responding to changes in grid frequency within 200 ms while the wind smoothing algorithm is capable of responding to wind power within 300 ms.

Initial testing to assess the performance of the frequency regulation algorithm was conducted by comparing grid frequency over repetitive periods of time, with the BESS alternatively turned off (inactive), then turned on (active). Results from one such period with the battery inactive for 20 min, and then active for 20 min is shown in the attached figure. During this period of time, total demand on the HELCO system was approximately 150 MW; total power supplied by the two wind farms was approximately 23 MW; and there was little contribution from PV due to the time of day. The top section of the figure shows the battery power, off during the inactive period, then cycling in response to frequency changes reaching charge/discharge power of up to 750 kW. The lower section of the figure shows grid frequency. The reduction in frequency variability with the battery active is clearly observed. Analysis of data to date, over a range of grid operating conditions, shows a typical reduction in the standard deviation of the frequency variability of 30% to 50%. Preliminary data also shows a significant reduction in frequency drop during larger wind drop events, e.g. > 1 MW. This paper will describe the BESS system, the control system, results under a variety of grid operating conditions, and statistical significance of the results.



Impact of BESS on HELCO Grid Frequency. Top: Battery Power during an inactive and active period. Bottom: Frequency variability test results. Standard deviation for active state reduced 35% compared to inactive period. This data was taken during March, 2013.