Battery Energy Storage for Grid Support

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Introduction

The integration of 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, power quality reduction, and loss of reliability. Fast-acting Battery Energy Storage Systems (BESS) have the potential to mitigate these adverse effects enabling increased 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 rapid 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. The Hawaii Natural Energy Institute (HNEI) at the University of Hawaii has initiated an integrated research, testing and evaluation program to assess the benefits of grid-scale BESS for various ancillary service applications. Specifically, HNEI has procured and is installing three fast-response BESS on the Hawaiian Island grids. The program includes laboratory testing of cells for better understanding of degradation, assessment of battery performance on the grid, and optimization of the BESS closed-loop control algorithms to maximize grid support with minimal battery cycling.

Discussion

The first of these, a 1MW, 250kWhr Li-ion titinate BESS, commissioned in December 2012 on the Big Island grid, is located at the point of common connection with a 10MW wind farm and is being operated to provide, at various times, either wind smoothing or primary frequency response. The second, also a 1MW, 250kWhr BESS, scheduled to be commissioned in summer 2015, will be sited on the island of Oahu on a circuit characterized by a high penetraton of PV and large, variable industrial loads. The primary functions intended for this BESS are power smoothing and voltage/VAr support. Also schedule for commissioning in summer 2015 is a 2MW, 375kWhr BESS. This system will be deployed on a small (5MW peak) isolated grid on the island of Molokai.

The Big Island grid is characterized by a peak load of approximately 180MW, with significant amounts of wind (~32MW) and solar (~ 40MW). Experiments conducted under a wide of grid operations has consistently shown the ability to significantly mitigate frequency variability, even with a BESS of only 1MW. **Figure 1** shows results from one such experiment, in which the BESS was repeatedly cycled on/off to separate BESS impact from normal grid frequency variability. The top half of the figure shows the charge/discharge of the battery. The lower half shows the grid frequency with the BESS off (black) and on (red).

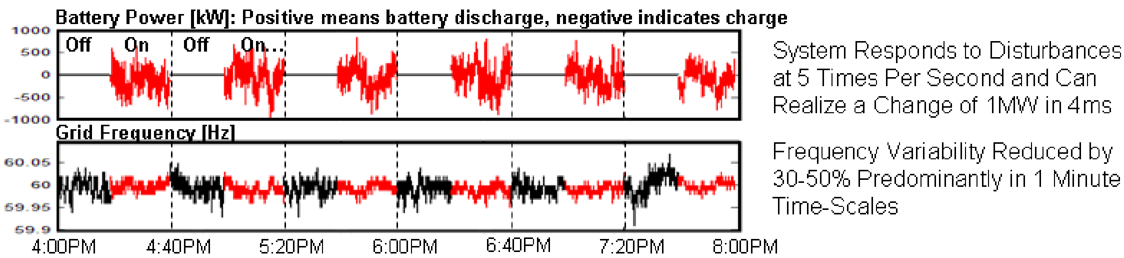

Figure 1: Experimental results when switching the BESS off (black lines) and on (red lines).

HNEI is currently also tuning the frequency response algorithm to provide the greatest grid benefit while maximizing the longevity of the system. Several lessons have already been learned in this process. For example, during initial testing, HNEI attempted to tune the BESS to run highly aggressively. This resulted in a rapid heating of the battery cells while providing no notable improvement to grid operations. The temperature of the cells increased by more than 15°C over a period of just 3 hours. Since temperature is a known contributor to cell degradation, operations were modified to minimize temperature excursions.

Conclusions

In this paper, we will provide an overview of HNEI's BESS program, present some of the results from the frequency response experiments from the Big Island, and discuss some of the lessons learned from this work.