



# Hawai'i Natural Energy Institute Research Highlights

## Electrochemical Power Systems

### Battery Energy Storage Systems Durability and Reliability

**OBJECTIVE AND SIGNIFICANCE:** The objective of this work is to better understand the degradation of batteries in grid deployed systems and how to monitor them better. The knowledge gained in this project will inform best practices to improve durability and safety of large batteries deployed on the electric grid.

**BACKGROUND:** Battery Energy Storage Systems (BESS) show promise in mitigating many of the effects of high penetration of variable renewable generation. HNEI has initiated an integrated research, testing, and evaluation program to assess the benefits and durability of grid-scale BESS for various ancillary service applications. Throughout the course of this project, three BESS serving different grid applications were deployed on different islands. The first one was deployed in December 2012 on the Big Island of Hawai'i. The other two were deployed on Moloka'i and O'ahu in 2016. Usage was closely monitored and maintenance cycles using protocols recommended by the manufacturer, as well as custom HNEI protocols, were applied.

**PROJECT STATUS/RESULTS:** Usage from the BESS was carefully analyzed to facilitate laboratory testing of individual cells representative of actual operating conditions. All cells used in the demonstrations and laboratory testing were Lithium titanate cells from Altairnano. Around 100 cells were tested in the lab to monitor aging patterns, reproduce the aging observed in real life, and accelerate the degradation.

This project showed that, because of their lower intrinsic voltages, these cells are far less sensitive to

degradation induced by calendar aging and high state of charges than traditional Li-ion batteries. Moreover, their capacity fading pace is also slower.

Based on our results, we are projecting that accelerated degradation, a typical occurrence in traditional lithium ion batteries, remains of concern under certain conditions, notably if the cells are kept consistently above 35° C, which does not appear to be the case on the deployed data. Therefore, a 20-year grid usage should be attainable for these Lithium Titanate cells with a total capacity loss around 20%. Results also showed that the capacity monitoring of deployed systems might not be accurate and that new tracking methods are necessary.

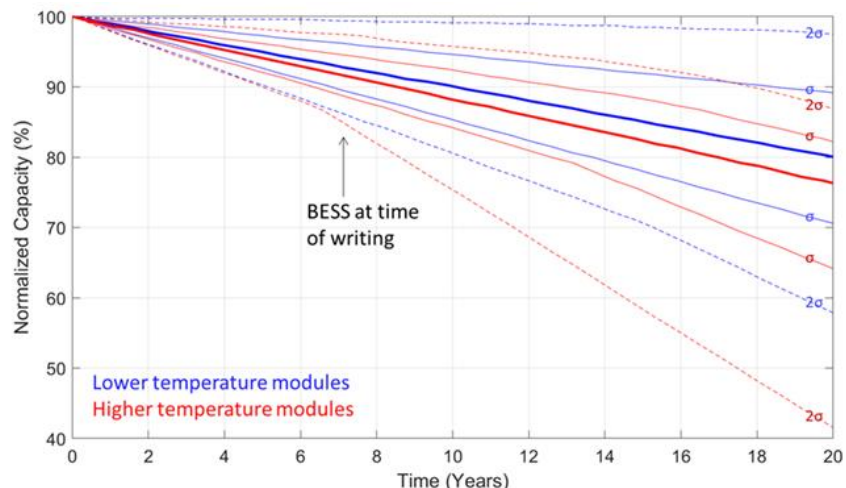
Research conducted for this project is completed in the [PakaLi Battery Laboratory](#).

This is an ongoing project, which has led to 11 publications, including the ones listed on the following page.

*Funding Source:* Office of Naval Research

Contact: Matthieu Dubarry, [matthieu@hawaii.edu](mailto:matthieu@hawaii.edu);  
Richard Rocheleau, [rochelea@hawaii.edu](mailto:rochelea@hawaii.edu)

*Last Updated:* November 2022



## ADDITIONAL PROJECT RELATED LINKS

### PAPERS AND PROCEEDINGS:

1. 2021, M. Dubarry, et al., [Battery Durability and Reliability under Electric Utility Grid Operations: Analysis of On-Site Reference Tests](#), Electronics, Vol. 10, Issue 13, Paper 1593. (Open Access: [PDF](#))
2. 2019, G. Baure, et al., [Battery Durability and Reliability under Electric Utility Grid Operations: Path Dependence of Battery Degradation](#), Journal of the Electrochemical Society, Vol. 166, Issue 10, pp. A1991-A2001. (Open Access: [PDF](#))
3. 2019, M. Dubarry, et al., [Battery energy storage system modeling: Investigation of intrinsic cell-to-cell variations](#), Journal of Energy Storage, Vol. 23, pp. 19-28. (Open Access: [PDF](#))
4. 2019, M. Dubarry, et al., [Battery energy storage system modeling: A combined comprehensive approach](#), Journal of Energy Storage, Vol. 21, pp. 172-185. (Open Access: [PDF](#))
5. 2018, K. Stein, et al., [Evaluation of a 1 MW, 250 kW-hr Battery Energy Storage System for Grid Services for the Island of Hawai'i](#), Energies, Vol. 11, Issue 12, Paper 3367. (Open Access: [PDF](#))
6. 2018, K. Stein, et al., [Characterization of a Fast Battery Energy Storage System for Primary Frequency Response](#), Energies, Vol. 11, Issue 12, Paper 3358. (Open Access: [PDF](#))
7. 2018, M. Dubarry, et al., [Battery durability and reliability under electric utility grid operations: Representative usage aging and calendar aging](#), Journal of Energy Storage, Vol. 18, pp. 185-195.
8. 2017, M. Dubarry, et al., [Battery Energy Storage System battery durability and reliability under electric utility grid operations: Analysis of 3 years of real usage](#), Journal of Power Sources, Vol. 338, pp. 65-73.
9. 2016, A. Devie, et al., [Overcharge Study in Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> Based Lithium-Ion Pouch Cell, II. Experimental Investigation of the Degradation Mechanism](#), Journal of Electrochemical Society, Vol. 163, Issue 13, pp. A2611-A2617. (Open Access: [PDF](#))
10. 2015, A. Devie, et al., [Overcharge study in Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub>-based Lithium-ion pouch cell. Part I: Quantitative diagnosis of degradation modes](#), Journal of The Electrochemical Society, Vol. 162, Issue 6, pp. A1033-A1040. (Open Access: [PDF](#))

### PRESENTATIONS:

1. 2022, M. Dubarry, et al., [Lithium Titanate Battery Durability and Reliability Under Electric Utility Grid Operations](#), Presented at the Material Research Society Spring Meeting, May 8-13.
2. 2021, M. Dubarry, et al., [Battery Durability and Reliability under Electric Utility Grid Operations](#), Presented at the International Battery Seminar & Exhibit, March 9-11.
3. 2021, M. Dubarry, [Battery Durability and Reliability Under Electric Utility Grid Operations](#), Presented at the Alaska Energy Storage Workshop, January 12-13.
4. 2020, G. Baure, et al., [Battery Durability and Reliability Under Electric Utility Grid Operations](#), Presented at the ECS PRiME Meeting, October 4-9.
5. 2020, M. Dubarry, et al., [Battery Durability and Reliability Under Electric Utility Grid Operations](#), Presented at the International Coalition for Energy Storage and Innovation Conference, Sydney, Australia, March 1-4.
6. 2019, M. Dubarry, et al., [Battery Durability and Reliability Under Electric Utility Grid Operations](#), Presented at the International Battery Association Meeting, March 3-8.
7. 2018, A. Devie, et al., [Battery Durability and Reliability Under Electric Utility Grid Operations](#), Presented at the ECS AiMES Meeting, Cancun, Mexico September 30 - October 4.
8. 2017, M. Dubarry, et al., [Asia Pacific Research Initiative for Sustainable Energy Systems: Batteries for Grid Management](#), Presented at ONR Program Review, Washington, DC, March 28-30.
9. 2016, M. Dubarry, [Overcharge Study in Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> Based Lithium-Ion Pouch Cell](#), Presented at the International Battery Association Meeting, Nantes, France, March 20-25.