Supplemental Project Notice

LFP BATTERY PERFORMANCE IN SUBSTATION APPLICATIONS

LiFePO4 Evaluation

This project seeks to explore the performance of LiFePO4 batteries in substation applications

PROJECT HIGHLIGHTS

- Understand capabilities and limitations of LiFePO4 battery and built-in battery monitoring for substation applications
- Gauge accuracy of battery monitor at reporting battery capacity, given substation usage profile
- Quanitfy charging rate of batteries subjected to high ambient temperatures found in outdoor enclosures
- Understand how well cell-to-cell mitigation technologies prevent propagation of thermal release
- Review design concepts that may mitigate thermal release

Background, Objectives, and New Learnings

Substation design typically includes the installation of battery banks to power protective relays, motorized switches, and high voltage circuit breakers when the low voltage AC supply of the station is otherwise in an outage. In this way, batteries serve an important purpose in ensuring customers remain in service during conditions that may otherwise force stations to drop their customer loads. Unfortunately, at times during these cases, substation batteries may be fully drained before field technicians are able to fully restore the AC supply. This is especially true in cases where natural phenomena hazards (i.e., flooding, hurricanes, extreme temperatures) may be affecting many substations and AC systems in a service territory simultaneously. Batteries may also fail—and at times in catastrophic manner, that results in combustion. In this latter case, both the batteries and nearby equipment may be ignited, resulting in loss of power to customers and a concern of fire spreading to nearby areas.

Lithium Iron Phosphate (LiFePO4 or LFP) is a battery chemistry widely used in electric vehicles, renewable energy storage, and as backup power for data center Uninterruptable Power Supplies (UPS). However, since the technology's creation in 1996, it has not been evaluated for use as a standard chemistry for substation applications. Data from other use cases indicate the batteries may less be costly, represent reduced hazards, and perform better electrically over time than the present-day standard substation battery chemistries of flooded lead-acid and valve-regulated lead acid batteries.

The overall goal of this project is to evaluate the performance of LiFePO4 batteries at typical substation DC backup system voltage and amp-hour sizing, subjected to conditions typically seen in substation battery enclosures during extreme summer or winter months across the United States. One major objective is to consider what conditions initiate thermal runaway—which may lead to combustion-- of the battery bank. A related objective is to estimate the level of thermal energy released if such an event occurs. Another objective is to assess how well the batteries and LiFePO4-compatible Battery Monitoring Systems (BMS) perform across a range ambient temperature swings.

Benefits

De-risking LiFePO4 battery technology by gathering empirical data enables EPRI, utilities, and the general public to be informed on its benefits and hazards. Results from this testing may validate a technology that improves the performance of standard substation battery designs.

This may improve the resiliency of the grid by extending the overall amount of time batteries can keep a station in-service during times of an outage. This, in turn, would benefit the general public by enabling more homes to remain electrified during these outages.

This project may also identify whether or not a range of substation operating conditions cause a release of thermal energy in this battery chemistry, and what could be done to mitigate this release. Documenting this could enable utilities to implement better designs, reducing the impact of combustion on the public areas near stations.

Project Approach and Summary

EPRI intends to size LiFePO4 batteries for substation applications and observe the battery and BMS behavior across a range of conditions. Then, EPRI intends to subject the batteries to a range of conditions such as high temperatures, punctures, or overcharging to evaluate which factors may influence thermal runaway in the batteries. Specifically, EPRI intends to perform the following:

- Assess the charging rate of the LiFePO4 batteries across a range of temperatures
- Observe the behavior of the BMS at externally imposed, high ambient temperatures
- Observe the BMS accuracy at reporting various battery capacities
- Gauge how well cell-to-cell mitigation technologies—such as air gaps, separators, or battery casing materials—prevent propagation of thermal events to neighboring battery cells
- Recommend design concepts that may mitigate thermal release

Deliverables

The anticipated deliverable is a technical report documenting the results of tasks associated with the project.

Price of Project

The price per participant is $40k. This project requires at least three utilities to conduct the full scope. This project qualifies for self-directed funding or co-funding.

Project Status and Schedule

A minimum of $120k total is required for full scope of the project. The project will begin when sufficient funding is achieved. The duration is anticipated to be 12 months.

Who Should Join

Utilities considering the use of alternative battery chemistries beyond traditional valve regulated lead acid or flooded lead acid in their future substations. This research is particularly applicable to those who want empirical data on the performance and safety of LiFePO4 batteries in substation-specific environments.

Contact Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

Technical Contact

Colleen Konsavage at 972.556.6575 (ckonsavage@epri.com)

Member and Technical Services Contacts

Northeast: Dan Tavani at 704.595.2714 (dtavani@epri.com)

Central: Jeff Hlavac at 972.556.6553 (jhlavac@epri.com)

Western: David Welch at 702.203.4210 (dwelch@epri.com)

Southeast: Brian Long at 704.408.8139 (blong@epri.com)

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EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA • 800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com