RESEARCH FOUNDATION
RESEARCH FOR THE NFPA MISSION

PROJECT SUMMARY

Landscape of Battery Energy Storage System Hazards & Mitigation Strategies

Background

Battery Energy Storage Systems (ESS) are a critical part of today's dramatic push for sustainable & renewable electrical energy. As a result, these systems are proliferating at an exponential pace. While the fire protection and emergency response communities are working with ESS providers and others to ensure acceptably safe installations, there are still gaps in the fundamental understanding of the hazard of li-ion ESS and serious safety questions remain unanswered.

It is imperative for the full landscape of battery ESS hazards and mitigation strategies to be thoroughly defined, reviewed, and communicated to the energy storage and fire safety communities to support safe proliferation of these units. This comprehensive review aims to support the development of best practices and inform updates to relevant safety standards, such as NFPA 855, Standard for Stationary Energy Storage Systems, FM Global Datasheet DS-5-33, Electrical Energy Storage Systems, and other relevant codes and standards.

Research Goal

The overall goal of this project is to establish an understanding of the landscape of lithium-ion battery-based energy storage system deployments, their hazards and consequences, and the factors that should be considered for a comprehensive protection and hazard mitigation strategy. This project will also aim to identify and prioritize the existing knowledge gaps to develop a future research plan.

Project Sponsors

This research project is sponsored by the members of the FPRF Energy Storage Research Consortium (ESRC):

- Electric Power Research Institute (EPRI)
- Energy Safety Response Group (ESRG)
- FM Global
- Southern Company

And a participating Sponsor:

- Honeywell

Project Tasks

This research project will involve the following tasks:

Task 1: Landscape of Li-ion ESS Deployments.
Establish a comprehensive understanding of the full landscape of lithium-ion battery-based energy storage system installations/deployments. Conduct an international questionnaire of li-ion battery ESS to identify and categorize the types and characteristics of commercially available li-ion battery ESS installations (generically, without identifying manufacturers) and the environment in which they are deployed (indoors or outdoors, type of construction, distance to combustibles, etc.). This review should also consider various applications and use cases.

Task 2: Post incident analysis of li-ion BESS incidents.
Conduct a post-incident analysis li-ion BESS failure incidents. This analysis should include, but not be limited to, a review of the li-ion BESS incidents identified in the EPRI ESS Failure Event Database. Where information is available, summarize the high-impact loss events over the event timeline, in the context of a bow-tie hazard mitigation analysis. For your reference, a sample HMA

Last Updated: November 2021

Landscape of Battery Energy Storage System Hazards & Mitigation Strategies

for a li-ion BESS installation is available from the EPRI "ESIC Energy Storage Reference Fire Hazard Mitigation Analysis" report. It is expected that this analysis will summarize, for each incident:

a) The characteristics of the installation, including construction characteristics, location, siting, and the type and presence of active or passive protection systems
b) Identify the hazard/threats present in the reference installation
c) Summarize the parameters of the incident, including the initiating event, thermal runaway, spread characteristics, gas release, temperature, etc.
d) Clarify the extent of incident thermal runaway propagation
e) Identify the impact of implemented mitigation strategies/barriers for hazard mitigation during the incident. Where applicable, analyze the effectiveness of the implemented tactics and identify successes, failures, and/or challenges from each incident.
f) Conduct an incident consequence analysis for each of these incidents. This should consider the extent of damage, personnel casualties/injures and other life safety impacts, post-incident environmental impact, and any other consequences resulting from the incident.

To conduct this analysis, the contractor is expected to review the available literature, including post-incident investigation reports, incident case study reports published through peer reviewed articles and conference proceedings, news articles, etc. It is also recommended that the contractor collects additional relevant information related to the incident through interviews with affiliated parties, such as facility owners, fire department representatives, and others.

Task 3: Identify, Review and Analyze Established Mitigation Strategies. Identify and summarize mitigation strategies (e.g., automatic fire protection systems and manual response actions) deployed and implemented by professional design and engineering communities, emergency responders, and others for Li-ion BESS.

a) Identify the various types of fire protection measures (fixed systems and manual interventions) that are required, permitted or have been implemented in ESS deployments.
b) Where information is available through literature or interviews with subject matter experts, clarify the impact and effectiveness of automatic fire/explosion protection system activations and manual firefighting response actions on hazard mitigation.
c) Where strategies are being deployed but technical substantiation is lacking, develop theories and hypotheses for conceptual protection strategies through a theoretical analysis that need to be validated through future testing efforts. This should also consider needs of regulatory bodies.

Task 4: Gap Analysis and Future Research Plan. Based on the findings of the previous tasks and expanding on the gaps identified in the EPRI Battery Storage Fire Safety Roadmap, identify the existing knowledge gaps and develop research plans to fill the identified knowledge gaps.

a) Review and summarize the gaps identified in the EPRI Battery Storage Fire Safety Roadmap and identify any additional gaps, based on the findings of the above tasks.

Landscape of Battery Energy Storage System Hazards & Mitigation Strategies

b) Present the identified gaps at a FPRF ESS Workshop (to be planned and hosted by FPRF) and participate in a prioritization exercise.
c) Based on the workshop outcomes, develop a detailed research plan for the prioritized research needs.

Schedule and Implementation

This 7-month research project will be conducted under the auspices of the Fire Protection Research Foundation and will be conducted in accordance with the "Research Foundation Policies for the Conduct of Research Projects".

The project will be guided by a Project Technical Panel who will provide input to the project, recommend contractor selection, review periodic reports of progress and research results, and review the final project report.

About the Fire Protection Research Foundation

The Fire Protection Research Foundation plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association

Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy; and by partnering with others who share an interest in furthering the NFPA mission. All NFPA codes and standards can be viewed online for free. NFPA's membership totals more than 65,000 individuals around the world.

LEARN MORE

FPRF has many resources available on a diverse range of topics. Reach out to us to learn more.

Contact FPRF'S Office: 1-617-984-7281

Email us at: foundation@nfpa.org

Visit us: 1 Batterymarch Park, Quincy, MA 02169

Access additional information: nfpa.org/foundation