



# RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

## REQUEST FOR PROPOSALS FOR PROJECT CONTRACTOR

### Landscape of Battery Energy Storage System Hazards and Mitigations Strategies

10 September 2021

**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 hazards and the factors that should be considered for a comprehensive protection strategy through a thorough literature review, hazard analysis, and gap analysis.

#### **Project Tasks:**

**Task 1: Literature and Case Study Review.** Establish a comprehensive understanding of the full landscape of lithium-ion battery-based energy storage system hazards through a thorough literature review. Assess all factors that need to be considered when evaluating a comprehensive protection strategy.

- a) **Li-ion ESS Installation Survey.** 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). This review should also consider various applications and use cases.
- b) **Incident Case Study Review.** Conduct case study review of any historical and/or recent incidents that report specific issues of failure in lithium-ion battery ESS units. Summarize the parameters, such as the initiating event, thermal runaway, spread characteristics, gas release, temperature, the type, presence, and activation (if applicable) of active or passive protection systems, and any other applicable details from the incidents identified. Where applicable, analyze the effectiveness of the implemented tactics and identify successes, failures, and/or challenges from each incident.
- c) **Literature Review.** Conduct a review of any prior studies including, but not limited to, peer reviewed articles, conference proceedings and research reports on lithium-ion battery energy storage system hazards and protection strategies to establish the current state of knowledge.

**Task 2: Li-ion ESS Hazard Analysis.** For the scenarios and applications identified in Task 1, conduct a comprehensive hazard analysis. Provide a detailed hazard analysis for the scenarios identified.

- a) **Identify potential failure modes.** Identify the various potential failure modes of a li-ion ESS and explain the factors that could influence the failure modes or their corresponding hazard.
- b) **Identify the hazards of Li-ion BESS.** Referencing available literature, identify and categorize the hazards that can result from a li-ion BESS undergoing the failure modes identified in Task 2(a).
- c) **Hazard Consequence Analysis.** Using supporting data, test results and video footage from available literature and other sources, identify and analyze the range of potential consequences for the hazard scenarios identified in Task 2a. Analyze the potential of hazardous incidents that could cause injuries, fatalities, and damage to property, assets, or the environment. Assess the consequences of each of the identified hazards, including both fire and explosions. Note, a consequence can be the result of a sequence of failures or a combination of hazards.
- d) **Hazard Mitigation Strategies.** Given the hazards and potential consequences identified in the previous tasks:
  - i. Assess all factors that need to be considered when developing or evaluating a comprehensive protection strategy for a li-ion battery ESS, such as a hazard mitigation assessment (HMA). This should include, but not be limited to, fire suppression, smoke or fire detection, gas detection, thermal management, ventilation, exhaust, and deflagration venting systems.
  - ii. Review the current regulatory protection requirements for battery energy storage systems and the technical substantiation in the applicable standards. Compare the findings of Task 2c(i) against the requirements in the applicable standards and identify any gaps.
  - iii. Identify the currently available mitigation solutions for li-ion battery energy storage systems and review available literature, test results and other sources to evaluate the effectiveness of existing mitigation strategies.

**Task 3: Gap Analysis.** Based on the findings of the literature review and hazard analysis, identify the existing knowledge gaps on:

- Understanding the hazard of lithium-ion battery energy storage systems
- Effectiveness of existing mitigation strategies
- Data needed to substantiate implementation of hazard mitigation strategies.

**Task 4: Research Plan.** Develop a research plan to fill the identified knowledge gaps.

**Implementation:** This research project is led by 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. At a minimum, three Panel meetings will be held: project kick-off, review of interim report, and review of draft final report. The Foundation will provide documentation of all Panel meetings.

**Deliverables:**

- **Interim Draft Report:** Prepare an interim draft report including the findings from Tasks 1 and 2 and review it with the panel.
- **Final Report:** Prepare a final report documenting the findings from all project tasks, including recommendations and the incorporation of panel feedback.
- **Presentation:** Prepare a presentation on the report findings and present the results at a minimum of one relevant venue (e.g., NFPA 855 Technical Committee meeting, relevant conference, etc.)

- **Written content for outreach:** The Foundation will pursue written publication opportunities through various industry magazines, journals, etc. The Contractor shall contribute written content for at least one article, if applicable, to assist in the dissemination of this work.

**Intellectual Property:** The Research Foundation will retain rights to all project deliverables including, the project report, which will be published on the Foundation website. The project deliverables may also include data collected over the course of the project.

**Schedule and Costs:**

This is a fixed price project in the amount of \$45,000. All indirect and travel costs incurred are intended to be included within this fixed price. The Foundation does not have a limit on indirect costs, but the total proposal cannot exceed this fixed price. Proposals for this project shall include a breakdown of costs by task.

The proposed schedule is provided in the table below. Suggested modifications to the proposed schedule can be provided with substantiation.

Tasks	Deliverable Timeline	Estimated Dates
Proposals due		8 October 2021
Selection of Contractor	2 weeks from proposal deadline	22 October 2021
Task 1: Literature and Case Study Review	6 weeks from project initiation	3 December 2021
Task 2: Hazard Analysis	16 weeks from project initiation	11 February 2022
Task 3 & 4: Gap Analysis & Research Plan	20 weeks from project initiation	11 March 2022
Draft Final Report	24 weeks from project initiation	8 April 2022
Final Report	28 weeks from project initiation	6 May 2022

**How to Respond:** Letter proposals shall be submitted electronically to Victoria Hutchison, Research Project Manager, of the Foundation, at [vhutchison@nfpa.org](mailto:vhutchison@nfpa.org) no later than **5:00 pm Eastern time October 8<sup>th</sup>, 2021**. For additional details see the “[Research Foundation Policies for the Conduct of Research Projects](#)”, the [Foundation Operating Principles](#), and “[Research Project Guidelines for Contractors](#)” on the Foundation website at: <https://www.nfpa.org/foundation>.

Each proposal shall include a description of the following weighted evaluation criteria: problem understanding (25 %), technical merit (include scope and approach) (25 %), prior relevant experience and personnel expertise (25%), and dissemination and distribution strategy (15%). An additional criterion, current level of active foundation engagement, will be considered as the remaining 10 % weighted evaluation criteria.

Please note, the body of the research proposal submittals shall not exceed six pages in length, including a short bio of the proposed personnel and not including the cover page. Any additional relevant information (e.g., Project participants’ CVs or resumes, letters of support, detailed description of past relevant experience, detailed description of RFP-Respondent’s organizational facilities, competencies, other capabilities, and references) not covered in the body of the proposal should be appended to the proposal, with a maximum combined page limit of 12 pages, including the body of the proposal and appendices.

Additionally, all bidders must submit a completed [disclosure statement](#) with the proposal (this does not count towards the page limit). This form can be downloaded [here](#).

**Note:** This project will proceed only on the basis of receipt of a proposal deemed acceptable to the Foundation and the project sponsor(s). Information on the Foundation's policies for the conduct of research can be found on our [website](#). Services received are subject to our [standard contractual terms](#).