Proactive First Responder Engagement for Battery Energy Storage System Owners and Operators

Technical Brief — *Environmental Aspects of Fueled Distributed Generation and Energy Storage*

Battery Energy Storage Systems (BESS) have an important role to play in the future of the electric grid, but only if they can be designed, operated and decommissioned in an environmentally responsible, safe, reliable and affordable manner. The evolution of BESS and associated technologies is occurring faster than the development of safety codes and standards can be created. Many options for safety design actions and emergency planning processes are available, despite ongoing updates and flux in the code development process. Consideration of these options during BESS development is increasingly important, as more than 30 large-scale BESS sited across the world, of varied designs and applications, have experienced catastrophic failures in the past four years (EPRI 2021a). Issues such as the subjective nature of safety evaluations, and the observation that ownership models can determine safety management and responsibilities, also play a role in robust safety management (EPRI 2021c; EPRI 2021d). As a result, there is a great need for insight, guidelines and best practices for creating safe and effective BESS design and use. There is as great a need for clear and effective communication of that information to a range of necessary stakeholders, including first responder organizations who must be prepared to safely mitigate emergency events, such as destructive fires, if a failure occurs.

This technical brief serves as a starting point for discussion on how BESS owners and operators can proactively interact with first responder organizations, such as fire fighters, paramedics or police, on environmental health and safety management aspects of BESS facilities. The focus is on *Pre-Incident Planning*, and covers practices that could be undertaken before a BESS has been installed or up to the point of operation. These pre-incident items have been found to provide critical value to owners, operators, responders and system integrators through clarification of responsibilities and detailed discussion of protocols and technologies. Possible preparatory or preventative activities in anticipation of the unlikely event of an emergency or abnormal operations will be included, but this document should not be used as a playbook in the event an emergency occurs. Such procedures should be contained in an *Emergency Response Plan* (ERP), which each facility should have on site to guide utility and first responder personnel to appropriate action.

In support of the development of this brief, EPRI hosted a workshop discussion with a range of electric utility representatives from several research programs,[1] as well as first responder and fire safety consultancy personnel. This allowed for the crowdsourcing of insights based on the real-world experiences of the participants in developing and evaluating BESS facilities, and allowed compilation of lessons learned from prior experiences of owner/operator engagement with first responders. Finally, specific practices from several electric utility companies were reviewed and highlights provided of their first responder engagement practices.

[1] Program 94 - Energy Storage and Distributed Generation; Program 197 - Environmental Aspects of Fueled Distributed Generation and Energy Storage; and the Fire Prevention and Mitigation project (EPRI 2021b).

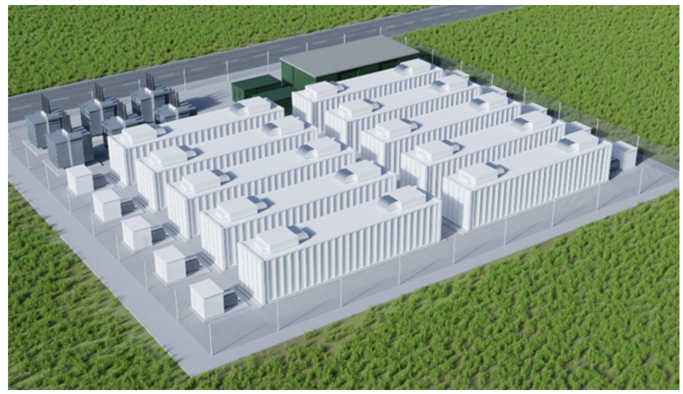

Figure 1. Common site elements and layout for a stationary storage facility. Image not to scale (e.g., larger spacings between containers, and between containers and fenceline, are now recommended).

In summary, this brief provides a range of practical actions, discussion topics and resources that could be undertaken or used to improve safety conditions for workers or first responders, reduce information barriers, streamline permitting, reduce project delays and costs, inform corporate risk discussions, and build confidence and trust with stakeholders.

Recommendations on the Overall Approach

It has been stressed by multiple fire services (EPRI 2018) and utilities that open communication between first responders and BESS representatives early in the design phase of the BESS is critical. Pre-incident planning provides the opportunity to guide system design to improve worker, first responder and public safety. According to active first responders, there are many cases in which discussions with the service do not begin until the end of the building permitting process. At this point building designs and construction plans have already been finalized. Retrofitting facilities with suppression or containment systems, or increasing separation and barriers after the fact, can be technically difficult and expensive, interfere with planned schedules, and provide suboptimal protections.

NFPA Recommendations for BESS Safety

The NFPA has specifically recommended the following steps in their Energy Storage Systems Safety Fact Sheet (NFPA 2020), which are reprinted here. These are directed to fire service personnel, but should also be understood by facility personnel.

1. *Understand the procedures included in the facility operation and emergency response plan described*
2. *Identify the types of ESS technologies present, the potential hazards associated with the systems, and methods for responding to fires and incidents associated with the particular ESS*
3. *Identify the location of all electrical disconnects in the building and understand that electrical energy stored in ESS equipment cannot always be removed or isolated*
4. *Understand the procedures for shutting down and de-energizing or isolating equipment to reduce the risk of fire, electric shock, and personal injury hazards*
5. *Understand the procedures for dealing with damaged ESS equipment in a post-fire incident, including the following:*
   a. *Recognize that stranded electrical energy in fire damaged storage batteries and other ESS has the potential for reignition long after initial extinguishment*
   b. *Contact personnel qualified to safely remove damaged ESS equipment from the facility (This contact information is included in the facility operation and emergency response plan.)*

Another primary need is to build a diverse utility subject matter expert (SME) team on battery safety, regardless of utility ownership or power purchase agreement (PPA) type arrangements. This team should create a mentality and methods for continuous evaluation of procedures and requirements, and ensure they are technology or risk-based. For example, lithium ion and flow batteries should not have the same requirements.

A comprehensive safety evaluation should be performed for each facility. One starting point is to review the details of the lessons learned from the EPRI Fire Prevention and Mitigation project (EPRI 2021d), which has conducted a series of BESS site visits and safety audits at 10 planned installations. Themes in the likely root causes of recent fire incident investigations are also reported. These include internal cell defects, faulty battery management systems, insufficient electrical isolation and environmental contamination. This information can be used to evaluate the sufficiency of the BESS and safety system designs.

Valuable information results from undertaking hazard or failure modes and effects analysis (FMEA) assessments for clarity on the range of potential threats and consequences. EPRI has created an example framework for such an analysis for BESS facilities (EPRI 2020a) that can be used as a reference, or site-specific analysis can be conducted

Protection plans should be developed to address the resulting hazards, and these should address the system as a whole, not individual components. Fire protection engineer(s) should be consulted on the adequacy of the protection plan and understanding of UL 9540A results. This will subsequently facilitate effective performance of the authority having jurisdiction (AHJ) on permit evaluation. Keep in mind that UL 9540A is a system test, and a very helpful start on one potential hazard pathway – thermal runaway – but it doesn't cover all potential risks. There is also a large degree of variability in 9540A reports, and results can depend upon the revision (e.g., prior 3rd revision vs current 4th revision) that was used. The resulting hazard reports and protection plans should be discussed directly with first responders.

Best Practices During Procurement, Design and Installation

The procurement, design and installation phase of a project entails review of many technology, site layout, protocols and settings options. Selecting options that provide early insight to unexpected operational changes allow for rapid evaluation and response. The following list provides examples for consideration.

Figure 2. Bi-directional training between BESS owners/operators and first responders is a important step in safety management.

Documentation

- Extensive documentation should be requested from the vendor and integrator that describes how the system design incorporates features to meet all necessary codes and standards for all relevant AHJs. Many owners and operators are now using this level of detail as a starting point for safety management, rather than an end point, as the rapid rate of technology evolution and safety research is surpassing that of the current nature of codes and standards. Examples of documentation could include results of UL 9540A testing (which provides insight on ventilation requirements and effectiveness of fire protection); analyses of explosion impacts; and details of fire suppression systems and impacts. Where relevant, consider requiring the vendor or analysis provider be licensed in the area of expertise, such as National Fire Protection Association (NFPA) 68 *Standard on Explosion Protection by Deflagration Venting* and NFPA 69 *Standard on Explosion Prevention Systems.*

- Appropriate staff at the utilities or companies that own and operate BESS facilities must be well-informed as to system design, potential safety risks, the mitigation systems in place and how they operate. This may involve communication or training across multiple departments within the utility, as well as to first responders and other external stakeholders.

Utility Case Study: Consolidated Edison

Consolidated Edison Emergency Management works closely with members of the first response community to develop site-specific Emergency Response Plans (ERP). ERP's are exercised annually, which allows the plans to be validated, and any deficiencies and opportunities for improvement to be identified and resolved. In addition, familiarization tours for fire companies remain paramount in keeping members current on site hazards and basic response tactics.

The ERP template is malleable to each individual BESS site. Key information incorporated into a plan serves as the platform for that site's BESS Hazard and Response Tactics Training Course. An extensive video slide deck was developed to educate members of the first response community on the conditions that may be found during their response to these low frequency high hazard events. Both the ERP and slide deck content focus on an overview of the site equipment, methods of detection, points of isolation, BMS data, chemical, electrical and explosive hazards, size-up and suppression operations.

Figure 3. Familiarization tour for fire company personnel.

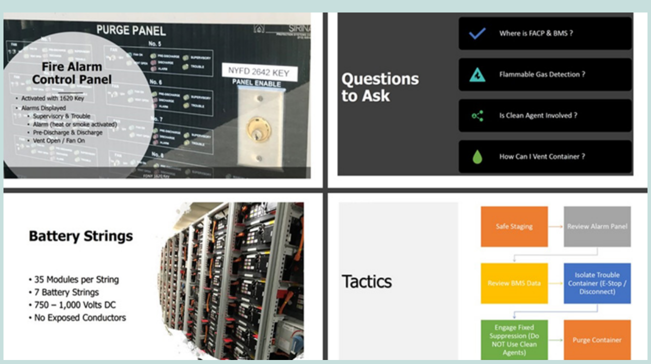

Figure 4. Selected descriptive photographs of battery and safety system components in Consolidated Edison's BESS training slide deck.

- Develop standard operating procedures (SOP) for operation, maintenance, emergency response, and pre-incident plan upkeep. Distribute these to the SME team and make available to first responders.
- An updated and maintained system of safety data sheets (SDSs) specific to the battery chemistry, chemicals used by fire suppression system, and foreseeable chemicals produced during battery failure; SDSs should include chemistry, health hazard, and firefighting measures.

Design Features

- Consider the use of a relatively narrow allowed temperature or voltage range for the batteries, so any deviations can be monitored, the performance tracked, cooling systems can be modified, or service discontinued.
- Avoid conditions that allow for overcharging or overdischarging.
- Evaluate the benefits and risks of full building exhaust fan and/or deflagration venting based on air volumes and other facility characteristics. Include assessment of the timing of ventilation triggers to avoid potential accumulation of flammable or explosive gases or dust/humidity intrusion during normal operations. Consider installing systems that can be operated from the outside, and on auxiliary power supplies.
- Provide multiple layers of alarming capability to provide backups in the event of failures.
- Design for auxiliary power backup to preserve sensed information and control in the event of a safety-related outage.
- Install clear and concise signage near equipment, at building entrances (e.g. night-visible numbered doors readable from 100' distances), and at fencelines. Denote locations of batteries, battery chemistries and hazards, locations of SDSs, and emergency disconnect switches. At least one utility has created an Incident Command Center or an interface point for first responders at the site entrance.
- Consider installing exterior indicators of human occupancy to determine if/how many people are in a building during an event. This could involve badging in/out or installing infrared sensors not powered to the battery system in the event of shutdown. This could assist first responders avoid entering a hazard area unnecessarily, although it is inherent to responder training to assume occupancy, especially if doors or vehicles are present.
- Consider maintaining stored water (e.g., tanks) on site, which could be use in the event of a fire or explosion if water supply is not otherwise guaranteed. Constraints, costs and benefits for stored water can be very site-dependent, and should be considered carefully. The need for secondary containment and retention basins for fire suppressants is an active area of research.

Emergency Planning

- Create an *Emergency Response Plan (ERP)*. This plan should include details and procedures for safely shutting down the system, periodic staff training and engagement with first responders. This plan should address both chemical and thermal hazards.
- Develop a responsibility matrix, also called a Responsibility, Accountablity, Consulted, and Informed (RACI) matrix, for activities and decision-making involved in incident response. Ensure this is shared broadly within the utility.

Figure 5: Site walkthroughs with first responders and BESS personnel facilitate emergency response planning.

- Review the emergency management system (EMS), battery management system (BMS), and fire alarm and control panel (FACP) functions and capabilities to provide guidance and clarity on the roles and capabilities of each control system, and their potential interactions or conflicts.
- Determine what real-time data will be available from the facility to support incident response, if it occurs. Understand how it can be accessed, by whom, and if this is still accessible if site power is shut down. For example, temperature tracking is a key metric for responders. One utility is installing weather stations, allowing for up to the minute information to first responders on potential wind speeds and expected direction of plumes that may develop from a battery incident.
- Develop clear procedures for shutting down, de-energizing and/or isolating equipment to reduce the risk of fire, electric shock, and personal injury hazards. Procedures for handling damaged equipment post-incident should also be specified, including recognizing the potential for re-ignition of fire-damaged modules after initial extinguishment.
- Identify personnel that will be the responsible party or parties to take over the site from the first responders post incident and watch the site for potentially 24-48 hours after an incident until the decommissioning team arrives.
- Identify personnel qualified to safely remove damaged BESS. This may involve contributions from the manufacturer; integrator; engineering, procurement and construction company, BESS owner/operator, and/or fire safety consultants.
- Consider provision of mass notifications of safety procedures to SMEs and first responders in the event of an emergency incident. Example metrics to transmit could include:
  – Digital emergency response plans
  – Remote emergency shutoff procedures
  – SDS / Hazardous material documentation
  – Maps or design drawings
  – Gas detection capabilities [e.g., Carbon Dioxide (CO_2), Carbon Monoxide (CO), Hydrogen (H_2), and battery off gas]
  – Fire control system data [e.g., temperature, alarming, suppression status, etc.]
  – Other documentation as required by local codes and standards [e.g., contact information for qualified personnel]

Learning from First Responder Incident Management Practices

Fire marshals, captains, battalion chiefs, and fire chiefs from several departments have repeatedly emphasized that emergency response strategies are highly dependent on the information immediately available to the incident commander in charge of the scene and to the crew members carrying out the fireattack strategies (EPRI 2018, EPRI 2021a). Each emergency situation is approached methodically because the details of the situation can change the order of emergency operations. Emergency response practices from first responders to BESS or other battery-related fires typically track the following approach:

1. Evaluate the scene ("size-up") upon arrival based on emergency call information and visual assessments.
2. Assess the scene with input from pre-incident plans, SDS documentation, and guidance from SMEs.
3. Prioritize civilian and responder lives while containing the incident to minimize property and environmental damage. This can include evacuation procedures for nearby structures and facilities.
4. Isolate BESS power through battery disconnects and main service breakers. In the event of a fire, extinguish with copious amounts of water (unless explicitly discouraged in SDS documentation).
5. In the event of an incident other than a fire, contain chemicals releases and contact a qualified hazardous materials (HAZMAT) team.
6. Monitor the incident with thermal imaging cameras and air-sampling gas meters both after extinguishment and during fire watch follow-up visit(s).
7. Document the incident and record lessons learned for potential updates to pre-incident plans.
8. Maintain open communication with BESS personnel to keep up with changes in the facility.

However, each AHJ may have pre-existing recommendations for pre-incident planning, and they may differ by jurisdiction. Owners/operators should determine how the AHJ over each facility prefers or requires pre-incident response preparations and documents to be created, stored and shared. BESS owners/operators should obtain a thorough understanding of relevant local, state and federal codes and standards. Do not depend on the manufacturer or integrator as the sole source of information on these topics.

Utility Case Study: Salt River Project

Salt River Project's ESS Codes and Safety Working Group provided pre-incident training in 2019 at a Power Purchase Agreement (PPA) location, hosting first responders from many different fire departments. These open conversations led to additional modifications in the newly commissioned Bolster Substation Battery Site, including the addition of an Incident Command Center (ICC). On-site trainings were held prior to commissioning the Bolster installation, which included review of the Pre-Incident Response Plan and acquainting the first responders with the safety features of the system. The ICC is accessed via Knox Box and holds the fire alarm panel, copies of the Incident Response Plan (IRP), SDS sheets, convenience outlets, and a site plan clearly identifying the storage modules. The IRP is accessible via the 9-1-1 emergency system, and will be updated as needed. Frank discussions were held on the roles the First Responder and SRP Incident Response Teams would play, along with discussions of the transfer of the site responsibility between them after an incident were critical. A first responder's comment "I won't feel comfortable transferring the site to someone in a suit" reinforced the need for the utility first responders to be properly outfitted in PPE and identified via badge or vest. These trainings were videotaped, and with additional material added, will be available to first responders to review at their fire stations in the future. This information is being merged into the regular substation training for first responders, so that the training is available multiple times a year.

Figure 6. Incident Response Center at the main BESS facility gate.

Figure 7. Signage indicating the partnership with local first responders.

Figure 8. On-site first responder training. Presence of overhead power lines should be considered.

Informing and Training First Responders on BESS

BESS owners/operators have a responsibility to keep first responder organizations aware of the technology and safety systems installed, SOPs, hazards, *Emergency Response Plans*, and qualified personnel to contact in the event of an incident. Specific actions that can be performed are listed below.

- Initiate pre-incident meetings with local first responders, both (1) during the site/system planning process to share plans, obtain feedback and understand responder policies and protocols, and (2) at the site once constructed. Do not wait until an emergency event occurs.
- Perform joint walkthroughs of the facilities, and discuss the SOPs of the utility and the responders. Have detailed conversations to understand why certain protocols exist and if they are relevant to battery storage facilities. These conversations should involve a number of SMEs with different relevant expertise.
- Point out building and equipment labeling as well as exits and other critical safety features [e.g., eye wash stations, muster points, SOPs, emergency response plans] on site during site walkthroughs. Clearly identify emergency disconnects.
- Provide contact information for SMEs familiar with the facility, facility operators and facility management. Note if live-link video or augmented reality are possible communication media.
- Discuss hazard mitigation analyses, SOPs, potential failure scenarios and anticipated outcomes, and *Emergency Response Plans* with first responders.

- Review together the lessons learned from prior incidents. For example, EPRI has created a public BESS Failure Event Database, which is maintained to current status and is a good starting point for such reviews (EPRI 2021a). The range of possible negative outcomes should be reviewed, with video or other documentation where available. Potential sources are an annotated EPRI video (EPRI 2020b) or a FM Global video and report (FM Global 2019). Incorporating examples of different failure modes is particularly helpful, as each may create a different firefighting scenario (e.g. an overcharged battery may proceed differently than a heat exposure scenario).
- Work with the local 9-1-1 organization to provide additional information in the system so responders can access it while en route. This could include a selection of graphics like a site layout or map, instructions, contact information for facility representatives, or this distribution could be part of the mass notification system described above.
- Perform training for first responders, BESS owners/operator, and other relevant SMEs through multiple frameworks [e.g., in-person, discussions, lectures, videos or real or modeled situations, tabletop and mock drill simulation exercises].

Utility Case Study: Entergy

Entergy's Risk Management Fire Protection Engineers are engaged in the conceptual design aspects of all BESS projects. This ensures that related fire risks are adequately addressed prior to construction. The design features incorporated are intended to be a "defense in depth" approach considering mitigating features to prevent fires from occurring, early identification of precursors to failure, suppression and venting capability, as well as emergency response. Prior to operation, a team of SME's is tasked with ensuing all related risks have adequately been addressed. The Entergy Risk Management team provides site-specific training to local emergency responders on the appropriate strategy and tactics for battery related emergencies. A review of operating experience from recent events involving stranded energy and explosions is also included.

- Lead ongoing/regular updates with local responders to make them aware of new training and documentation, and to keep them current with facility changes. Once a year seems to be a common frequency.
- Ongoing communication is particularly important if the local responders are a volunteer crew, as the participants may change frequently over time, and their units may not have as many resources available for training as larger permanently-staffed units.
- For future first responder training purposes and potential updates to pre-incident plans, it is important to document incidents and lessons learned. One option is to use the template found in the Energy Storage Integration Council (ESIC) Energy Storage Safety Incident Gathering and Reporting List (EPRI 2019) to frame appropriate questions and facilitate uniform data gathering.

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Appendix

Additional resources for first responder training or orientation in support of stationary BESS or electric vehicle platforms are compiled here for reference.

- The first source of information pursued should be manufacturers of the batteries, storage system or vehicles, or the integrators and engineering, procurement and construction companies. These entities are most familiar with the technology design and safety requirements and may compile educational materials for stakeholders beyond those needed to support compliance with codes and standards, which are a common part of the RFP and permitting processes.
- NFPA also provides a self-paced online course on battery energy storage systems, titled Energy Storage Systems Safety Online Training, Fire Service Edition, which can be found at their website (https://www.nfpa.org/esstraining). This course educates the fire service on how to respond safely to emergency situations involving high-voltage commercial and residential energy storage systems, and provides recommended mitigration and emergency responses. The recommendations include general protocols for initial action upon scene arrival, hazard mitigation, and handling BESS-specific incidents, such as electrolyte release, overheated batteries, and BESS fires.
- NFPA 1620: *Standard for Pre-Incident Planning* (2015) recommends a number of items be considered during the pre-incident planning process for any type of facility. These include: the potential life safety hazard, including emergency responder safety; structure size and operation complexity; economic impact; importance to the community; location and seasonal variations; presence of hazardous materials, and susceptibility to natural disasters. NFPA 1620 is in the process of being consolidated with NFPA 1660 *Standard on Community Risk Assessment, Pre-Incident Planning, Mass Evacuation, Sheltering, and Re-Entry Programs, through the Emergency Response and Responder Safety Document Consolidation Plan*. More information can be found at the https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1660&tab=nextedition.
- The Pacific Northwest National Laboratory and Sandia National Laboratory created the Energy Storage System Safety: Plan Review and Inspection Checklist (Cole and Conover, 2017), which was developed by a task force with representatives from many stakeholder organizations.
- The U.S. DOE also recently awarded the NFPA $1M through the EMPOWERED funding program to create training for first responders on new energy technologies, such as solar energy and storage systems, and alternative fuel vehicles (DOE 2020). Other recipients were granted support for development of new educational materials on codes and standards, permitting, and inspection specifically for new energy technology installations in residential and commerial buildings. It will take several years before these materials are available for use.
- The Energy Storage Association (ESA) has created an Emergency Response Plan template as part of their Corporate Responsibility Initiative that could be tailored for a company or site-specific plan (https://energystorage.org/wp/wp-content/uploads/2019/09/Corporate-Responsibility-Initiative-Emergency-Response-Plan.pdf).
- The New York State Energy Research and Development Authority (NYSERDA) holds workshops for first responders on potential procedures for incident management, as well as New York State requirements for preventive safety measures to be applied at all BESS installations. More information on the workshop titled Battery Energy Storage for First Responders can be found here: https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Siting/Technical-Assistance-and-workshops.

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