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Attachment E-2: Trimount Energy Fire Protection Basis of Design Report

Pictured: Jupiter's Callisto | BESS in Harris County, TX

Prepared For:

Massachusetts Department of Energy Resources

Electric Distribution Companies:

Fitchburg Gas & Electric Light Company d/b/a Unitil

Massachusetts Electric Company and Nantucket Electric Company, each d/b/a National Grid

NSTAR Electric Company d/b/a Eversource Energy

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Jupiter Power LLC

Trimount ESS LLC
Fire Protection Basis of Design
Trimount Energy Storage
Everett, Massachusetts

FINAL REPORT | REV1 | September 2024

Prepared for:

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Everett, MA

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REVISION CONTROL SHEET

REVISION	SECTION	CHANGE NOTED

EXECUTIVE SUMMARY

Fire and Risk Alliance, LLC. (FRA) was retained by Jupiter Power LLC (Client), to develop a Fire Protection Basis of Design (BOD) to document the applicable fire protection codes and standards for lithium-ion battery energy storage system (BESS) and provide the proposed fire protection system design narrative.

The Trimount Energy Storage project, managed by Trimount ESS LLC, is located in Everett City, Massachusetts. This project involves the installation of 816 Hithium Gen 2 BESS units with a combined energy capacity of approximately 700 MW across two storage phases, one at 345 kV and the other at 115 kV. The applicable fire protection code for the project is the 2021 Massachusetts Fire Code, which references the 2020 edition of NFPA 855.

A distinctive feature of the Trimount Energy Storage facility is its two-level arrangement of BESS units, using a structural platform. The Hithium BESS units and SMA medium voltage power stations are installed at two elevations. The ground level hosts the first set of BESS units, while the second set is placed on elevated steel structural platform above the ground level units. This two-level configuration requires careful consideration in the design of fire protection systems to manage fire risks involving BESS units.

The BOD provides a comprehensive analysis of the fire protection criteria, particularly focusing on the outdoor installation of BESS near exposures. It emphasizes the need for a Hazard Mitigation Analysis (HMA) due to the large energy capacity exceeding 600 kWh, which surpasses the threshold set by NFPA 855, and due to the distinctive installation characteristics.

The BOD addresses the following:

- Outdoor BESS Installation Code Requirements: Compliance with NFPA 855 mandates specific installation standards for outdoor BESS near exposures, including size limitations, clearance to exposures, means of egress separation, and enclosures. The project exceeds the maximum allowed stored energy, necessitating an HMA to seek exemptions from the Massachusetts Fire Code.
- Fire Control and Suppression System, Fire Alarm System, and Explosion Control System: NFPA 855 does not require fire control and suppression systems for outdoor non-walk-in units. An explosion control system is integrated, featuring a flammable gas exhaust system to prevent potential explosions. The BESS containers will be equipped with an addressable fire alarm system, incorporating smoke, heat, and gas detectors.
- Exposure Protection Systems: To mitigate the risk of fire spreading between containers and protect the integrity of the structures, a water spray system is recommended to be designed and installed for exposure protection, particularly for the steel platform structures supporting the BESS units.

Furthermore, the BOD narrative outlines the water supply requirements and the design criteria for the water spray systems, emphasizing the need for reliable water sources and the potential installation of a fire pump system to meet the pressure demands. Narrative details on the fire protection design of the Trimount Energy Storage are provided, in consideration of the distinctive challenges presented by the two-level BESS installation configuration. The facility design is currently conceptual, as such the fire protection system design described in this BOD is not final and is subject to change.

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1.0 INTRODUCTION

Jupiter Power LLC (Client) has retained Fire & Risk Alliance (FRA) to provide Fire Protection Engineering (FPE) consultation services for the Trimount Energy Storage project, located in Everett, Massachusetts. The State of Massachusetts adopts the 2021 edition of NFPA 1, *Fire Code*, as the Massachusetts Fire Code, which in turn references the 2020 edition of NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*. The 2023 edition of NFPA 855 is also referenced to supplement the Basis of Design (BOD) where new industry guidelines have been provided.

The Trimount Energy Storage project site consists of two (2) substations and 816 BESS. For the purposes of this BOD, the Hithium Gen 2 BESS will be used as the stand-in technology for all analyses. The Hithium BESS is a pre-assembled, non-walk-in (NWI) style lithium-ion BESS container with an energy capacity of 5,015 kWh. Trimount consists of two storage phases: 345 kV and 115 kV. The 345 kV storage phase will have an approximate energy capacity of 500 MW. The 115kV storage parcel will have an approximate energy capacity of 200 MW. Additionally, the site includes space for future augmentation to ensure the required energy capacity can be maintained throughout the facility's operating life.

The facility will utilize SMA medium voltage power stations and SMA inverters, paired with the BESS. The SMA medium voltage power stations and inverters will be located adjacent to the BESS equipment. The BESS units and the SMA medium voltage power stations will be installed at two different elevations. Some equipment will be installed at ground level, with additional equipment placed on an elevated steel structural platform located directly above the ground level BESS units.

This BOD includes information about the proposed BESS installation, applicable codes, building code analysis, fire alarm system, site water supply, explosion control system, and exposure protection. It has been prepared to outline the required code requirements to support the development of the fire protection design. The Trimount Energy Storage facility design is conceptual, as such the fire protection system design described in this BOD is preliminary and will be revised based on updates to the facility design, structural design, and further engineering analysis.

2.0 APPLICABLE CODES AND STANDARDS

The facility must comply with the 2015 Massachusetts State Building Code – 780 CMR (MSBC), which is based on the 2015 edition of the International Building Code (IBC), and the 2021 Massachusetts Comprehensive Fire Safety Code, which is based on the 2021 edition of NFPA 1 – *Fire Code*. As specified by the MSBC, fire protection systems must comply with various standards published by the National Fire Protection Association (NFPA) as modified by the MSBC. The following is a list of the applicable reference codes and standards:

- Massachusetts Building Code, 2015 (ICC, *International Building Code* (IBC), 2015 Edition [as adopted/amended by the State of Massachusetts, 2015])
- Massachusetts Comprehensive Fire Safety Code, 2021 (NFPA 1, The Fire Code, 2021 Edition [as adopted/amended by the State of Massachusetts, 2021])
- Massachusetts Electrical Code , 2023 (NFPA 70, *National Electrical Code*, 2023 Edition)
- Massachusetts Fire Alarm Code, 2013 (NFPA 72, *National Fire Alarm and Signaling Code*, 2013 Edition)
- Massachusetts Fire Sprinkler Code 2013 (NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2013 Edition)
- NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 Edition
- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2016 Edition
- NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2016 Edition
- NFPA 69, *Explosion Prevention Systems*, 2014 Edition
- NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, 2020 Edition

The following standards are also considered for additional guidance where there is a lack of guidance in the referenced codes and standards, but these have not been formally adopted by the State of Massachusetts:

- NFPA 291, *Recommended Practice for Fire Flow Testing and Marking Hydrants*, 2016 Edition
- NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*, 2020 Edition
- NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, 2023 Edition
- IEEE 979, *Guide for Substation Fire Protection*, 2012 Edition

3.0 CODE ANALYSIS

The fire protection criteria pertaining to the outdoor installation BESS, specifically locations near exposures, is governed under the 2021 edition of the Massachusetts Fire Code which adopts the 2021 edition of NFPA 1 2021, with amendments. NFPA 1 references the 2020 edition of NFPA 855 for specific requirements of BESS installations. As referenced by NFPA 1, §52.1.1, because a single installation of Hithium BESS exceeds the 20 kWh threshold for lithium-ion batteries in NFPA 855, Table 1.3, NFPA 1, Chapter 52, and referenced NFPA 855 criteria apply for the site.

The Hithium BESS utilizes a containerized unit type designed for easy delivery and installation. The unit is considered a non-walk-in (NWI) style unit, as the container is not occupiable, and all components are accessible via exterior equipment doors.

The proposed Trimount Energy Storage facility exceeds the maximum stored energy of 600 kWh for outdoor locations near exposures. In addition, the system will be installed on two levels using a structural steel platform. Therefore, per NFPA 855 §4.8.2, a Hazard Mitigation Analysis (HMA) that contains UL 9540A fire and explosion testing data that incorporates additional engineering analysis for the two-level installation shall be prepared upon further site design maturity for AHJ review in order to seek the Massachusetts Fire Code allowed exemptions and approvals.

3.1 OUTDOOR BESS NEAR EXPOSURES INSTALLATION REQUIREMENTS

The NFPA 855 Chapter 4 and Chapter 9 code requirements pertaining to outdoor BESS installations are shown in Table 1.

Compliance Required	**Code Reference**
General installation requirements	§4.1-4.3
Maximum size	§4.4.3.2
Clearance to Exposures	§4.4.3.3[1]
Means of Egress Separation	§4.4.3.4[1]
Vegetation control	§4.4.3.6
Enclosures	§4.4.3.7
Size and Separation	§4.6[2]
Maximum stored energy	§4.8[2]
Smoke and fire detection	§4.10
Fire control and suppression	§4.11
Water supply	§4.13[3]
Signage	§4.3.5
Technology Specific Protection	
Thermal runaway	§9.3
Explosion Control	§4.12

Notes:
1. Not applicable for remote locations BESS installation.
2. Not required for remote locations BESS installation.
3. When agreeable with the ESS owner and approved by the AHJ, fire suppression systems and water supply shall not be required for remote locations BESS installation.

Table 1. Outdoor ESS Near-Exposures Installations and Technology-Specific Requirements [NFPA 855 Table 4.4.3 and Table 9.2]

3.1.1 Maximum Size

Per NFPA 855 §4.4.3.2, BESS enclosure shall not exceed 53 ft x 8.5 ft x 9.5 ft. As the Hithium BESS is 20 ft x 8 ft x 9.5 ft, it meets this requirement.

3.1.2 Clearance to Exposures

According to NFPA §4.4.3.3, it is required that outdoor BESS should be positioned no less than 10 feet away from property lines, public pathways, buildings, stored flammable materials, dangerous materials, high-stacked goods, and other potential exposure hazards unrelated to electrical grid infrastructure. Adherence to this guideline will be confirmed once the general layout of the Trimount Energy Storage facility has progressed to a point where the necessary information can be obtained.

3.1.3 Means of Egress Separation

Per NFPA 855 §4.4.3.4, outdoor BESS must be separated from any means of egress per the discretion of the AHJ, but never less than 10 ft. Per preliminary site plans, there are no occupiable buildings in the vicinity of the BESS installation.

3.1.4 Vegetation Control

Per NFPA 855 §4.4.3.6, areas within 10 feet of each side of an outdoor BESS installation shall be cleared of combustible vegetation and other combustible growth. Single specimens of trees, shrubbery, or cultivated ground cover such as green grass shall be permitted to be exempt from this requirement provided that they do not form a means of readily transmitting fire.

3.1.5 Enclosures

Per NFPA 855 §4.4.3.7, BESS electrical circuitry in outdoor installations shall be housed within weatherproof enclosures marked with the environmental rating suitable for the type of exposure required by NFPA 70.

3.1.6 Size and Separation

Per NFPA 855 §4.6.2 and §4.6.3, outdoor BESS near exposures shall be comprised of groups with a maximum stored energy of 50 kWh each, and each group shall be separated by a minimum of three (3) feet from each other. The BESS system for this project exceeds the 50-kWh limit.

NFPA 855 §4.6.4 permits the AHJ to approve groups with larger energy capacities or smaller separation distances based on large scale fire testing in accordance with §4.1.5.

3.1.7 Maximum Stored Energy

Per NFPA 855 §4.8(2), outdoor BESS installations near exposures shall not exceed the maximum stored energy values provided in Table 4.8 of NFPA 855. Specifically, for lithium-ion batteries, the maximum stored energy should not exceed 600 kWh.

The installation in the Trimount Energy Storage exceeds this allowance. NFPA 855 §4.8.2 permits an exception to the maximum stored energy allowance based on AHJ approval of an HMA complying with §4.1.4 and large-scale fire testing complying with §4.1.5 of NFPA 855. An HMA has to be prepared using UL 9540A test data to seek AHJ approval to increase the maximum stored energy. In addition, the HMA should incorporate additional engineering analysis unique to the two-level installation, identifying risks and mitigation solutions.

3.1.8 Smoke and Fire Detection

NFPA 855 requires smoke and fire detection in outdoor installations. The Hithium BESS is equipped with a smoke and fire detection system consisting of heat detectors, smoke detectors, horn/strobes, control modules, monitor modules, and a manual pull station. These devices are monitored by the site fire alarm control panels (FACP) in the control house serving each parcel. The FACPs will transmit signals via Modbus to the BESS facility operator to a 24/7 monitored client remote operation center (ROC) and via cellular transmitter to an approved remote supervisory station.

3.1.9 Fire Control and Suppression

Section 4.11.1 of NFPA 855 specifies the necessity of fire control and suppression systems for rooms or areas within buildings and outdoor walk-in units housing BESS. Given that the Trimount BESS containers are outdoor non-walk-in units, the requirement for fire control and suppression

systems does not apply. However, an exterior NFPA 15 deluge water spray type system will be provided due to the two-level installation arrangement.

3.1.10 Water Supply and Hydrant

Per NFPA 855 §4.13, sites where nonmechanical BESS are installed shall be provided with a permanent source of water for fire protection, specifically for fire-fighting purposes. Where no permanent adequate and reliable water supply exists for fire-fighting purposes, the requirements of NFPA 1142 shall apply.

According to the hydrant flow test data, a 16-inch city water main is located along Beacham Street near the Trimount Energy Storage facility.

Massachusetts has not adopted NFPA 1 2021 Edition requirements for hydrant spacing. IBC 2015, which was adopted by Massachusetts, requires that private hydrants shall be located and installed as approved by the head of the fire department [Massachusetts Building Code §917.1]. Additional hydrants must be provided to meet the NFPA 24 requirements and as required by the fire department.

3.1.11 Signage

In NFPA 1, Section 52.1.18 includes the requirements for signage, which are cross-referenced from Section 4.3.5.1 of NFPA 855. Any new BESS Enclosure installation shall adhere to the signage requirements specified in the NFPA 704 *Standard System for the Identification of the Hazards of Materials for Emergency Response* identification markings and ANSI Z535.

3.1.12 Fire Department Access

NFPA 855 §4.4.3.8 requires fire department access roads to be provided for outdoor BESS installations in accordance with the local fire code. Everett, Massachusetts adopts the 2021 edition of NFPA 1, with chapter 18 addressing fire department access.

An approved fire apparatus access road shall extend to within 150 ft of all portions of the facility [NFPA 1 §18.2.3.2.2]. The access road shall have an unobstructed width of not less than 20 ft [NFPA 1 §18.2.3.5.1.1]. The access road dead-ends in excess of 150 ft in length shall be provided with an approved area for turning around fire apparatus [NFPA 1 §18.2.3.5.3.3]. The dead-end roads within each substation access shall be under 150 ft, and the roads shall be at least 20 feet wide. Fire department access should be coordinated with the AHJ.

3.1.13 Emergency Response Plan

NFPA 855 §4.1.3.2.1.1 requires that an emergency response plan (ERP) shall be readily available at the Trimount BESS Facility for use by facility operations and maintenance personnel. The ERP is a living document that should be updated when conditions for the site change that affect the response considerations and procedure changes. At a minimum, the ERP shall include the following [NFPA 855 §4.1.3.2.1.4]: procedures for safe operational shutdown, inspection testing and maintenance, BESS response procedures, fire response procedures, safety data sheets, emergency contact information, AHJ operations and response procedures, etc. An Emergency Response Plan complying with NFPA 855 will be provided.

3.1.14 Fire Department Training

NFPA 855 requires the owner of the BESS unit or their authorized representative to engage in emergency planning and training of emergency responders such that any foreseeable hazards associated with the outdoor BESS units can be effectively addressed [NFPA 855 §4.1.3.1]. Fire department training has been completed with the Boston, Everett, and Chelsea fire departments. Additional future fire department training is planned.

3.1.15 Explosion Control

NFPA 855 2020 requires explosion control measures for outdoor NWI BESS units containing lithium-ion battery technology. Explosion control will be provided using a gas exhaust system utilizing the performance requirement of NFPA 69. Refer to Section 1.1.

3.1.16 Thermal Runaway

BESS thermal runway protection must be provided for lithium-ion technologies [NFPA 855 §9.3]. The thermal runaway protection is permitted to be part of an energy storage management system (ESMS) that has been evaluated with the battery as part of the evaluation to UL 1973 [NFPA 855 Table 9.2 Exception f].

The provided BMS with ESMS control and monitoring for the Hithium BESS monitors the voltage and will respond to trigger undervoltage protection. Layers of protection are provided by the ESMS that provide reliable means to prevent an internal short. An HMA will be prepared using UL 9540A test data that will consider thermal runaway protection.

3.2 STORAGE OF LITHIUM-ION BATTERIES

Although not currently adopted by the State of Massachusetts, NFPA 855 2023 Edition provides additional guidance on the storage of lithium-ion batteries that may be needed for Trimount Energy Storage maintenance operations. According to Section 12.1.1 of NFPA 855, the additional guidance is not required for areas within a facility that are operated in accordance with procedures that provide for the state of charge of lithium-ion batteries to be 30% or less.

It is anticipated that all shipped BESS systems will be charged at a state of charge 30% or less and the additional guidance is not applicable to this project, and indoor storage is not anticipated.

4.0 FIRE PROTECTION SYSTEM BASIS OF DESIGN NARRATIVE

4.1 BESS FIRE SUPPRESSION

The Hithium Gen 2 BESS includes six open sprinklers within the container that can be optionally manifolded to a fire sprinkler system or a common manual fire department connection. As previously stated, NFPA 855 §4.11 does not require fire control and suppression in outdoor NWI units. Regardless, the interior open sprinklers are not recommended and will not be used.

A short circuit of BESS caused by unintentional water intrusion is a source of ignition, with multiple documented incidents. The recommended fire protection practice is a strategic application for exposure protection, reducing the incident heat flux of the involved BESS to adjacent equipment and structures. This approach minimizes the risk of fire propagation to adjacent BESS or exposures. The use of interconnected BESS interior open sprinklers increases the risk of incident escalation, as the high failure risk potential for water application in unaffected BESS units exceeds the benefit that may be gained.

4.2 NFPA 15 WATER SPRAY EXPOSURE PROTECTION

The Trimount Energy Storage facility design sites the Hithium BESS units and SMA medium voltage power stations at two distinct elevations within the BESS facility. Specifically, the ground level will host the first set of units, while the second set will be placed on elevated steel platform structures above the ground level BESS units. A fire in one BESS unit could create an external fire hazard to the surrounding steel platform structures and neighboring BESS units. This hazard includes exposure to heat through radiation and convection, as well as the danger of flying brands from the fire. Therefore, it is necessary to take proactive measures to protect the steel platforms from failure and prevent adjacent BESS units from igniting.

To address these potential hazards, the installation of water spray systems is recommended and will be provided as an exposure protection solution. These systems will provide protective measures by discharging water spray directly onto the exposed surfaces of the structures and BESS units with the primary objective of eliminating or reducing the heat transfer from the burning BESS enclosure to these components.

The water spray system design narrative is preliminary. FRA is conducting computational fluid dynamics modeling, including a simulation of a BESS fire and water spray discharge to validate the system design criteria. In the event that lower than the prescriptive required discharge density is recommended for structural steel exposure protection, an engineering analysis certified by a registered professional engineer will be provided to the AHJ as part of an alternative engineering analysis approval in accordance with NFPA 15.

4.2.1 Water Spray System for Exposure Protection

An NFPA 15 water spray system will be provided using a stationary piping system connected to a reliable water source and equipped with spray nozzles. These integrated systems are designed to be initiated by automatic fire detection systems, activating automatically when a fire is detected. The system will be designed such that the water spray pattern will envelop the incident BESS container, in addition to adjacent BESS containers and the structural. Water spray systems are typically employed to safeguard specific pieces of equipment by providing surface coverage. The water spray system will be NFPA 15 and NFPA 13 compliant.

As the Trimount Energy Storage facility design is currently conceptual, the water spray system design will be revised to incorporate future design changes. However, the design process will evaluate the following:

1. Determine equipment dimensions and the required water density.
2. Define individual design areas as well as the total design area.
3. Calculate the water demand for each individual and the total design area.
4. Assess the water supply conditions and determine the likely available pressure for each design area.
5. Specify the necessary number, type, and orientation of nozzles to ensure sufficient coverage and water delivery.

4.2.2 Equipment and Structures Being Protected

Figure 1 shows the preliminary conceptual structure design of Hithium BESS units with SMA medium voltage power stations installed at two different levels. Both the Hithium BESS container and power station have dimensions of 20 ft in length, 8 ft in width, and 9.5 ft in height. In , four BESS containers are arranged closely together, with separation between each group along the x-axis. The power stations are positioned on both sides of the BESS groups along the y-axis. The arrangement of the BESS and power stations at ground level mirrors the configuration observed at the elevated level.

The platform structure consists of hollow structural steel columns and wide flange steel beams with varying sizes, forming a grid structure. Steel open gratings cover the surface of the platform, providing a walking surface and support for the upper level BESS equipment. The platform includes safety railings along the perimeter.

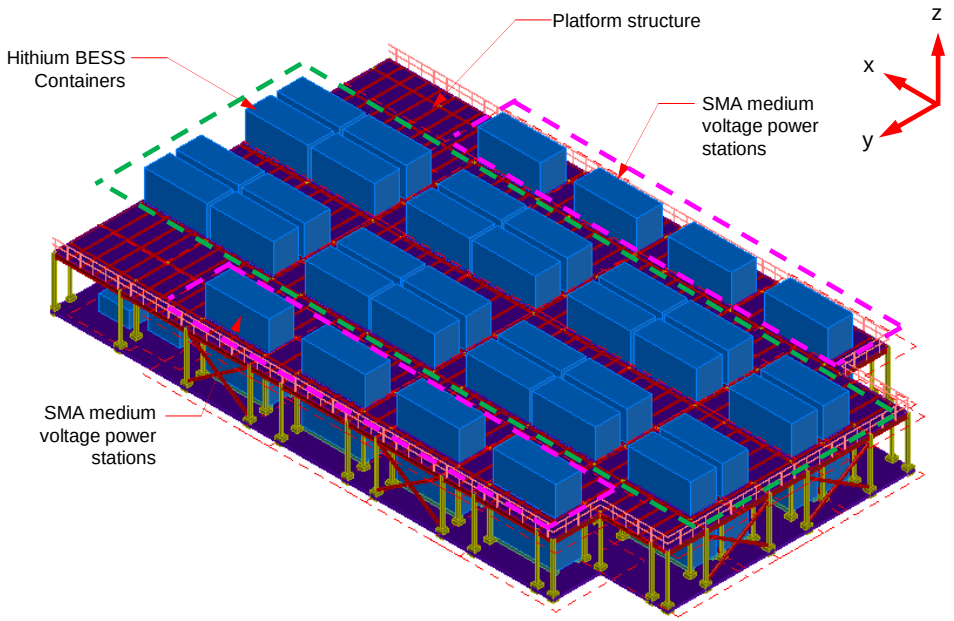


Figure 1. Isometric View of the Hithium BESS Units with SMA Medium Voltage Power Stations at Two Different Levels (Preliminary Concept)

4.2.3 Water Density, Design Area, and Water Demand

The NFPA 15 Standard for Water Spray Fixed Systems for Fire Protection offers guidance for designing water spray systems to safeguard structures and equipment from fire exposure. Water spray systems are intended to discharge an adequate amount of water onto the exposed structures or equipment, to absorb heat, restrict surface temperature, and thereby minimize damage and prevent failure.

Unless fire-resistant insulation is provided surrounding structural steel, exposure protection needs to be achieved by water spray discharge. NFPA 15, Section 7.4.3 outlines the required water spray design density for protecting structures and providing exposure protection for miscellaneous equipment. The standard distinguishes between two types of structural steel: horizontal and vertical. Horizontal structural steel members require a water spray design density of 0.10 gpm/sf over wetted surfaces, while vertical structural steel members require a density of 0.25 gpm/sf. The wetted surface of a structural member, such as a beam or column, is defined as one side of the web and the inside surface of one side of the flanges, as shown in .

Figure 2. Wetted Surface of a Structural Member

The close proximity of the four adjacent containers within a group, shown in , requires the water spray system to encompass the entire group in case of a fire outbreak in any one BESS container. Additionally, considering the similar configuration of containers on both upper and lower levels, the water spray systems should be designed to simultaneously cover both groups of containers to prevent vertical fire propagation in the event of a fire in any single container within the two groups. Thus, a single water spray system needs to be designed to provide water spray coverage to at least eight (8) BESS containers and the surrounding structural steel members.

Each BESS container on the upper level has four (4) sides: top, bottom, small, and large sides, which require water spray discharge, while a container on the lower level has three sides since the bottom side is facing the ground. The platform structure, which supports the BESS containers on the upper level, comprises several types of steel beam and column members. The water spray system is designed to apply the water discharge only to the parts of these steel beams and columns that directly support the load of the BESS container. The detailed view of this portion of structural members is shown in .

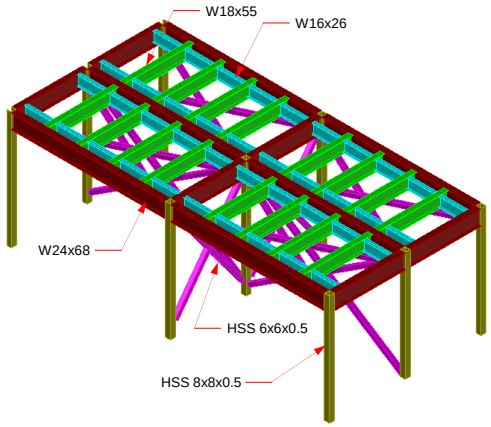


Figure 3. Structural Members of the Platform (Preliminary Concept)

The design area for a water spray system protecting eight (8) BESS containers and surrounding structural steel members is summarized in Table 2.

A fire on a BESS container can have a thermal impact not only on containers in the same group and the surrounding structural members but also on BESS containers and platform structures located across the adjacent aisle. Thus, the water spray systems installed in neighboring groups, as well as in the group where the fire occurred, will need to operate simultaneously. The number of water spray systems operating simultaneously will be determined based on the final layout of the BESS container groups. The fire water supply system will be designed in such a way as to ensure that an adequate supply of fire water is available for the simultaneous operation of multiple water spray systems at the BESS facility.

Table 2. Design Area, Density, and Flow Summary of Water Spray System

Structure/Equipment	Surface area to be protected (ft^2)	Quantity/ Length	Total area (ft^2)	Density (gpm/ft^2)	Flow rate (gpm)
BESS container (lower level)	Top: 160 Sides: 190 & 76	4 ea	1,704	0.10	170.4
BESS container (upper level)	Top & bottom: 2 x 160 Sides: 190 & 76	4 ea	1,864	0.10	186.4
W24x68 beam[1]	2.6 per ft	177.5 ft	461.5	0.10	46.2
W16x26 beam[1]	1.7 per ft	140.0 ft	238.0	0.10	23.8
W18x55 beam[1]	2.0 per ft	146.7 ft	293.4	0.10	29.3
HSS 8x8x0.5[2]	1.33 per ft	119.3 ft	158.7	0.25	39.7
HSS 6x6x0.5[2,3]	1.0 per ft	178.0 ft	178.0	0.10	17.8
Minimum flow for a water spray system					**513.6**

Notes:
1. Wetted surfaces are considered, as depicted in .
2. Two sides of the columns are considered.
3. The bracings positioned between BESS containers are not considered in the water discharge calculations as a result of their restricted access conditions.

FRA is conducting computational fluid dynamics modeling, including a simulation of a BESS fire and water spray discharge to validate the system design criteria.

Water spray systems need to be triggered by dedicated fire detectors. Exterior weatherproof heat detectors will be used to initiate the water spray systems. Detectors for the water spray system will be zoned to prevent the possibility of false alarms causing extensive water discharge onto the BESS containers.

In addition, fire department connections (FDC) equipped with check valves and automatic drip valves shall be provided for the water spray systems. The FDC and water spray system zones will be coordinated. The location of the FDC will be provided at a safe location away from the BESS.

4.2.4 Water Spray System Layout

The arrangement of water spray system pipes and nozzles should ensure direct impingement of water spray onto all protected surfaces. The nozzles should be strategically spaced and directed to fully cover the plane of protection with the required average density as per NFPA 15 guidelines and CFD analysis results.

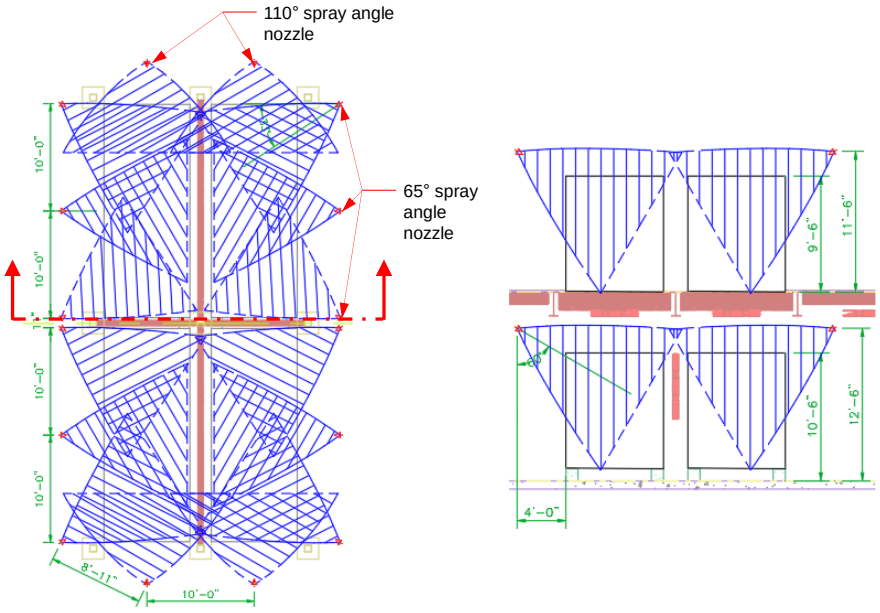
The water spray systems utilized for the Trimount BESS facility will be equipped with Tyco D3 medium velocity spray nozzles featuring selected spray angles of 65 and 110 degrees. The nozzles have a minimum discharge pressure requirement of 20 psi at the nozzle inlet and a nozzle K-factor of 5.6.

The preliminary conceptual design of the water spray system includes a total of twenty-four (24) 65-degree spray angle nozzles will be positioned along the longer sides of the BESS containers, while eight (8) 110-degree spray angle nozzles will be arranged along the shorter sides to provide complete coverage of the BESS containers. The nozzles for the lower level BESS containers are positioned at 12’-6” off from the ground, and those on the upper level are located at 11’-6” from the top of the platform. Both types of nozzles are directed downward at a fixed angle of 60 degrees. The layout of the spray nozzles in both plan and section views is presented in . A preliminary water spray system layout drawing is also provided in **Appendix A**.

The minimum required flow for a single water spray system can be calculated based on the given parameters of a minimum nozzle pressure of 20 psi, a K-factor of 5.6, and the number of spray nozzles in operation. Using the $Q = K\sqrt{P}$ relationship, the computed value is 801.4 gpm, which surpasses the design minimum flow of 513.6 gpm, confirming the suitability of the current spray nozzle arrangement. The performance of the water spray system will be validated through CFD modeling, including a simulation of the BESS fire and water spray discharge.

As part of the water spray system design process, hydraulic calculations shall be performed in the detailed design phase to verify the availability of required pressure and flow at each nozzle according to the NFPA 15 requirements.

The water-filled components of the water spray system, including supply pipes, control valves, deluge valves, and others, shall be situated in a valve room where the temperature is maintained at a minimum of 40°F, or they shall be safeguarded against freezing using methods capable of preserving a minimum temperature of 40°F.



*The blue cones with hatching represent the spray nozzle coverage.

Figure 4. Plan (left) and Section (right) View of Water Spray Nozzle Arrangement

The water spray system will be zoned, such that the system discharge will be limited to the incident event. The system activation zone area will be determined through CFD analysis. The water spray system and the fire protection water supply will be sized for a simultaneous activation of two zones, due to the likelihood of a fire between a zone triggering both.

4.2.5 Fire Protection Water Supply

Four (4) hydrant flow tests were conducted near the Trimount BESS facility site in October 2023. A 16-inch city main runs along Beacham Street and provides water to the hydrants used for the flow tests. The results of the tests are outlined in Table 3.

Table 3. Summary of Hydrant Flow Tests

Test no.	Test hydrant ID.	Static & residual pressure (psi)	Test flow (gpm)	Estimated flow at 20 psi residual pressure (gpm)
1	WH-113	S: 64, R: 60	1,656	6,046
2	WH-113	S: 64, R: 58	1,678	4,920
3	WH-117	S: 66, R: 60	1,678	5,039
4	WH-117	S: 66, R: 62	1,100	4,114

The available water from the city main is able to meet the flow demand for multiple water spray systems simultaneously. However, it is likely that a fire pump will be required to meet the pressure demand for the operation of two water spray system zones. A fire pump will be provided in accordance with NFPA 20 to supply the required pressure for the water spray system.

Section 7.4.1 of NFPA 15 requires that exposure protection water spray systems operate for the expected duration of the exposure fire. Testing and real-life incidents have shown that thermal

runaway events involving lithium-ion BESS can last for several hours. Therefore, it is important to ensure that the water source has sufficient storage capacity to support the continuous operation of the water spray system for multiple hours.

If there are concerns regarding the substantial amount of water discharge in the event of a fire, a watery spray system with a cycling operation (i.e. on-off deluge valve) can be considered. The system can be cycled to spray water for an initial ~3 minutes upon heat detection and pause for ~3 minutes. Upon heat detection, while the system is paused, the system cycles for another ~3 minutes. If at the end of ~3 minute pause, the system can be made to stop flow upon no further heat detection. Additionally, the system will automatically reactivate if a fire condition should reignite. The cycling system design will be validated through CFD analysis and structural analysis.

4.3 FIRE ALARM SYSTEM

A new addressable fire alarm system with gas exhaust control will be provided in each BESS container. The devices will communicate with an FACP in the control house serving the parcel of land. There will be two FACPs on site. The FACPs will transmit signals via Modbus to the BESS facility operator and cellular transmitter to an approved remote supervising station.

4.3.1 Initiating Devices

The fire alarm system initiating devices will consist of smoke detectors, heat detectors, gas detectors, control modules, monitor modules, and manual pull stations.

Two smoke detectors and two heat detectors shall be installed in each Hithium BESS as indicated in the user manual. Upon activation of a smoke detector, heat detector, or manual pull station, the FACP will send the alarm signal to the battery management system and activate the clear horn/strobe. Additional heat detectors will be provided above BESS containers to activate exposure protection water spray systems.

Each container will be provided with two combustible gas detectors. Upon detection of concentrations of combustible gas greater than 10% of the LFL, the FACP will send the combustible gas signal to the BMS and activate the amber horn/strobe, and the fan controller will start the ventilation system.

Manual pull stations are installed on each BESS container. The manual pull station activation shall transmit a fire signal to the FACP, which will activate the clear horn/strobe and transmit an alarm signal.

4.3.2 Notification Appliances

Fire alarm notification audible and visual notification appliances will consist of one clear electronic horn/strobe and one amber electronic horn strobe on each BESS container. The clear horn/strobe will activate upon detection of smoke or high heat. The amber horn strobe will activate upon detection of 10% LFL combustible gas.

4.3.3 Fire Alarm Signaling Lines and Circuits

Class B fire alarm circuit wiring shall be manufacturer-provided for monitoring of BESS fire alarm system. The Trimount site will utilize Class B circuitry with redundant pathways.

4.4 BESS EXPLOSION CONTROL

The BESS units are provided with a flammable gas exhaust system acting as an explosion prevention system in accordance with NFPA 69. The system consists of combustible gas detectors, an air inlet electrical shutter, a fan controller, and an exhaust fan. The performance of the explosion prevention system will be verified as part of the HMA risk assessment.

Upon detection of a concentration of flammable gas above 10% of the lower flammable limit (LFL), the fan controller will activate the ventilation system. Per NFPA 855 §9.6.5.5.6(2), the ventilation system must remain on to ensure the concentration of flammable gas does not exceed 25% of the LFL of the gas mixture or individual gases. The site fire alarm system provides monitoring and control of the BESS explosion prevention system.

4.4.1 Standby Power System and Recommendations

NFPA 855 2020 Edition provides no requirements for standby power of explosion control systems. NFPA 855 2023 Edition requires that the combustible gas concentration reduction system be provided with a minimum of two hours of standby power [§9.6.5.6.7(3)]. Each Hithium container is equipped with a 220V 50/60Hz fan assembly, and the anticipated power consumption of the fan assembly is 0.61 Amp/135 Watts. The power consumption of the fan assembly will be confirmed as part of the facility design.

The standby backup power duration and the quantity of simultaneous activation should be determined as part of an HMA risk assessment. The preliminary recommendation for standby power sizing is N+3, a total of four (4) Hithium BESS in alarm, or for each group of BESS containers.

APPENDIX A. PRELIMINARY WATER SPRAY SYSTEM LAYOUT DRAWING