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MEMORANDUM

To:	California Energy Commission
From:	Compass Energy Storage LLC
Subject:	Response to Data Request REV 2 DR HAZ-1 & HAZ-2
Date:	February 20, 2025
Attachment(s):	Community Risk Assessment

On January 14, 2025, Compass Energy Storage LLC and Affiliates received two hazardous materials handling-related data requests from the California Energy Commission (CEC) for the Compass Battery Energy Storage Project (Docket Number 24-OPT-02) in response to the most recent set of data responses (Data Request Response #4):

The Data Request Response to REV 1 DR HAZ-1 (Data Request Response #4 [TN 260324], p. 10) includes a discussion of non-flammable toxic vapors/emissions from the selected MP2XL battery cell that could be released by a thermal runaway event and/or fire based on the results of UL 9540A testing. The response also notes that no flammable gasses are released during normal operations of the lithium iron phosphate (LFP) batteries.

REV 2 DR HAZ-1. *Please list and provide a discussion of the flammable gasses that could be produced if a MP2XL battery is damaged or thermal runaway occurs. How are the flammable gasses measured within the cabinet? Is there a trigger level of these gasses that must be reached before the sparkers that are part of the explosion control system engage?*

The Data Request Response to REV 1 DR HAZ-2 (Data Request Response #4 [TN 260324], pp. 10 to 11) includes a discussion of hazardous materials and potential spills associated with the MP2XL batteries and the thermal management system glycol-water solution. The response does not include any discussion of other hazardous materials that may be used or present onsite during project operation and associated spill control measures/features. Table 4.5-1 in application Section 4.5, Hazards and Hazardous Materials (TN 255535-9, pp. 4.5-3 to 4.5-5), lists several hazardous materials that would be present during project operation, including diesel fuel, lubricating oil, and glycol-based antifreeze to be used for the emergency generator; limited quantities of cleaning solvents; and dielectric fluids (including mineral oil) for the transformers.

REV 2 DR HAZ-2. *Please provide a discussion of volumes, storage types and locations for all hazardous materials, including those listed above, that would be used and/or stored onsite during operation. The discussion should also include the potential for hazardous materials spills or leaks during project operation; the measures and features that would be used to reduce the risk of spills or releases during project operation; and, resulting adverse effects to people and the environment from spills or leaks.*

Applicant Response to REV 2 DR HAZ-1:

In keeping with ENGIE North America's "Safety First" mandate, Compass Energy Storage, LLC proactively requested that Fire & Risk Alliance (FRA), a nationally recognized battery energy storage system risk assessor, prepare a Community Risk Assessment (CRA) to ensure that both the CEC and the public have sufficient information to evaluate and understand the potential worst case scenarios if a thermal runaway event were to occur at the Project. Notably, significant concerns have been raised by the public and elected officials about the potential for a thermal runaway event to generate toxic gases with offsite impacts. The CRA delivers timely information that can put those concerns into context.

The CRA has been performed to evaluate the plume dynamics from a hypothetical thermal runaway event from a Tesla Megapack 2 XL (MP2XL) lithium-iron phosphate Battery Energy Storage System (BESS), intended for installation at the Project site. The CRA is attached herein. This analysis examines four hypothetical scenarios that may result from the release of post-combustion gas products (e.g., flammable gases, carbon monoxide [CO], and carbon dioxide [CO2]) during a flaming thermal runaway event, and models the resulting plume dispersion of each scenario. As determined in the CRA, no modeled post-combustion plume scenario resulted in consequences (flammable cloud extent, flash-fire envelope, vapor cloud explosion, fireball, CO IDLH, or CO2 IDLH) that could be of risk to any persons or property offsite from the Compass BESS.

The four modelled hypothetical thermal runaway scenarios, range from seven (7) cells going into thermal runaway (the UL 9540A Scenario), to an entire MP2XL unit going simultaneously into thermal runaway (8,064 cells, a highly improbable event), using data collected during UL 9540A testing of the Tesla MP2XL, and assuming worst-case atmospheric conditions. Then each of these scenarios was assessed for potential risk to human health and the environment.

The specific flammable gas mixture and toxic gases modeled in the CRA are based on the gases identified and quantified during UL 9540A module level testing of the MP2XL. For the flammable vapor cloud, FRA modeled the extent of both the lower flammability limit (LFL) and one-half LFL of the flammable gas mixture. For the toxic gases, FRA modeled the concentrations of CO and CO2 within a post-combustion cloud, as they relate to the Immediately Dangerous to Life and Health (IDLH) levels for each gas. Based on the results of the UL 9540A module level test, however, there were no other toxic gases released that had high enough concentrations to meet the minimum release requirements for PHAST modeling. Details on each of these measurements and testing conditions are provided in the attached CRA Report.

Importantly, the CRA finds that none of the modeled scenarios would result in air quality impacts that would pose a significant risk to persons or property outside the Project site. No modeled post-combustion plume scenario resulted in consequences (flammable cloud extent, flash-fire envelope, vapor cloud explosion, fireball, CO IDLH, or CO2 IDLH) that would be of risk to any persons or property offsite from the Compass BESS.

Note, the Tesla MP2XL design includes the sparker system. The purpose of the sparker system is to ignite the flammable gas before it collects at a concentration which can cause explosions. There is no gas detection and no sensors, just the sparkers operated every minute. The sparker system is continually discharged, and flammable gases are not measured to trigger the sparker system. Thermal runway is detected by the MP2XL battery management system (BMS) temperature sensors. The BMS would stop operation and disconnect the batteries. If pressure inside the MP2XL increases during the flammable gas ignition, the top of the MP2XL is equipped with pressure release elements to allow the enclosure to depressurize in a controllable manner.

Applicant Response to REV 2 DR HAZ-2:

The following table provides a discussion of volumes, storage types and locations for all hazardous materials that would be used and/or stored onsite during operation. The table follows the format and contents of Table 4.5-1 in application Section 4.5, Hazards and Hazardous Materials (TN 255535-9, pp. 4.5-3 to 4.5-5) and includes relevant new information that has been provided in prior data request response (i.e., Data Request Response to REV 1 DR HAZ-2 (Data Request Response #4 [TN 260324]).

Table REV 2 DR HAZ-2. Hazardous Materials Used or Stored Onsite during Project Operations

Hazardous Material	Stored or Used Onsite	Volume	Storage Type	Storage Location	Measures and Features to Reduce the Risk of Spills or Releases
Diesel	Will not be stored onsite; will be used only in temporary emergency generators if brought to the site in the event of an outage scenario.	Up to 1 temporary emergency generator assumed to hold up to 300 gallons of diesel would be used in the event of an outage scenario.	The temporary emergency generator will include built-in secondary containment.	The temporary emergency generator would be placed outside the substation control enclosure.	O&M workers will conduct routine inspection for leaks. O&M workers will be trained to handle materials and inspect for leaks. Subject to HMBP[1].
Gasoline	Will not be stored onsite; will be used when maintenance equipment and vehicles visit the site during operations (no maintenance equipment or vehicles would be stored on-site overnight).	Up to approximately 150 gallons (3 trucks and 1 forklift).	Within maintenance and equipment vehicles.	Within maintenance and equipment vehicles.	Vehicles and equipment will be adequately maintained. Drip pans would be placed underneath vehicles and equipment when not in use. O&M workers will conduct routine inspection for leaks. O&M workers will be trained to handle materials and inspect for leaks. Subject to HMBP[1].
Lubricating oils/grease/hydraulic fluids/gear oils	Will not be stored onsite; would be used only in temporary emergency generators when brought to the site in the event of an outage scenario.	Up to 1 temporary emergency generator assumed to hold up to 5 gallons of lubricating oil would be used in the event of an outage scenario.	The temporary emergency generator would include built-in secondary containment.	The temporary emergency generator would be placed outside the substation control enclosure.	O&M workers will conduct routine inspection for leaks. O&M workers will be trained to handle materials and inspect for leaks. Subject to HMBP[1].
Glycol-based antifreeze (coolant)	Will be stored and used onsite.	The BESS facility would be equipped with a thermal management system that utilizes 106 gallons of a glycol-water solution. There would be up to 6 additional 5-gallon pails of the glycol-water solution onsite for maintenance.	The glycol water solution would be housed within the individual self-contained BESS enclosures. The additional 6 pails would be stored within secondary containment trays.	Throughout the BESS yard. The additional 6 pails would be within the O&M area.	O&M workers will conduct routine inspection for leaks. O&M workers will be trained to handle materials and inspect for leaks. Subject to HMBP[1].
Lead-acid storage batteries and electrolyte solution	Will be stored and used onsite.	Up to 20 gallons.	Within the self-contained backup batteries; backup	Within the substation control enclosure.	O&M workers will conduct routine inspection for leaks. Subject to HMBP[1].

Hazardous Material	Stored or Used Onsite	Volume	Storage Type	Storage Location	Measures and Features to Reduce the Risk of Spills or Releases
			batteries will be within secondary containment.		
Lithium-iron phosphate batteries	Will be stored and used onsite.	Approximately 316 BESS enclosures. Each battery module will include the following materials (Tesla 2024): • Anode (including carbon/graphite): 14,755 kg • Cathode (including lithium transition metal oxides or lithium iron phosphate): 12,765 kg • Electrolyte (including lithium salts and carbonate esters): 18,440 kg • Coolant: 237 kg • Refrigerant: 1.5 kg	Within the individual self-contained BESS enclosures.	Throughout the BESS yard.	O&M workers will conduct routine inspection for leaks. O&M workers will be trained to handle materials and inspect for leaks. Under normal usage conditions, the materials do not exhaust vapors. Cell electrolyte should not be encountered by anyone handling a battery, making the risk of a spill of electrolyte from any commercial battery pack very remote. Furthermore, in most commercial cells, the electrolyte is largely absorbed in electrodes, such that there is no free or “spillable” electrolyte within individual sealed cells. In those instances, severe mechanical damage (e.g., severe crushing) can cause a small fraction of total electrolyte quantity to leak out of a single cell; however, any released electrolyte is likely to evaporate rapidly (NFPA 2016). Subject to HMBP[1].
Cleaning solvents	Will not be stored or used onsite.	N/A	N/A	N/A	N/A
Dielectric fluids	Will be stored and used onsite within the	Approximately 1,500 gallons of ester oil (FR3)	Each medium voltage transformer will include	Throughout the BESS yard.	O&M workers will conduct routine inspection for leaks.

Hazardous Material	Stored or Used Onsite	Volume	Storage Type	Storage Location	Measures and Features to Reduce the Risk of Spills or Releases
	medium voltage transformers and main power transformer.	in each of the 79 medium voltage transformers. Approximately 16,000 gallons of mineral oil in the main power transformer.	a white rock base per SPCC requirements. The main power transformer will include secondary containment.		O&M workers will be trained to handle materials and inspect for leaks. A filtration system is provided as part of the underground stormwater detention system. Subject to HMBP[1]. Subject to SPCC[2].
Herbicides	Will not be stored or used onsite.	N/A	N/A	N/A	N/A
Touch Up Paint	Will be stored and used onsite.	Approximately sixty 12-ounce cans (approximately 6 gallons).	Within secondary containment trays.	Within the O&M area.	O&M workers will conduct routine inspection for leaks. O&M workers will be trained to handle materials and inspect for leaks. Subject to HMBP[1].

1 HMBP (Hazardous Materials Business Plan) is required under California Health & Safety Code (HSC) 25500 for any hazardous material or waste stored on site for more than 30 days in quantities greater than 55 gallons of liquid, 500 pounds of solid, or 200 cubic feet of compressed gas. The HMBP requires hazardous material type, quantity, and storage details be reported to the local Certified Unified Program Agency (CUPA), which are delegated enforcement authority for CalEPA. The CUPA for the project site is Orange County Environmental Health. Under HMBP regulations, hazardous material storage will be subject to inspection, training is required for onsite staff that will handle hazardous materials, and spill prevention and response measures must be implemented.

2 SPCC (Spill Prevention, Control, and Countermeasure) Plans are required under Code of Federal Regulations Title 40 Section 112 (40 CFR 112) for sites that store a total aboveground volume of oil products greater than 1,320 gallons in containers greater than 55 gallons each. Under SPCC Rules, the site must implement spill prevention and response procedures for all oil containers greater than 55 gallons, including secondary containment, inspections, training, and spill response kits.

Tesla Megapack 2XL

Community Risk Assessment
Compass Battery Energy Storage System
San Juan Capistrano, CA

Report | Rev0 | January 30, 2025

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Date	Revision	Reason for Issue	Developed By	Checked By	Approved by
01/30/2025	Rev0	Initial Report	YL	MR	AFB

EXECUTIVE SUMMARY

Fire and Risk Alliance, LLC (FRA) performed a Community Risk Assessment (CRA) to evaluate the plume dynamics from a hypothetical thermal runaway event from a Tesla Megapack 2 XL (MP2XL) lithium-ion Battery Energy Storage System (BESS), intended for installation at the Compass BESS site, located at 29251 Camino Capistrano, San Juan Capistrano, CA 92675. This CRA involves modeling the dispersion and mixing of gases released from a hypothetical flaming thermal runaway event in a MP2XL to assess the health risks and establish the safe distances from the Compass BESS.

The Compass BESS site is anticipated to initially include 316 MP2XL cabinets, with an approximate capacity of 250 megawatts/1,238 megawatt hours. It will store energy from grid-based electrical generation systems and discharge that energy back onto the grid at a later time. The MP2XL is a 3,916-kilowatt hour BESS and is populated with twenty-four battery modules made up of prismatic, lithium iron phosphate (LFP) cells. This analysis examines four hypothetical scenarios that may result from the release of post-combustion gas products (e.g., flammable gases, carbon monoxide [CO], and carbon dioxide [CO_2]) during a flaming thermal runaway event, and models the resulting plume dispersion of each scenario.

As summarized below, this CRA relies on data collected during UL 9540A testing for the MP2XL, which evaluates the fire safety of BESS by assessing how well they can contain and prevent the spread of fire during a thermal runaway event. The test evaluates the BESS at the cell, module, and cabinet level.

Analysis Approach

The following four scenarios were modeled using Process Hazard Analysis Software Tools (PHAST), for post-combustion gas products:

- Scenario 1: UL 9540A Based Scenario (7 cells).
- Scenario 2: One Tray (112 cells).
- Scenario 3: One Module (3 trays, 336 cells).
- Scenario 4: One MP2XL (24 modules, 8,064 cells).

Each scenario was modeled using PHAST to determine the maximum extent (i.e., the horizontal distance) of the post-combustion flammable vapor and toxic gas cloud. Note, the specific flammable gas mixture and toxic gases modeled in this CRA are based on the gases identified and quantified during UL 9540A module level testing of the MP2XL. For the flammable vapor cloud, FRA modeled the extent of both the lower flammability limit (LFL) and one-half LFL[1] of the flammable gas mixture. For the toxic gases, FRA modeled the concentrations of CO and CO_2 within a post-combustion cloud, as they relate to the Immediately Dangerous to Life and Health

[1] FRA modeled the extent of the one-half LFL to provide additional data and a safety factor when analyzing the Compass BESS site.

(IDLH) levels for each gas.[2] Based on the results of the UL 9540A module level test, however, there were no other toxic gases released that had high enough concentrations to meet the minimum release requirements for PHAST modeling.

Analysis Objective

These modeling results can be used to understand the potential consequences of a gas release from a flaming thermal runaway event (plume analysis) at the Compass BESS. The model evaluates the potential for a flammable vapor cloud, flash-fire envelope, vapor cloud explosion, fireball, CO levels IDLH, or CO_2 levels IDLH. The results, in turn, can be used to inform whether any reasonable and feasible mitigation measures should be incorporated into the project plans.

Summary of Findings

No modeled post-combustion plume scenario resulted in consequences (flammable cloud extent, flash-fire envelope, vapor cloud explosion, fireball, CO IDLH, or CO_2 IDLH) that would be of risk to any persons or property offsite from the Compass BESS.

This executive summary is an abbreviated list of findings. Refer to the main report for details of the analysis**.**

[2] According to National Institute for Occupational Safety and Health (NIOSH), the IDLH of CO is 1,200 parts per million (ppm) and 40,000 ppm for CO_2.

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LIST OF ACRONYMS AND ABBREVIATIONS

Battery Energy Storage System	BESS	Lithium Iron Phosphate	LFP
Carbon Monoxide	CO	Lower Flammability Limit	LFL
Carbon Dioxide	CO_2	Parts per Million	PPM
Community Risk Assessment	CRA	Process Hazard Analysis Software Tools	PHAST
Fire & Risk Alliance, LLC	FRA	Unified Dispersion Model	UDM
Failure Modes and Effect Analysis	FMEA	Vapor Cloud Explosion	VCE
Immediately Dangerous to Life or Health	IDLH		

1.0 INTRODUCTION

Fire and Risk Alliance, LLC (FRA) performed a Community Risk Assessment (CRA) to evaluate the plume dynamics from a hypothetical thermal runaway event from a Tesla Megapack 2 XL (MP2XL) lithium-ion Battery Energy Storage System (BESS), intended for installation at the Compass BESS site, located at 29251 Camino Capistrano, San Juan Capistrano, CA 92675. This CRA involves modeling the dispersion and mixing of gases released from a hypothetical flaming thermal runaway event in a MP2XL to assess the health risks and establish the safe distances from the Compass BESS.

The Compass BESS site is anticipated to initially include 316 MP2XL cabinets, with an approximate capacity of 250 megawatts/1,238 megawatt hours, as shown in Figure 1. It will store energy from grid-based electrical generation systems and discharge that energy back onto the grid at a later time. This analysis examines four hypothetical scenarios that may result from the release of post-combustion gas products (e.g., flammable gases, carbon monoxide [CO], and carbon dioxide [CO_2]) during a flaming thermal runaway event, and models the resulting plume dispersion of each scenario.

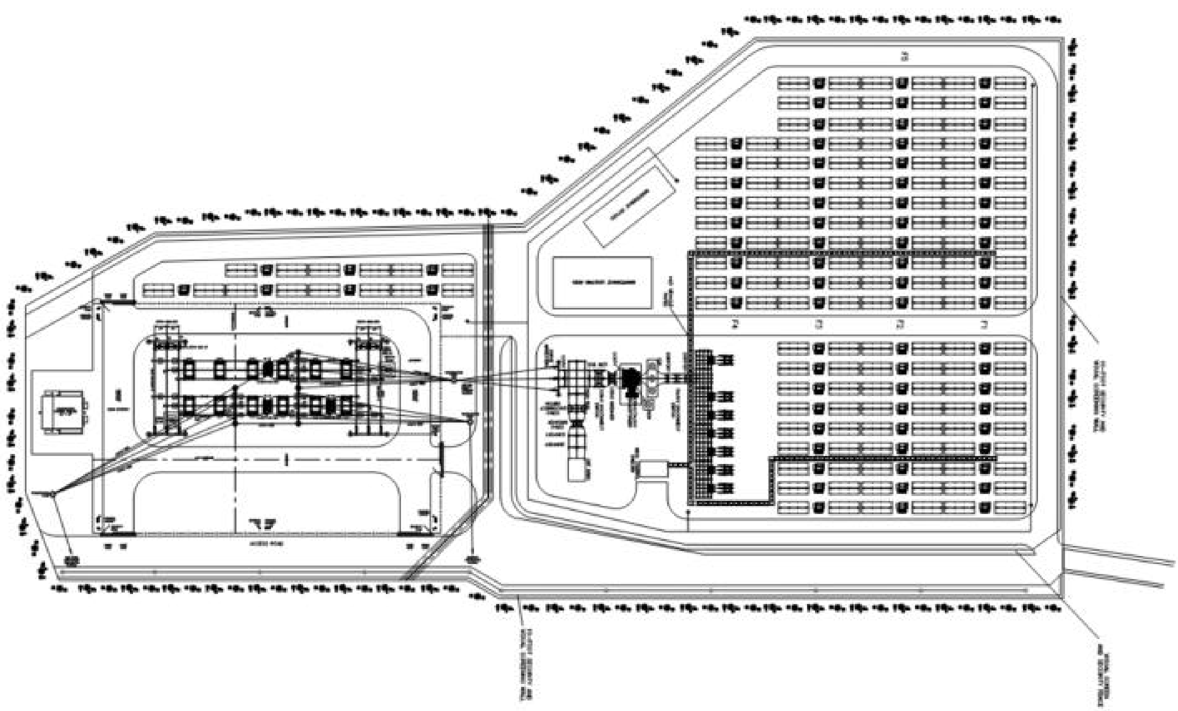

Figure 1. Compass BESS site layout

2.0 MP2XL OVERVIEW

The MP2XL is a 3,916-kilowatt hour BESS cabinet that is approximately 28.9 feet (ft) in length, 5.4 ft deep, 9.2 ft in height, and can weigh up to 84,000 pounds. It is intended for outdoor installations, ground mounted to a foundation or base. The MP2XL is populated with twenty-four battery modules. Each battery module contains three (3) battery trays, as shown in Figure 2, which are arrays of prismatic, lithium iron phosphate (LFP) cells. The LFP cells (the cells) are individually hermetically sealed and are approximately 2 inches, or 50.75 millimeters (mm) by 6.5 inches (166.0 mm) by 6.7 inches (169.3 mm), and weigh 6.6 pounds (2,991 grams). Each battery tray contains 112 cells; meaning, each battery module has 336 cells. In total, the 24-battery module MP2XL cabinets being utilized at the Compass BESS will each have 8,064 cells.[3]

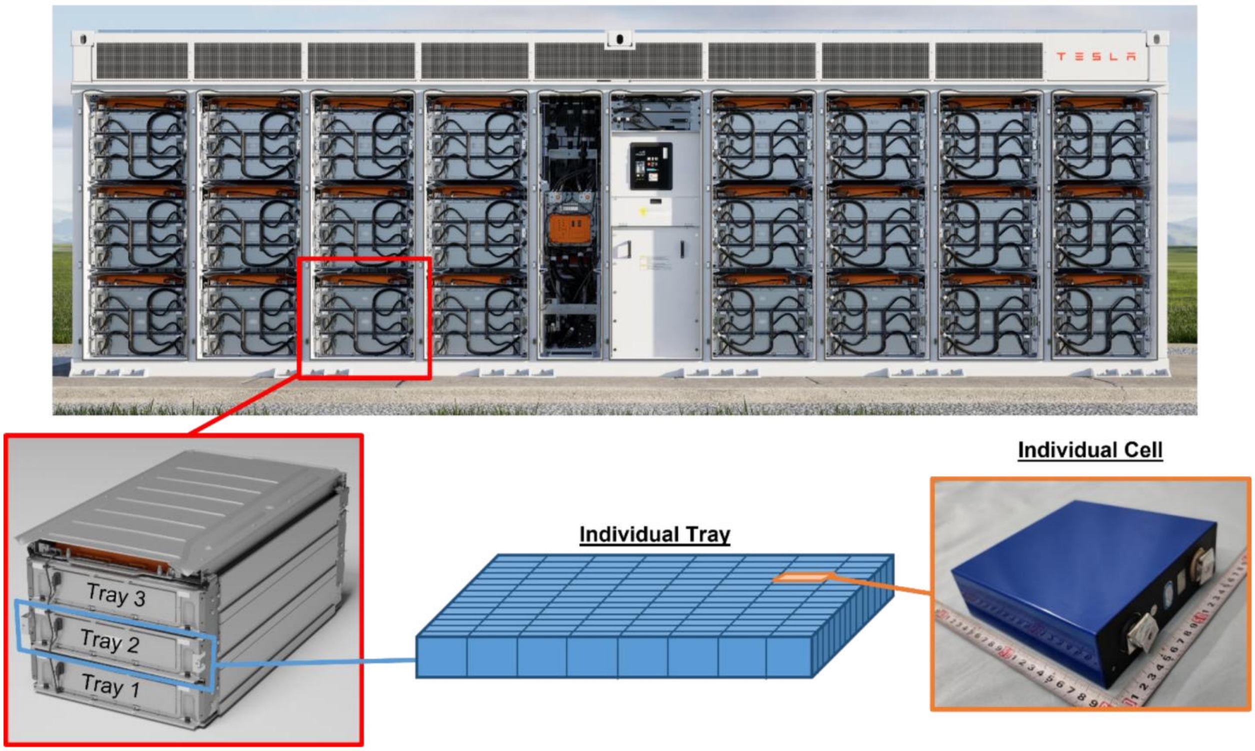

Figure 2. MP2XL unit layout, module layout, generalized tray layout, and an individual cell

The MP2XL was tested to the 4th Edition of UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (UL 9540A). The UL 9540A test method provides a way to evaluate thermal runaway and fire propagation of a lithium-ion BESS at the cell level, module level, unit level, and installation level. The data generated from the test method can be used to determine the fire and explosion protection systems/features required for a BESS installation. This includes, but is not limited to, thermal runaway characteristics of the cell; cell thermal runaway gas composition; the fire propagation potential from cell to cell, module to module, and unit to unit; products of combustion; heat release rate; smoke release rate; and

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3 This report provides a brief description of the MP2XL and UL 9540A test results pertinent for the post-combustion plume analysis. For a more detailed discussion on all the MP2XL components, fire safety features and the UL 9540A tests, refer to the Compass BESS Hazard Mitigation Analysis.

performance of fire protection systems. The data needed to perform the plume modeling is drawn from the UL 9540A tests that have been performed on the MP2XL. Meaning, the plume modeling results presented in this CRA are based on the specific gases released during a MP2XL fire event that were measured during UL 9540A testing.

During MP2XL UL 9540A module level testing, six cells were forced into thermal runaway simultaneously. This forced failure of six cells propagated from the initiating cells to all the cells in the MP2XL tray in a flaming fire event. The test was performed under and hood where the products of combustion from this flaming event could be captured, identified, and quantified. The flammable and toxic gases captured during UL 9540A module level testing are listed in Table 1 as well as their corresponding lower flammability limit (LFL).[4]

Table 1 UL 9540A Module Level Testing: Products of Combustion

Gas Name	Chemical Structure	Vol % Measured	Component LFL %
Carbon Monoxide	CO	2.05	10.9
Carbon Dioxide	CO_2	67.21	N/A
Hydrogen	H_2	4.46	4.0
Methane	CH_4	0.68	4.4
Acetylene	C_2H_2	0.17	2.3
Propane	C_3H_8	2.47	1.7
Benzene	C_6H_6	0.09	1.2
PHAST Calculated LFL and ½ LFL for the Gas Mixture			**5.8% / 2.9%**

[4] The LFL is defined as the lower end of the concentration range over which a flammable gas in the air can be ignited at a given temperature and pressure.

3.0 PHAST CONSEQUENCE MODELING

The Process Hazard Analysis Software Tools (PHAST) Unified Dispersion Model (UDM) was used to calculate the downwind dispersion distances, concentration profiles, and widths of flammable and toxic releases of post-combustion gaseous products. The following four scenarios and associated sub-scenarios were modeled in PHAST:

- Scenario 1: UL 9540A Based Scenario (7 cells)
    - 1.1: Propagation rate of 7-cells per 36.51 minutes from UL 9540A module level test (42.43 l/min)
    - 1.2: 10-minute release duration (theoretical upper bounding release)
- Scenario 2: One Tray Release (112 cells)
    - 2.1: Propagation simultaneously through each cell at a rate of 7-cells per 12.17 minutes from the UL 9540A module level test for all cells (290.94 l/min for 85.19 min)
    - 2.2: 10-minute release duration (theoretical upper bounding release)
- Scenario 3: One Module Release (3 trays: 336 cells)
    - 3.1: Propagation simultaneously through each module at a rate of 7-cells per 12.17 minutes from the UL 9540A module level test for all cells (872.73 l/min for 85.19 min)
    - 3.2: 10-minute release duration (theoretical upper bounding release)
- Scenario 4: One MP2XL Release (24 modules: 8064 cells)
    - 4.1: Propagation simultaneously through each module at a rate of 7-cells per 12.17 minutes from the UL 9540A module level test for all cells (6981.86 l/min for 85.19 min)
    - 4.2: 10-minute release duration (theoretical upper bounding release)

Sub-Scenarios 1.1, 2.1, 3.1, and 4.1 represent models with a calculated release duration based on the cell-to-cell propagation rate observed in the UL 9540A test data, scaled to the number of cells within a tray. This scaled release duration was then utilized as the duration for all subsequent tray/module/enclosure level releases. This is a conservative approach that assumes a common fault/failure leading to thermal runaway in all modules at the enclosure level.

Sub-Scenarios 1.2, 2.2, 3.2, and 4.2 represent the theoretical upper bounding release condition, achieved by condensing the entire post-combustion gas volume into a 10-minute duration release for all tray/module/enclosure level scenarios. These upper bounding theoretical worst-case sub-scenarios are only included in this analysis for understanding the hypothetical peak potential impacts from a condensed release and are not representative of the consequences to be expected from a propagating flaming thermal runaway event, nor utilized for evaluating facility siting.

Post-combustion products from each of the above scenarios were modeled in PHAST to determine the maximum extent of the post-combustion flammable cloud[5] (2.9% ½LFL and 5.8% LFL), the

[5] FRA modeled the extent of the one-half LFL to provide additional data and a safety factor when analyzing the Compass BESS site.

CO IDLH (1,200 ppm) component of the post-combustion cloud, and the CO_2 IDLH (40,000 ppm) component of the post-combustion cloud.

Note, when analyzing IDLH values, the Centers for Disease Control and Prevention (CDC) states the following in terms of both quantity of the gas exposure (in ppm) and the duration of the exposure for CO:

"It has been stated that a 1-hour exposure to 1,000 to 1,200 ppm would cause unpleasant but no dangerous symptoms, but that 1,500 to 2,000 ppm might be a dangerous concentration after 1 hour [Henderson et al. 1921a, 1921b]. In general, a carboxyhemoglobin (COHb) level of 10-20% will only cause slight headaches [NIOSH 1972] and a COHb of 11-13% will have no effect on hand and foot reaction time, hand steadiness, or coordination [Stewart and Peterson 1970]. At a COHb of 35%, manual dexterity is impaired [Stewart 1975]. At 40% COHb, mental confusion, added to increasing incoordination, precludes driving an automobile [Stewart 1975]. A 30-minute exposure to 1,200 ppm will produce a COHb of 10-13% [NIOSH 1972]."

For CO_2, the CDC states:

"Signs of intoxication have been produced by a 30-minute exposure at 50,000 ppm [Aero 1953], and a few minutes exposure at 70,000 to 100,000 ppm produces unconsciousness [Flury and Zernik 1931]. It has been reported that submarine personnel exposed continuously at 30,000 ppm were only slightly affected, provided the oxygen content of the air was maintained at normal concentrations [Schaefer 1951]. It has been reported that 100,000 ppm is the atmospheric concentration immediately dangerous to life [AIHA 1971] and that exposure to 100,000 ppm for only a few minutes can cause loss of consciousness [Hunter 1975]."

3.1 PHAST Model Parameters

Dispersion models require the use of an averaging time to calculate the maximum concentration and plume width for the duration of the release and subsequent time until the cloud concentration falls below threshold values for flammable and toxic levels. The averaging time for the maximum extent of flammable dispersion models in PHAST is 18.75 seconds and 30 minutes for IDLH concentrations. All release timing and mass flow rates for PHAST modeling were based on the conservative values obtained from UL 9540A module level test data, which collected, identified and quantified the products of combustion. This resulted in a mass flow rate for total post-combustion gaseous products of 0.000316 kilograms per second (kg/s) for each cell.

Atmospheric stability and wind speed impact the consequence analysis results by increasing or decreasing the turbidity of the air flow, which in turn will maximize or minimize the dispersion of the vapor cloud. Pasquill stability classes were used to define atmospheric stability for dispersion models, with more stable conditions leading to less turbulent mixing and greater dispersion extents. The stability classes are listed in Table 3. Stability Class F (i.e., stable) was used in the PHAST modeling because it is the most conservative approach and maximizes the extent and concentration of the vapor cloud.[6]

[6] The wind study in this section of the report shows the low wind conditions actually result in worst case exposure conditions for flammable and toxic gas exposure (i.e., largest radius). This is because higher winds allow for more

Table 2 Pasquill Stability Classes

Stability Class	Definition	Stability Class	Definition
A	Very Unstable	D	Neutral
B	Unstable	E	Slightly Stable
C	Slightly Unstable	F	Stable

Wind speed data was obtained for the site based on long-term weather data from the below local stations.

Table 3 Local Weather Stations Utilized

Station ID	Station Name
KNZJ	El Toro Mcas
KNXF	Oceanside Harbor

The average daily maximum, daily average, and daily minimum wind speeds for the site location (10 miles per hour (mph), 5.1 mph, 1 mph, respectively) were used in a sensitivity analysis to determine which produced the furthest extent of the vapor cloud. As shown below in Figure 3 and Figure 4, the 1 mph wind speed produced the farthest extents for the flammable cloud and toxic gas clouds. As such, this wind speed was used as the baseline for all PHAST modeling scenarios.

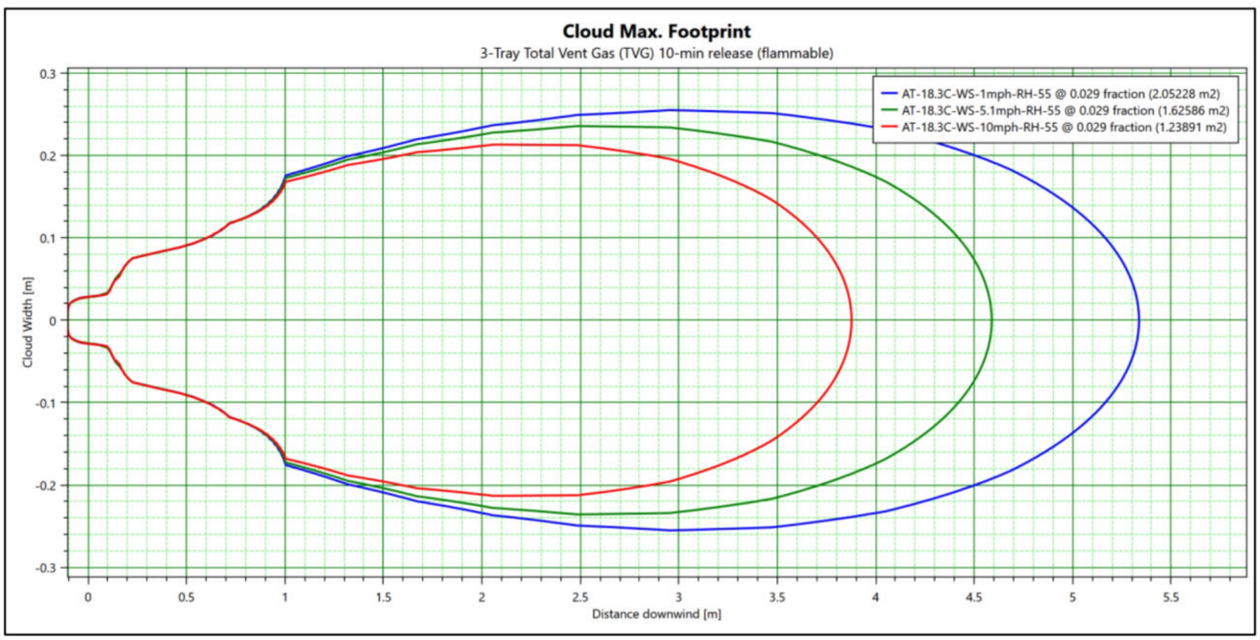


Figure 3. Wind speed comparison for ½ LFL extent (Blue = 1 mph)

mixing of the products of combustion with air, which dilutes the mixture. As such, the higher wind conditions at the site would result in a lesser affected area.

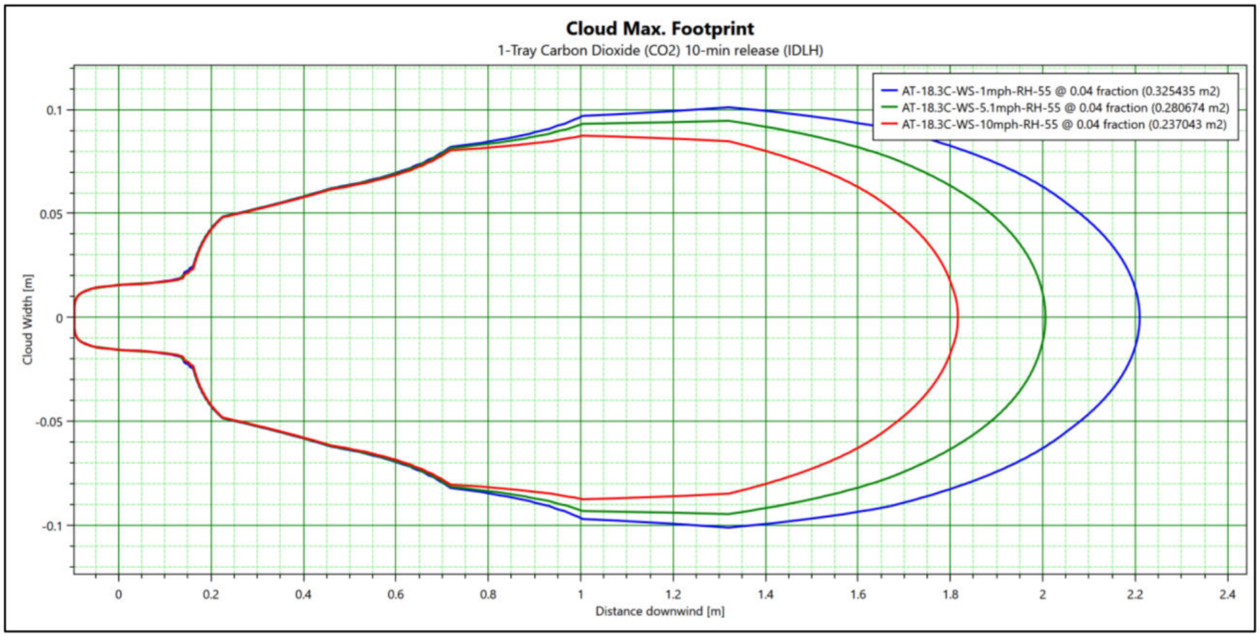


Figure 4. Wind speed comparison for CO_2 IDLH extent (Blue = 1 mph)

Table 4 Representative Weather Conditions

Component	Input Value
Average Minimum Wind Speed (mph)	1
Pasquill Stability Class	F
Ambient Temperature (°F) / (°C)	65 / 18.3
Relative Humidity (%)	55

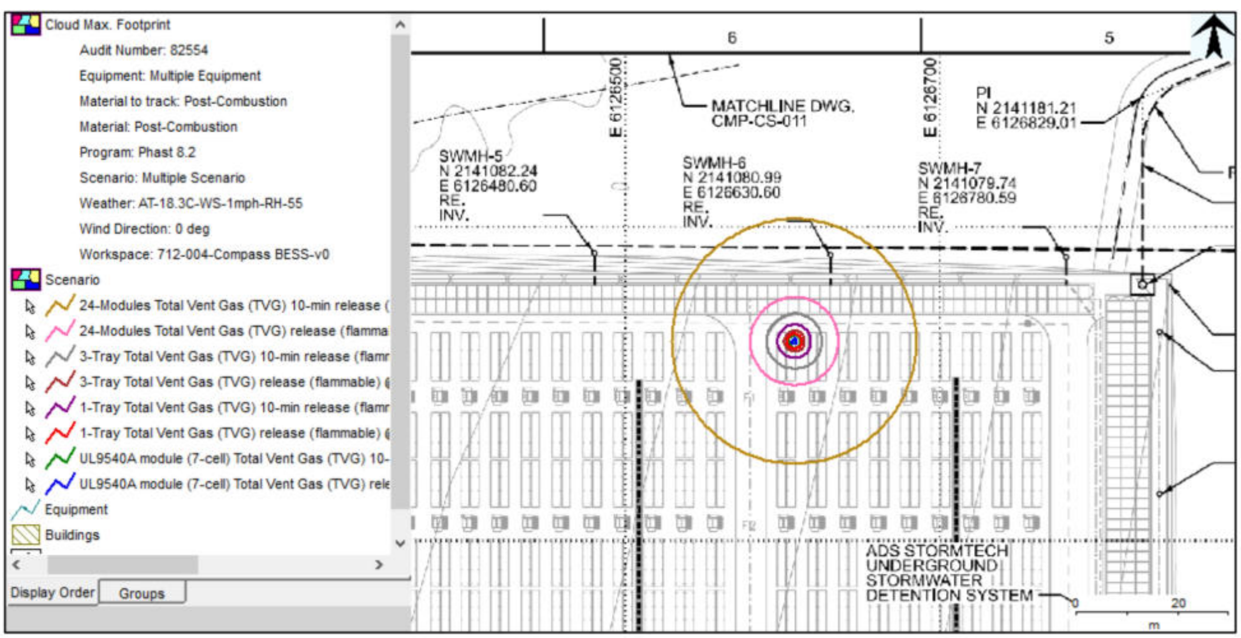
4.0 PHAST RESULTS

Results of the PHAST consequence analysis for the four flaming combustion scenarios (7 cells, one tray, one module, and one entire MP2XL release) and associated sub-scenarios are presented below in Table 5. Images of the vapor cloud dispersion (the maximum extent of the vapor cloud) are presented in Sections 4.1 through 4.5 and a narrative discussion of these results is presented in Section 5.

Table 5 Results Summary of Flammable and Toxic Gas Extents

Scenario	Sub-Scenario (Duration)	Flash-Fire Extent (m)	LFL (m)	½ LFL (m)	CO IDLH* (m)	CO_2 IDLH* (m)
1 (7 cells)	1.1 (36.51 min)	<0.10	0.26	0.49	0.34	0.33
	1.2 (10 min)	<0.10	0.48	1.17	0.62	0.61
2 (1 tray)	2.1 (85.19 min)	0.27	1.01	1.39	1.11	1.1
	2.2 (10 min)	1.04	1.83	3.22	2.23	2.21
3 (1 module)	3.1 (85.19 min)	0.47	1.32	2	1.51	1.5
	3.2 (10 min)	1.47	3.02	5.34	3.74	3.70
4 (1 MP2XL)	4.1 (85.19 min)	2.18	4.93	8.53	6.07	6.01
	4.2 (10 min)	6.17	13.60	23.68	16.59	16.38

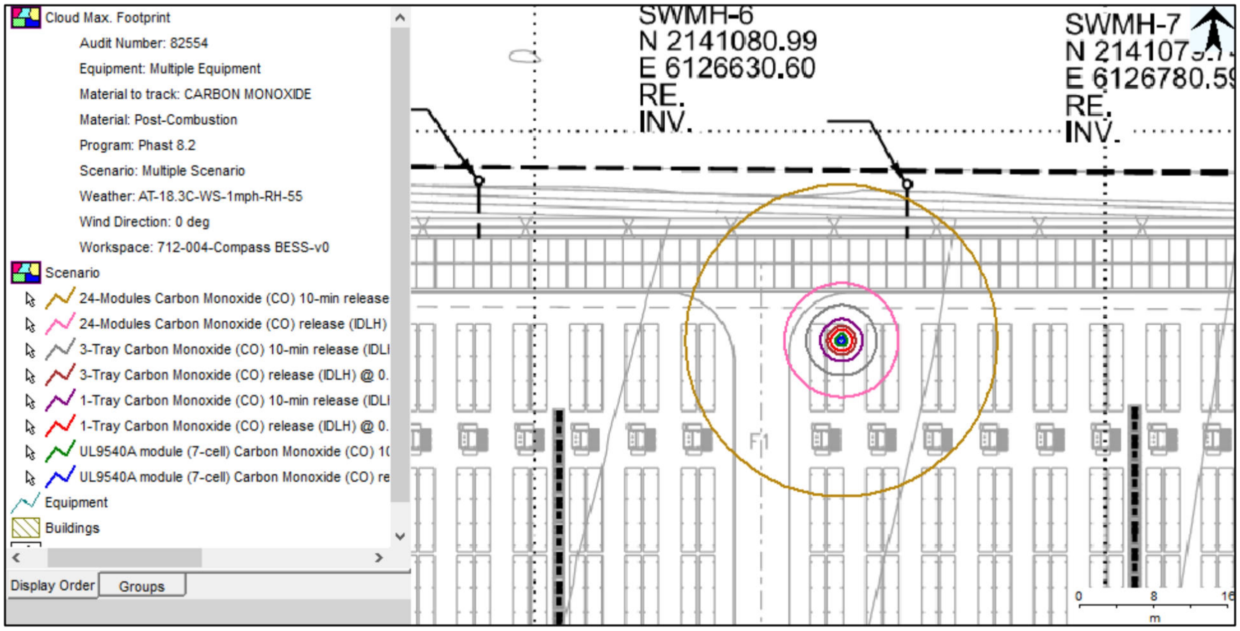
4.1 Vent Gas Flammability (1/2 LFL) Extents Post Combustion



Scenario: 1.1 (Blue), 1.2 (Green), 2.1 (Red), 2.2 (Purple), 3.1 (Maroon), 3.2 (Grey), 4.1 (Pink), & 4.2 (Gold)

Figure 5 Map of horizontal extent of flammable vapor cloud (½ LFL)

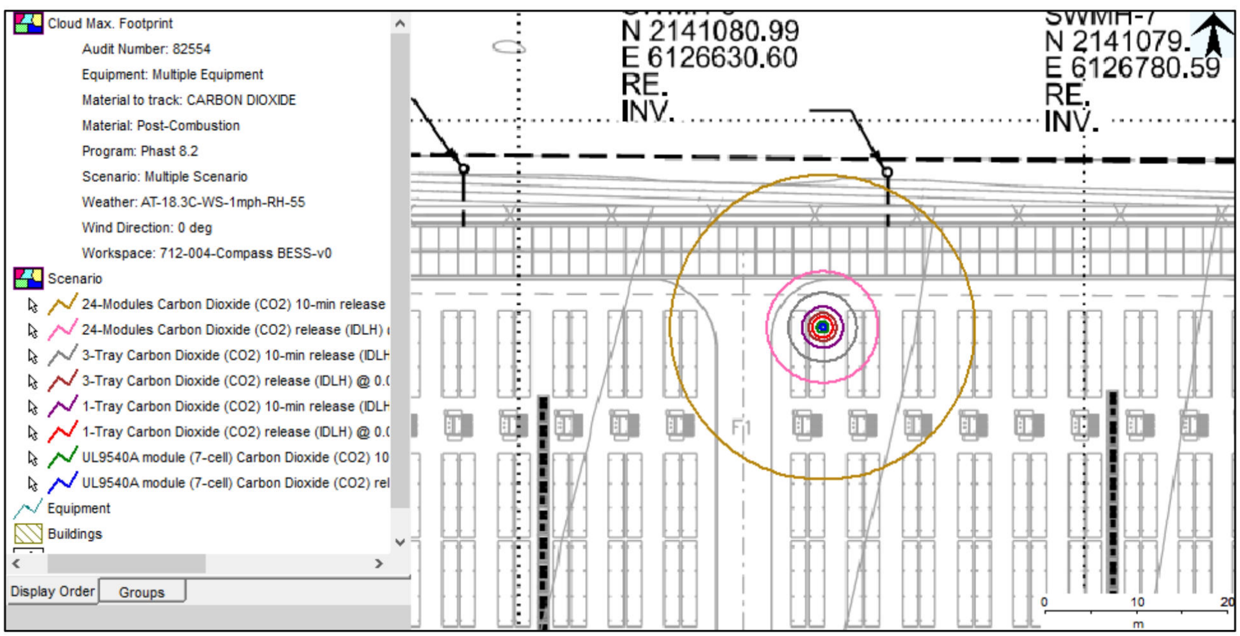
4.2 Carbon Monoxide IDLH (1,200 ppm) Extents Post Combustion



Scenario: 1.1 (Blue), 1.2 (Green), 2.1 (Red), 2.2 (Purple), 3.1 (Maroon), 3.2 (Grey), 4.1 (Pink), & 4.2 (Gold)

Figure 6 Map of horizontal extent of vapor cloud for CO IDLH (1,200 ppm)

4.3 Carbon Dioxide IDLH (40,000 ppm) Extents Post Combustion



Scenario: 1.1 (Blue), 1.2 (Green), 2.1 (Red), 2.2 (Purple), 3.1 (Maroon), 3.2 (Grey), 4.1 (Pink), & 4.2 (Gold)

Figure 7 Map of horizontal extent of vapor cloud for CO_2 IDLH (40000 ppm)

4.4 Flash Fire Extents Post Combustion Gas

Flash fires occur when the post-combustion gas components are diffused in the air such that all flammable fuel is consumed nearly instantaneously once ignited. In a flash fire, the flame front accelerates rapidly from the ignition point to the outer limit of the flammable cloud, after which the flame immediately goes out. For a flash fire to occur in a post-combustion vapor cloud, reignition of the cloud must occur at some point downwind from the fire source itself, representing an unlikely scenario.

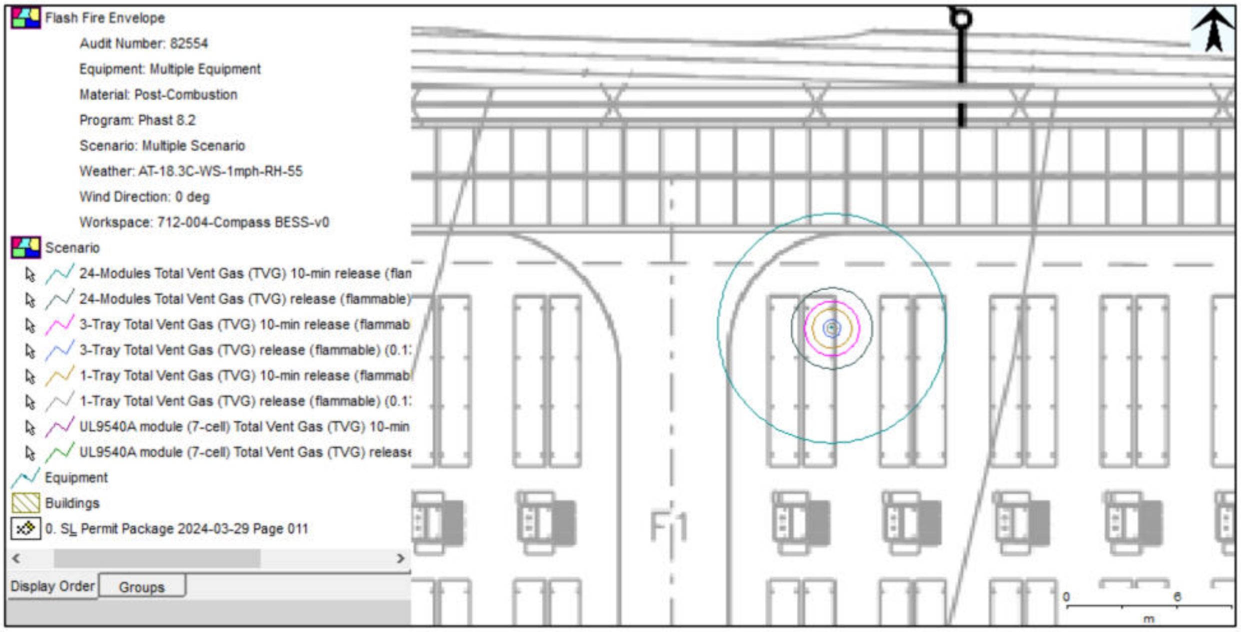


Figure 8 Maximum Extent of Flash Fire Envelope (Duration < 3 sec)

4.5 Explosion & Fireball Results

In general, in order for a vapor cloud explosion (VCE) or fireball to occur from the ignition of a flammable vapor cloud, the flame speed must accelerate to a sufficiently high velocity to produce significant overpressure or burning rates. For this to occur, the following conditions listed in Table 6 must be met. As demonstrated in Table 6, none of the modeled post-combustion gas product release scenarios led to the consequence of a VCE or fireball occurring. Therefore, there was no explosion or fireball risk identified.

Table 6 VCE and Fireball Conditions

Condition	Modeled Condition Met / Not Met
The released material must be flammable and in suitable conditions. The more reactive the fuel, the lower the fuel burden required.	Met
An ignition source is needed. The presence of an ignition source is assumed.	Met

Condition	Modeled Condition Met / Not Met
Ignition of the flammable cloud must be delayed until the formation of a suitable cloud volume occurs	Not Met
If ignition occurs as the flammable material is escaping, a flash fire will occur instead.	Met
Adequate turbulence, confinement, and/or congestion within the cloud is required for the flame front to accelerate to the speeds required for a VCE; otherwise, a flash fire will result.	Not Met
Under near-laminar flow conditions, flame speeds are below those required to produce significant overpressure, resulting in a flash fire	Met
Confinement of the cloud results in rapid increases in pressure during combustion	Not Met
Absence of confining obstacles such that outward expansion of the cloud is unmitigated during combustion. As such, sufficient flame speeds are not reached upon ignition, and a flash fire occurs.	Met

5.0 CONCLUSIONS

All of the post-combustion scenarios modeled in this analysis (using the post-combustion gas composition data from the MP2XL UL 9540A test data) resulted in endpoints that showed no risks to persons or property extended offsite of the project property boundaries. Modeled potential risks from post-combustion gas components (flammable cloud extent, flash-fire envelope, vapor cloud explosion, fireball, CO IDLH, or CO_2 IDLH) within the project site can be mitigated with proper site management, emergency response planning, and training.

It must be noted that while Scenario 4.2 provides the greatest extents of flammable and vapor clouds, this scenario was only modeled to represent the theoretical upper bounding release condition. This upper bounding theoretical worst-case scenario is only included in this for understanding the hypothetical peak potential impacts from a condensed release and are not representative of the consequences to be expected from a propagating thermal runaway event, where thermal runway propagates from cell to cell through a module and to adjacent modules. In reality, the potential for an entire MP2XL to release all post-combustion gas volume (i.e., fully burn itself out in 10 minutes and release all of the products of combustion in this 10-minute duration) is not a likely or even feasible scenario. Nor should these hypothetical worst case bounding release results be utilized for evaluating facility siting. These results should help guide emergency response planning and first responder training.

5.1 Flammable Gases

5.1.1 LFL

Modeling results for all scenarios and sub-scenarios showed no significant impacts from flammable post-combustion gas dispersion offsite. Being conservative and analyzing the ½ LFL extent, the maximum extent of the ½ LFL flammable vapor cloud was 23.68 meters (77.69 feet) from the MP2XL. This distance was from Scenario 4.2, which is the hypothetical upper-bounding 10-minute duration event for an entire MP2XL. However, as stated above, this scenario is not meant for facility-siting, rather to provide a theoretical upper bounding distance to guide emergency response planning. The maximum extent of the ½ LFL cloud based upon the UL 9540A based flaming propagation rate, was 8.53 meters (27.99 feet). This distance was from Scenario 4.1 and is well below the distance to all property boundaries. **As such, there is no significant risk to persons or property offsite from a flammable vapor cloud**.

5.1.2 Flash Fires

Modeling results for all scenarios and sub-scenarios showed no significant impacts from flash-fires offsite. The maximum extent of impact from the flash-fire envelope was 6.17 meters (20.24 feet) from the MP2XL. This distance was from Scenario 4.2, which is the hypothetical upper-bounding 10-minute duration event for an entire MP2XL. Even at this hypothetical upper bounding scenario, the flash-fire envelope is well below the distance to all property boundaries. Within the small, affected area onsite, the duration of heat flux values equal to those sufficient to ignite flammable clothing or cause second-degree burns to exposed skin does not occur for more than 1 to 3 seconds (NFPA defines the upper limit of a flash fire to be 3 seconds) in any single location within the flash fire envelope. **As such, there is no significant risk to persons or property on or offsite from flash fires.**

5.1.3 Explosion & Fireballs

None of the modeling results for all scenarios and sub-scenarios led to a consequence of a VCE or fireball occurring. As such, there is no significant risk to persons or property on or offsite from a VCE or fireball.

5.2 Carbon Monoxide

Modeling results for all scenarios and sub-scenarios showed no significant impacts from CO IDLH (1,200 ppm) offsite. The maximum extent of impact from the CO component of the vapor cloud gas dispersion for an IDLH of 1,200 ppm was 16.59 meters (54.43 feet) from the MP2XL. This distance was from Scenario 4.2, which is the hypothetical upper-bounding 10-minute duration event for an entire MP2XL. This distance extends up to and could pass the Compass BESS property line (the closest MP2XL cabinet to the property line was measured to be approximately 53 feet). However, as stated above, this scenario is not meant for facility-siting, rather to provide a theoretical upper bounding distance to guide emergency response planning. The maximum extent of the CO IDLH cloud based upon the UL 9540A based flaming propagation rate, was 6.07 meters (19.91 feet). This distance was from Scenario 4.1 and is well below the distance to all property boundaries. **As such, there is no significant risk to persons or property offsite from a CO cloud**.

5.3 Carbon Dioxide

Modeling results for all scenarios and sub-scenarios showed no significant impacts from CO_2 IDLH (40,000 ppm) offsite. The maximum extent of impact from the CO_2 component of the vapor cloud gas dispersion for an IDLH of 40,000 ppm was 16.38 meters (53.74 feet) from the MP2XL. This distance was from Scenario 4.2, which is the hypothetical upper-bounding 10-minute duration event for an entire MP2XL. This distance extends up to and could pass the Compass BESS property line (the closest MP2XL cabinet to the property line was measured to be approximately 53 feet). However, as stated above, this scenario is not meant for facility-siting, rather to provide a theoretical upper bounding distance to guide emergency response planning. The maximum extent of the CO_2 IDLH cloud based upon the UL 9540A based flaming propagation rate, was 6.01 meters (19.72 feet). This distance was from Scenario 4.1 and is well below the distance to all property boundaries. **As such, there is no significant risk to persons or property offsite from a CO_2 cloud**.

6.0 LIMITATIONS

At the request of Engie North America, FRA performed a CRA to evaluate the plume dynamics from a hypothetical thermal runaway event from a Tesla MP2XL lithium-ion BESS, intended for installation at the Compass BESS site, located at 29251 Camino Capistrano, San Juan Capistrano, CA 92675. This CRA involves modeling the dispersion and mixing of gases released from a hypothetical flaming thermal runaway event in a MP2XL to assess the health risks and establish the safe distances from the Compass BESS. This analysis was limited to conducting a post-combustion plume analysis for a fully populated MP2XL (24 modules) utilizing the cells and UL 9540A test results identified within this report.

Disclaimer

The scope of services performed during this analysis may not adequately address the needs of other users of this report, and any re-use of this report or its conclusions presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the analysis. This assessment relied on the products of combustion data collected from the MP2XL UL 9540A tests. These tests were performed by others and the UL 9540A test data was provided to FRA for inclusion in this analysis. No guarantee or warranty as to future performance of any reviewed condition is expressed or implied.

The results presented in this report do not constitute a guarantee or warranty of performance in the field. The accuracy and applicability of this report’s findings may be subject to changes in conditions, technology, and standards that are beyond the scope of this analysis. As such, the conclusions presented herein are applicable solely to the specific product and site, and the application described in this report.