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Fire Safety Study (FSS)

Project Name: Bendigo BESS - 20
Hattam Street, Golden
Square
Job Number: 10051
Date: 21 August 2026
Client: Pacific Blue
Revision: 06

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1 EXECUTIVE SUMMARY

NJM Design has been engaged by Pacific Blue to undertake a Fire Safety Study (FSS) for the Bendigo Battery Energy Storage System (BESS) located in 20 Hattam Street, Golden Square, Victoria, to the north of the existing Bendigo Terminal Station.

Bendigo BESS is a 201MW/866MWh BESS units connected to the 220kV Bendigo terminal station via underground cable. The primary access to the site is via Hattam Street to the north.



Figure 1: Bendigo BESS – General Location/Site plan.

Bendigo BESS facility is as presented in Figure 5. The project and associated infrastructure include:

- BESS compound, including power conversion systems (PCS) units, containerised battery energy storage units and underground and overhead cabling.
- On-site substation, including High Voltage (HV) power transformer, switch room, control room and other electrical infrastructure.
- Transmission connection infrastructure consisting of an underground 220kV cable to the Bendigo Terminal

Station.

- Operation and maintenance (O&M) compound, including storage shed and car park.
- Security fencing and monitoring systems.
- Water storage system and firefighting infrastructure.
- Perimeter fire break and internal access tracks.
- Temporary construction laydown area.
- Noise walls.
- Medium Voltage (MV) power stations.

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This fire safety study has been prepared based upon a concept design for the purposes of supporting a planning permit application. If a planning permit is approved, it is expected that conditions of permit and further detailed design will address additional fire risk and mitigation items.

The assessment in this study of the worst-case scenarios where equipment is on fire has demonstrated that any fire originating in one element of the project (i.e., BESS unit, transformer or building) will not propagate to adjacent equipment or adjoining allotments/vegetation.

Given the proposed measures set out in Section 3 below are achieved, it is considered that the development complies with the Design Guidelines and Model Requirements: Renewable Energy Facilities, Country Fire Authority (CFA), June 2025 (v4.4) (see Table 1 below and detail in Section 10.2).

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Section and Requirement	Compliant/Addressed (Yes/No) - Comment
Section 2.2.2 of the Guide states that the bushfire risk is required to be addressed according to the Victorian Planning Provisions.	Yes - Section 6.1.4 and Section 9.2.8.
Section 3.3.3 states that for BESS facilities the following hazards be addressed (electrical, chemical, fire spread, mechanical, landscape).	Yes – See Section 8.
Section 3.3.5 also recommends a fire safety study for large scale battery energy storage systems (BESS) over 1MWh based on CFA's Fire Safety Studies for Battery Energy Storage Systems Guideline (v1, 2025) [1] to be undertaken.	Yes – It is this FSS and see Section 5.1.
Section 4.1 indicates the low-risk location attributes.	Yes – Refer to per Section 6.1.4.
Section 4.2.1 requires the following with respect to fire brigade vehicle access.	Yes – Refer to above requirements, Figure 5 and Section 10.2.
Section 4.2.2 requires the following with respect to firefighting water supply.	Yes - Refer to above requirements and Section 10.2.
Section 4.2.3 requires the following with respect to fire detection and suppression equipment.	Yes - Refer to above requirements and Section 10.2.
Section 4.2.4 requires the following with respect to management of Landscape Screening and on-site vegetation.	Yes - Refer to above requirements.

Section and Requirement	Compliant/Addressed (Yes/No) - Comment
Section 4.2.5 requires the following with respect to fire breaks.	Yes - Refer to above requirements and Section 10.2.
Section 4.2.6.4 requires the following with respect to management of Fire Water Runoff.	Yes - Refer to above requirements and Section 10.2.
Section 4.3 recommends the element to provide to the battery energy storage systems.	Yes - Refer to above requirements and Section 10.2.

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2 ABBREVIATIONS

AC	Alternating Current
AS	Australia Standard
BAL	Bushfire Assessment Level
BESS	Battery Energy storage System
BMS	Battery Management system
BMO	Bushfire Management Overlay
CFA	Country Fire Authority
DC	Direct Current
ESV	Energy Safe Victoria
FAA	Federal Aviation Administration
FBIM	Fire Brigade Intervention Model
HIPAP	Hazardous Industry Planning Advisory Paper
HRR	Heat release rate
HV	High Voltage
IFEG	International Fire Engineering Guidelines
IN1Z	Industrial Zone
MV	Medium Voltage
NCC/BCA	National Construction Code/Building Code of Australia
NFPA	National Fire Protection Association
NSW	New South Wales
O&M	Operations and Maintenance
SCADA	Supervisory Control and Data Acquisition
SCBA	Self-contained breathing apparatus
SOC	State of charge
SUT	Set up Transformer
THC	Total Hydrocarbon Content
UL	Underwriters Laboratories
VBB	Victorian Big Battery

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3 MAIN FINDINGS AND REQUIREMENTS

The assessment in this study of the worst-case scenarios where equipment is on fire achieving compliance with the requirements below has demonstrated that any fire originating in one equipment (i.e., BESS unit, transformer or building) will not propagate to adjacent equipment or adjoining allotments/vegetation and will not increase the risk to occupant life safety.

The following specifications and recommendations are to be implemented to satisfy the objectives of the relevant authorities and the client, and to mitigate the risks discussed in this document.

Refer to Figure 5 for overall site plans indicating the main Fire Engineering Requirements.

1. The BESS supplier must provide the results of a large-scale test in accordance with CSA TS-800:24 and/or UL9540A, and the laboratory/centre certifications.
2. The BESS units must have the following safety measures (not limited to):
 - Provision of a BMS (Battery management system).
 - Smoke and heat detection.
 - Gas detection.
 - Fire alarm.
 - Door alarms.
 - Electrical safety measures (e.g., ground faults, high voltage, communication faults, etc.).
 - Automatic and manual stops that shutdown the battery.
 - Temperature controls.
 - Deflagration and ventilation systems / overpressure vents designed as per NFPA 68 and NFPA 69.
 - Lighting protection.
 - BESS enclosure must be sealed with IP55 rating.
3. The proposed BESS layout must be reviewed to match the supplier's specifications and the large-scale tests.
4. The clearances between BESS units must not be less than 3.0m unless a large-scale test in accordance with CSA TS-800:24 and/or UL9540A is provided.
5. All equipment must be SCADA Alarmed and will allow automatic notification to the operators, who will proceed according to the Emergency plan and the protocols.
6. A Fire hydrant system as per AS 2419.1 must be provided throughout the facility for fire brigade intervention procedures. The location of hydrants must be designed as follows:
 - The hydrants will be located such that all infrastructure can be covered by at least 2 hydrants.
 - Two hydrants located to opposite sides are required to achieve full hydrant coverage within the space covered by the noise walls (to be designed by the fire services consultant).
 - Fire services consultant must provide the hydrant coverage to any point by 2 fire hydrants.

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7. Transformers must comply with AS2067 separation distances for transformers and other surfaces:

- Where transformers are oil-insulated, transformers shall use an FR3 (or similar) Ester oil where practical in lieu of the normal mineral oil.
- MV/SUT transformers, if provided with less combustible liquid-insulated transformers (K) with enhanced protection, must not be located to less than 0.9m from the non-combustible surfaces/equipment to comply with the requirements of the AS 2067.
- MV/SUT transformers, if provided with FR3 (or similar) Ester oil must not have an oil capacity of more than 38,000 litres (38 m³) and must not be located to less than 1.5m from the non-combustible surfaces/equipment to comply with the requirements of the AS 2067.
- HV transformers should have a bund with the capacity to hold the oil volume to account for water and overflow.
- HV transformers must keep a clearance to other equipment and buildings as per with AS2067 (see figure below) subject to the final HV transformer specifications.

Transformer type	Liquid volume L m ³	Clearances to other transformers or equipment		Clearances to buildings	
		Horizontal separation G ₁ to other transformers or non-fire resistant surfaces m	Horizontal clearance G ₂ to non-fire resistant surfaces of buildings m	Horizontal clearance G ₃ to non-fire resistant surfaces of buildings m	Vertical extent G ₄ for 2 hour fire resistant surfaces of buildings m
Oil-insulated transformers (O)	100 ≤ 1000	1	6	1	4.5
	>1000 ≤ 2000	3	7.5	1.5	7.5
	>2000 ≤ 20 000	4	10	4.5	15
	>20 000 ≤ 45 000	10	20	7.5	30
	>45 000 ≤ 60 000	15	30	7.5	30
	>60 000	23	30	7.5	30
Less combustible liquid-insulated transformers (K) without enhanced protection	100 ≤ 1000	1	6	1	4.5
	>1000 ≤ 38 000	1.5	7.5	1.5	7.5
	>38 000	4.5	15	4.5	15
Less combustible liquid-insulated transformers (K) with enhanced protection (refer to Note 1)	Clearance G ₁ to other transformers or building surfaces				Vertical extent G ₄ for 2 hour fire resistant surfaces of buildings
	Horizontal m				Vertical m
	0.9				1.5
Dry-type transformers (A) Fire behaviour class F ₀	1.5				3.0

Figure 2 – AS 2067:2016-Table 6.1 – Clearance for outdoor transformers [2].

- A firewall must be provided to the transformer as per AS2067 where non-fire rated buildings or roads are located within 23m from the HV transformers as shown in Figure 3 below.

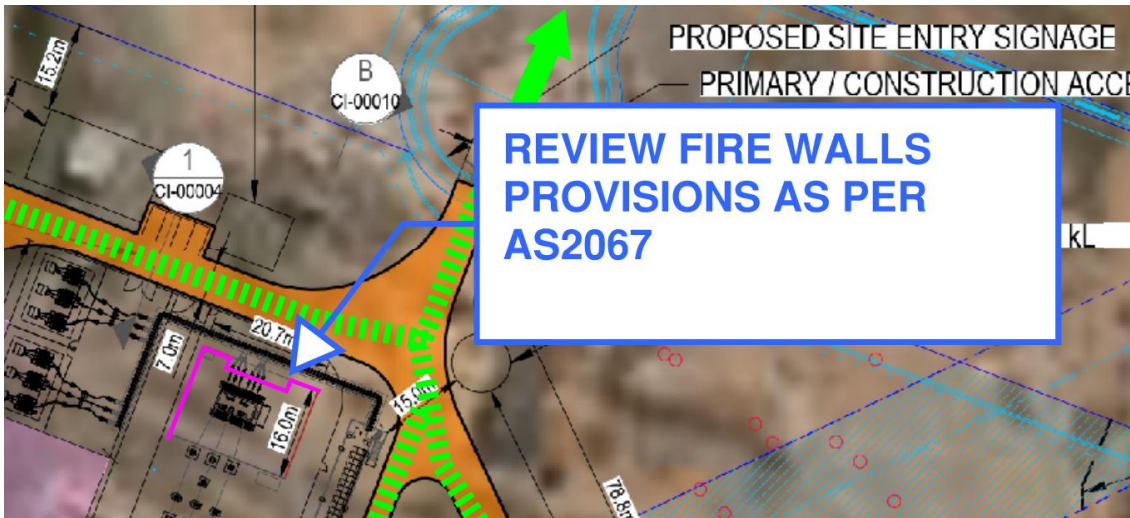


Figure 3 – Firewall to HV transformer.

8. All buildings within the facility must comply with the performance requirements of the NCC where the DTS provisions are not satisfied:

- O&M Building, Storage Shed and Control/Switch room buildings must be constructed with non-combustible cladding.
- The control/switch room building must be provided with a fire-rated walls with an FRL of at least 2 hours. Its external doors must be provided with fire rated doors - /120/30 and self-closing device.
- The control/switch room building must be located to not less than 7.5m from the bund of the HV transformer.
- All buildings (i.e., storage shed, detention storage, O&M building, control building) must be separated from each other and other equipment by at least 6m as per the NCC DTS provisions, or
- Where clearances between buildings are less than 6m, non-combustible and/or fire rated walls are recommended.

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9. The firefighting water will be sufficient for 4 hours supply based on at least 4 hydrants; hence the water storage must be at least 576kL (2 water tanks of 288kL each).
10. Water storage of not less than 576kL (2 water tanks of 288kL each) must be provided at an entrance of the facility with a compliant hard stand and booster assembly in accordance with the latest CFA Guidelines Revision 4 [3] as follows:
- Water access points must be clearly identifiable and unobstructed to ensure efficient access.
 - Static water storage tank installations must comply with AS 2419.1-2021: Fire hydrant installations – System design, installation and commissioning.
 - The static water storage tank(s) must be an above-ground water tank constructed of concrete or steel.

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- The static water storage tank(s) must be capable of being completely refilled automatically or manually within 24 hours.
- The static water storage tanks must be located at vehicle access points to the facility and must be positioned at least ten (10) metres from any structure and 23m from the HV transformer.
- The hard-suction point must be provided, with a 150mm full bore isolation valve equipped with a Storz connection, sized to comply with the required suction hydraulic performance.
- Adapters that may be required to match the connection are: 125mm, 100mm, 90mm, 75mm, 65mm Storz tree adapters with a matching blank end cap to be provided.
- The hard-suction point must be positioned within four (4) metres to a hardstand area and provide a clear access for emergency services personnel.
- An all-weather road access and hardstand must be provided to the hard-suction point. The hardstand must be maintained to a minimum of 15 tonne GVM, eight (8) metres long and six (6) metres wide or to the satisfaction of the CFA.
- The road access and hardstand must be kept clear at all times.
- The hard-suction point must be protected from mechanical damage (e.g., bollards) where necessary.
- Where the access road has one entrance, an eight (8) metre radius turning circle must be provided at the tank.
- An external water level indicator must be provided to the tank and be visible from the hardstand area.
- Signage indicating 'FIRE WATER' and the tank capacity must be fixed to each tank.
- Signage must be provided at the front entrance to the facility, indicating the direction to the static water tank.
- Signage must be provided to the alternative entrances of the facility, indicating the direction to the static water tank.

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11. The following Table 2 summarises the requirements for the roads within the BESS development:

Table 2 – Requirements for the roads review.

Recommendations	Compliance/Comments
A firebreak of at least 10m wide must be designed and maintained.	Compliant in the proposed layout in Figure 5.
The six (6) metre perimeter road within the perimeter fire break must be maintained and designed to comply with the requirements of the CFA Design Guidelines for renewable Energy Facilities [3] and to facilitate fire brigade intervention procedures.	Compliant in the proposed layout in Figure 5.
All corners of the roads and BESS isles must be provided with bollards.	To be incorporated at a later stage in the design.

Recommendations	Compliance/Comments
Two (2) entrances must be provided to the facility. The location of the secondary/alternative access to the east side of the development has been assessed in Section 9, demonstrating that both entrances will remain accessible given the worst location for the worst fire.	Compliant as seen in proposed layout in Figure 5.
Provide a turn-around point in the construction compound to facilitate fire brigade intervention procedures, as shown in Figure 5 below	To be incorporated at a later stage in the design.

12. Access through the entrances must be provided by opening 003-key padlocks or intercom systems.
13. Each vehicle and heavy equipment must carry at least a nine (9)-litre water stored-pressure fire extinguisher with a minimum rating of 3A, or other firefighting equipment as a minimum when on-site during the Fire Danger Period [3].
14. The BESS facility must be provided with portable fire extinguishers as per AS2444.
15. A containment and management plan of contaminated fire water runoff from the BESS is to be developed by the facility. The following applicable as part of the plan.
- HV transformers should have a bund with the capacity to hold the oil volume to account for water and overflow.
 - The Construction Techniques for Sediment Pollution Control (1991) and Managing soil disturbance: guidance sheet (2020) could be used to develop a Developing and Implementing an Erosion and Sediment Control Plan (ESCP).
16. Fire brigade and Staff intervention during an emergency is expected to be managed to the degree necessary given the following safety measures:
- Provision of warning signs. Some signage includes the following examples (not limited to):
 - Exit signs.
 - First aid firefighting equipment (fire hydrants, water storage tanks, fire extinguishers, etc.).
 - Electrical hazards (e.g., high voltage).
 - Equipment use instruction signs.
 - Entrances to the facility and buildings (e.g., RMUs, SUT, SWG, Control building, etc.).
 - Presence of chemical hazards.
 - Toilets and facility related signs.
 - Rescue and resuscitation signs.
 - Fire exit doors.
 - Restricted personal access to specific areas/buildings.
 - Name to equipment/enclosures (e.g., RMUs, SUT, SWG, Control building, etc.).

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- Firefighters should wear self-contained breathing apparatuses (SCBAs) and structural firefighting gear.
 - Firefighters will not enter the facility unless instructed and accompanied by a qualified employee.
17. Develop a Fire Management Plan as required by the CFA Design Guidelines [3] for Renewable Energy Facilities and it must consider/include the following:
- This plan must be performed as part of secondary consents and as a condition of planning permit.
 - Must contain at least the following content (figure below).

Fire Management Plan Structure and Content	
A summary of fire hazards and risks to and from the site, specific to its location, infrastructure, activities and occupancy.	Based on sound hazard identification and risk management processes. This must include risks to firefighter safety during emergencies.
Description of control measures to prevent fire occurring and limit the consequences of fire at the facility.	Fire permits, ignition source controls, hot work permits, job hazard analyses, infrastructure/vehicle/equipment/road/fence/access maintenance, waste management, compliant dangerous goods storage and handling, vegetation/fuel reduction and management, peat management, Emergency Plan.
Description of control measures to prevent and reduce the consequences of external fire impacting the facility.	Bushfire monitoring, bushfire preparedness, reduced personnel presence/activities/travel on days of Severe and above Fire Danger Rating, creation and management of fire breaks at the site perimeter and around infrastructure, vegetation/fuel reduction and management, Emergency Plan.
Details of equipment and resources to manage fire at the facility.	Fire detection and suppression systems, fire water supplies, automatic shut-down and isolation systems, monitored alarms, communications equipment, occupant warning systems, designated evacuation assembly areas, Emergency Information Container(s), Emergency Plan.
Policies and procedures that ensure all control measures are appropriate and effective, and remain so.	Performance standards for risk controls, specific activities to verify controls (servicing/maintenance, housekeeping inspections, external audits), review processes for risk control effectiveness.
Procedures for review of the Fire Management Plan.	Review triggers and schedule, organisational accountability for the Plan, allocated responsibilities (to persons or roles) for the ongoing review and development of the Plan.

Figure 4: Fire Management Plan Requirements as per CFA Design guidelines [3].

- The plan must consider (not limited to) the personnel/staff involved in emergency response, fire brigade, operations and maintenance.
- This plan must be trained on and drilled. All personnel working onsite must be informed of and provided within training regarding the policies and procedures set out in the Fire Management Plan.
- Must be communicated with local regulatory authorities is essential to ensure alignment on the Emergency Management Plan.
- The plan must be updated, communicated, and relevant personnel retrained promptly whenever emergency-

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related information changes.

- The plan must account for scenarios where simultaneous bushfire and battery fires occur.
- The plan must account for scenarios where an immediate fire brigade response is not available.

18. The BESS development must develop a vegetation management plan and implement the recommendations provided in the Bushfire Hazard Assessment (Bushfire Hazard Assessment – Bendigo BESS. Agilus.

19. An electrical hazards and risk assessment is to be performed by the facility (another consultant to address).

20. The site layout is summarized in Figure 5 below.



Figure 5: General Site Layout and roads.

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4 SCOPE

4.1 GENERAL

A review of the design to applicable standards has been undertaken as well as a comparative risk assessment to existing power utility infrastructure and industrial facilities in the same setting.

An assessment of the likelihood of ignition and fire spread from a battery unit was undertaken. This assessment included the investigation of the likely heat release rate (HRR) of a fire and its impact on an adjacent building as a result of radiant heat transfer.

It is beyond the scope of this fire risk assessment to assess the likely spread at ground level of firefighting water run-off. However, it is noted that, as per the architectural drawings, a grassed swale leads to a retention pond on the west side, and its management must be documented as part of the Emergency Management Plan of the facility.

NJM Design makes all reasonable efforts to incorporate practical and advanced fire protection concepts into its advice. The extent to which this advice is carried out affects the probability of fire safety. It should be recognised, however, that fire protection is not an exact science. No amount of advice can, therefore, guarantee freedom from either ignition or fire damage.

The implementation of the findings of this report is the responsibility of others, including but not limited to:

- Development of drawings and specifications.
 - The installation of hardware and construction system
 - The operation and maintenance of those systems.
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4.2 SOURCES OF INFORMATION

The development of the study was based on the review of the below standards, reports and manuals:

- Table of Assumptions provided by Cogency, dated 17 February 2026.
- Bushfire Management Plan, provided by Tomkinson dated 13 November 2024.
- Bushfire Management Statement Revision A, provided by Tomkinson in August 2024.
- Best Practice Guide for Battery Storage Equipment - Electrical Safety Requirements, Version 1.0 – Published 06 July 2018.
- Country Fire Authority (CFA) Specialist Risk and Fire Safety Unit, Design Guidelines and Model Requirements - Renewable Energy Facilities. v4.4, Victoria: State of Victoria (Country Fire Authority), June 2025 [3].
- Country Fire Authority (CFA) Specialist Risk and Fire Safety Unit, Fire Safety Studies for Battery Energy Storage Systems, Version 1, State of Victoria (Country Fire Authority), June 2025 [1].
- AS 2067-2016 [2] has also been reviewed to is used for guidance on required clearance for transformers.
- AS 3000: Electrical installations.
- Building Code of Australia (BCA) 2022.
- Energy Safe Victoria (ESV) "Statement of Technical Findings - Fire at the Victorian Big Battery.

- AS 2419.1-2021: Fire hydrant installations [4].
- Hazardous Industry Planning Advisory Paper No.1 (HIPAP No. 1). NSW Government, January 2011.
- Hazardous Industry Planning Advisory Paper No.2 (HIPAP No. 2). NSW Government, January 2011.
- Incident Report – Bouldercombe BESS. Tesla Energy products. Revision 04 dated 29/02/2024.
- Elkhorn BESS Fire of September 20, 2022. Public Report of Technical findings. Dated 01/05/2023.
- Fire Protection Engineering and UL 950A Interpretation Report. Fire & Risk Alliance. Dated 04/03/2024 [5].
- Laboratory Test Data – CSA/ANSI C800 Test Data Pack (LSFT). CSA GROUP [7]

4.3 PROJECT INFORMATION

The development of the study was based on the following information:

- Bendigo BESS Site General arrangement plan, provided by Pacific Blue, Revision P04, dated 06/08/2026 (refer to Figure 5).
- Table of Assumptions. Cogency, February 2026.
- Bushfire Management Plan, provided by Tomkinson dated 13 November 2024.
- Bushfire Hazard Assessment – Bendigo BESS Agilus Reference 2026-0779, Version V1.0 dated 05/08/2026.

4.4 PROJECT STAKEHOLDERS

The relevant stakeholders in accordance with NCC A262(4) for the Bendigo BESS - 20 Hattam Street, Golden Square project are detailed in Table 3:

Table 3 – Design and Regulatory Stakeholders.

Role	Organisation
Client/Developer	Pacific Blue
Planning Consultant	Cogency Australia
Fire Safety Engineer	NJM Design (Vic) Pty Ltd.
Fire Brigade	CFA

4.5 LEGISLATIVE REQUIREMENTS

The primary objectives of the NCC, as summarised in the first edition of the International Fire Engineering Guidelines (IFEG) [8], are to protect:

- Life safety of occupants – the occupants must be able to leave the building (or remain in a safe refuge) without being subjected to hazardous or untenable conditions.
- Adjacent buildings – structures must not collapse onto adjacent property, and fire spread by radiation should not occur.
- Life safety of fire fighters – fire fighters must be given a reasonable time to rescue any remaining occupants before

hazardous conditions or building collapse occurs.

4.6 CLIENT OBJECTIVES

It is understood that the client's objectives are to comply with the requirements of the NCC (National Construction Code), CFA (Country Fire Authority) and Greater Bendigo Planning Scheme.

The fire safety objectives are met if the relevant legislation and regulations are complied with as stated in Clause A2G1 of the NCC, 'Compliance with the NCC is achieved by satisfying the Performance Requirements.'

The NCC Performance Requirements are intended to meet the objectives and functional statements of the NCC, being:

- Life safety of occupants – the occupants must be able to egress the building, or remain in a safe location, without being exposed to untenable conditions.
- Allow for Fire Brigade Intervention – provisions should be made to allow the Fire Brigade to undertake firefighting operations before the onset of untenable and hazardous conditions, as defined in the Fire Brigade Intervention Model (FBIM) [9].
- Protection of neighbouring buildings – structures should not collapse onto adjacent property or spread fire due to flame extensions or radiation.

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5 RISK ASSESSMENT METHODOLOGY

5.1 INTRODUCTION

Fire Safety Studies for Battery Energy Storage Systems (Version 1, June 2025) [1] is a guideline that, where a Fire Safety Study is requested by the CFA, must be followed.

The summary of the requirements in the proposed guideline and the sections that cover those requirements in this report are provided below.

Table 4: CFA Guidelines requirements Table 4.

Guideline Parts	Relevant Report Sections
1: Facility Description	- Information, including general details and the site layout locality map, is outlined in Section 6. - The BESS supplier has not been defined at this stage, however, in order to perform a preliminary assessment, this document will perform the assessment based on statistical data. The BESS supplier will be finalised during the detailed design stage.
2: Identify BESS Hazards	This copied document to be made available for the sole purpose of enabling its consideration and review as part of a planning process under the Planning and Environment Act 1987. The document must not be used for any purpose which may breach any copyright - Section 8 addresses potential fire hazards associated with the BESS units. - The BESS supplier must provide the results of a large-scale test in accordance with UL9540A (or CSA TS-800:24 as available) and the laboratory/centre certifications. - BAL assessment is presented in Section 9.2.8.
3: Identify Consequences	- The consequence of a fire in a battery and a transformer has been modelled and assessed in Section 9.2 - Section 8 discusses past events and findings related to BESS fire hazards.
4: Fire and Explosion Prevention	- Sections 3 include the outcomes of the risk assessment and the required fire safety measures to reduce fire risk. - The BAL assessment is undertaken in Section 9.2.8, which also covers the required fire safety requirements.
5: Fire Detection and Protection	- The subject BESS has not defined the BESS provider at this stage, once it is finalized, the final fire detection and protection must be provided. - Expectations for the BESS units' safety measures are listed in Section 3.
6: Fire Water Demand and Supply	The required fire water for the site is assessed in Section 10.2, based on CFA Design Guidelines and Model Requirements: Renewable Energy Facilities (Version 4.4, June 2025) [3].

Guideline Parts	Relevant Report Sections
7: Fire Water Management	As mentioned in Section 3, a containment and management plan of contaminated fire water runoff from the BESS is to be developed by the facility. Under the current layout, the firefighting water runoff will be captured by the proposed internal retention basin located in the north-west corner of the site, where it will be treated accordingly, rather than discharged directly into the municipal system.
8: Emergency Planning	As mentioned in Section 3, an emergency plan must be provided in accordance with AS 3745-2010: Planning for Emergencies in Facilities, and CFA's Design Guidelines and Model Requirements for Renewable Energy Facilities.
9: Recommendations and Implementation	Conclusions and proposed fire engineering requirements are summarized in Section 3.

This Fire Safety Study formulates part of an integrated assessment process for safety assurance of development proposals, which are potentially hazardous. The assessment is based on the methodology outlined in the Hazardous Industry Advisory Papers (HIPAPS) [10]. The process is shown diagrammatically in Figure 6.

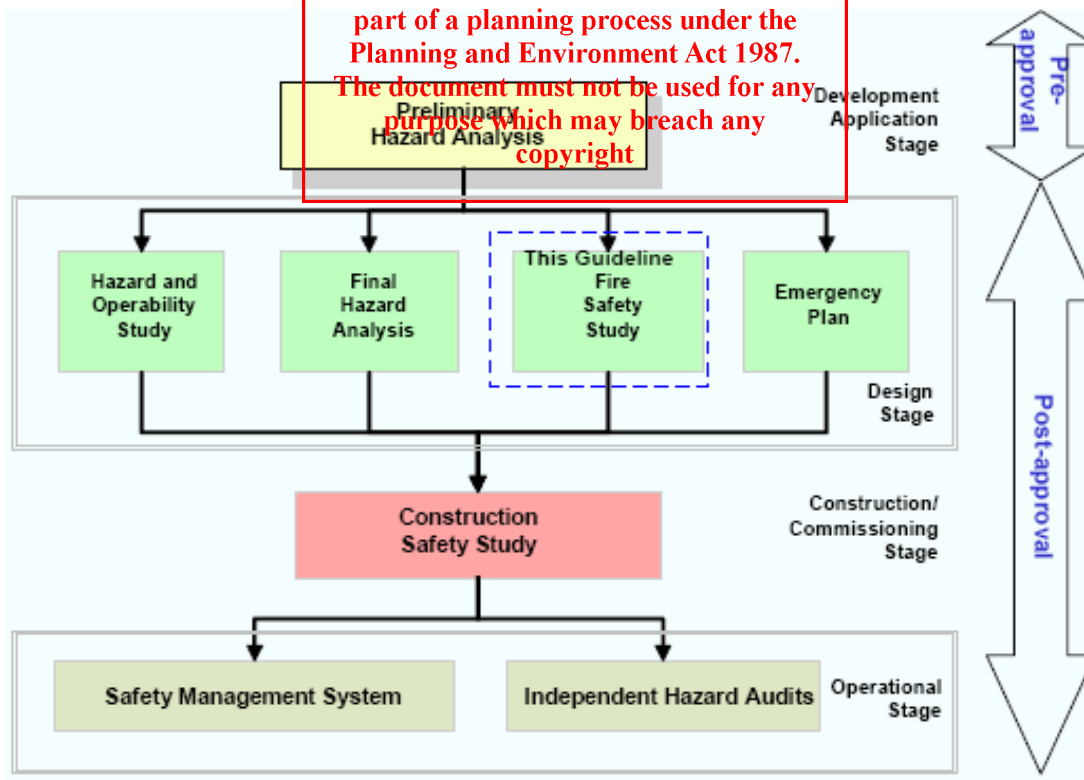


Figure 6: The Hazards-Related Assessment Process [10].

Several Hazardous Industry Advisory Papers (HIPAPS) have been published to assist stakeholders in implementing the process, i.e.:

- No. 1 - Industry Emergency Planning Guidelines.
- No. 2 - Fire Safety Study Guidelines.
- No. 3 - Environmental Risk Impact Assessment Guidelines.
- No. 4 - Risk Criteria for Land Use Planning.
- No. 5 - Hazard Audit Guidelines.
- No. 6 - Guidelines for Hazard Analysis.
- No. 7 - Construction Safety Studies.
- No. 8 - HAZOP Guidelines.
- No. 9 - Safety Management System Guidelines.
- No. 10 - Land Use Safety Planning (Consultation Draft).

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The studies detailed in the HIPAP papers involve case-specific hazard analyses and design of fire safety arrangements to meet those hazards. The approach is particularly important where significant quantities of hazardous materials as is the case with BESS units involved.

5.2 FIRE SPREAD ACCEPTANCE CRITERIA

- IEEE Std 979-2012 [11]:

Table B.3 of IEEE Std 979-2012 [11] gives some typical examples of the amount of radiant heat necessary to ignite common materials used in substations.

Table 5: Typical radiant heat flux intensities (Table B.3 IEEE Std 979-2012) [11].

Impact of radiant heat flux	Heat flux (kW/m ²)
Sufficient to cause damage to process equipment	37.5
Equipment failure	35
Damage to unprotected metal	30
Spontaneous ignition of wood	25
Cable insulation degrades	20
Pilot ignition of wood	12.5
Plastic melts	12.5
Pain threshold reached after 8s. Second degree burns after 20s.	9.5
Possible failure of ceramic bushings	5
Skin burns	5

Ausgrid Network Standard NS187 [12] parameters will be considered to assess the porcelain supports of ROI OHL Steelworks.

Table 6: Radiant Heat Exposure Limits [12].

Item	Maximum allowable radiant heat flux (kW/m ²)	Comment
Porcelain bushing/Insulators	12.5	Damage may occur requiring replacement or in extreme case resulting in catastrophic failure.

■ AS 1530.4-2014 [13]:

Where other façade/lining materials are present in adjoining building or equipment, Table A3 of AS 1530.4-2014 [13] contains a listing of heat flux required for radiant ignition for piloted and unpiloted ignition. The heat flux (q_{cr}) level for piloted ignition is taken as 13 kW/m², and for non-piloted ignition is taken as 25 kW/m². Refer to the table below.

Table 7: Typical radiant heat flux intensities based on AS 1530.4-2014 [13].

Phenomena (Maximum for indefinite exposure for humans)	kW/m ²
Pain after 10s to 20s	4
Pain after 3 s	10
Piloted ignition of cotton fabric after a long time	13
Piloted ignition of timber after a long time	13
Non-piloted ignition of cotton fabric after a long time	25
Non-piloted ignition of timber after a long time	25
Non-piloted ignition of gaberdine fabric after a long time	27
Non-piloted ignition of back drill fabric after a long time	38
Non-piloted ignition of cotton fabric after 5s	42
Non-piloted ignition of timber in 20s	45
Non-piloted ignition of timber in 10s	55

The assessment methodology requires that a fire will not cause a received heat flux (q_r) in excess of the critical heat flux (q_{cr}) on the allotment boundary or equipment.

Acceptance will be demonstrated if $q_r < q_{cr}$.

■ Fire Brigade:

Acceptable levels of radiation for firefighter operations shall be a maximum of 3.0 kW/m² at 2.0 m AFFL [14].

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■ Equipment criteria:

Based on the critical heat flux criteria outlined above, the following standards will be applied to the equipment or structures in the proposed development:

Table 8: Critical heat flux criteria.

Equipment / Building / Vegetation	kW/m ²
BESS Units	37.5
HV transformers (Substation)	5.0
O&M Building and other buildings	13.0
Storage containers	13.0
Control building/ Switch room (provided with fire rated construction)	45.0
Fire Brigade	3.0

5.3 GAS CONCENTRATION CRITERIA

Given a transformer fire, oil and cellulose burn the most. Toxic, corrosive and pollutant gasses such as alkanes, alkenes, some ketone, alcohol, aromatic, anhydride species, CO, CO₂ will be released; however, the most common gasses are CO and CO₂.

As per CO₂ Specialists [15], the following figures show the critical concentration levels when humans will feel discomfort.

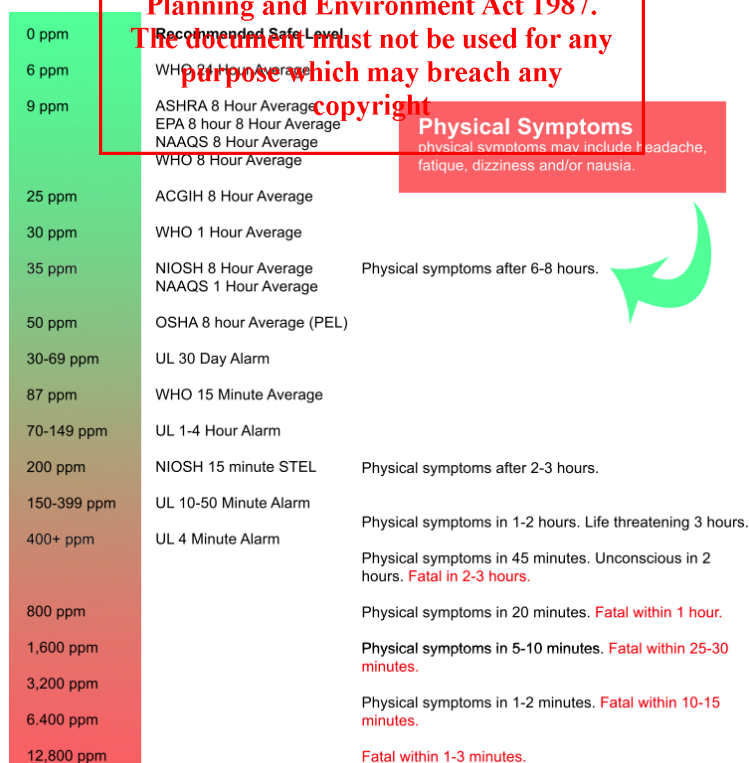


Figure 7: Carbon Monoxide levels chart [15].

400 ppm 0.04%	Normal outdoor air
400-1,000 ppm 0.04-0.1%	Typical CO2 levels found indoors
1,000-2,000 ppm 0.1-0.2%	Common complaints of drowsiness or poor air quality
2,000-5,000 ppm 0.2-0.5%	Headaches, fatigue, stagnant, stuffiness, poor concentration, loss of focus, increased heart rate, nausea
> 50,000 ppm > 5%	Toxicity due to oxygen deprivation occurs
> 100,000 ppm > 10%	Oxygen deprivation in seconds: convulsions, coma, and death

Figure 8: Carbon Dioxide levels chart [15].

The following critical thresholds will be used as a conservative measure:

Table 9: Critical human thresholds for gases

Gas	ppm
Carbon Monoxide (CO)	35
Carbon Dioxide (CO ₂)	2,000

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6 FACILITY CHARACTERISTICS

6.1 FACILITY LAYOUT AND EQUIPMENT DESCRIPTION

6.1.1 General

The proposed Bendigo Battery Energy Storage System (BESS) is located in 20 Hattam Street, Golden Square, Victoria, to the north-east of the existing Bendigo Terminal Station.

Bendigo BESS is a 201MW/866 MWh BESS units connected to the 220kV Bendigo terminal station via underground cable. The primary access to the site is via Hattam Street to the north. The BESS development has the below layout distribution, and the facility will be enclosed within a security fence (see also Figure 5). There are also two easements over the subject site for the purpose of electrical connections to Bendigo Terminal Station to the south.



Figure 9: BESS layout.

The development will be managed remotely, however members from the operations team will be responsible to come on for routine maintenance, inspections, and emergency events.

The proposed Bendigo BESS has the following equipment/facilities:

- BESS units.
- Substation and associated electrical infrastructure.
- Transmission connection infrastructure, including HV transformer, protection devices, earthing systems, connecting infrastructure and switch gear.
- Underground electrical and communication cabling.
- Water storage systems and fire-fighting infrastructure.
- Access points and internal tracks.
- Operation and maintenance building.
- Switch room and control room.
- Security fencing and monitoring systems.

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The facility has no less than 10m wide firebreaks to mitigate the risk of fire spread, and 12.0m wide road access to facilitate fire brigade intervention procedures.

As part of the fire-fighting measures, the site will also be provided with a water storage of 576L (2 water tanks of 288kL each), a fire hydrant system and portable fire extinguishers as per AS 2444.

There 2 alternative access entrances. The primary access is located at the North side via Hattam Street, and the second access is located at the east side via Coonooer Street.

6.1.2 Dominant Occupant Characteristics

Based on the use of the subject site, the occupant characteristics and attributes have been identified as part of the performance process and are summarised in Table 10 below.

Table 10 - Dominant Occupant Attributes.

Attributes	Description
Staff	
State of awareness	Generally alert, awake and aware of their surroundings. It is considered that being a place of work the staff members will not be under the influence of drugs or alcohol.
Familiarity with the building	Due to being members of staff, it is expected that they will generally be aware of the building configuration and exit routes.
Mental and physical aspects	Staff are generally not expected to have a mental or physical impairment.
Emergency training	It is not expected that the members of staff are trained in the operations of the firefighting systems. However, it is expected that the staff members will be aware of the actions required during an event requiring an evacuation, use of portable fire extinguishers and summoning the fire Brigade.

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6.1.3 Location and adjacent allotments

The proposed Bendigo Battery Energy Storage System (BESS) is located in 20 Hattam Steet, Golden Square, Victoria, to the north-east of the existing Bendigo Terminal Station (Figure 5).

The new BESS development and the existing Bendigo Terminal Station are located within an Industrial Zone (IN1Z), and the adjoining allotments are comprised of residential zones, industrial zones and environmental and transport areas (Figure 11).

Within 500m radius of the site, there are over 200 residential properties which are mostly clustered to the west and north sides. The nearest property is located ~190m to the north and is an aged care facility. The industrial areas are largely located to the west and south of the subject site whilst a regional park is located along the eastern boundary of the subject site.



Figure 10: Location of northern residential areas.

6.1.4 Land Zones

Land use for most of the surrounding area includes general residential areas. To the southwestern boundary is the existing Bendigo Terminal Station, and the northern boundary is Hattam Street.

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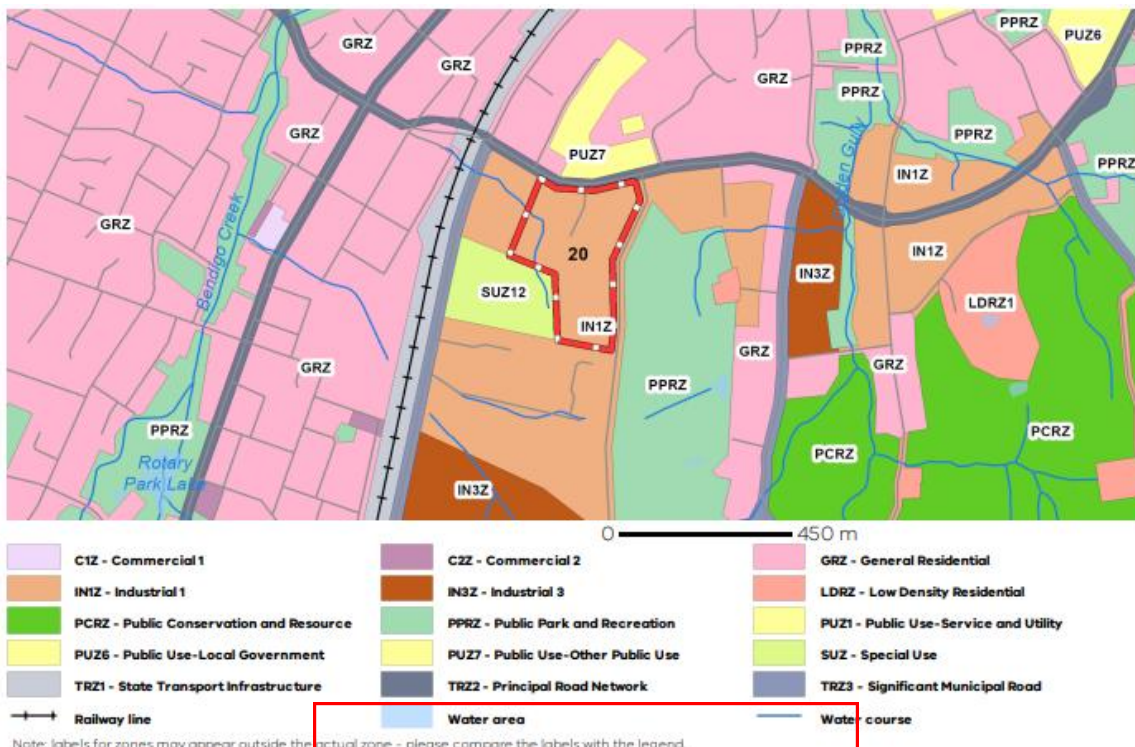


Figure 11: Development within an Industrial Zone.

The subject allotment is classified as a BPA (Bushfire Prone Area) in accordance with the VIC Planning portal (Figure 12). However, it is also an Industrial zone and Public Park and Recreation zone to the east, and therefore owners and Park management must maintain the land to minimize the risk of fire spread.

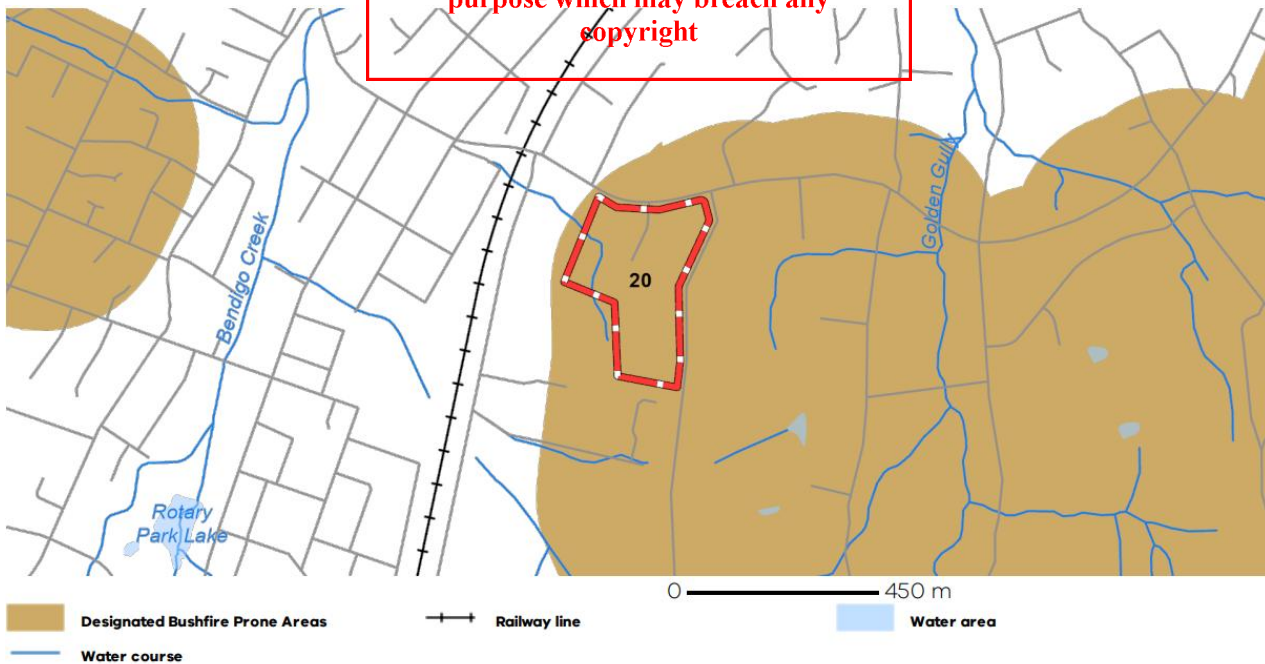


Figure 12: Site Zoning (Bushfire prone areas)

A Bushfire Risk Assessment is required for the subject site as there is a Bushfire Management Overlay (BMO) to the eastern part of the site. This has been undertaken for the approved subdivision and is not required to be undertaken for the project's planning permit application. The initial Stage 1 Bushfire Management Statement by Tomkinson, dated August 2024 requires that buildings within the site must comply with a minimum Bushfire Attack Level of BAL 12.5. Agilus [16] confirm that the setback exceeds the BAL 12.5 setback requirements as the design includes a 38 m setback along the eastern boundary of the site.

6.1.5 Bendigo weather conditions

The closest weather station to Bendigo Substation and the new BESS development is at the Bendigo Airport weather station [17]. In accordance with the available data at the Bureau of Meteorology, the average weather conditions are the following (Refer to Figure 13):

- The average temperature is 21.3°C and the highest temperature can reach up to 30.4°C in January.
- The mean relative humidity is 69% in the morning, and 45% in the afternoon.
- Wind statistics:
 - Wind is calm 1% of the time.
 - The strongest wind comes from the west with a speed of more than 40 km/hr (11.1m/s), approximately 18% of the time.
 - Wind predominantly comes from the west (18% of the time), followed by the north (17%), the south (14%), and the east (5%).
 - Maximum average speed of the wind is 19.2km/h and the average speed is 17.3km/h.

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Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	Plot	Map
Temperature																
Mean maximum temperature (°C)	30.4	29.7	26.3	21.4	16.7	13.4	12.7	14.3	17.2	21.0	24.7	27.6	21.3	34	1991-2026	
Mean minimum temperature (°C)	14.5	14.4	12.0	8.2	5.3	3.6	2.7	3.0	4.6	6.9	9.9	12.0	8.1	34	1991-2026	
Rainfall																
Mean rainfall (mm)	37.6	27.0	30.9	36.2	45.1	52.2	53.4	51.4	50.2	46.2	46.0	39.2	515.2	34	1991-2026	
Decile 5 (median) rainfall (mm)	24.2	14.9	23.3	24.6	38.6	49.3	55.1	53.2	40.4	33.4	41.5	30.4		35	n/a	
Mean number of days of rain ≥ 1 mm	3.8	3.0	3.6	4.1	6.2	7.5	8.9	8.1	7.2	6.1	5.7	4.5	68.7	34	1991-2026	
Other daily elements																
Mean daily sunshine (hours)																
Mean number of clear days	12.9	12.7	13.6	11.8	8.1	5.9	4.9	6.8	6.5	7.6	8.5	10.6	109.9	19	1991-2010	
Mean number of cloudy days	6.6	4.6	4.6	6.9	11.1	12.3	13.4	11.9	10.7	8.3	7.7	7.4	105.5	19	1991-2010	
9 am conditions																
Mean 9am temperature (°C)	19.5	18.9	16.3	14.0	10.3	7.5	6.5	8.0	10.9	13.8	15.9	17.9	13.3	19	1991-2010	
Mean 9am relative humidity (%)	56	60	65	67	80	87	88	80	71	61	59	55	69	19	1991-2010	
Mean 9am wind speed (km/h)	15.9	15.1	13.7	12.4	10.0	9.9	9.0	11.1	14.3	15.6	15.3	16.1	13.2	19	1991-2010	
9am wind speed vs direction plot																
3 pm conditions																
Mean 3pm temperature (°C)	27.8	27.7	24.6	20.3	15.9	12.5	11.7	13.3	15.7	19.4	22.7	25.4	19.8	19	1991-2010	
Mean 3pm relative humidity (%)	30	32	35	41	55	65	65	57	51	41	36	31	45	19	1991-2010	
Mean 3pm wind speed (km/h)	19.1	17.6	16.8	15.9	14.3	14.8	15.4	17.5	18.8	19.0	18.9	19.2	17.3	19	1991-2010	
3pm wind speed vs direction plot																

Figure 13: Bendigo Airport weather statistics.

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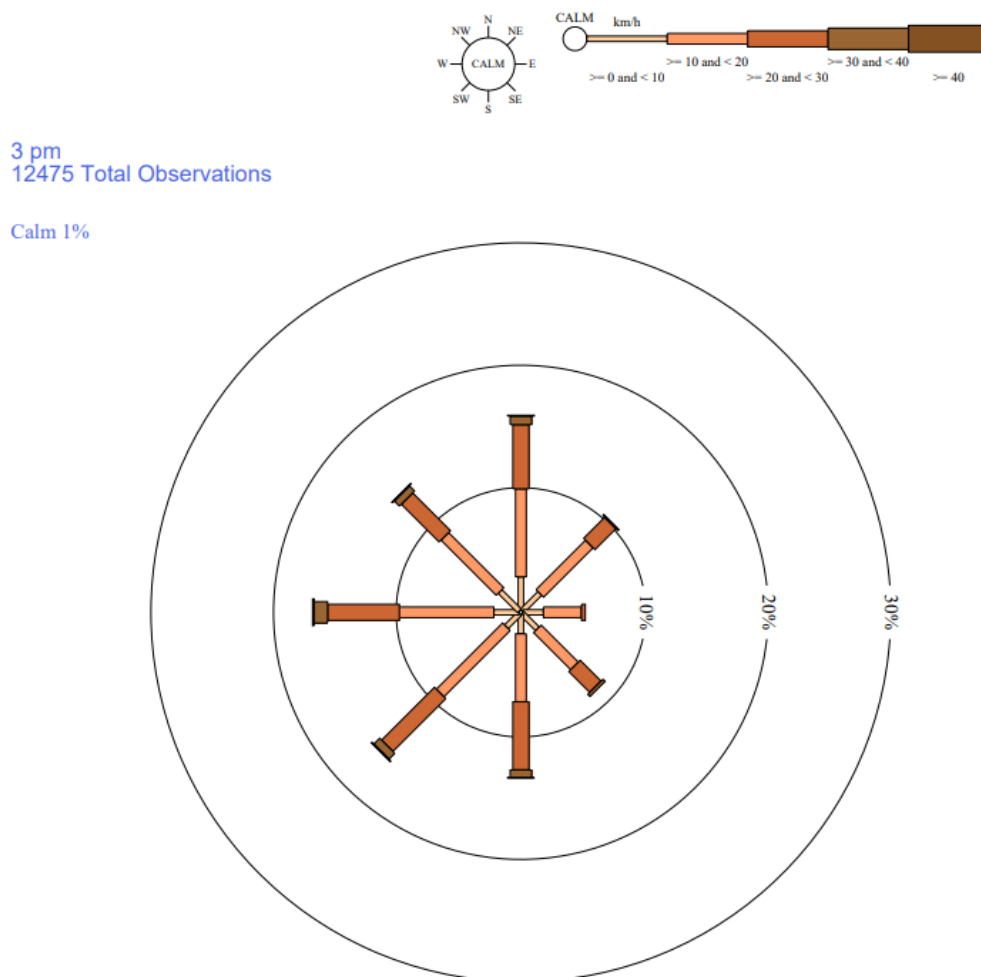


Figure 14: Wind Rose from Bendigo Airport station.

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7 FIRE BRIGADE

7.1 FIRE BRIGADE OBJECTIVES

The overall philosophy of the Fire Brigade objectives throughout Australia is to protect life, property and the environment from fire as noted in the FBIM [9].

Firefighters must be given reasonable time to enter buildings to conduct occupant search and rescue activities and to carry out internal firefighting before exceeding conditions that are likely to threaten fire fighter safety and prior to building collapse.

Under reasonable circumstances, structures must not collapse onto adjoining property, and fire spread must be prevented. Also, fire spread within a building must be limited.

The Fire Brigade also has functions with regard to property protection and considerations regarding occupational health and safety for its employees. These issues are outside the building regulatory framework and NCC.

A preliminary desktop review of the proposed BESS project has also been performed in March 2026 between the CFA representatives, Pacific Blue, Cogency Australia and NJM Design stakeholders. The main conclusions of the review were the following:

- The CFA guidelines and the FSS guidelines should be followed to develop the fire safety study.
Note: Those have been referenced in Sections 5 and 10.2 of this document.
- A BAL assessment is required given the site is part of a BMO.
Note: This has been addressed in Section 9.2.8 of this document.
- Develop a review of the location of the entrances to prevent both entrances are compromised due a single fire.
Note: This has been addressed in Section 9 of this document.

7.2 FIRE BRIGADE STATIONS

The primary fire station for emergency response is the Golden Square CFA Station (69-71 Specimen Hill Road, Golden Square) located 2.5km to the north of the subject site, and then the Bendigo CFA Fire Station (Unit 2/17 Deborah St, Golden Square) located 2.7km to the northeast of the site.

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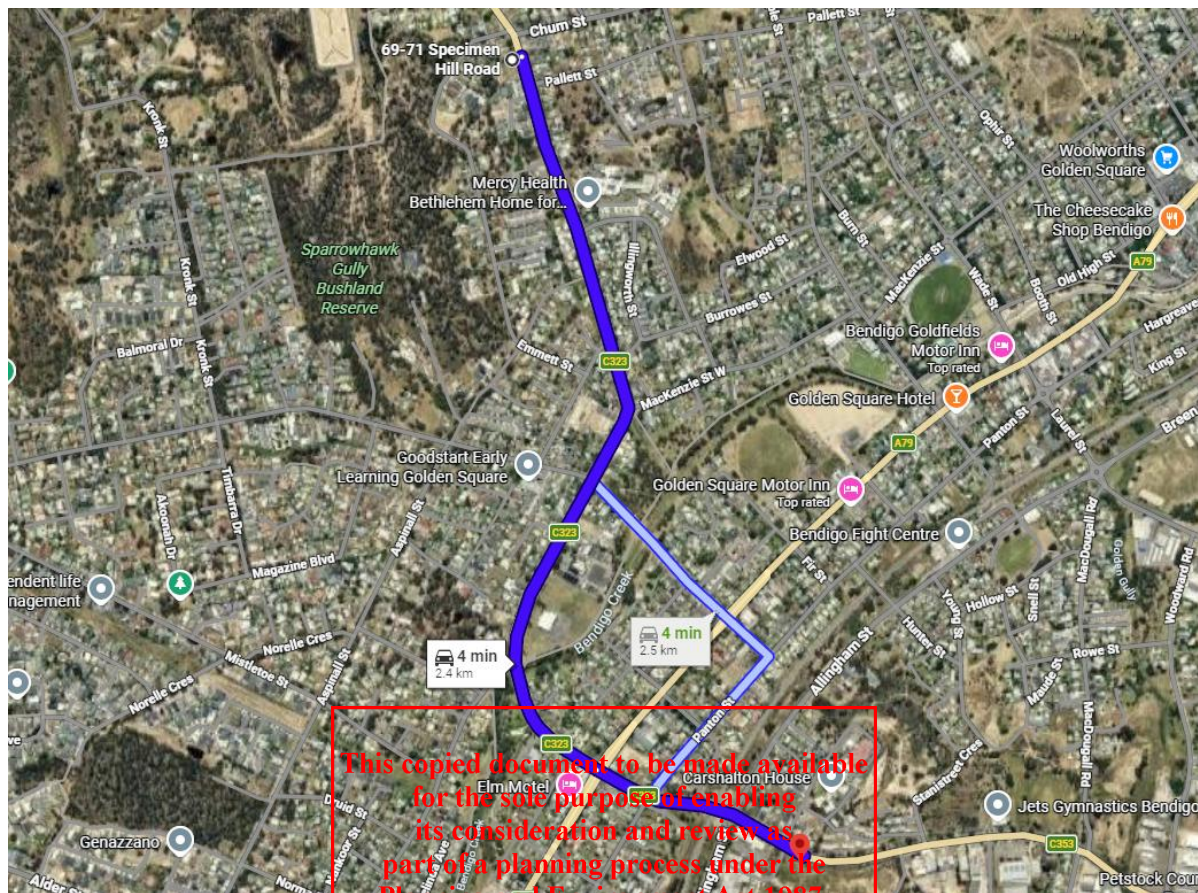


Figure 15: 69-71 Specimen Hill Road, Golden Square CFA Fire Station to subject site.

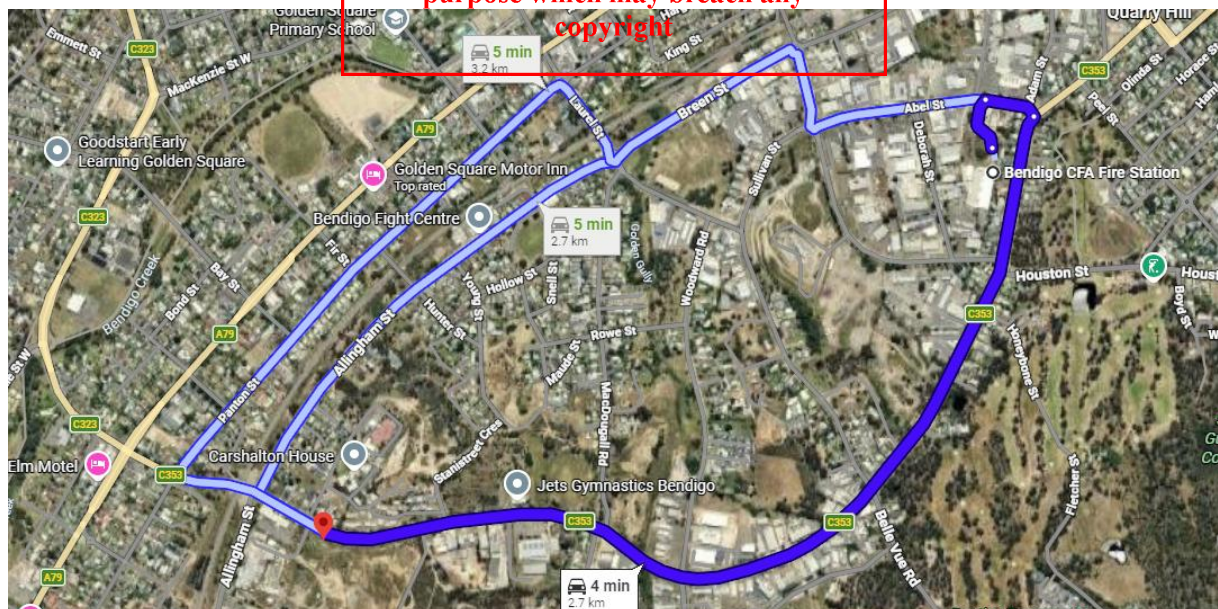


Figure 16: Unit 2/17 Deborah St, Golden Square, Bendigo CFA Fire Station to subject site.

7.3 FIRE BRIGADE ACCESS

The access roads (2 alternative entrances) to the new Bendigo BESS development are located on the north side of the development via Hattam Street and on the east side of the development via Coonooer Street (see Figure 5).

The access roads and roads around the BESS array areas are not less than 6.0m wide, surpassing the requirements of the CFA guidelines [3].

The roads are for the fire brigade truck and maintenance purposes, and the roads extend around and within the facility. The fire truck will run within the fence that encloses the facility to reach all equipment.

7.4 GENERAL FIRE SAFETY STRATEGY

(a) Fire to an equipment within the BESS development.

All equipment will be SCADA alarmed and will notify automatically the operators, who will proceed according to the Emergency Management Plan and the protocols provided by the equipment suppliers.

In the worst-case scenario where a BESS Unit is on fire, the total burn out of the equipment can be allowed without the need of fire brigade intervention given that fire spread is not expected to occur between equipment. Depending on the final BESS technology selected for the project, the duration of a BESS fire event and subsequent burnout may vary accordingly. Section 9.2.4 provides the results of fire tests undertaken in accordance with UL 9540A and CSA TS-800:24 for various BESS models.

If a building is on fire, the Fire Brigade will respond to site after notification of an event by an emergency call from the staff on site, the staff monitoring the site remotely or a member of the public when any of them visualise a fire. When the fire brigade intervenes, they are expected to help control a safe perimeter around the fire and allow equipment on fire to self-extinguish.

It is expected that the responding Fire Brigade will respond to site after notification of an event by an emergency call from the staff on site, the staff monitoring the site remotely or a member of the public when any of them visualise a fire. When the fire brigade intervenes, they are expected to help control a safe perimeter around the fire and allow equipment on fire to self-extinguish.

Firefighters should wear self-contained breathing apparatuses (SCBAs) and structural firefighting gear.

The attending personnel and vehicles will be equipped to commence the firefighting activities including investigations, set up and firefighting.

Although fire spread is not expected provided there are firewalls and enough clearances, the fire brigade is expected to help preventing any unexpected fire spread risk with the use of the fire trucks, the water supplied at the entrance of the site.

Also, as part of the fire brigade expertise, the fire brigade can assist in the management of fire of any of the ancillary buildings, such as the O&M Building, storage sheds and Switch gear buildings.

Before the worst-case scenario above occurs to a BESS Unit, the risk of a potential fire may be detected by the fire safety measures. When any of those sensors is triggered, the signal of the abnormal condition is detected by the safety systems and sent to the 24/7 remote monitoring centre for appropriate action and/or the staff on site.

Where a BESS Unit or SUT transformer fire occurs, the efforts of the local fire authorities should focus on cooling down adjacent infrastructure and protecting adjacent bushland as required (i.e., not extinguish the BESS unit on fire). Two hydrants and roads are provided to facilitate this. However, as per the large-scale test is it noted that fire spread from a BESS unit on fire is not expected to occur to adjacent BESS units.

Detailed contacts and further emergency responses will be listed in the Emergency Management Plan of the site, and it will also consider the input from the equipment suppliers where provided.

This is a protected document under the standard Fire Brigade intervention procedures as they judge convenient given the fire protection systems provided and the training from the staff.

It is expected that the responding Fire Brigade will respond to site after notification of an event by an emergency call from the staff on site, the staff monitoring the site remotely or a member of the public when any of them visualise a fire. When the fire brigade intervenes, they are expected to help control a safe perimeter around the fire and allow equipment on fire to self-extinguish.

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The site must have an available Fire Management Plan which must indicate the roles, responsibilities and actions to take when an emergency signal is detected. The plan must comply with some of the following (not limited to):

- Determine who (roles and names) and actions to take to fix the matter.
- It must provide guidance to staff to determine when and how will contact the Fire Brigade so they can start the Fire Brigade intervention procedures when required.
- Indicate the expected role and strategy of the Fire Brigade (e.g., allow the BESS unit to burn out by itself and mitigate fire spread only, to extinguish fire and mitigate fire spread, maintain safe perimeter around the fire, etc.).

The Fire Management Plan must be shared with the assigned Fire Brigade.

(b) Bushfire around the BESS development.

Bushfire events will be notified to the fire brigade by either a member of the public (e.g., landowners, drivers, or residents) or staff at the BESS development, by calling Triple Zero (000) immediately.

The procedures will follow a coordinated multi-agency action with public warning systems and community safety protocols.

The proposed site will have on-site static water storage (tanks) to account for a bushfire event at the boundary, and fire spread or equipment damage is not expected due to the current clearances of more than 12m (i.e., 38m). The clearances will mitigate the risk of fire spread and will provide space to the fire brigade to perform the fire brigade intervention procedures.

The secondary/alternative entry located to the east side of the development accessible via Coonoor Street can be obstructed by a nearby bushfire, however it will not obstruct the main entrance to the north via Hattam Street. The main entrance to the north via Hattam Street is planned to be more than 100m from the identified vegetation, surpassing required clearance associated to a BAL 12.5 risk.

The *Bushfire Hazard Assessment – Bendigo BESS* performed by Agilus states the following: “Subject to implementation of the recommended bushfire protection measures, the proposed development is considered capable of meeting the objectives of Clause 13.02 of the Victorian Planning Scheme while providing an appropriate level of protection for life, property and emergency responders.”

The staff are not expected to take an active role in the attack of the bushfire and must monitor what occurs within the facility to identify any potential damage caused by the bushfire; however, staff must assist to the authorities any access and use of the water supply to attack a bushfire if required.

(c) Delayed response due to unavailable fire brigade response.

All equipment will be SCADA alarmed and will notify automatically the operators, who will proceed according to the Emergency Management Plan and the protocols provided by the equipment suppliers. After those procedures the BESS staff call Triple Zero (000) immediately if it is concluded that the fire brigade is required on site.

If a planning permit is issued, it will require preparation of Emergency Management Plan and Fire Management Plan, where protocols for on-site staff and management of an emergency will be set out. This will include likely CFA scenarios, such as local brigade attendance, and circumstances where responses may be delayed.

The staff will continue to monitor all equipment remotely and do all the safety procedures established by the providers to mitigate a risk to life safety due to smoke spread, toxic gasses, fire and explosion.

The BESS Unit or transformer on fire will be allowed to total burn out without the need of fire brigade intervention given that fire spread is not expected to occur between equipment or to buildings.

Upon arrival at the site, the fire brigade will meet the on-call technician at the main site access point. The technician will provide access to the Emergency Information Container and assist the fire brigade in reviewing relevant emergency information, including the Emergency Management Plan, site layout, hazards, isolation points and available monitoring data. Site staff will support the fire brigade and follow its directions.

The fire brigade will determine the appropriate response strategy, operational clearances and exclusion zones based on measured data, identified hazards and prevailing site conditions. Any changes to established clearances or procedures will occur under the direction of the fire brigade, in consultation with the technician where site-specific technical advice is required.

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8 BESS DEVELOPMENT HAZARDS

The subject Bendigo BESS will comprise a number of equipment components that have a risk of fire ignition, and hence a risk of fire and spread to the boundary or adjoining equipment.

The main fire hazards are given by the following equipment:

- BESS units.
- HV transformers at the Substation.
- Buildings (e.g., switch rooms, control buildings, storage buildings etc).

Furthermore, given the location of the development, the risk of a bushfire will also be addressed.

The following section will explain past events and findings regarding the above fire risks.

8.1 BATTERY HAZARDS

One of the main hazards associated with the use of lithium batteries for energy storage is overheating and thermal runaway resulting in a fire. Cell thermal runaway refers to rapid self-heating of a cell derived from the exothermic chemical reaction of the highly oxidizing positive electrode and the highly reducing negative electrode; it can occur with batteries of almost any chemistry.

Lithium-ion batteries contain highly energetic materials and combustible materials (i.e., electrode, separator, electrolyte and organic solvents). If they are subject to overcharging, short circuit, extrusion, collision or exposed to fire, this can trigger thermal runaway and lead to a fire and explosion.

The combustion process of batteries could be summarized into the following stages: heating to ignition, violent ejecting or explosion, stable burning, and weakening and extinguishment. Both the state of charge and incident heat flux have significant impact on the combustion behaviour of the battery. The battery with high charge presents a fierce combustion process and higher surface temperature than the others, especially when imposed with a high external heat flux.

8.1.1 Past BESS Fires

In order to obtain an understanding of the hazards associated with BESS facilities a summary of past fires is presented below including the Moorabool Fire.

8.1.1.1 Incident Report – Bouldercombe BESS.

The Bouldercombe BESS is a 50MW and 100 MWh battery comprised of 40 individual Megapack 2 (MP) energy storage systems (See Figure 17).

The report provided by Tesla Energy Products stated the following:

“On Tuesday September 26, 2023, a single Megapack caught fire and was left to fully consume itself over approximately 48hrs without the need for water/fire suppressant to be applied by First Responders as per Tesla’s Industrial Lithium-Ion Battery Emergency Response Guide. No workers were at risk of harm and the battery failed in a safe manner, as the system is designed to do in the event of a fire”.

“A second Megapack (MP2TG122340001W76), installed directly behind the initiator Megapack, was found to have signs of secondary heat effects and was removed. The total impact to the site was 2 out of the 40 MPs on site”.

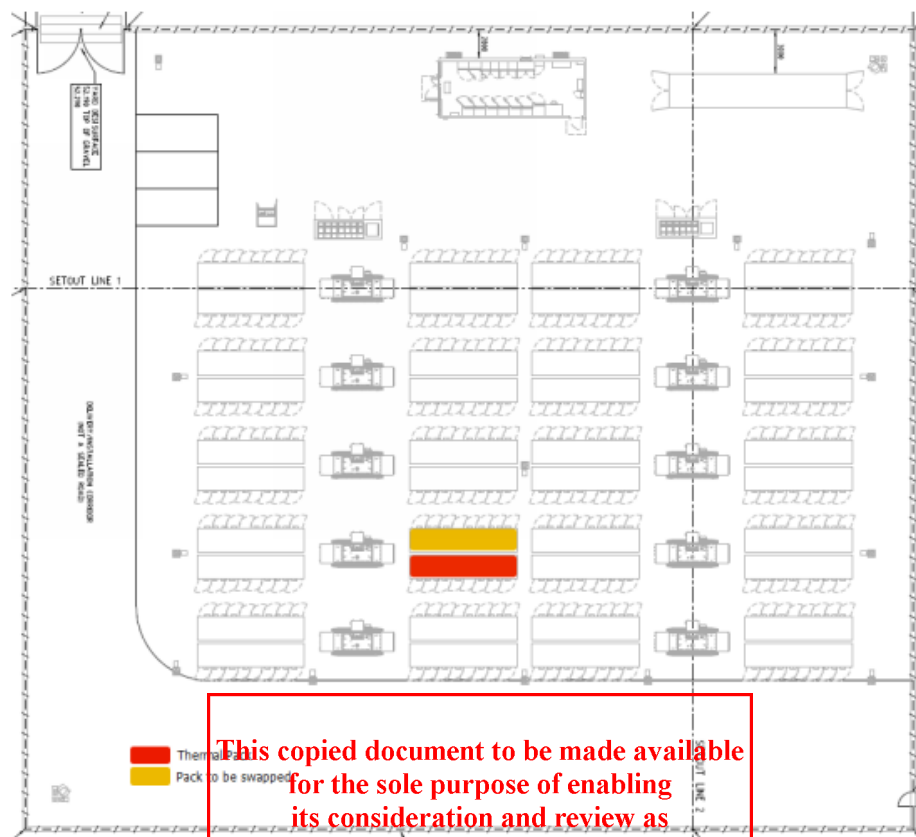


Figure 17: Bouldercombe BESS Site Layout and Megapacks involved in the event.

The incident demonstrated that given a fire to a Megapack, fire will be limited to the affected Megapack only and fire will not spread to adjoining Megapacks, transformer structures, however heat may damage some of the components of the Megapack at the back.

The Bouldercombe BESS had a normal operation despite of the event due to the provision of safety and redundancy systems, the loss of the 2 megapacks did not affect the normal operation of the BESS development.

In regard to the root cause of the fire, the analysis determined a load-side AC fault occurred leading to fault cascading within the Megapack. Further studies and tests are being performed in order to assess further electrical faults of the Megapack.

8.1.1.2 Elkhorn BESS Fire of September 20, 2022. Public Report of Technical findings.

The Elkhorn BESS is located at the Moss Landing Electric Substation in Monterey County, California, and it has the capacity to store and dispatch up to 730 megawatt hours (MWh) of energy.

The facility is provided with the first version of the Megapack (also referred to as the Megapack 1 to distinguish it from second-generation of Tesla BESS called the Megapack 2).

In September 2022, a fire occurred to a single Megapack as shown in the picture below (Figure 18). In summary, "The fire proceeded in accordance with its design and consumed itself. It burned as a flaming fire for about 6 hours and then generated visible smoke and off-gas for another 12 hours. As per the instructions in Tesla's Lithium-Ion Battery Emergency Response Guide (ERG), which were incorporated into the PG&E Pre-Fire Plan, the Megapack was allowed to burn and consume itself while being monitored by first responders at a safe distance".



Figure 18: Overview of Elkhorn BESS and Megapack on fire.

The above demonstrated that where a Megapack is on fire, fire is not expected to spread to adjacent Megapacks or adjoining structures, and fire will be limited to the affected Megapack.

The Root Cause Analysis of the incident identified the following causes:

- Significant water ingress, which allowed electrical shorts to initiate the thermal runaway of the battery cells.
- There were additional confounding factors that influenced the fire event during the pre-incident time frame, that is, the two days prior to the fire event. These included: (1) Auto-Safe Discharge; (2) Tesla Monitoring Alarm; and (3) Playbook Guidance.

Given the Root Cause Analysis above, the enclosure, manuals and software for the Megapack 2 and Megapack 2XL were updated accordingly to mitigate the risk of ignition of the Megapack.

8.1.1.3 Victorian Big Battery fire

The Energy Safe Victoria (ESV) "Statement of Technical Findings – Fire at the Victorian Big Battery" provides a summary of the key findings into the fire.

On 30 July 2021, the Victorian Big Battery (VBB) experienced a fire that involved two Battery units during commissioning.

The root cause of the fire was found to be a leak within the cooling system that caused a short circuit that led to a fire in an electronic component. This resulted in heating that led to a thermal runaway and fire in an adjacent battery compartment within one unit, which spread to an adjacent second unit.

The contributing factors into the fire were reported to be:

- The supervisory control and data acquisition (SCADA) system took 24 hours to 'map' to the control system and provide full data functionality and oversight to operators. The unit that caught fire had been in service for 13 hours before being switched into an off-line mode when it was no longer required as part of the commissioning process. This prevented the receipt of alarms at the control facility.

- A key lock was operated correctly to switch the unit to off-line service mode (which was no longer required for ongoing commissioning), but this caused:
 - Telemetry systems for monitoring the condition of the (now out of service) unit to shut down and so remove visibility of the developing event.
 - The battery cooling system to shut down.
 - The battery protection system to shut down, including the high voltage controller (HVC) that could have operated a pyrotechnic fuse to disconnect the faulty battery unit.

The lessons learnt from the fire were reported to be:

- Each cooling system is to be fully functional, and pressure tested when installed on site and before it is put into service.
- Each cooling system in its entirety is to be physically inspected for leaks after it has been functionally, and pressure tested on site.
- The SCADA system has been modified such that it now 'maps' in one hour and this is to be verified before power flow is enabled to ensure real-time data is available to operators.
- A new 'battery module isolation loss' alarm has been added to the firmware; this modification also automatically removes the battery module from service until the alarm is investigated.
- Changes have been made to the procedure for the usage of the key lock during commissioning and operation to ensure the telemetry system is operational.
- The high voltage controller (HVC) that operates the pyrotechnic fuse remains in service when the key lock is isolated.

The over pressure vents in the roof of the units involved in the VBB fire were seen as the main fire propagation method and a weakness in the fire spread prevention. (The effect of vents on possible fire spread scenarios versus the consequence of an overpressure event if they were not installed will be assessed as part of the detailed assessment of the final unit design).

The wind conditions at the time of the VBB fire were 37 – 56km/hr which based on the wind data for the Bendigo BESS location would only occur approximately 18% of the time, i.e., a probability of 0.18.

It was recommended in the report that one of the hardware mitigation measures is the installation of newly designed, thermally insulated steel vent shields within the thermal roof of all units.

The fire did not spread beyond the two units and no members of the public or emergency services were indicated to have suffered significant injuries.

8.1.1.4 Drogenbos, Belgium – 11 November 2017 [18]

A fire broke out at Engie's Drogenbos test site in Belgium on November 11, 2017, during the commissioning of a lithium-ion battery system, causing significant damage to the Engie Ineo battery container. The firefighters arrived quickly at the site and rapidly extinguished the fire, which did not spread to other containers or parts of the site. Despite the fast response, the Engie Ineo lithium-ion battery system was damaged severely enough to be considered a "total loss." Two neighbouring containers, containing battery systems from GE and Alphen, sustained only light external, peripheral, and easily repairable damage.

The fire was contained quickly, preventing it from spreading to the neighbouring containers, which sustained only light, repairable damage. Despite the presence of fire detection and extinguishing systems, the fire could not be extinguished in time, raising concerns about the safety of lithium-ion batteries. While the cause of the fire remains uncertain, this incident underscores the critical importance of designing Battery Energy Storage Systems (BESS) with safety features that prevent a fire in one cell from overheating and causing a cascade failure to adjacent equipment—a crucial consideration to avoid widespread damage in future system designs.

8.1.1.5 S&C Electric Lithium-Ion ESS fire in Wisconsin

The fire occurred in the S&C Electric facility in 2016. Within this facility, energy storage systems are designed, assembled, and operated before being deployed. The fire was initially assumed to have initiated with the lithium-ion batteries, however, the investigation later determined that the fire started in the battery manufacturer's DC power and control compartment – not the batteries themselves. The DC power and control unit that started the fire was part of a larger system that was being assembled – therefore the safety features normally integrated into an ESS were not yet installed in this particular fire event.

The units at the proposed site will be fully functional at the time of delivery and installed and commissioned at the time of installation including safety systems.

8.1.1.6 Explosion risks

Since 2011 to 2023, Electric Power Research Institute (EPRI) has recorded 81-88 incidents of BESS failures worldwide and has registered the following events with explosions since year 2020, where most of them are indoor installations [19]:

TABLE		MAP		PLOTS (COMING SOON)	
Location	Date ↓	Capacity (MWh)	Capacity (MWh)	Chemistry	Install Year
Spain, Valencia, Port of Gandia	5 January 2025	1	4	Li ion	2023
Singapore	10 September 2024			Li ion	
Japan, Kagoshima, Isa	27 March 2024		3.5	Li ion	
France, Martinique, Saint-Esprit	29 September 2023		1.3	Li ion	2021
France, Corsica, Aghione	6 April 2023	4	3.5	Li ion	
Australia, Brisbane	17 March 2020			Li ion	

Figure 19: BESS units with explosion events.

8.1.2 Thermal Runaway / Fire within a battery

One of the reasons lithium-ion cell thermal runaway reactions can be very energetic is these cells have very high-energy densities compared to other cell chemistries. The other reason that lithium-ion cell thermal runaway reactions can be very energetic is because these cells contain flammable electrolyte, and thus, not only do they store electrical energy in the form of chemical potential energy, but they also store appreciable chemical energy (especially compared to cells with water-based electrolytes) in the form of combustible materials.

Self-heating of lithium-ion graphitic anodes in the presence of electrolyte initiates at temperatures in the 70 to 90°C range. Thus, if a cell is brought to this initiating temperature in an adiabatic environment, it will eventually self-heat to the point thermal runaway initiates. For a typical 100% charged cell brought to its self-heating temperature, thermal runaway will occur after approximately two days if the cell is well-insulated. Should initial temperature be higher, time to thermal runaway will be shorter. For example, if a typical lithium-ion cell is placed into an oven at more than 150°C (300°F), such that separator melting occurs, additional heating due to shorting between electrodes will occur and cell thermal runaway will initiate within minutes. However, if heat is allowed to escape, time to thermal runaway may be longer, or the cell may never achieve thermal runaway.

Measurement of cell case temperatures during thermal runaway experiments have been performed by laboratories such as UL. For fully charged cells, these temperatures can reach in excess of 600°C case temperatures. The temperature rise is driven by reactions of the electrodes with electrolyte and release of stored energy. Some cathode materials will decompose and may change their crystalline structure which may result in the release of small quantities of oxygen that can participate in reactions internal to the cell (e.g., oxidation of the aluminium current collector).

This fact has led to a misconception that lithium-ion cells burn vigorously because they “produce their own oxygen.” This idea is incorrect. No significant amount of oxygen is found in cell vent gases¹. Any internal production of oxygen will affect cell internal reactivity, cell internal temperature, and cell case temperature, but plays no measurable role in the flammability of vent gases.

8.1.2.1 Research and Testing of Lithium-Ion Batteries and BESS

Testing has been conducted to provide insight into the fire hazards associated with lithium-ion battery energy storage systems. A few of the larger-scale testing and research reports will be summarized below:

- FPRF/Exponent Hazard Assessment of Lithium-Ion Battery Energy Storage Systems.
- FAA Fire Hazards of Lithium-Ion Batteries Testing of payload of lithium-ion batteries in an aircraft cargo hold.
- DNV GL/Con-Edison Considerations for ESS Fire Safety.

8.1.2.1.1 FPRF/Exponent Hazard Assessment of Lithium-Ion Battery ESS

Exponent Inc. and the NFPA’s Fire Protection Research Foundation conducted a full-scale fire test of a Tesla Powerpack – 100kWh lithium-ion BESS at 100% SOC². Two tests were conducted, one with an external ignition source of 400 kW and another with an internal ignition by heater cartridges. The internal test set individual cells into thermal runaway to simulate an internal failure, and the external test led the internal cells into failure through heat exposure.

The results of the external ignition test determined the following:

- A fire in the Powerpack resulted in internal temperatures exceeding 1,093°C.
- External temperatures reached 232°C.
- Flames were observed coming out of the exhaust vent and out of the BESS front door.

¹ Lithium-Ion Batteries Hazard and Use Assessment, Final Report, Celina Mikolajczak, PE, Michael Kahn, PhD, Kevin White, PhD, Richard Thomas Long, PE, Exponent Failure Analysis Associates, Inc., July 2011 National Fire Protection Association, Fire Protection Research Foundation.

² Blum, A. F., & Long, Jr., R. T. (2016). Hazard Assessment of Lithium-Ion Battery Energy Storage Systems. Quincy: National Fire Protection Association

- Flames several feet high were observed from the exhaust vent of the Powerpack.
- Heat flux of approximately 25kW/m² measured 1.8m from front of BESS.
- All batteries and electronics of the BESS were damaged.

The internal ignition test gave the following results:

- A fire in the Powerpack resulted in internal temperatures exceeding 1,093°C.
- Temperatures at pods below the initiator pod showed temperature ranges between 26 and 82°C.
- External temperatures reached 21°C.
- Initiator pod was damaged, but other cells were not damaged.

8.1.2.1.2 US FAA-Style Flammability Assessment of Lithium-Ion Cells and Battery Packs in Aircraft Cargo Holds

The exponent conducted flame attack tests on single prismatic batteries and prismatic battery packs inside a cargo hold³. The result of this testing provides insight into battery behaviour under fire conditions as well as temperature profiles of the fire events.

Key findings from these small-scale tests include the following:

- Frequent battery case rupture events were observed in the prismatic battery pack testing.
- Direct flame impingement on small, unpackaged quantities of prismatic battery packs can lead to thermal runaway of individual cells and venting of gases. The vent gases are generally ignited by the pre-existing flame, increasing the total heat flux produced by the fire.
- Testing of 4 cell li-ion battery packs produced ceiling temperatures between 400°C and 600°C.

8.1.2.1.3 FAA Energetics of Lithium-Ion Battery Failure

The Federal Aviation Administration (FAA) has worked to quantify the hazard of lithium-ion batteries under a fire event since a fleet of the Boeing 787 Dreamliner were grounded as a result of hazards associated with LIB fires. In addition to the fire events, large numbers of lithium-ion batteries are being shipped as cargo on aircraft. Although the failure of a single cell is a low probability event (1/1,000,000), the large quantity of batteries on aircraft and the severe impact of an event on the survivability of the aircraft make the risk a safety concern to the passengers.⁴

To analyse the hazard of lithium-ion batteries undergoing a thermal runaway event in an aircraft, a pallet load of 18,650 cylindrical batteries were forced into thermal runaway within a cargo hold of an aircraft. This test showed that all the batteries became involved in the fire. This testing provided data regarding lithium-ion battery fires and heat release rate curves providing insight into the growth function of a fire involving multiple packs of lithium-ion batteries. This study is applicable to quantifying a fire event in a BESS due to the number of batteries in a confined compartment.

The results indicated the heat release rate per battery cell was approximately 5kW.

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³ Mikolajczak, C. (2005). US FAA-Style Flammability Assessment of Lithium-Ion Cells and Battery Packs in Aircraft Cargo Holds. Exponent. Menlo Park: Exponent.

⁴] Lyon, R. E., Walters, R. N., Crowley, S., & Quintiere, J. G. (2015). Fire Hazards of Lithium-Ion Batteries. Federal Aviation Administration. Atlantic City: Federal Aviation Administration.

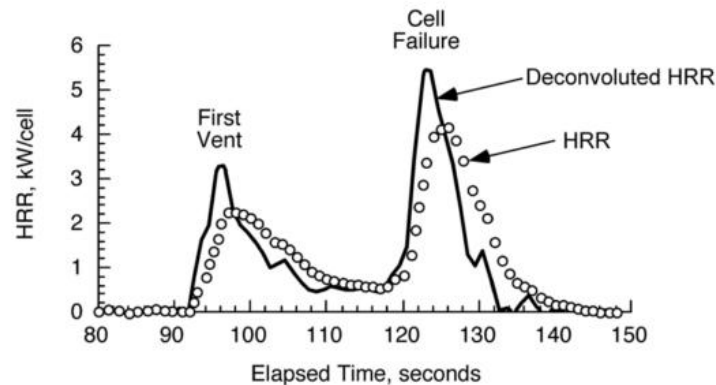


Figure 2. Lithium-ion cell failure at 70% SOC exposed to 50 kW/m² irradiance in fire calorimeter; points are data from standard method; solid line is data corrected for instrument response

Figure 20: Results of a single group of batteries.

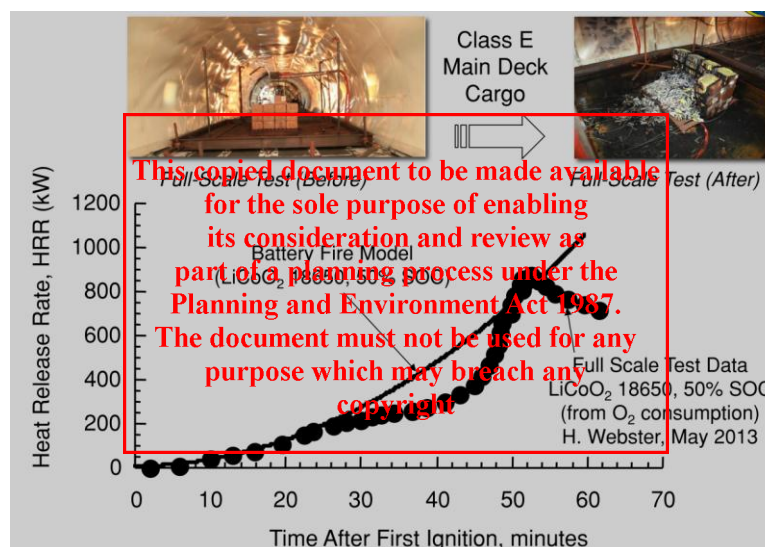


Figure 21: Results of full-scale tests on 18650 batteries.

The peak heat release rate is approximately 1MW.

8.1.2.1.4 DNV GL Considerations for ESS Fire Safety

DNV GL and Rescue Methods were contracted by Con-Edison Power and the New York State Energy Research and Development Authority (NYSERDA) to address a series of frequently asked questions regarding BESS Fire Safety⁵. This work included testing of lithium-ion batteries of various chemistries as individual cells and battery modules. The individual cells were exposed to a 4-kW radiant heat source until they vented inside DNV GL's Large Battery Destructive Testing Chamber. For the module testing, modules between 7.5 and 55 kWh were ignited inside a partially closed metal container by direct flame impingement from a propane torch. The module testing provided data concerning the effect of oxygen, toxicity, and heat release rate of the fire.

⁵ DNV GL. (2017). Considerations for ESS Fire Safety. Dublin: DNV GL

A few key findings from this testing are discussed below:

- Batteries are more volatile at higher states of charge (SOC).
- Mass loss rate is proportional to SOC. Average mass loss rate: 18% mass loss over 41.7 min.
- If flames are visible and temperature is rising, the ESS is likely to have multiple batteries and/or modules involved in the fire. Rising temperatures within the ESS is an indication of increasing risk.
- The batteries themselves emit flammable gases.
- Recommended Ventilation Rate Correlation of 0.095 – 0.15 l/s/Wh.
- HRR produced variable results. The range was between 2.5 – 80 kW/kg, depending on volume of gases, duration of release, rate of ignition, and gaseous mixture.
- Partially burned systems can continuously emit flammable gases as long as the cells retain their heat – even if the fire has been extinguished.

8.1.2.2 Rate of Heat Release

The Rate of Heat Release for the battery units is dependent on the state of charge as well as the size of the batteries and the incident heat flux.

It was reported in “Fire behaviour of lithium-ion battery with different states of charge induced by high incident heat fluxes”, by Zhi Wang that the peak heat release rate of a battery unit is approximately 700kW/m² to 1050kW/m² and an average of approximately 150 – 200kW/m².

Note these are individual small batteries and not part of a BESS unit and the area is the surface area of the batteries. Based on the size of the units in the VBE Fire investigation (7.5m x 1.6m x 2.5m) and assuming the front and the top of the unit are burning based on the location of the venting, the heat release rate is predicted to be 4.5MW to 6MW.

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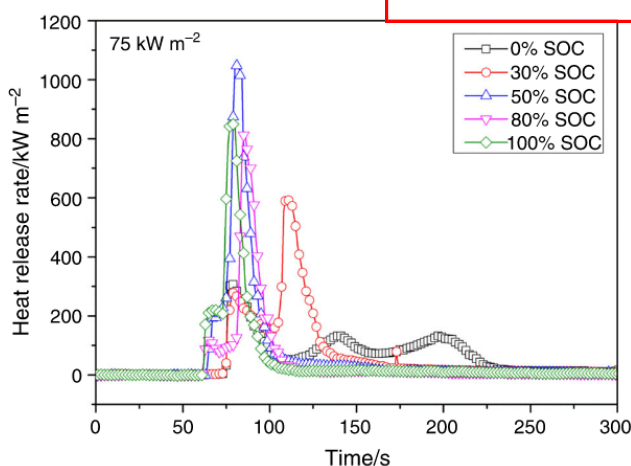


Fig. 7 Heat release rate of batteries at different SOC levels under an incident heat flux of 75 kW m⁻²

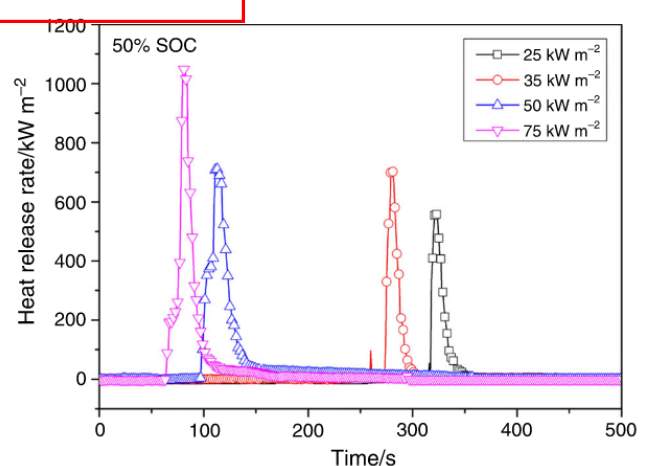


Fig. 8 Heat release rate of batteries with 50% SOC under different incident heat fluxes

Figure 22: Tested heat release rates for Lithium-ion batteries.

8.2 SUBSTATIONS

The combustible materials in distribution substations and equipment involved in substation fires may include the electrical wire or cable insulation, transformers (e.g., transformer fluids, especially oil), valves, outdoor or indoor oil-insulated equipment, oil-insulated cable, hydrogen-cooled synchronous condensers, PCB-insulated equipment and other items.

The Ministry of Economic Development (MED) provides annual statistics reports in New Zealand. In accordance with MED, from the substation's fires in New Zealand between 1946 and 1995, 65% of these fires had the electrical wire or cable insulation as the object first ignited (Figure 23). Compared to the cable insulation, the probability of having transformer or transformer fluid as the object first ignited is much lower (20%).

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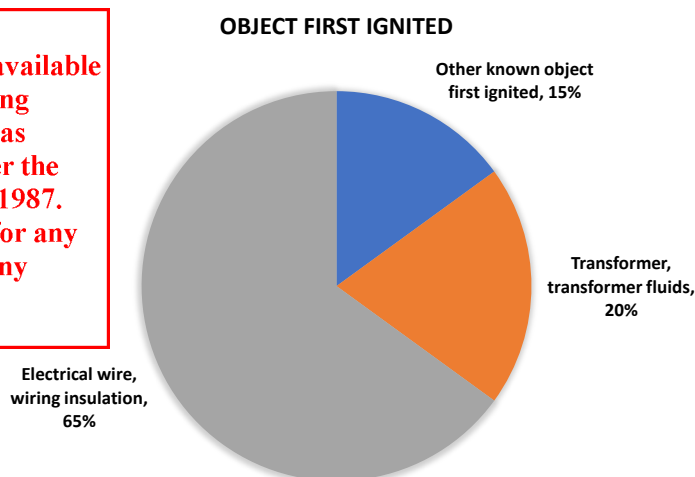


Figure 23: Substation fires distribution.

The EEP (Electrical Engineering Portal) [20] indicates that fires in substation are not common, however consequences are catastrophic for the company and consumers. The EEP lists the types and origins of fires in substations between 1971 and 1994 in Figure 24.

Types and Origins of Fires	Percentages
Oil-insulated circuit breakers	14.0
Current transformers	14.0
Power transformers	9.3
Hot work procedures (welding, cutting, and grinding)	9.3
Potential transformers	7.8
Engine-driven generators	7.0
Arson	6.3
Smoking	6.0
Lightning	4.7
Flammable liquid storage or handling	3.1
Terrorism	1.6
Miscellaneous fires	15.8

Figure 24 – Types and origins of Substations fires [20].

Also, CIGRE [21] has completed a survey of reliability and failures of in-service high voltage equipment, such as SF6 circuit breakers, disconnectors, earthing switches, instrument transformers and GIS. The survey gathered data from 90 utilities from 30 countries. The main findings were the following:

- The overall failure frequency for circuit breakers is 0.30 major failures per 100 circuit breaker years of service.
- For disconnectors and earthing switches the overall major failure frequency is determined to be 0.21 major failures per 100 circuit breaker years of service.
- Instrument transformers have an overall failure frequency of 0.053 major failures per 100 single phase instruments transformers years of service.
- In general, individual equipment installed in GIS appears to have lower failure frequencies than equipment in air insulated substations. The overall major failure frequency for GIS bays is about 0.37 major failures per 100 GIS circuit breaker bay years of service (a GIS circuit breaker bay includes one circuit breaker and all associated disconnectors, instrument transformers, interconnecting busducts and/or parts of busbars and associated terminals).

8.3 TRANSFORMERS

The following section details the likelihood of transformer fires from various sources:

- The last Australian CIGRE reliability report in 1995 came up with a failure rate for a failure causing a fire as 0.01%, i.e., 1×10^{-4} /yr. This was for transformers above 60 kV.
- A more recent survey (not a formal survey) covering 1800 transformer tanks from 6 utilities over 7 years calculated a risk of causing a fire as 0.09%, i.e., 9×10^{-4} /year (re CIGRE transformer Technology Conference 2008, presentation on Risk of Transformer fires by Arne Petersen).
- With regard to the Victorian transmission system for transformers 220 kV and above, there has only been one fire in 32 years giving a rate of 0.021%, 2.1×10^{-4} /yr.
- The New Zealand Ministry of Commerce, now known as the Ministry of Economic Development (MED), is a government department responsible for the government ownership of public properties. The number of distribution substations and the population in New Zealand are provided in their annual statistics reports. The statistical data on the number of distribution substations in New Zealand was obtained from the MED between 1946 and 1995. Since the statistical data after 1995 was not available, the number of distribution substations between 1995 and 2006 is estimated based on the growth rate measured in the previous 50 years. The NZFS FIRS database during the 6 years period from January 2000 to January 2006 indicated 24 fire incidents, 20 fire incidents were related to distribution substations, and 4 fire incidents are related to power or terminal substation. The 4 fires related to power or terminal substations were indicated to originate in switchgear areas or transformer vaults as shown in Figure 25.

Therefore, the average rate of fire starts in a transformer is – 4×10^{-4} /year.

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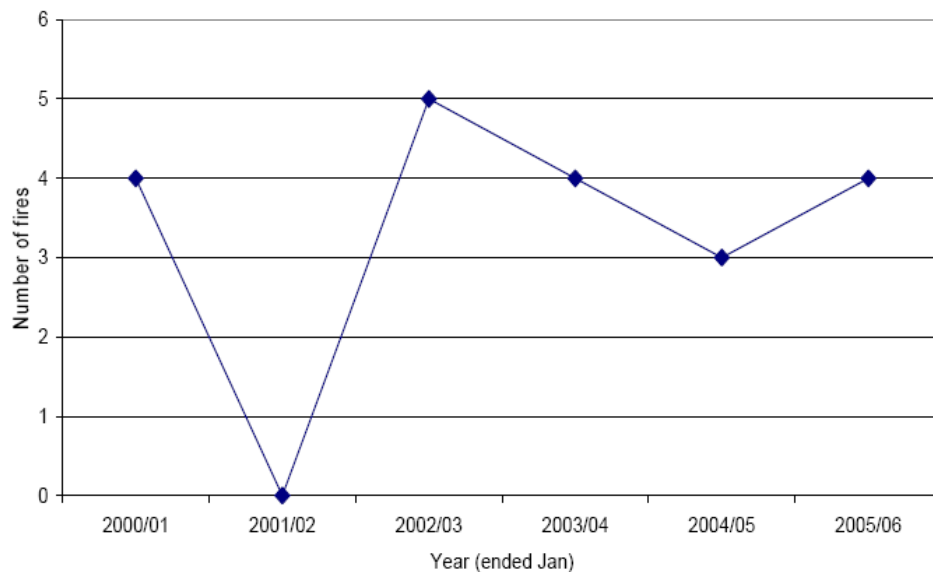


Figure 25: Number of distribution substation fires in 2000/06 (Source NZFS FIRS).

8.4 LEAKAGE OF THE TRANSFORMERS' OIL AND CONTAMINATED WATER RUNOFF.

Oil transformers and the water storage of 570kl (2 water tanks of 285kl each) have the risk of contaminated runoff water. The following measures are proposed:

- Transformers:
 - The HV transformers have a bund with the capacity to hold the oil volume to account for water and overflow. This will also prevent potential environmental damage and fire spread.
- Water runoff:
 - A containment and management plan for fire water runoff from the BESS is to be developed by the facility. Under the current layout, the firefighting water runoff will be captured by the proposed internal retention basin located in the north-west corner of the site, where it will be treated accordingly, rather than discharged directly into the municipal system.
 - The Construction Techniques for Sediment Pollution Control (1991) and Managing soil disturbance: guidance sheet (2020), will be used to develop an Erosion and Sediment Control Plan (ESCP).

8.5 IMPACT HAZARDS

Most equipment is enclosed by a metal enclosure, protecting the vital parts from most minor impacts, nonetheless they are not protected against car impact. Most equipment is exposed to a car impact given the access from the roads.

In order to mitigate this risk, all corners of the roads and BESS isles will be provided with bollards (final location to be designed based on the extent of the noise walls and the final layout of the BESS isles).

8.6 FLAMMABLE LIQUIDS OR GASSES

Storage of flammable liquids or liquefied flammable gasses in tanks do not occur within this site, therefore this risk and associated events are not applicable to this study.

8.7 ELECTROCUTION AND EMF HAZARDS.

Further assessment to electrocution and EMF hazards is out of the scope of this study.

This documentation is listed as a requirement in Section 3 of this document, and safety measures are to be added in the Emergency Management Plan.

It is recognized however that the site will provide masts for lighting protection, and the BESS units are expected to be provided with a lighting protection design.

8.8 RELEASE OF CONTAMINANT GASSES (I.E., POLLUTION CO AND CO₂).

The most common pollutants from a fire are CO (Carbon monoxide), CO₂ (Carbon dioxide), mix of multiple gasses and smoke from the equipment and oil's decomposition.

Those gasses are a hazard to the human life safety (people to the surrounding community and the fire brigade), and may prevent the fire brigade intervention procedures if the exposure thresholds are surpassed.

An analysis of this hazard is performed in this study, nonetheless it is recognized that given the location of the closest residential communities (i.e., approximately ~190m away), it is not expected that those communities will be affected by a fire at any of the equipment of the BESS facility.

8.9 BUSHFIRE HAZARD FROM ADJOINING ALLOTMENTS.

The subject allotment is classified as a BPA (Bush Fire Prone) area in accordance with the VIC Planning portal (Figure 12) and a Bushfire Management Overlay (BMO) applies to the eastern part of the site.

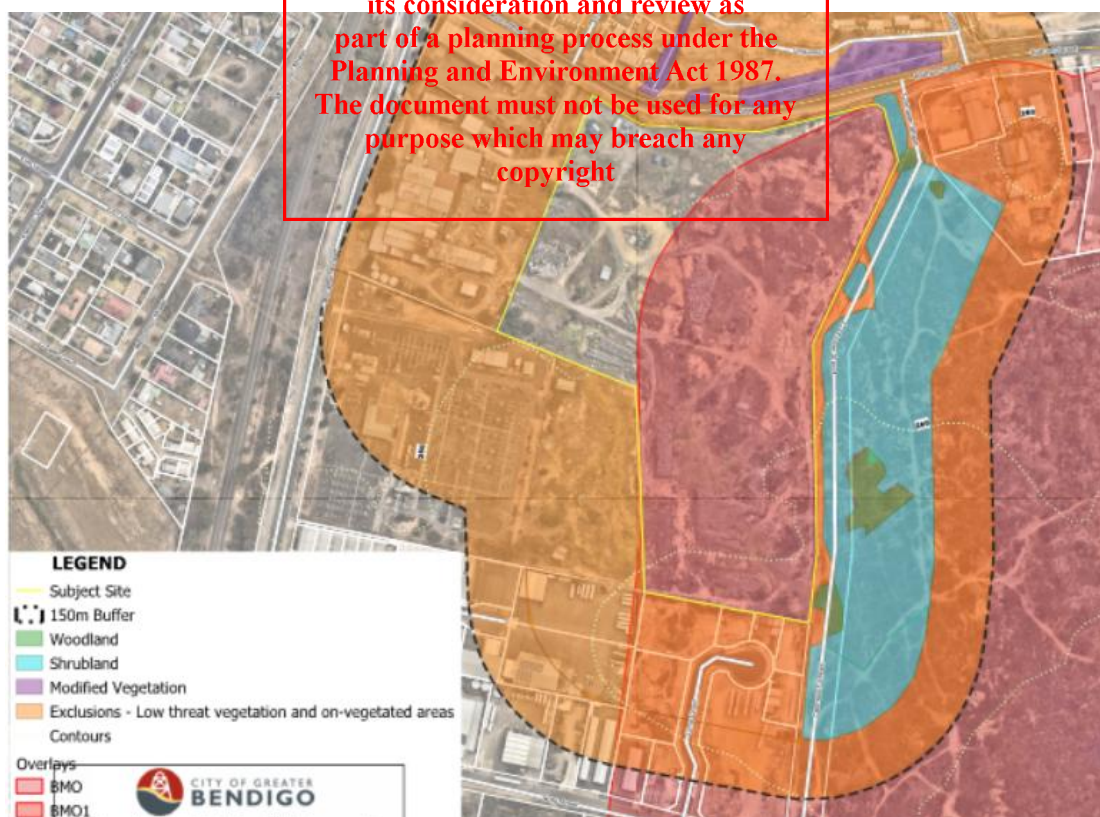
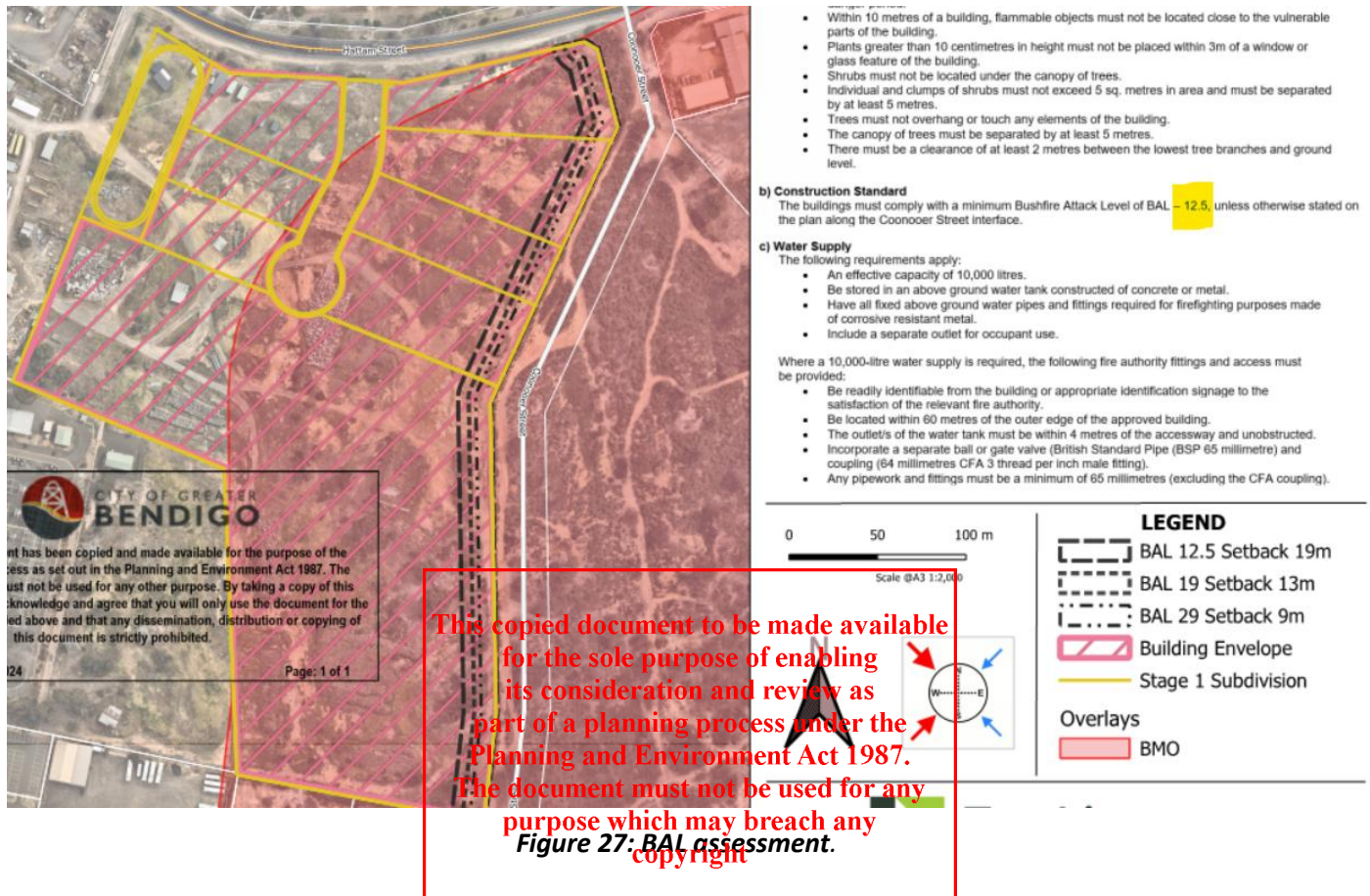


Figure 26: BMO area (red area).

A bushfire assessment as per AS 3959:2018 [22] has been performed. The initial Stage 1 Bushfire Management Statement by Tomkinson, dated August 2024 requires that buildings within the site must comply with a minimum Bushfire Attack Level of BAL 12.5.



In order to mitigate the risk of fire spread from the adjoining vegetation, the following measures will be implemented:

- BESS enclosure must be sealed with IP55 rating.
- A firebreak of at least 10m wide must be designed and maintained around the facility.
- All buildings must be constructed with non-combustible cladding.
- The initial Stage 1 Bushfire Management Statement by Tomkinson assessment, dated August 2024, mapped the BAL 12.5, 19 and 29 setbacks as shown in Figure 27. The BAL 12.5 rating is 19m setback from eastern boundary. Agilus [16] confirm that the setback exceeds the BAL 12.5 setback requirements as the design includes a 38 m setback along the eastern boundary of the site.

Furthermore, it is recognized that there are no buildings within 38m of the eastern boundary, surpassing the above requirements.

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9 CONSEQUENCE ON INCIDENTS

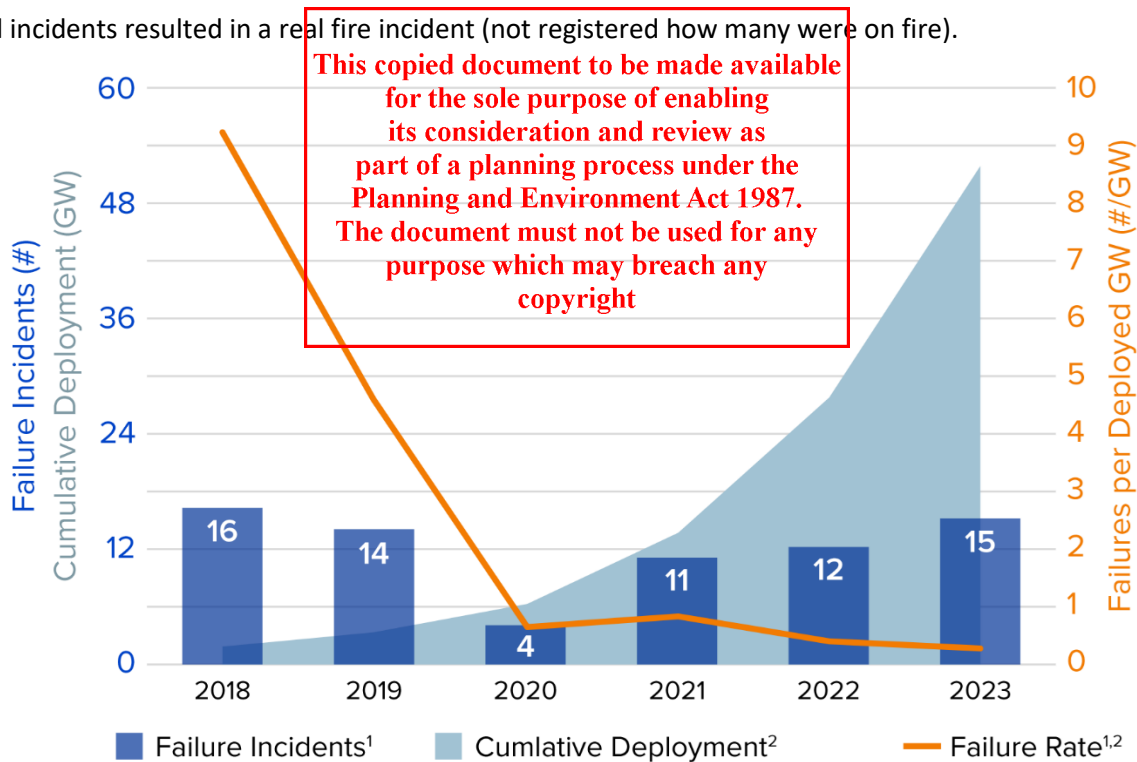
9.1 BESS FIRE LIKELIHOOD AND CONSEQUENCES

In the Article “Burning concern: Energy storage industry battles battery fires”, in the S&P Global Market Intelligence website, 24 May 2019 it was reported by Ken Boyce, a principal engineer at product safety certification, testing and advisory firm UL LLC that: “In general, it’s a very safe technology. Lithium-ion battery cells fail at a rate of only around one in every 12 million”. This is the rate of 8×10^{-8} per year.

From May 2, 2020, to Jan. 22, 2021, 21 ESS fires were reported across Korea from 1490 systems installed. This is a rate of 1.4%, i.e., rare based on table 2 from Appendix G of AS 5139.

Since 2011 to 2023, Electric Power Research Institute (EPRI) has recorded 81-88 incidents of BESS failures worldwide, and the following are the conclusions of the gathered statistics [19]:

- Battery storage failure incident rate dropped 97% between 2018 and 2023.
- Number of BESS units is increasing but failure rate is decreasing.
- EPRI defines failure incident as an occurrence which resulted in increased safety risk, caused by a BESS system or component failure rather than an exogenous cause of failure (e.g., wildfire impacting the BESS).
- Not all incidents resulted in a real fire incident (not registered how many were on fire).



Sources: (1) EPRI Failure Incident Database, (2) Wood Mackenzie. Data as of 12/31/23.

Figure 28: Global Grid-scale BESS deployment and failure statistics [19].

The likelihood of a fire is therefore considered to be rare. Accordingly, the risk of a fire would be rated as Very Low.

9.2 CONSEQUENCE

The consequence of a fire in a battery and a transformer has been assessed as part of the fire engineering report in accordance with the CFA's 'Fire Safety Studies for Battery Energy Storage Systems'.

It has been demonstrated that given the fire separation to the adjacent buildings and provided safety measures, fire spread is not predicted to occur at a greater level than for NCC compliant buildings within the community. (Note this is based on units similar to those in the VBB fire and further assessment will be performed once the final BESS unit design is known).

The below assessments consider as applicable the fire safety measures described in Section 3, fire dynamic simulations and mathematical calculations in order to assess the risks of fire spread from/to the equipment in the proposed BESS development.

The following fire scenarios have been considered:

Table 11 – Design Fire Scenarios

Equipment on fire	Description	Peak HRR (MW)	Wind
HV Transformer	Flashover without fire hydrant intervention	422.0	No
HV Transformer	Flashover without fire hydrant intervention and wind in the direction of the equipment and access/exits points.	422.0	Yes
Bess Unit (single unit)	Flashover without fire hydrant intervention	6.0	No
Bess Unit (6 units)	Flashover without fire hydrant intervention and wind in the direction of the equipment and access/exits points.	6.0	Yes
BESS Unit (single unit)	Explosion	NA	NA
Bushfire	Bushfire as per BAL Assessment	NA	NA
Bushfire & BESS Unit (6 units)	Bushfire as per BAL Assessment, tests data and modelling	NA	Yes

The above fire scenarios have excluded the fire hydrant intervention, which will be an additional layer of protection at the time of a real fire scenario to cool down the equipment.

9.2.1 HV Substation.

In order to assess the impact of a transformer fire on other objects and exits, the transformer fire was treated as a pool fire as it is based on liquid hydrocarbon fire. The method used to calculate the heat flux received at a target was one that is generally accepted in the risk engineering discipline detailed in the Yellow Book (Committee for the Prevention of Disasters).

Enclosure Fire Dynamics gives a correlation equation (Equation 3.6) to estimate the free burn mass loss rate as below:

$$\dot{m}'' = \dot{m}''_{\infty} (1 - e^{-k\beta D}) \quad (\text{Equation 3.6, Enclosure Fire Dynamics})$$

Where:

- $\dot{m}''_{\infty}$: 0.039 kg/m²s
- $k\beta$: 0.7 (m⁻¹)
- D: diameter of the pool fire as a circle.

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As it can be seen from the above equation the fire size in terms of mass loss rate and hence heat release rate is independent of the transformer size and volume of oil.

A liquid fuel pool fire in the transformer will be modelled using the NIST Fire Dynamics Simulator model.

The National Institute of Standards and Technology (NIST) has been developing Fire Dynamics Simulator (FDS), to predict fire spread in a structure. Over the past few years, it has also been used to predict smoke and hot gas plume behaviour produced by outdoor fires. FDS is well documented and is widely used by fire protection engineers around the world. The model is being extended to include fire spread from structure to structure and generalizing FDS to include a means to predict fire spread in both continuous and discrete natural fuels.

The fire growth and spread were modelled using the National Institute of Standards and Technology (NIST) Fire Dynamics Simulator (FDS) software package and Smoke view which is used to view the results.

Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model of fire-driven fluid flow. The software solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport from fires.

In accordance with the methodology described above and considering the characteristics of the transformer of a typical 220kV substation, a bund of approximately 336m³ with a fire of 422.41 MW (Figure 29) is estimated (the actual bund of the transformer will be reviewed later in the detailed design).

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Volume oil	60000.00	L	
	60.00	m ³	
Bund			
Area TK & Radiator	0.00		
L	21.00	m	
W	16.00	m	
H	0.18	m	
Ideal mass loss	0.039	kg/sm ²	
A	336.00	m ²	
V Bund	60.00	m ³	
D	20.68	m	
m''	0.039	kg/m ² .s	$\dot{m}'' = \dot{m}''_{\infty} (1 - e^{-k\beta D})$ (Equation 3.6, Enclosure Fire Dynamics)
Hc	4.605E+07	J/kg	
q	1257.16	kW/m ²	
Ballast Factor	1.00	-	Without ballast = 1, with ballast = 0.2.
Q	422.41	MW	$\dot{Q} = A_f \dot{m}'' \chi \Delta h_c$ (Equation 3.5, Enclosure Fire Dynamics)

Figure 29: HRR Calculation substation.

The FDS model boundary conditions are presented in Figure 30 and the fire scenario characteristics are as follows:

- Fire Origin: Transformer at substation HV.
- Fire growth: Instant.
- Weather conditions (refer to Section 6.1.5): Wind speed: 5.3m/s; Temperature: 20°C; Relative Humidity: 45%.
- Heat release rate: 422.41MW (Figure 29 above).
- Hydrocarbon (transformer fires, properties obtained from Table 3-4.19 of SFPE handbook):
 - REAC ID="REAC"
 - C=4.00 N=0.00
 - H=10.00 HEAT_OF_COMBUSTION=4.605 x10⁷
 - O=0.00 SOOT_YIELD=0.0600 gr/gr

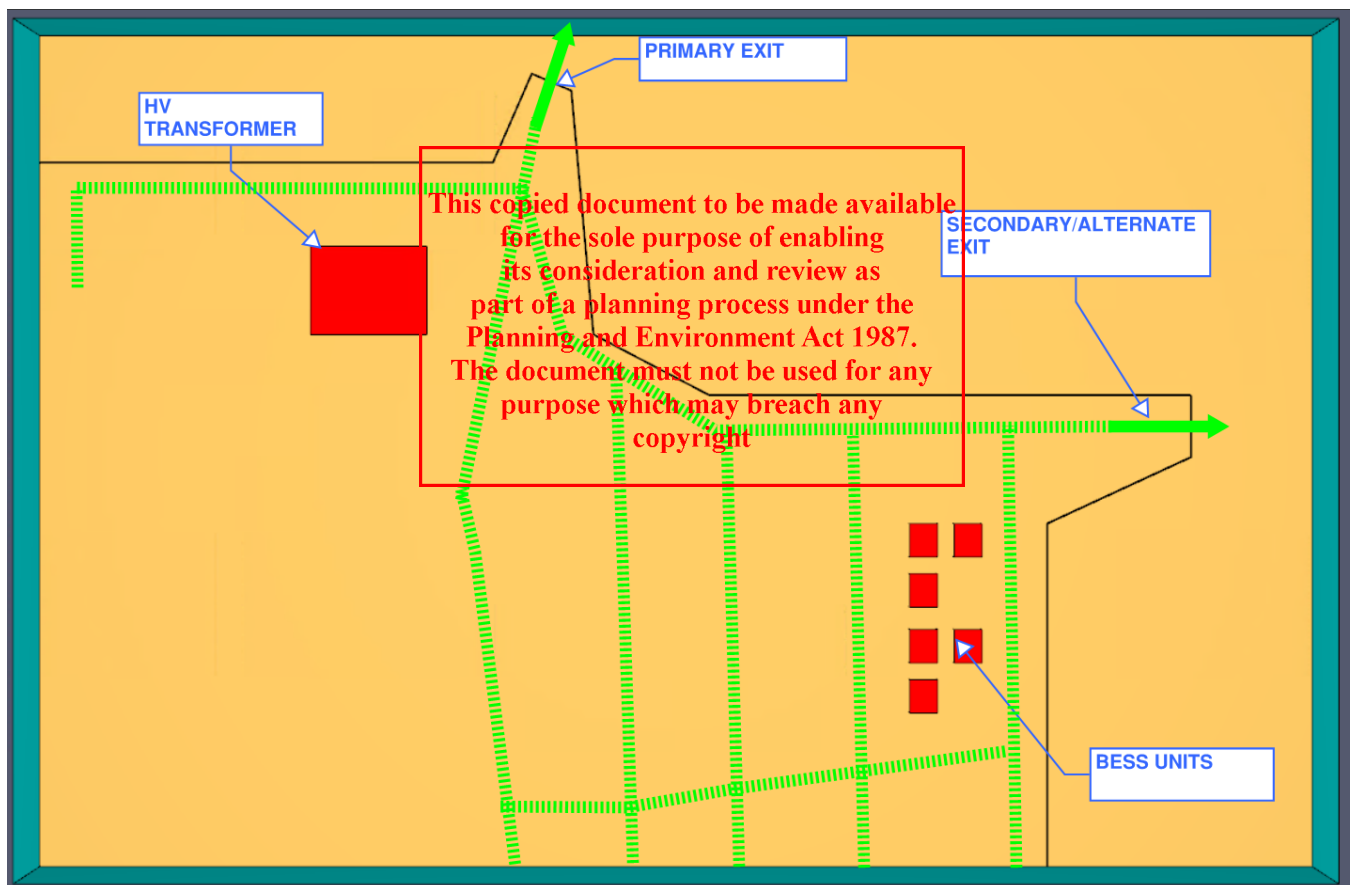


Figure 30 – FDS Model.

9.2.1.1 Risk of fire spread

Given the location of the subject facility equipment, Table 12 below summarizes the heat flux received at the different locations (approximate distances) within Bendigo BESS.

Table 12: Heat flux results based on HV substation fire (red is not acceptable).

Exposed equipment	Distance (m)	Incident Radiation (kW/m ²)			
		Wind (without walls to HV transformer) (Figure 31)	Wind (with walls to HV transformer) (Figure 33)	No Wind (Figure 32)	Critical Criteria
BESS (Closest)	72.0	1.8	1.7	1.7	37.5
Control/Switch room (with fire rated walls)	7.5	≥ 45	5.60	4.7	45.0
Detention Storage	58.0	2.7	1.73	1.8	13.0
O&M Building and Storage Shed	16.3	≥ 13	2.0	2.0	13.0
Primary Entrance (north)	42.0	2.0	1.74	1.7	13.0

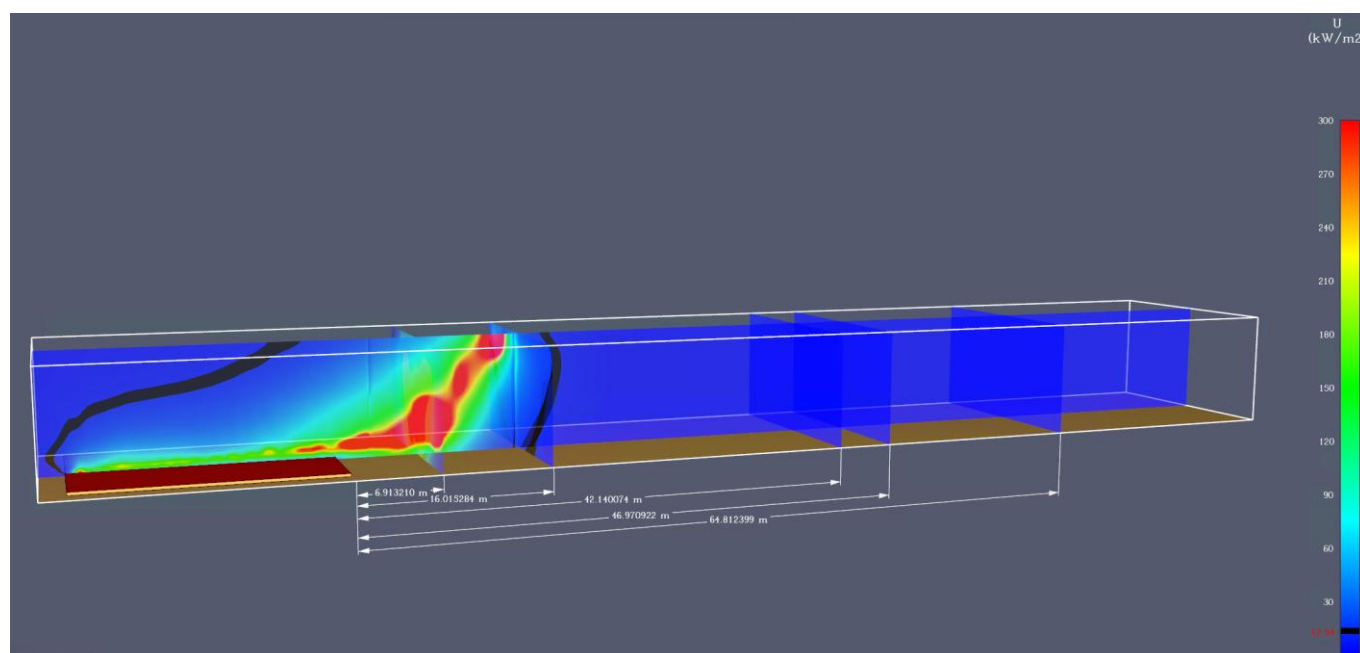


Figure 31: Radiant heat flux intensities with wind (HV-Transformer).

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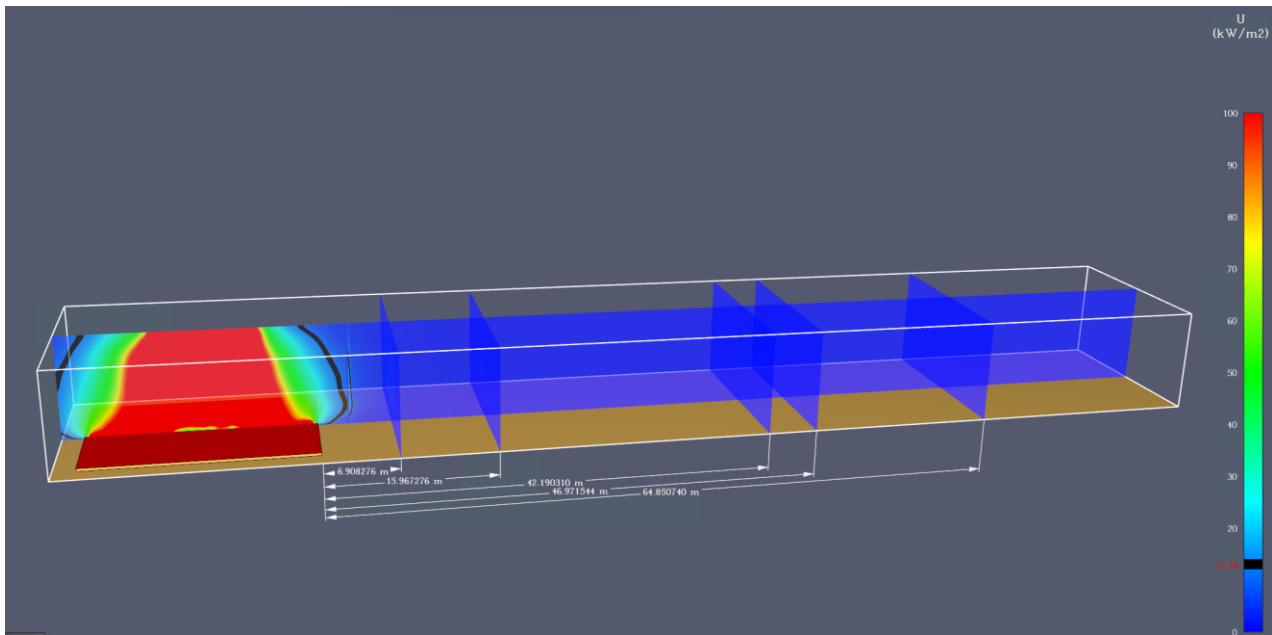


Figure 32: Radiant heat flux intensities no wind (HV-Transformer).

The results indicate that, with the presence of wind, the maximum heat flux levels at critical locations (Control/Switch room, O&M building and the storage shed), from a fire at the substation are above the critical heat flux for equipment, and buildings (13 kW/m^2). Hence, fire spread or damage of equipment may occur to these locations with the presence of wind. In order to mitigate this risk, a 2-hour fire rated wall will be provided between the buildings and the transformer as shown in Figure 34 below.

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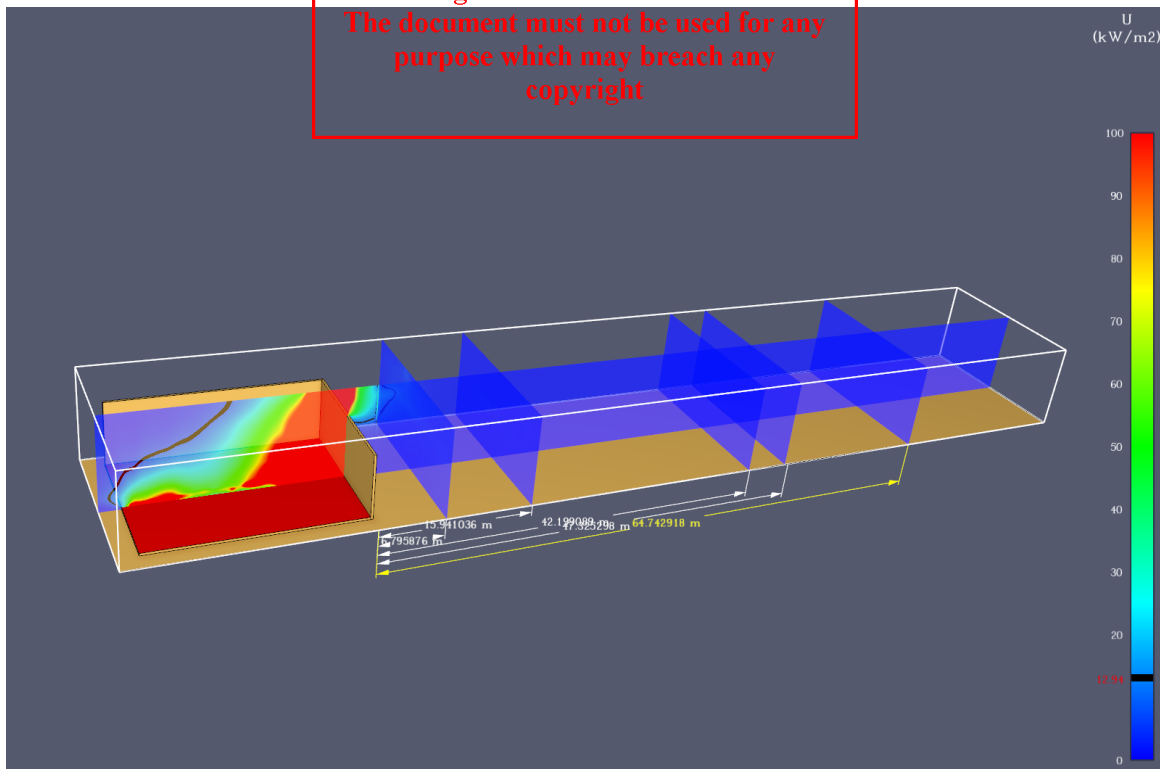


Figure 33: Radiant heat flux intensities with firewalls, with wind (HV-Transformer).

The results also indicate that, without the presence of wind, the maximum heat flux levels at critical locations from a fire at the substation remain well below the critical heat flux for vegetation, equipment, and buildings. Hence, fire spread is not expected to occur when there is no wind.

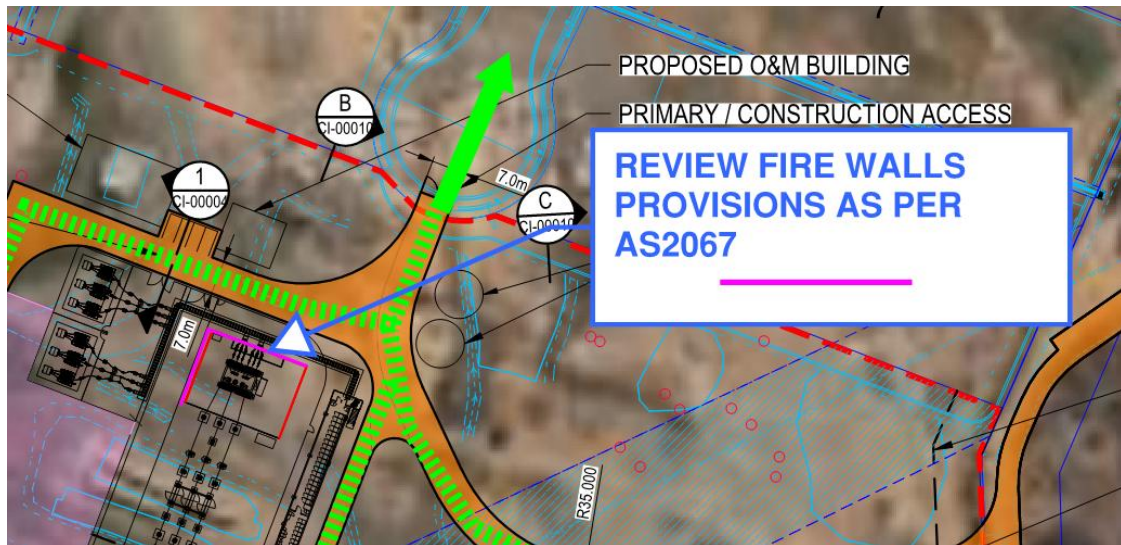


Figure 34: Location of fire walls to HV substation in accordance with AS 2067.

9.2.1.2 Obstruction of Exits (HV transformer fire)

The following modelling assesses whether a HV transformer fire could impact both the access of both the primary and secondary exits and Fire Brigade access to the subject site with wind coming from the northwest, blowing in the direction of the secondary/alternative exit. The model incorporates a domain height of 15m from ground level.

Based on the results, the critical heat flux at the secondary/alternative exit does not exceed 3 kW/m^2 (Figure 35) and the temperature at the secondary exit does not exceed 22°C below 2.0m height (Figure 36). Visibility below 2m also remains above 10m at the secondary/alternative exit (Figure 37).

As a conservative measures, the initial assessment does not include the effect of the firewalls and noise walls, and their effect is included afterwards to show it positive effect.

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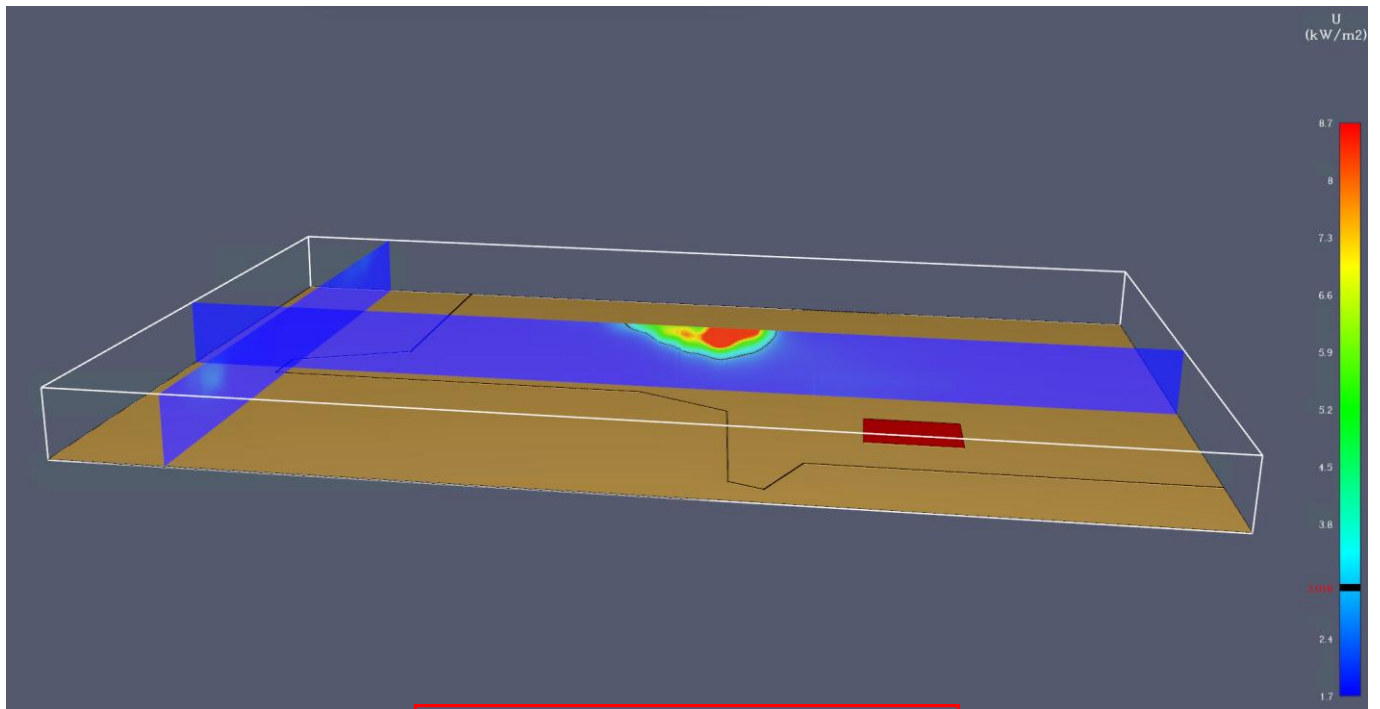


Figure 35: Radiant heat flux higher than 3kW/m^2 at the secondary exit with wind.

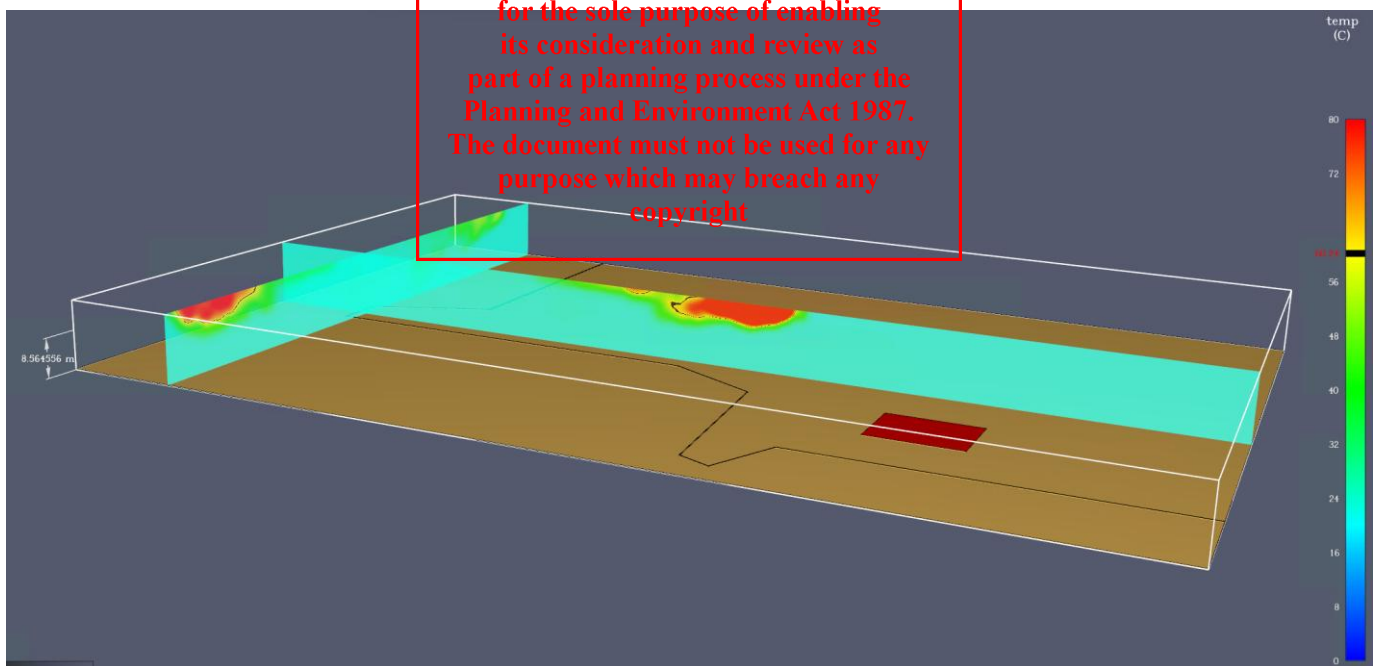


Figure 36: Temperature higher than 60°C at the secondary exit, with wind.

The visibility of the adjacent path to the east of the transformer decreases below 10m at a height of 2m from the ground level for up to 15m, as seen in Figure 37 and the access pathway directly to the east of the transformer is obstructed as radiation exceed 3kW/m^2 below 2.0m (Figure 38) however, the primary entrance is still tenable and the Fire Brigade operations will not be impacted as an alternative access path to the west of the transformer is available to access other areas of the site as seen in Figure 30.

Furthermore, note that at this stage the modelling is not considering the noise walls and fire walls.

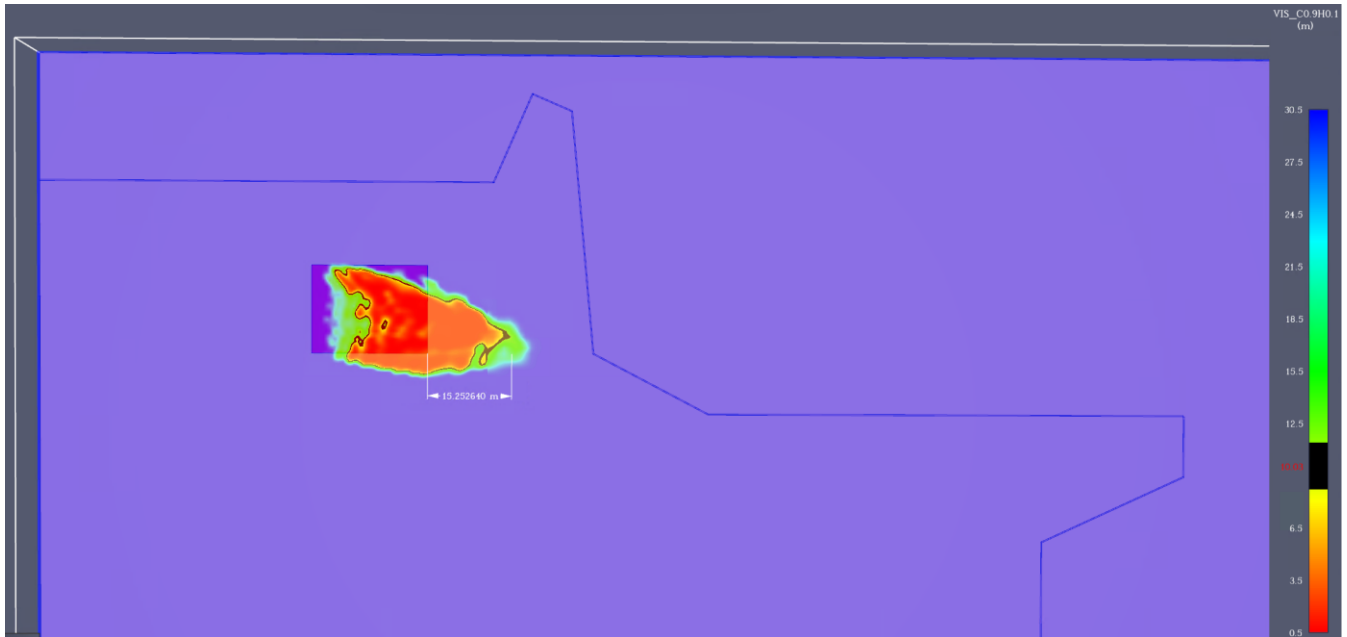


Figure 37: Visibility less than 10m with wind.

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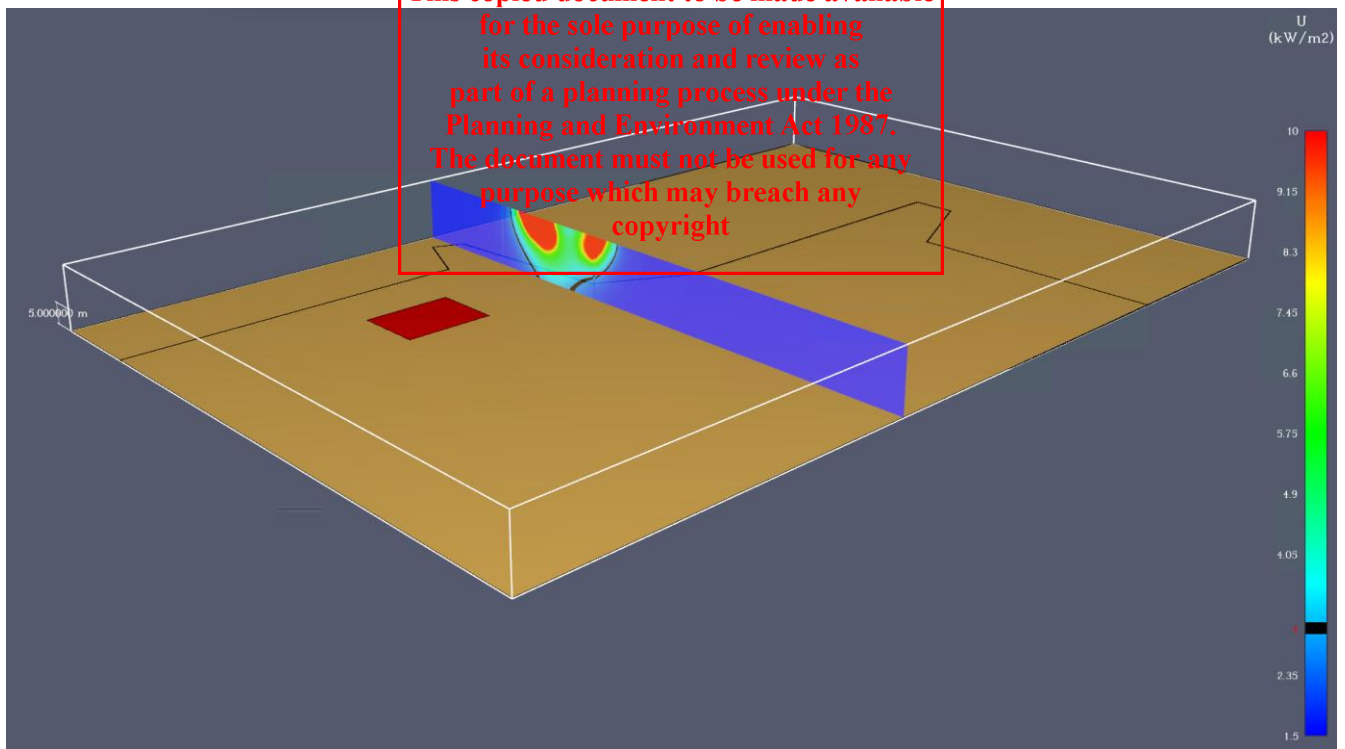


Figure 38: Radiant heat flux higher than 3kW/m² at the adjacent access path to primary exit, with wind.

A 2-hours fire wall will reduce significantly the distance affected from the transformer and will shield the main access road and nearby buildings.

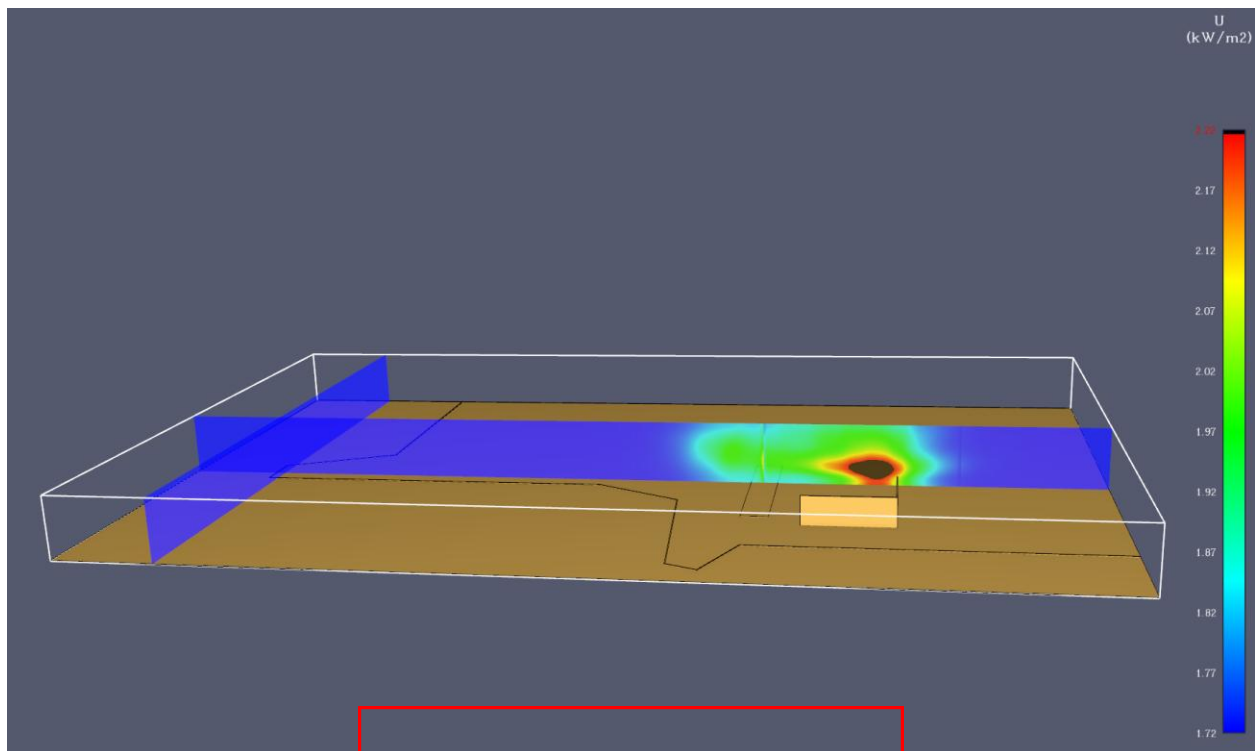


Figure 39: Radiant heat flux higher than 3 kW/m^2 at the secondary exit with firewalls and with wind.

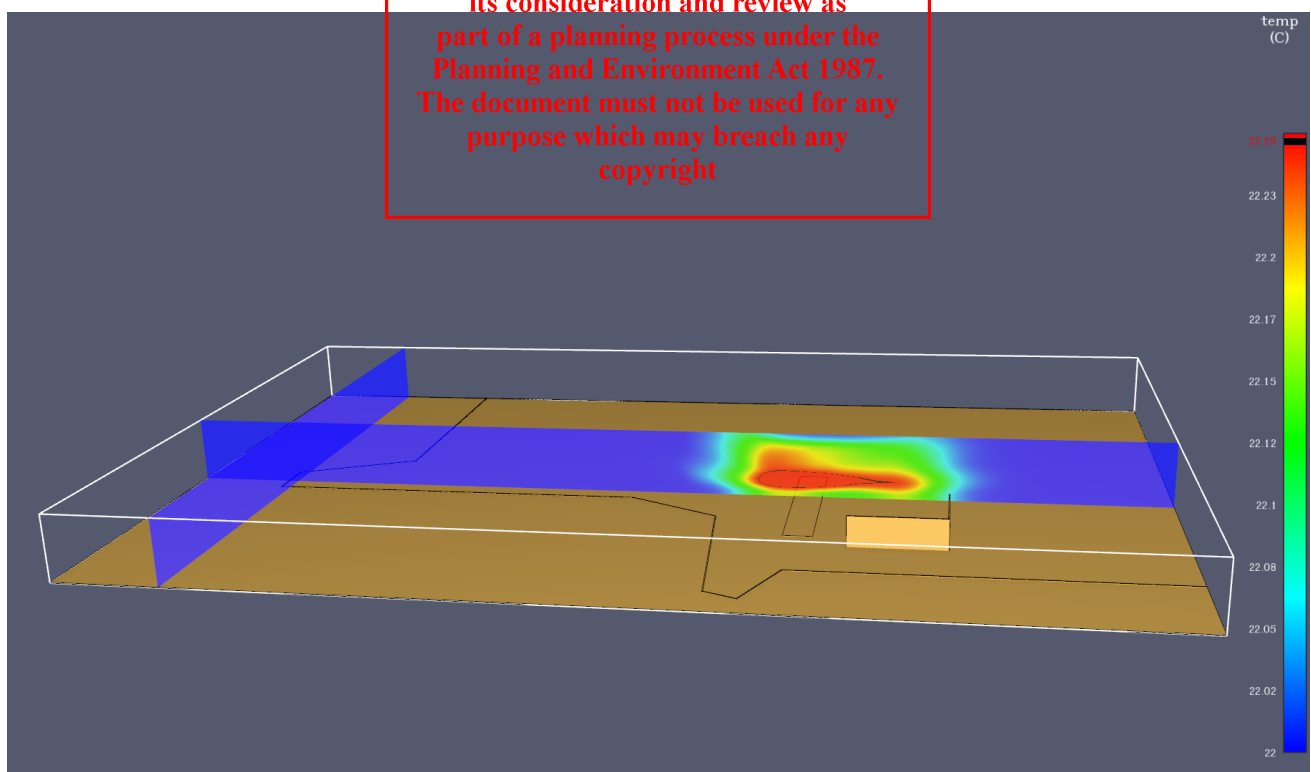


Figure 40: Temperature higher than 60°C at the secondary exit with firewalls and with wind.

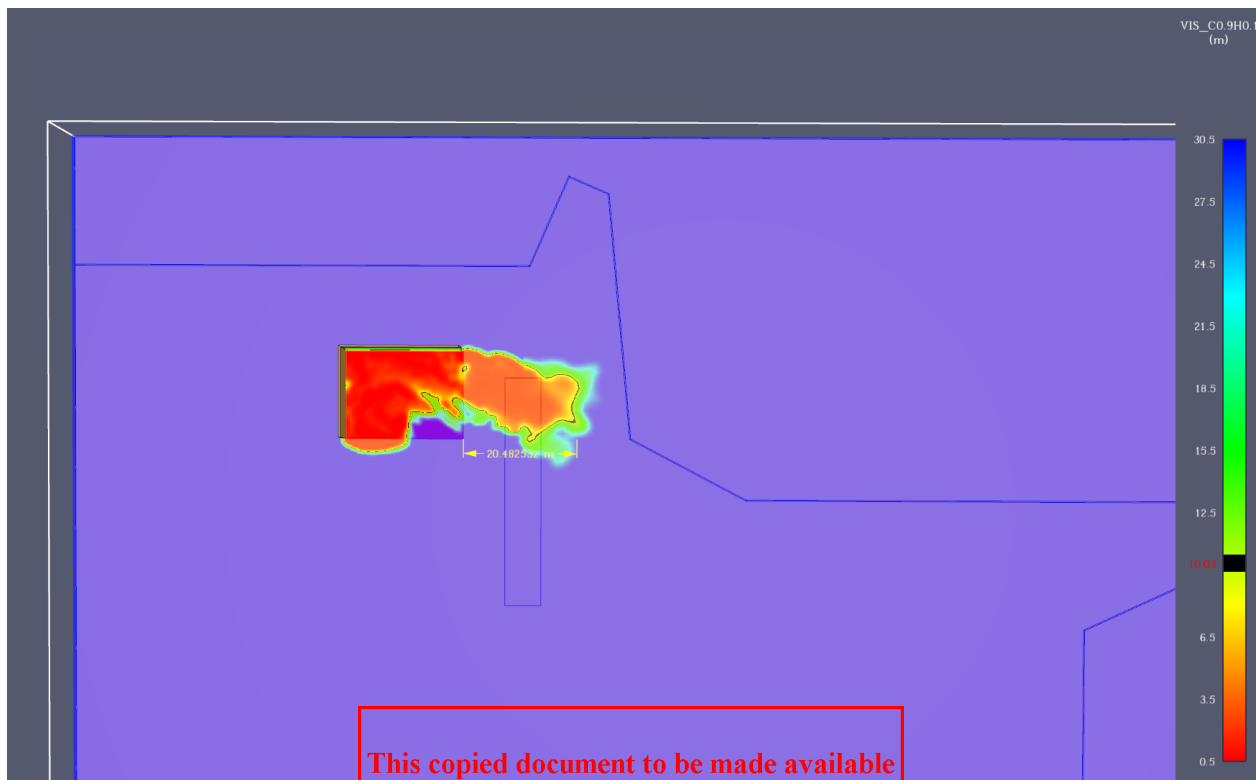


Figure 41: Visibility less than 10m with firewalls and with wind.

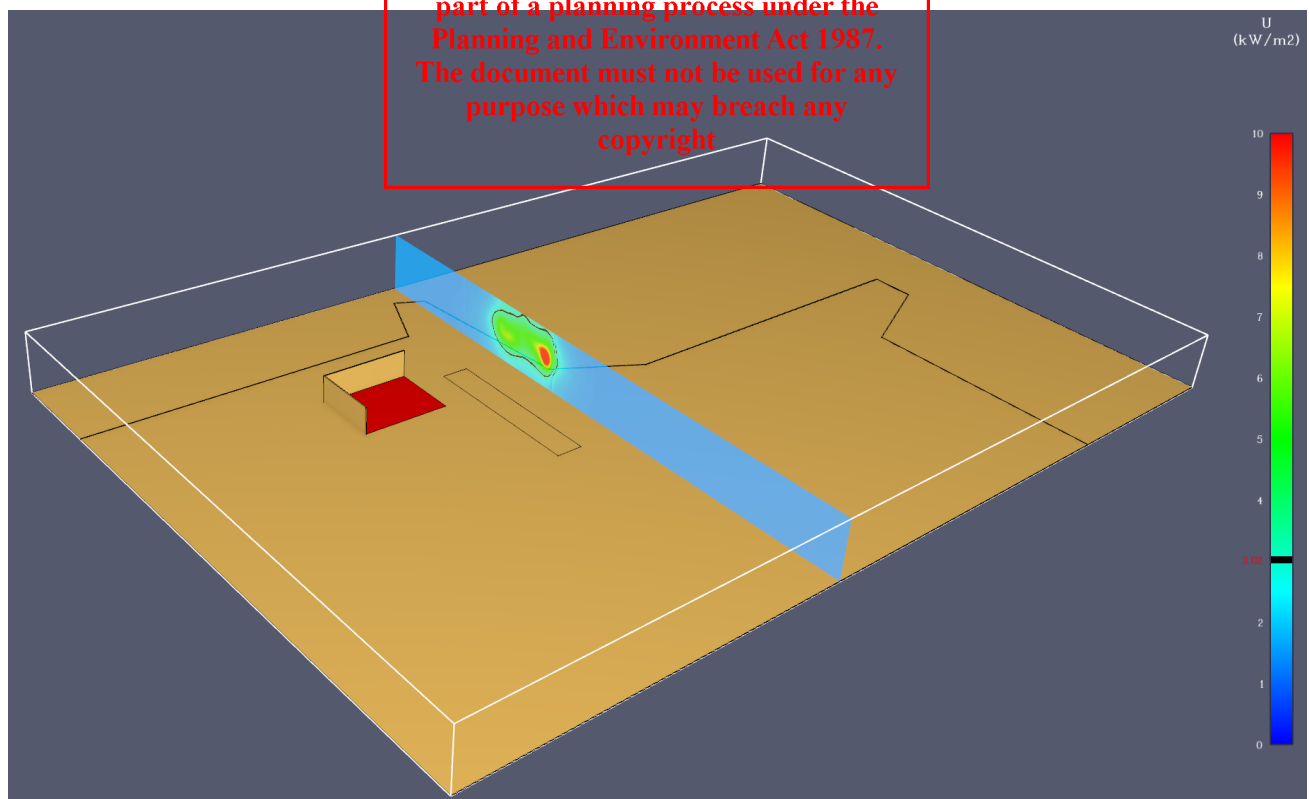


Figure 42: Radiant heat flux higher than 3kW/m² at the adjacent access path to primary exit, with fire walls and with wind.

9.2.1.3 Contaminant/harmful gasses

It was discussed in previous sections that the closest residential areas are located at ~190m to the north from the HV transformer.

Given the location of the subject facility, Table 13 below summarizes the expected gas concentration on site and to nearby communities (Figure 43 to Figure 46) at the level of 2m above the ground level.

When the wind is not present and fire vent just upwards, CO and CO₂ levels remain within the vicinity of the subject site. Figure 43 and Figure 45 show that gases flow upwards and the gases concentration remain acceptable around the transformer within a range of 40m (which is the approximate distance of the north primary exit from the HV transformer), hence it is expected that residential communities to 200m away will not be affected in this scenario.

Where the wind is present the critical thresholds are not reached around the transformer. At 2m above the ground, CO₂ levels are well below the critical value of 2000 ppm, and CO levels are also well below the critical level of 35 ppm in the direction of the wind at 40m. Hence, it is expected that residential communities more than 190m away will not be affected by harmful gases.

Table 13 below also demonstrates the effect of the fire walls and noise walls, where critical concentrations to residential area are not reached.

In this scenario, only fire brigade and staff on site will need to keep clear the area around the transformer and use PPE to mitigate health consequences.

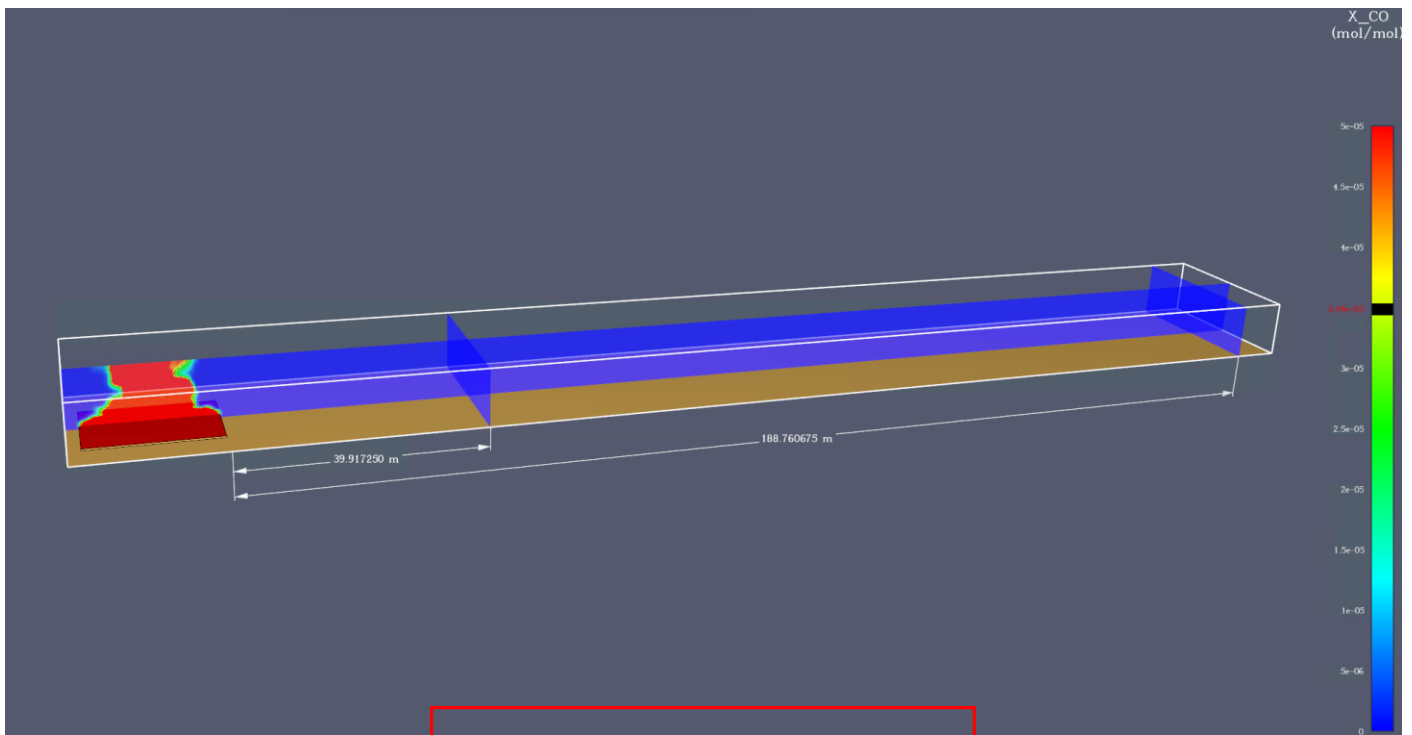
Where firewalls are installed, gases are still expected to go upwards due to the firewalls and will not affect occupants at the level of the ground.

Table 13: Gases concentrations

Gas	Distance (m)	Incident Radiation (kW/m ²)			Critical ppm
		No wind	Wind (without walls to HV transformer)	Wind (with walls to HV transformer)	
CO	40	< 35	< 35	< 35	35
	189	< 35	< 35	< 35	35
CO ₂	40	< 2,000	<2000	<2000	2,000
	189	< 2,000	< 2,000	< 2,000	2,000

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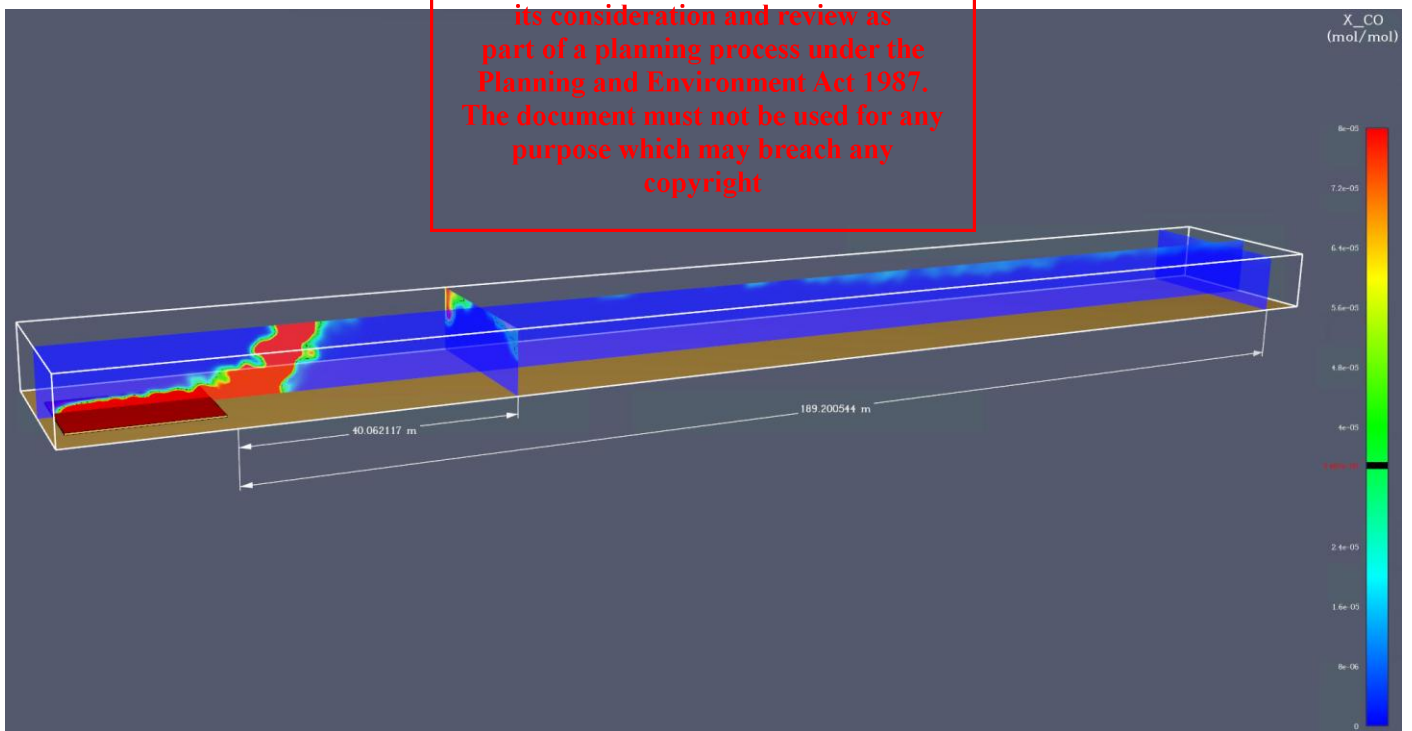
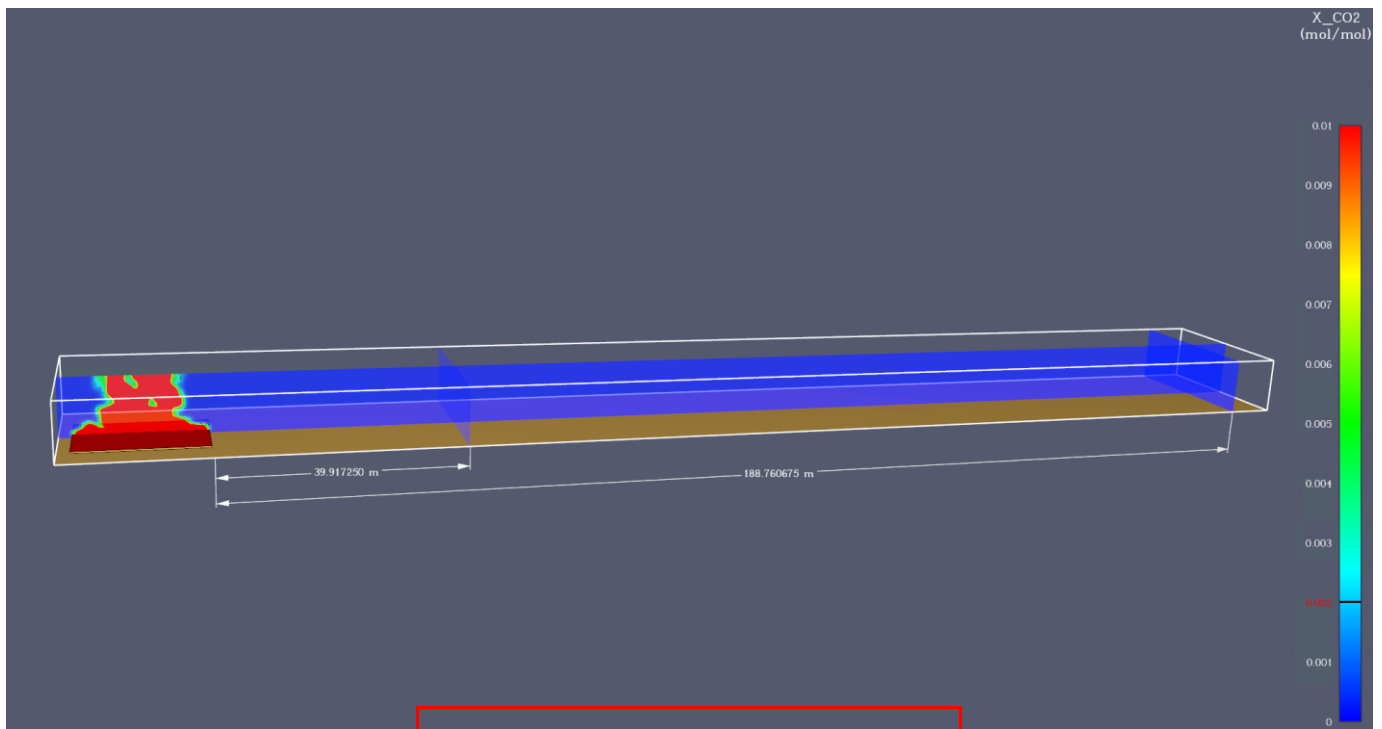


Figure 44: CO concentration with wind.

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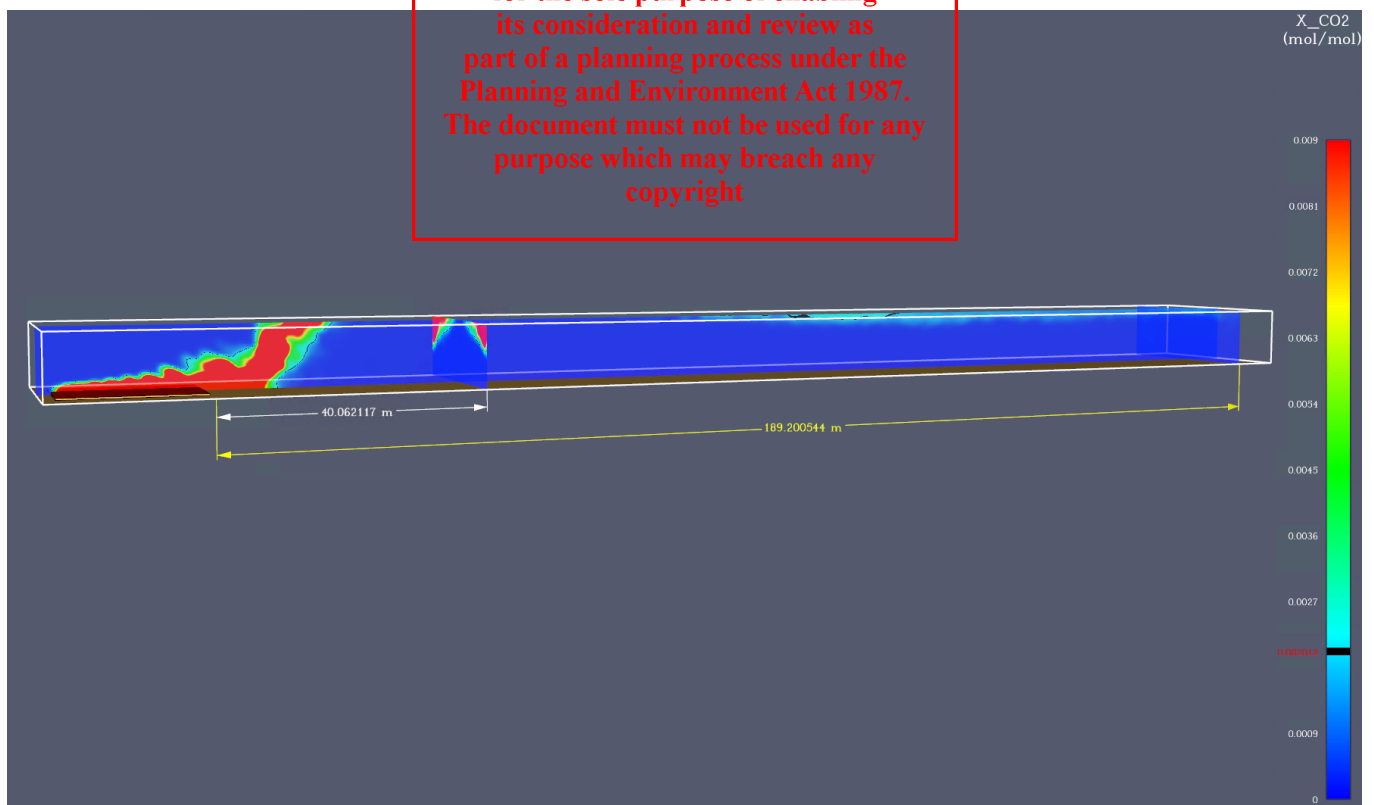


Figure 46: CO₂ concentration with wind.

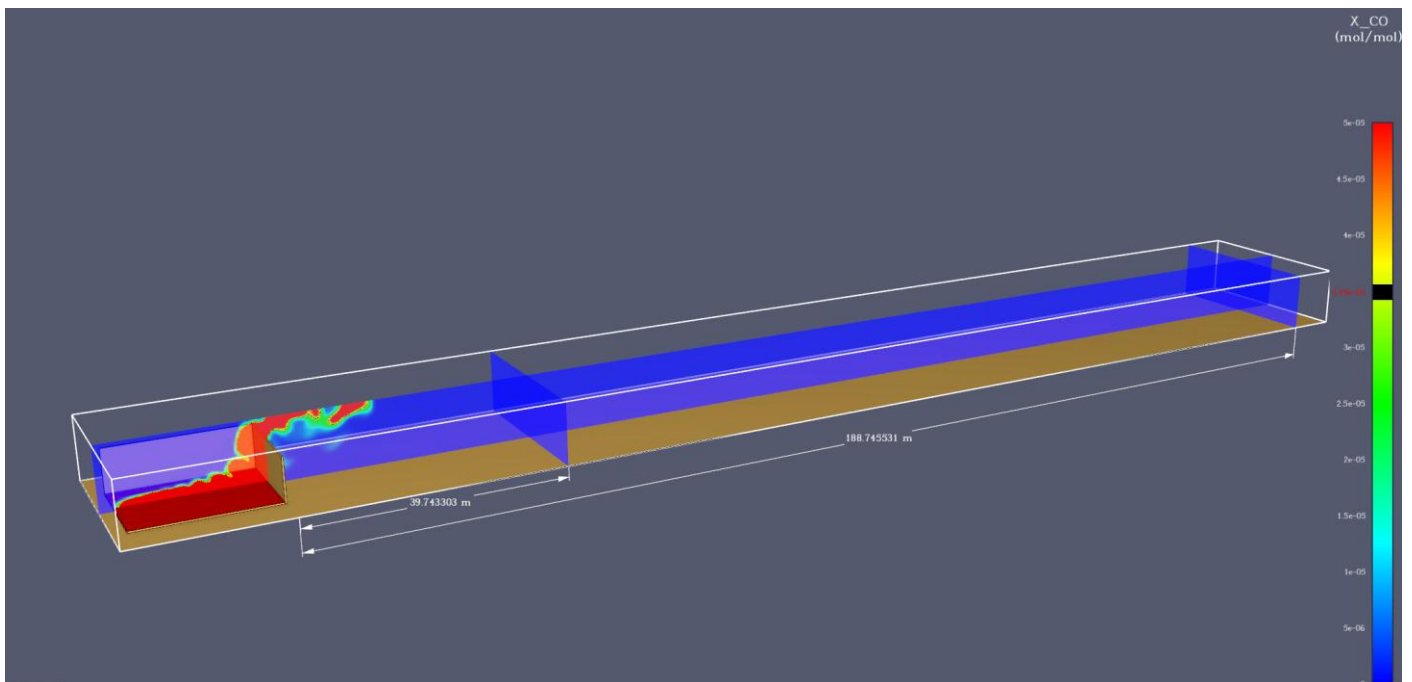


Figure 47: CO concentration with wind, with firewalls.

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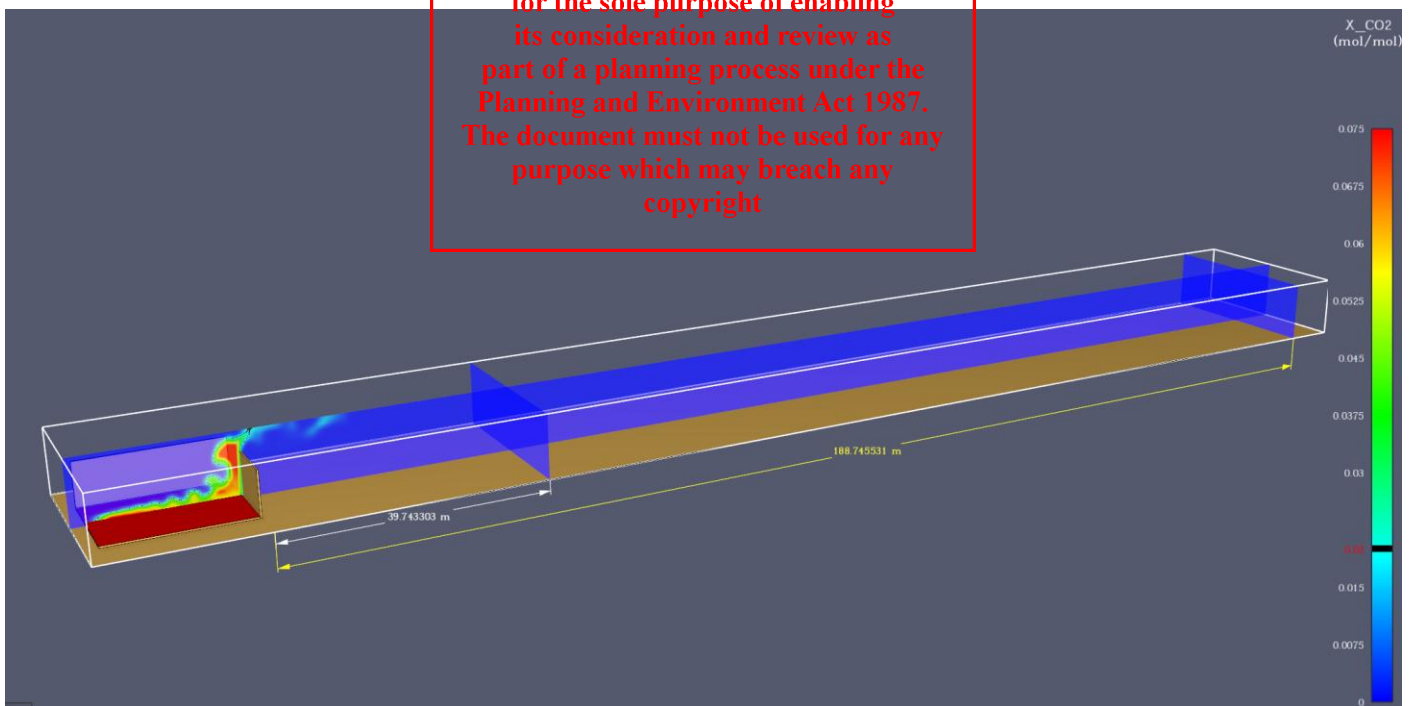


Figure 48: CO_2 concentration with wind, with firewalls.

9.2.2 MV/SUT transformers

Any proposed MV/SUT transformers are expected to have Natural Ester filled FR3 oil, an oil volume of not more than 38,000 L, and potentially enhanced protection.

The MV/SUT transformer is a self-bundled transformer that includes splash guards for AS1940 compliance. The self-bund construction will prevent potential environmental damage and fire spread, and therefore also compliant with AS2067.

Australian Standard AS2067-2016 is the most relevant standard with respect to the location of existing power utility infrastructure. The minimum separation distances are specified in AS2067 Table 6.1 unless a fire rated wall is used to provide protection.

The proposed transformers must be located to not less than 0.9m from any equipment/facility where enhance protection is provided, or not more than 1.5m if enhanced protection is not provided.

The above recommendation demonstrates that all the equipment have compliant distances in accordance with the Australian Standard AS2067, in order to mitigate the risk of fire spread. However, a further review will be performed when the specifications are defined.

9.2.3 Battery Fire - FDS Modelling

The proposed BESS units usually consist of a modular design with battery module bays, a customer interface bay, with a HVAC system and monitoring systems within an enclosure (e.g., IP55 enclosure).

As described in section 8.1.2.2, in accordance with Zhi Wang's report and the dimensions of the battery storage, if a BESS unit is on fire (BESS unit provider TBC), it will achieve an average heat release rate of approximately 6.0MW.

The battery fire is modelled based on the dimensions in the architectural drawings (6m*5m*2.5m). Based on this configuration, a review of the BESS fire is expected to reach an average heat release rate of approximately 6.0MW. **This is not a fire safety document for the sole purpose of enabling its consideration and review as part of a planning process under the Planning and Environment Act 1987. The document must not be used for any purpose which may breach any copyright.**

A flashover fire of the battery storage unit has been modelled in accordance with the layout shown in Figure 30. This is a conservative model considering that a fire of this scale is not expected to occur (i.e., where all sides of the BESS unit are on fire as shown in Figure 49).

It is noted that the Big Battery fire event in Victoria in 2021 and the Zhi Wang's report involved lithium-ion batteries, which have considerable fire safety disadvantages compared to the lithium iron phosphate batteries used by the equipment manufacturer. Lithium iron phosphate batteries are more thermal and chemically stable, stay cool in higher temperatures and have low energy density. Therefore, a lower HRR could be expected and the proposed HRR is considered a conservative measure.

9.2.3.1 Risk of fire spread

Given the location of the equipment within the subject facility, Table 14 below summarizes the heat flux received at various locations (approximate distances) within Bendigo BESS.

Table 14: Heat flux results (Red is not accepted).

Exposed equipment	Distance (m)	Incident Radiation (IR) (kW/m ²)		
		Wind	No wind	Critical Criteria
BESS Units (The closest)	3.0	28.5	5.80	37.5
HV Transformer	71.6	1.77	1.70	5.0
Control/Switch Room (with fire rated walls)	38.6	1.82	1.71	45.0
O&M Building and Storage Shed	106.7	<1.75	<1.70	13.0

Exposed equipment	Distance (m)	Incident Radiation (IR) (kW/m ²)		
		Wind	No wind	Critical Criteria
Detention Storage	>105.5	<1.75	<1.70	13.0

Further assessment is required subject to information provided by the BESS supplier, who must provide results from a large-scale UL 9540A test to demonstrate that there is no fire spread between BESS units, however, the preliminary assessment indicate that the maximum heat flux levels received at 3.0m are below the critical heat flux for vegetation, equipment, and buildings (noting that switch rooms are provided with non-combustible cladding). Hence, fire spread is not expected to occur.

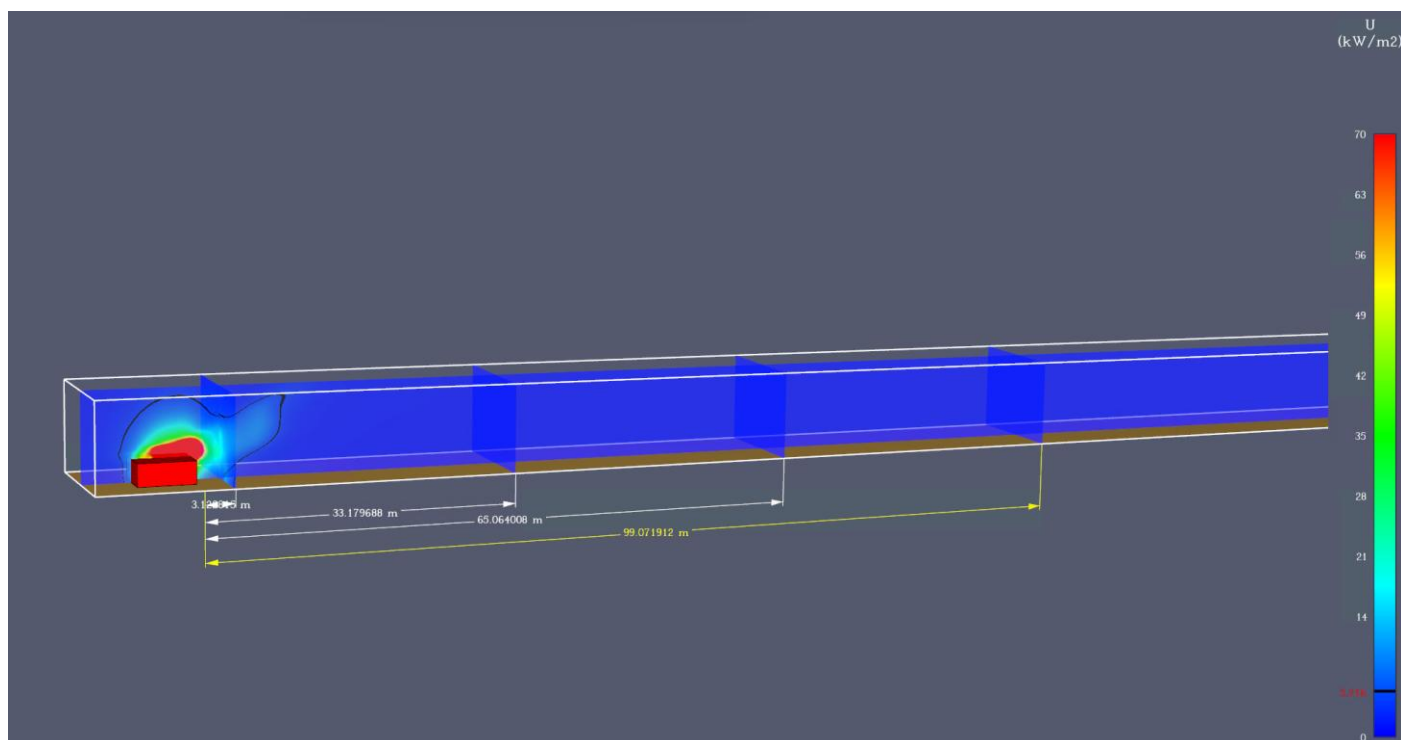


Figure 49: Radiant heat flux intensities with wind– BESS.

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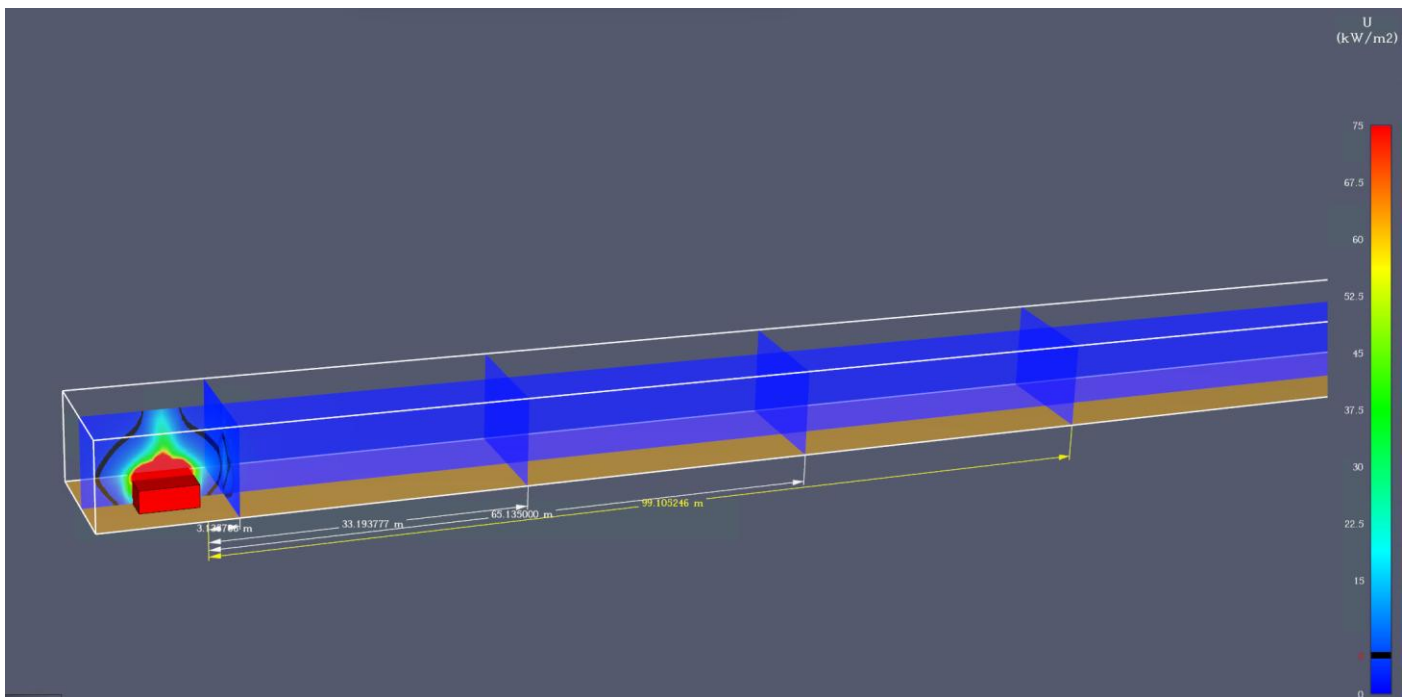


Figure 50: Radiant heat flux intensities without wind- BESS.

Based on the results of the model, fire brigade operations may be impacted within 5.0m from the transformer due to a heat flux higher than 3.0 kW/m² (Figure 51).

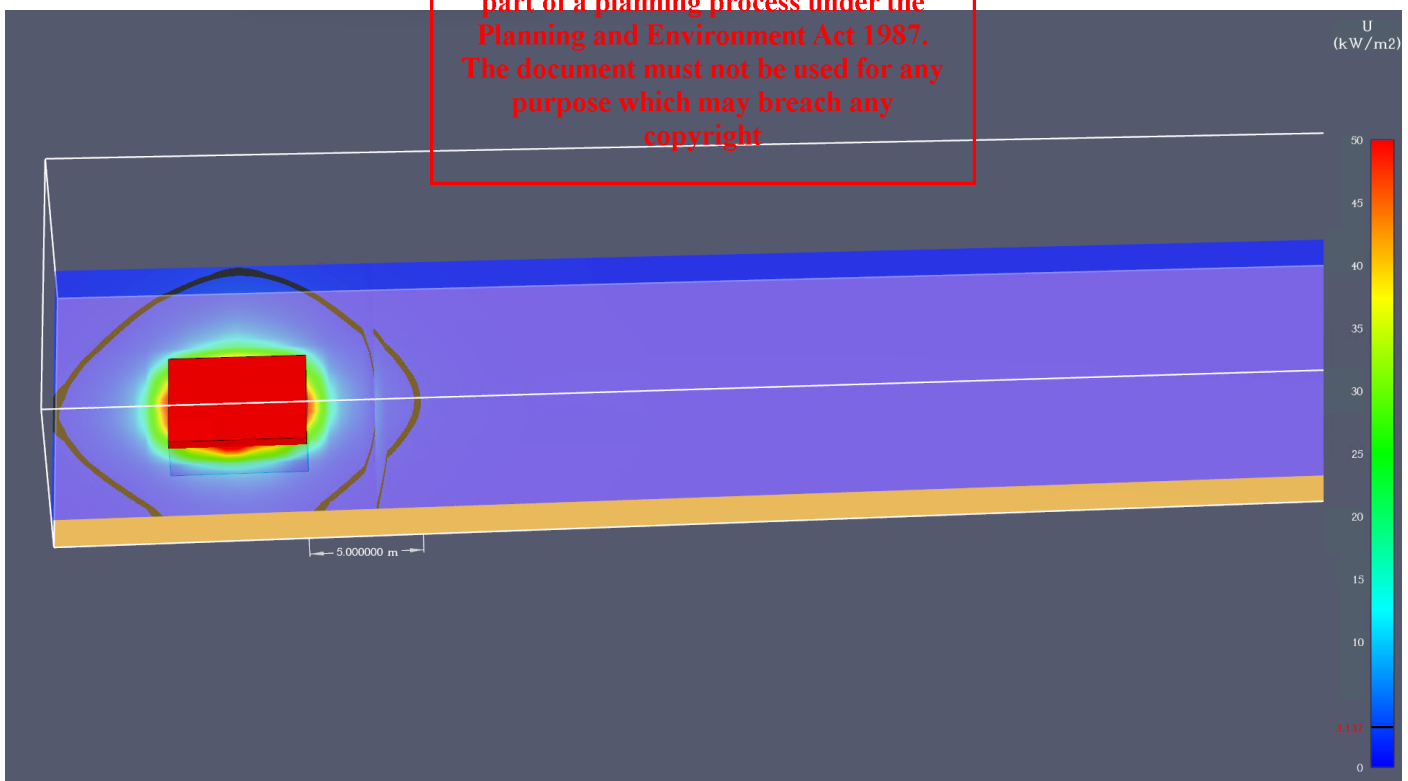


Figure 51: Radiant heat flux higher than 3kW/m² with wind (Top view).

The above results however are subject to a flashover fire. In a real fire scenario, when a BESS unit releases gases or goes through a thermal runaway process, any of the multiple safety measures will be triggered to send a signal to the staff.

Some of the fire safety measures that will be provided with at least the following:

- Provision of a BMS (Battery management system).
- Smoke and heat detection.
- Gas detection.
- Fire alarm.
- Door alarms.
- Electrical safety measures (e.g., ground faults, high voltage, communication faults, etc.).
- Automatic and manual stops that shutdown the battery.
- Temperature controls.
- Deflagration and ventilation systems / overpressure vents designed as per NFPA 68 and NFPA 69.
- Lighting protection.
- BESS enclosure must be sealed with IP55 rating.

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9.2.3.2 Risk of explosion

An FDS model for a BESS unit is outside of this report. However, assessing the risk of explosion will rely on the large-fire scale tests documentation and statistics gathered by EPRI [19].

The BESS units must be provided with Deflagration and ventilation systems / overpressure vents compliant with the NFPA 68 & 69 and validated as per CSA TS-800:24 and/or UL9540A. The completion of these tests will ensure to the degree necessary that an explosion to a BESS unit will be managed without damaging the adjoining equipment.

Nevertheless, EPRI [19] has identified that some explosion events still occur and can endanger the life safety of occupants or the fire brigade.

In accordance with Ian Lines, Atkins Ltd. [23], BESS explosions can have light debris (e.g., insulation, ventilation hoods, or door latches) within 6 to 20 meters; and heavy components (e.g., structural pieces, heavy-duty access doors) flying 70 to 80 meters during severe gas deflagrations.

The BESS are provided with explosion vents and are tested as per Test UL 9540A. Hence explosions are not expected to occur.

9.2.3.3 Obstruction of Exits (BESS fire)

The following results assess whether a BESS fire could impact both the access of both the primary and secondary exits and Fire Brigade access to the subject site with wind coming from the southeast, blowing in the direction of the primary exit. To analyse the tenability of the exits, the worst-case scenario of 6 battery units on fire were modelled, based on previous recommendations by the Fire Brigade. The model incorporates a domain height of 15m from ground level.

Based on the results, the heat flux at the primary and secondary exits are well below the critical value of 3kW/m^2 as shown in Figure 52 and Figure 53 respectively, with and without the noise walls in the models.

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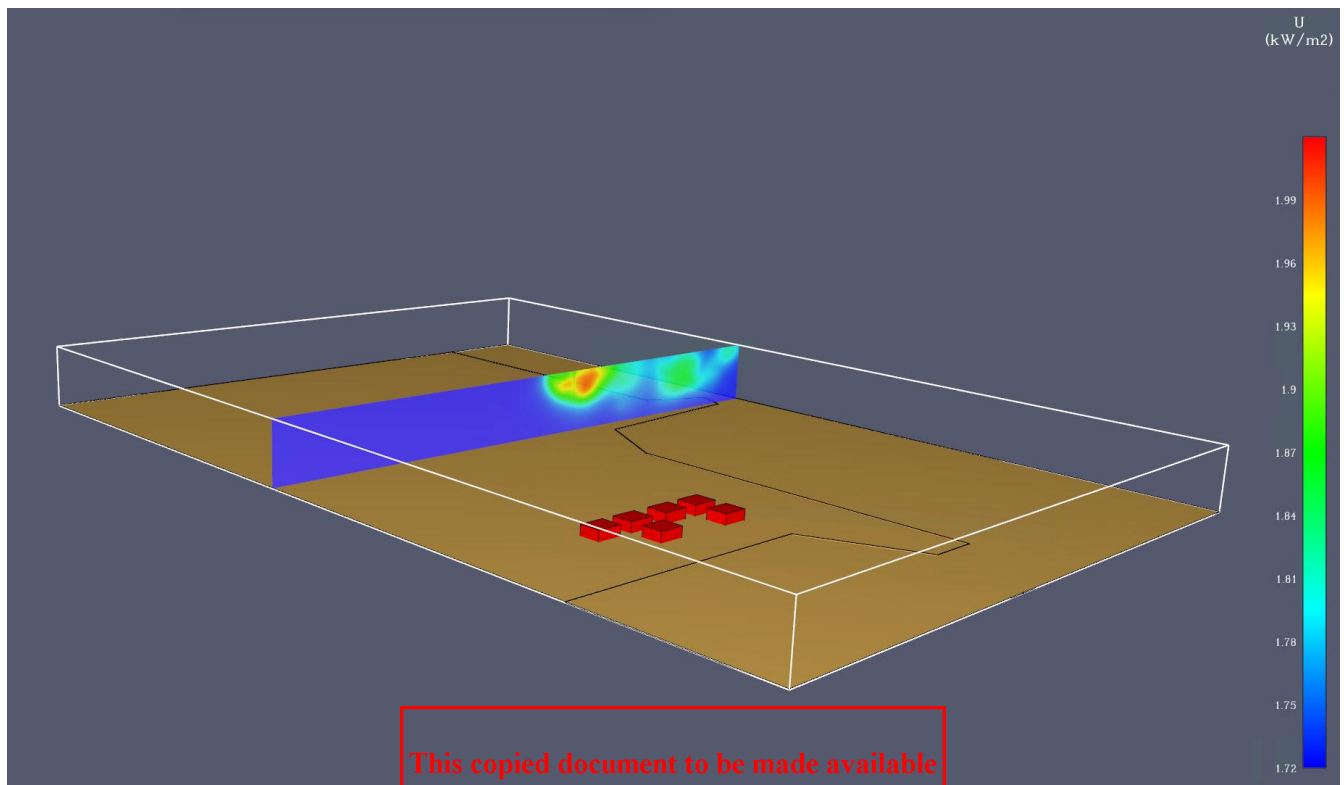


Figure 52: Radiant heat flux higher than 3 kW/m^2 at the primary exit with wind.

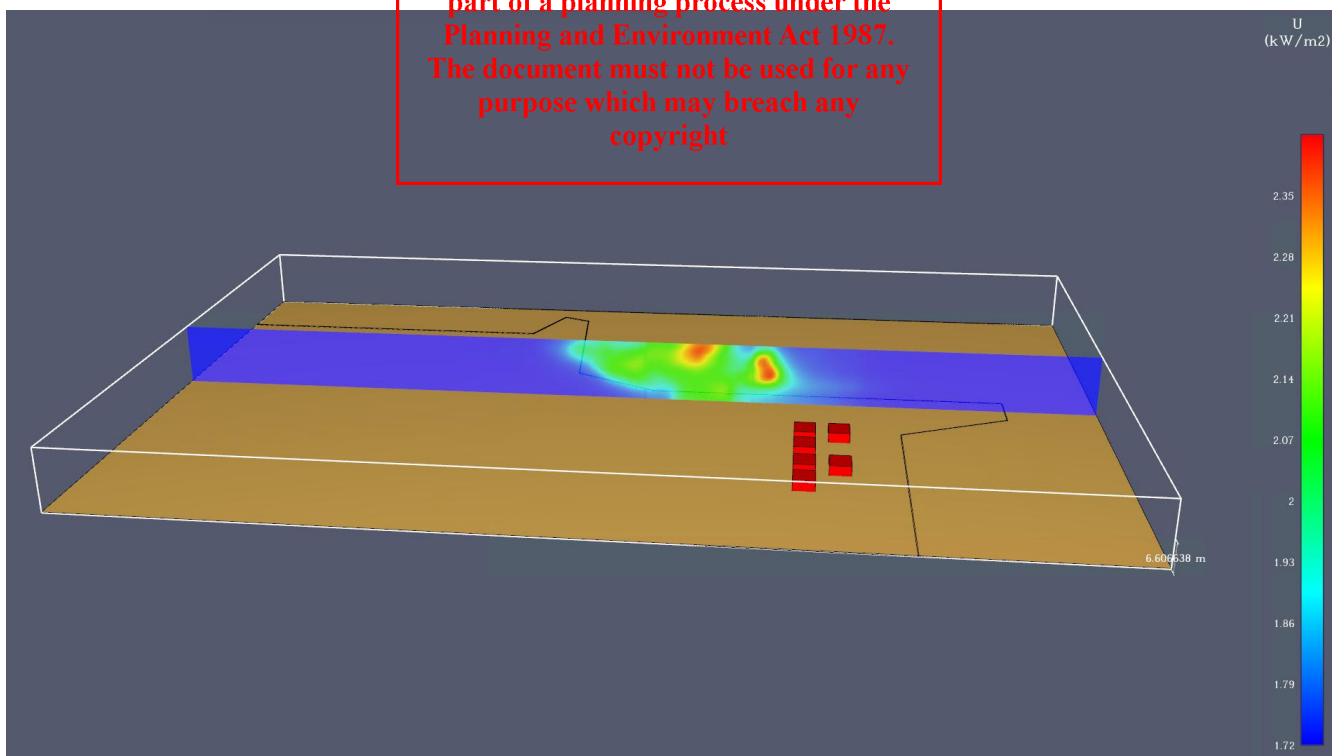


Figure 53: Radiant heat flux higher than 3 kW/m^2 at the secondary exit with wind.

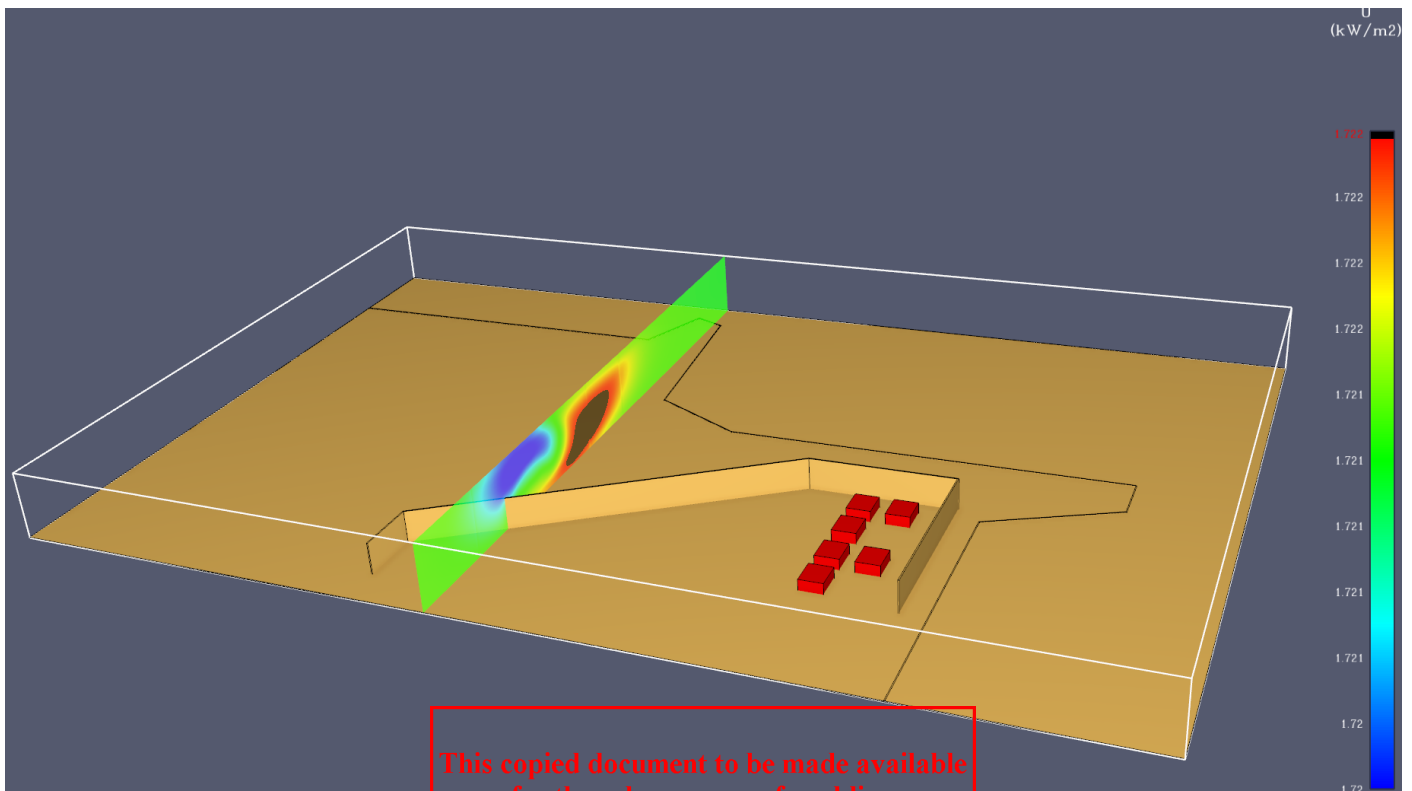


Figure 54: Radiant heat flux higher than 3kW/m² at the primary exit with noise walls and with wind.

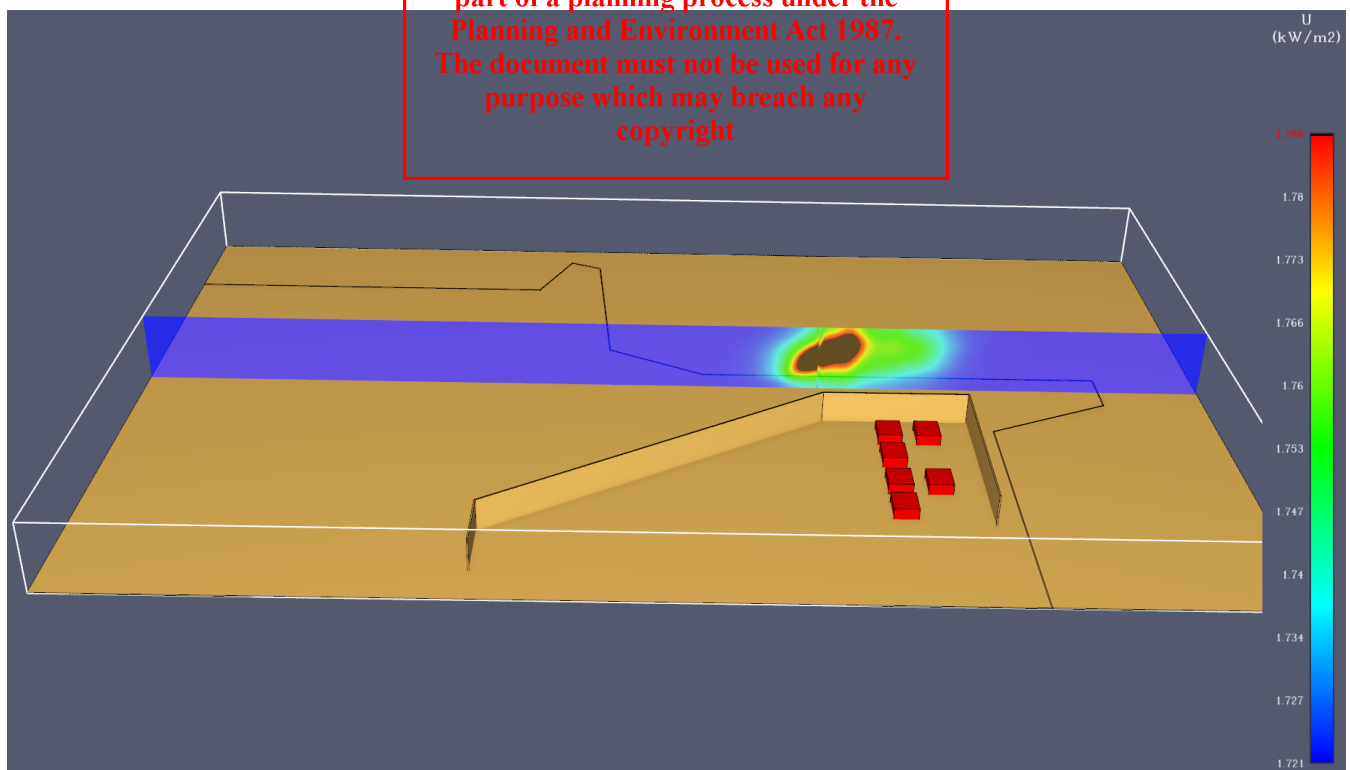


Figure 55: Radiant heat flux higher than 3kW/m² at the secondary exit with noise walls and with wind.

Temperature at the primary exit and along the access path leading to this exit to the northwest of the BESS units remains well below 60°C as shown in Figure 56. The temperature at the secondary exit and along the path directly north of the BESS units reaches the critical temperature of 60°C as shown in Figure 57, however this occurs at 6.6m above the ground level, hence Fire Brigade operations are not expected to be impacted.

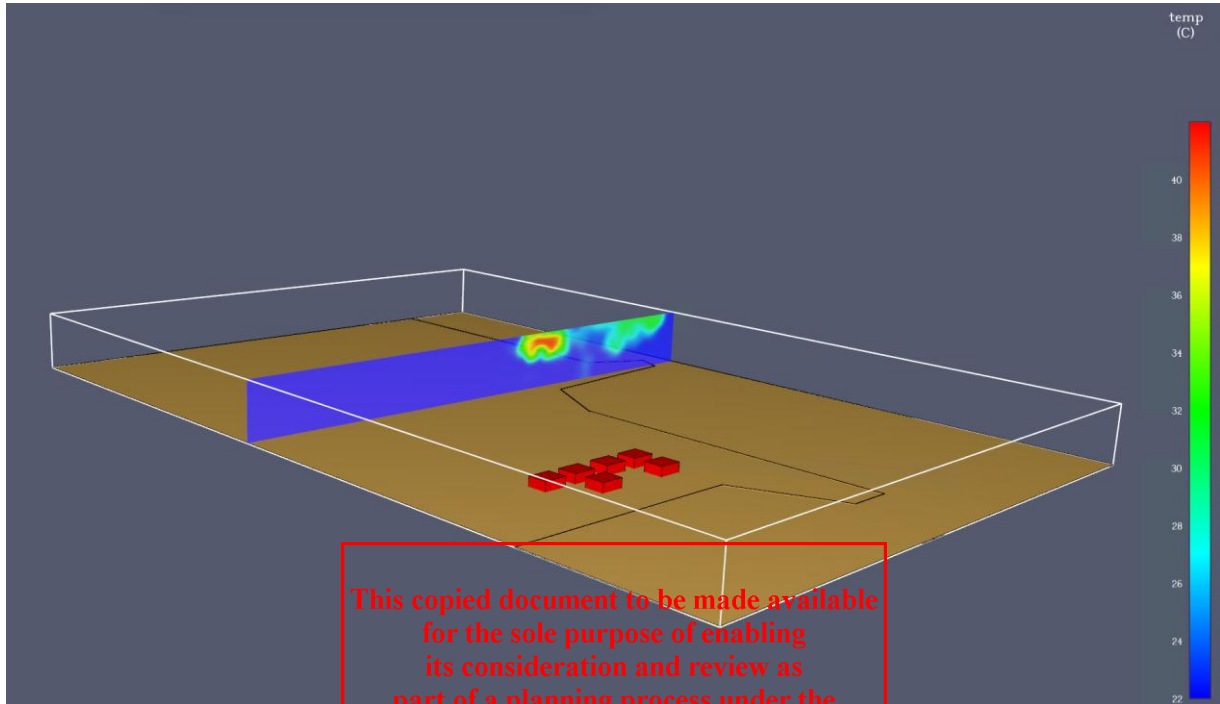


Figure 56: Temperature higher than 60°C at the primary exit, with wind.

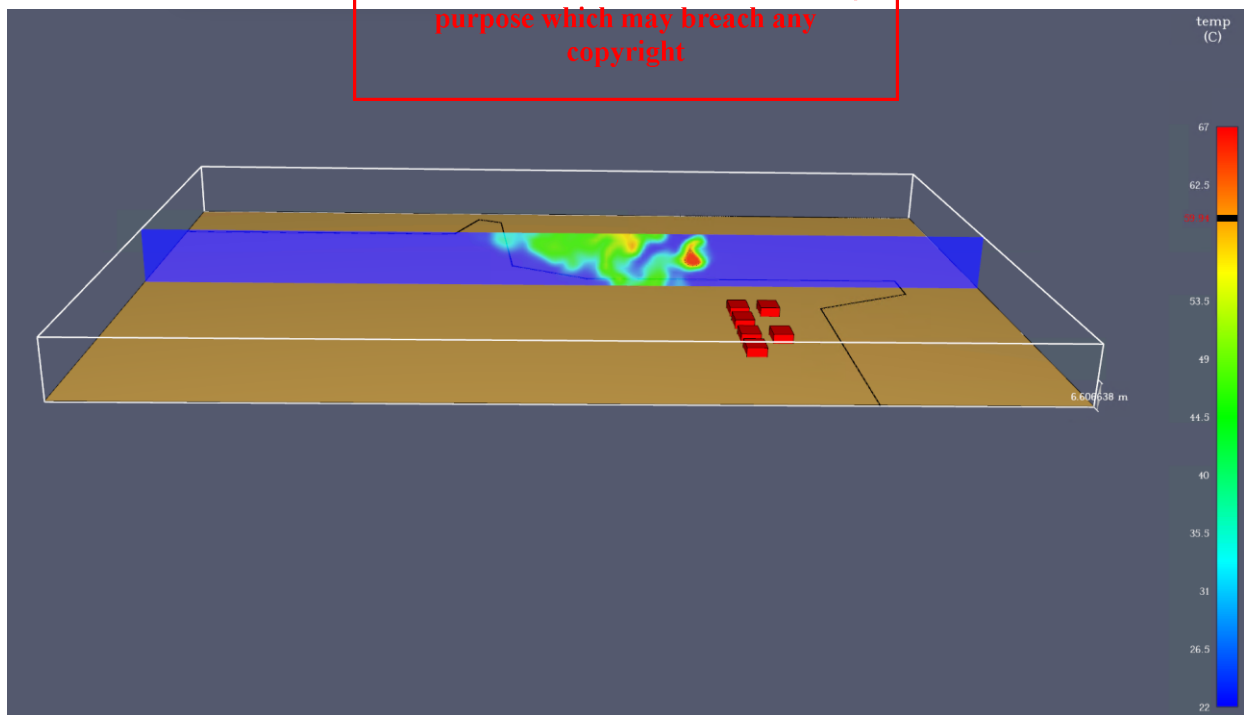


Figure 57: Temperature higher than 60°C at the secondary exit, with wind.

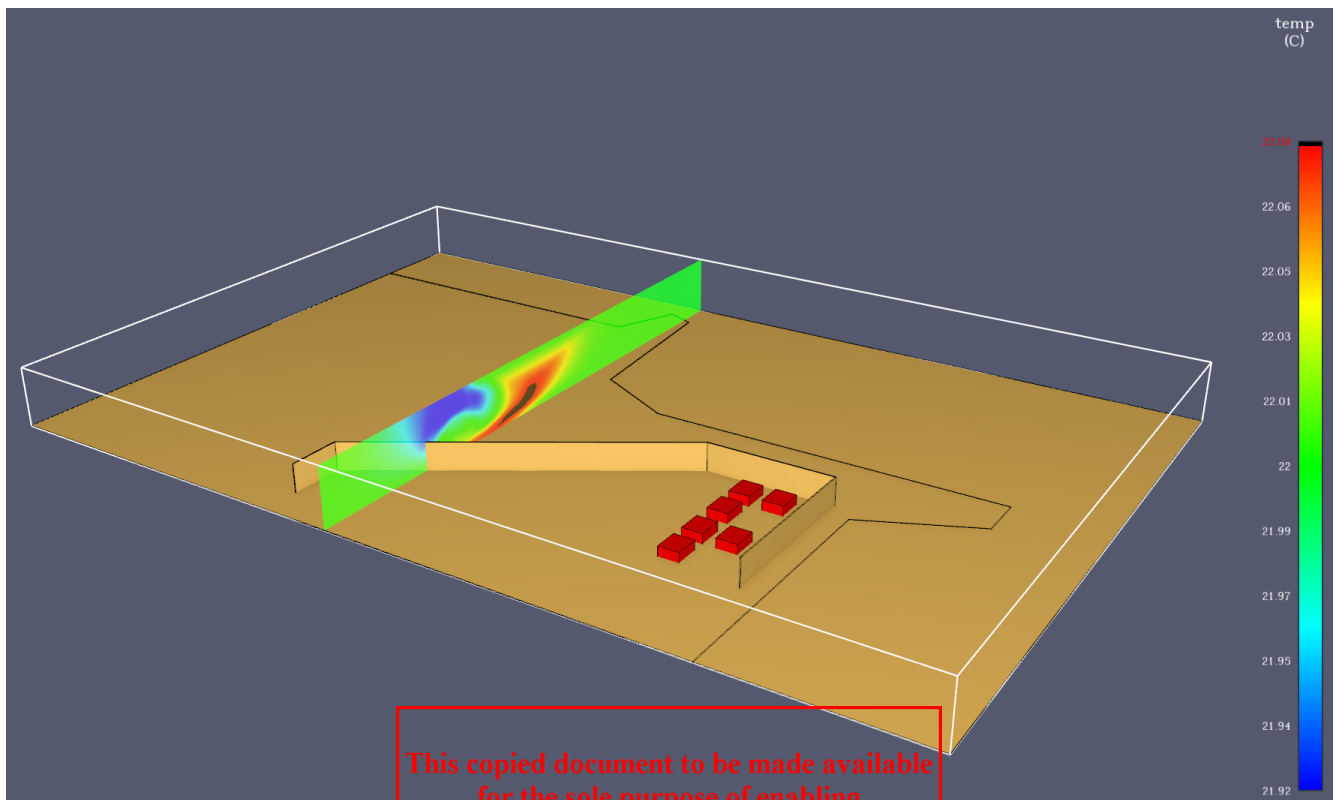


Figure 58: Temperature higher than 60°C at the primary exit, with noise walls and with wind.

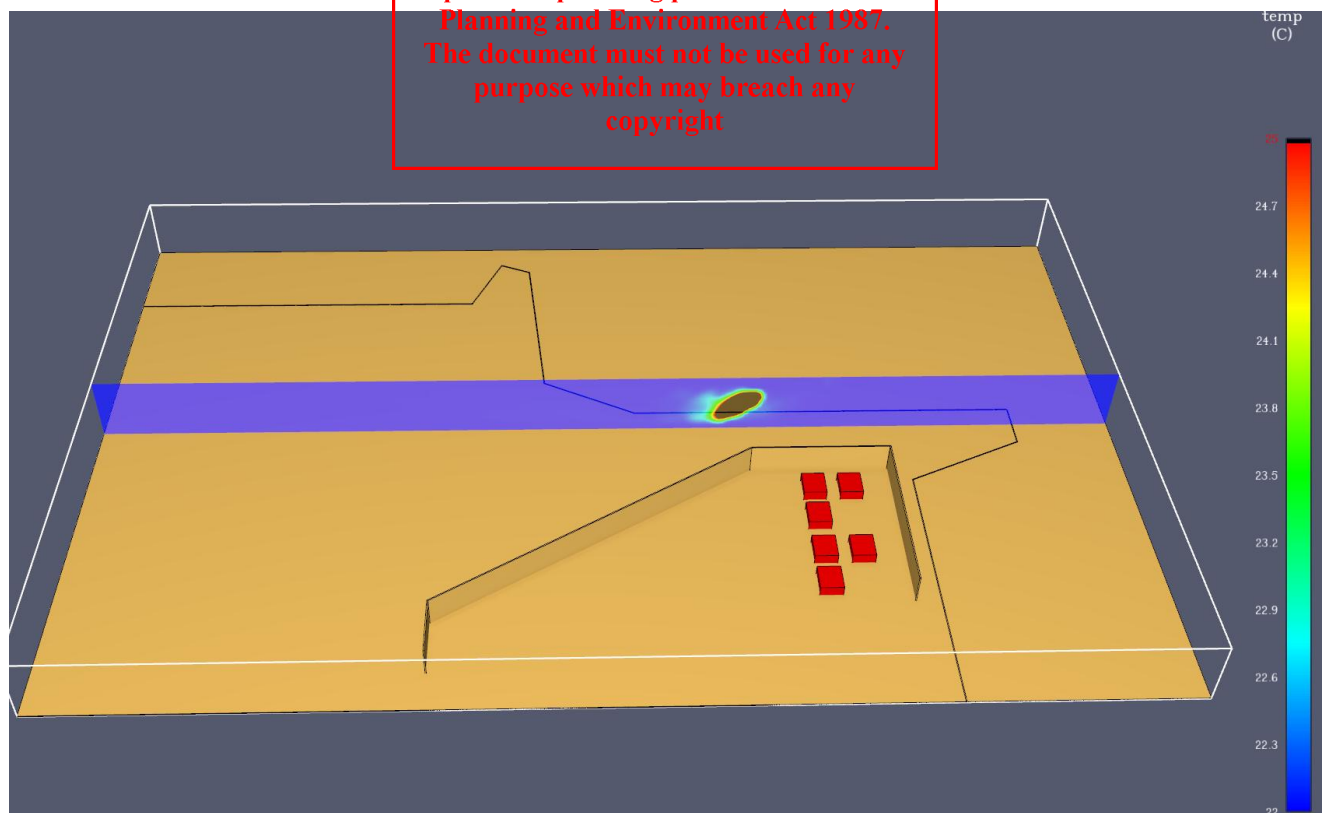


Figure 59: Temperature higher than 60°C at the secondary exit, with noise walls and with wind.

The visibility of the access path 23m to the north and northwest of the BESS units is obstructed as visibility decreases below 10m at a height of 2m from the ground level as shown in Figure 60. However, as noted previously the Fire Brigade is still able access the site via the eastern secondary exit (given conditions remain tenable) or via the primary exit which is not predicted to be obstructed by the BESS fire.

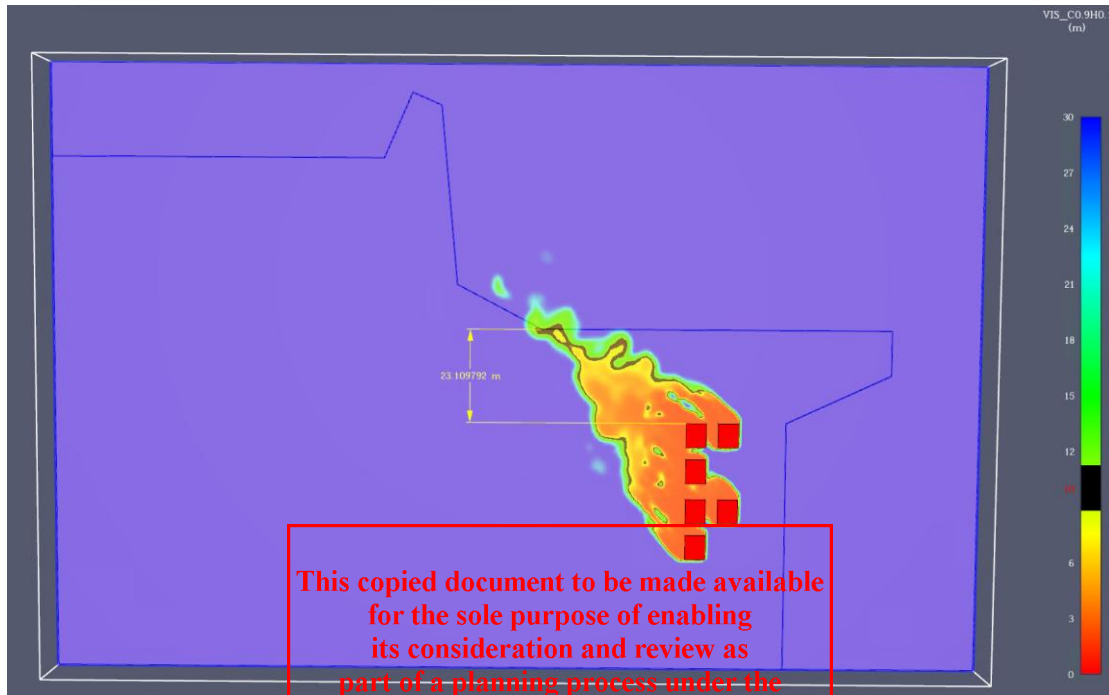


Figure 60: Visibility higher than 10m at the secondary exit, with wind.

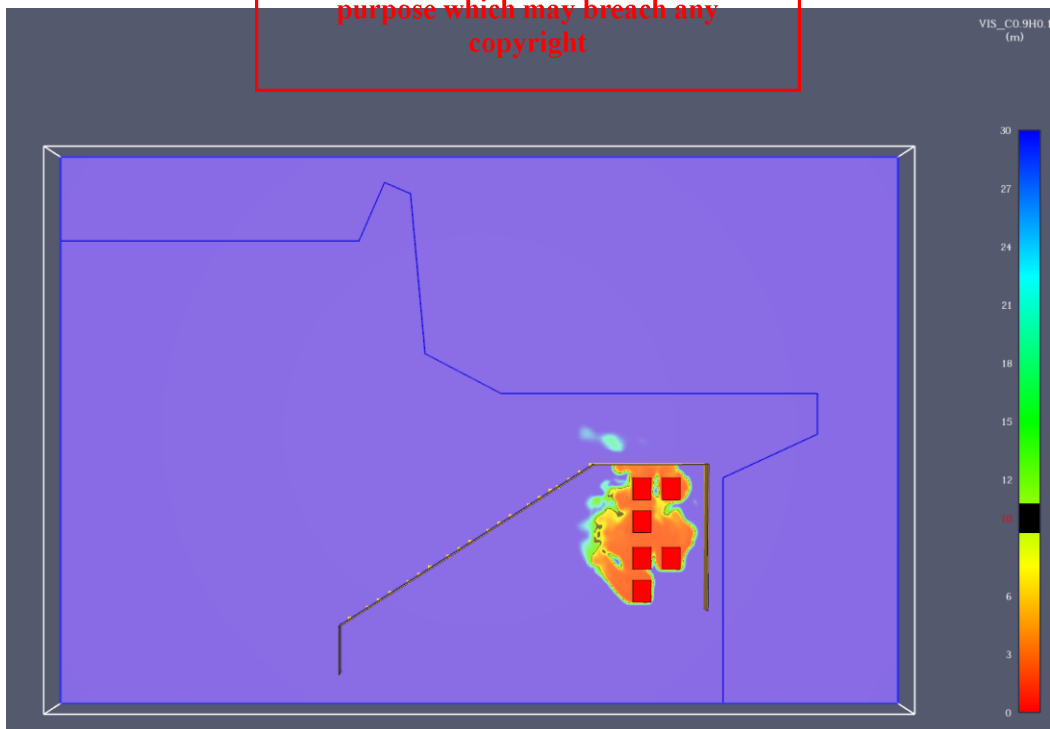


Figure 61: Visibility higher than 10m at the secondary exit, with noise walls and with wind.

9.2.4 Battery Fire – Testing

Large fire scale tests have been performed to varied BESS models. Below are described two tests to BESS units manufactured by EVE Power Co., Ltd. and Tesla.

Those are representative examples of the latest technology available in the market which comply with the requirements of this report in accordance with the case guidelines listed in Section 10.2. It is expected that the BESS unit selected for this project will have similar performance when complying with the requirements of this study.

9.2.4.1 Large scale fire destructive test to model: S556H201, S556H205 manufactured by EVE Power Co., Ltd.

The BESS model: S556H201, S556H205 manufactured by EVE Power Co., Ltd. was tested in accordance with CSA C800:9.7 and UL 9540A in December 2025 by ChuWeiNeng Testing Technology Co. Ltd (ChuWeiNeng Lab), an ISO 17025 accredited test laboratory [7]. The tests setup is shown in the figure below.

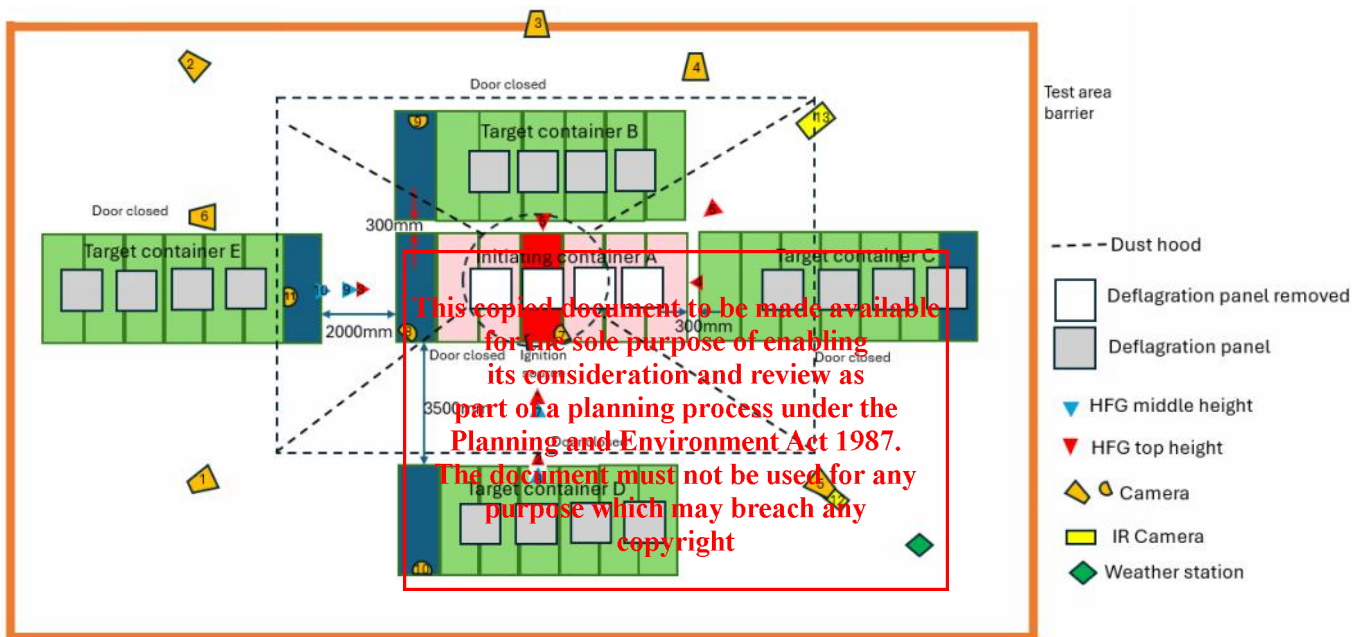


Figure 62: Teste Set-up.

The fire in the initiating BESS burned for approximately 13 hours and consumed all battery modules in the initiating BESS [7], and the final observations are the following:

- Peak module surface temperatures of 100.4°C, 54.1°C, 118.3°C, were measured for target BESS B, C, D respectively.
- Temperatures on cell and module enclosures inside target containers did not exceed the cell venting temperature of 176°C as measured by the UL 9540A cell level test report (4791318019-1),
- The maximum heat flux measured in the aiseways was 25.3 kW/m².
- A peak heat release rate of 15.64 MW was measured by oxygen consumption calorimetry with maximum observed flame projections of approximately 5.0 meters vertically above the BESS and 0.5 meter horizontally.
- No propagation to adjacent units was observed.

- The fire in the initiating BESS burned for approximately 13 hours and consumed all battery modules in the initiating BESS.
- The mains gasses released were *before flaming* CO (20.9%), CO₂ (18.4%), H₂ (37.9%), THC (22.8%); and *after flaming* CO (0.3%), CO (99.3%), H (0.2%), THC (0.2%). The main gasses CO and CO₂ are part of this FSS in Section 9.2.1.3.

9.2.4.2 Large scale fire destructive test to BESS Megapack 2XL/ Megapack 2

Tesla performed large-scale tests to the 3 test levels (i.e., cell, module and unit) in accordance with UL9540A [5] [24] [25], and also a large-scale fire destructive test.

The cell and module tests released flammable gasses, therefore the test to unit level was performed.

The test at unit level was performed by Northern Nevada Research Center (NNRC). NNRC is a Tesla operated facility. For UL9540A unit level testing, the test was observed and certified by an NRTL. For both the UL9540A and Destructive test, the results and were reviewed by a licensed third-party fire protection engineer (i.e., Fire & Risk Alliance).

NNRC performed the test to a Tesla MP2 on March 9, 2022, and was certified by TÜV (Technical Inspection Association). TÜV is an OSHA-approved NRTL and offers the cTUVus mark (i.e., canadian and US safety certification mark issued by TÜV Rheinland), which is equivalent to other NRTL marks such as UL, ETL or CSA.

The test was performed on a Megapack MP2XL [5], where all the safety measures were disabled and the BESS was tested at the highest energy density used to induce the thermal runaway event [5]. The initiating battery of the fire is shown in the figure below:

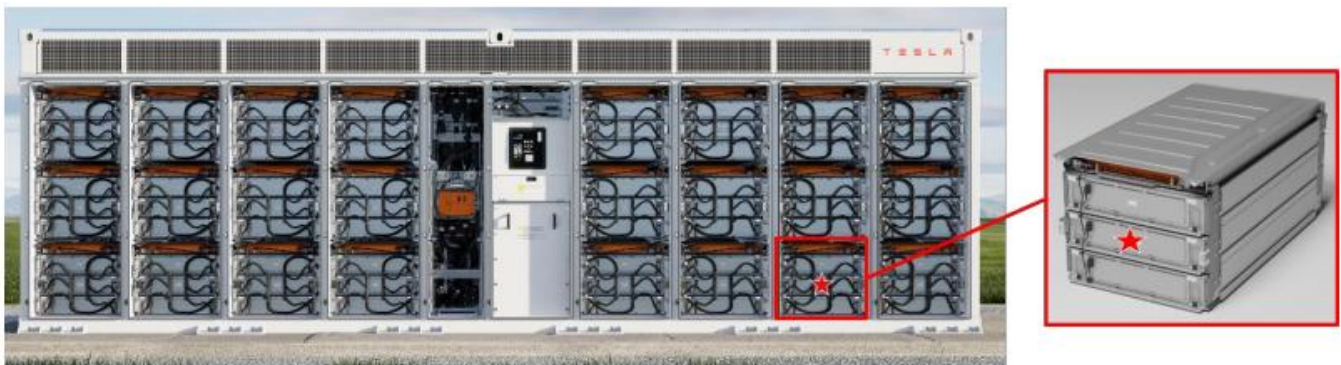


Figure 63: Initiating battery.

Forty-eight interior cells were simultaneously heated via thirty-two film heaters, as shown below, and the heaters were programmed to provide a heating rate of 5°C (9°F) per minute, as specified by UL 9540A. Note that the number of cells surpasses the requirements of the UL 9540A to create a severe fire scenario, given that previous large-scale tests to Unit Levels to MP2 as per the UL 9540A does not cause a large fire.

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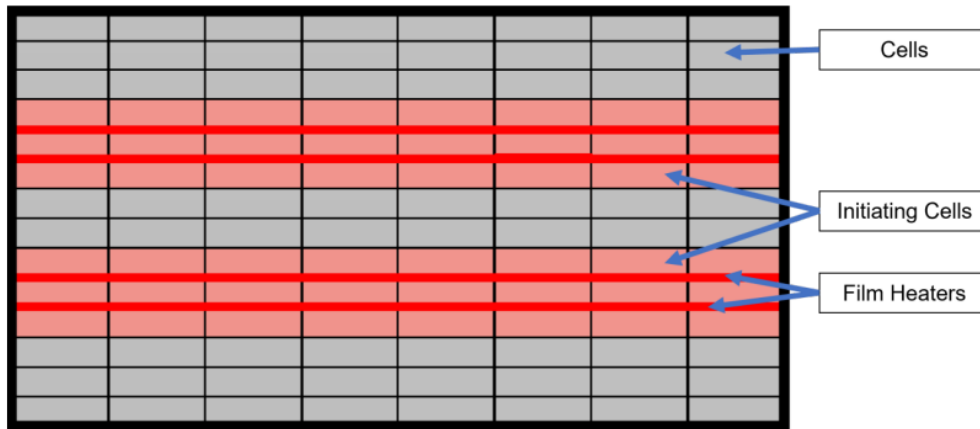


Figure 64: Heater location.

The timeline of events shows (figure below) that smoking starts after 1 hour, then fire spreads by thermal runaway to 3 of the adjoining battery bays within the Megapack 2XL and finally flames start to decrease.

Approximate Elapsed Time hr:min:sec	Event
00:00:00	Start of Test. Cameras, DAQ and heaters turned on.
0:40:44	First thermal runaway confirmed.
1:14:08	An overpressure event occurred and an overpressure vent opened, and the cabinet doors remained closed. Smoking observed.
1:24:00	Flames observed predominantly coming out the front doors of the cabinet and out the front grill of the thermal roof (just above the doors).
2:30:00	Flames spread to the adjacent battery bays 8 and 10. Approximate peak flame intensity.
4:00:00	Flames spread to adjacent battery bay 7.
8:04:00	Flaming ceases. Flames did not spread to any other battery bays. End of Test.

Figure 65: Timeline of events for Megapack 2XL.

Some of the observations listed in the Fire Protection Engineering Analysis [5] are listed below:

- The fire developed with 3.5m high flames and damaged only half of the BESS unit (adjoining bays), the bays on the other side remained unaffected. Also, the cabinet doors remained closed, no pressure waves or debris was ejected from the Megapack 2XL, and the pressure relief system prevented the deflagration event.
- The above demonstrates that the Overpressure vents/Explosion control system will prevent a deflagration event.

The test to the Megapack MP2 had the cells with film heaters as shown below as per UL9540A (Figure 66) and target Megapacks MP2 were placed to the side, front and back of the MP2 on fire (Figure 67).

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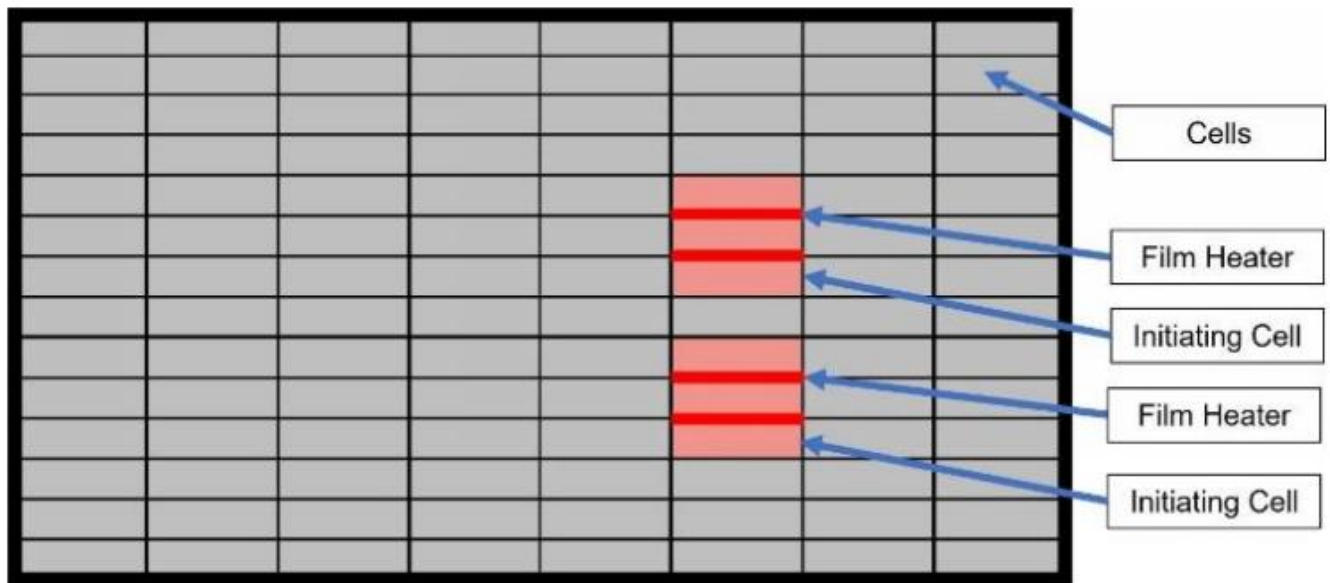


Figure 66: Initiating fire to MP2.

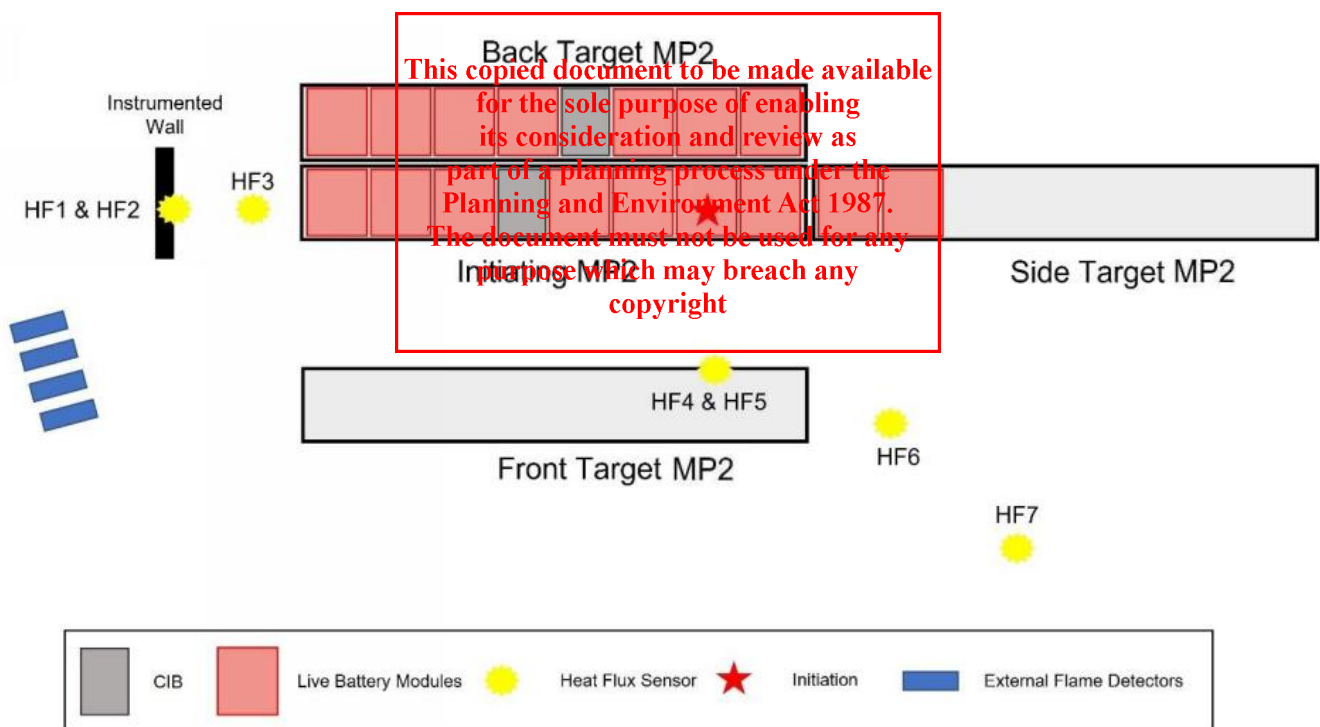


Figure 67: General test set-up – Target units and instruments (top view).

The timeline of events of the test is described below:

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Elapsed Time hr:min:sec	Event
00:00:00	Start of Test. Cameras and Data acquisition system (DAQ) turned on.
0:09:25	Heaters ON.
1:18:18	First group of initiating cells reach thermal runaway temperature of 239°C (462°F).
1:33:38	Second group of initiating cells reach thermal runaway temperature of 239°C (462°F).
1:39:28	Smoke observed exiting out the bottom of the initiating MP2 cabinet's bay door where instrumentation was routed into the cabinet.
1:45:48	Confirmation of cell propagation to a 7 th cell via internal thermocouple measurements.
1:51:09	Heaters turned OFF.
2:00:00	No additional smoke was observed from the initiating MP2 cabinet. Internal temperatures subside.
2:30:00	End of Test.
Post Test Overhaul	The initiating MP2 cabinet was observed for several hours afterwards and allowed to cool. No additional off-gassing, smoking, elevated temperatures, fire, thermal runaways, or signs of off-normal conditions were observed.

Figure 68: Events of the Unit level test to MP2.
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The above timeline of events already suggests that this situation and is not likely to occur for the Project without having the attention of the staff and the safety procedures, considering that thermal runaway and smoke occur after 1.5 hour, time at which those events can be detected with detectors and cameras on site. The test was performed with deactivated safety measures to allow thermal runaway to occur, however in a real scenario, all safety measures will be activated to prevent thermal runaway in a timeframe of 1.5 hour.

The main results of the test to Unit level are listed below:

- Cell and module level UL 9540A testing demonstrated that flammable gases vent from the MP2/2XL cells during thermal runaway; however, they do not release toxic gases sometimes associated with the failure of lithium-ion batteries, such as HCN, HCL and HF [5].
- Unit level UL 9540A testing demonstrated that the MP2/2XL meets or exceeds all the performance criteria of UL 9540A, Table 9.1 and UL 9540A installation level testing is not required for a MP2/2XL installation. Six cells were simultaneous heated, they failed and extended the thermal runaway to a seventh cell only. The failure did not result in any observations of explosion hazards, including but not limited to, observations of a deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases [5].
 Fire & Risk Alliance, LLC (FRA) and Tesla indicates that this seven-cell failure event is beyond what has been identified by Tesla's DFMEA, which is based on extensive field data from all Tesla products (EVs and BESSs) and first-principles assessments as a worst-case scenario [25].
- Internal destructive unit level testing demonstrated that the MP2/2XL is capable of safely failing in the extreme case of a catastrophic failure of a battery module (**the forced thermal runaway of 48 cells simultaneously**). This destructive unit level test led to a slow progressing fire that burned for 6 hours and 40 minutes until flaming ceased, only consuming one-half of the battery modules in the cabinet [5].

- Fire modelling demonstrated that, in the unlikely event of a fire, it would not propagate from one MP2/2XL cabinet to adjacent cabinets installed 6 inches behind, 6 inches to the side and 8 feet directly in front of the initiating MP2/2XL. This result was analysed for both no wind and worst-case wind conditions where flames could tilt towards the adjacent MP2/2XL cabinets [5].
- The MP2/2XL explosion control system can mitigate the deflagration hazard even with an extreme failure scenario of a battery module (the forced thermal runaway of 48 cells simultaneously) resulting in the MP2/2XL safely failing [5].
- An integral fire suppression system or an external fire suppression system is not required to stop the spread of fire from a MP2/2XL cabinet to adjacent MP2/2XL cabinets when installed at clearances of 8 feet in front, 6 inches behind and 6 inches to the sides [5].
- Manual fire suppression (hose lines) is not required to stop the spread of fire from a MP2 cabinet to adjacent MP2/2XL cabinets when installed at clearances of 8 feet in front, 6 inches behind and 6 inches to the sides [5].
- Based on a review of the MP2/2XL, its fire safety features, UL 9540A test results, additional internal MP2/2XL unit level fire testing and fire propagation modelling, the MP2/2XL can meet or exceed installation level codes and standards, such as the IFC and NFPA 855, required for outdoor, ground mounted BESS installations when installed in accordance with the MP2 and MP2XL Design and Installation Manual [5]. Currently the MP2/2XL is listed to all product design standards (such as UL and IEC).
- “UL 9540A unit level fire testing of the MP2 demonstrated that an internal failure event causing thermal runaway of six cells nearly simultaneously will not propagate thermal runaway throughout the battery module. The nearly simultaneous failure resulted in thermal runaway propagating only to one additional cell and no further.” [5] (Figure 69).

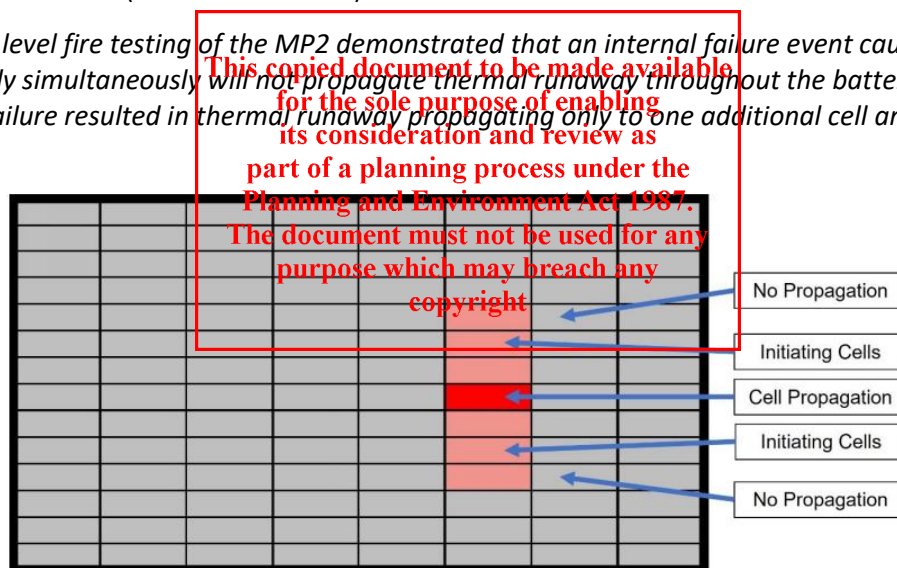


Figure 69: Cell propagation during UL9540A unit level fire testing.

- “Surface temperatures of battery modules within the target MP2 cabinets adjacent to the initiating MP2 cabinet did not exceed the temperature at which thermally initiated cell venting occurs. The maximum temperatures recorded at the battery modules of the adjacent MP2 cabinets were 13.8°C (56.4°F) and 13.2°C (55.8°F). These temperatures are significantly below the temperature at which cell venting occurs (174°C or 345°F).” [5].

The temperature criteria indicated that thermal runaway would occur at 239°C. The test showed that this threshold is not reached at the adjoining Megapacks (it reaches up to 13.8°C) during the tests, and the test [5] also performed a thermal runaway model to demonstrate that critical temperatures in adjoining BESS units are not reached. It is recognized however that in the event of real fire events such as Bouldercombe (section 8.1.1), the back Megapack may be affected and therefore it is better to be replaced after such an event (it is noted even though the back Megapack was affected, the effects did not caused fire spread level).

Given the results of tests and real events, the critical scenario is to be considered. Therefore, a Fire hydrant system is also provided throughout the facility for fire brigade intervention procedures. Where a BESS unit is on fire, the fire brigade can use the fire hydrant system to cool adjoining BESS units if required while the main BESS unit on fire extinguish itself (i.e., not to attempt to extinguish the fire).

9.2.5 Fire spread by thermal runaway

As described in section 8.1.2, if a typical lithium-ion cell is exposed to a temperature of 150°C (300°F), the separator melting occurs and additional heating due to shorting between electrodes will occur and cell thermal runaway will initiate within minutes.

Therefore, a critical temperature of 150°C (300°F) is considered in the analysis of thermal runaway between BESS units.

Further assessment will be performed with the information provided by the BESS supplier. The supplier must provide results from a large-scale UL 9540A or CSA TS-800:24 tests to demonstrate that there is no fire spread or induced thermal runaway between BESS units.

9.2.6 Adjacent Buildings

The batteries are located more than 30m from the equipment of the substation and at least 14m from the boundary fence.

The NCC allows non-load bearing openings within buildings to be 3m from the boundary or 6m from another building on the same allotment. Given the separation distances of the battery units and buildings from the boundary it is considered that the likelihood of a fire and the consequence are no worse than in the general community and no worse than a compliant NCC DTS building.

9.2.7 Fire in other areas of the facility

The facility contains a control/switch room, a 600kV detention stage, one storage shed and an Operations & Maintenance building. The fire associated with these buildings are considered to be no greater than a small office type building.

Based on the International Fire Engineering Guidelines the likelihood of an office fire is 6.2×10^{-3} per year and a fire size of approximately 250kW/m². Accordingly, the peak fire size is predicted to be 23MW assuming adequate ventilation.

Given the separation distances to the BESS units and other equipment of 3m and over, it is considered that the risk of fire spread is equivalent to that of a building with NCC compliant separation distances (3m to the boundary) that are considered to represent the community acceptance level for fire spread.

9.2.8 Bushfire Attack Level (BAL) Assessment

The subject allotment is classified as a BPA (Bush Fire Prone) area in accordance with the VIC Planning portal (Figure 12) and a Bushfire Management Overlay (BMO) applies to the eastern part of the site.

A bushfire assessment as per AS 3959:2018 [22] has been performed. The initial Stage 1 Bushfire Management Statement by Tomkinson, dated August 2024 and the *Bushfire Hazard Assessment – Bendigo BESS* performed by Agilus [16] concluded that the site has a Bushfire Attack Level of BAL 12.5.

In order to mitigate the risk of fire spread from the adjoining vegetation, the following measures will be implemented as part of the requirements of this Study:

- BESS enclosure must be sealed with IP55 rating. This will prevent the embers from a bushfire to fly into the BESS

containers

- A firebreak of at least 10m wide must be designed and maintained around the facility.
- All buildings must be constructed with non-combustible cladding. This will mitigate the risk of fire spread to the building with embers.
- Two access points are provided to the facility. The secondary/alternative entry located to the east side of the development accessible via Coonooer Street can be obstructed by a nearby bushfire, however it will not obstruct the main entrance to the north via Hattam Street. The main entrance to the north via Hattam Street is located to more than 100m from the identified vegetation, surpassing required clearance associated to a BAL 12.5 risk.

It is recognized that the east side of the development does has a clear area of 38m, surpassing the above requirements.

The *Bushfire Hazard Assessment – Bendigo BESS* performed by Agilus states the following requirements to mitigate the risk of fire spread from a bushfire:

- The 38m separation provided between the BESS infrastructure and the eastern boundary is to be managed in a low fuel condition, consistent with the following requirements:
 - Grass must be short cropped and maintained during the declared fire danger period.
 - All leaves and vegetation debris must be removed at regular intervals during the declared fire danger period.
 - Within 10 metres of a building or the units, flammable objects must not be located close to the vulnerable parts of the building or units.
 - Plants greater than 10 centimetres in height must not be placed within 3m of a window or glass feature of buildings.
 - Shrubs must not be located under the canopy of trees.
 - Individual and clumps of shrubs must not exceed 5 sq. metres in area and must be separated by at least 5 metres.
 - Trees must not overhang or touch any elements of the building or units.
 - The canopy of trees must be separated by at least 5 metres.
 - There must be a clearance of at least 2 metres between the lowest tree branches and ground level.

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- A perimeter firebreak of 10 metres from screening vegetation, as well as a 10m firebreak around property infrastructure, is to be provided in all other directions.
- Minimum fire water retention of 576,000 litres connected to a minimum of 4 hydrants located around the site. A minimum of one hydrant is to be located on the eastern side of the BESS.
- Fire hydrant system that complies with AS2419.1, and booster assembly and pumps that enables appropriate pressures at the fire hydrant.
- An Emergency Management Plan that outlines that staff are not to attend site on Catastrophic fire danger days, apart from critical maintenance.
- Access to the site to include full perimeter access to the BESS area, including appropriate widths and load limits from access gates.
- Access via the secondary accessway is to meet the following requirements:
 - All weather construction.
 - A load limit of at least 15 tonnes.
 - Provide a minimum trafficable width of 3.5 metres.
 - Be clear of encroachments for at least 0.5 metres on each side and at least 4 metres vertically.

Figure 70: BAL safety measures as per BAL assessment (Agilus).

The development will proceed as per the EMP procedures when a bushfire is identified nearby the facility.

9.2.9 Simultaneous bushfire and battery fires

The identified vegetation is located only to the east side of the development and according to Agilus' [16] report, the vegetation to the east presents the primary bushfire hazard to the site.

The *Bushfire Hazard Assessment – Bendigo BESS* performed by Agilus states the following:

“The assessment found that the site is located within a developed urban environment where bushfire pathways are fragmented by surrounding development. While vegetation to the east presents the primary bushfire hazard, the proposed 38 metre setback, perimeter firebreaks, defendable space, dedicated fire water supply, compliant emergency access and emergency management procedures reduce the bushfire risk to an acceptable level. The site has been assessed as Landscape Type 2 and achieves a BAL-12.5 outcome for the development.

Subject to implementation of the recommended bushfire protection measures, the proposed development is considered capable of meeting the objectives of Clause 13.02 of the Victorian Planning Scheme while providing an appropriate level of protection for life, property and emergency responders.”

The development will proceed as per the EMP procedures when a bushfire is identified nearby the facility. Staff will notify the authorities and monitor what occurs within the facility to identify any potential damage caused by the bushfire, however fire spread to the equipment is not expected to occur due to the current clearances of more than 12m (i.e., 38m).

The staff are not expected to take an active role in the attack of the bushfire; however, staff must enable authorities any access and use of the water supply to attack a bushfire if required.

If a BESS unit fire occurs at the same time of a bushfire, staff must proceed as per the original procedures to manage

the BESS event. The staff will not notify the authorities about the fire until they had followed all the safety protocols and identify that a fire is imminent and cannot be controlled.

The fire brigade is expected to assist upon the call to the facility, however, where the fire brigade is not available and all the initial safety procedures fail (those established by the design team and the suppliers), staff must keep clearances from the BESS units of up to 80m to account for the risk of explosion until an available fire brigade unit arrives to site.

If the wind travels from the east of the facility when there is a bushfire and a BESS fire, the secondary/alternative entry located to the east side of the development accessible via Coonooer Street can be obstructed by the bushfire, however it will not obstruct the main entrance to the north via Hattam Street (refer to Section 9.2.3.3). The main entrance to the north via Hattam Street is located to more than 100m from the identified vegetation, allowing the fire brigade to access the facility to perform the required fire brigade intervention procedures.

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10 COMPARISON WITH RELEVANT STANDARDS

10.1 AS 2067

Australian Standard AS 2067 [2] is the most relevant standard with respect to the location of existing power utility infrastructure. The standard is based on oil transformer equipment and not batteries. However, the fire risk from a transformer is considered to be similar to that of a BESS.

The minimum separation distances are specified in AS 2067 Table 6.1 unless a fire rated wall is used to provide protection. Note, that fire walls must be provided to the HV substation as mentioned in Section 3.

Transformer type	Liquid volume	Clearances to other transformers or equipment	Clearances to buildings		
		Horizontal separation G_1 to other transformers or non-combustible surfaces	Horizontal clearance G_2 to combustible surfaces	Horizontal clearance G_3 to 2 hour fire resistant surfaces of buildings	Vertical extent G_4 for 2 hour fire resistant surfaces of buildings
	L	m	m	m	m
Oil-insulated transformers (O)	100	1	6	1	4.5
	≤ 1000	1	6	1	4.5
	> 1000	1.5	7.5	1.5	7.5
	$\leq 20\ 000$	5	10	4.5	15
	$> 20\ 000$	10	20	7.5	30
	$\leq 45\ 000$	15	30	7.5	30
Less combustible liquid-insulated transformers (K) without enhanced protection	$> 45\ 000$	15	30	7.5	30
	$> 60\ 000$	20	30	7.5	30
	> 1000	1.5	7.5	1.5	7.5
Less combustible liquid-insulated transformers (K) with enhanced protection (refer to Note 1)	$\leq 38\ 000$	4.5	15	4.5	15
	$> 38\ 000$	4.5	15	4.5	15
	Clearance G_1 to other transformers or building surfaces				Vertical extent G_4 for 2 hour fire resistant surfaces of buildings
Dry-type transformers (A) Fire behaviour class F_0	Horizontal m				Vertical m
	0.9				1.5
Dry-type transformers (A) Fire behaviour class F_0	1.5				3.0

Figure 71: AS 2067:2016-Table 6.1 – Clearance for outdoor transformers [2].

It is assumed the subject facility will have the following transformers:

- HV Substation: There will be one transformer that will use mineral oil, and their oil capacity is expected to be not more than 60,000 litres (60.0 m³).
- Where transformers are oil-insulated, transformers shall use an FR3 (or similar) Ester oil where practical in lieu of the normal mineral oil.

- MV/SUT transformers, if provided with less combustible liquid-insulated transformers (K) with enhanced protection, must not be located to less than 0.9m from the non-combustible surfaces/equipment to comply with the requirements of the AS 2067.
- MV/SUT transformers, if provided with FR3 (or similar) Ester oil must not have an oil capacity of more than 38,000 litres (38 m³) and must not be located to less than 1.5m from the non-combustible surfaces/equipment to comply with the requirements of the AS 2067.

Table 15 below summarizes the distances of the HV transformers from the adjoining equipment/buildings where there is the main risk of fire spread, compared with the requirements of the Australian Standard AS 2067. The review of the MV/SUT transformers will be checked at a later stage of the project, however they will be located based on AS 2067.

Table 15: Distance assessment.

Equipment to assess	Adjoining equipment	Required Distance (m) as per AS 2067	Proposed Distance (m)	Compliant (Yes/No)
HV Substation transformers	Control/Switch room with fire rated walls	≥ 7.5 without fire wall	7.5	Yes
	O&M Building	≥ 23 without fire wall ≤ 23 with fire wall	16.3	Yes (with firewall)
	Storage shed	≥ 23 without fire wall ≤ 23 with fire wall	16.3	Yes (with firewall)
	All other equipment	≥ 23 without fire wall ≤ 23 with fire wall	≥ 23	Yes

The above demonstrates that all the equipment have compliant distances between them in accordance with the Australian Standard AS 2067, where the Control/switch storage shed and the O&M buildings will be located less than 23m from the HV transformer with the provision of a two (2) hour fire rated wall as shown in Figure 5.

This is consistent with the fire spread assessment and results performed in Section 9.

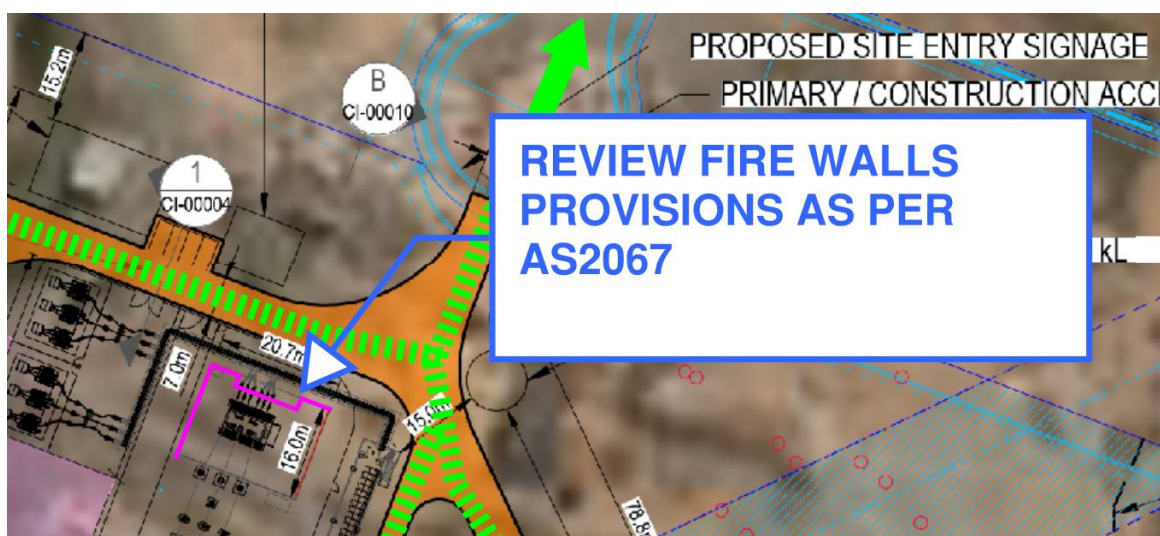


Figure 72 – Firewall to HV transformer.

10.2 DESIGN GUIDELINES AND MODEL REQUIREMENTS: RENEWABLE ENERGY FACILITIES, COUNTRY FIRE AUTHORITY (CFA), JUNE 2025 (v4.4)

Section 2.2.2 of the Guide states that the bushfire risk is required to be addressed according to the Victorian Planning Provisions.

Response - As per Section 6.1.4, the subject BESS is part of an Industrial Zone (IN1Z) and is classified as a Bushfire Prone area. A bushfire assessment (i.e., BAL as per AS 3959:2018) has been performed in Section 9.2.8 of this document and a Bushfire Management Statement has also been provided by Tomkinson for the subject site.

The requirement to undertake a bushfire assessment and the Bushfire Management Statement were specifically triggered by the subdivision works occurring in the BMO.

Section 3.3.3 states that for BESS facilities the following hazards be addressed:

- Electrical hazards, such as battery faults; overcharging; rapid discharge; loss of remote monitoring systems; internal short circuits; overheating; water ingress; lightning strike (leading to thermal events/runaway).

Response - The batteries will be monitored such that if there is a fault or electrical runaway the system will be shut down.

- Chemical hazards, such as the inherent hazards of the stored dangerous goods; spills and leaks of transformer oil/diesel spills/leaks, refrigerant gas/coolant; chemical reactions from ignition.

Response - No dangerous goods are indicated to be stored on the site. The MV/SUT Transformers will be assessed at a later stage and the HV Transformers have been reviewed in Section 10.1 in accordance with AS 2067.

- Potential fire spread due to proximity of batteries (and containers/enclosures) to each other, on-site infrastructure and vegetation (including screening vegetation).

Response - The battery units are separated from adjacent properties by over 30 meters, and BESS units are to be separated as per large-scale tests. Hence fire spread from the site to the vegetation is not expected. This distance is considered to be acceptable based on the preliminary assessment within this report in section 9.

- Mechanical damage to battery containers/enclosures due to vehicular impact.

Response - The facility has a security fence such that only maintenance vehicles can access the site. There is a 6.0m wide road around the facility, within the facility and around the batteries. Bollards will also be provided around the BESS isles.

- Landscape hazards, such as bushfire/grassfire ignition from fire within the facility, or external ignition of site infrastructure from embers, radiant heat and flame contact.

Response - As per Section 6.1.4,, the subject BESS is part of an Industrial Zone (IN1Z) and is classified as a Bushfire Prone area. Furthermore, the proposed BESS is within a Bushfire Management Overlay (BMO) to the eastern side of the BESS. Given the location of the BESS site, a bushfire assessment has been performed in Section 9.2.8 of this document.

Section 3.3.5 also recommends a fire safety study for large scale battery energy storage systems (BESS) over 1MWh based on CFA's Fire Safety Studies for Battery Energy Storage Systems Guideline (v1, 2025) [1] to be undertaken.

Response – This report is the FSS required. Section 5.1 describes how this document covers the requirements from the CFA's Fire Safety Studies for Battery Energy Storage Systems Guideline (v1, 2025) [1]

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Section 4.1 indicates the following are low risk location attributes:

- Grassland.
- No continuous other vegetation types within 1-20 km of the project site.
- Generally flat topography, some undulation may be present.
- Slopes are less than 5 degrees.
- Good road access with multiple routes available to and from the project site.
- No Bushfire Management Overlay applies.

Response - As per Section 6.1.4, the subject BESS is part of an Industrial Zone (IN1Z) and is classified as a Bushfire Prone area. Given the location of the BESS site, which is within the BMO, a bushfire assessment (i.e., BAL as per AS 3959:2018) has been performed in Section 9.2.8 of this document. Hence, this location is not considered an area with low-risk attributes.

Section 4.2.1 requires the following with respect to fire brigade vehicle access:

- Construction of a four (4) metre perimeter road within the perimeter fire break.

Response – Roads around and within the site are at least 6.0 m wide. There is a single 4m wide light vehicle access road to the west of the BESS units. Hence the provided is compliant.

- Roads must be of all-weather construction and capable of accommodating a vehicle of fifteen (15) tonnes (e.g., no compacted earth).

Response - Roads will be constructed to satisfy CFA Guidelines, i.e., the emergency vehicle access road around the facility is considered as being a hardstand, and therefore shall also be designed to withstand a point load of 15 tonnes (or 150kN) so that it can withstand an aerial appliance at any location within the boundaries of the hardstand.

- Constructed roads should be a minimum of four (4) metres in trafficable width with a four (4) metre vertical clearance for the width of the formed road surface.

Response - Roads around and within the site are at least 6.0 m wide, surpassing the required width. There is a single 4m wide light vehicle access road to the west of the BESS units. Hence the provided is complaint.

- The average grade should be no more than 1 in 7 (14.4% or 8.1°) with a maximum of no more than 1 in 5 (20% or 11.3°) for no more than fifty (50) metres.

Response - The site is relatively flat and complies with the above.

- Dips in the road should have no more than a 1 in 8 (12.5% or 7.1°) entry and exit angle.

Response - The site is relatively flat and complies with the above, however the road design must assure this requirement is achieved.

- Roads must incorporate passing bays at least every 600 metres, which must be at least twenty (20) metres long and have a minimum trafficable width of six (6) metres. Where roads are less than 600 metres long, at least one passing bay must be incorporated.

Response – Item not applicable. Roads are not more than 600m long.

- Road networks must enable responding emergency services to access all areas of the facility, including fire service infrastructure, buildings, and battery energy storage systems and related infrastructure.

Response – Access roads are present around and within the facility such that all areas can be accessed and are expected to be accessible regardless the location of an equipment fire.

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- The provision of at least two (2) but preferably more access points to the facility, to ensure safe and efficient access to and egress from areas that may be impacted or involved in fire. The number of access points must be informed through a risk management process.

Response – The subject site can be accessed from the north via Hattam Street, and then a bifurcation in the road will allow the fire brigade to reach the site via alternative entries. A secondary/alternative entry is located to the east side of the development, which is accessible via Coonooer Street (Refer to Figure 5).

Section 4.2.2 requires the following with respect to firefighting water supply:

- Water access points must be clearly identifiable and unobstructed to ensure efficient access.

Response – Signage will be provided to indicate the location of the water tanks (Refer to Section 3 And Figure 5).

- Static water storage tank installations must comply with AS 2419.1-2021 [26]: Fire hydrant installations – System design, installation and commissioning.

Response – Water storage of 576kL (2 water tanks of 288kL each) will be provided at the entrance to the facility with a compliant hardstand.

- The static water storage tank(s) must be an above-ground water tank constructed of concrete or steel.

Response – It is considered the design will comply with this requirement.

- The static water storage tank(s) must be capable of being completely refilled automatically or manually within 24 hours.

Response – This matter will be addressed as a condition on the planning permit that requires a Fire Management Plan.

- The static water storage tanks must be located at vehicle access points to the facility and must be positioned at least ten (10) metres from any infrastructure (solar panels, wind turbines, battery energy storage systems, etc.).

Response – Complies.

- The hard-suction point must be provided, with a 150mm full bore isolation valve equipped with a Storz connection, sized to comply with the required suction hydraulic performance.

Response – It is considered the design will comply with this requirement.

- Adapters that may be required to match the connection are: 125mm, 100mm, 90mm, 75mm, 65mm Storz tree adapters with a matching blank end cap to be provided.

Response – It is considered the design will comply with this requirement.

- The hard-suction point must be positioned within four (4) metres to a hardstand area and provide a clear access for emergency services personnel.

Response – Complies.

- An all-weather road access and hardstand must be provided to the hard-suction point. The hardstand must be maintained to a minimum of 15 tonne GVM, eight (8) metres long and six (6) metres wide or to the satisfaction of the CFA.

Response – It is considered the design will comply with this requirement.

- The road access and hardstand must be kept clear at all times.

Response – It is an ongoing practice that must be part of the Fire Management Plan.

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- The hard-suction point must be protected from mechanical damage (e.g., bollards) where necessary.

Response – It is considered the design will comply with this requirement.

- Where the access road has one entrance, an eight (8) metre radius turning circle must be provided at the tank.

Response – This is compliant, as shown below.

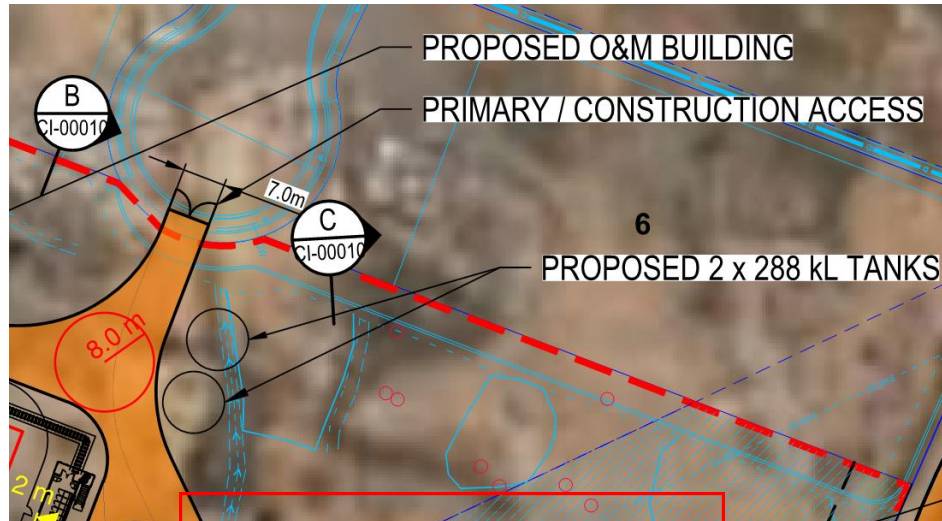


Figure 73: An 8m radius turning circle at the tanks.

- An external water level indicator must be provided to the tank and be visible from the hardstand area.

Response – It is considered the design will comply with this requirement.

- Signage indicating 'FIRE WATER' and the tank capacity must be fixed to each tank.

Response – It is considered the design will comply with this requirement.

- Signage must be provided at the front entrance to the facility, indicating the direction to the static water tank(s).

Response – It is considered the design will comply with this requirement.

- For facilities with battery energy storage systems, the fire protection system must include at a minimum: b) Where no reticulated water is available, a fire hydrant system that complies with AS 2419.1-2021 must be provided:

- (i) The fire water supply must be of a quantity no less than 288,000L or as per the provisions for Open Yard Protection of AS 2419.1-2021 flowing for a period of no less than four hours at 20L/s, whichever is the greater.
- (ii) The quantity of static fire water storage is to be calculated from the number of hydrants required to flow from AS 2419.1-2021: Fire hydrant installations, Table 2.2.5(D).

Response – Table 2.2.5(D) of AS 2419.1-2021 is extracted below:

Yard area, m ²	Number of fire hydrant outlets
≤ 3 000	1
> 3 000 ≤ 9 000	2
> 9 000 ≤ 27 000	3
> 27 000	4

Figure 74: AS 2419.1-2021 - Table 2.2.5(D) (Extracted) [26].

The proposed layout has an aggregated area of approximately 11,431 m² (less than 12,000m²), as shown in figures below, resulting of 3 hydrants, however, the fire hydrant system will have a reticulated system with water storage of not less than 576kL (2 water tanks of 288kL each) to support 4 hydrants, surpassing the requirements of the table above in order to account for reduced water availability during mayor bushfire events.



Figure 75: Aggregated area for Layout.

- (i) Fire hydrants must be provided and located so that every part of the battery energy storage system is within reach of a 10m hose stream issuing from a nozzle at the end of a 60m length of hose connected to a fire hydrant outlet.

Response – A Fire hydrant system as per AS 2419.1 must be provided throughout the facility, and hydrants will be located such that all infrastructure can be covered by at least 2 hydrants.

- (ii) The fire water supply must be located at vehicle entrances to the facility, at least 10m from any infrastructure (electrical substations, inverters, battery energy storage systems, buildings).

Response – The proposed layouts comply with this requirement.

- (iii) The fire water supply must be reasonably adjacent to the battery energy storage system and shall be accessible without undue danger in an emergency. (E.g., Fire water tanks are to be located closer to the site entrance than the battery energy storage system).

Response – The proposed layouts comply with this requirement as shown in Figure 5. The water tanks are located at the main entry of the subject site.

- (iv) The fire water supply must comply with AS 2419.1-2021: Fire hydrant installations - Section 5: Water storage tanks.

Response – This is compliant as assessed above. Water storage of 576,000 Liters will be provided (2 water tanks of 288kL each).

- Requirements for Battery Energy Storage Systems (Decentralized) are not included in this document, given that the subject site is not considered a decentralized BESS.

Section 4.2.3 requires the following with respect to fire detection and suppression equipment:

- For on-site buildings and structures, according to the requirements of the National Construction Code.

Response – Buildings at the facility are considered to comply with the DtS provisions where possible and are considered to achieve the performance requirements of the NCC (refer to Section 3).

- For storage of dangerous goods, according to the requirements of any Australian Standards for storing and handling of dangerous goods.

Response – No dangerous goods are indicated to be stored on the site.

- For electrical installations, a minimum of two (2) suitable fire extinguishers must be provided within 3m-20m of each PCU.

Response – Buildings at the facility are considered to comply with the DtS provisions where possible and are considered to achieve the performance requirements of the NCC. It includes the provisions for the fire protection and extinguish systems (i.e., portable fire extinguishers, water supply).

- In all vehicles and heavy equipment, each vehicle must carry at least a nine (9)-litre water stored-pressure fire extinguisher with a minimum rating of 3A, or other firefighting equipment as a minimum when on-site during the Fire Danger Period.

Response – This is required as part of the fire safety requirements for the subject site; hence it is considered to be compliant.

Section 4.2.4 requires the following with respect to management of Landscape Screening and on-site vegetation:

- Any proposed or existing vegetation must be considered in the Risk Management Plan for its potential to intensify and propagate fire within and away from the site.

Facilities must be designed so that the radiant heat flux (output) from vegetation does not create the potential for ignition of on-site infrastructure or other vegetation.

Response – As per Section 6.1.4, the subject BESS is part of an Industrial Zone (IN1Z) and is classified as a Bushfire Prone area. Given the location of the BESS site, a bushfire assessment (i.e., BAL as per AS 3959:2018) has been performed in Section 9.2.8 of this document.

Section 4.2.5 requires the following with respect to fire breaks:

- A fire break must be established and maintained around the perimeter of the facility, commencing from the boundary of the facility or from the vegetation screening inside the property boundary, and around the perimeter of control rooms, electricity compounds, substations and all other buildings on-site. The width of fire breaks must be a minimum of 10m, and at least the distance where radiant heat flux (output) from the vegetation does not create the potential for ignition of on-site infrastructure.

Response – It complies with the proposed layout options. The subject site is provided with a general fire break of 10m. A bushfire assessment (i.e., BAL as per AS3959) has been performed in Section 9.2.8 of this document.

Section 4.2.6.4 requires the following with respect to management of Fire Water Runoff:

- CFA recommends that infrastructure is provided for the containment and management of contaminated fire water runoff from battery energy storage systems. Infrastructure may include bunding, sumps and/or purpose-built, impervious retention facilities. A fire water management plan may include the containment and disposal of contaminated fire water.

Response – A drainage detention pond is designed and provided in the northwest corner of the site to this, in addition to the provided 576kL water storage. This matter will be further addressed as a condition on the planning permit that requires a Fire Management Plan, and it will be also a requirement from the Risk assessment.

Section 4.3 recommends that battery energy storage systems are equipped with the following elements:

- Battery management/monitoring systems for monitoring the state of battery systems to ensure safe operation.
- Detection systems for smoke, heat (thermal), fire and toxic gas (off-gassing) within battery containers.
- Suppression systems for fire within battery containers.
- Systems to prevent heat/fire spread within battery containers (such as thermal barriers, shut-down separators, isolation systems, cooling systems).
- Systems to prevent explosion within battery containers (such as ventilation, pressure relief and exhaust systems).
- Warning and alarm systems within the battery containers, and/or the facility, to enable early warning for faults, operation of the battery energy storage system above 'normal'/safe parameters, smoke, off-gassing, and fire.

Response – In general it is considered that the latest commercial BESS comply with these requirements, however the review will be performed when a BESS supplier is identified.

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10.3 SUMMARY

Based on the provided assessment in this report it is concluded that:

- Fire spread to adjacent allotments is not expected, as the separation distances exceed the minimum requirements set by the NCC and relevant Australian Standards, confirmed by the fire spread analysis in Section 9.
- Fire spread between equipment is unlikely subject to comply with the safety measures listed in Section 3 (e.g. clearances, fire walls and large-scale fire tests to BESS) and the fire spread analysis in Section 9. BESS units must provide evidence (i.e., large-scale fire tests as per CSA TS-800:24 and/or UL9540A).
- The HV transformer and the Control/Switch room must be provided with fire walls in accordance with AS2067 as there are buildings located less than 23m from the substation.
- Buildings' location complies with the NCC DtS provisions subject to comply with the safety measures listed in Section 3.
- The safety measures listed in Section 3 of this report will mitigate to the degree necessary the risk of fire spread between allotments and equipment and will facilitate the Fire Brigade intervention procedure.

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11 CODES AND REFERENCES

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Appendix A. LARGE SCALE FIRE TESTS RESULTS

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Laboratory Test Data - CSA/ANSI C800 Test Data Pack
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Master Contract:	305851	Model:	S556H201, S556H205	Page number 1 of 135
Project / Network:	80271222	Description:	Rechargeable lithium-Ion Battery Energy storage system	

Standard(s): CSA/ANSI C800:2025 – Testing Protocol for Energy Storage System Reliability and Quality Assurance Program.

CSA Laboratory Name:	CCIC-CSA International Certification Co.,Ltd. Kunshan Branch
Address:	2F-1, Building C12, No 555 Dujuan Road, Kunshan Economic & Technical Development Zone, Kunshan, Jiangsu, China 215331

If tests were performed at another facility, then described below:

Testing Laboratory Name:	ChuWeiNeng Testing Technology (Shanghai) Co.Ltd
Address:	East Road 200 meters north of the intersection of 206 National Road and Yanshan Road, Suxu Modern Industrial Park, Caocun Town, Yongqiao District, Suzhou City, Anhui Province, China
Facility Qualification Program:	☐ TPC, ☐ WTC, ☐ EMC, ☐ APD, ☒ APT, ☐ Subcontract
Witness By:	This type of document is available for the sole purpose of enabling its consideration and review as part of a planning process under the Planning and Environment Act 1987. The document must not be used for any purpose which may breach any copyright Elly Ai, Certifier Name, Title 2026-01-09 to 2026-01-15 Date (YYYY-MM-DD)

Customer:	EVE Power Co.,Ltd.
Address:	No.68,Jingnan Avenue, Duodao,Jingmen Hi-tech Zone, Jingmen City, Hubei 448124, China

Prepared By:	Elly Ai, Certifier
	Name, Title
	Elly Ai
	2026-02-13 to 2026-03-13
	Signature Date (YYYY-MM-DD)

Reviewed By:	Josh Dinaburg, Fire testing specialist
	Name, Title
	Joshua P Dinaburg
	2026-03-13
	Signature Date (YYYY-MM-DD)
	CSA Cleveland
	8801 E. Pleasant Valley Road, Independence, OH 44131 USA
	Address (If different than CSA Test Lab above)

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Master Contract: 305851	Model: S556H201, S556H205	Page number 2 of 135
Project / Network: 80271222	Description: Rechargeable lithium-Ion Battery Energy storage system	

Executive Summary

CSA Project 80271222 was a large-scale fire test to assess the performance of Rechargeable lithium-Ion Battery Energy storage system, model: S556H201, S556H205 manufactured by EVE Power Co.,Ltd. under fully developed fire conditions. Test samples were provided by EVE Power Co.,Ltd. on December 26th, 2025, to ChuWeiNeng Testing Technology Co. Ltd (ChuWeiNeng Lab), an ISO 17025 accredited test laboratory. A fully involved fire was initiated by heating four cells inside of a single battery module and igniting the thermal runaway gas with a propane torch. Combustion air was provided by opening the ventilation inlet and outlet and by removing the panels from the four deflagration pressure vents on top of the battery system cabinet. The fire in the initiating BESS burned for approximately 13 hours and consumed all battery modules in the initiating BESS.

The initiating BESS unit was surrounded by target BESS as shown in Figure 1 with separation consistent with the manufacturers' installation instructions. There was no evidence of cell damage, venting, or thermal runaway to live battery modules inside the target BESS. Peak module surface temperatures of 100.4°C, 54.1°C, 118.3°C, and peak cell surface temperatures of 51.8°C, 26.1°C, 44.6°C were measured for target BESS B, C, D respectively. Peak battery compartment outside surface wall temperature 90.5°C was measured for target BESS E. Temperatures on cell and module enclosures inside target target containers did not exceed the cell venting temperature of 176°C as measured by the UL 9540A cell level test report (4791318019-1). Temperature measured on target BESS E wall did not exceed 110% the cell venting temperature. Thermal damage was limited to the exterior surfaces of target BESS B, C, D, E where some surface paint burnt black and peeling were observed. The maximum heat flux measured in the aisles was 25.3 kW/m².

A peak heat release rate of 15.64 MW was measured by oxygen consumption calorimetry with maximum observed flame projections of approximately 5.0 meters vertically above the BESS and 0.5 meter horizontally toward the front aisle, and about 1.0 meter toward the left side from the initiating BESS. No evidence of structural damage was observed on the target BESS units or laboratory equipment outside of the initiating unit.

The test was executed in accordance with CSA C800:9.7 and UL 9540A Installation Level proposal dated Nov. 7, 2025. The resulting target BESS temperatures complied with clause 10.1J.1 Outdoor installations Temperature criteria. No propagation to adjacent units was observed in compliance with clause 9.2.1.2.1 of NPFA 855: 2026.

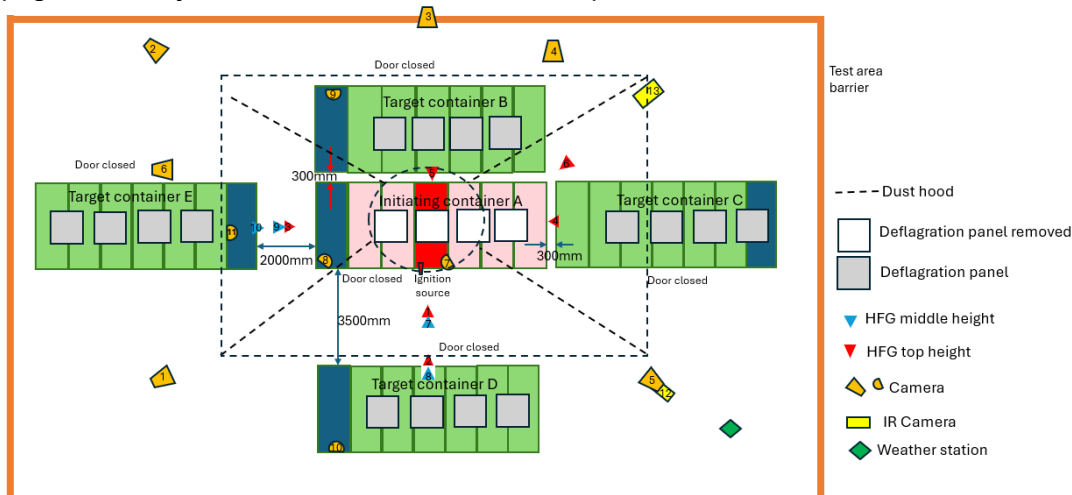


Figure 1: Test setup



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Master Contract:	305851	Model:	S556H201, S556H205	Page number 3 of 135
Project / Network:	80271222	Description:	Rechargeable lithium-Ion Battery Energy storage system	

Cell Level Test Summary (From UL 9540A)

Name of test laboratory perform cell level testing:	UL(Changzhou) Quality Technical Service Co., LTD
Unique identification of test report:	Project No.: 4791318019-1
Standard and its edition used for testing:	UL 9540A: 2025, 5th edition
Manufacturer:	EVE POWER Co.,Ltd.
Brand name / Trademark:	N/A
Model number:	MB56
Nominal cell voltage, (V)	3.2
Cell capacity, (Ah)	628
Cell chemistry:	LFP
Physical format of cell:	Prismatic
Cell certification available? (Yes/No)	Yes
Standard(s) used to certify product:	ANSI/CAN/UL 1973:2022
Certification organization name and its certificate number:	UL Solutions, MH63503

Module Level Test Summary (From UL 9540A)

Name of test laboratory perform module level testing:	UL(Changzhou) Quality Technical Service Co., LTD
Unique identification of test report:	Project No.: 4792074097.1
Standard and its edition used for testing:	UL 9540A: 2025, 5th edition
Manufacturer:	EVE POWER Co., Ltd.
Brand name / Trademark:	N/A
Model number:	P156H201
Nominal voltage rating, (V)	166.4
Nominal capacity rating, (Ah)	628



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Master Contract:	305851	Model:	S556H201, S556H205	Page number 4 of 135
Project / Network:	80271222	Description:	Rechargeable lithium-Ion Battery Energy storage system	

Additional Information:	Metal enclosure
-------------------------	-----------------

Unit Level Test Summary (From UL 9540A)		
Name of test laboratory perform unit level testing:	UL(Changzhou) Quality Technical Service Co., LTD	
Unique identification of test report:	Project No.: 4792074097.2	
Standard and its edition used for testing:	UL 9540A: 2025, 5th edition	
Manufacturer:	EVE POWER Co., Ltd.	
Brand name / Trademark:	N/A	
Model number:	C856H201, C856H202	
Nominal voltage rating, (V)	This copied document to be made available for the sole purpose of enabling its consideration and review as part of a planning process under the Planning and Environment Act 1987. The document must not be used for any purpose which may breach any copyright	1331.2
Nominal capacity rating, (Ah)		628
Unit certification available?, (Yes/No)		Yes
Standard(s) used to certify product:		ANSI/CAN/UL 1973:2022
Certification organization name and its certificate number:		UL Solutions, MH65421

Large Scale Fire Test Summary	
Manufacturer:	EVE Power Co.,Ltd.
Brand name / Trademark:	N/A
Model number:	S556H201, S556H205
Nominal voltage rating, (V)	1331.2
Nominal capacity rating, (Ah)	3768
Rated Energy, (kWh)	5015
Approximate dimension, (mm)	(LxWxH): 6058*2438*2896
EESS test configuration/intended installation:	Non-residential outdoor ground mounted/ Non-residential outdoor ground mounted
EESS certification available? (Yes/No)	Yes
Standard(s) used to certify product:	ANSI/CAN/UL 9540:2025
Certification organization name and its certificate number:	UL Solutions, E534864

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Master Contract:	305851	Model:	S556H201, S556H205	Page number 5 of 135
Project / Network:	80271222	Description:	Rechargeable lithium-Ion Battery Energy storage system	

Large Scale Fire Test Summary

Electrical configuration of module in BESS:	1P52S cells for each module, 8S modules for each rack, 6P racks in BESS
Number of modules in BESS:	48
Ventilation condition before test:	Initiating BESS: deflagration vent panel (size: 580 mm×780 mm) and air inlet (diameter: 222 mm) and outlet (diameter: 222 mm) kept open, Target BESS: deflagration panels and air inlet & outlet kept closed
Fire detection and suppression system integral part of EESS: (Yes/No)	Yes
Test conducted with fire detection system: (Yes/No/Not Applicable)	Fire detection system including two smoke detectors, two heat detectors, two hydrogen detectors, two CO detectors. All detectors were kept active in all BESS before testing;
Test conducted with fire suppression system: (Yes/No/Not Applicable)	Fire suppression system including one water sprinkler system and one aerosol extinguishing system were deactivated in all BESS before testing
Method used to initiate thermal runaway:	Attached eight heating films to both surfaces of cells 7, 20, 33 and 46 inside the initiating module heated per UL9540A test method. The ramp rate is 4.5°C/min. After gas release an external spark igniter used to initiate flaming.
Number of modules exhibited thermal runaway within initiating EESS:	48
Peak chemical heat release rate, (MW)	15.6
Peak convective heat release Rate, (MW)	11.5
Flammable gas generation, (Liter)	Before Flaming: 9,169 After Flaming: 29,048
Total gas generation, (Liter)	Before Flaming: 11,238 After Flaming: 4,191,199
Gas composition:	Before Flaming: CO (20.9%), CO ₂ (18.4%), H ₂ (37.9%), THC (22.8%) After Flaming: CO (0.3%), CO ₂ (99.3%), H ₂ (0.2%), THC (0.2%)

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Laboratory Test Data - CSA/ANSI C800 Test Data Pack
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ORIGINAL TEST DATA

The results relate only to the items tested.

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Master Contract:	305851	Model:	S556H201, S556H205	Page number 6 of 135
Project / Network:	80271222	Description:	Rechargeable lithium-Ion Battery Energy storage system	

Large Scale Fire Test Summary

Maximum target BESS temperature, (°C)	118.3 (BESS D module 1-8 surface)
Maximum incident heat flux on target wall surfaces, (kW/m ²)	N/A
Maximum incident heat flux on target BESS, (kW/m ²)	16.7 (On target BESS B back side, top height)
Maximum incident heat flux of aisle, (kW/m ²)	21.7
Total smoke release, (m ²)	190.67
Peak smoke release rate, (m ² /s)	402,479

Additional Information:

1. Target BESS E only employs the container enclosure for the battery compartment external wall temperature measurement. The enclosure of BESS E used with different battery compartment wall thickness between the electrical compartment, TCs are arranged on the external side to represent the enclosure interior, which is more severe condition.
2. Model difference:
 - a. The model S556H205 is identical with model S556H201 except for mirror structure design. For model S556H201 the electrical compartment and chiller are on the left side. For model S556H205 the electrical compartment and chiller are on the right side. Both models were used for this test.
 - b. Model comparison between S556H201, S556H205, S556H202, S556H206, S556H203, S556H207, list below:

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Master Contract:	305851	Model:	S556H201, S556H205	Page number 7 of 135
Project / Network:	80271222	Description:	Rechargeable lithium-Ion Battery Energy storage system	

Large Scale Fire Test Summary

Location in the Container	Sub System	Component	Model: S556H201, S556H205(mirror) UL Version (UL Standard)	Model: S556H202, S556H206(mirror) EU Version (IEC/EN Standard)	S556H203, S556H207(mirror) AU Version (AS Standard)
Battery Compartment	Fire Detection and Suppression System	Smoke, heat, gas detector	Same quantity, different part number		
		Audible and Visual Alarm	Different quantity, different part number		
		Bell	Same quantity, different part number		None
		Air Inlet / Exhaust Fan	Same brand/model/quantity, different implementation standard		
		Water Spray	Same system layout, the sprinklers have same quantity but different part number		
		Aerosol Fire Extinguishing Device	Different quantity, different part number		
	Window for Audible and Visual Alarm Components	Located in the upper side of the container	The size of the opening on the container is the same (W435*H231.7mm).		The size of the opening is W452*H452mm.
Electrical Compartment	DC Combiner Cabinet	Isolation Switch, Molded Case Circuit Breaker (MCCB), Residual Current Operated Circuit Breaker with Overcurrent Protection (RCCB), UPS	Same quantity, different part number		
		LV cables for mains power	Same specs, only different in cable color		
	Fire Detection and Suppression System	Fire Alarm Releasing Control Panel	Same quantity, different part number		
		E-stop Button	Same quantity, different part number		None
		Emergency Release Manual Pull Station	Same quantity, different part number		None
		Disable switch (Used to prevent aerosol spraying during installation and debugging)	1pc	None	
		UPS	Same quantity, different part number		
	Module Box	Used to convert the signal from the fire control panel	1pc	None	
	Transformer	Used to convert the mains voltage from 277V to 220V	1pc	None	
	Reserve Socket	For maintenance	Same quantity, different part number		

Table 0.1: Difference between country versions

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Master Contract:	305851	Model:	S556H201, S556H205	Page number 8 of 135
Project / Network:	80271222	Description:	Rechargeable lithium-Ion Battery Energy storage system	

Large Scale Fire Test Summary

c. Based above Table 0.1, BESS model with different cluster quantity used listed as below:

QTY. of Cluster		2	3	4	5
UL Version	Container A	S156H201	S256H201	S356H201	S456H201
	Container B	S156H213	S256H209	S356H213	S456H209
EU Version	Container A	S156H202	S256H202	S356H202	S456H202
	Container B	S156H214	S256H210	S356H214	S456H210
AU Version	Container A	S156H203	S256H203	S356H203	S456H203
	Container B	S156H215	S256H211	S356H215	S456H211

Remark: The cluster in above table is a parallel grouping of 8 modules in series.

d. Based above Table 0.1, BESS model with different module quantities (6 clusters) used listed as below:

QTY. of Modules per Cluster	UL Version		EU Version		AU Version	
	Container A	Container B	Container A	Container B	Container A	Container B
2	S156H206	S156H216	S156H208	S156H217	S156H210	S156H218
3	S156H205	S156H219	S156H207	S156H220	S156H209	S156H221
4	S256H205	S256H212	S256H206	S256H213	S256H207	S256H214
5	S356H206	S356H216	S356H208	S356H217	S356H210	S356H218
6	S356H205	S356H219	S356H207	S356H220	S356H209	S356H221
7	S456H205	S456H212	S456H206	S456H213	S456H207	S456H214

Note: Container B is the mirror construction.

Based on above differences, test results that no fire propagation to the target BESS could be covered for the models listed above a, b, c, d. The largest number of modules/clusters was tested for fire propagation. Fire detection and alarm signals may be different between the different EU and AU models.

Sample Information:

Sample No.	Date Received (YYYY/MM/DD)	Date or other dating period of manufacture	Model No.	Description
CWN260114XF01	2025/12/26	2025/12/21 to 2025/12/24	S556H201, S556H205	One initiating BESS and four target BESS

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