Preliminary Hazard Analysis

MIDDLEBROOK SOLAR FARM BATTERY ENERGY STORAGE SYSTEM

OCTOBER 2025

Prepared for NGH Consulting Pty Ltd on behalf of Middlebrook Solar Farm Pty Ltd as trustee for the MSF Project Trust

TotalEnergies

PANDO CONSULTING

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Table of Contents

Acronyms & abbreviations

AC	Alternating Current
ALARP	As Low As Reasonably Practicable
APZ	Asset Protection Zone
BESS	Battery Energy Storage System
CCTV	Closed-circuit television
DC	Direct Current
DPE	Department of Planning and Environment (NSW) (now DPHI)
DPHI	Department of Planning, Housing and Infrastructure
EIS	Environmental Impact Statement
EMFs	Electric and Magnetic Fields
ELF	Extremely Low Frequency
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2000 (NSW)
FRNSW	Fire and Rescue NSW
ha	hectares
km	kilometres
kV	kilovolts
LEP	Local Environment Plan
LGA	Local Government Area
m	metres
MW	Megawatt
MWh	Megawatt hours
O&M	Office and Maintenance
OEM	Original Equipment Manufacturer
PCU	Power Conversion Unit
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
RFS	(NSW) Rural Fire Service
SEARs	Secretary's Environmental Assessment Requirements
WHS	Work Health and Safety

1 Introduction

The Middlebrook Solar Farm (the Project) is a New South Wales (NSW) State Significant Development (SSD-10455) which received Planning approval on 11 November 2024. The Project includes the construction, operation and decommissioning of a ground-mounted PV solar array which would generate approximately 320MW Alternating Current (AC) from an installed Direct Current (DC) capacity of 450MW.

It is located approximately 22 kilometres (km) south of Tamworth in the Tamworth Regional Local Government Area (LGA) in NSW. The Project is in the pre-construction planning phase.

NGH Consulting Pty Ltd (NGH), on behalf of Middlebrook Solar Farm Pty Ltd as trustee for the MSF Project Trust (the Proponent), is preparing Modification 1 under Section 4.55 1A of the *Environmental Planning and Assessment Act* 1979. Modification 1 seeks to facilitate the following changes to the Project:

1. Minor increases to the consented Development Footprint to:
    a. Allow for the removal of a host landowner residence, and expand the solar array in this area (R2)
    b. Expand temporary construction laydown areas
    c. Expand the construction impact area for New England Highway / Middlebrook Road upgrades
2. Change in security fencing type, allowing for barbed wire in the substation area only
3. Change to Goonoo Goonoo Bridge assessment approach, reflecting more recent assessments for this bridge
4. Increase of assumed substation infrastructure height, including two new 30-meter-tall transmission towers (gantries/poles) for the ‘cut in’ to the existing 330kV line
5. Relocation of an existing private landholder access within the consented Development Footprint, to allow them to access their property independent of the solar farm
6. Increase in Battery Energy Storage System (BESS) to:
    a. 1606.5 MWh nameplate capacity (1450 MWh delivery capacity)
    b. 4.5+ hours duration at the point of connection
7. Change in number and size of transformers at substation, from 2 to 3
8. Inclusion of blast walls around the transformers, in the event that these may be required by TransGrid.

This Preliminary Hazard Analysis (PHA) has been updated to analyse the proposed modification to the BESS.

The BESS Original Equipment Manufacturer (OEM) will be selected during detailed design. As the OEM is currently unknown, this PHA presents the results of a generalised BESS PHA using Lithium Iron Phosphate ($LiFePO_4$) (LFP) cell chemistry.

1.1 Objectives

The objectives of this PHA are to:

- Develop a comprehensive understanding of the hazards and risks associated with the operation of a generalised BESS for the Project and the adequacy of safeguards.
- Detail commitments made by the Proponent, including separation distances, and justify that the land area required for the BESS, including separation distances, is sufficient.

1.2 Scope

This PHA has been updated to address the Planning Secretary's Environmental Assessment Requirements (SEARs) for the Project, including:

- Battery Storage – include a Preliminary Hazard Analysis prepared in accordance with *Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011); and
- An assessment of potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*.

This PHA has assessed a generalised AC coupled co-located BESS and considered LFP BESS chemistry. No other BESS chemistry has been considered. This PHA provides a basis for an informed judgment to be made on the acceptability of the Project.

1.3 Exclusion and limitations

- This report has been prepared by Pando Consulting Pty Ltd for NGH Consulting Pty Ltd (NGH) on behalf of Middlebrook Solar Farm Pty Ltd as trustee for the MSF Project Trust (the Proponent)
- This report is limited to a desktop study and is based on information supplied by NGH and the Proponent
- This report does not provide a complete assessment of the environmental status of the site and is limited to the scope outlined above
- This PHA is based on concept design, industry design standards and guidelines, and standard safety controls. Some information is limited as complete data on the design and precise controls is not available at the concept design stage
- The scope of this PHA does not include a transport route analysis and/or assessment of other risks, including, but not limited to, aviation safety, health, landslide/subsidence and telecommunications.

2 Site location and description

2.1 Site location

The Project is located approximately 22km south of Tamworth within the Tamworth Regional Local Government Area. (LGA) in New South Wales (NSW).

The location of the Modification is shown on Figure 2-1.

2.2 Surrounds

The surrounding region supports primary agriculture including sheep and cattle grazing and large-scale dryland cropping. The subject land is bordered by eight neighbouring lots, also zoned RU1 Primary Production. Grazing and cropping are the dominant enterprises. The Project will be accessed from Middlebrook Road, 3.8km from the New England Highway.

2.3 Sensitive receivers

The nearest National Parks/Nature Reserves are Back River Nature Reserve (28 km), Crawney Pass National Park (28 km), Ben Halls Gap Nature Reserve (33 km) and Tomalla Nature Reserve (37 km). All are located southeast of the Project.

As shown on Figure 2-1, there are 14 receivers within 2km including 5 associated receivers (R1, R2, R3, R4 and R7).

The closest non-involved dwelling is approximately 360 metres (m) from the Project. Two existing TransGrid 330 kV transmission lines traverse the subject land.

2.4 Sensitive developments

There are no sensitive developments, as defined by HIPAP 4 and HIPAP 6, within 1 km of the Project. Sensitive developments include:

- Hospitals and aged care facilities
- Schools and Childcare Centres
- Residential areas
- Critical Infrastructure.

2.5 Health

The surrounding environment includes existing sources of Extremely Low Frequency (ELF) Electromagnetic Field (EMF) (i.e., 50 Hz) including the existing electricity transmission lines and easements.

The Project would introduce additional sources of EMF including BESS enclosures and transformers.

Due to the rapid attenuation of EMF with distance and the inclusion of BESS enclosures, it is anticipated that EMF will decrease significantly beyond the immediate vicinity of the Project. The EMF levels are expected to be well below the ICNIRP *Guidelines For Limiting Exposure To Time-Varying Electric And Magnetic Fields* (1 Hz – 100 kHz) (ICNIRP Guidelines) reference levels (refer to Table 2-1) at the nearest receivers.

Table 2-1 ICNIRP reference levels for general public exposure at 50 Hz

Frequency	Electric field (kV/m)	Magnetic field (μT)
50 Hz	5	200

Additionally, the ICNIRP Guidelines literature review determined that the epidemiological and biological data concerning chronic conditions (i.e., long-term) were carefully reviewed and it was concluded that there is no compelling evidence that they are causally related to low-frequency

EMF exposure.

The impacts of EMF have been assessed in the hazard register (refer to Table 5-6) and in the risk assessment (refer to Section 7).

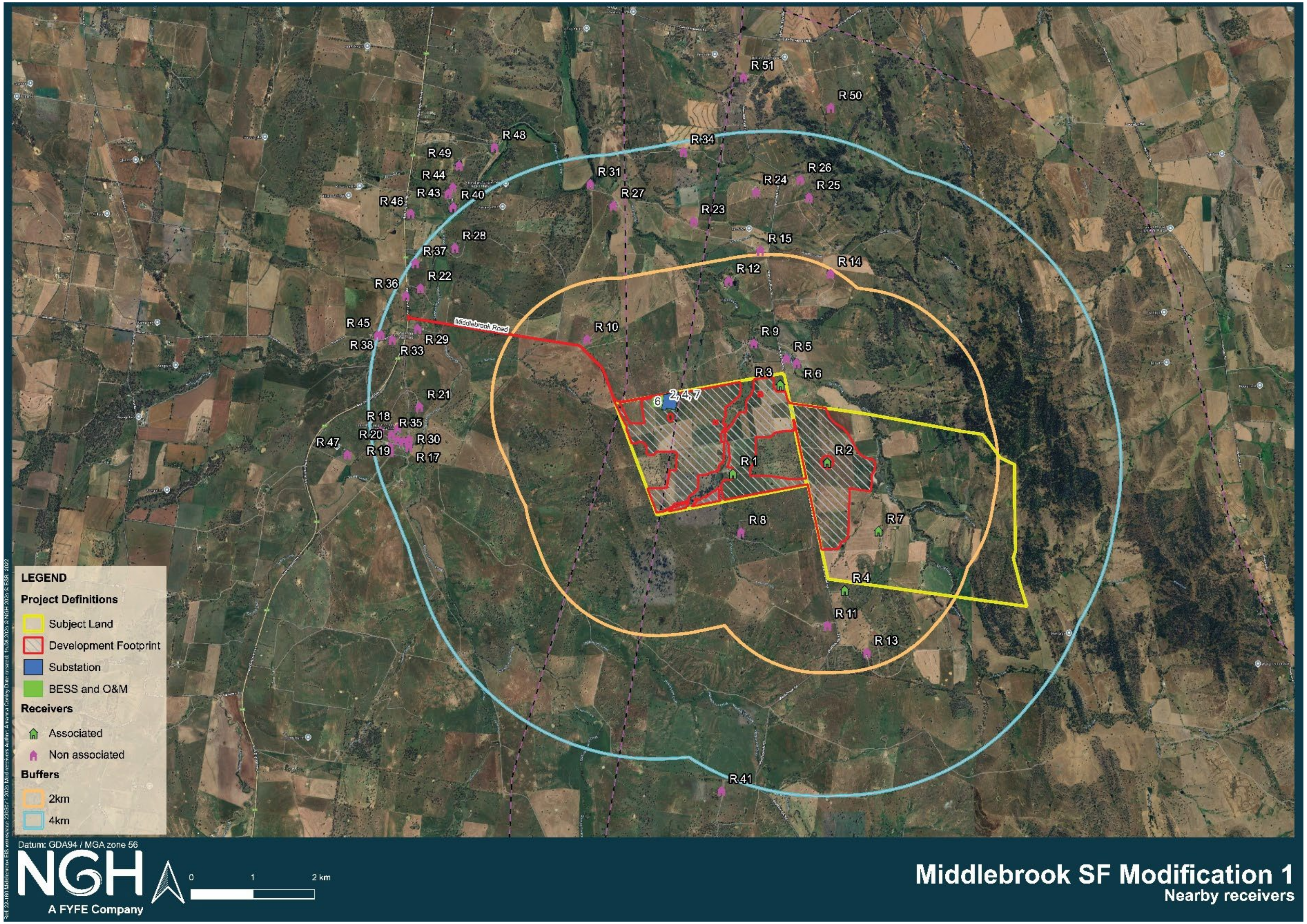

Figure 2-1 Sensitive receivers (source: NGH)

3 Summary of Project as modified

3.1 Overview

The key features of the Project as modified are presented in Table 3-1 and Figure 3-1. The BESS layout is presented in Figure 3-2.

Table 3-1 Key features of the Project

Proposal element	Description
Nominal capacity	320MW AC from an installed DC capacity of 450MW. Note: the approximate capacity is based on the proposed technology available at the time of concept design but may change through the solar farm's life as technological advances occur.
Solar array	Up to 750,000 solar panels mounted in arrays, arranged in rows on single-axis trackers with a maximum height of up to 3 m above the natural ground level.
BESS & Power Conversion Unit (PCU)	A 1450 MWh delivery capacity AC coupled co-located BESS (including up to 4.5+ hours duration). The BESS and PCU is described in Section 3.2.
On-site substation and switchyard	A substation with three transformers up to 480 MVA would be constructed in a gravelled hardstand area with security fencing. The substation would be located adjacent to the existing (TransGrid-owned) 330 kV transmission line.
Ancillary Area	An ancillary area, of equal area to one group of ESS blocks, would be constructed for parking, control building, Operation and Maintenance (O&M) Facility and spares storage. The ancillary area may be reduced during detailed design if UL9540A fire testing of the selected OEM BESS requires greater than 3.25 m separation distance between ESS blocks.
Security fencing, lighting and Closed-Circuit Television (CCTV)	Continuous security lighting (infra-red) and CCTV cameras would be installed on posts up to 3.5 m high adjacent to the perimeter security fencing. Security fencing installed around the site would indicatively be 2.4 m high.

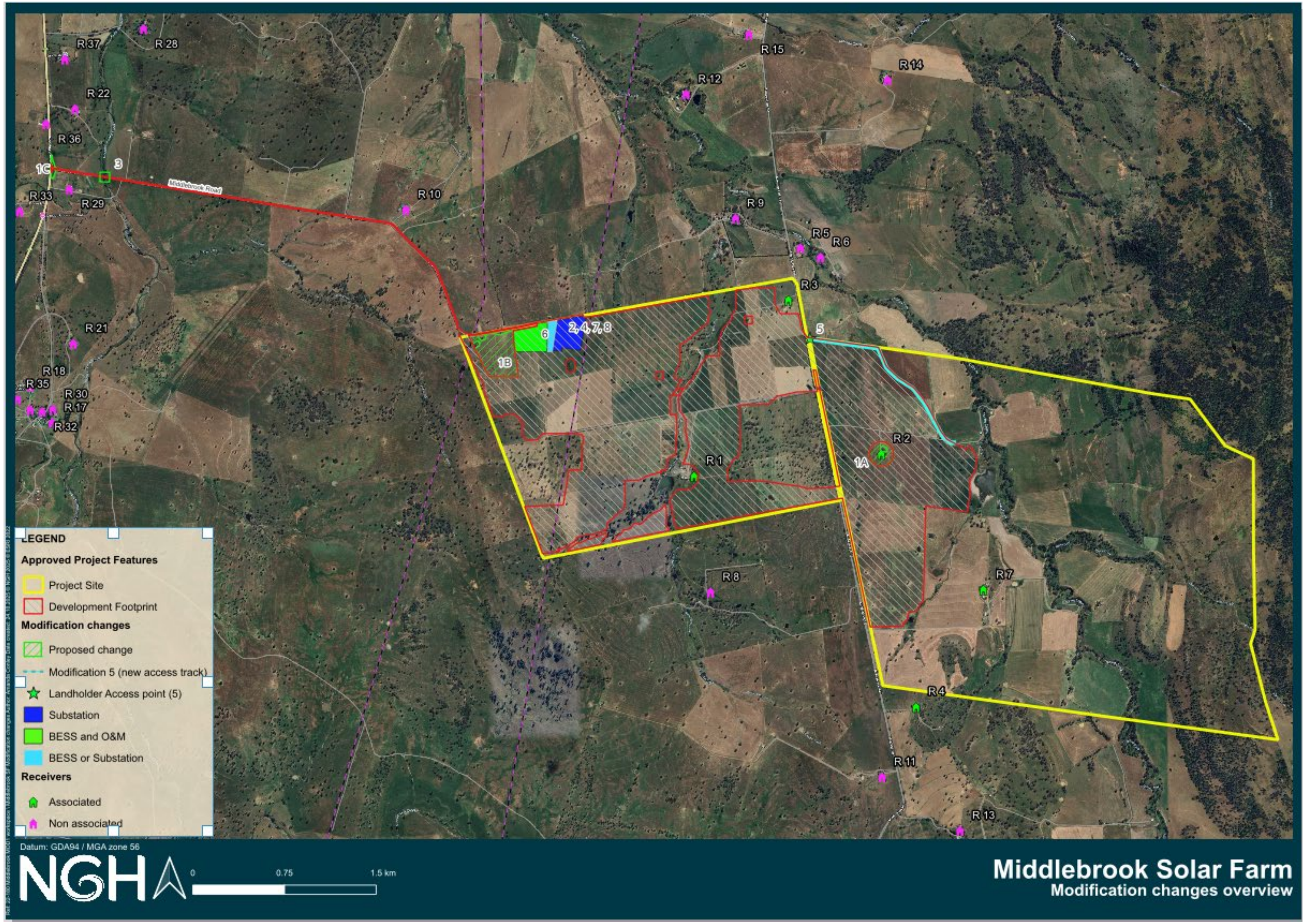

Figure 3-1 Project as modified indicative layout (source: NGH)

3.2 Battery Energy Storage System

Battery storage would include a containerised 1450 MWh AC coupled BESS (delivery capacity). Containerised BESS are designed to be modular and scalable, making them easy to expand or contract based on the requirements of the energy storage application. The use of standard-sized containers also makes it easier to transport and install the system, reducing the time and cost of construction.

The BESS, as presented in Figure 3-2, would include 315 BESS containers. Subject to detailed design, the BESS arrangement would include 63 BESS container areas with 5 BESS containers in each. Each BESS container area would have one PCU.

The BESS capacity is expected to include:

- 4.5+ hours duration at the point of connection
- 1606.5 MWh nameplate capacity (based on 315 containers at 5.1MWh each)
- 1450 MWh delivery capacity.

The AC coupled BESS arrangement allows for the use of grid-forming battery inverters with advanced capabilities, including:

- Provide system strength services to the local network
- Provide faster frequency response
- Provide improved fault ride through capability
- Provide active power oscillation dampening
- Provide System Restoration Support (if contract is agreed with Australian Energy Market Operator (AEMO)).

3.2.1 BESS safeguards

Risk mitigation strategies considered in siting the BESS include:

- A minimum 10 m wide APZ maintained to the standard of an Inner Protection Area (IPA) in accordance with Appendix 4 of *Planning for Bush Fire Protection 2019*
- About 6 m wide internal roads in the BESS facility suitable for emergency access and/or exit including an unobstructed clearance height of 4 m. Internal roads will consider the vehicle turning requirements described in Appendix 3 of *Planning for Bush Fire Protection 2019.*

Subject to detailed design and OEM recommendations, the BESS would include:

- Gas detection and suppression
- Water suppression
- Pressure relief vent
- Pressure blast panels

In accordance with NFPA 855 14.3.2.2, the containerised BESS would be designed to include a 2-hour fire resistance rating, a fire alarm system, and an automatic sprinkler system. Other safeguards include:

- Emergency stop
- Ground fault detection
- Manual Service Disconnect (MSD) switch
- Overcurrent protection
- Battery Management System (BMS).

3.2.2 BESS separation distances

Separation distance may be the most effective control to reduce the likelihood and consequence of fire propagation as a result of thermal runaway events (self-heating of an electrochemical system in an uncontrollable fashion). The separation distances for BESS, as presented in Figure 3-2, include:

- Minimum clearance of 3 m between BESS container areas
- Minimum clearance of 3 m between BESS container areas and PCU
- No more than four BESS containers in a back to back arrangement with a minimum back to back separation of 0.5 m
- Ten metre wide APZ.

In accordance with the National Fire Protection Agency (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* (NFPA 855), the minimum clearance to enclosures for outdoor stationary Energy Storage Systems (ESS) installations is 10 feet. A minimum clearance of 3 m between BESS containers can be reasonably approximated to 10 feet (or compliant within acceptable tolerance).

The Proponent is yet to specify a battery OEM and procure UL9540A test reports for the selected battery OEM. Selection of technology is typically finalised during detailed design, and given the early stage of the Project, no certainty about technology can be provided.

Publicly available product specification and/or cell level UL9540A test reports for utility scale LFP batteries, indicate that 100 millimetres (mm) to 500 mm separation is suitable to prevent thermal runaway from propagating from battery unit to battery unit (refer to Table 3-2). Based on this data, it is reasonable to anticipate that a back-to-back separation of 500 mm is practical at the planning phase (and may be reduced during detailed design).

Table 3-2 OEM recommended minimum separation distances

OEM	Minimum required spacing between battery units (back-to-back)
Sungrow	160 mm
CATL	100 mm
EVE Power	160 mm
Ruipu Energy	160 mm
Tesla Megapack 2XL	152.4 mm (6 inches)
Saft	500 mm

Recent full-scale fire tests of grid-scale BESS, conducted in accordance with UL9540A protocols, indicate that many leading OEMs are now achieving non-thermal propagation between adjacent BESS units. These results, observed in tests by manufacturers such as Hithium, Sungrow, Fluence, and Canadian Solar, demonstrate that with appropriate system design and fire containment measures, thermal runaway events can be effectively confined to the initiating unit without spreading to neighbouring systems.

Based on the above, the BESS configuration and separation distances are considered appropriate at the planning phase of the development. Following the implementation of the recommendations of this PHA, including the proposed separation distances, the likelihood of a multi-module fire would be minimised to a non-credible event.

Figure 3-2 BESS layout (source: the Proponent)

3.2.3 BESS detailed design standards

The detailed design of the BESS will be in accordance with standards provided in Table 3-3 and Table 3-4. The detailed design will also review and comply with OEM product specifications, UL9540A test report recommendations and the fire safety study.

Table 3-3 Consideration of standards and codes in BESS design

Standard / code	Consideration
AS 2067	Substations and high voltage installations exceeding 1.0kVAC considering electrical, operation and safety separation
IEC 61000-6	Electromagnetic Compatibility (EMC)
IEC 62477-1	Safety requirements for power electronic converter systems and equipment
IEC 62619	Safety requirements for secondary lithium cells and batteries, for use in industrial applications
IEC 62897	Stationary Energy Storage Systems with Lithium Batteries - Safety Requirements
NFPA 855	Standard for the Installation of Stationary Energy Storage Systems
NSW Fire + Rescue	Large-scale external lithium-ion battery energy storage systems – fire safety study considerations
UL 1973	Standard for Safety Batteries for Use in Stationary and Motive Auxiliary Power Applications
UL 9540	Standard for Energy Storage Systems and Equipment
UL 9540A	Test method - testing the fire safety hazards associated with propagating thermal runaway within battery systems
UN 38.3	Transportation Testing for Lithium Batteries and Cells

Table 3-4 Consideration of standards and codes for BESS separation distances

Source	Infrastructure	Items for consideration
FM Global DS 5-33	Outdoor LIB-ESS Enclosures and Containers	**2.3.2.1** Select or construct LIB-ESS enclosures/containers using only non-combustible materials. *Separation distance is based on doors being located on only one side of the enclosure and no vents or unprotected openings on any other sides. It is also based on active systems (HVAC or liquid cooling) maintaining cell or module temperatures in the target enclosure or container.* **2.3.2.2** For containerized LIB-ESS comprised of lithium iron phosphate (LFP) cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors or deflagration vents. ~~2.3.2.3 For containerized LIB-ESS comprised of lithium nickel manganese cobalt (NMC) cells where wall construction is unknown or has an ASTM E119 rating less than 1 hour, provide aisle separation of at least 13 ft (4.0 m) on sides that contain access panels, doors, or~~

Source	Infrastructure	Items for consideration
		~~deflagration vents. For containerized NMC LIB-ESS where wall construction is documented as having at least a 1 hour rating in accordance with ASTM E119, aisle separation of at least 8 ft (2.4 m) is acceptable.~~ 2.3.2.4 Provide separation between solid walls having no openings based on installation-level testing that demonstrates thermal runaway cannot propagate between containers. Where a fire test report is not available or the test did not result in a fire in the unit of origin, provide separation as indicated in Sections 2.3.2.2 ~~or 2.3.2.3~~ as appropriate. 2.3.2.4.1 If any penetrations are present, the separation should be extended, or the penetrations should be protected or equipped with FM Approved fire-safe wall penetrations. 2.3.2.4.2 Where explosion vents or other penetrations are provided, ensure they are arranged and directed away from surrounding equipment and buildings. In a fire, these enclosures may have vents or penetrations that could allow hot gas and products of combustion to escape the enclosure, causing an exposure to adjacent equipment or buildings. Penetrations could include electrical conduit, doors, HVAC units, etc. 2.3.2.5 Provide a minimum space separation between LIB-ESS enclosures and adjacent buildings or critical site utilities or equipment in accordance with Data Sheet 1-20, Protection Against Exterior Fire Exposure, using hazard category 3 for the exposing building occupancy.
NPFA 855	BESS	In accordance with section 9.4.2.2 of NPFA 855, each ESS group (i.e. container) shall be spaced a minimum 3 ft (0.9 m) from other groups and from walls in the storage room or area.
ASNZS 5139.2019 6.2.6.2	MV power station	Minimum of 900 mm distance between battery system and power conversion equipment.

4 Recommendations following the Victorian Big Battery Fire

Recommendations were provided in the *Victorian Big Battery Fire Statement of Technical Findings* – Victorian Government 2021 following an investigation into the Victorian Big Battery Fire. In response to the recommendations, the Proponent, TotalEnergies, makes the commitments presented in Table 4-1.

Table 4-1 The Proponents response to recommendations of the Victorian Big Battery Fire

Victorian Big Battery Fire Statement of Technical Findings - lessons learned and preventing a recurrence	Proponents' commitment
Tesla Megapack	The Proponent is unlikely to use the Tesla Megapack. If they do, they will implement all recommendations from the Victorian Big Battery Fire Statement of Technical Findings – Victorian Government 2021
Each Megapack cooling system is to be fully functionally and pressure tested when installed on site and before it is put into service	Following installation, the Proponent will commission any liquid chillers and cooling pipes to check they are fully functional and undertake subsequent pressure tests.
Each Megapack cooling system in its entirety is to be physically inspected for leaks after it has been functionally, and pressure tested on site	The Proponent will undertake physical inspections of any liquid chillers following commissioning and pressure testing.
The Supervisory Control And Data Acquisition (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	The Proponent is unlikely to use the Tesla Megapack. If they do, the SCADA will be modified in accordance with this recommendation.
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	The Proponent is unlikely to use the Tesla Megapack. Any selected BESS units will include a battery module isolation loss alarm that 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 for Megapacks during commissioning and operation to ensure the telemetry system is operational	The Proponent is unlikely to use the Tesla Megapack. If they do, the procedure for the usage of the key lock for Megapacks during commissioning and operation will 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	DC fuses remain in service for protection purpose no matter if the key lock is isolated or not.

5 Preliminary hazard analysis

5.1 PHA methodology

The methodology undertaken to prepare this PHA includes:

- Identification of the nature and scale of all hazards at the proposed development, and the selection of representative incident scenarios.
- Analysis of the consequences of these incidents on people, property, and the biophysical environment.
- Evaluation of the likelihood of such events occurring and the adequacy of safeguards.
- Calculation of the resulting risk levels of the facility.
- Comparison of these risk levels with established risk criteria and identification of opportunities for risk reduction.

A schematic of the hazard analysis process is included below in Figure 5-1.

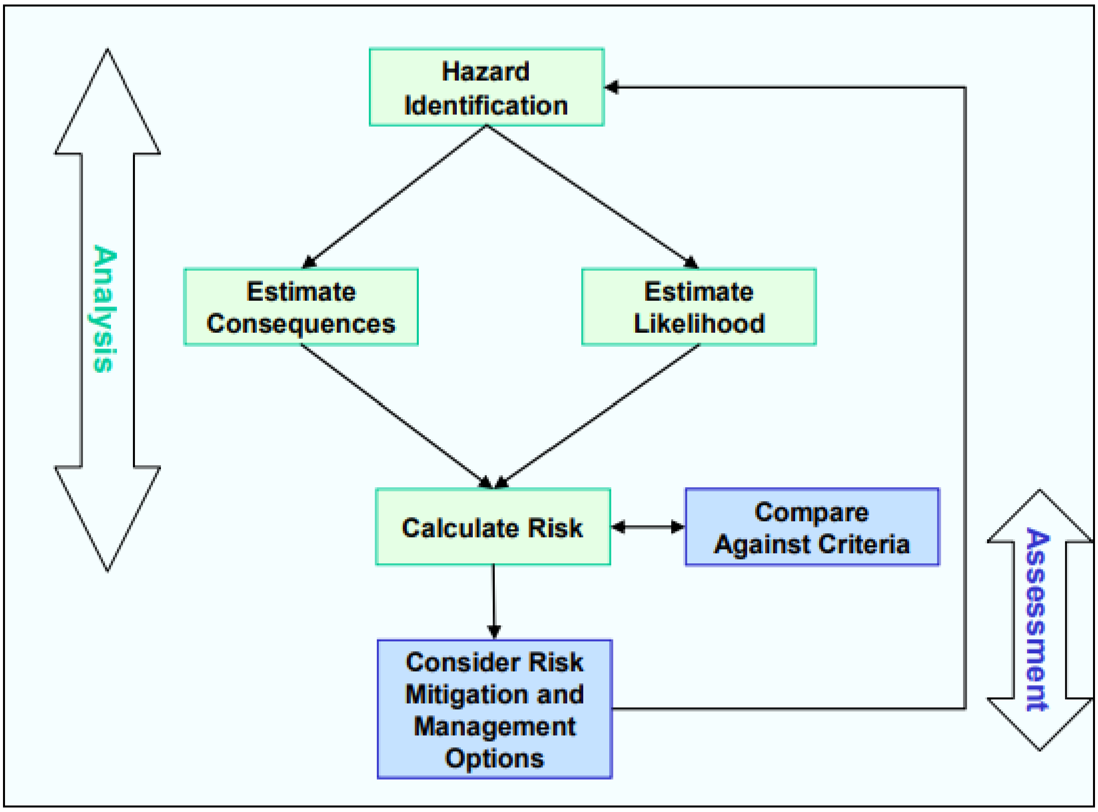

Figure 5-1 Basic methodology for hazard analysis (Source: HIPAP 6)

5.2 Hazard Identification

Hazard identification includes the systematic identification of possible hazards, both on-site and off-site including:

- BESS activities and infrastructure
- Type of equipment
- Hazardous materials present

- Natural events such as floods, cyclones, earthquakes, or lightning strikes
- Hazardous events on neighbouring sites.

The identified hazards and events are presented in Table 5-1.

Table 5-1 Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
Electric and Magnetic Fields (EMF)	Exposure to EMF
Fire	Infrastructure fire
Chemical	Release of hazardous materials
Reaction	Battery thermal runaway
External factors	Vandalism, flooding

5.3 Consequence analysis

Consequence

For each identified event, the resulting consequence was qualitatively described and categorised in accordance with Table 5-2. These include impacts to personnel (e.g., fatality/injury), environment and/or assets.

Table 5-2 Consequence categories

Consequence category	Description
4 – Major	Fatality / permanent injury (on-site or off-site)
3 – Moderate	Severe injury, hospitalisation, serious off-site exposure
2 – Minor	Minor injury or health impact, small localised release
1 – Insignificant	First aid only, nuisance or procedural deviation

Likelihood

Using a qualitative approach, the likelihood of an event was estimated using the category scale shown in Table 5-3. The likelihood ratings were assigned based on knowledge of historical incidents in the industry. The likelihood ratings were assigned accounting for the initiating causes, resulting consequences with controls (prevention and mitigation) in place.

Table 5-3 Likelihood category

Category	Description
1. Extremely Unlikely	Never heard of in the industry, not realistically expected to occur

Category	Description
2. Very Unlikely	Heard of in the industry, but not expected to occur
3. Unlikely	Could occur in the next 10 years
4. Likely	Could occur in the next year

5.4 Hazard Register

The identified hazards, events and the relationships with causes, consequences, controls, and likelihood ratings are summarised in the hazard register. A summary of the information contained in the hazard register is provided in Table 5-4.

Standard control measures, relevant to all hazards and events are presented in Table 5-5.

The hazard register for the Project is presented in Table 5-6.

Table 5-4 Information used in hazard register

Column Heading	Description
Hazard	Description of the source of potential harm
Event	Description of mechanism by which the hazard potential is realised
Cause	Description of the potential ways in which the event could arise
Consequence	Description of consequences of the event and potential impact to people, environment and/or asset
Controls	Any existing aspects of the design which prevent and/or mitigate against the event and resulting consequences
Likelihood Rating	Likelihood rating assigned for the event accounting for the initiating causes, resulting consequences with controls in place

Table 5-5 Standard control measures

Project phase	Standard control measure
Detailed design	• Verify with the manufacturer or integrator that the BESS design, including cell type, BMS, is appropriate for the application. • Establish a management of change procedure to ensure that batteries or BMS components are compatible with modified system requirements or that replacements are appropriate to the existing system requirements. • Do not use refurbished or previously used BESS components, including cells or modules. • Equipment and systems will be designed and tested to comply with international standards and guidelines • Implement Emergency Response Plan

Project phase	Standard control measure
	• All relevant Transgrid's requirements will be met
Construction and operation	• Site inductions • Engagement of reputable contractors • Independent certifiers/owner's engineers • Installation and maintenance will be done by trained personnel • Warning signs (electrical hazards, arc flash) • Use of appropriate PPE • Bushfire Emergency Management and Operations Plan • External assistance for firefighting (FRNSW & RFS)

Table 5-6 Hazard register

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
1	Electrical	Exposure to voltage	• Short circuit/electrical connection failure • Faulty equipment • Incorrect installation • Incorrect maintenance • Human error during maintenance • Safety device/circuit compromised • Battery casing/enclosure damage	• Electrocution • Injury and/or fatality • Fire	• Electrical switch-in & switch-out protocol (pad lock) • BMS including fault detection and shut-off function • Ground fault detection • Manual Service Disconnect (MSD) switch • Overcurrent protection • Rescue kits (i.e., insulated hooks)	Very Unlikely
2	Arc flash	Arc flash	• Incorrect procedure (i.e., installation/ maintenance) • Faulty equipment (e.g., corrosion on conductors) • Faulty design (e.g., equipment too close to each other) • Insulation damage • Human error during maintenance	• Burns • Injury and/or fatality • Exposure to intense light and noise • Arc blasts and resulting heat, may result in fires and pressure waves	• Maintenance procedure (e.g., deenergize equipment) • Preventative maintenance (insulation)	Very Unlikely
3	EMF	Exposure to EMF	• Operations of power generation equipment	• High level exposure (i.e., exceeding the reference limits) may affect function of the nervous system (i.e., direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) • Personnel injury	• Location and selection (incl. separation distance) • Optimising equipment layout and orientation • Reducing conductor spacing • Balancing phases and minimising residual current • Incidental shielding (i.e., BESS building/enclosure, switchroom) • Exposure to personnel is short duration in nature (transient) • Studies found that the EMF for commercial solar power generation facilities comply with ICNIRP occupational exposure limits	Extremely Unlikely
4	Fire	Transformers and PCS fire	• Transformer oil leak • Faulty equipment • Arc flash	• Fire in transformer and/or PCS • Release of toxic combustion products • Injury/fatality • Asset damage • Interruption in power supply	• Preventative maintenance (e.g., insulation, replacement of faulty equipment) • Activation of emergency shutdown (ESD button)	Very Unlikely
5	Fire	Switchroom fire	• Equipment failure • Arc flash • Vandalism • External fire (e.g., bushfire, adjacent infrastructure)	• Fire in substation and escalation to switchyard • Release of toxic combustion products • Injury/fatality • Asset damage • Interruption in power supply	• Inverter/transformers (PCU) are in designated area • Preventative maintenance (e.g., insulation, replacement of faulty equipment) • Electrical switch-in & switch-out protocol (pad lock) • Circuit breakers • Substation is locked and located in designated area • Security fence and controlled access • Activation of emergency shutdown (ESD button)	Extremely Unlikely
6	Fire	Fire in temporary construction facilities	• Kitchen fire • Paper fire • Smoking	• Injury/fatality • Asset damage	• Cooling water supply on-site • Defendable boundary for firefighting will be established (i.e., APZ) • Dedicated smoking area • Fire protection system in the temporary construction facilities	Very Unlikely
7	Fire	Bushfire	• Encroachment of off-site bushfire	• External Fire Exposure & Thermal Runaway	Bushfire Protection Measures (BPM) in accordance with	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
			• Escalated event from facility fire	• Toxic Gas Emissions • Explosion Risks • Structural Damage & Grid Impact • Firefighting Challenges	*Planning for Bush Fire Protection 2019*, including: • APZs • Access • Construction siting and design • Landscaping • Services • Emergency and evacuation planning (fire safety study, emergency response plan and bush fire emergency management and operations plan). Additional controls including: • Separation between BESS containers • Fire-resistant enclosures and passive fire barriers between battery racks • Gas detection & venting systems to prevent pressure buildup • Remote monitoring & emergency response plans for early intervention.	
8	Reaction	Thermal runaway in battery	• Elevated temperature • Bushfire • External fire (e.g., substation, transformer) • Electrical failure • Short circuit • Excessive current/voltage • Imbalance charge across cells • Mechanical failure • Internal cell defect • Damage (crush/penetration/puncture) • Systems failure • Battery Management System (BMS) failure • HVAC failure	• Fire in the battery cell • Injury/fatality • Escalation to the enclosure/ building • Escalation to the entire BESS	• Separation distances in accordance with product specifications and UL9540A test reports • LFP battery cells with high thermal stability • Fire protection system • Integrated cooling system • 2-hour fire resistance rating, a fire alarm system, and an automatic sprinkler system. • Emergency stop • Ground fault detection • Manual Service Disconnect (MSD) switch • Overcurrent protection • Battery module isolation loss alarm • Battery Management System (BMS)	Very Unlikely
9	Chemical	Release of electrolyte (liquid/ vented gas) from the battery cell	• Mechanical failure/damage • Dropped impact (installation/maintenance) • Damage (crush/penetration/puncture) • Abnormal heating/elevated temperature • Thermal runaway • Bushfire • External fire (e.g., substation, transformer)	• Release of flammable liquid electrolyte • Vapourisation of liquid electrolyte • Release of vented gas from cells • Fire and/or explosion in battery enclosure/building • Release of toxic combustion products • Injury/fatality	• Layers of battery case (pod and external casing) • Spill cleanup using dry absorbent material • BMS including fault detection and shut-off function • HVAC system • BESS fire protection system	Very Unlikely
10	Chemical	Coolant leak	• Mechanical failure/damage • Incorrect maintenance	• Irritation/injury for personnel on exposure (inhalation)	• Layers of battery case (pod and external casing) • Spill cleanup using dry absorbent material • BMS fault detection and shut-off function	Very Unlikely
11	Chemical	Refrigerant leak	• Mechanical failure/damage • Incorrect maintenance	• Irritation/injury for personnel on exposure (skin contact)	• BESS layers of battery case (pod and external casing) • BESS BMS fault detection and shut-off function • Chiller Unit separation distance to other equipment	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
12	Chemical	Exposure to hazardous material	• Inappropriate storage use and handling of pesticides/herbicides for vegetation management and landscaping	• Irritation/injury for personnel on exposure	• Product will be stored in dedicated storage area in a bund • A spill kit will be kept near the dedicated storage area • Quantity kept in work area will be minimised • No spraying will be done during high wind • Limited usage prior to and during rain events	Very Unlikely
13	Diesel	Release of diesel from storage tank or filling point or during handling/ transfer to generator set	• Mechanical failure • Human error during transfer	• Fire (if ignited) • Injury/fatality	• Diesel is a combustible liquid and will be stored away from other flammable materials (e.g., gasoline) • Secondary containment (i.e., bunding) • Defendable boundary for firefighting will be established	Very Unlikely
14	Gasoline	Release of gasoline from storage tank or filling point	• Mechanical failure • Human error during transfer	• Fire • Injury/fatality	• Secondary containment (i.e., bunding) • Defendable boundary for firefighting will be established	Very Unlikely
15	External factors	Fire (BESS, Inverter/transformers (PCU), substation switchrooms)	• Water ingress (e.g., rain, flood)	• Electrical fault/short circuit • Fire • Injury/fatality	• Location siting (i.e., outside of flood prone area) • Switchrooms and BESS are housed in dedicated enclosure/building. which will be designed and constructed with ingress protection and in accordance with relevant standards • Drainage system • Preventative maintenance (check for leaks)	Extremely Unlikely
16	External factors	Vandalism	• Unauthorised personnel access	• Asset damage • Potential hazard to unauthorized person (e.g., electrocution)	• Project infrastructures are in secure fenced area • Onsite security protocol • During construction, the area will be patrolled, and fence will be installed	Unlikely
17	External factors	Lightning strike	• Lightning storm	• Injury/fatality • Fire • Asset damage	Project designed in accordance with *Australian Standard AS/NZS 1768 Lightning protection*, including: • Earthing • Lightning protection mast (substations) • Site exclusion/closure	Very Unlikely

6 Multi-level risk assessment

Multi-Level Risk Assessment (DoP, 2011) recommends a multi-level approach to risk assessment where the level and extent of the analysis reflects the nature, scale and location of the Project. The objective is to progress the analysis, and its assessment only as far as is needed to demonstrate that the operation of the Project does not or will not pose a significant risk to surrounding land uses. The approach is presented in Figure 6-1.

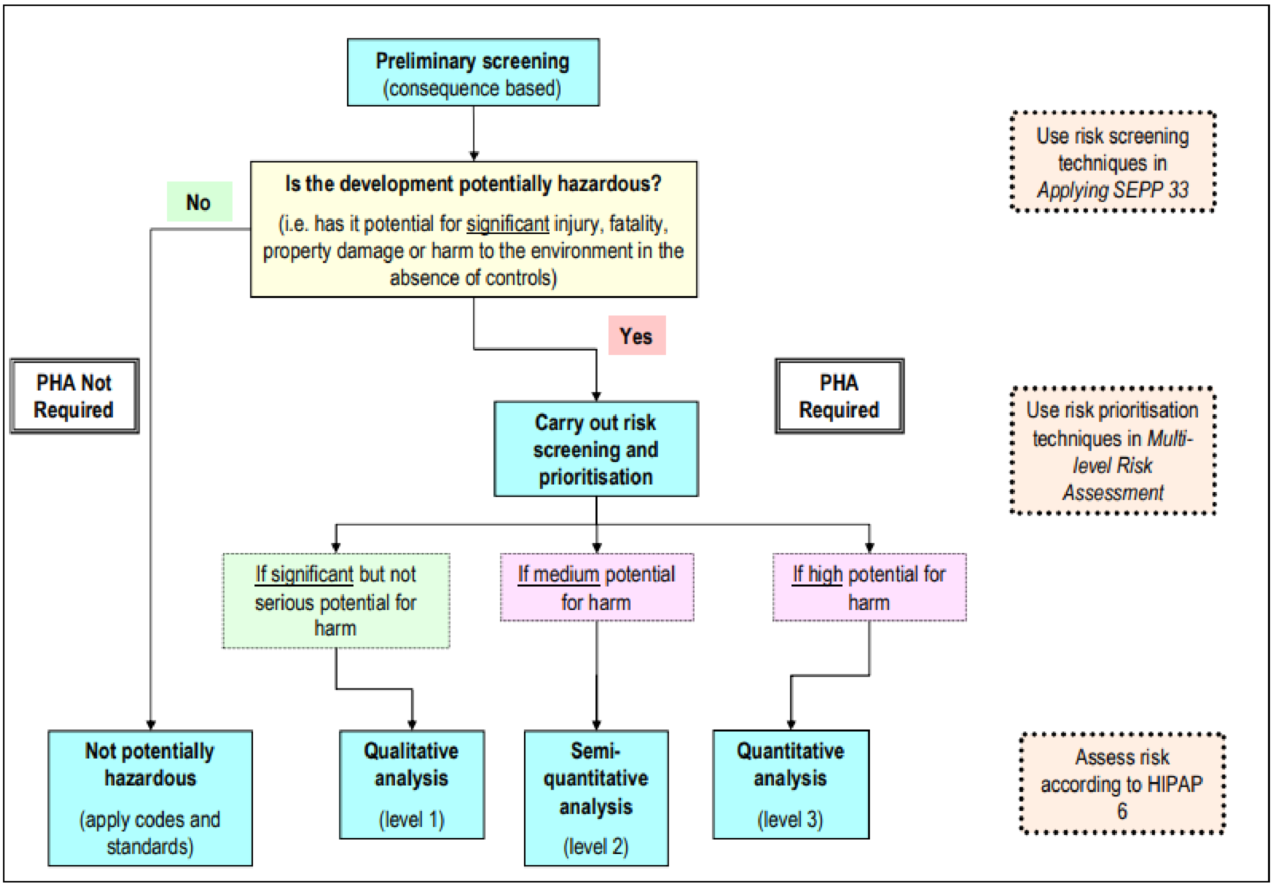

Figure 6-1 The Multi-Level Risk Assessment Approach (source: Muli-level Risk Assessment (DoP, 2011))

The levels of assessment include:

1. Level 1 is an essentially qualitative approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant off-site risk
2. Level 2 supplements the qualitative analysis by sufficiently quantifying the main risk contributors to show that risk criteria will not be exceeded
3. Level 3 is a full quantitative analysis.

As the Project is 'potentially hazardous and there is 'significant but not serious potential for harm' a Level 1 qualitative analysis has been completed. This is justified as the operation of the Project demonstrates societal risk in the negligible zone and there are no potential accidents with significant off-site consequences.

7 Risk assessment

Risk is the likelihood of a defined adverse outcome. To calculate risk, it is necessary to consider the likelihood and the consequences of each of the hazardous scenarios identified.

Using a qualitative approach, the risk of an event was estimated using the study risk matrix shown in Figure 7-1.

For each identified hazard and associated event, the resulting consequences and likelihood pair was determined from the hazard register. The consequence and likelihood of the identified events are presented in Table 7-1.

			Likelihood			
			1 Extremely Unlikely	**2 Very Unlikely**	**3 Unlikely**	**4 Likely**
			Never heard of in the industry, not realistically expected to occur	Heard of in the industry, but not expected to occur	Could occur in the next 10 years	Could occur in the next year
Severity	**4 Major**	Fatality / permanent injury				
	3 Moderate	Severe injury / lost time				
	2 Minor	Minor injury / visit to doctor				
	1 Insignificant	Slight injury / first aid				

Risk Acceptance Criteria	
	High - Unlikely to be tolerable; review activity
	Medium - Tolerable if reasonably practicable
	Low - Broadly acceptable

Figure 7-1 Qualitative risk matrix

Table 7-1 Risk assessment

Hazard	Event	Consequence (Impact to People)	Likelihood	Risk
Electrical	Exposure to voltage	Major	Very unlikely	Medium
Arc flash	Arc flash	Major	Very unlikely	Medium
EMF	Exposure to EMF	Insignificant	Extremely unlikely	Low
Fire	Fire – transformers and PCU	Major	Very unlikely	Medium
	Fire – substation	Major	Extremely unlikely	Medium
	Fire – temporary construction facilities	Major	Very unlikely	Medium
	Bushfire	Major	Very unlikely	Medium
Reaction	Thermal runaway in battery	Major	Very unlikely	Medium
Chemical	Release of electrolyte from the battery cell (liquid/vented gas) resulting in fire and/or explosion	Major	Very unlikely	Medium
	Battery coolant leak	Minor	Very unlikely	Low
	Refrigerant leak (BESS and refrigeration/chiller units)	Minor	Very unlikely	Low
	Exposure to hazardous material (herbicide/pesticide)	Minor	Very unlikely	Low
	Release of diesel from storage tank, filling point or during handling resulting in fire	Major	Very unlikely	Medium
	Release of gasoline from storage tank or filling point resulting in fire	Major	Very unlikely	Medium
External factors	Water ingress resulting in fire (BESS, PCU or switchrooms)	Major	Extremely unlikely	Medium
	Vandalism due to unauthorised personnel access	Moderate	Unlikely	Medium

Hazard	Event	Consequence (Impact to People)	Likelihood	Risk
	Lightning strike	Major	Very unlikely	Medium

8 Risk assessment results

8.1 Consequence

The risk assessment indicates that the worst-case consequence is a fire from a variety of causes (e.g., release of flammable materials, battery thermal runaway, transformer fire). These fires may have the potential to initiate bushfire to surrounding grasslands.

8.2 Likelihood

The risk assessment indicates that the highest likelihood rating for the identified events is unlikely (i.e., could occur in the next 10 years). This relates to unauthorised personnel access to the Project resulting in vandalism/asset damage to the project infrastructure.

8.3 Risk assessment

A total of 17 risk events were identified. The breakdown of these events according to their risk ratings is as follows:

- 13 medium-risk events
- 4 low-risk events.

In accordance with the risk acceptance criteria, the overall risk profile for the Project is considered tolerable, with residual risks reduced to a level that is As Low As Reasonably Practicable (ALARP) through the application of the identified control measures.

Most of the medium-risk events are related to fire incidents resulting from various causes, such as the release of flammable materials, battery thermal runaway, transformer fire, and bushfires. The analysis identified proposed prevention controls to reduce the likelihood of these fire events, as well as mitigation controls to contain fires and minimise the potential for escalation (e.g., Bushfire Emergency Management and Operations Plan). Considering the identified controls, the highest likelihood for these events was rated as very unlikely, indicating that while such incidents have been heard of in the industry, they are not expected to occur.

Considering the size of the Project site, the proposed location of Project infrastructure within that footprint, the proposed controls, and the distance to neighbouring land uses (including neighbouring properties and agricultural operations), the exposure to fire events will primarily affect the Project's construction and operations workforce.

The risk assessment has determined that there is negligible potential for off-site fatalities or injuries, and that the Project satisfies the land-use safety planning criteria of HIPAP 4. The residual risks are considered tolerable and ALARP following implementation of the proposed controls.

8.3.1 Qualitative risk assessment against HIPAP 4

An assessment of the BESS against the qualitative land use planning risk criteria from HIPAP 4 is provided in Table 8-1.

Table 8-1 HIPAP 4 qualitative risk criteria assessment

HIPAP 4 qualitative risk criteria	AC-coupled co-located
All ‘avoidable’ risks should be avoided. This necessitates the investigation of alternative locations	Alternative locations:

HIPAP 4 qualitative risk criteria	AC-coupled co-located
and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	No other locations, outside the Project area, have been considered as this would introduce avoidable risks to a new area. The separation distances and distances to nearby receivers will reduce the fire risks from the BESS. Alternative technologies: Lithium Ion BESS are the most common electrochemical BESS type for grid scale developments due to their high energy densities, high efficiency and size. All 'avoidable' risks have been avoided and no feasible alternatives are possible or justified.
The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.	The risk assessment presented in section 8 includes feasible controls that reduce hazards wherever practicable. The outcome of the risk assessment (ALARP), including the separation distances described in Section 3 and the distances to nearby receivers, indicates that the controls are adequate and relevant.
The consequences (effects) of the more likely hazardous events (i.e., those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	The risk assessment presented in section 8 indicates that hazardous events are likely to be contained within the boundaries of the development footprint. The separation distances described in section 3 will minimise fire propagating between BESS modules and reduce the intensity of any fire (and therefore reduce the likelihood of fire extending beyond the development site).
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that	There are no other known high risk hazardous installations in the area.

HIPAP 4 qualitative risk criteria	AC-coupled co-located
existing risk.	

9 Conclusion

This PHA demonstrates that the risk levels associated with the BESS do not impede the approval of the Modification. This PHA demonstrates that the Project as modified does not pose a significant off-site risk and that a Level 1 assessment is appropriate in accordance with *Multi-Level Risk Assessment* (DoP, 2011).

With the existing mitigation measures, the impact of the modification is considered low.

The steps undertaken to prepare this PHA include:

- Identification of BESS hazards. It analysed potential incident scenarios arising from these hazards and assessed the resulting consequences for people, property, and the environment
- Estimation of the likelihood of hazardous incidents that could have significant consequences
- Recommendations for controls to mitigate the consequences and reduce the likelihood of potentially hazardous incidents.

Based on the risk assessment, it was determined that the risk profile for the Project is considered tolerable under the principle of ALARP. Most of the medium-risk events are related to fire events. The primary exposure to fire events will be to the Project's construction and operations workforce, with minimal offsite impacts anticipated. The risk assessment determined that there is negligible potential for offsite fatality or injury identified, therefore achieving the land use planning criteria.

As the separation distance exceeds the requirements described in section 3.2.3, and the risks at the site boundary are not considered to exceed the acceptable risk criteria, the proposed separation distances are considered appropriate at the planning phase of the development. Following the implementation of the recommendations of this PHA, including the proposed separation distances, the likelihood of a multi-module fire would be minimised to a non-credible event.

10 Recommendations

It is recommended that the results of this PHA should be used as inputs into other safety studies required including:

- Emergency response plan
- Fire safety study
- Bushfire Emergency Management and Operations Plan that identifies all relevant risks and mitigation measures associated with the construction and operation of the Project, including:
  - Detailed measures to prevent or mitigate fires igniting
  - Work that should not be carried out during total fire bans
  - Availability of fire-suppression equipment, access and water

- Storage and maintenance of fuels and other flammable materials
- Notification of the local NSW RFS Fire Control Centre for any works that have the potential to ignite surrounding vegetation, proposed to be carried out during a bushfire fire danger period to ensure weather conditions are appropriate
- Appropriate bushfire emergency management planning.

In addition to the above it is required that:

- The Proponent should only procure a BESS where the OEM has conducted and documented full-scale fire testing in accordance with UL 9540A protocols, demonstrating non-propagation of thermal runaway between adjacent BESS units
- Following a decision of the BESS OEM, the detailed design of the BESS will be undertaken to comply with the requirements of section 3.2, including separation distances, UL9540A test reports and OEM recommendations
- If the Proponent chooses to use the Tesla Megapack, all recommendations from the Victorian Big Battery Fire Statement of Technical Findings – Victorian Government 2021 will be implemented.