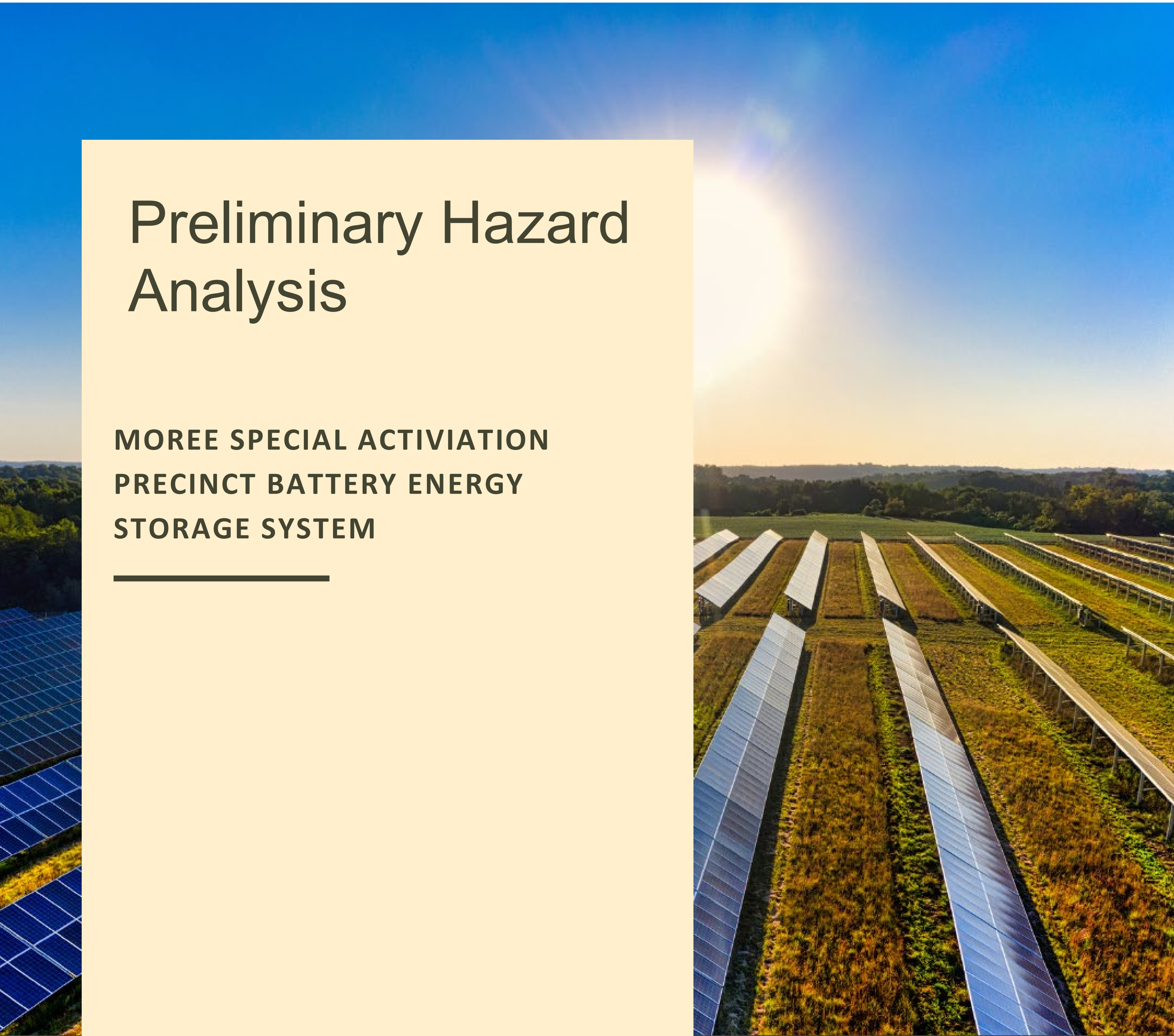

Preliminary Hazard Analysis

MOREE SPECIAL ACTIVIATION PRECINCT BATTERY ENERGY STORAGE SYSTEM

FEBRUARY 2025

Prepared for: NGH on behalf of AE BESS 2 Pty Ltd as Trustee for AE BESS 2 Unit Trust

PANDO
CONSULTING

Version control

Revision	Date	Task	By	Organisation	File name
Rev0.1	6/02/2024	Draft excluding risk assessment	Scott McGrath	Pando Consulting	23-025 Moree zone substation BESS PHA Rev0.1 20240205
Rev0.2	21/02/2024	Complete draft	Scott McGrath	Pando Consulting	23-025 Moree zone substation BESS PHA Rev0.2 20240221
Rev0.3	8/05/2024	Final report	Scott McGrath	Pando Consulting	23-025 Moree SAP substation BESS PHA Rev0.3 20240503
Rev0.4	12/06/2024	Final report – revised design	Scott McGrath	Pando Consulting	23-025 Moree SAP substation BESS PHA Rev0.4 20240612
Rev0.5	29/01/2025	Updated to include preliminary risk screening	Scott McGrath	Pando Consulting	23-025 Moree SAP substation BESS PHA Rev0.5 20250129
Rev0.6	13/02/2025	Updated sensitive receivers figure	Scott McGrath	Pando Consulting	23-025 Moree SAP substation BESS PHA Rev0.6 20250213

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Acronyms & abbreviations

AC	Alternating Current
ADGC	Australian Dangerous Goods Code
APZ	Asset Protection Zone
BESS	Battery Energy Storage System
CCTV	Closed-circuit television
DC	Direct Current
DG	Dangerous Goods
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
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
LFP	Lithium Iron Phosphate
LGA	Local Government Area
MV SG	Medium Voltage Switchgear
MV TX	Medium Voltage Transformer
m	metres
MW	Megawatt
MWh	Megawatt hours
NEM	National Electricity Market
O&M	Office and Maintenance
OEM	Original Equipment Manufacturer
PCS	Power Conversion System
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
RFS	(NSW) Rural Fire Service
SDS	Safety Data Sheet
SEARs	Secretary’s Environmental Assessment Requirements
SFARP	So Far As Is Reasonably Practicable
WHS	Work Health and Safety

1 Introduction

AE BESS 2 Pty Ltd as Trustee for AE BESS 2 Trust (the Proponent) intends to develop a 120MW/480MWh AC coupled lithium-ion Battery Energy Storage System (BESS) at Bulluss Drive, Moree. The BESS would connect to the National Electricity Market (NEM) via TransGrid's 132kV Moree Bulk Supply Point substation, located immediately to the north of the development site. The connection to the substation would be via an underground transmission line and subject to TransGrid requirements.

The BESS assessed in this PHA includes Lithium Iron Phosphate (LFP) cell chemistry and the CATL EnerC+ containerised liquid-cooling battery system designed and constructed to the manufacturers specifications.

1.1 Objectives

The objectives of this PHA are to:

- Develop a comprehensive understanding of the hazards and risks associated with the operation of the nominated BESS 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 prepared to address the State Environmental Planning Policy (Resilience and Hazards) 2021 (Resilience and Hazards SEPP) and has been prepared in accordance with the Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis (DoP, 2011) (HIPAP 6) and Multi-Level Risk Assessment (DoP, 2011) (MLRA). This PHA provides a basis for an informed judgment to be made on the acceptability of the Project.

This PHA has assessed the nominated BESS and considered LFP batteries only. No other BESS chemistry or manufacturer and model has been considered.

1.3 Exclusion and limitations

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, telecommunications, electromagnetic field and bushfire.

2 Site location and description

2.1 Site location

The subject land (the full area of all involved lots) comprises Lot 82 DP 751780 and part of Lot 144 DP751780, which total 17.58 hectares (ha) of privately-owned land. The area to be developed (referred to as the development site) would comprise approximately 4.06 ha.

The subject land is currently undeveloped. It is devoid of stands of remnant vegetation. An existing borrow pit turned farm dam is present in the north-western portion.

2.2 Surrounds

The proposed development sits within the Moree Special Activation Precinct (SAP), located in the far north of NSW. The Moree SAP currently comprises of mostly industrial and agri-industrial development. The subject land is adjacent to the Moree Bulk Supply Point substation and fronts Bullus Drive.

2.3 Sensitive receivers

Sensitive receivers within 500 metres of the Project are presented in Figure 2-1. Moree Regional Airport is located approximately 1km south west. The Inland Rail corridor and the Newell Highway are about 300m west of the site. Grain storage and rail associated infrastructure are the closest developments to the site. General industrial development, such as metal fabrication, concrete manufacture and vehicle associated industry, is located to the south around Industrial Drive and to the north, beyond the rail corridor, along James Street. The Gwydir Thermal Pools Motel and Caravan Park is located around 400m west.

Figure 2-1 Project location and sensitive receivers (source: NGH)

3 Project description

3.1 Overview

The key features of the Project are presented in Table 3-1 and Figure 3-1.

Table 3-1 Key features of the Project

Proposal element	Description
Nominal capacity	120MW/480MWh AC coupled
BESS	Approximately 140 20ft battery containers, containing LFP battery cells in modules
Power Conversion Systems (PCS)	Approximately 42 20ft skid-mounted PCS comprising of: • Inverters, which convert direct current (DC) to alternating current (AC) • Medium-voltage transformer, which converts the inverter output voltage to the medium-voltage of the system (33 kilovolt) • Medium voltage switchgear, which contains the medium voltage circuit breakers and disconnectors for the PCS
Switchroom	A 33 kilovolt (kV) switchroom, which collects all the individual medium voltage cables from the PCS units in one location before connection to the high-voltage transformer. The auxiliary power is also supplied from the low-voltage room that is connected to the medium-voltage switch room.
Control room	A control room, which will contain battery-monitoring equipment and allows operators to control the plant remotely.
Transmission line	A short underground transmission cable will connect the proposed BESS to the adjacent Moree Bulk Supply Point Substation. The connection type will be subject to TransGrid's requirements and will involve termination at either an existing 132kV bay or a newly constructed 132kV bay on the 132kV TransGrid busbar. As part of this connection, TransGrid will be responsible for the following works within their lot: • Construction of either a new 132kV bay or preparation of an existing 132kV bay to facilitate the integration of the BESS with the substation infrastructure. • Installation of associated secondary high-voltage equipment required for the selected connection option, ensuring compliance with TransGrid's technical and operational standards. • Execution of any necessary civil works to support the bay construction or modification, including foundation works, trenching, and structural reinforcements as required. • The final design and scope of these works will be determined in coordination with TransGrid's technical and regulatory requirements.
Ancillary infrastructure	Associated ancillary infrastructure, including: • Bunding • Construction laydown areas • Drainage • Fencing and landscaping • Internal access tracks • Security fencing • On-site car parking • Operations and maintenance (O&M) building • Ancillary storage • Staff amenities • Underground cables connecting site infrastructure

Proposal element	Description
	• Auxiliary low-voltage transformers • Water tank • Pumpable sewerage holding tank.

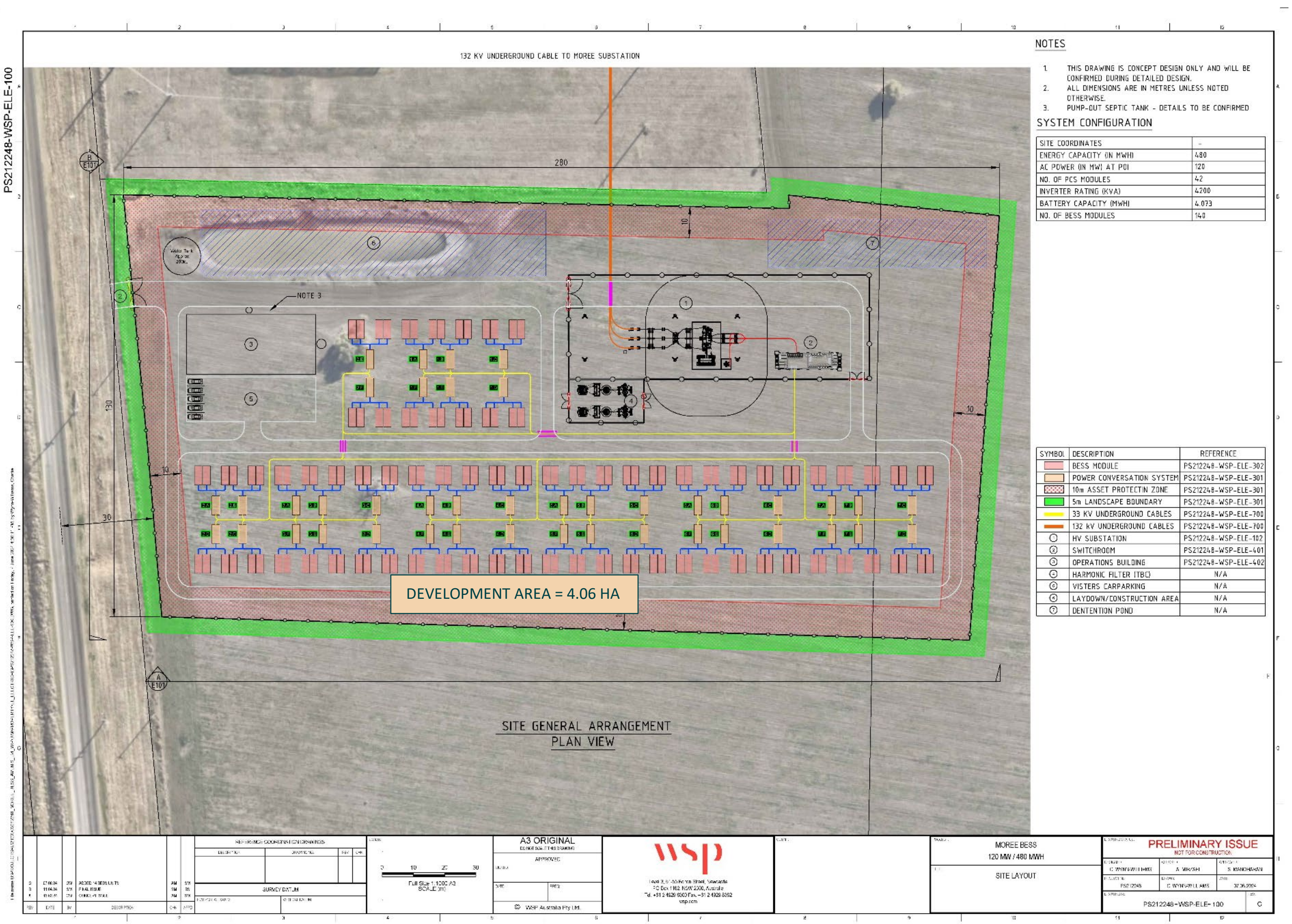

Figure 3-1 BESS layout (source: The WSP/Proponent)

3.2 Battery Energy Storage System

Battery storage would include a containerised 120MW/480MWh AC coupled BESS. 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 and Figure 3-3, would include 140 EnerC+ containerised liquid-cooled battery system containers. Each container includes:

- 40 modules comprising 104 LFP battery cells per module
- Cooling unit
- Fire suppression system
- Distribution box
- Master control box
- Slaved control box
- Rated energy of 4.073 MWh per container

The containers would be positioned in back to back pairs with one PCS per three or four containers (refer to Figure 3-1).

Risk mitigation strategies considered in siting the BESS include:

- Ten metre wide Asset Protection Zone (APZ)
- Provision of fire safety separation distances
- Internal roads suitable for emergency access and/or exit.

Figure 3-2 EnerC+ containerised liquid cooling battery system containers - external (Source: CATL)

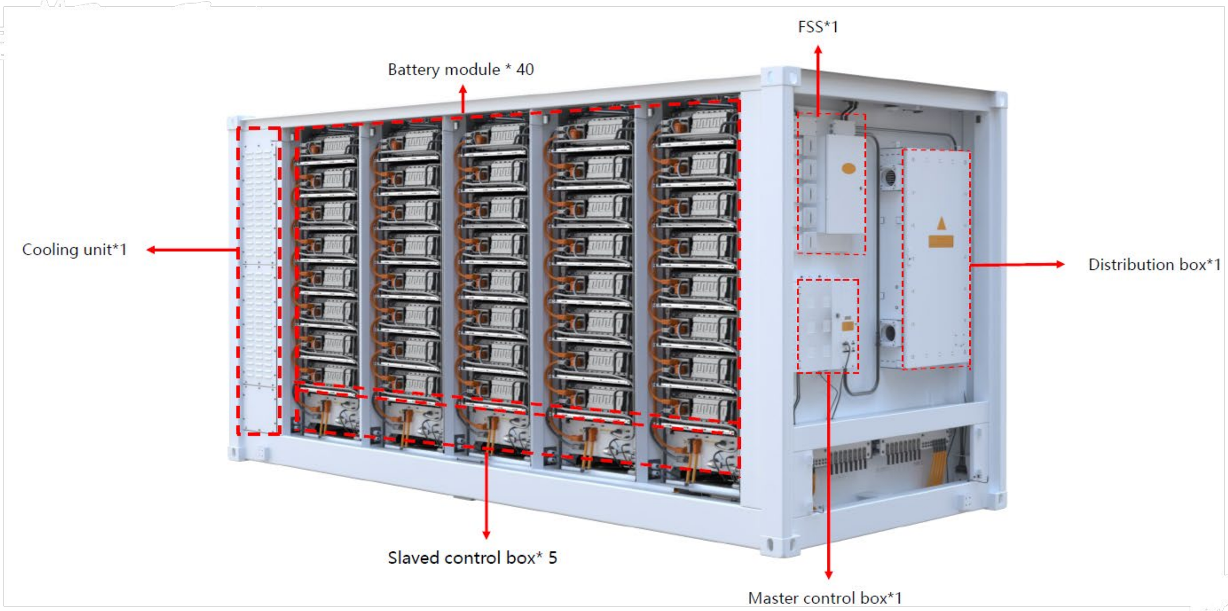

Figure 3-3 EnerC+ containerised liquid cooling battery system containers - internal (Source: CATL)

3.2.1 BESS safeguards

The CATL EnerC+ containerised liquid-cooled battery system includes:

- LFP battery cells with high thermal stability
- Fire protection system
- Integrated liquid cooling system (ethylene glycol aqueous solution)

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 proposed safeguards include:

- Emergency stop
- Ground fault detection
- Manual Service Disconnect (MSD) switch
- Overcurrent protection
- Battery module isolation loss alarm
- 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 event. The separation distances for the BESS include:

- Ten metre wide APZ
- Minimum clearance of 3.5 m between pairs of containers (refer to Figure 3-4)
- Minimum clearance of 0.2 m between back to back containers.

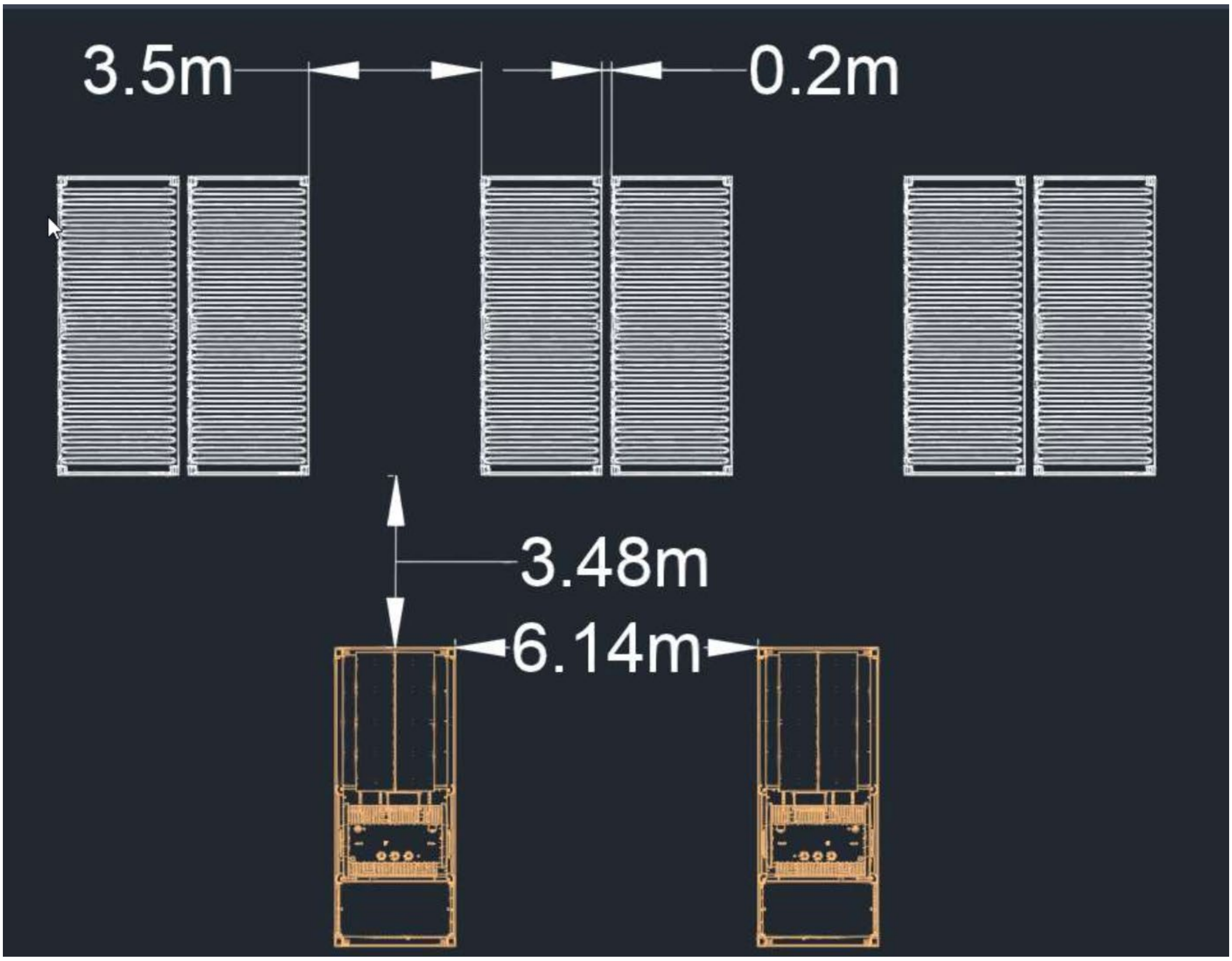

Figure 3-4 BESS separation distances (source: the Proponent)

3.2.2.1 Justification

The separation distances described above are in accordance with the CATL EnerC+ container product specification for back to back containers (presented in Figure 3-5), including:

- L1: 3.0m
- L2: 3.0m
- L3: 3.00m (recommend 3.5m)
- L4:0.20m (C4 or below)
- L5: 3.00m (recommend 3.5m)

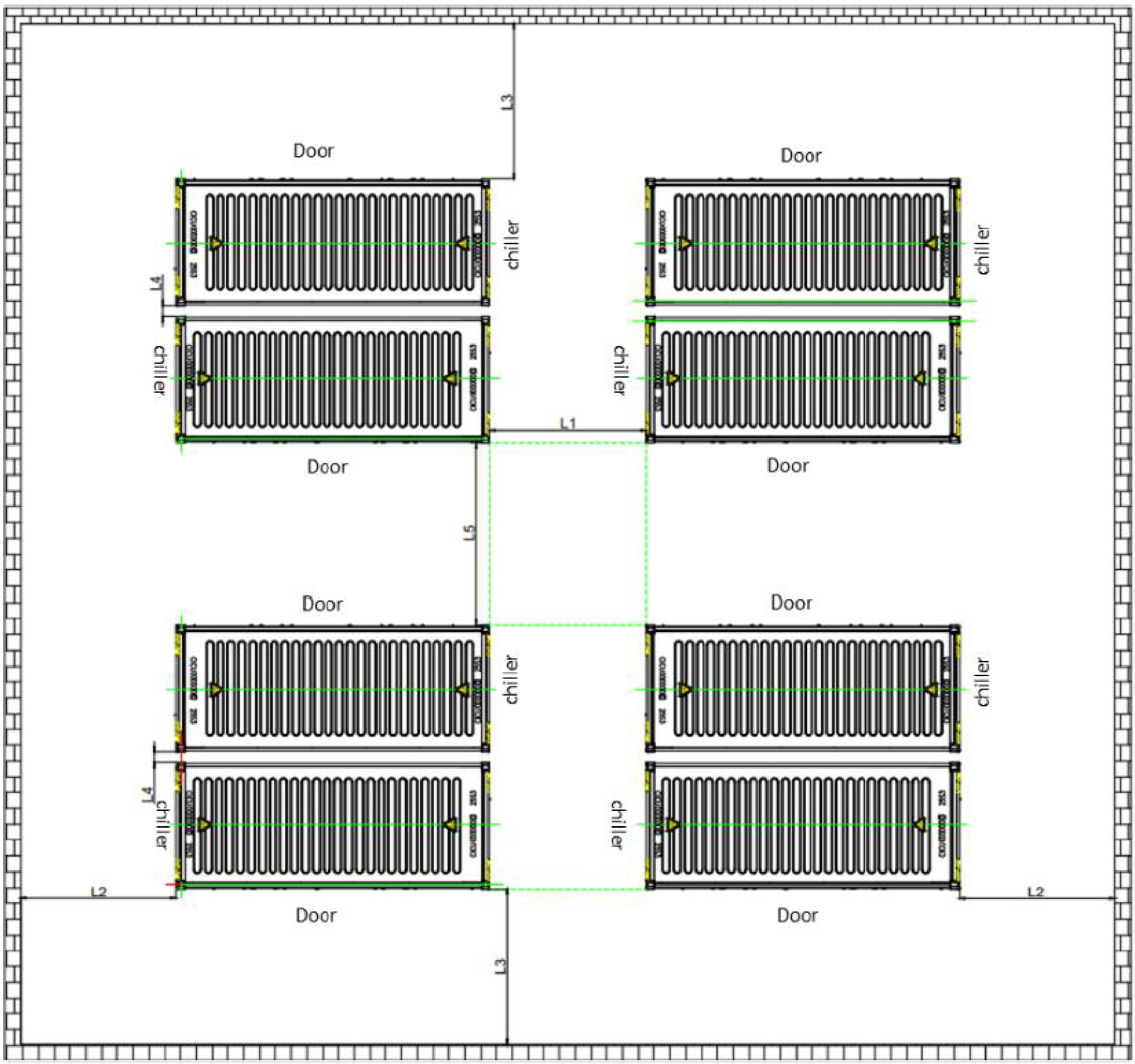

Figure 3-5 CATL EnerC+ container product specification - separation distances

The UL9540A test report (available confidentially to DPHI by request) for the CATL battery module model M02306P05L01 including cell models CBDD0 (LFP) did not observe any of the following as a result of induced thermal runaway:

- Flaming outside of unit
- Flying debris
- Explosive discharge of gas
- Sparks or electrical arcs

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 (3.05 metres).

FM Global DS 5-33 requires containerized Lithium-Ion BESS comprised of Lithium Iron Phosphate (LFP), cells to provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors or deflagration vents.

A review of the NSW major projects website identified that the Beresfield BESS EIS included a PHA for a 170 MW generalised BESS (i.e., OEM not yet selected). The Beresfield BESS PHA did not include heat radiation modelling and concluded that, as the minimum separation distance between BESS units is 3.1 m in compliance with NFPA 855, the risks at the site boundary are not considered to exceed the acceptable risk criteria.

As the separation distance of 3.5 m exceeds the following, it is considered appropriate at the planning phase of the development:

- CATL EnerC+ container product specification
- CATL UL9540A test report
- NFPA 855
- Readily available UL9540A test reports (for LFP only)
- Other BESS facilities approved by DPHI.

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.

3.2.3 BESS detailed design standards

The detailed design of the BESS will be in accordance with standards provided in Table 3-2 and Table 3-3. The detailed design will also comply with the CATL EnerC+ container product specification, UL9540A test report recommendations and the fire safety study.

Table 3-2 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
AS/NZ 5139:2019	Electrical installations - Safety of battery systems for use with power conversion equipment
FM Global DS 5-33	Property Loss Prevention Data Sheets
FM Global	Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems
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
IFC 2018	International Fire Code – chapter 12 energy systems
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

Standard / code	Consideration
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 3-3 Consideration of standards and codes for BESS separation distances

Source	Infrastructure	Safety Clearance
NPFA 855	BESS	The minimum clearance to enclosures for outdoor stationary Energy Storage Systems (ESS) installations is 10 feet (3.05 metres).
FM Global DS 5-33	BESS	For containerized Lithium Nickel Manganese Cobolt Oxide (NMC) Lithium-Ion BESS, 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. For containerized Lithium-Ion BESS 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.
ASNZS 5139.2019 6.2.6.2	MV power station	Minimum of 900mm 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, The Proponent, 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.

Victorian Big Battery Fire Statement of Technical Findings - lessons learned and preventing a recurrence	Proponents' commitment
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. The 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 risk screening

5.1 Introduction

The objective of the preliminary risk screening is to determine whether the proposed development is considered as 'potentially hazardous industry' as defined by the Resilience and Hazards SEPP. The Resilience and Hazards SEPP defines 'potentially hazardous industry' development as:

'Potentially hazardous industry' means a development for the purposes of any industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:

(a) to human health, life or property, or

(b) to the biophysical environment,

and includes a hazardous industry and a hazardous storage establishment.

Projects that are classified as 'potentially hazardous' industry require a PHA in accordance with HIPAP 6 to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is considered as a 'hazardous industry' and may not be permissible within NSW. In this circumstance, a PHA for the BESS is also required in accordance with the SEARs and has been prepared regardless of the outcome of this preliminary risk screening.

The process to undertake the preliminary risk screening, as required by MLRA (DoP, 2011), is taken from the *Hazardous and Offensive Development Application Guidelines – Applying SEPP 33* (DoP, 2011) (Applying SEPP 33) and presented in Figure 5-1.

The risk screening process considers the type and quantity of hazardous materials to be stored on site as well as the expected number of transport movements.

'Hazardous materials' are defined as substances that fall within the classification of the Australian Dangerous Goods Code (ADGC) (i.e. have a Dangerous Goods (DG) classification). Detail of the DG classification is obtained from the materials' Safety Data Sheet (SDS).

Risk screening is undertaken by comparing the storage quantity and the number of road movements of the hazardous materials with the screening threshold specified in the guideline. The screening threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

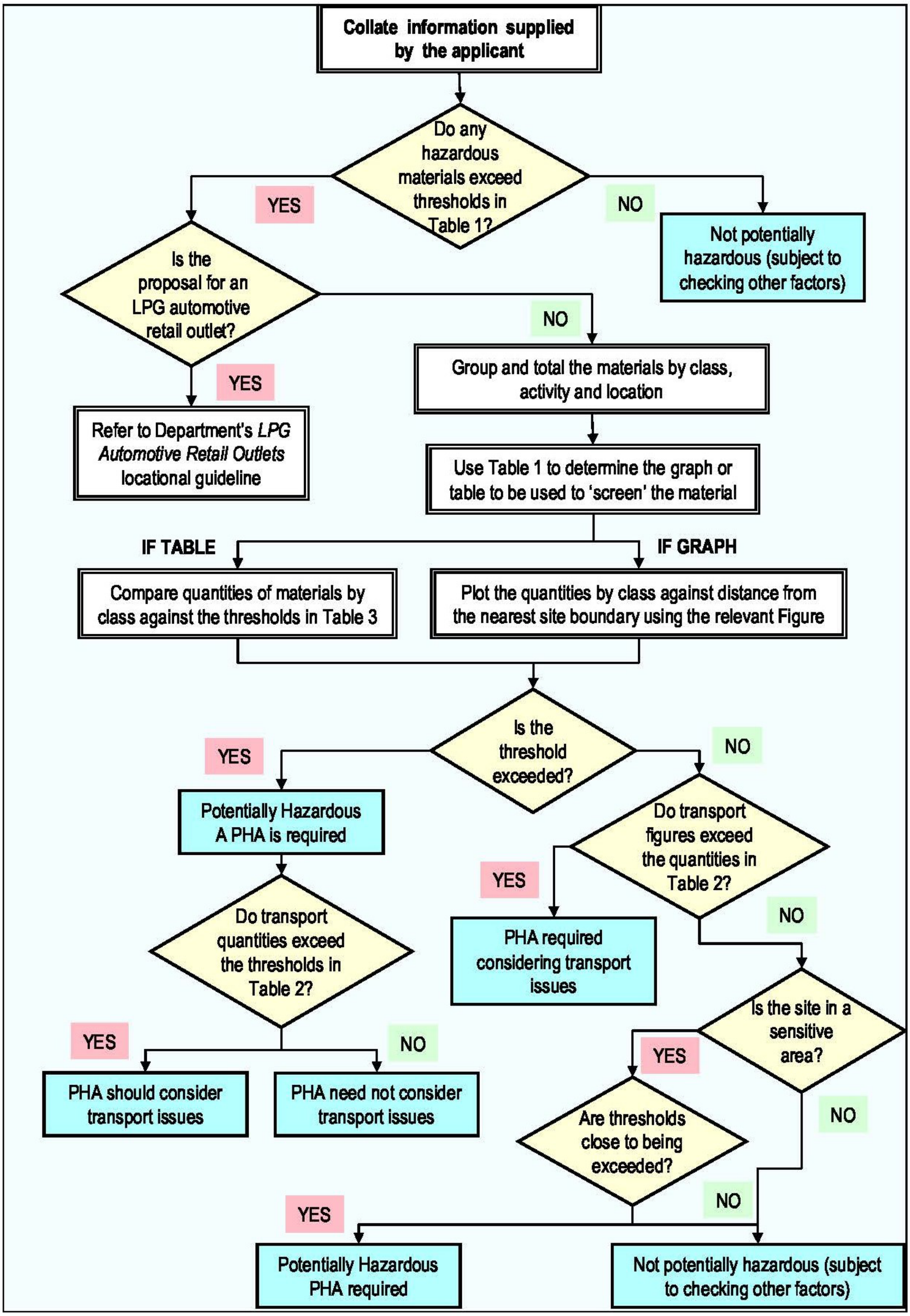

Figure 5-1 The risk screening process (Applying SEPP 33)

5.2 Storage and transport of hazardous material

A summary of the expected hazardous materials to be stored and handled on site for the Project, transport movements and the relevant Resilience and Hazards SEPP screening threshold is presented in Table 5-1.

Table 5-1 Threshold quantities for Hazardous Materials storage and transport

Hazardous material	Use	DG class	DG category	UN Number	Packing group	AS 1940	Estimated storage quantity and movements	Storage threshold	Transport threshold - movements	Transport threshold - quantities	Is the SEPP33 threshold exceeded?
Refrigerant	BESS refrigeration/chiller units	2.2	Non-flammable, non-toxic gas	UN3159 (For R134a, R407C, etc.)	N/A	Excluded from AS 1940	Storage: About 3kg per BESS container Transport: Negligible in comparison to transport threshold	Class 2.2 is excluded from the risk screening. Non-flammable, non-toxic gases not considered to be potentially hazardous with respect to off-site risk.	>1,000 (annual) >60 (peak weekly)		No
Miscellaneous flammable liquids in small containers	Solvents to be used during construction and maintenance	3	Flammable liquids	UN1993	PGI	Class 3 Flammable Liquids	< 20L	2t			No
Oil products	Switchgear and transformers (mineral insulating oils)	Non-DG (i.e. flashpoint >60℃)	Oil and other petroleum products	C1 and C2 combustible liquids are not a dangerous good under UN classification	PGII or PGIII	C1 combustible liquid	200 000L (distributed in switchgear and transformers) Transport: <1,000 annually and <60 peak weekly	Combustible liquid is excluded from the risk screening	>1,000 (annual) >60 (peak weekly)		No
Herbicide	Weed control	9	Miscellaneous dangerous goods	UN3082 (For liquid pesticides, if applicable)		Not specifically classified under AS 1940	< 20L	Excluded from risk screening			No
Coolant (50% ethylene glycol aqueous solution)	BESS coolant	9 or N/A	Miscellaneous dangerous goods or not a DG (i.e., not combustible or toxic)	UN3082 (If considered hazardous under transport regulations)		Excluded from AS 1940	Storage: 2000L per BESS = 280 000L Transport: <1,000 annually and <60 peak weekly	Excluded from risk screening	>1,000 (annual) >60 (peak weekly)		No
Diesel fuel	Vehicle operation	N/A	Not a DG. Categorised as C1 combustible liquid	UN1202	PGIII	C1 combustible liquid	1000L Transport: <1,000 annually and <60 peak weekly	C1 combustible liquids do not have a general screening threshold	>1,000 (annual) >60 (peak weekly)	N/A	No
LFP battery cells	Store energy	9	Miscellaneous dangerous goods	UN3480 (Lithium-ion batteries) / UN3481 (Lithium-ion batteries contained in equipment)		Excluded from AS 1940	Storage: Each cell weighs ~5.5kg =~3,200t Transport: <1,000 annually and <60 peak weekly	Excluded from risk screening	>1,000 (annual) >60 (peak weekly)	No limit	No

5.3 Other risk factors

Appendix 2 (b) of Applying SEPP 33 includes a checklist of information required to identify other risk factors. The details of other risk factors are provided in Table 5-2.

Table 5-2 Other risk factors

Other risk factors	Applicable (Yes or No)	Details
Any incompatible materials (hazardous and non-hazardous materials)	No	None identified
Any wastes that could be hazardous	No	None identified
The possible existence of dusts within confined areas	No	None identified
Types of activities the dangerous goods and otherwise hazardous materials are associated with (storage, processing, reaction)	No	No additional activities identified
Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition	No	No additional risk factors than those discussed in section 6 (i.e., thermal runaway)
Storage or processing operations involving high (or extremely low) temperatures and/or pressures	No	None identified
Details of known past incidents (and near misses) involving hazardous materials and processes in similar industries	Yes	Fire, as a result of thermal runaway in BESS has occurred in the past. This is assessed further in section 6.

5.4 Conclusion

The results of the preliminary risk screening indicates that the storage and transport of hazardous materials does not exceed the Appling SEPP 33 thresholds. Accordingly, the Project would not be considered potentially hazardous industry (with the implementation of codes and standards) and it can be assumed that significant off-site risk is unlikely.

6 Preliminary hazard analysis

6.1 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 6-1.

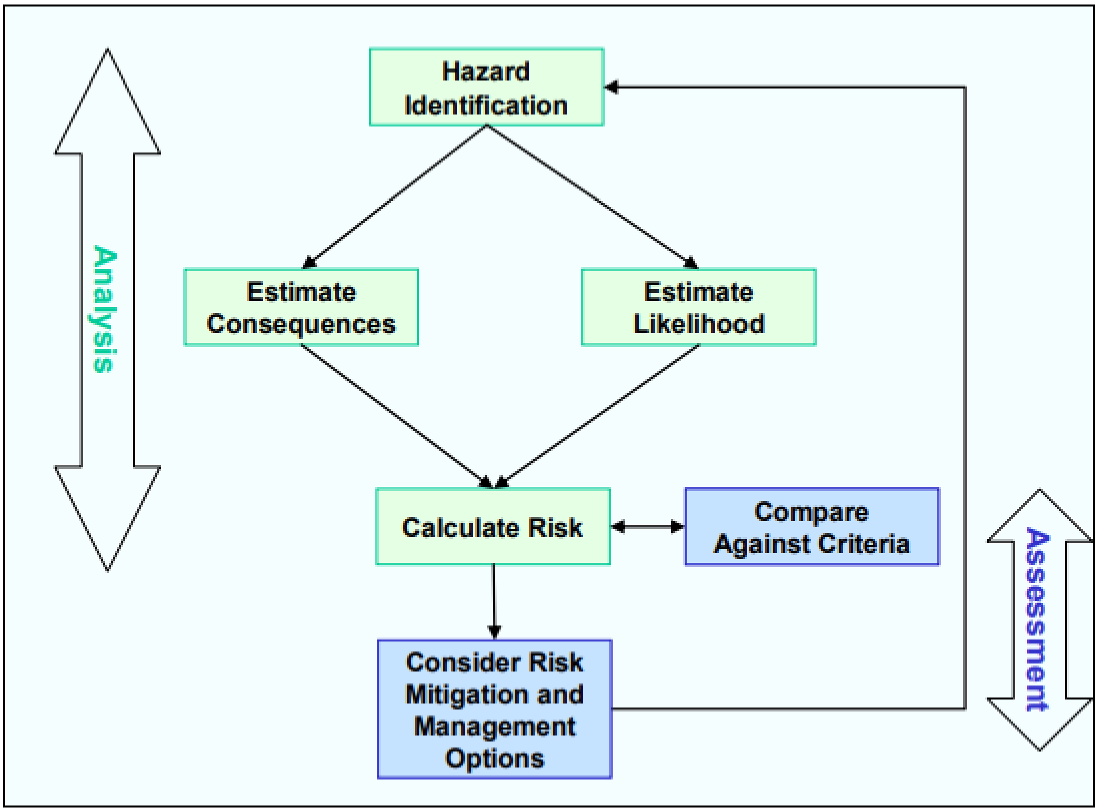

Figure 6-1 Basic methodology for hazard analysis (Source: HIPAP 6)

6.2 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 6-1.

Table 6-1 Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
Electric and Magnetic Fields (EMF)	Exposure to EMF

Hazard	Event
Fire	Infrastructure fire
Chemical	Release of hazardous materials
Reaction	Battery thermal runaway
External factors	Vandalism, flooding

6.3 Consequence analysis

Consequence

For each identified event, the resulting consequence was qualitatively described. These include impacts to personnel (e.g., fatality/injury), environment and/or assets.

Likelihood

Using a qualitative approach, the likelihood of an event was estimated using the category scale shown in Table 6-2. 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 6-2 Likelihood category

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

6.4 Hazard Register

The identified hazards, events, applicable infrastructure and the relationships with causes, consequences, controls, and likelihood ratings are summarised in the hazard register. Information contained in the hazard register is provided in Table 6-3.

The hazard register for the project is presented in Table 6-4.

Table 6-3 Information used in hazard register

Column Heading	Description
Hazard	Description of the source of potential harm
Infrastructure/Area	Project infrastructure or area the hazard/event is applicable to
Event	Description of mechanism by which the hazard potential is realised

Column Heading	Description
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 6-4 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	• Equipment and systems will be designed and tested to comply with international standards and guidelines • Engagement of reputable contractors • Independent certifiers/owner's engineers • Installation and maintenance will be done by trained personnel • 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 • Warning signs (electrical hazards, arc flash) • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS) • Use of appropriate PPE • 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	• Equipment and systems will be designed and tested to comply with international standards and guidelines • Engagement of reputable contractors • Independent certifiers/owner's engineers • Site induction/substation training (i.e., high voltage areas) • Installation and maintenance will be done by trained personnel • Maintenance procedure (e.g., deenergize equipment) • Preventative maintenance (insulation) • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS) • Warning signs (arc flash boundary) • Use of appropriate PPE for flash hazard	Very Unlikely
3	EMF	Exposure to electric and magnetic fields	• 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 siting 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) • Equipment and systems will be designed and tested to comply with international standards and guidelines • Exposure to personnel is short duration in nature (transient) • Physical warning signs (e.g., danger or restricted access)	Extremely Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
					• Studies found that the EMF for commercial solar power generation facilities comply with ICNIRP occupational exposure limits	
4	Fire	Fire	• Transformer oil leak • Faulty equipment • Arc flash • External fire (e.g., bushfire, adjacent infrastructure)	• Fire in switchyard and escalation to switchroom • Release of toxic combustion products • Injury/fatality • Asset damage • Interruption in power supply	• Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines • Equipment will be procured from reputable supplier • Independent certifiers/owner's engineers • All relevant Transgrid's requirements will be met • Installation, operations and maintenance by trained personnel (e.g., reputable third party) in accordance with relevant procedures • Preventative maintenance (e.g., insulation, replacement of faulty equipment) • Activation of emergency shutdown (ESD button) • Fire Management Plan • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS)	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	• Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines • Equipment will be procured from reputable supplier • Independent certifiers/owner's engineers • All relevant Transgrid's requirements will be met • Inverter/transformers (PCSs) are in designated area • Installation, operations and maintenance by trained personnel (e.g., reputable third party) in accordance with relevant procedures • 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) • Fire Management Plan • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS)	Extremely Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
6	Fire	Fire in temporary construction facilities	• Kitchen fire • Paper fire • Smoking	• Injury/fatality • Asset damage	• Fire Management Plan • Cooling water supply on-site • Defendable boundary for firefighting will be established (i.e., asset protection zone) • Dedicated smoking area • Fire protection system in the temporary construction facilities • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS) • Use of appropriate PPE	Very Unlikely
7	Fire	Bushfire	• Encroachment of off-site bushfire • Escalated event from facility fire	• Injury/fatality • Asset damage	• Fire Management Plan • Cooling water supply on-site • Defendable boundary for firefighting will be established (i.e., APZ) • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS) • Use of appropriate PPE	Very Unlikely
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	• Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines • Equipment will be procured from reputable supplier • Independent certifiers/owner's engineers • Separation distances in accordance with product specifications and UL9540A test reports • LFP battery cells with high thermal stability • Fire protection system • Integrated liquid cooling system (ethylene glycol aqueous solution) • 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) • Fire Management Plan • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS)	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
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	• Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines • Equipment will be procured from reputable supplier • Independent certifiers/owner's engineers • Engagement of reputable contractors • Installation and maintenance will be done by trained personnel • 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)	• Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines • Equipment will be procured from reputable supplier • Independent certifiers/owner's engineers • Engagement of reputable contractors • Maintenance will be done by trained personnel • Layers of battery case (pod and external casing) • Spill cleanup using dry absorbent material • BMS fault detection and shut-off function • PPE	Very Unlikely
11	Chemical	Refrigerant leak	• Mechanical failure/damage • Incorrect maintenance	• Irritation/injury for personnel on exposure (skin contact)	• Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines • Equipment will be procured from reputable supplier • Independent certifiers/owner's engineers • Engagement of reputable contractors • Maintenance will be done by trained personnel • BESS layers of battery case (pod and external casing) • BESS BMS fault detection and shut-off function • Chiller Unit separation distance to other equipment • PPE	Very Unlikely
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 • PPE (as required by Safety Data Sheet)	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
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	• Equipment and systems will be designed and tested to comply with Australian standards & guidelines (e.g., AS 1940) • Engagement of reputable contractors • Independent certifiers/owner's engineers • Installation and maintenance will be done by trained personnel • Diesel is a combustible liquid and will be stored away from other flammable materials (e.g., gasoline) • Secondary containment (i.e., bunding) • Warning signs (combustible material) • Fire Management Plan • Defendable boundary for firefighting will be established • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS) • Use of appropriate PPE	Very Unlikely
14	Gasoline	Release of gasoline from storage tank or filling point	• Mechanical failure • Human error during transfer	• Fire • Injury/fatality	• Equipment and systems will be designed and tested to comply with Australian standards & guidelines (e.g., AS 1940) • Engagement of reputable contractors • Independent certifiers/owner's engineers • Installation and maintenance will be done by trained personnel • Secondary containment (i.e., bunding) • Warning signs (flammable material) • Fire Management Plan • Defendable boundary for firefighting will be established • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS) • Use of appropriate PPE	Very Unlikely
15	External factors	• Fire (BESS, Inverter/transformers (PCSs), 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 constructed 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 • Warning signs • 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	• Earthing • Lightning protection mast (Substations) • PPE	Very Unlikely

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 **Error! Reference source not found.**.

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 if activity should proceed.
Medium	Tolerable, if so far as 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 PCSs	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

Hazard	Event	Consequence (Impact to People)	Likelihood	Risk
External factors	Water ingress resulting in fire (BESS, PCSs or switchrooms)	Major	Extremely unlikely	Medium
	Vandalism due to unauthorised personnel access	Moderate	Unlikely	Medium
	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.

Based on the risk acceptance criteria used for the study, the risk profile for the project is considered tolerable, given the measures taken So Far As Is Reasonably Practicable (SFARP).

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, among others. The analysis identified proposed prevention controls to reduce the likelihood of these fire events, as well as mitigation controls to contain fires and minimize the potential for escalation (e.g., fire management 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 area, 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. Offsite impacts are expected to be minimal.

The risk assessment concluded that there is no potential for offsite fatalities or injuries. Therefore, the Project aligns with land use planning criteria. The identified risk events pertain to onsite impacts and were assessed against the requirements of the *Work Health and Safety (WHS) Act* to reduce risk to SFARP. The Project deemed these risks as tolerable, considering the measures taken SFARP.

8.3.1 Qualitative risk assessment against Hazard Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning (DoP, 2011)

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	Option 1: DC-coupled Distributed BESS
All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	Alternative locations: 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 (SFARP), 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).

HIPAP 4 qualitative risk criteria	Option 1: DC-coupled Distributed BESS
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	There are no other known high risk hazardous installations in the area.

9 Conclusion

This PHA has been conducted to demonstrate that the risk levels associated with the BESS do not impede the approval of the Project. The PHA findings did not identify any significant offsite consequences or societal risks.

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 "So Far As Is Reasonably Practicable" (SFARP). 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 concluded that there is no potential for offsite fatality or injury identified, thus meeting the land use planning criteria.

The qualitative assessment of a thermal runaway event indicates that, due to the separation distances, a multi module fire (i.e., fire propagating from battery container to battery container or battery unit to battery unit) is 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

In addition to the above it is required that:

- 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.