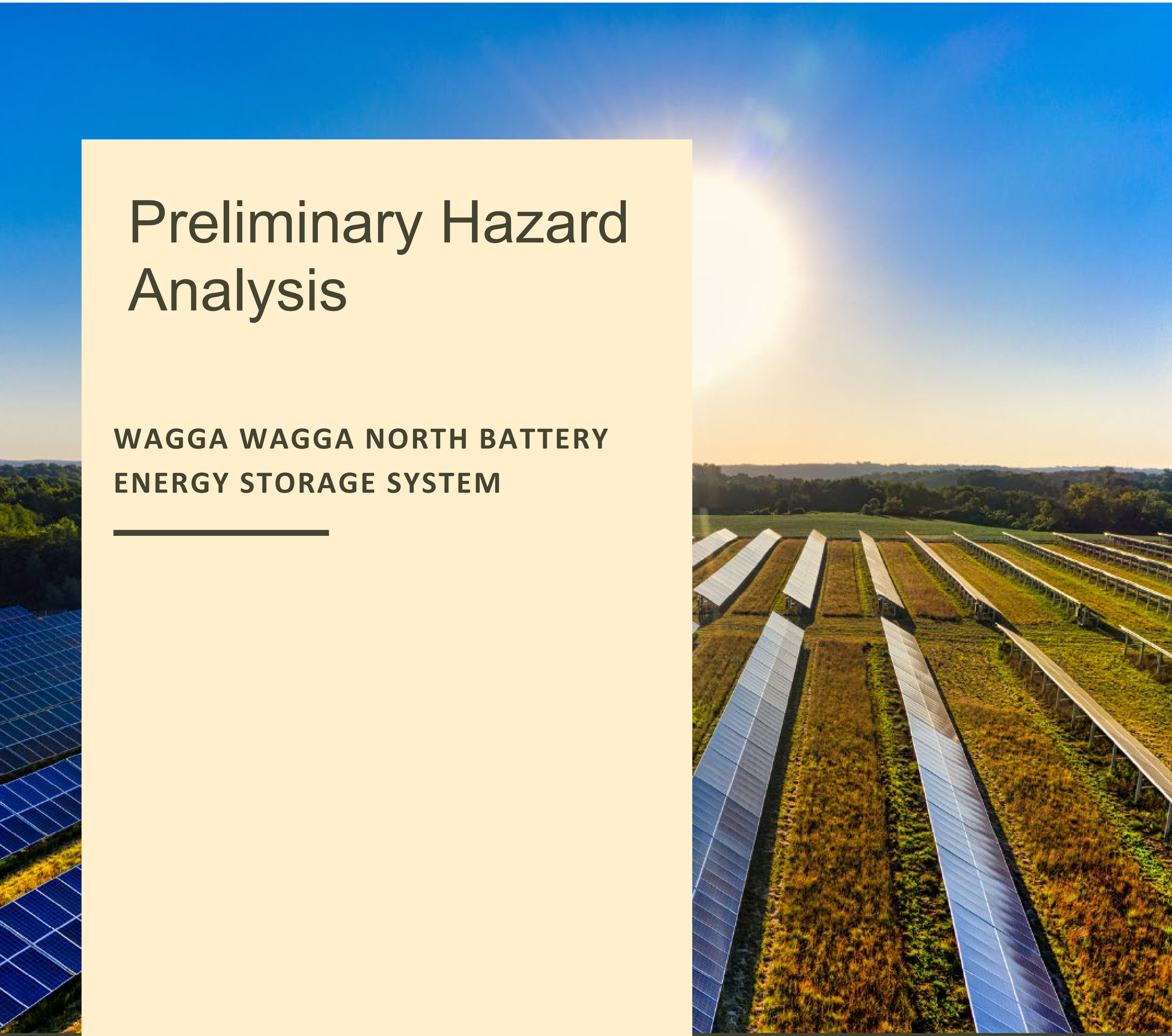

Preliminary Hazard Analysis

WAGGA WAGGA NORTH BATTERY ENERGY STORAGE SYSTEM

APRIL 2025

Prepared for: NGH on behalf of ib vogt

Version control

Revision	Date	Task	By	Organisation	File name
Rev0.1	21/02/2024	Draft	Scott McGrath	Pando Consulting	23-001 Wagga Wagga Borth BESS PHA Rev0.1 20240221
Rev0.2	21/02/2024	Draft update with additional details	Scott McGrath	Pando Consulting	23-001 Wagga Wagga North BESS PHA Rev0.2 20240304
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Appendix A EnerC+ 306 container product specification 1

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Acronyms & abbreviations

AC	Alternating Current
Ah	Ampere hours
APZ	Asset Protection Zone
BESS	Battery Energy Storage System
BMS	Battery Management System
CATL	Contemporary Amperex Technology Company Limited
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
EMS	Energy Management System
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
FSS	Fire Suppression System
ha	hectares
km	kilometres
LEP	Local Environment Plan
LFP	Lithium Iron Phosphate
LGA	Local Government Area
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
PTC	Positive Temperature Co-efficiency
Resilience and Hazards SEPP	State Environmental Planning Policy (Resilience and Hazards) 2021
RFS	(NSW) Rural Fire Service
SCADA	Supervisory Control And Data Acquisition
SEARs	Secretary's Environmental Assessment Requirements
SFARP	So Far As Is Reasonably Practicable
TMS	Thermal Management System
UPS	Uninterruptible Power Supply
WHS	Work Health and Safety

1 Introduction

The Proponent, ib vogt, intends to develop a 120MW/480MWh AC coupled Battery Energy Storage System (BESS) within the Wagga Wagga Special Activation Precinct (SAP) at 116 Bavin Road, Bomen. The BESS would connect to the National Electricity Market (NEM) via the TransGrid Wagga North substation.

The BESS assessed in this PHA includes Contemporary Amperex Technology Company Limited (CATL) new generation Lithium Iron Phosphate (LFP) 306 Ampere hours (Ah) cells and the EnerC+ containerised liquid-cooling battery system designed and constructed to the manufacturers specifications (refer to Appendix A).

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 proposed BESS would be construction on land at 116 Bavin Road, Bomen (refer to Figure 2-1). The land is identified as Lot 2 DP1115229.

There are no dwellings or structures present on the land. It is currently used for livestock grazing. It is largely devoid of native vegetation, with only limited boundary plantings/windbreaks present. The property is bisected by a crest that generally separates the northern half from the southern.

The BESS would be connected via an underground connection to the TransGrid Wagga North Zone Substation, located immediately to the north on Lot 1 DP1115229.

Two potential access options are being investigated; one to Byrnes Road, via an existing access road through adjoining land and one to Bavin Road which would involve a new internal access road within the subject property.

2.2 Surrounds

The subject land occurs within the Wagga Wagga Special Activation Precinct (SAP). The land is zoned Rural Activity. The land comprising the TransGrid zone substations is zoned SP2 Infrastructure (for the identified purpose of Electricity Transmission or Distribution). Land to the west comprising one of the access options is zoned Regional Enterprise under the provisions of the State Environmental Planning Policy (Precincts —Regional) 2021 (Regional Precincts SEPP).

2.3 Sensitive receivers

Sensitive receivers within 500 metres of the Project are presented in Figure 2-2. The site is within an established and expanding industrial area, with industrial tenancies comprising manufacturing, warehousing and vehicle repair located immediately to the west. Other industry in the immediate area includes an abattoir, waste oil re-refining, food manufacture/processing, concrete manufacturing and livestock sale yards. Existing dwellings within the industrial area are located approximately 650m south-west and 1km south-east from the proposed BESS. The site is approximately 700m from Byrnes Road and 2.5km from the Olympic Highway. The North Wagga village is about 3.8km south-west, with the Wagga Wagga Central Business District (CBD) about 6km south-west.

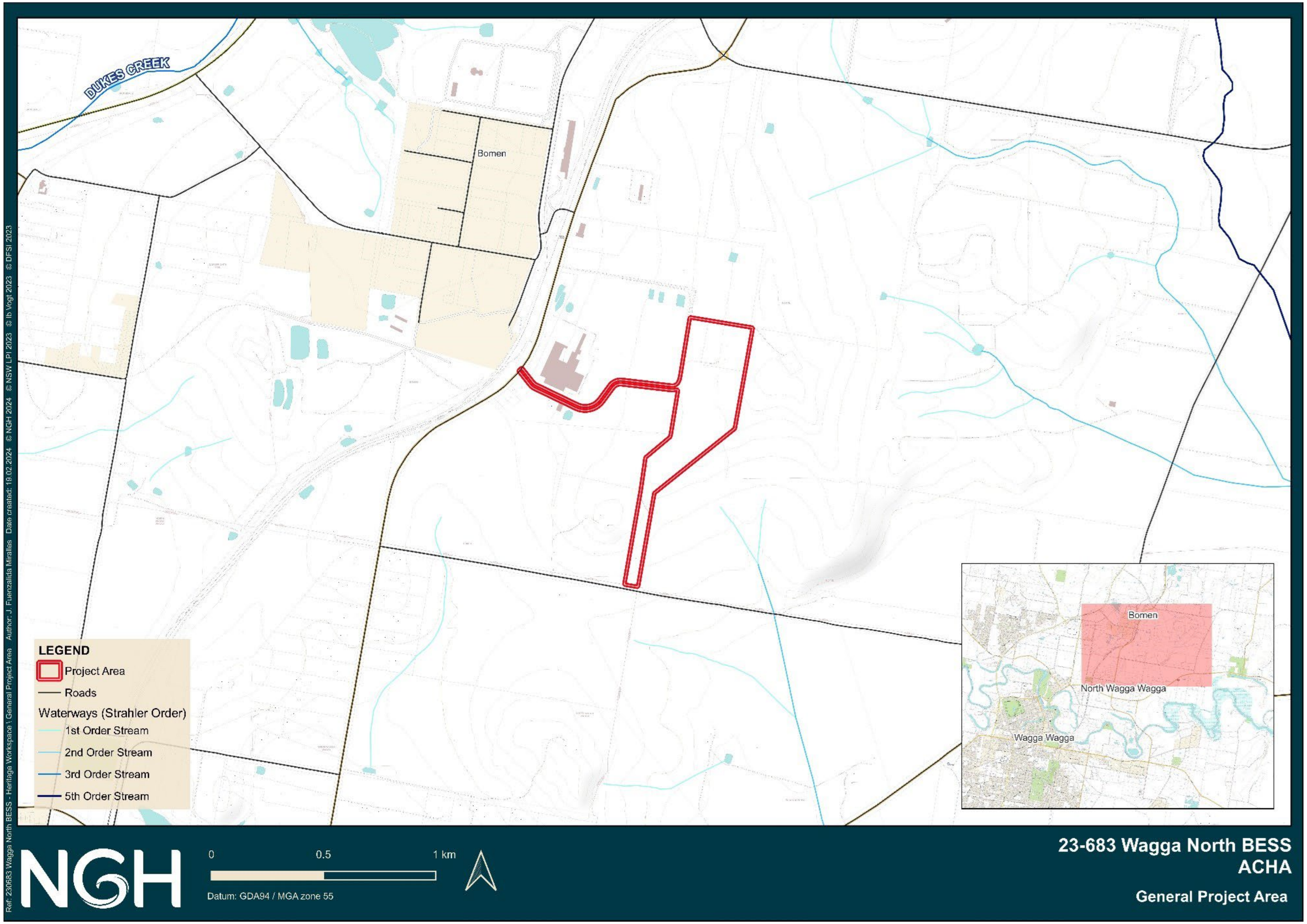

Figure 2-1 General Project area

Figure 2-2 Receivers within 500m of the Development footprint (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 126 battery containers, housing battery cells in modules and associated cooling systems.
BESS area	1.7 hectares
Power Conversion Systems (PCS)	Approximately 42 associated PCS comprising of: • The inverters, which convert Direct Current (DC) to Alternating Current (AC) • The medium-voltage transformer, which converts the inverter output voltage to the medium-voltage of the system (33 kilovolt) • The medium voltage switchgear, which contains the medium voltage circuit breakers and disconnectors for the PCS.
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 line which would connect the BESS to the adjacent TransGrid Wagga North substation at its western side. The connection type is subject to TransGrid requirements and further detailed design.
Switching substation	A switching substation, which collects all the individual medium voltage cables from the PCS units in one location, including: • 33kW switchgear • One 33/132kV transformer • A 132kV circuit including busbars, circuit breakers, disconnectors, isolators, surge arresters, etc • A plant auxiliary transformer and diesel generator.
Operations and Maintenance (O&M) building	A prefabricated Operations and Maintenance (O&M) building
Ancillary infrastructure	Associated ancillary infrastructure, including: • Staff amenities • Water tanks for firefighting purposes • Earthworks and stormwater management infrastructure (e.g. diversion banks, etc.) • Perimeter security fencing. • Temporary and/or permanent laydown area.

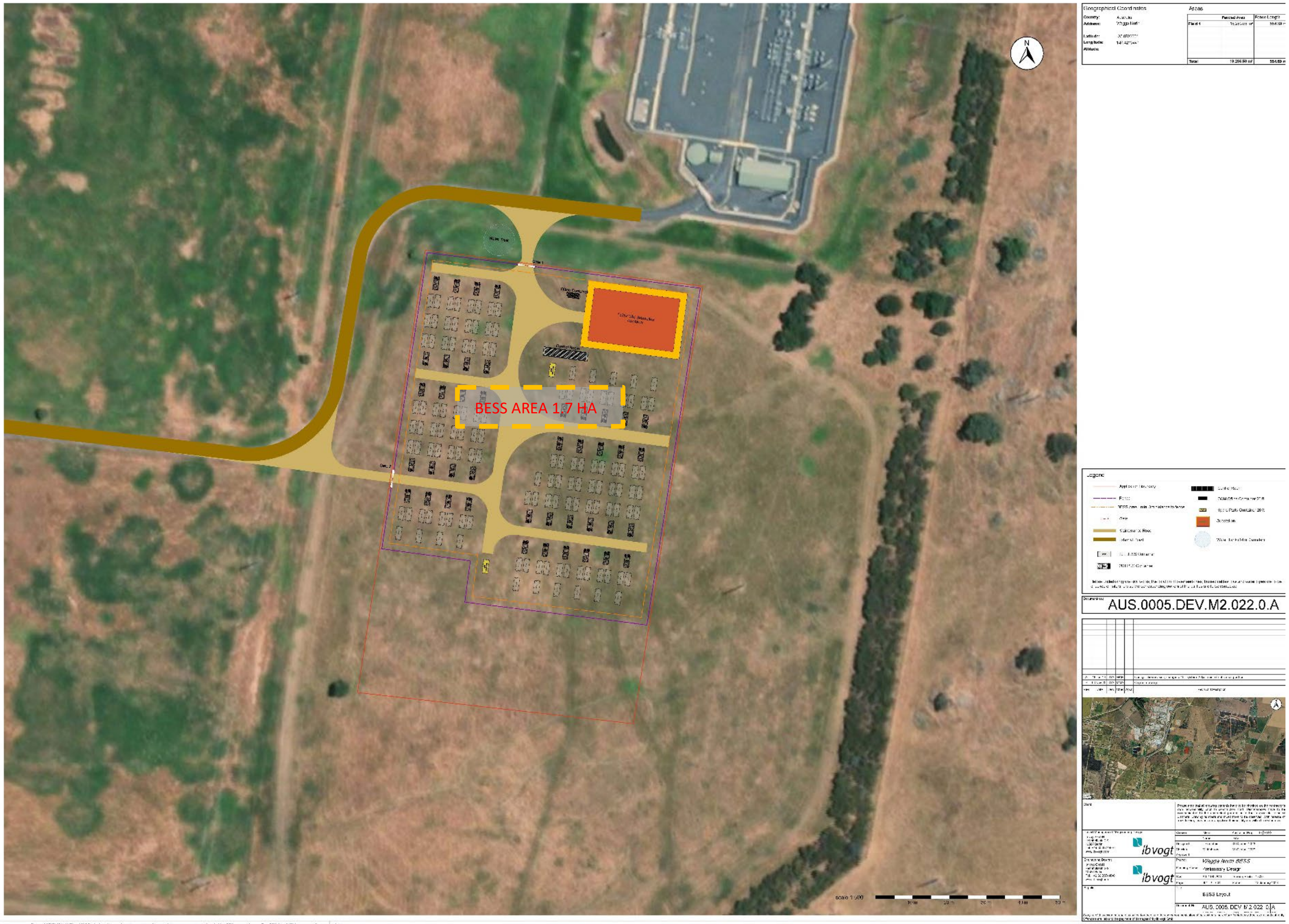

Figure 3-1 BESS layout (source: ib vogt)

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 occupy about 1.7 hectares and include approximately 126 EnerC+ containerised liquid-cooled battery system containers. Each container includes:

- 40 modules comprising approximately 104 LFP battery cells per module (52S2P cell configuration)
- Battery Management System (BMS)
- Fire Suppression System (FSS)
- Thermal Management System (TMS)
- Rated energy of approximately 4 MWh per container

The battery containers would be in groups of three with one PCS per group. Most containers would be in a back to back pairs.

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 - sideview (Source: CATL)

Figure 3-3 EnerC+ containerised liquid cooling battery system containers – sideview without door (Source: CATL)

3.2.1 BESS safeguards

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

- BMS to ensure the stable operation of the energy storage system The BMS would manage energy absorption and release, the thermal management system and low voltage power supply according to the detected data
- FSS consisting of smoke detectors, heat detectors (optional), H_2 detectors, fire control panel, aerosol, dry pipe (optional), smoke exhaust ventilation system and the Uninterruptible Power Supply (UPS). The FSS monitors for, and extinguishes, flame fire from a thermal run-away event.
- TMS consisting of one powerful chiller, Positive Temperature Co-efficiency (PTC) heater and liquid cooling pipe. The TMS will control and manage the temperature of the battery within an optimised range.
- New generation LFP battery cells with high thermal stability.

Additional details can be found in the product specification, attached as Appendix A.

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.

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 rows of container pairs and 3.0 m between back to back pairs (refer to Figure 3-4)
- Minimum clearance of 0.9 m between back to back containers.

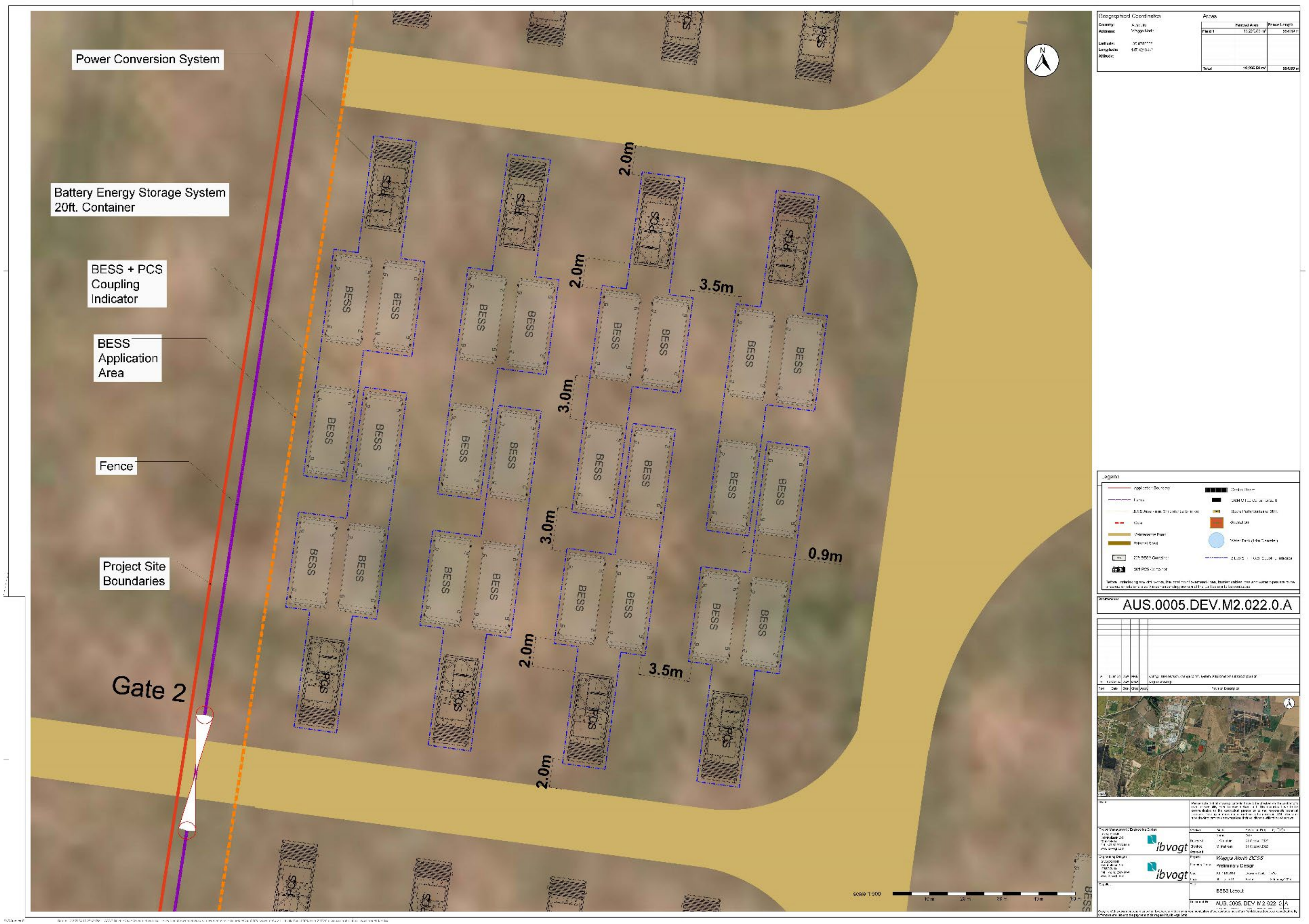

Figure 3-4 BESS separation distances (source: Ib vogt)

3.2.2.1 Justification

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

- L1: 3.0m
- L2: 3.0m
- L3: 3.00m (recommend 3.5m)
- L4: 0.90m (C5 or above), 0.20m (C4 or below)
- L5: 3.00m (recommend 3.5m)

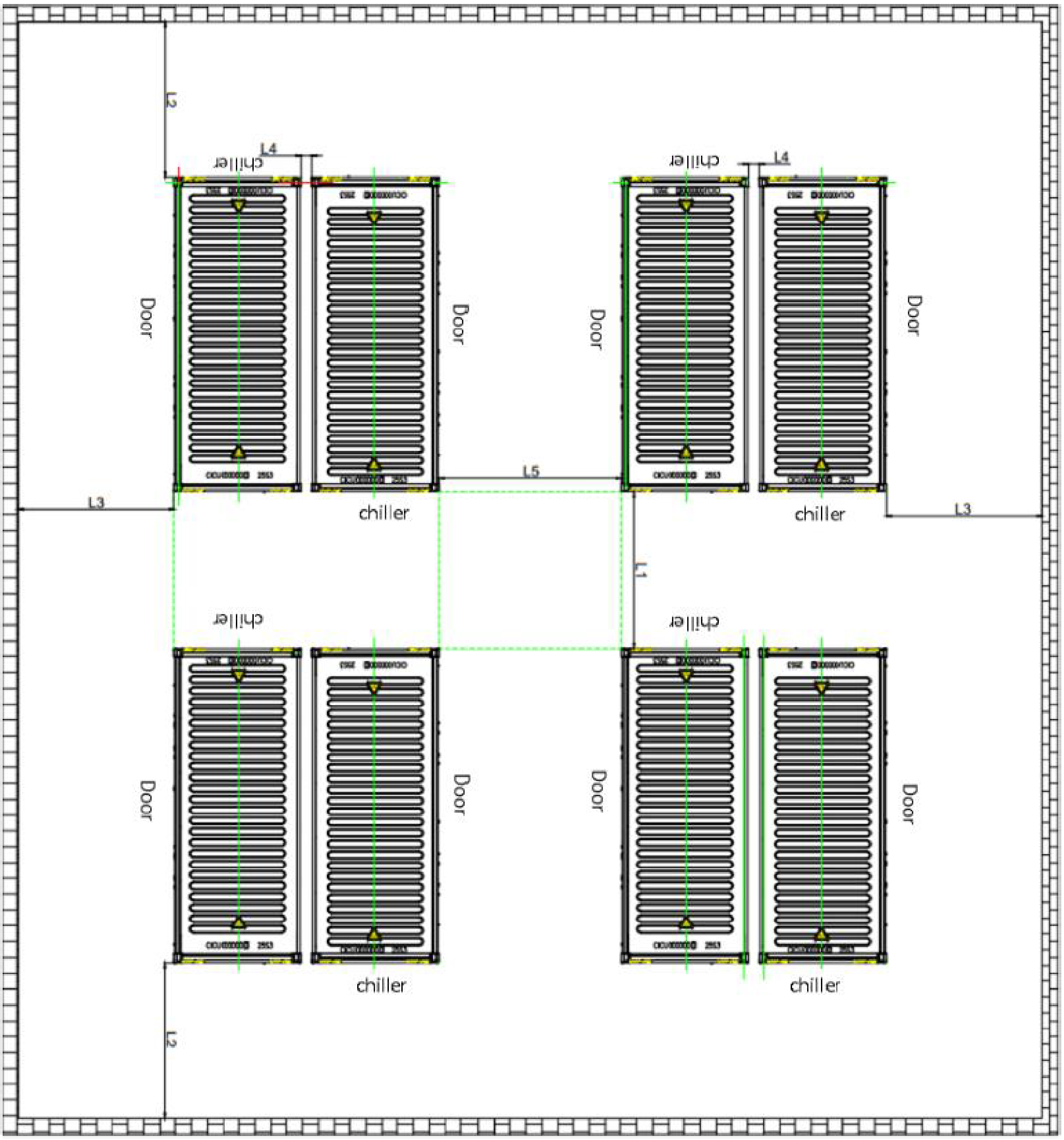

Figure 3-5 CATL EnerC+ container product specification - separation distances

The UL9540A test report (refer to Appendix B) 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
- Further reignition during post test observation.

The observed thermal runaway propagation resulted in the initiating cell propagated to three adjacent cells only.

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 m).

The proposed separation distance of 3.0 m and 3.5 m between pairs of containers is within an acceptable range of the NFPA 855 minimum clearance guidelines (>3.05 m), especially when considering the use of LFP cells rather than lithium-ion cells.

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.

Publicly available UL9540A test reports for utility scale LFP battery systems, indicates that 10 mm to 160 mm separation is suitable to prevent thermal runaway from propagating from battery unit to battery unit (refer to Table 3-2).

Table 3-2 OEM recommended minimum separation distances

OEM	Model (if known)	Minimum required spacing between battery units
Sungrow	ST2752UX	160 mm
CATL (Contemporary Amperex Technology Co., Limited)		10 mm
EVE Power		160 mm
Ruipu Energy		160 mm

A separation of 3.0 and 3.5 m between pairs of containers exceeds the minimum required spacing between battery units of readily available UL9540A test reports.

As the separation distance of 3.0 m and 3.5 m achieves the following, it is considered appropriate at the planning phase of the development:

- CATL EnerC+ container product specification (Appendix A)
- CATL UL9540A test report (Appendix B)
- 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 3-3 and Table 3-4. The detailed design will also comply with the CATL EnerC+ container product specification, 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
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
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	Safety Clearance
NPFA 855	BESS	Battery containers must be 0.9m from other battery collection containers and combustible materials

Source	Infrastructure	Safety Clearance
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 Preliminary risk screening

4.1 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 section 7 and Appendix 4 of the *Hazardous and Offensive Development Application Guidelines – Applying SEPP 33* (DoP, 2011) (Applying SEPP 33) and presented in *Figure 4-1*.

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.

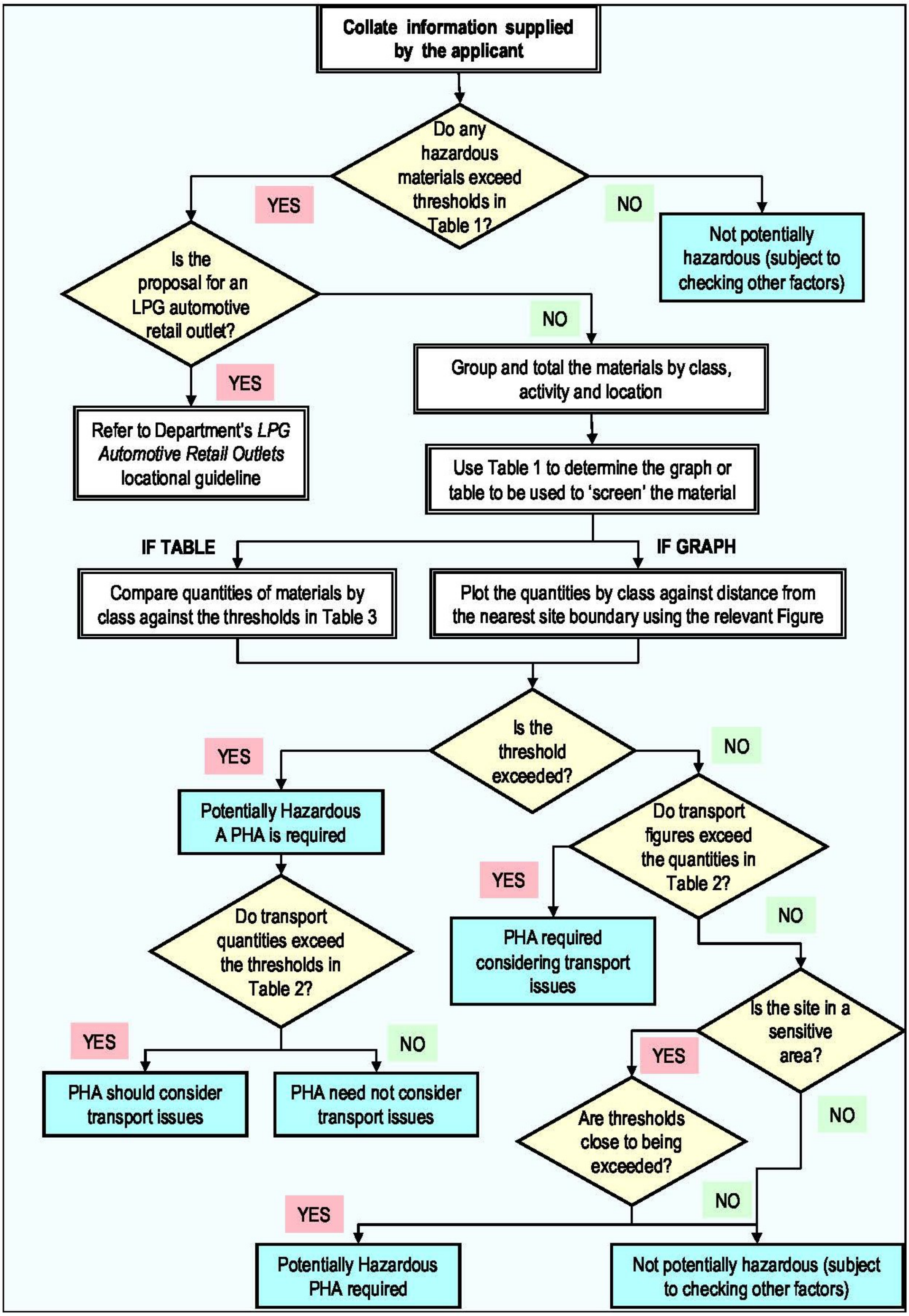

Figure 4-1 The risk screening process (Applying SEPP 33)

4.2 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 4-1 and Table 4-2.

Table 4-1 Threshold quantities for Hazardous Materials storage

Hazardous material information							Storage		Is the SEPP33 threshold exceeded?
Hazardous material	Use (including mode of storage i.e., bulk or packages/containers)	DG class and distance from boundary for DG classes 1.1, 2.1 and 3	DG category	UN Number	Packing group	AS 1940	Estimated storage quantity[1]	Storage threshold	
Refrigerant	BESS refrigeration/chiller units stored in equipment and packages	2.2	Non-flammable, non-toxic gas	UN3159 (For R134a, R407C, etc.)	N/A	Excluded from AS 1940	3kg per BESS container	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.	No
Miscellaneous flammable liquids in small containers	Solvents to be used for maintenance and stored in packages	3 Stored in O&M facility about 500 m from the boundary	Flammable liquids	UN1993	PGI	Class 3 Flammable Liquids	< 20L	Applying SEPP33 Figure 8 graph if greater than 2 tonne	No
Coolant (50% ethylene glycol aqueous solution)	BESS coolant stored in equipment and packages	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	2000L per BESS = 280 000L	DG Class 9 excluded from risk screening	No
LFP battery cells	Store energy within BESS containers	9	Miscellaneous dangerous goods	UN3480 (Lithium-ion batteries) / UN3481 (Lithium-ion batteries contained in equipment)		Excluded from AS 1940	Each cell weighs ~5.5kg =~3,200t	DG Class 9 excluded from risk screening	No
Oil products	Switchgear and transformers (mineral insulating oils). Stored in equipment and packages	Not classified as 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)	Combustible liquid is excluded from the risk screening	No
Herbicide (water based glyphosate)	Weed control and stored in packages	Not classified as DG		UN3082 (For liquid pesticides, if applicable)		Not specifically classified under AS 1940	< 20L	Excluded from risk screening	No
Diesel fuel	Vehicle operation stored in vehicles bunded tank	Not classified as DG	Not a DG. Categorised as C1 combustible liquid[2]	UN1202		C1 combustible liquid	1000L	C1 combustible liquids do not have a general screening threshold	No

[1] Where several hazardous materials of the same class are kept on site in the same general location, total the quantities by class and activity (that is, total all quantities of each class stored in bulk then separately total the quantities of each class stored in packages/containers).

[2] If combustible liquids of class C1 are present on site and are stored in a separate bund or within a storage area where there are no flammable materials stored they are not considered to be potentially hazardous. If, however, they are stored with other flammable liquids, that is, class 3PGI, II or III, then they are to be treated as class 3PGIII, because under these circumstances they may contribute fuel to a fire.

Table 4-2 Threshold movements and quantities for Hazardous Materials transport

Hazardous material information						Transportation								Is the SEPP33 threshold exceeded?
Hazardous material	Use (including mode of storage i.e., bulk or packages/containers)	DG class and distance from boundary for DG classes 1.1, 2.1 and 3	DG category	UN Number	Packing group	Estimated vehicle movements		Estimated minimum quantity per load (tonne)		Threshold vehicle movements		Threshold minimum quantity per load (tonne)[3]		
						Cumulative annual	Peak weekly	Bulk	Packages	Cumulative annual	Peak weekly	Bulk	Packages	
Refrigerant	BESS refrigeration/chiller units stored in equipment and packages	2.2	Non-flammable, non-toxic gas	UN3159 (For R134a, R407C, etc.)	N/A					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.				No
Miscellaneous flammable liquids in small containers	Solvents to be used for maintenance and stored in packages	3 Stored in O&M facility about 500 m from the boundary	Flammable liquids	UN1993	PGI	<50	<3	<1	<1	>500	>30	1	1	No
Coolant (50% ethylene glycol aqueous solution)	BESS coolant stored in equipment and packages	9 or N/A	Miscellaneous dangerous goods or not a DG (i.e., not combustible or toxic)	UN3082 (If considered hazardous under transport regulations)	N/A	<1,000	<60	No limit	Not specified	>1000	>60	No limit	Not specified	No
LFP battery cells	Store energy within BESS containers	9	Miscellaneous dangerous goods	UN3480 (Lithium-ion batteries) / UN3481 (Lithium-ion batteries contained in equipment)	N/A	<1,000	<60	No limit	Not specified	>1000	>60	No limit	Not specified	No
Oil products	Switchgear and transformers (mineral insulating oils). Stored in equipment and packages	Not classified as 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					Not classified as DG (i.e. flashpoint >60℃)				No
Herbicide (water based glyphosate)	Weed control and stored in packages	Not classified as DG		UN3082 (For liquid pesticides, if applicable)	N/A					Not classified as DG				No
Diesel fuel	Vehicle operation stored in vehicles bunded tank	Not classified as DG	Not a DG. Categorised as C1 combustible liquid[4]	UN1202	N/A	Transport: <1,000 annually and <60 peak weekly				Not classified as DG				No

[3] If quantities are below this level, the potential risk is unlikely to be significant unless the number of traffic movements is high

[4] If combustible liquids of class C1 are present on site and are stored in a separate bund or within a storage area where there are no flammable materials stored they are not considered to be potentially hazardous. If, however, they are stored with other flammable liquids, that is, class 3PGI, II or III, then they are to be treated as class 3PGIII, because under these circumstances they may contribute fuel to a fire.

4.3 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 4-3.

Table 4-3 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 **Error! Reference source not found.** (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 **Error! Reference source not found.**.

4.4 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.

5 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, ib vogt, makes the commitments presented in Table 5-1.

Table 5-1 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. 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.

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.

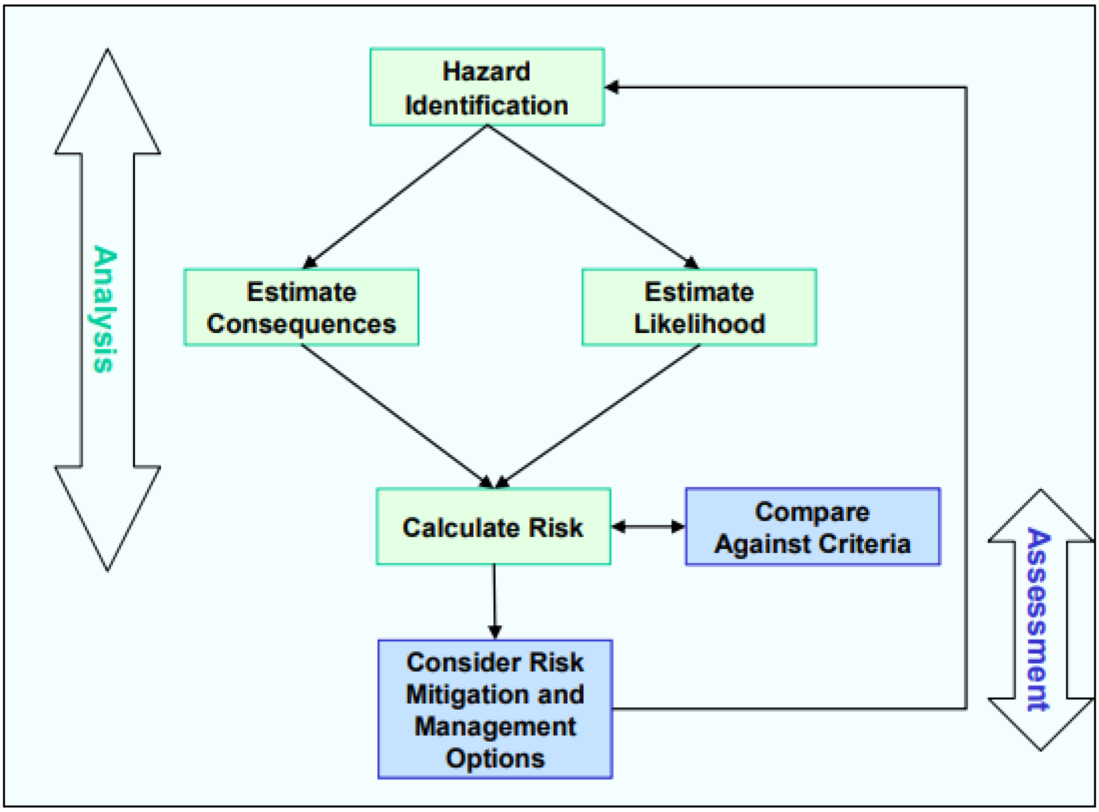

Figure 6-1 Basic methodology for hazard analysis (Source: HIPAP 6)

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
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
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) • Studies found that the EMF for commercial solar power generation facilities comply with ICNIRP occupational exposure limits	Extremely Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
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
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	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
					established (i.e., APZ) • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS) • Use of appropriate PPE	
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 • Battery Management System (BMS) • Fire Suppression System (FSS) • Thermal Management System (TMS) including Integrated liquid cooling system (ethylene glycol aqueous solution) • LFP battery cells with high thermal stability • 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 • Fire Management Plan • Emergency Response Plan • External assistance for firefighting (FRNSW & RFS)	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	• 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

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
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
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)	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
					• Use of appropriate PPE	
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 Figure 6-1.

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.

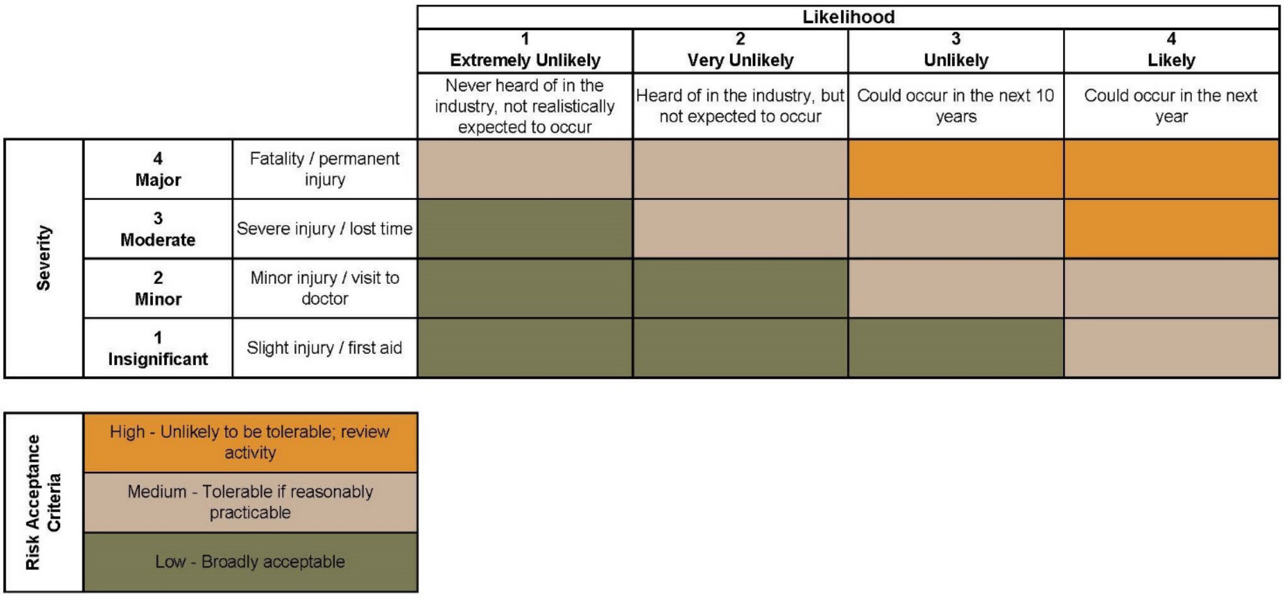

Figure 7-1 Qualitative risk matrix

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	AC-coupled 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	AC-coupled 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.

APPENDIX A ENERC+ 306 CONTAINER PRODUCT SPECIFICATION

APPENDIX B UL9540A TEST REPORT: CATL BATTERY MODULE MODEL M02306P05L01 AND CELL MODEL CBDD0 (LFP)