Preliminary Hazard Analysis

SOUTH COREE BATTERY ENERGY STORAGE SYSTEM

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Prepared for: NGH Pty Ltd on behalf of Samsung C&T Renewable Energy Australia Pty Ltd (SREA)

PANDO
CONSULTING

Version control

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Acronyms & abbreviations

AC	Alternating Current
APZ	Asset Protection Zone
ALARP	As Low As Reasonably Practicable
BESS	Battery Energy Storage System
BMS	Battery Management System
BPM	Bushfire Protection Measures
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
ELF	Extremely Low Frequency
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
FSS	Fire Suppression System
ha	hectares
km	kilometres
LEP	Local Environment Plan
LFP	Lithium Iron Phosphate
LGA	Local Government Area
m	metres
MP2XL	Megapack 2XL
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
PBP	NSW Rural Fire Service Planning for Bush Fire Protection 2019
PPE	Personal Protective Equipment
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
SWREZ	South-West Renewable Energy Zone
TMS	Thermal Management System
WHS	Work Health and Safety

1 Introduction

Samsung C&T Renewable Energy Australia Pty Ltd (the Applicant) is proposing the development of the South Coree Battery Energy Storage System (the Project) at 384 Broockmanns Road, Finley NSW 2713.

The Project would involve the construction, operation and decommissioning of a Battery Energy Storage System (BESS) with a delivery capacity of up to approximately 80 Megawatts (MW) / 320MWh (4hr). It would supply electricity to the National Electricity Market (NEM) during peak periods.

This report supports a State Significant Development (SSD) Development Consent approval under Part 4, Division 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) (SSD-77238990), as part of the Environmental Impact Statement (EIS) for the Project.

This Preliminary Hazard Analysis (PHA) has assessed the Tesla Megapack 2XL (MP2XL) BESS with Lithium Iron Phosphate (LFP) cells designed and installed in accordance with the *Megapack 2XL Design and Installation Manual* (Tesla, 2024) (attached as Appendix A).

The MP2/MP2XL has been reviewed and validated by an Independent Engineer (Fisher Engineering, Inc). This fire protection engineering analysis included a review of the MP2/2XL, its construction, design, fire safety features, UL 9540A cell, module and unit level test data, additional internal unit level fire tests and fire propagation modelling. These results are attached as Appendix B.

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 Applicant, 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 Hazards key issues from the Planning Secretary's Environmental Assessment Requirements (SEARs) shown in Table 1-1.

Table 1-1 SEARs key issues addressed in this PHA

SEARs key issue	Where addressed
Health – an assessment of potential hazards and risks including but not limited to fires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure against the International Commission on *Non-Ionizing Radiation Protection* (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*	Section 2.6 and Section 5
Bushfire - identify potential hazards and risks associated with bushfires / use	Section 2.7 and

SEARs key issue	Where addressed
of bushfire prone land including the risks that a BESS would cause a bush fire and demonstrate compliance with the NSW Rural Fire Service (RFS) RFS *Planning for Bush Fire Protection 2019* (PBP)	Section 5
Dangerous Goods - a preliminary risk screening completed in accordance with the State Environmental Planning Policy (Resilience and Hazards) 2021	Not included in this PHA. Addressed in EIS
Battery Energy Storage System - a PHA prepared in accordance with *Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011). The PHA must consider all recent standards and codes and verify separation distances to on-site and off-site receptors to prevent fire propagation and compliance with *Hazardous Industry Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning* (DoP, 2011). The PHA must consider the effect of bushfires on batteries or other components of the BESS. The PHA must also consider nearby proposed / approved BESS's and verify the cumulative impacts on surrounding land use.	This PHA

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 and telecommunications.

2 Site location and assessment

2.1 Site location

The Project, as shown on Figure 2-1, is located at 384 Broockmanns Road approximately 39.2 km south southeast of the nominated South-West Renewable Energy Zone (SWREZ). The Project is located within the Berrigan Shire LGA and situated in the Riverina Murry Region of NSW.

It is located within a land parcel that is adjacent to an existing 66 kilovolt (kV) line and in proximity to the Finley Substation and Finley Solar Farm.

The Project Site includes rural farmland that is predominantly cleared of overstorey vegetation. The Project Site is used for agricultural purposes (predominantly horse grazing), and includes a residence, several sheds and a farm dam.

2.2 Surrounds

The immediate area consists of broadscale irrigated areas with irrigation water supplied via the Mulwala Canal. The Project Site is located approximately 5km west of the township of Finley NSW, 20km northwest of Tocumwal, Victoria and approximately 27km east of the township of Berrigan, NSW.

2.3 Sensitive receivers

The proximity of sensitive receivers from the Project Site has been considered within 2km from the boundary of Subject Lot (refer to Figure 2-1). Within 2km, there are 11 identified non-associated receivers. There is one associated receiver that exists within the subject lot labelled as R1. R1 is about 186 metres from the BESS.

2.4 Sensitive developments

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

- Residential Areas – Where people live, particularly high-density housing and aged care facilities
- Schools and Childcare Centres – Places where children, who are less capable of responding to emergencies, are concentrated
- Hospitals and Aged Care Facilities – Where occupants may be mobility-impaired or require assistance during an emergency
- Public Spaces with High Occupancy – Such as parks, shopping centres, or entertainment venues
- Critical Infrastructure – Including emergency services, transport hubs, and communication centres.

2.5 Flood prone land

The Project Site is not mapped as flood prone land.

The Mulwala No. 19 Channel runs across the northern border of the Subject Lot, to the west along Canalla Road. There are no mapped waterways within the Project Site. A farm dam is located within the Subject Lot, separated by the private access road to the property.

2.6 Health

The surrounding environment includes existing sources of Extremely Low Frequency (ELF) Electromagnetic Field (EMF) (i.e., 50 Hz) including the existing 66 kV line, the Finley Substation and Finley Solar Farm. The Project would introduce additional sources of EMF including BESS enclosures, transformers and connection infrastructure to the Finely substation.

Due to the rapid attenuation of EMF with distance and the inclusion of BESS enclosures, it is anticipated that EMF will decrease significantly beyond the immediate vicinity of the Project. The EMF levels are expected to be well below the ICNIRP *Guidelines For Limiting Exposure To Time-Varying Electric And Magnetic Fields* (1 Hz – 100 kHz) (ICNIRP Guidelines) reference levels (refer to Table 2-1) at the nearest sensitive receiver (associated receiver R1).

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

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

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

The impacts of EMF have been assessed in the hazard register (refer to Table 4-5) and in the risk assessment (refer to Section 5).

2.7 Bushfire

The Project Site is not mapped as bushfire prone land. It is also surrounded by broadscale irrigated areas which would minimise the hazard and risks associated with an encroaching bushfire.

The nearest mapped bushfire prone land is along the Murray River near Tocumwal. About 18 kilometres from the Project Site.

As the land is not mapped as bushfire prone land and the development is not potentially exposed to a bushfire threat (and likely to be referred under the s4.15 of the EP&A Act) the *NSW Rural Fire Service Planning for Bush Fire Protection 2019* (PBP) does not apply.

However, the requirements of wind and solar farms from PBP have been assessed in Table 2-2. PBP does not include specific requirements for standalone BESS.

Additionally, the potential hazards and risks associated with bushfires, including the risks that a BESS would cause a bush fire are considered in the hazard register (refer to Table 4-5) and in the risk assessment (refer to Section 5).

Table 2-2 PBP requirements for wind and solar farms

PBP requirements for wind and solar farms	Where addressed
Minimum 10m Asset Protection Zone (APZ) for the structures and associated buildings/infrastructure (excludes roads, power and other services to the site and fencing)	Section 3.2 includes an 11m APZ
APZ must be maintained to the standard of an Inner Protection Area (IPA) for the life of the development	Section 10 includes the requirement for maintenance as an IPA
Prepare a Bush Fire Emergency Management and Operations Plan including: • Detailed measures to prevent or mitigate fires igniting	Section 10 includes the requirement for preparation of a Bush Fire Emergency Management and Operations Plan Section 3.2 includes a 50,000 L Static Water Supply (SWS)

PBP requirements for wind and solar farms	Where addressed
• Work that should not be carried out during total fire bans • Availability of fire-suppression equipment, access and water • Storage and maintenance of fuels and other flammable materials • Notification of the local NSW RFS Fire Control Centre for any works that have the potential to ignite surrounding vegetation, proposed to be carried out during a bush-fire fire danger period to ensure weather conditions are appropriate • Appropriate bush fire emergency management planning	

Additionally, the internal roads comply with the vertical clearance and vehicle turning requirements specified in Appendix 3 of PBP.

Figure 2-1 Key features and sensitive receivers (source: NGH)

3 Project description

3.1 Overview

The Project would include the following:

- BESS including battery enclosures, inverters, transformers, switchgear and control room
- Onsite substation including transformer switch bays and switchgear housed in portable substation containers
- Underground or overhead 132 kV transmission lines to connect the BESS to the Finley substation
- Finley substation upgrade works to facilitate connection with the BESS
- Permanent office, Operation and Maintenance (O&M) buildings, hardstands and Project signage
- Site access to the BESS from Broockmanns Road, internal site access tracks and parking
- Landscaping
- Stormwater management infrastructure, lighting, fencing and security.

The Project will connect to the Finley substation via an overhead 132 kV transmission line, that will run along the southern boundary of Broockmanns Road road reserve and potentially Canalla Road, before entering the TransGrid lot (B//961693).

The key features of the Project are presented in Table 3-1, Figure 3-1 and Figure 3-2.

Table 3-1 Key features of the Project

Proposal element	Description
BESS	• BESS with a delivery capacity up to 80MW / 320MWh • 88 Tesla Megapack 2XL • 22 4.6 MVA step-up transformers • 4 ring main units • 1 HV transformer
BESS area	• 13.80ha (Final Development Footprint)
Substation and switch yard	• 33kV switch room • Auxiliary low-voltage transformer • 33/132kV Transformer
Transmission line	• Approximately 900m of 132kV overhead (lines) or underground (cabling)
Existing Transgrid substation	• Utilise existing bay
Site access and intersection upgrades	• New site access off Brookmanns Road
Permanent ancillary infrastructure	• Security fencing • Water tank • Pumpable sewage holding tank

Proposal element	Description
	• Control room • O&M building • Onsite car parking • Internal access tracks • Noise wall (optional, subject to landowner agreement)
Temporary works areas: Construction compound, and construction parking/laydown areas	• Construction compound • Construction laydown area • Storage • Bunding • Drainage • Carpark

Figure 3-1 Indicative Project layout (source: NGH)

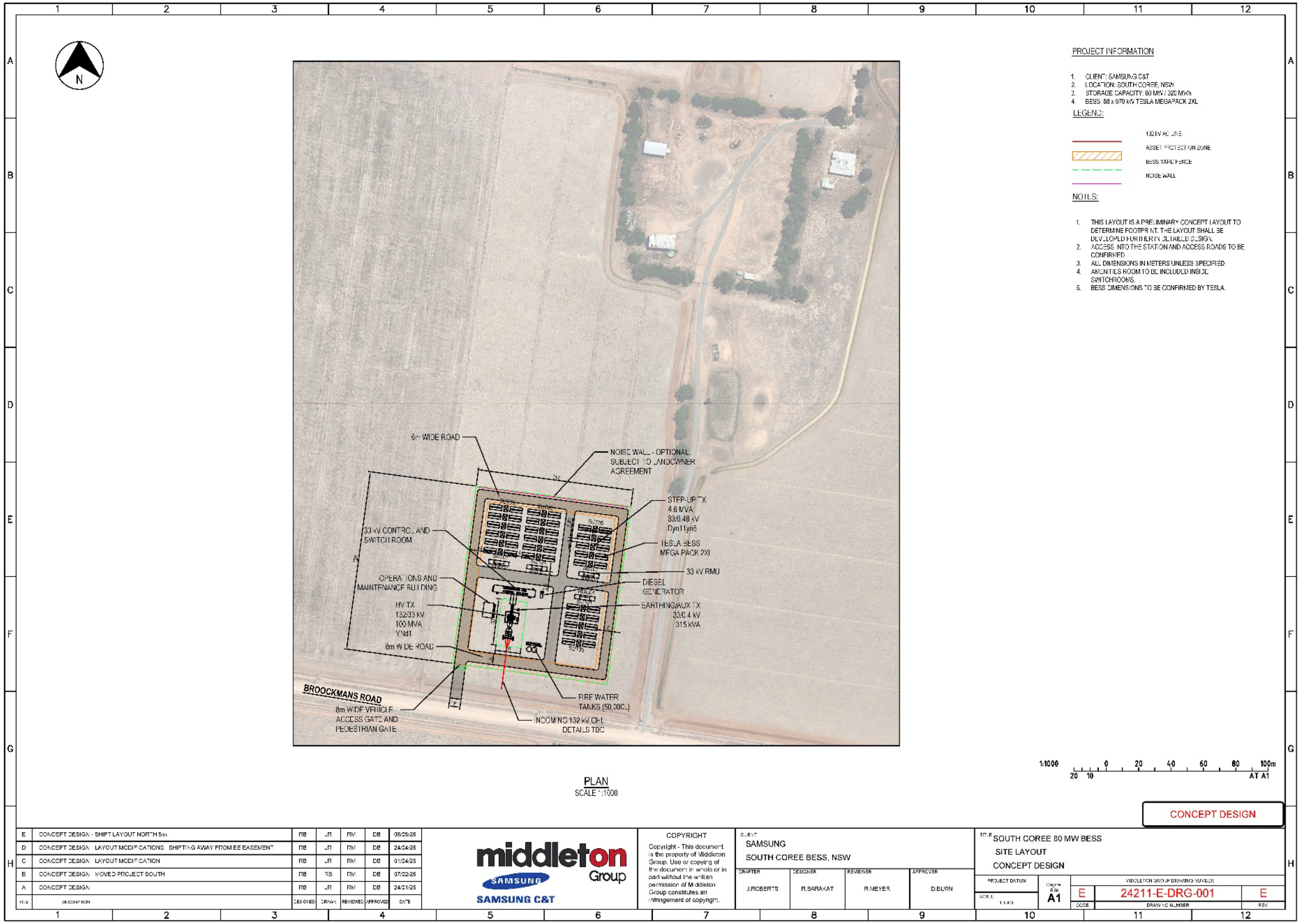

Figure 3-2 Project site layout concept design (source: the Applicant)

3.2 Battery Energy Storage System

The BESS layout would include multiple modular segment units arranged in rows, such as those shown in Figure 3-3, and include:

- 88 Tesla Megapack 2XL units measuring approximately 8.8m x 1.7 x 2.8 m. Each Megapack unit can house up to 24 battery modules and inverter modules
- Each unit contains integrated inverter modules (also known as Power Conversion Systems (PCS)). Each PCS is a bi-directional power conversion system that couples each Tesla Megapack 2XL with the power grid (AC power)
- System controller to centralise the operation, monitoring and integration of the BESS
- 22 generator step up transformer
- 4 33 kV ring main units
- 5 ring main units.

Each battery module is made up of prismatic LFP battery cells. Battery modules are connected in parallel to Tesla Megapack 2XLs internal AC bus (which converts the DC energy into AC energy), each with an AC power and communications output connection. An example of a battery module and inverter configuration is shown in Figure 3-4.

Figure 3-3 Indicative Tesla Pack configuration (source Tesla.com)

Figure 3-4 Battery module and inverter example (source Tesla.com)

As described in the *Tesla Megapack and Megapack 2XL Fire Protection Engineering Analysis* (Fisher Engineering, Inc., 2023), attached as Appendix B, the MP2XL includes the following fire safety and life features:

- Thermal Management System (TMS) to provide active heating and cooling using liquid cooling via a 50/50 mixture of ethylene glycol and water and R-134a refrigerant
- Battery Management System (BMS) to protect cells from harmful excesses of voltage, temperature, and current
- System controller (Tesla's Local Operations Center)
- Electrical fault protection devices, including:
  - Battery module overcurrent protection
  - Inverter DC protection
  - Inverter AC protection
  - Ground fault protection
- Explosion control system

The MP2XL does not have an internal fire detection system or fire suppression system. The UL 9540A unit level fire test results (refer to Appendix B) demonstrate that a suppression system is not required to stop the spread of fire from cell to cell, module to module or MP2XL cabinet to cabinet when a near simultaneous failure of up to six cells occurs within the same battery module.

The UL 9540A unit level fire test also demonstrated that manual fire suppression (hose lines) is not required to stop the spread of fire from a MP2XL cabinet to adjacent MP2XL cabinets installed 150 mm behind and to the sides when a near simultaneous failure of up to six cells occurs within the same battery module.

Risk mitigation strategies considered in siting the BESS include:

- 11 m APZ comprising:
  - 1 m from external fence to perimeter road
  - 6 m wide perimeter road
  - 4 m separation from the perimeter road to Project infrastructure

- Provision of fire safety separation distances
- Internal roads, including 8 m wide access gate, suitable for emergency access and/or exit. The perimeter road and internal loop roads provide suitable turnarounds for emergency egress.
- SWS tanks (50,000L)

3.2.1 BESS separation distances

BESS separation distance may be the most effective control to reduce the likelihood and consequence of multi module fire propagation as a result of a thermal runaway event. The separation distances, as shown in Figure 3-5, include:

- 4.0 m between back to back pairs of MP2XL units (east/west)
- 2.45 m between back to back pairs of MP2XL units (north/south)
- >460 mm between back to back MP2XL units
- 4.0 m from accessible means of egress and exposures (such as buildings, public ways, and hazards not associated with electrical grid infrastructure)
- 1.5 m between MP2XL units and step up transformers.

The separation distances comply with the *Megapack 2XL Design and Installation Manual* (Tesla, 2024) (attached as Appendix A) including the exposure clearance requirements from ordinary combustibles, vertical combustible or ignitable and ignitable liquids.

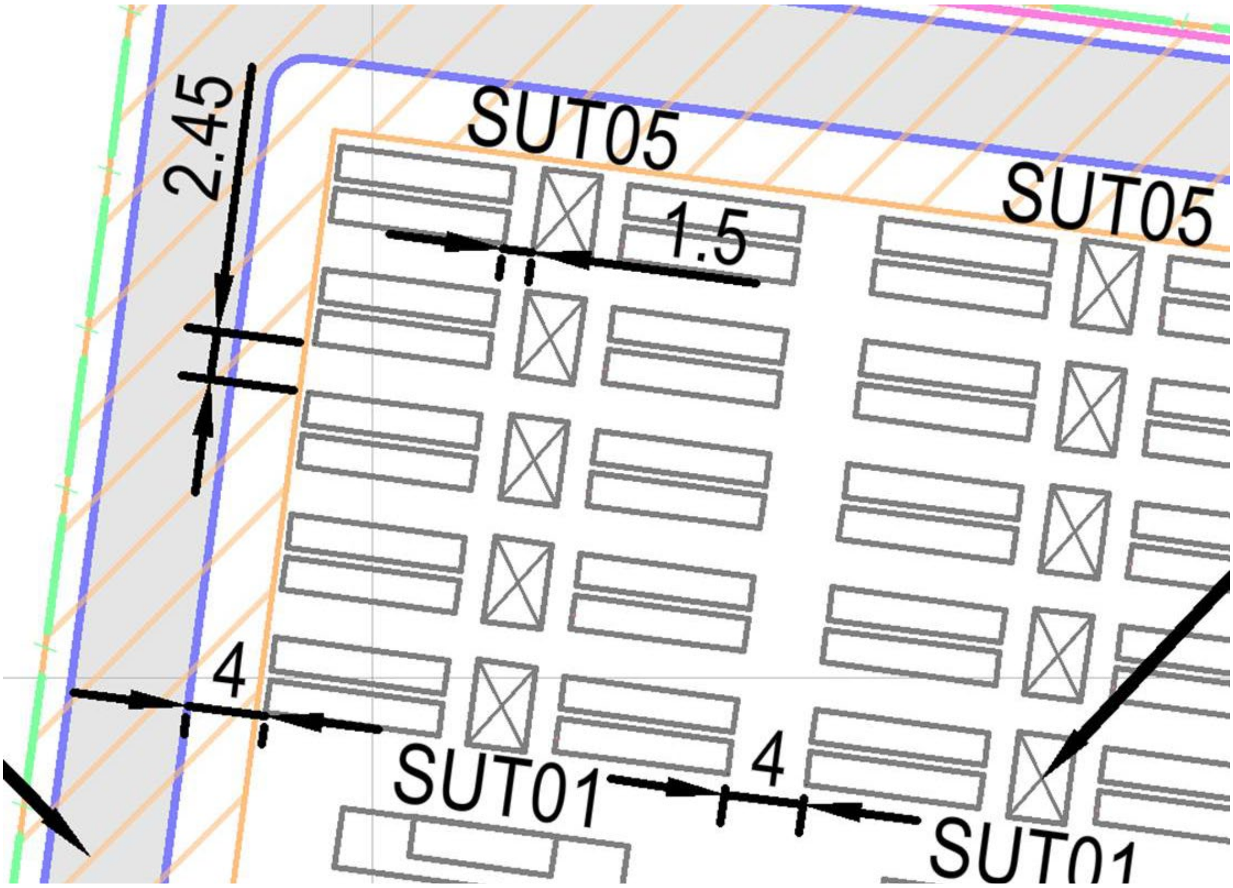

Figure 3-5 BESS separation distances (source: the Applicant)

3.2.2 Fire Protection Engineering Analysis

In accordance with the *Tesla Megapack and Megapack 2XL Fire Protection Engineering Analysis* (Fisher Engineering, Inc., 2023), attached as Appendix B, the MP2XL has been tested to UL 9540A at the cell, module, and unit level. The summary of the findings include:

- Cell and module level UL 9540A testing demonstrated that flammable gases vent from the MP2/2XL cells during thermal runaway; however, they do not release toxic gases sometimes associated with the failure of lithium-ion batteries, such as Hydrogen Cyanide (HCN), Hydrogen Chloride (HCL) and Hydrogen fluoride (HF)
- Unit level UL 9540A testing demonstrated that the MP2/2XL meets or exceeds all the performance criteria of UL 9540A. Heating and failure of six cells initiated thermal runaway in a seventh cell. However, thermal runaway did not propagate any further than the seventh cell, nor did this failure lead to a fire within the MP2 cabinet.
- The failure did not result in any observations of explosion hazards, including but not limited to, observations of a deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases.
- Internal destructive unit level testing demonstrated that the MP2/2XL is capable of safely failing in the extreme case of a catastrophic failure of a battery module (the forced thermal runaway of 48 cells simultaneously). This destructive unit level test led to a slow progressing fire that burned for 6 hours and 40 minutes until flaming ceased, only consuming one-half of the battery modules in the cabinet.
- Fire modelling demonstrated that, in the unlikely event of a fire, it would not propagate from one MP2/2XL cabinet to adjacent cabinets installed 6 inches behind, 6 inches to the side and 8 feet directly in front of the initiating MP2/2XL. This result was analysed for both no wind and worst-case wind conditions where flames could tilt towards the adjacent MP2/2XL cabinets.

The *Tesla Megapack and Megapack 2XL Fire Protection Engineering Analysis* (Fisher Engineering, Inc., 2023) concluded that:

- The MP2/2XL explosion control system can mitigate the deflagration hazard even with an extreme failure scenario of a battery module (the forced thermal runaway of 48 cells simultaneously) resulting in the MP2/2XL safely failing.
- An integral fire suppression system or an external fire suppression system is not required to stop the spread of fire from a MP2/2XL cabinet to adjacent MP2/2XL cabinets when installed at clearances of 8 feet in front, 6 inches behind and 6 inches to the sides.
- Manual fire suppression (hose lines) is not required to stop the spread of fire from a MP2 cabinet to adjacent MP2/2XL cabinets when installed at clearances of 8 feet in front, 6 inches behind and 6 inches to the sides.
- Based on a review of the MP2/2XL, its fire safety features, UL 9540A test results, additional internal MP2/2XL unit level fire testing and fire propagation modelling, the MP2/2XL can meet or exceed installation level codes and standards, such as the IFC and NFPA 855, required for outdoor, ground mounted BESS installations when installed in accordance with the MP2 and MP2XL Design and Installation Manual (attached as Appendix A).

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:

- *Megapack 2XL Design and Installation Manual* (Tesla, 2024) (attached as Appendix A)
- *Tesla Megapack and Megapack 2XL Fire Protection Engineering Analysis* (Fisher Engineering, Inc., 2023) (attached as Appendix B)
- Fire safety study (to be undertaken post approval)

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
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
NCC 2022	National Construction Code 2022 (E1D17 and E2D21 in accordance with FRNSW feedback)
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 3-3 Consideration of standards and codes for BESS separation distances

Source	Infrastructure	Items for consideration
FM Global DS 5-33	Outdoor Lithium-Ion Battery Energy Storage Systems (LIB-ESS) Enclosures and	**2.3.2.1** Select or construct LIB-ESS enclosures/containers using only non-combustible materials. *Separation distance is based on doors being located on only one side of the enclosure and no vents or*

Source	Infrastructure	Items for consideration
	Containers	*unprotected openings on any other sides. It is also based on active systems (HVAC or liquid cooling) maintaining cell or module temperatures in the target enclosure or container.* **2.3.2.2** For containerized LIB-ESS comprised of lithium iron phosphate (LFP) cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors or deflagration vents. ~~2.3.2.3 For containerized LIB-ESS comprised of lithium nickel manganese cobalt (NMC) cells where wall construction is unknown or has an ASTM E119 rating less than 1 hour, provide aisle separation of at least 13 ft (4.0 m) on sides that contain access panels, doors, or deflagration vents. For containerized NMC LIB-ESS where wall construction is documented as having at least a 1 hour rating in accordance with ASTM E119, aisle separation of at least 8 ft (2.4 m) is acceptable.~~ 2.3.2.4 Provide separation between solid walls having no openings based on installation-level testing that demonstrates thermal runaway cannot propagate between containers. Where a fire test report is not available or the test did not result in a fire in the unit of origin, provide separation as indicated in Sections 2.3.2.2 ~~or 2.3.2.3~~ as appropriate. 2.3.2.4.1 If any penetrations are present, the separation should be extended, or the penetrations should be protected or equipped with FM Approved fire-safe wall penetrations. 2.3.2.4.2 Where explosion vents or other penetrations are provided, ensure they are arranged and directed away from surrounding equipment and buildings. In a fire, these enclosures may have vents or penetrations that could allow hot gas and products of combustion to escape the enclosure, causing an exposure to adjacent equipment or buildings. Penetrations could include electrical conduit, doors, HVAC units, etc. 2.3.2.5 Provide a minimum space separation between LIB-ESS enclosures and adjacent buildings or critical site utilities or equipment in accordance with Data Sheet 1-20, Protection Against Exterior Fire Exposure, using hazard category 3 for the exposing building occupancy.
NPFA 855	BESS	In accordance with section 9.4.2.2 of NPFA 855, each ESS group (i.e. container) shall be spaced a minimum 3 ft (0.9 m) from other groups and from walls in the storage room or area.
ASNZS 5139.2019 6.2.6.2	MV power station	Minimum of 900 mm distance between battery system and power conversion equipment.

4 Preliminary hazard analysis

4.1 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 4-1.

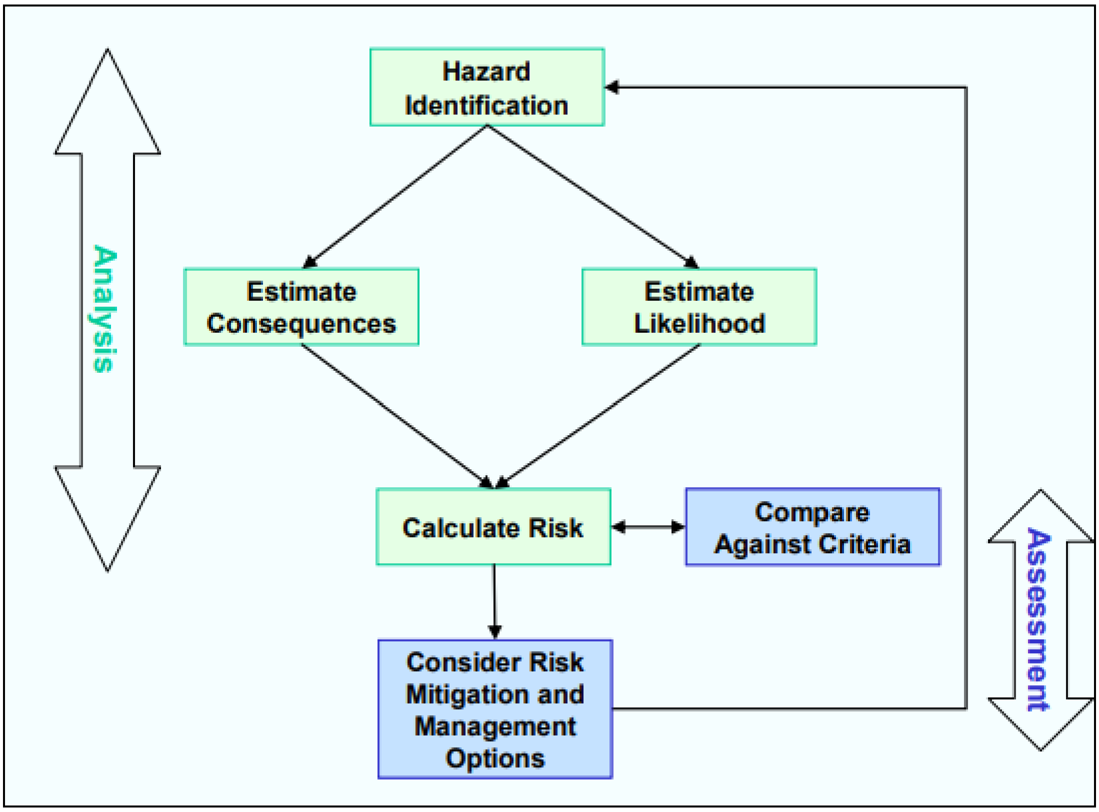

Figure 4-1 Basic methodology for hazard analysis (source: HIPAP 6)

4.2 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 4-1.

Table 4-1 Identified hazards and events

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

4.3 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 4-2. 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 4-2 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

4.4 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 4-3.

Standard control measures, relevant to all hazards and events, are presented in Table 4-4. The hazard register for the project is presented in Table 4-5.

Table 4-3 Information used in hazard register

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

Table 4-4 Standard control measures

Project phase	Standard control measure

Detailed design	• APZ and internal roads
	• TMS
	• BMS
	• System controller (Tesla's Local Operations Center)
	• Explosion control system
	• Tesla system protection features (refer to 5.5 of Appendix A) including:
	  ○ Battery module overcurrent protection
	  ○ Inverter DC protection
	  ○ Inverter AC protection
	  ○ Ground fault protection
	• Tesla safety disconnect features (refer to 5.6 of Appendix A) including:
	  ○ Megapack AC circuit breaker
	  ○ Enable circuit
	  ○ Enable switch
	  ○ Remote shutdown terminals
	  ○ Remote shutdown in islanding applications
	• Verify with the manufacturer that the BESS design is appropriate for the application.
	• Establish a management of change procedure to ensure that batteries or BMS components are compatible with modified system requirements or that replacements are appropriate to the existing system requirements.
	• Do not use refurbished or previously used BESS components, including cells or modules.
	• Equipment and systems will be designed and tested to comply with international standards and guidelines
	• Implement Emergency Response Plan
	• All relevant Transgrid's requirements will be met

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

Table 4-5 Hazard register

ID	Hazard	Event	Cause	Consequence	Additional controls (in addition to standard control measures in Table 4-4)	Likelihood Rating
1	Electrical	Exposure to voltage	• Short circuit/electrical connection failure • Faulty equipment • Incorrect installation • Incorrect maintenance • Human error during maintenance • Safety device/circuit compromised • Battery casing/enclosure damage	• Electrocution • Injury and/or fatality • Fire	• Electrical switch-in & switch-out protocol (pad lock) • Manual Service Disconnect (MSD) switch • Overcurrent protection • Rescue kits (i.e., insulated hooks)	Very Unlikely
2	Arc flash	Arc flash	• Incorrect procedure (i.e., installation/ maintenance) • Faulty equipment (e.g., corrosion on conductors) • Faulty design (e.g., equipment too close to each other) • Insulation damage • Human error during maintenance	• Burns • Injury and/or fatality • Exposure to intense light and noise • Arc blasts and resulting heat, may result in fires and pressure waves	• Maintenance procedure (e.g., deenergize equipment) • Preventative maintenance (insulation)	Very Unlikely
3	EMF	Exposure to EMF	• Operations of power generation equipment	• High level exposure (i.e., exceeding the reference limits) may affect function of the nervous system (i.e., direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) • Personnel injury	• Location and selection (incl. separation distance) • Optimising equipment layout and orientation • Reducing conductor spacing • Balancing phases and minimising residual current • Incidental shielding (i.e., BESS building/enclosure, switchroom) • Exposure to personnel is short duration in nature (transient) • Studies found that the EMF for commercial solar power generation facilities comply with ICNIRP occupational exposure limits	Extremely Unlikely
4	Fire	Transformers and PCS fire	• Transformer oil leak • Faulty equipment • Arc flash	• Fire in transformer and/or PCS • Release of toxic combustion products • Injury/fatality • Asset damage • Interruption in power supply	• Preventative maintenance (e.g., insulation, replacement of faulty equipment) • Activation of emergency shutdown (ESD button)	Very Unlikely
5	Fire	Control and switchroom fire	• Equipment failure • Arc flash • Vandalism • External fire (e.g., bushfire, adjacent infrastructure)	• Fire in substation and escalation to switchyard • Release of toxic combustion products • Injury/fatality • Asset damage • Interruption in power supply	• Inverter/transformers (PCSs) are in designated area • Preventative maintenance (e.g., insulation, replacement of faulty equipment) • Electrical switch-in & switch-out protocol (pad lock) • Circuit breakers • Substation is locked and located in designated area • Security fence and controlled access • Activation of emergency shutdown (ESD button)	Extremely Unlikely
6	Fire	Fire in temporary construction facilities	• Kitchen fire • Paper fire • Smoking	• Injury/fatality • Asset damage	• Cooling water supply on-site • Defendable boundary for firefighting will be established (i.e., APZ) • Dedicated smoking area • Fire protection system in the temporary construction facilities	Very Unlikely
7	Fire	Bushfire	• Encroachment of off-site bushfire • Escalated event from facility fire	• External Fire Exposure & Thermal Runaway • Toxic Gas Emissions • Explosion Risks	Bushfire Protection Measures (BPM) in accordance with *Planning for Bush Fire Protection 2019*, including: • APZs	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Additional controls (in addition to standard control measures in Table 4-4)	Likelihood Rating
				• Structural Damage & Grid Impact • Firefighting Challenges	• Access • Construction siting and design • Landscaping • Emergency and evacuation planning (fire safety study, emergency response plan and Bush Fire Emergency Management and Operations Plan). Additional controls including: • Separation between BESS containers • Fire-resistant enclosures and passive fire barriers between battery racks • Gas detection & venting systems to prevent pressure buildup • Remote monitoring & emergency response plans for early intervention.	
8	Reaction	Thermal runaway in battery	• Elevated temperature • Bushfire • External fire (e.g., substation, transformer) • Electrical failure • Short circuit • Excessive current/voltage • Imbalance charge across cells • Mechanical failure • Internal cell defect • Damage (crush/penetration/puncture) • Systems failure • Battery Management System (BMS) failure • HVAC failure	• Fire in the battery cell • Injury/fatality • Escalation to the enclosure/ building • Escalation to the entire BESS	• Separation between BESS containers • LFP battery cells with high thermal stability	Very Unlikely
9	Chemical	Release of electrolyte (liquid/ vented gas) from the battery cell	• Mechanical failure/damage • Dropped impact (installation/maintenance) • Damage (crush/penetration/puncture) • Abnormal heating/elevated temperature • Thermal runaway • Bushfire • External fire (e.g., substation, transformer)	• Release of flammable liquid electrolyte • Vapourisation of liquid electrolyte • Release of vented gas from cells • Fire and/or explosion in battery enclosure/building • Release of toxic combustion products • Injury/fatality	• Layers of battery case (pod and external casing) • Spill cleanup using dry absorbent material	Very Unlikely
10	Chemical	Coolant leak	• Mechanical failure/damage • Incorrect maintenance	• Irritation/injury for personnel on exposure (inhalation)	• Layers of battery case (pod and external casing) • Spill cleanup using dry absorbent material	Very Unlikely
11	Chemical	Refrigerant leak	• Mechanical failure/damage • Incorrect maintenance	• Irritation/injury for personnel on exposure (skin contact)	• BESS layers of battery case (pod and external casing) • Sealed system	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	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Additional controls (in addition to standard control measures in Table 4-4)	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	• Diesel is a combustible liquid and will be stored away from other flammable materials (e.g., gasoline) • Secondary containment (i.e., bunding)	Very Unlikely
14	Gasoline	Release of gasoline from storage tank or filling point	• Mechanical failure • Human error during transfer	• Fire • Injury/fatality	• Secondary containment (i.e., bunding)	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 designed and constructed with ingress protection and in accordance with relevant standards • Drainage system • Preventative maintenance (check for leaks)	Extremely Unlikely
16	External factors	Vandalism	• Unauthorised personnel access	• Asset damage • Potential hazard to unauthorized person (e.g., electrocution)	• Project infrastructures are in secure fenced area • Onsite security protocol • During construction, the area will be patrolled, and fence will be installed	Unlikely
17	External factors	Lightning strike	• Lightning storm	• Injury/fatality • Fire • Asset damage	• Project designed in accordance with *Australian Standard AS/NZS 1768 Lightning protection*, including: o Earthing o Lightning protection mast (substations) o Site exclusion/closure • Lightning protection design in accordance with 5.5.2 of Appendix A	Very Unlikely

5 Multi-level risk assessment

Multi-Level Risk Assessment (DoP, 2011) recommends a multi-level approach to risk assessment where the level and extent of the analysis reflects the nature, scale and location of the Project. The objective is to progress the analysis, and its assessment only as far as is needed to demonstrate that the operation of the Project does not or will not pose a significant risk to surrounding land uses. The approach is presented in Figure 5-1.

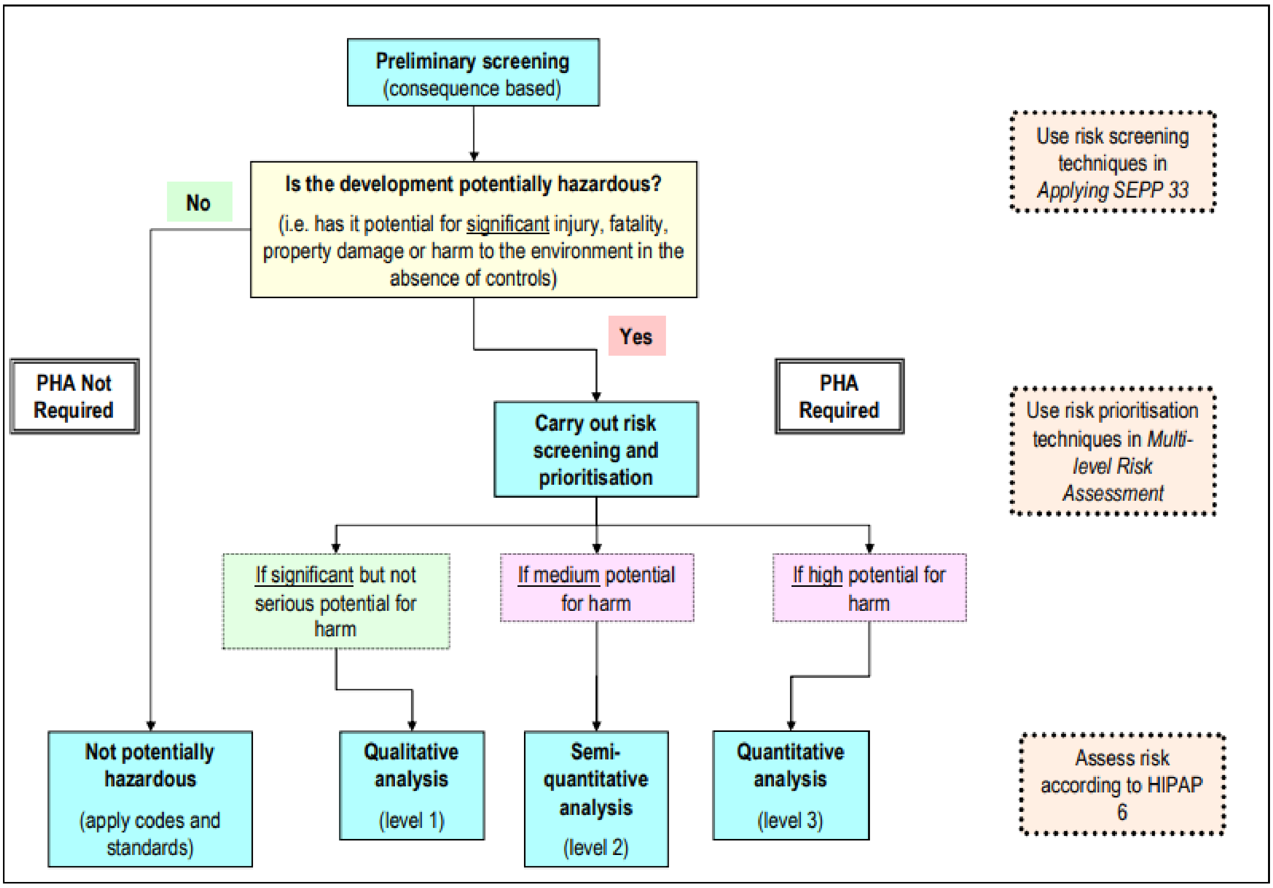

Figure 5-1 The Multi-Level Risk Assessment Approach (source: Muli-level Risk Assessment (DoP, 2011))

The levels of assessment include:

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

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

6 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 5-1.

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 6-1.

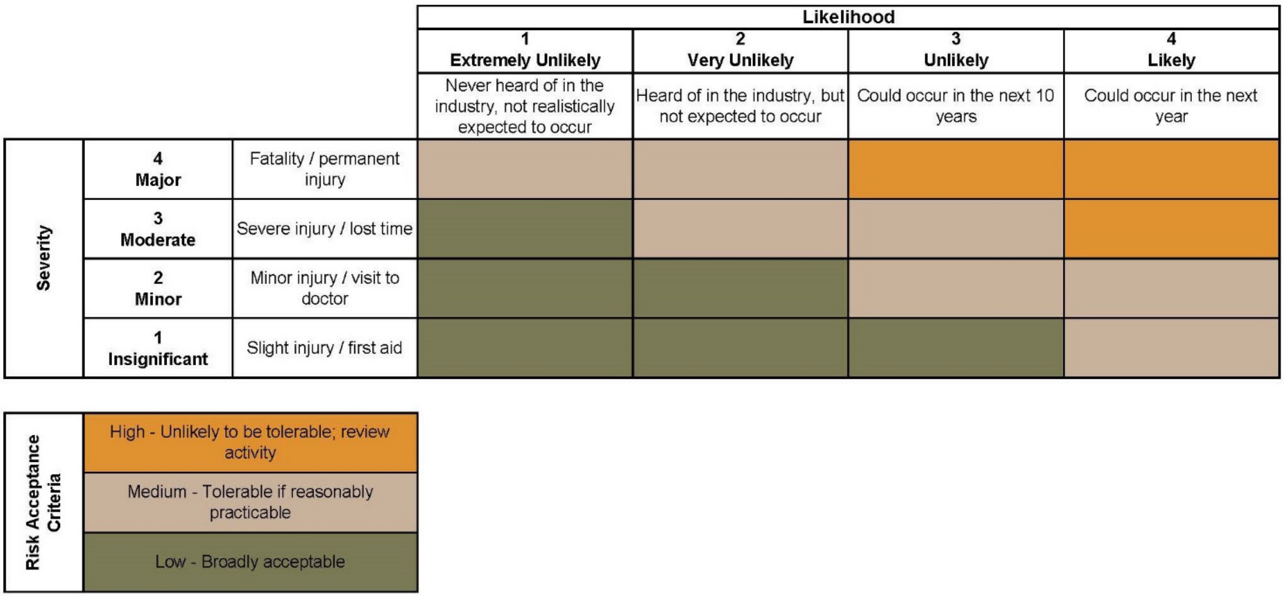

Figure 5-1 Qualitative risk matrix

Table 6-1 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 – control and switchroom	Major	Extremely unlikely	Medium
	Fire – temporary construction facilities	Major	Very unlikely	Medium
	Bushfire	Major	Very unlikely	Medium
Reaction	Thermal runaway in battery	Major	Very unlikely	Medium
Chemical	Release of electrolyte from the battery cell (liquid/vented gas) resulting in fire and/or explosion	Major	Very unlikely	Medium
	Battery coolant leak	Minor	Very unlikely	Low
	Refrigerant leak (BESS and refrigeration/chiller units)	Minor	Very unlikely	Low
	Exposure to hazardous material (herbicide/pesticide)	Minor	Very unlikely	Low
	Release of diesel from storage tank, filling point or during handling resulting in fire	Major	Very unlikely	Medium
	Release of gasoline from storage tank or filling point resulting in fire	Major	Very unlikely	Medium
External factors	Water ingress resulting in fire (BESS, PCSs or switchrooms)	Major	Extremely unlikely	Medium
	Vandalism due to unauthorised personnel access	Moderate	Unlikely	Medium

Hazard	Event	Consequence (impact to people)	Likelihood	Risk
	Lightning strike	Major	Very unlikely	Medium

7 Risk assessment results

7.1 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.

7.2 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.

7.3 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 As Low As Reasonably Practicable (ALARP).

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

Considering the site location and assessment described in Section 2 including the size of the Project site, the proposed location of Project infrastructure within that footprint, the proposed controls, and the distance to neighbouring land uses (including neighbouring properties and agricultural operations), the exposure to fire events will primarily affect the Project's construction and operations workforce.

The risk assessment concluded that there is negligible potential for offsite fatalities or injuries. Therefore, the Project aligns with land use planning criteria. The Project deemed these risks as tolerable, considering the measures taken ALARP.

7.3.1 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 7-1.

Table 7-1 HIPAP 4 qualitative risk criteria assessment

HIPAP 4 qualitative risk criteria	BESS
All 'avoidable' risks should be avoided. This necessitates	Alternative locations:

HIPAP 4 qualitative risk criteria	BESS
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.	No other locations 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: LFP batteries are considered superior for BESS compared to traditional lithium-ion batteries because they offer enhanced safety, longer lifespan, and better thermal stability. LFP batteries are less prone to overheating and thermal runaway, reducing the risk of fires. They also endure more charge-discharge cycles with minimal capacity degradation, providing a more cost-effective solution over time. 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 6 includes feasible controls that reduce hazards wherever practicable. The outcome of the risk assessment (ALARP), including the separation distances described in section 3 and the distances to nearby receivers, indicates that the controls are adequate and relevant.
The consequences (effects) of the more likely hazardous events (i.e., those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	The risk assessment presented in section 6 indicates that hazardous events are likely to be contained within the boundaries of the development footprint. The separation distances described in section 3 will minimise fire propagating between BESS modules and reduce the intensity of any fire (and therefore reduce the likelihood of fire extending beyond the development site).
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	There are no other known high risk hazardous installations in the area.

8 Recommendations following the Victorian Big Battery Fire

The Tesla MP2XL supersedes the model of Tesla Megapack which was the subject of the Victorian Big Battery Fire (VBBF) in 2021. Learning from the VBBF contributory factors, the Tesla MP2XL includes improvements in commissioning procedures, fault protection devices, and thermal roof design, including:

- A new commissioning procedure which improves the inspection of the coolant system, avoids using the keylock switch, reduces the telemetry setup connection time for new Megapacks from 24 hours to 1 hour, and avoids the keylock switch unless the unit is actively being serviced
- Firmware improvements including additional alarms to possible coolant leaks, electrical safety protection which remain active regardless of keylock position, and active monitoring and controls for the Pyro-fuse's power supply circuit
- Thermally insulated steel vent shields are now installed in the newly designed thermal roof, which can protect the plastic overpressure vents from direct flame impingement or hot gas intrusion inside the unit.

Following an investigation into the VBBF, recommendations were provided in the *Victorian Big Battery Fire Statement of Technical Findings* – Victorian Government 2021 . In response to the recommendations, the Applicant, Samsung C&T Renewable Energy Australia Pty Ltd (SREA), makes the commitments presented in Table 8-1.

Table 8-1 The Applicants response to recommendations of the Victorian Big Battery Fire

Victorian Big Battery Fire Statement of Technical Findings - lessons learned and preventing a recurrence	Applicants' commitment
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 Applicant 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 Applicant 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 updated SCADA will be used and verified 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 MP2XL 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 procedure for the usage of the key lock for MP2XL 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.

9 Conclusion

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

The steps undertaken to prepare this PHA include:

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

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

As the separation distance comply with the *Megapack 2XL Design and Installation Manual* (Tesla, 2024) (attached as Appendix A) and the detailed design standards described in section 3.2.3, and the risks at the site boundary are not considered to exceed the acceptable risk criteria, the proposed separation distances are considered appropriate at the planning phase of the development. Following the implementation of the recommendations of this PHA, including the proposed separation distances, the likelihood of a multi-module fire would be minimised to a non-credible event.

9.1 Cumulative impacts

The SWREZ will include two new transmission projects and additional BESS including, but not limited to:

- Finley BESS
- Berrigan BESS
- South Coree BESS
- Dinawan Energy Hub.

As the Project does not pose a significant off-site risk, other BESS in the SWREZ would not pose a significant off-site risk and there is an absence of credible mechanisms for interaction between them the cumulative risk of BESS in the SWREZ is considered negligible.

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 and bush fire emergency management and operations plan
- APZs to be maintained as IPAs in accordance with Appendix 4 of PBP for the life of the Project
- 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

- All recommendations from the Victorian Big Battery Fire Statement of Technical Findings – Victorian Government 2021 will be implemented.

APPENDIX A MEGAPACK 2XL DESIGN AND INSTALLATION MANUAL (TESLA, 2024)

CONFIDENTIAL – TO BE SHARED WITH DPHI ONLY

APPENDIX B TESLA MEGAPACK AND MEGAPACK 2XL FIRE PROTECTION ENGINEERING ANALYSIS (FISHER ENGINEERING, 2023)

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