PRELIMINARY HAZARD ANALYSIS FOR AUSGRID'S

HOMEBUSH BATTERY ENERGY STORAGE SYSTEM, NSW

Prepared for: Ausgrid

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Preliminary Hazard Analysis for AusGrid's Homebush Battery Energy Storage System, NSW

Disclaimer

Ausgrid have commissioned Planager to prepare a Preliminary Hazard Analysis (PHA) for the BESS. The material in it reflects Planager's best judgement in the light of the information available to it at the time of preparation. However, as Planager cannot control the conditions under which this report may be used, Planager and its related corporations will not be responsible for damages of any nature resulting from use of or reliance upon this report. Planager's responsibility for advice given is subject to the terms of engagement with Ausgrid. All predictions in the document are based on the information available at the date of the report. These are subject to change due to factors beyond the scope of work or beyond Planager's control or knowledge. Nothing in this document is a guarantee or assurance of any particular condition or energy output.

The analysis of fire safety within BESS' is limited to the available data and current hazards analyses on similar / applicable BESS'. As such, the analysis in this report represents the current understanding of the subject matter but is subject to the limitations of available data at the time of this report. In addition, this report relies on the assumptions and calculations pertained from the Tesla Fire Engineering contractors as reported in their report in Ref 15.

Rev	Date	Description	Prepared By	Checked By	Authorised By
A	27/12/2024	Draft I for comments	K Nilsson, J Kang	A Lewis	K Nilsson
B	20/02/2025	Draft II for comments	J Kang	K Nilsson	K Nilsson
C	01/04/2025	Final Draft	K Nilsson	J Kang	K Nilsson
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1	12/05/2025	Updates addressing client comments	J Kang	K Nilsson	K Nilsson

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Ausgrid is seeking development consent for the Homebush Battery Energy Storage System (*BESS*) in Mason Park (adjoining Homebush) in New South Wales (NSW) (*the Project*).

The Project would involve the construction, operation and decommissioning of the BESS, including associated infrastructure for its management and connection to the national electricity market (*the BESS*). The BESS would be located within the Sydney suburb of Mason Park near Homebush, approximately 12 kilometres (km) west of Sydney's Central Business District in NSW (*the site*).

The Project would connect to the Mason Park sub-transmission switching station (STSS).

Key features of the Project would include:

- Construction, operation, and maintenance of a BESS with a 200 MW maximum power output capacity with 2-hour duration (i.e. 400 MWh)
- Containerised battery units (112 Megapacks) and associated infrastructure, including inverters and 56 medium voltage transformers
- 33kV underground cable connection from the battery units to Mason Park STSS infrastructure
- Combined switch room and control room building
- 8 Ring Main Units (RMU)
- Onsite workshop facility
- One auxiliary transformer
- Backup diesel generator
- Two spaces for onsite car parking
- Other ancillary infrastructure including fire suppression, stormwater management, 2.4m high boundary security chain wire fencing, acoustic barriers, lighting and CCTV.

The overall study objective is to address Hazards component of the Secretary's Environmental Assessment Requirements (***SEARs***) for the Project. The Hazards assessment requirements are:

- 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;
- Bushfire – identify potential hazards and risks associated with bushfires including the risks that a BESS would cause a bush fire and demonstrate compliance with Planning for Bush Fire Protection 2019; Dangerous Goods - a preliminary risk screening completed in accordance with the State Environmental Planning Policy (Resilience and Hazards) 2021; and
- Battery Energy Storage System - a Preliminary Hazard Analysis (PHA) prepared in accordance with Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis (DoP, 2011) and Multi-Level Risk Assessment. 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.

The hazard analysis combines qualitative and quantitative methods to assess the adequacy of the proposed controls for the BESS. The aim is to show that the BESS can be developed with risks kept As Low As Reasonably Practicable (*ALARP*), and appropriate land use safety planning can be achieved in accordance with relevant land use criteria (as defined in Hazardous Industry Advisory Paper No. 4, HIPAP4).

This PHA focusses on potential high consequence - low likelihood incidents in construction, commissioning and operation of the BESS that may affect the health and safety of people and the environment outside the site, in accordance with the requirements in *Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis* (*HIPAP6*) and the *Multilevel Risk Assessment* guideline (*MLRA*). In addition, with the potential for first responders from the public authorities (e.g. from the FRNSW) to access the site in an emergency, the risk inside the site are also discussed in this PHA.

The findings are as follows:

- The Project is not considered *potentially hazardous* in accordance with DPHI's definition, based on the intended storage and transport of hazardous material.
- Potential hazards from the Project are predominantly associated with the *Other types of hazards* and principally with the risk of a fire associated with the Lithium Iron Phosphate (LFP) batteries, and of environmental pollution from a spill of oil or other pollutant.
- Using a risk matrix which has been calibrated following the risk criteria imposed by the Department of Planning, Housing and Infrastructure (in the *Hazardous Industry Planning Advisory Paper No 4 – Risk criteria* document), the PHA found that the risk profile for the Project is consistently between *Moderate* and *Low* risk, with no *High* or *Very High* risks identified.

- Off-site risk: The PHA found that the risk profile for land outside of the site boundary is *Acceptable*

- On-site risk: The PHA found that the risk profile for personnel working within the site boundary the risk is consistently *ALARP*, except for exposure to EMF which is Acceptable (i.e. even lower risk than ALARP).

The assessment also found that the facilities associated with the Project can be managed in accordance with the established risk criteria and in accordance with ALARP principles, including the risk to the nearby residents. Most hazards can be prevented or mitigated by employing a combination of standard measures, including following all applicable Australian/New Zealand Standards and Codes and referring to international Standards where appropriate. Measures include separation distances and setbacks, physical protection, and automatic control systems.

Table E1 below provides an overview of the risk assessment results and ALARP conditions.

Table E1: Overview of risk assessment results and ALARP conditions

BESS hazardous incident event	Finding	Risk result and ALARP evaluation
1. Thermal runaway (including due to spontaneous ignition) and fire in a battery enclosure	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in a battery escalating into a fire at a battery enclosure. Key controls include continuous battery management system (BMS) with automatic shut-down batteries and battery racks are certified with respect to not posing a fire propagation risk in accordance with international methodologies (e.g. the UL 9540A tests and the Destructive Unit Level Test) and establishment of minimum separation distances within the BESS and between the BESS and the external boundaries (Recommendations 1, 2 and 3). The need for external firefighting or water to suppress/disperse gases evolved in a battery fire is unlikely for electrical and other fires associated with BESS infrastructure but would need to be determined in consultation with FRNSW and DPHI (Recommendation 1). On-site hazardous effects are possible in case of a battery fire, and the risk associated with generation of flammable and toxic combustion products has been minimised in design. Further considerations of safe evacuation routes and procedures for the site or nearby areas (in a worst-case fire scenario) should be established, and the toxicity of combustion gas should be considered in emergency response (Recommendation 2).	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk* Managed to ALARP principles in the early design stage; and with recommended consultation with FRNSW and DPHI in the detailed design to demonstrate non-propagation of a fire considering local weather conditions and the final layout; and to determine any need for external firefighting or water to suppress/disperse gases evolved in a BESS fire
2. Loss of containment of pollutant material from the BESS infrastructure	Environmental pollution may occur from a failure to contain pollutants, and the need for secondary containment of a spill would be considered in detailed design including at the transformers (Recommendation 3). The requirements under the Australian Standards (including AS 1940) are sufficient to ensure the risk associated with environmental pollution at the electrical infrastructure associated with the BESS is to be managed to ALARP principles.	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk*

BESS hazardous incident event	Finding	Risk result and ALARP evaluation
		Conforms to ALARP provided the applicable requirements in Codes and Standards are followed
3. Electrical fault or failure to control electrical energy (EMF; electrical interference) at electrical equipment (inverters, MV transformers, and electrical cabling) causing fire, arc flash, and/or exposure to excessive levels of EMF	The requirements under the Australian Standards (e.g. AS 2067) and typical management practices for Low and Medium Voltage systems are sufficient to ensure the risk associated with fire at the electrical infrastructure associated with the BESS is to be managed to ALARP principles. The EMF impact assessment concluded that the EMF levels generated by the BESS are compliant with the applicable Australian and international standards and guidelines, specifically the ICNIRP reference levels and therefore the on-site risk from EMF is acceptable.	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk* On-site (EMF): *Acceptable risk* Conforms to ALARP provided the applicable criteria are followed as per Codes and Standards
4. External threat of mechanical or thermal damage (neighbouring fire or light poles and overhead powerlines) causes damage, or incident during construction activity	An incident in a neighbouring area may affect the BESS infrastructure. Key controls include normal control of construction activities and emergency response. The risk associated with the presence of light poles and overhead cables across the Project area is low and can be managed using Australian Standards and Ausgrid Codes of Practice. Natural hazards from wind, lightning, etc. would be managed using Codes and Standards. Construction risks are well known and understood, and existing Codes and Standards are established within the industry to manage construction risk.	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk* Conforms to ALARP provided the normal control of construction activities and emergency response

Mitigation measures are available to reduce the severity of the hazards, should they occur, including specific secondary containment, e.g. as built into the battery enclosure, and operational training.

The assessment found that provided the recommendations listed below are implemented, the Project can be managed in line with the HIPAP4 established risk criteria and ALARP principles, including risk to the nearby residents and to nearby businesses, including to the DFO and the Homebush Olympic Park.

Recommendations:

The following recommendations are made as part of the PHA:

1. Vegetation management within the Project Area and provision of an Asset Protection Zone to separate any major vegetation that is retained, e.g. trees and overhanging tree branches, from the BESS infrastructure on the Project area should be established in accordance with the exposure clearances recommended by the OEM.
2. A Fire Safety Study should be prepared for the Project in consultation with FRNSW and DPHI during the detailed design stage. Adherence to the requirements specified in the FRNSW Fire Safety Guideline, Technical Information entitled “Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations” (current latest version is D22/107002) should be demonstrated. While a fire at the BESS is highly unlikely, given the location of the site, any need for fire water to suppress and/or disperse combustion products that could be generated in a fire (soot, gases) would need to be determined and approved by FRNSW and DPHI.
3. Emergency Management Plan and Procedures should be developed for Project construction and operation, including establishment of evacuation protocols for those not involved in emergency response and any person not wearing appropriate PPE. While highly unlikely, the possibility of gas and pressure release from a battery enclosure during a thermal battery runaway event, including the risk associated with opening a door, should be considered and communicated to first responders with appropriate responses.
4. Measures to prevent leaks from the BESS and transformers, and for containing spills if they occur, should be addressed in the detailed design phase. If fire water is to be used on site, e.g. to suppress and/or disperse combustion products that could be generated in a fire (soot, gases), containment would need to be determined.
5. If a pole was to fall over it could damage a BESS enclosure and initiate a thermal runaway and fire. The wooden light poles which are currently installed within the Project area are to be removed prior to commencement of Project construction.

GLOSSARY AND ABBREVIATIONS

AEGL	Acute Exposure Guideline Levels: Used by emergency planners and responders worldwide as guidance in dealing with rare, usually accidental, releases of chemicals into the air. AEGLS are expressed as specific concentrations of airborne chemicals at which health effects may occur. They are designed to protect the elderly and children, and other individuals who may be susceptible
AC	Alternating current
ALARP	As Low As Reasonably Practicable – term used by the DPHI for a similar concept to the SFAIRP (So Far As Is Reasonably Practicable) concept in the WHS Regulation
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
Battery rack	Physical rack which is made up of several battery cells arranged within modules connected in series or parallel. Each enclosure houses several battery racks, and each battery rack houses several battery modules (numbers to be confirmed in detailed design)
BESS	Battery Energy Storage System, a form of energy storage system relying on electrochemical batteries to store energy. A BESS consists of battery enclosure(s), a power conversion system (PCS), and associated auxiliary equipment (AC switchgear, meters, relays, and telecommunications equipment)
BMS	Battery Management System, protects the battery from harmful operation and maximises its lifespan by constantly controlling and monitoring the battery's parameters such as voltage, current, temperature, state-of-charge and state-of health, and ensuring they are within operating specifications
CCTV	Closed Circuit Television
CO	carbon monoxide
CO_2	carbon dioxide
DC	Direct Current
deflagration	a fire in which the flame travels rapidly, but at subsonic speed, and produces potentially damaging pressures
DG	Dangerous Goods
DN	diametre nominal
DPHI	Department of Planning, Housing and Infrastructure (NSW), formerly the Department of Planning (DoP)
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency

EMF	Electric and Magnetic Fields
Enclosure	A discrete energy-storage unit that includes batteries within battery racks, a cooling system, communication interface and other equipment and accessories necessary to maintain health and long-term operation in an outdoor environment. Enclosures are interconnected to form rows of enclosures. The enclosure is the fundamental building block of the ESS plant layout
ERP	Emergency Response Plan
ESD	Emergency Shut Down
ESS	Energy Storage System. ESS technologies can be classified into five categories based on the form in which energy is stored: Mechanical, Electrochemical (using batteries), Thermal, Electrical and Chemical. The proposed BESS is an electrochemical ESS
FRNSW	Fire and Rescue NSW
ha	hectare
H_2	Hydrogen (gas)
HCl	hydrogen chloride (gaseous)
HCN	hydrogen cyanide (gas)
HCs	hydrocarbons (NOS)
HF	hydrogen fluoride (gas)
HIPAP	Hazardous Industry Planning Advisor Paper (guidelines by the Department of Planning)
HV	High Voltage
HVAC	Heating, Ventilating, and Air Conditioning
IP	Ingress Protection
kg	kilogram
kL	kilolitre
km	kilometre
kV	kilovolts
LEL	Lower Explosive Limit
LFP	lithium iron phosphate
LGA	Local Government Area
LFP	Lithium Iron Phosphate (battery)
LTI	Lost time injury
LV	low voltage
m	metre

mG	milligauss
MLRA	Multilevel Risk Assessment (guidelines by the Department of Planning)
MP	Megapack
MPa	megapascal
MV	medium voltage
MVA	Mega Volt Ampere
MW	Megawatt
MWh	Megawatt-hour
NEM	National Electricity Market
NFPA	National Fire Protection Association
NSW	New South Wales
NOS	Not Otherwise Specified
PCS	Power Conversion System, converts alternating current (AC) to direct current (DC), and vice versa, to allow power flow between the BESS and the grid
PG	Packaging Group
PHA	Preliminary Hazard Analysis
PM	Preventative Maintenance
PPE	Personal Protective Equipment
ppm	parts per million
Project	Construction, operation and decommissioning of the Homebush BESS
Project Area	The area that is located within the site and constitutes the Project footprint i.e. the area that will be physically disturbed for the construction and operation of the Project, covering approximately 3.39 hectares
PTW	Permit To Work
row	A number of enclosures, connected to form a row.
runaway	Occurs when excessive heat is generated and accumulated within the battery, e.g. due to poor system design, installation or mishandling, leading to the build-up of heat and flammable (and possibly toxic) gas
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheets
SEPP	State Environmental Planning Policy
site	The area of land owned by Ausgrid forming Lot 16, Deposited Plan (DP) 270249, covering an area of 6.2 hectares
SWMS	Safe Work Method Statement
TMS	Thermal Management System

thermal runaway	See “runaway”
UL	Underwriters Laboratories
UN	United Nations
V	Volt
VOC	volatile organic compound
WHS	Work Health & Safety

REPORT

1 INTRODUCTION

Ausgrid is seeking development consent for the Homebush Battery Energy Storage System (*BESS*) in Homebush, New South Wales (NSW) adjacent to the Mason Park Sub-transmission Switching Station (STSS), located at 10 Homebush Bay Drive, Homebush (the Project).

The Project would involve the construction, operation and decommissioning of the BESS including associated infrastructure for its management and connection to the national electricity market (NEM) (the Project). The Project would be located withing the Sydney suburb of Homebush, approximately 12 kilometres (km) west of Sydney's Central Business District in NSW (*the site*).

1.1 PROJECT OVERVIEW

The Project would connect to the Mason Park sub-transmission switching station (STSS).

Key features of the Project would include:

- Construction, operation, and maintenance of a BESS with a 200 MW maximum power output capacity with 2-hour duration (i.e. 400 MWh)
- Containerised battery units (112 Megapacks) and associated infrastructure, including inverters and 56 medium voltage transformers
- 33kV underground cable connection from the battery units to Mason Park STSS infrastructure
- Combined switch room and control room building
- 8 Ring Main Units (RMU)
- Onsite workshop facility
- One auxiliary transformer
- Backup diesel generator
- Two spaces for onsite car parking
- Other ancillary infrastructure including fire suppression, stormwater management, 2.4m high boundary security chain wire fencing, acoustic barriers, lighting and CCTV.

1.2 SITE DESCRIPTION

The site is characterised by flat, sparsely vegetated land.

The site is approximately 6.2 hectares (ha) in size and is located within the suburb of Homebush, in NSW.

The Mason Park STSS, including the HV connection infrastructure, which is outside of the scope of this PHA, is located directly to the north of the BESS (on the same site) and includes above ground high voltage (HV) electricity cabling and the HV transformer. Separation distances and risk mitigation from HV transformers are set in the Australian Standard AS2067-2017 and are generally sufficient to manage risks from these to the Project. Further discussion refer to Section 4.5.2.

There are three existing (above ground) HV electricity towers adjacent and external to the BESS site boundary, with the HV cabling running externally to the site. These are of structurally sound construction and outside of the Project area, and not identified as credible threat for the Project.

A number of redundant wooden light poles are located within the Project area with cables for the lighting traversing the Project area. If a pole was to fall it could damage the BESS enclosure, initiating a thermal runaway and fire. The poles are identified as possible threat for the BESS and discussed further in this PHA. These poles will be removed prior to construction of the Project commencing.

A figure showing the site location is presented on Figure 1-1.

The key Project components of relevance to the PHA is the BESS and the connecting underground and overhead medium voltage (MV) cabling. Further details are provided in Section 2.4.

Figure 1-1: Site location

1.3 PURPOSE OF THIS REPORT

The overarching objectives of this PHA are to:

- Address the Secretary's Environmental Assessment Requirements (SEARs) for Hazards (refer to Section 1.4)
- Provide a preliminary risk screening to determine the need for and the focus for the PHA
- Address the potential hazards and risks associated with the BESS to people, property and the environment at adjacent land use, particularly from:
    - Reactions and fires associated with electrical infrastructure and flammable material, including from a battery runaway reaction
    - Spills of hazardous material
    - Threats from the surrounding development
    - Exposure to electromagnetic fields (*EMF*)
    - Threat to and from the existing Mason Park STSS and the HV connection traversing the site.

1.3.1 Report structure

This report is structured as follows:

- Sections 1 and 2 introduce the Project in the context of the PHA
- Section 3 includes the risk screening to determine whether the proposed Project is potentially hazardous industry as per the definition in use by the NSW Department of Planning, Housing and Infrastructure (DPHI)
- Section 4 includes the preliminary hazard and risk assessment covering hazard identification, the results of the risk analysis the proposed risk treatments, and the risk profile for the Project
- Section 5 includes the Conclusion of the study and lists the recommendations, including further study, to allow the Project to be established within the hazard and risk management framework set by the DPHI for land use planning
- Section 6 lists the key references and sources used for the PHA.

1.4 Secretary's Environmental Assessment Requirements

The SEARs for the Project were issued on 20 November 2024. The SEARs presented in Table 1-1 have informed the preparation of this PHA:

Table 1-1: SEARs – Preliminary Hazard Analysis

Relevant SEARs Preliminary Hazard Analysis	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;	Bushfire: Section 2.3.1 Spontaneous ignition (thermal battery runaway): Sections 4.1 and 4.2.1 Electric, Magnetic and Electromagnetic Fields: Sections 4.1.3 and 4.2.2
• Bushfire – identify potential hazards and risks associated with bushfires including the risks that a BESS would cause a bush fire and demonstrate compliance with Planning for Bush Fire Protection 2019; Dangerous Goods - a preliminary risk screening completed in accordance with the State Environmental Planning Policy (Resilience and Hazards) 2021; and	Bushfire: Section 2.3.1 Risk Screening: Section 3
• Battery Energy Storage System - a Preliminary Hazard Analysis (PHA) prepared in accordance with Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis (DoP, 2011) and Multi-Level Risk Assessment. 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.	Section 4

Ausgrid has appointed Planager Pty Ltd (*Planager*) to prepare this PHA.

As specified in the SEARS, the PHA has been prepared in accordance with the methodology in the Hazardous Industry Planning Advisory Paper No. 6 *Hazard analysis* (*HIPAP6*, Ref 1) and *Multi-level risk assessment* (*MLRA*, Ref 2) and the risk is compared with the risk criteria in HIPAP No 4 *Risk criteria for land use planning* (*HIPAP4*, Ref 3).

1.5 Exclusions and Limitations

- The PHA is based on concept design, and the results depend on the assumptions, and implementation of the commitments, made during the study and the recommendations made in the PHA
- The assessment of hazards and risks included in this PHA should be reviewed if there are any significant Project description changes as part of detailed Project development.

1.6 Safety Management Systems

This risk assessment assumes that the Project would be managed in accordance with an appropriate safety management system including control of work health and safety and asset integrity. Without such controls, the range and impact of potential hazards becomes unpredictable, and the likelihood at which incidents of any type may occur cannot be adequately estimated using historical data.

Safety management systems allow the risk from potentially hazardous installations to be managed through a combination of hardware, software and human factors. It is essential to ensure that the reliability of the hardware and software systems and management procedures allows for safe operation of the facility.

Typical workplace health and safety practices for management of potentially hazardous facilities are listed below. Policies and procedures to support the establishment and maintenance of a safe workplace will be established as part of Project development, typically including the following:

- Safe work system and procedures
- Monitoring and control of operations associated with BESS infrastructure including routine inspection and testing of protective systems
- Emergency management, including emergency procedure and procedure for pollution incident response
- Incident reporting and response systems, and first aid station(s) installed at suitable locations throughout the site
- Staff (including contractor) competency for operation, maintenance, and support of the BESS infrastructure
- Personal protective equipment (*PPE*), including those determined in the Fire Safety Study and Emergency Response Planning phase
- Site compliance with relevant Australian Codes and statutory requirements with respect to design and work conditions continued throughout the life of the BESS.

2 DESCRIPTION OF THE PROJECT

2.1 OVERVIEW

A description of the Project location is provided in Table 2-1 below, with Figure 2-1 and Figure 2-2 providing the following supporting information:

- Location of the Project area within the broader context is provided in Figure 1-1
- Locational details within the local context are shown on the map in Figure 2-1
- Zoning of the Project and the surrounding areas is provided in Figure 2-2.

Table 2-1: Locational details

Element	Description
Local Government Area (LGA)	Strathfield, Deposited Plan 1218218
Address	10 Homebush Bay Drive, Homebush 2140
Location	The Project would be located within the south east portion of the site which is located within the Sydney suburb of Homebush, approximately 12 kilometres (km) west of the township Sydney CBD in NSW
Zoning	SP2 Electricity Supply
Project site	The Project site covers approximately 6.2 ha of land, which would be occupied by the BESS including battery enclosures, MV transformers and inverters, and electrical connections (above or below ground).
site access	Access to the Project Area is proposed via an existing driveway to the Westconnex Fulton Hogan Egis Motorway MCC office and warehouse, off the eastbound on-ramp onto the M4 Western Motorway via Homebush Bay Drive.

2.2 DESCRIPTION OF THE LOCAL AREA AROUND THE SITE

Being a suburb in Sydney, the area adjacent to the site is relatively densely populated.

The land uses immediately adjacent to the site are as follows:

- The north eastern edge of the site is bordered by the DFO overflow carpark and then buildings of DFO Homebush, an outlet shopping centre and food court. This land is zoned E3: *Productivity Support*.
- The eastern edge of the site is bordered by a business centre which is on land zoned E3: *Productivity Support*. There is also a stormwater channel on the eastern border.

- The northern, western and southern edges of the site are bordered by Homebush Bay Drive (to the north-north west) and the M4 Western Motorway (to the south and south west). There is also the WestConnex Fulton Hogan Egis Motorway MCC Office and Warehouse in this location.

Beyond the major roads listed above the following are within 1 kilometre of the site:

- to the north-north west is Sydney Olympic Park (zoned B4: High Density Residential) including the Ken Rosewall Arena, Tennis World Sydney, Quay Centre and Netball Centre and other indoor and outdoor sports venues and associated facilities including food stores, carparks, roadways etc.

- to the west is a small parkland area, and then further along to the south west are “BOUNCEinc Homebush” (a recreation centre), the Wentworth Hotel and other associated facilities, and then further south west, Paddy’s Markets and Sydney Markets (zoned E3: Productivity Support and E4: General Industrial).

- The closest residential area is at Wentworth Road North and Bellona Avene [zoned R4: High Density Residential], with the closest residential houses located at approximately 60 metres from the site boundary (139 metres from the nearest battery enclosure). Another residential area, located at Flemington Rd is to the south, south west, between Park Road and Parramatta Road, is at 200 metres from the site boundary. There is another residential area approximately 600 metres to the west of the site at Telopea and Courallie Avenues (zoned R3: Medium Density Residential).

The closest sensitive developments (using the definitions in HIPAP4, Ref 3) are:

- Hospitals, including Concord Repatriation General Hospital (approximately 2.5 km away), Newington Medical (approximately 3 km away), and Auburn Hospital (approximately 4 km away)

- Schools, including Concord West Public School (approximately 2.5 km away) and Newington Public School (approximately 3 km away)

- Daycare centres, including Kids First Learning Centre (approximately 2 km away) and St Joseph’s Child Care Centre (approximately 2.5 km away).

- Prison, Silverwater Correctional (approximately 3.5 km away).

Clearance to onsite and off-site receptors is discussed in Section 4.5.

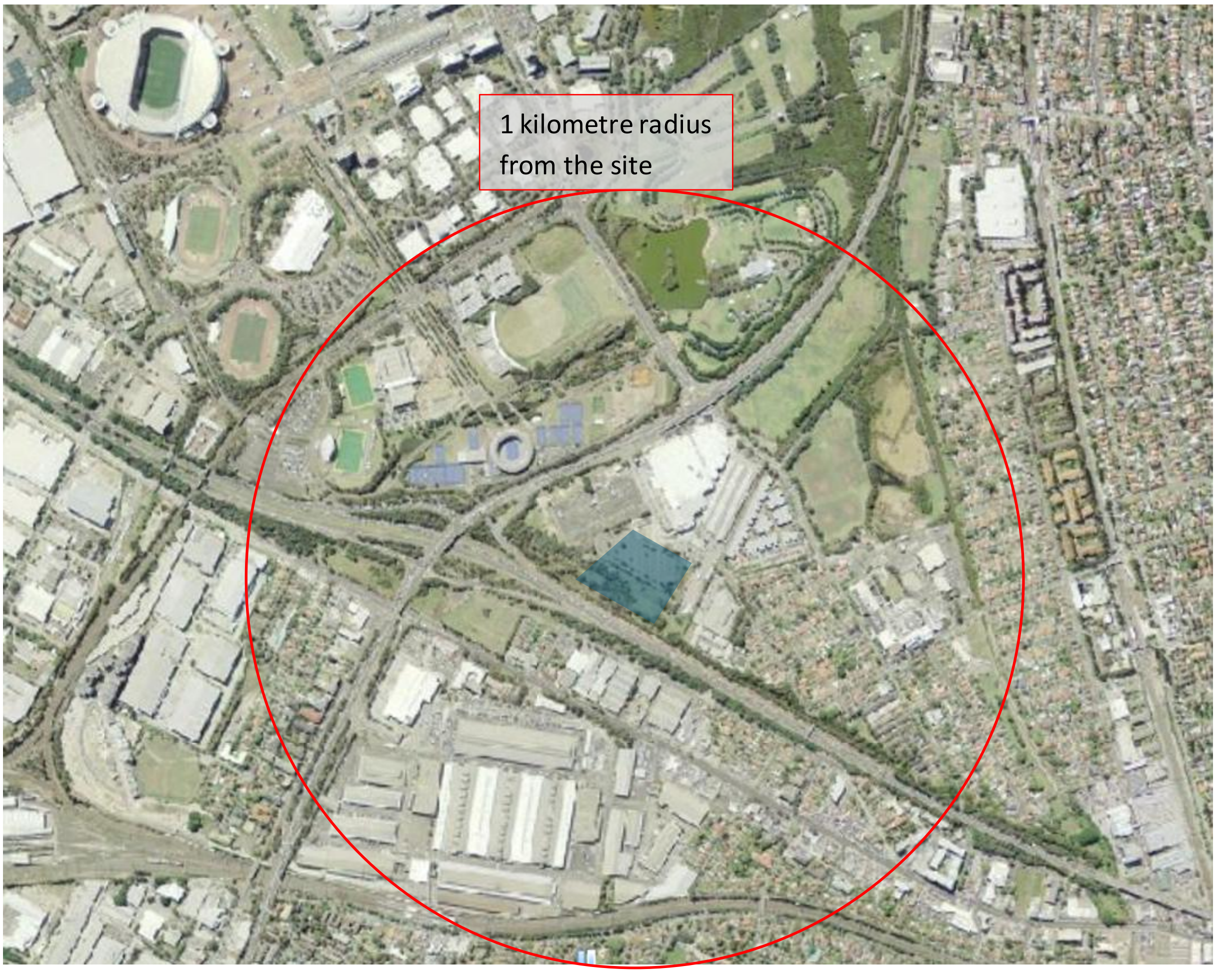

Figure 2-1: Locality map

Figure 2-2: Land zoning map

2.3 ENVIRONMENTAL BASELINE

The BESS potential for exposure to a nearby fire, flooding, earthquake, land subsidence events and for lightning strike is moderate to low, as detailed below.

2.3.1 Fire in the nearby area

Should a fire occur in the nearby area, including a bush or grass fire, it has the potential to impact the site infrastructure. If damage occurs at the BESS battery enclosures this may initiate a thermal runaway reaction and fire at the batteries, and/or oil spill and fire at the MV transformers.

A fire at the BESS presents unusual risks to firefighters, such as potential electrocution and/or inhalation of toxic fumes. It is anticipated that the site infrastructure, including battery enclosures, will be installed on compacted gravel or concrete slabs, with combustible materials reduced as far as possible to lower the risk of fire being initiated within, or propagated from, the BESS.

Given the type of construction in the area adjacent to the BESS, and the distance between battery enclosures and the boundary and between battery enclosures and any major locations where combustible material is held, the threat from nearby fires impacting the BESS can be managed in accordance with the OEM manual which specifies a minimum of 1.53m exposure clearance (refer to recommendation 1). Given the low amount of vegetation at the Project area, the removal of existing vegetation to the south east of the site, and the site not being located on bushfire prone land, the risk of a bush fire threatening the BESS is very low and a bushfire assessment against Planning for Bush Fire Protection 2019 is not warranted for the Project. Therefore, this threat is not discussed further in the present PHA, but a recommendation of continued vegetation management is included.

2.3.2 Flooding

Should flooding occur during construction and/or operation of the BESS it has the theoretical potential to result in the accidental spill or discharge of chemicals or hydrocarbons, such as fuels and oils in vehicles and/or equipment, with the potential to contaminate surface water and/or groundwater.

Potential impacts to surface water quality and flooding on surrounding land, including impediments to the flow of water will be considered in the hydrology assessment as part of the EIS, and will be prepared as part of detailed design. Any recommendations following completion of the surface water and hydrology assessment will be managed as part of the detailed design stage, and the risk of flooding is not discussed further in the present PHA.

2.3.3 Earthquake and landslide

The EIS indicates that the Project would not be located within a known mapped mine subsidence district, and that the risk of landslide is low.

Should earthquake occur, it has the theoretical potential to result in an initiation of a thermal runaway reaction and fire at the batteries, and an oil spill and fire at the transformers. The Geoscience earthquake risk map (sourced from Ref 4), shown in Figure 2-3, indicates a low earthquake risk for the site.

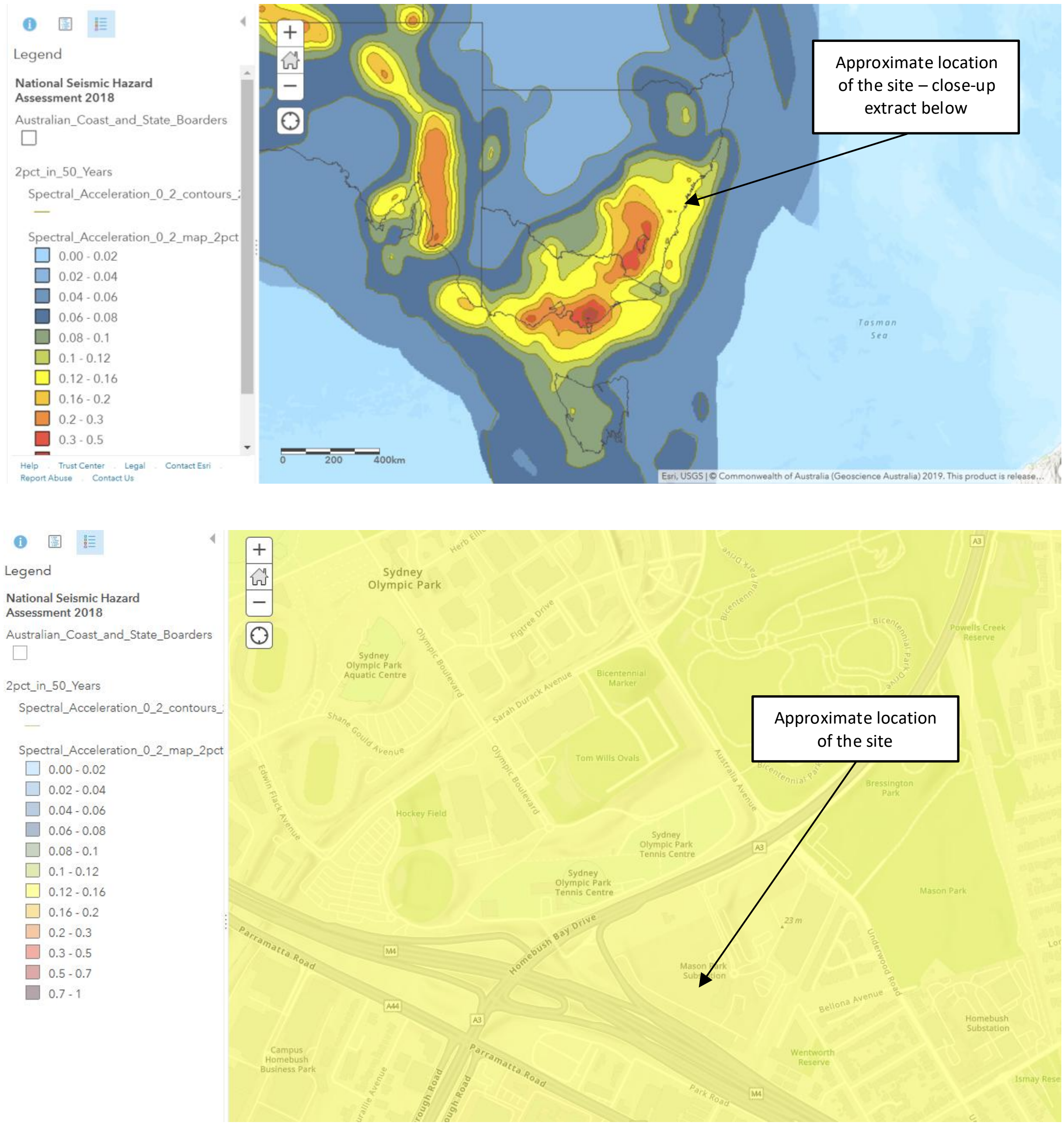

Figure 2-3: Extract from Geoscience earthquake risk map showing earthquake risk at the BESS area (downloaded from Geoscience Australia website on 28 November 2024)

This risk would be adequately managed by implementing the requirements under the Australian Standard AS/NZ 1170 Part 4 *Earthquake actions in Australia*.

The risk associated with landside and earthquake is low and is not discussed further in the present PHA.

2.3.4 Lightning strike

Should a lightning strike occur during construction and/or operation of the BESS, it has the theoretical potential to result in damage to BESS infrastructure, the initiation of a thermal runaway reaction and fire at the batteries, and an oil spill and/or fire at the MV transformers. In addition, a lightning strike has the theoretical potential to result in damage to overhead transmission infrastructure and equipment associated with the BESS.

The Bureau of Meteorology annual average thunder days and lightning-ground flash density map for Australia (Ref 5), shown in Figure 2-4, indicates that the site is located in a region that experiences 1 to 3 flashes per square kilometre per year (20 to 25 thunder events per day per square kilometre per year), which is similar to that for much of the East Coast in Australia, including Sydney.

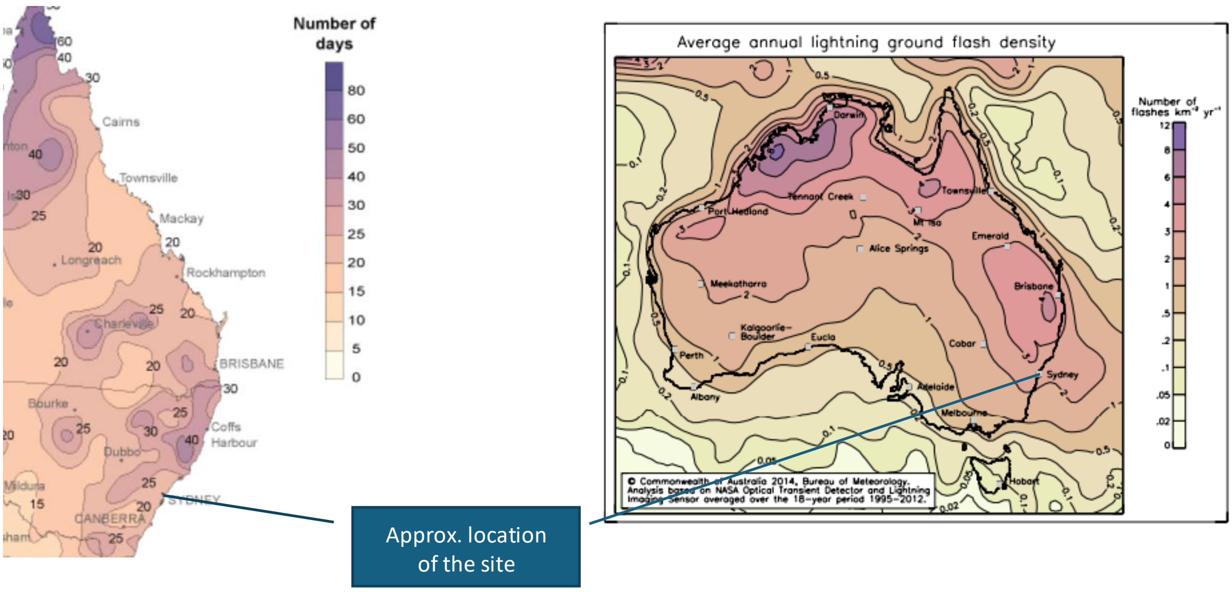

Figure 2-4: Extract from Bureau of Meteorology maps: LEFT - Annual average thunder days for the BESS area; and RIGHT - Average annual lightning ground flash density (downloaded from BoM website 28 November)

The likelihood of lightning strike is moderate and would be adequately managed by implementing the requirements under the Australian Standard AS/NZS 1768 *Lightning protection* in the design and installation of BESS infrastructure, including installation of lightning rods, and the risk is not discussed further in the present PHA.

2.4 BESS AREA LAYOUT AND INFRASTRUCTURE

An indicative Project configuration is provided in Figure 2-5 and the layout is provided in Figure 2-5. A summary of the major design parameters for the Project is presented in Table 2-2. These may change through the detailed design and procurement stages of the BESS.

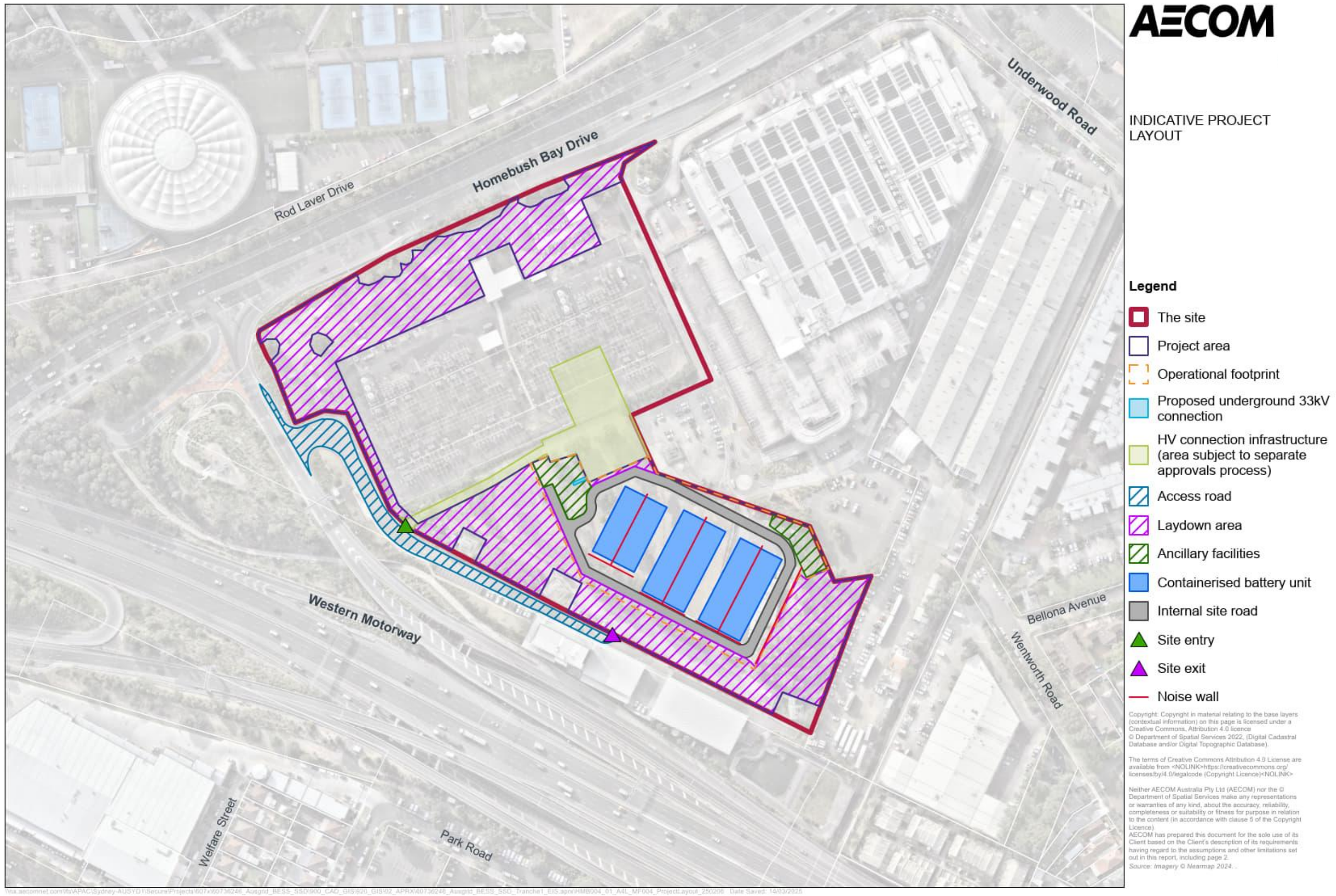

Figure 2-5: Indicative Site layout

Table 2-2: Summary of major design parameters

BESS element	Description
Overall area	The Project will be located within the site (of 6.2 hectares, not in the scope of this PHA), which includes the existing Mason Park STSS, switchyards and transmission line and a new HV transformer.
BESS battery, inverters, and Medium Voltage (MV) transformers (medium voltage)  	BESS storage and discharge capacity : 200 MW/400 MWh. The registered capacity of the Project with AEMO will be 200MW/400MWh. To achieve the registered capacity at the point of connection the number of battery units equates to 112 Megapack units with a total capacity of 431MWh to account for losses within the system Operating cycle: One cycle per day is expected[1] but is not material for the outcome of this PHA. Battery technology: lithium iron phosphate (LFP) LiFePO4 Battery module and enclosure model and manufacturer: Tesla MegaPack 2XL (*MP2XL*) Battery modules arranged in racks within BESS containers (referred to as enclosures in this PHA). This enclosure would stand at a height of approximately 2.75 m, with a footprint of 1.65 m by 8.8 m (Ref 6). The site would fit 112 Megapacks separated in accordance with Tesla's recommendations. Power Conversion System (PCS), including inverters and transformers, are integrated within the BESS enclosures. These increase the voltage from low (LV) to medium voltage (MV). The maximum height of the infrastructure (the enclosures and the PCS units) within the BESS would be 2.8 metres and up to 7 metres with the lightning masts (to be confirmed during detailed design). A typical BESS arrangement is shown in Plate 1.
Permanent ancillary infrastructure	• Combined switch room and control room building • 8 Ring Main Units (RMU) • Onsite workshop facility • One auxiliary transformer • Backup diesel generator • Two spaces for onsite car parking

[1] The actual frequency of charge / discharge cycles will depend on market conditions in the National Electricity Market.

BESS element	Description
	• Other ancillary infrastructure including fire suppression, stormwater management, 2.4m high boundary security chain wire fencing, acoustic barriers, lighting and CCTV.
Construction laydown area	The laydown area is likely to include: • Temporary construction compound located as indicated as 'Laydown area' in Figure 2.5 • Temporary workers' carpark • Stockpiles and laydown areas for equipment and materials
Control and safety features	Control and safety features would include a fully integrated operating system for comprehensive control, asset management, and system visibility. The battery enclosures would be equipped with: • An integrated battery management system (BMS) to provide monitoring and safety functions, including detection and response to abnormal operation and emergency shutdown • A thermal management system, using liquid cooling, to maintain a suitable operating temperature within the enclosures • Fire and gas detection and shut down would be integrated within the Thermal Management System (TMS) • Physical safety functions such as overpressure/deflagration venting, locks, open door sensors etc.
Design environment of buildings and battery enclosures on the site	Environmental conditions, to be considered/defined at the detailed design stage, typically include: • Maximum and minimum design temperatures • Ingress Protection (IP) rating such that the battery enclosures would be protected against dust and water ingress that could be harmful for the normal operation of the battery • Level of lightning protection required as per AS 1768-2021 *Lightning protection*

An indicative example of the battery enclosure arrangement is shown in Plate 1.

Plate 1: Example of a MegaPack 2XL containerised BESS arrangement

2.5 SECURITY, ACCESS AND EGRESS

2.5.1 Security

The site is currently fenced along the property boundary with chain mesh wire fence which will remain in place throughout the operation of the BESS. A new padlock will be installed on the gate entry into site during construction. Following completion of construction, the site will retain the same fencing around the site boundary, and the BESS footprint will have new fencing installed around it with chain mesh wire 2.4m high (to be finalised in detailed design).

The existing Mason Park STSS is located on the same site but bounded by security fencing to delineate the infrastructure. The new substation HV (132kV/33kV) transformer will also be located within the project area but will be fenced separately to the existing STSS and the BESS.

Access to the site during operation would be restricted by locked security gates. Movement-triggered security lighting and security devices such as closed-circuit television (CCTV) cameras would also be installed around the Project footprint.

Warning signs would be installed at the entry point to the site and at the various battery enclosures and new substation in accordance with Codes and Standards, and will clearly communicate the presence of hazardous areas, the need for authorised access, and any specific safety protocols to be followed. The signage will include emergency contact information and directions for safe evacuation in case of an incident.

2.5.2 Access and egress

The site is accessed via Homebush Bay Drive, which connects the recreational precinct on Australia Avenue and the commercial precinct of DFO Homebush, off Underwood Road. The primary access point to the Project would be off a slip road which can be accessed from the eastbound onramp onto the M4 via Homebush Bay Drive. The Project does not require any new access points and will take access off an existing driveaway to the Westconnex Fulton Hogan Egis Motorway MCC office and warehouse, off the eastbound on-ramp onto the M4 Western Motorway via Homebush Bay Drive.

Internal access roads would be provided to enable vehicular access around the site during both construction and operation.

2.6 EASEMENTS

There are three HV transmission lines leaving the Ausgrid substation which run adjacent to the Project area, and do not traverse the Project area.

There are a number of wooden light poles located within the Project area, with cables for the lighting traversing the site. The risk of the light poles and cables causing a harm to the BESS is assessed in Section 4.2.4.

2.7 ACTIVITIES

2.7.1 Construction and commissioning phase

The construction and commissioning work that would be required for the BESS is summarised in Table 2-3.

Table 2-3 Summary of construction and commissioning work

Aspect	Description
General activities	• Site establishment and enabling works, including establishment of site access; erosion and sediment controls; exclusion zones etc. and transport plant, equipment and materials to the site

Aspect	Description
	• Construction of BESS foundations for enclosures, MV transformers and any buildings, including earthworks, footings and construction of hardstand to support BESS infrastructure; construction of internal access roads for transporting BESS elements to their respective site location; construct, install and connect above ground plant, equipment and structures. Connect to surrounding utilities (including to the existing Mason Park STSS). • Commissioning, including testing of BESS elements to ensure their safe operation in accordance with relevant electrical standards and quality and environmental management systems and processes. • Demobilisation and rehabilitation works, including removal of construction equipment and temporary construction facilities and rehabilitation of disturbed areas (e.g. laydown areas).
Construction hours	• Monday to Friday 7.00 am to 6.00 pm • Saturday 8.00 am to 1.00 pm • No works on Sundays and Public Holidays
Workforce	• During the peak of construction, it is estimated around 50 workers per day would enter and exit the site. This number would vary throughout construction, with commissioning only requiring up to five workers.
Duration of construction activities	• It is anticipated that construction of the Project would commence in Q3 2025 and be completed by Q2 2027 (approximately 24 months). However, these dates are subject to change pending equipment lead times and availability.
Vehicle movements	• Vehicle movement during site construction will include trucks delivering the Tesla Megapacks and other infrastructure to the site (concrete, materials, floats for large equipment, and tankers with oil for the MV transformers). Light vehicles will also be used to transport workers and light equipment and materials.

2.7.2 Operational phase

The details of the operational phase of the Project are summarised in Table 2-4.

Table 2-4 Summary of operational phase activities

Aspect	Description
Design life	Up to 50 years (this may be extended subject to replacement of components).
Operational hours	The BESS is designed for one charging and one discharging cycler per day on average but can also operate at reduced power and adopting several shallow cycles. The BESS would be operated remotely 24 hours per day, 7 days per week.

Aspect	Description
Workforce	The BESS is expected to operate unmanned on a 24 hours per day, seven days per week basis, with regular maintenance undertaken during normal operating hours. One full-time equivalent employee would be expected to regular undertake operational and maintenance activities. If necessary, reactive or emergency maintenance can be undertaken outside of standard operating hours, however this would be a rare occurrence. During these occasions the number of personnel on site may increase to approximately five persons.
Typical operational activities	Typical operational activities are: • Remote monitoring and control of the BESS and substations • Maintenance and management of equipment, site buildings and landscaping • General office activities • Receipt of goods • Waste removal.
Typical operation and maintenance procedures and/or management plans	Activities requiring procedures and/or management plans would typically include, but would not necessarily be limited to: • Routine inspections covering electrical, civil and environmental operational performance • Pest control and vegetation management, including weed control • Preventative maintenance and other activities as defined in the operation and maintenance management plans • Corrective maintenance activities including testing and replacing of faulty plant components such as modules, fuses and other corrective actions within operation and maintenance scope.
Deliveries	• There will be minimal vehicle movement on and off the Project area during the operational phase of the facility. • Ad hoc deliveries of replacement parts would be unlikely to exceed one delivery per day on average.

2.8 Significant Guidelines and Regulatory Compliance

An overview of the statutory framework that applies to ensuring the safety of BESS infrastructure, and that forms the basis of this PHA, is listed below[2]. Only those that are directly related to the PHA are included.

Legislation and Regulation:

- NSW *Work Health and Safety Act 2011* and *Work Health and Safety Regulation 2017*
- NSW *Electricity Supply Act 1995*, Electrical Supply (General) Regulation 2014 and *Electricity Supply (Safety and Network Management) Regulation 2014*
- *NSW Environmental Planning and Assessment Act 1979* and *Environmental Planning and Assessment Regulation 2021*.

Governmental policy and guideline documents:

- State Environmental Planning Policy (SEPP) *Resilience and Hazards*, 2021 (Ref 7), Chapter 3 *Hazardous and offensive development*
- *Applying SEPP 33*, 2011 (Ref 8)
- *HIPAP 6: Guideline for Hazard Analysis,* 2011 (Ref 1)
- *Multi-level Risk Assessment guideline*, 2011 (Ref 2)
- HIPAP 4: Risk criteria for land use planning, 2011 (Ref 3)
- HIPAP 10: *Land use safety planning,* 2011 (Ref 9)
- *Planning for Bushfire Protection*: A guide for councils, planners, fire authorities and developers, 2019 (Ref 10).

Codes and Standards

While large-scale BESSs, such as the one proposed for the Project, are relatively new in Australia, there are numerous Australian Codes and Standards and protocols that apply.

[2] The full list of Acts, Codes, Standards and guidelines would be identified by the Engineering Contractor selected for each element of this BESS, with the Engineering Contractor ultimately responsible for nominating the applicable Codes and Standards.

In addition, as per common practice in BESS development, the Tesla MP2XL documentation refer to a number of several international Codes and Standards including:

- (US) National Fire Protection Association (NFPA), e.g. NFPA-855, Ref 11
- (US) Underwriters Laboratories (UL)

3 RISK SCREENING

3.1 INTRODUCTION

The objective of risk screening described in the MLRA guideline (Ref 2), is to determine whether a proposed development or facility is considered to be '*potentially hazardous industry*' as per the following definition by the DPHI:

> *'Potentially hazardous industry' means a development for the purposes of an 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.*

Additionally, and irrespective of the outcome of the risk screening process, DPHI can request that a PHA be developed for a proposal, based on other considerations in a PHA (Refs 7, 9).

Development that is deemed to be *potentially hazardous industry* must undergo a rigorous PHA as per the requirements set in the guidelines for hazard analysis in SEPP (*Resilience and Hazards*) 2021 (Ref 7) Chapter 3 and HIPAP 6 (Ref 1), to determine the risk to people, property and the environment. *Other types of hazards* have been assessed in accordance with the DPHI guideline document *Applying SEPP 33* (Ref 8).

In this PHA, the *development* is referred as *the Project*.

3.2 RESULTS

The MLRA screening for the BESS is presented in the following tables:

- Table 3-1: *Storage of hazardous materials*
- Table 3-2: *Transport of hazardous materials*
- Table 3-3: *Other types of hazards*.

Table 3-1: Storage of hazardous materials

DG Class	Category	Hazardous material proposed	Proposed quantities	SEPP33 threshold[3]	Exceeds SEPP33[3] threshold?
2.2	Non-flammable, non-toxic gas	Refrigerant compressed gas in the enclosures	3 kg per enclosure (total of 336 kg, distributed in small quantities in discrete locations)	DG Class 2.2 is excluded from screening process	No
3 PGI PGII or PGIII	Flammable liquids	Flammable liquids in small containers	Minor, in DG cabinet on-site (e.g. solvents for maintenance or during construction phase, not exceeding 20 L typical).	2 tonnes (3PGI) or 5 tonnes (3PGII and PGIII) for no restrictions on distance to boundary	No
6	Toxic and infectious substance	Weedicide / herbicide	Small amounts, held on-site in DG cabinets. Would not exceed 1 tonne	2.5 tonnes	No
8	Corrosive material	Corrosive liquids in small containers	Small amounts e.g. acids for use during maintenance cleaning, held on-site in DG cabinets. Would not exceed 5 tonnes	5t PG I 25t PG II 50t PG III	No
9	Miscellaneous dangerous goods	Lithium ion (LFP) batteries held on-site	Each enclosure can weigh up to 40 tonnes in total, with a proportion of this being LFP. (total of 4,480 tonnes, distributed in 112 in discrete locations)	DG Class 9 is excluded from screening process	No
9	Miscellaneous dangerous goods	Coolant in each enclosure: mixture of ethylene and glycol	400 L per enclosure. (total of 45 m^3, distributed in small quantities in 112 discrete locations)	DG Class 9 is excluded from screening process	No

[3] Now incorporated within the SEPP *Resilience and Hazards*

DG Class	Category	Hazardous material proposed	Proposed quantities	SEPP33 threshold[3]	Exceeds SEPP33[3] threshold?
-	Oil	Oil and other petroleum products for use in switchgear and in the transformers	In the MV transformers within the BESS: nominally 4 m^3/unit; 56 units = 224m^3 total, distributed in discrete locations	Combustible liquid is excluded from screening process	No
Legend:			Not potentially hazardous (Ref 8)		Potentially hazardous (Ref 8)

Table 3-2: Transport of hazardous materials

Hazardous material	DG Class and Packaging Group	Category	Vehicle movements applicable for the BESS		SEPP33[3] threshold (vehicles carrying DGs)	Proposal exceeds SEPP33[3] threshold?
			Cumulative annual	Peak weekly		
LFP batteries (BESS)	DG Class 9	Miscellaneous dangerous goods	Ongoing operations: 1 During construction: Less than the threshold of 1,000 vehicles annually	Ongoing operations: Zero During construction: Less than the threshold of 60 vehicles weekly	>1,000 (annual) >60 (peak weekly)	No
Coolant	Not a DG	Not expected to be combustible or toxic	Ongoing operations: Zero During construction: Less than the threshold of 1,000 vehicles annually	Ongoing operations: Zero During construction: Less than the threshold of 60 vehicles weekly	>1,000 (annual) >60 (peak weekly)	No
Refrigerant compressed gas may be used in battery enclosures or racks (at the BESS)	DG Class 2.2	Non-Flammable, Non-Toxic Gases	Ongoing operations: Zero During construction: Less than the threshold of 1,000 vehicles annually	Ongoing operations: Zero During construction: Less than the threshold of 60 vehicles weekly	>1,000 (annual) >60 (peak weekly)	No
Petroleum products (in transformers) and diesel	Not DGs	Combustible liquid C1 (AS 1940)	Ongoing operations: 10 During construction: Less than the threshold of 1,000 vehicles annually	Ongoing operations: Zero During construction: Less than the threshold of 60 vehicles weekly	>1,000 (annual) >60 (peak weekly)	No
Legend:		Not potentially hazardous (Ref 8)		Potentially hazardous (Ref 8)		

Table 3-3: Other types of hazards

Other Types of Hazards	Applicable (Yes or No)	Results of the screening	Proposal exceeds SEPP333 threshold?
Any incompatible materials (hazardous and non-hazardous materials)	No	No incompatible materials identified for this BESS	No
Any wastes that could be hazardous	Yes	No significant hazardous wastes identified for the construction or operation of BESS infrastructure	No
Types of activities the dangerous goods and otherwise hazardous materials are associated with (storage, processing, reaction) – if different to tables above	No	No additional, associated activities	No
Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition	Potentially yes	Runaway reaction associated with LFP batteries has occurred in other similar BESSs in the past. Hydrogen release is possible under fault conditions, with subsequent fire/explosion hazard. If toxic gas is released in a battery fire, then toxic exposure may occur.	YES, due to potential for runaway reaction within battery cells which may become a precursor for a battery fire
Storage or processing operations involving high (or extremely low) temperatures and/or pressures	No	No conditions with high (or extremely low) temperatures and/or pressures identified as associated with BESS infrastructure	No

Other Types of Hazards	Applicable (Yes or No)	Results of the screening	Proposal exceeds SEPP333 threshold?
Details of known past incidents (and near misses) involving hazardous materials and processes in similar industries	Potentially yes	Runaway reaction associated with LFP batteries has occurred in other similar BESS facilities in the past. Overhead powerlines cross the Project Area. Incidents have occurred in Australia and internationally where construction activities have damaged buried transmission lines.	YES, due to past thermal runaway reaction (spontaneous ignition) at incidents similar BESSs and due to construction hazards near the overhead powerlines
The BESS may threaten the particular qualities of the environment (for example, the likely presence of rare or threatened species, watercourses)	Potentially yes	No threatened environment in the vicinity of the BESS	NO
The nature of the hazards that the environment would be exposed to, and the likely response of the environment to such a hazard, and the reversibility of any hazardous impact	Potentially yes	Information available for the BESS is such that environmental pollution cannot be ruled out at the concept design stage	YES: subject to detailed design

Legend:		Not potentially hazardous (Ref 8)		Potentially hazardous (Ref 8)

3.3 CONCLUSIONS OF THE PRELIMINARY RISK SCREENING

The results of the preliminary risk screening show the following:

- The expected storage of hazardous materials associated with the Project would not exceed the relevant risk screening threshold
- The expected transport of hazardous materials associated with the Project would not exceed the relevant risk screening threshold.

On the basis of storage and transport alone, the Project would not be considered *Potentially hazardous* under the definition within the MLRA guidelines, which correspond to that in Chapter 3 of SEPP (*Resilience and Hazards*) 2021. The application of Codes and Standards is sufficient to mitigate the risk, and no further assessment would be required in the present study.

Based on *Other types of hazards* (Ref 8), DPHI considers the Project to be *potentially hazardous industry* and as such requires a PHA for the Project as per the requirements set in the guidelines for hazard analysis in SEPP (*Resilience and Hazards*) 2021 (Ref 7) Chapter 3 and HIPAP6 (Ref 1), to determine the risk to people, property and the environment.

An assessment of *Other types of* hazards have found that the following potential hazards are associated with this Project:

- *Thermal runaway (including due to spontaneous ignition) and fire in a battery enclosure*, which has the potential to be harmful to people in the area and to lead to propagation to nearby infrastructure
- *Loss of containment of pollutant material from the BESS infrastructure* if there is a spill from the battery enclosure, transformers, generator or landing gantries, e.g. oil, cooling medium, or diesel. In particular, the environmentally constrained land within the Project area is vulnerable to any degree of pollution and requires protection
- *Electrical fault or failure to control electrical energy (including EMF)* has the potential to be harmful to people in the area, and an arc flash can lead to propagation to nearby infrastructure
- *Fire in nearby area (overhead powerlines traverse the site)* may cause damage and escalation to BESS infrastructure
- *Incident during construction activity causes impact with infrastructure*, e.g. damage to the light poles and cables for the lighting which traverses the site, or to a battery enclosure.

Based on *Other types of hazards,* and on DPHI's particular requirements for a PHA for the BESS, a Hazard Analysis including a detailed Risk Analysis are included in the following sections of this report.

4 PRELIMINARY HAZARD AND RISK ASSESSMENT

4.1 HAZARD IDENTIFICATION

4.1.1 Introduction

A rigorous hazard identification process has been conducted for the Project to ensure the following are identified and defined, at the early design phase of the Project:

- All reasonably foreseeable hazards and associated events that may arise during the construction, commissioning and operation of the Project, and
- The proposed management of these hazards.

The hazard identification is based on a desktop review undertaken by Planager, including a review of the following factors and inputs:

- BESS infrastructure, location, workforce, local environment, adjacent land use, and construction, commissioning, operation and maintenance activities and threats
- Type of equipment and other known significant incidents that have occurred in similar facilities, and recent developments in research and standards for BESS facilities
- Materials and their energies and properties
- External factors, including a fire in the nearby area, flooding, earthquake and landslide, lightning strike, and the proximity of the light poles and cables for the lighting which traverses the Project area. Based on the findings in Section 2.3, only the light poles and cables is carried forward for further assessment in this PHA, with other potential threats being managed using the applicable Codes and Standards (refer to details in Section 2.3).

Events with a potential to result in major consequence impacts to people (injury and/or fatality), the environment and to assets are identified. The study excludes hazards related with Work Health & Safety (*WHS*), i.e. slips, trips and falls.

4.1.2 Material hazards and inventories

The inventories and potentially hazardous properties of materials typically stored and handled during the construction, commissioning and operations phases of the BESS are detailed in Table 4-1 (inventories from Table 3-1).

Table 4-1: Materials inventory and hazardous properties associated with the BESS

Material	Inventory	Description and potential hazards
Commissioning and operations phases		
Lithium Iron Phosphate (LFP) batteries	*Commissioning & operations:* Nominally 40 tonnes/unit, 112 units = total 44,800 tonnes, with a proportion of this being LFP *Construction:* none prior to delivery of enclosures to site, then as above	Fire at a LFP battery may be caused through uncontrolled reaction (e.g. thermal runaway leading to spontaneous ignition), overcharge, short-circuit, damage or decomposition within a cell. Thermal runaway is triggered when battery cells reach a certain temperature (anticipated around 270°C for LFP batteries). The heat source can be internal (i.e. due to a fault at the battery cell or electrical connection) or external (e.g. from a bush or grass fire, or other source of fire in the nearby area). The self-heating ignition occurs when the heat release rate from exothermic chemical reactions exceeds the environmental cooling rate. Because of the exothermic reactions involving the electrodes and electrolyte, the battery can undergo self-heating in the absence of external impact. A fire event would generate heat and possible deflagration overpressure if flammable vapours were ignited. Projectiles may be generated and/or cell explosions may occur if off-gases are not vented effectively. Generation of toxic gases may also be formed during a worst-case thermal runaway event (Ref 12). It is possible for a LFP battery to re-ignite due to the exothermic reactions that continue to occur within the battery cell. Where burning battery cells are located close to combustible material within the enclosure, or close to other battery cells, or if the battery enclosure is located close to other infrastructure, there is a potential for propagation to other areas and escalation of the fire event. Detailed analysis, refer to Section 4.2.1.
Coolant	*Commissioning and operations*: Nominally 400 L per unit, 112 units = total 45 m^3 (Ref 15) *Construction*: none prior to delivery of enclosures to site, then as above	Some type of coolant may be used in the battery racks or enclosures, likely to be a non-DG material of low hazard. The battery coolant consists of a mixture of ethylene glycol and water. While pure ethylene glycol is a combustible liquid (Ref 13), when mixed with water it becomes non-combustible, but, if water is driven off in a fire it can participate in the combustion reaction. This is unlikely to significantly increase the heat radiation from a battery fire which would largely be defined by the combustible material within the battery and enclosure. The effects from this potential hazard are likely to be confined to the site or during transport to the site (well below the SEPP33 screening thresholds, Ref 8).

Material	Inventory	Description and potential hazards
Refrigerant	*Commissioning and operations*: Nominally 3 kg/unit, 112 units = total 336 kg, distributed in small quantities in discrete locations *Construction*: none prior to delivery of enclosures to site, then as above	The battery rack includes a refrigerant, composed of a single or mixture of non-flammable non-toxic compressed gases (DG Class 2.2) or solids. If refrigerant compressed gases are used, the chiller unit may explode if heated. Contact with compressed gases may cause frostbite. Exposure is likely to be harmful (all routes). The effects from this potential hazard are likely to be confined to the site or during transport to the site (well below the SEPP33 screening thresholds, Ref 8).
Oil	*Commissioning and operations:* Typical quantities, up to around 220m^3 in separate discrete location around the BESS area in the MV transformers (nominally 4 m^3/unit; 56 units = 224m^3) *Construction*: limited amounts (typically up to 5 m^3) and other materials typical for construction activities, prior to delivery of transformers etc. to site, then as above.	*Oil* is expected to be used and handled, e.g. as insulating oils and in the transformers. The main hazard associated with oil relates to environmental pollution in case of a loss of containment, and with toxicity in case of human exposure. Oil is combustible and, while difficult to ignite in atmospheric conditions, it can result in a pool fire and can pose a serious fire hazard if not contained. The effects from the potential hazards associated with oils are likely to be confined to the site or during transport to the site (well below the SEPP33 screening thresholds, Ref 8).
Small amounts of flammable and/or combustible material, e.g. oil, diesel, acetone, and other solvents. Small amounts Corrosive liquids and aerosols. For use e.g. for cleaning during construction and maintenance activities	*Commissioning, construction and operations*: Limited amounts, typical for construction activities	Small amounts of flammable or combustible material (e.g. diesel, petrol, superglue, solvents, thinners and paints) and small amounts of corrosive and toxic liquids (e.g. small containers of hydrochloric acid and other corrosives for surface preparation, pesticide for ground clearing etc.) are expected to be stored and handled during the construction phase of the Project. The quantities of DGs and other potentially hazardous/pollutant material would be held well below the SEPP33 screening thresholds (Ref 8). Further, transportation of DGs would be well below the SEPP33 *Transportation Screening Thresholds* (Ref 2, Table 2). These are not considered *potentially hazardous* (Ref 2), and application of Codes and Standards cover this hazard and is not discussed further in this PHA.

4.1.3 Potential hazards and their control

The outcome of the hazard identification review is formally detailed in the *Hazard identification word diagram* in Appendix 1, including:

- Hazardous incident / event
- Possible causes
- Worst-case credible consequences (assuming no active controls in place)
- Preventative and protective safeguards
- Potential for impact outside boundary.

A summary of the types of hazards associated with the BESS is provided in Table 4-2.

Only those hazards that may give rise to a significant potential for harm, in accordance with HIPAP6 (Ref 1), are included.

4.1.4 Hazard identification findings

As detailed in the Hazard Identification Word Diagram, a total of 4 hazardous events have been identified, as follows:

1. *Thermal runaway (including due to spontaneous ignition) and fire in a battery enclosure* within the BESS leads to a fire and generation of heat, and flammable vapours and with the potential to generate toxic combustion gases
2. *Loss of containment of pollutant material from the BESS infrastructure*, e.g. oil from the MV transformers, or cooling water from the refrigerant system in the BESS
3. *Electrical fault or failure to control electrical energy (EMF; electrical interference)* at electrical equipment (inverters, MV transformers, and electrical cabling) causing fire, arc flash, and/or exposure to excessive levels of EMF
4. *Mechanical or thermal damage of enclosures (fire in neighbouring area, light poles and cables damage or construction activity)* leads to fire in the battery enclosure.

These may arise due to a range of causes including impact, failure to manage operating conditions and failure to maintain, as per the Hazard Identification Word Diagram in Appendix 1.

Table 4-2: Overview of the types of hazards associated with the BESS (HIPAP6 type hazards only)

BESS element	Electrical hazards	Energy hazard incl. EMF	Fire hazard	Explosive hazard	Pollution hazard	Toxic hazard	Key Standard
BESS	Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	NFPA 855, UL9540, (AS 5139)
MV transformers and inverters.	✓	Note 2	Note 6	Note 2	Note 5	✓	AS 2067, AS 1940
MV electrical connections	✓	Note 2	Note 6	✓	Note 5	✓	AS 2067, AS 1940
General fires in buildings	-	-	Note 3	-	-	✓	NCC, National Construction Code
External (natural events), overhead powerlines or construction impact	Note 7	Note 7	Note 7	-	-	-	Various see Appendix 4

Notes:

1. Electrical hazard remains when battery is isolated
2. Arc flash incident and exposure to EMF
3. Fire may be caused by internal or external threats
4. Batteries may release flammable gases such as hydrogen under fault conditions, which is regarded as an explosive gas hazard. Fire or heat exposure to the refrigerant unit may cause it to disintegrate releasing overheated compressed (non-flammable) gases with ejection of material
5. Failure to contain a spill e.g. of transformer oil or coolant, may cause pollution
6. The UL 9540A *Cell* and *Module Level Testing* for the Tesla MP battery did not measure any toxic gases venting from the cells or the module. However, a worst case fire may involve plastics and other combustible construction material within the enclosure (e.g. in electrical cabling or building material/contents) and evolve toxic combustion material. As no gas sampling was reported for the Unit Level Test or the Destructive Unit Level Test (Ref 15) to rule out this hazard, toxic combustion products cannot be ignored for a worst-case fire in a Tesla MP2XL enclosure.
7. A. nearby building or structure fire hazards; lightning strike; security breach event, construction activities – Application of Codes and Standards suffice.

   Overhead powerlines traverse the site.

In addition (outside the scope of the PHA) mechanical hazards are associated with the BESS infrastructure, e.g. weight, sharp edges and corners, moving parts, falling over, tripping, seismic, and lack of lifting or securing.

4.1.5 Level of analysis

The MLRA guidelines (Ref 2) provides a decision tool that is to be used to determine the level of analysis in a PHA.

The tool is based on quantities of DGs and their distance to the site boundary and other considerations.

The level of analysis for each potential hazardous incident is shown in Figure 4-1 below. Further details are provided in Table 4-3.

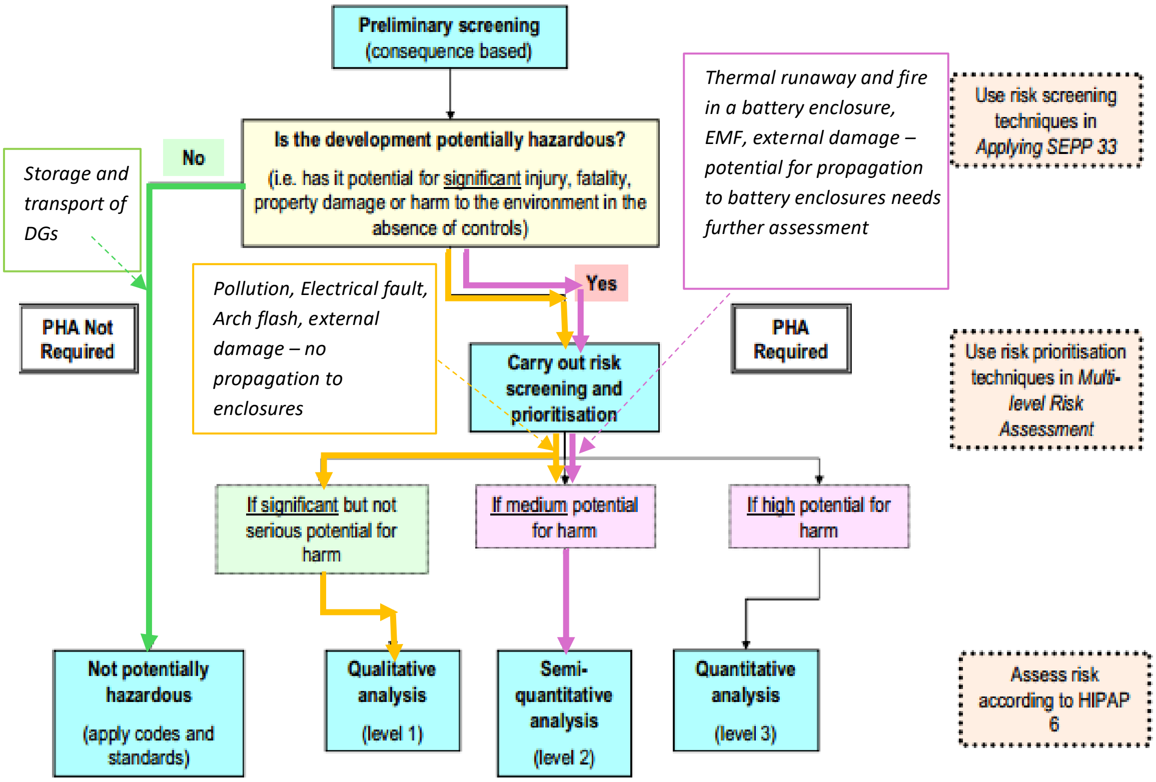

Figure 4-1: Level of analysis in the PHA (figure extracted from the per Multi-level Risk Assessment guidelines, Ref 2)

Table 4-3: Level of risk analysis required, as determined using MLRA guideline methodology

Incident	Type effect	Qualitative	Semi-quantitative	Quantitative	Comment
1. Thermal runaway (including due to spontaneous ignition) and fire in a battery enclosure within the BESS	Heat radiation		✓		Purple arrow in Figure 4-1. Medium potential for harm outside site boundary. If uncontrolled, heat radiation from a major fire technically has the potential to initiate an incident in adjacent environment and infrastructure or escalate to further BESS infrastructure. Semi-quantitative assessment in Section 4.2.1.
	Deflagration / overpressure	✓			Orange arrow in Figure 4-1. Significant but not serious potential for effect outside site boundary. While potentially significant within the site, it is not expected to cause significant effects outside the boundary. Qualitative assessment in Appendix 2.
	Toxic gas		✓		Purple arrow in Figure 4-1. Medium potential for harm outside site boundary. If uncontrolled, heat radiation from a major fire technically has the potential to initiate an incident in adjacent environment and infrastructure or escalate to further BESS infrastructure. Semi-quantitative assessment in Section 4.2.1.
2.Loss of containment of pollutant material (transformer oil, cooling water, diesel)	Environmental pollution	✓			Orange arrow in Figure 4-1. Significant but not serious potential for effect outside site boundary. While potentially significant on site, it is not expected to cause significant effects outside the boundary. Qualitative assessment in Appendix 2.

Incident	Type effect	Qualitative	Semi-quantitative	Quantitative	Comment
3. Electrical fault or failure to control electrical energy at electrical equipment (inverters, MV transformers, electrical cabling)	Arc flash	✓			Orange arrow in Figure 4-1. Significant but not serious potential for effect outside site boundary. While potentially significant on site, it is not expected to cause significant effects outside the boundary. Qualitative assessment in Appendix 2.
	Heat radiation transformer oil / cabling fire	✓			Orange arrow in Figure 4-1. Significant but not serious potential for effect outside site boundary. While potentially significant on site, it is not expected to cause significant effects outside the boundary. Qualitative assessment in Appendix 2.
	Electromagnetic fields		✓		Purple arrow in Figure 4-1. If uncontrolled, electro, magnetic and electromagnetic fields technically have the potential to cause harm. Medium potential for harm outside site boundary. Semi-quantitative assessment in Section 4.2.3.
4. External threat of mechanical or thermal damage (fire in neighbouring area or overhead powerlines) causes damage, or incident during construction activity	Impact with battery enclosure	✓	✓ (if escalation to scenario #1		Purple arrow and Orange arrow in Figure 4-1 depending on the outcome: - Unless the incident causes a thermal runaway reaction at a battery enclosure, the outcome would be Significant but not serious potential for effect outside site boundary. Qualitative assessment in Appendix 2. - If the incident causes a thermal runaway reaction at a battery enclosure (scenario #1), then Medium potential for harm outside site boundary. Semi-quantitative assessment included in Section 4.2.4.
	Impact with light poles and overhead powerlines	✓	✓ (if escalation to scenario #1)		
Notes: No high potential for harm outside of the site boundaries has been identified as part of this PHA. Threats from natural events or from the nearby area, such as a nearby building fire, lightning strike, flooding etc. are analysed in Section 2.2, covered using Australian Standards, and not discussed further in this PHA.					

4.2 Risk analysis and risk treatment

A detailed evaluation of all potentially hazardous incident scenarios is provided in Appendix 2, with further details for those scenarios that have been deemed to have the potential for impact outside of the site boundary provided in the following sections below:

- Thermal runaway and fire in a battery enclosure: discussed in Section 4.2.1 (heat radiation) and Section 4.2.2 (toxic combustion products)
- Electromagnetic Field (EMF), discussed in Section 4.2.3.

4.2.1 Thermal runaway and fire in a battery enclosure: Heat radiation

A battery event may be initiated by a thermal runaway and spontaneous ignition within a battery cell which propagates to other parts (cells, modules, racks) within the enclosure. This may be caused by electrical system failures (damage to wiring, fuse or breaker failure) or by mechanical interference (mishandling, rodents, impact during construction activities).

While the following three possible outcomes are considered in Appendix 2, the first two (generation of heat from a fire and toxic combustion gases[4]) are assessed to have the most significant consequences if not controlled, and are assessed further in the body of the report:

- Generation of heat from a fire in the battery enclosure
- Generation of toxic combustion gases from a thermal event in the battery enclosure
- Overpressure from a deflagration event in the battery enclosure.

Generation of heat from a fire

A thermal runaway in a battery enclosure is possible despite all precautions taken during design, operation and maintenance. Provided the BESS (cells, modules, enclosures) are designed such that a fire does not propagate to other areas within the BESS it is unlikely that the event will cause significant harm outside of the Project area.

[4] This potential threat is assessed due to the proximity of the BESS to populated areas

Four sets of tests have been performed to assess the fire potential in the Tesla MP2XL enclosure during a thermal runaway event:

- UL 9540A *Cell Level Testing*, consisting of a test whereby thermal runaway is initiated via film strip heaters installed on both of the wide side surfaces of five individual battery cells in separate tests
- UL 9540A *Module Level Testing*, consisting of a test on an entire MP2/2XL tray of batteries, whereby six cells are simultaneous heated, forcing multiple cells into thermal runaway at the same time
- UL 9540A *Unit Level Testing*, similarly to the Module Level Testing, consisting of a test on an entire MP2/2XL tray of batteries, whereby six cells are simultaneous heated, forcing multiple cells into thermal runaway at the same time, but within a fully populated battery enclosure.
- *Destructive Unit Level Test*, simultaneously heating forty-eight interior cells withing a fully populated enclosure, with the objective to simulate a mass failure of nearly half the tray resulting in a forced thermal event.

The final test (the *Destructive Unit Test*) is regarded by Tesla as representing the most severe (and least likely) fire scenario involving a Tesla MP2XL and is additional to and more severe than the UL 9540A testing regime.

A fire propagating within, and involving, an entire battery enclosure as a result of thermal runaway or other means and in the absence of active fire safety systems is considered by FRNSW as a credible (although highly unlikely) scenario (refer to the FRNSW Ref 14). To meet the requirements of FRNSW for fire safety, an enclosure design, together with BESS layout and separation distances (enclosure to enclosure and to other potential receptors) must demonstrate that an enclosure fire will not propagate to other battery enclosures or equipment/infrastructure.

Only the results of the Destructive Unit Level Test, representing a worst case credible fire scenario for a single enclosure, are discussed in this report.

The Tesla MP2XL configuration is provided in Figure 4-2 (reproduced from Ref 15).

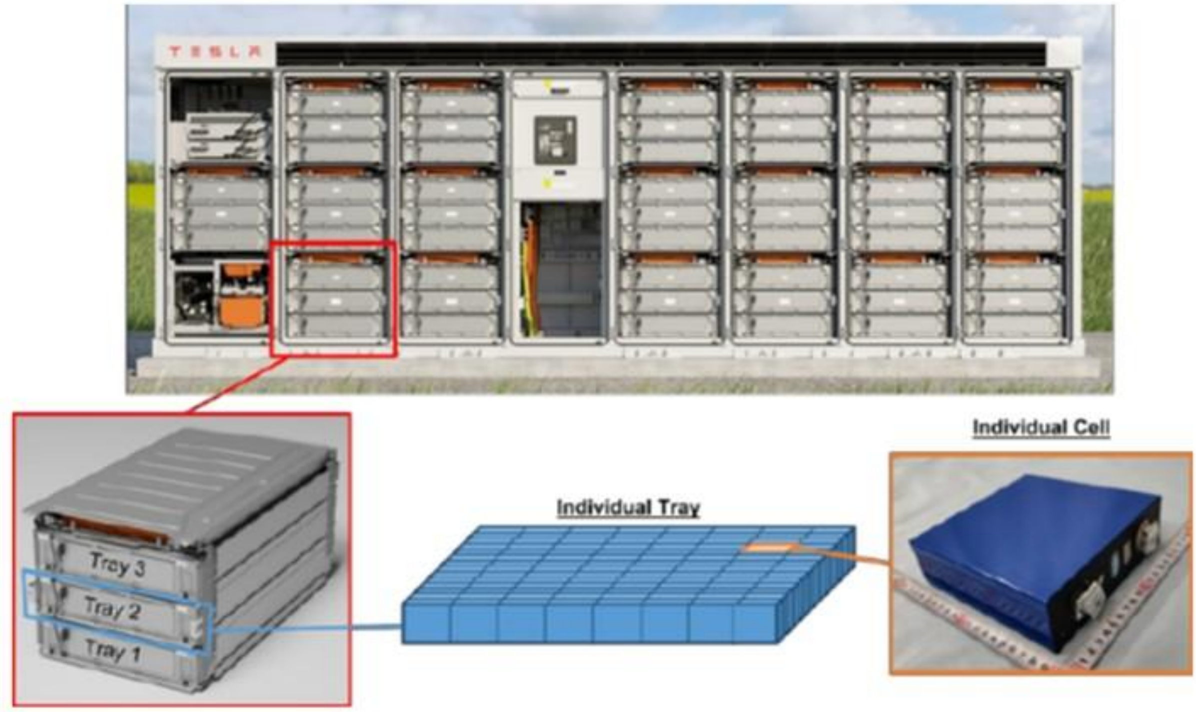

Figure 4-2: Configuration inside one Tesla MP2XL; figure reproduced from Ref 15)

The heat flux model developed by Tesla (as reported by Fisher Engineering, Ref 15) was used to determine the potential for propagation of a thermal event in one battery enclosure to adjacent enclosures. A summary of the results from the heat flux calculation model is presented in Table 4-4. All assumptions and calculations are as per the information pertained from the Fisher Engineering report in Ref 15.

Table 4-4: Heat flux model summary results (Tesla MP2XL, Ref 15)

Radiation emitting from	Wind weather condition	Receptor location and distance		Max predicted (calculated) heat flux (kW/m^2)
Enclosure cabinet (hot surface)	With or without wind	Back / side receptor	0.152 m	5.12
			0.457 m	4.40
			0.914 m	3.65
			1.219 m	3.18
			2.438 m	2.90
Flames: front of the MP2/2XL Enclosure cabinet	No wind (vertical flames)	Front receptor	2.438 m	8.50
	Wind tilts flames 45° towards the receptor	Front target	2.438 m	11.77
Flames: top of the MP2/2XL Enclosure cabinet	Wind tilts flames 45° towards the receptor	Back / side receptor	0.152 m	12.83

The heat radiation impact at neighbouring infrastructure in case of a large-scale fire in a battery enclosure is shown in Table 4-5.

Table 4-5: Heat radiation at the closest off-site receptors from a large-scale fire

<table>
<tr><th>Nearby infrastructure</th><th>Distance from closest BESS enclosure (metres)</th><th>Heat radiation (Fisher Engineering, Ref 15)</th><th>Comments</th></tr>
<tr><td colspan="4">Off-site receptors</td></tr>
<tr><td>Closest boundary, i.e. that to the south</td><td>16</td><td>Less than 2 kW/m^2</td><td>Well below 3 kW/m^2 which is commonly defined as the heat radiation level which could cause discomfort[5]</td></tr>
<tr><td>Main carpark (multi-storey building) at the DFO (closest infrastructure to the BESS)</td><td>58</td><td rowspan="5">Much less than 2 kW/m^2</td><td rowspan="5">At this distance, the heat radiation associated with a fire at the BESS facility is not likely to be significant</td></tr>
<tr><td>Overflow carpark at the DFO</td><td>18</td></tr>
<tr><td>Building at DFO, closest to the BESS</td><td>113</td></tr>
<tr><td>Nearest residential boundary (off Verley Drive)</td><td>139</td></tr>
<tr><td>WestConnex Fulton Hogan Egis Motorway MCC Office</td><td>40.5</td></tr>
<tr><td colspan="4">On-site receptors</td></tr>
<tr><td>Closest adjacent row of enclosure</td><td>2.44</td><td>No wind: 8.50 kW/m^2
Wind tilting fames 45^{o} towards the receptor: 11.70 kW/m^2</td><td>Based on the fire propagation model developed by Fisher Engineering (Ref 15), in the unlikely event of a battery enclosure fire, and accounting for severe wind conditions tilting the fames 45^{o} towards the adjacent row of enclosures, thermal runaway is not likely to propagate to the adjacent row of enclosures.</td></tr>
</table>

[5] This assessment does not include the potential for embers generated in the fire, starting a fire beyond the site boundary. There would be no significant impact on adjacent land users expected from this scenario.

The National Fire Protection Association (*NFPA*) 855 is widely regarded as one of the world´s most comprehensive Codes of Practice for BESS. NFPA 855 specifies that BESS may be installed with 3.048 metres between units but allows smaller separation distances if the enclosures meet with the stringent requirements set in the UL 9540 A *Test method for evaluation thermal runaway fire propagation in Battery Energy Storage Systems*, or equivalent standard. UL9540A testing examines the propagation potential of BESS systems at cell, module and unit level. This distance can be reduced to 0.914 metres where the abovementioned large-scale fire test demonstrates that the fire will not propagate or otherwise threaten the closest exposure.

The Tesla MP2XL has achieved certification to UL 9540A.

This, together with the Destructive Unit Level Test results, are used by Tesla to demonstrate that a thermal runaway does not propagate (enclosure to enclosure and to other potential receptors), and the key performance criteria for adequate safety has been met.

On the basis of the results of the heat flux modelling by Fisher Engineering (Ref 15) on behalf of Tesla, the Tesla MP2XL, presents a low risk of on-site impact from this scenario.

4.2.2 Generation of hazardous combustion products

Two sets of tests were performed to assess the generation of flammable and toxic combustion products during a thermal runaway event, in the absence of any active controls such as the BMS or the TMS:

- UL 9540A Cell Level Testing, consisting of a test whereby thermal runaway is initiated via film strip heaters installed on both of the wide side surfaces of five individual battery cells in separate tests.
- UL 9540A Module Level Testing, consisting of a test on an entire MP2/2XL tray of batteries, whereby six cells are simultaneous heated, forcing multiple cells into thermal runaway at the same time.

The combustion products released during the tests were collected and analysed. Similar gases evolved during both cell and module tests. The gases evolved during the module test, being the largest of the 2 tests, are listed in Table 4-6.

Table 4-6: Products of Combustion: UL 9540A Module Level Testing (Tesla MP2X, Ref 15)

Gas Name	Chemical Structure	Measurement Peak (ppm)	Gas Name	Chemical Structure	Measurement Peak (ppm)
Carbon monoxide	CO	204.84	Hydrofluoric acid	HF	Not detected
Carbon dioxide	CO2	6720.62	Hydrogen chloride	HCl	Not detected
Methane	CH4	67.83	Hydrogen cyanide	HCN	Not detected

Gas Name	Chemical Structure	Measurement Peak (ppm)	Gas Name	Chemical Structure	Measurement Peak (ppm)
Acetylene, Ethene, Ethane	C_2H_2, C_2H_4, C_2H_6	17.11 Not detected, Not detected	Hydrogen	H_2	446
Propane, Butane	C_3H_8, C_4H_{10}	Not detected, Not detected			
Pentane, Benzene, Hexane	C_5H_{12}, C_6H_6, C_7H_{16}	Not detected, 9.01 Not detected			
Total hydrocarbons	Propane equivalent	246.53			

The test results showed that gases generated during the cell and module were flammable.

The tests also showed that, despite the fact that toxic gases are sometimes associated with lithium-ion batteries, such as HF, HCl, and HCN, such toxic combustion products were not detected during the cell or module tests.

To provide additional products of combustion data, gas samples were collected during an internal, UL 9540A Unit Level Test performed by Tesla on the MP2. The test results found that HF was detected at values of 0.10 and 0.12 parts per million (ppm) in the two sampling locations. This trace quantity was detected over the entire 2½ hour test duration, meaning it was the cumulative quantity that was measured over the entire duration of the test. For reference, according to National Institute for Occupational Safety & Health (NIOSH), HF's Immediately Dangerous to Life or Health (IDLH) value is 30 ppm, indicating the quantity of HF detected during the unit level products of combustion fire test is well below, two orders of magnitude lower, than the IDLH value for HF.

As described previously, FRNSW considers a credible incident to be one in which a fire propagates within the battery enclosure with the active fire safety systems disabled and involves a full battery enclosure. This incident is beyond the UL 9540A testing regime and is more closely aligned with the Destructive Unit Level Test that was conducted by Tesla, whereby 48 cells were simultaneous heated, forcing multiple cells into thermal runaway at the same time.

Combustion gases were not collected by Tesla during the Destructive Unit Level Test. It is therefore not possible to rule out that toxic gases would be generated during a full enclosure fire. These gases were generated during other battery enclosure fire tests, (e.g. Ref 16).

DNV research (Ref 16) into the emissions from battery fires concluded as follows:

The average emissions rate of a battery during a fire condition is lower per kilogram of material than a plastics fire, as shown in Figure 5. However, the peak emissions rate (during thermal runaway of a Li-ion battery, for example) is higher per kilogram of material than a plastics fire, as shown in Figure 4. This illustrates that a smouldering Li-ion battery on a per kilogram basis can be treated with the same precautions as something like a sofa, mattress, or office fire in terms of toxicity, but during the most intense moments of the fire (during the 2-3 minutes that cells are igniting exothermically) precautions for toxicity and ventilation should be taken.

The fumes may be released from the opening of the deflagration panel in the roof of the enclosure or via other openings (vent, seals, door etc).

Considering that hazards associated with building fires involving plastic, sofa, mattress, office materials are well known and understood by fire authorities, this risk is unlikely to pose a significant hazard to surrounding land use. It is unlikely that the toxic combustion products would pose a significant hazard for people outside of the site boundary, due to the following factors:

- In an open air, outdoor BESS, as is the case for the Homebush BESS, the concentrations of toxic gas generated may pose a hazard on the site.
- The smoke plume generated by the fire would be at a temperature that is significantly higher than ambient and most of the combustion products are likely to be carried up to an altitude where they would be dispersed to below hazardous levels, without harm to people in the vicinity.
- Atmospheric monitoring was undertaken at two locations during the Victorian Big Battery fire incident at Geelong (which occurred on 31/7/2021) and subsequent response. This monitoring did not identify air quality outside limits. The learnings from the Victorian BESS fire indicate that at least on a windy day there was only limited toxicity in the fire plume emitted from the fire. While a toxic smoke warning was initially issued by the Fire Rescue Victoria (FRV) to people downwind of the fire, there appears to have been no real threat to the community from the toxic gases in the smoke, as confirmed by atmospheric monitoring[6].

Despite the low likelihood of the major enclosure fire and the very low likelihood of the harm from toxic combustion products, emergency responders should take a precautionary approach and always don protective equipment and breathing apparatus before approaching a burning or smoking battery enclosure or other electrical fire. Those on the site or near a fire who are not involved in providing emergency response and who are not wearing appropriate breathing apparatus should be evacuated away from the incident area. Advice regarding the use of PPE, including breathing apparatus, and evacuation will be included in the emergency planning documentation for the Project.

[6] Refer to EPA AirWatch data Moorabool Sites and to various news articles online at the time of the fire

Given that the toxic combustion products from a BESS fire are likely to be similar to those from a building fire, such as one involving construction plastics or general furnishing (sofa, mattress, Ref 16), current understanding is that the consequences to people's health and safety is unlikely to be severe at the nearest off-site occupied locations (such as at the main road, DFO or at one of the other nearby residential areas).

Standard practices by FRNSW, to manage combustion products from a building fire would apply also for those potentially generated in a major incident at the BESS.

The need for fire water to aid in the dispersion of combustion products generated in the fire (soot, gases) would need to be determined as part of the detailed design process including during the Fire Safety Study development; and Emergency Response Plans and Procedures would need to be developed for the site, in consultation with FRNSW (refer to Recommendations 2 and 3).

4.2.3 Electromagnetic Field (EMF)

Whenever electrical equipment is in service, it produces an electric field and a magnetic field. The electric field is associated with the voltage of the equipment and the magnetic field is associated with the current (amperage). In combination, these fields cause energy to be transferred along electric wires.

- *Electric fields*: Being related to voltage, the electric fields associated with high voltage equipment remain relatively constant over time, except where the operating voltage changes. The strength of the electric field depends on the voltage and is present in any live wire whether an electrical appliance is being used or not.
- *Magnetic fields*: Being related to current, the magnetic field strength resulting from an electrical installation varies continually with time as the load on the equipment varies.

The electric and magnetic fields associated with electrical equipment, whilst interrelated, are not dependent on each other and as such can exist independently.

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) states (in Ref 17) that there is no established scientific evidence that exposure to electric and magnetic fields (EMF) causes adverse health effects. However, there are some epidemiological (population) studies that have reported a possible association between prolonged exposure to extremely low frequency (ELF) magnetic fields at levels higher than typical and increased rates of childhood leukaemia.

Typical values of magnetic fields measured near powerlines and substations are listed in Table 4-7. The values can be compared with typical values of magnetic fields in household appliances in Table 4-8 (from Ref 17).

Since late 2016, ARPANSA has adopted the international guideline published by ICNIRP in 2010. The *Reference Levels* set out in the guideline are derived from the levels at which interactions with the central nervous system are established, with a safety factor applied and a further adjustment to simplify compliance measurement. It should be noted that these criteria are independent of duration of exposure. The reference levels established by the ICNIRP and adopted by ARPANSA are provided in Table 4-9.

Table 4-7: Typical values of magnetic fields measured near powerlines and substations

Source	Location of measure	Range of measurement (milligauss (mG))	Reference
Substations	At substation fence	1 – 8	Ref 17
High voltage connection (HV powerlines)	Directly underneath (if overhead)	10 – 200	Ref 17
High voltage connection (HV powerlines)	At edge of easement	2 - 50	Ref 17
33 kV above or belowground cable	Above ground option: - Directly underneath - At edge of easement Below ground option[7]: - 1m above ground - 20 m from source	 10 – 200 2 - 50 24 1	 Ref 17 Ref 17 Ref 18 Ref 18
The PCU – assuming the same levels as substations[8]	Outside PCU	1 – 8	Ref 17
The BESS – assuming the same levels as substation[8]	Outside battery enclosure	1 – 8	Ref 17

Table 4-8: Typical values of magnetic fields (ARPANSA, Ref 17)

Source	Location of measure	Range of measurement	(milligauss (mG))
Electric stove	at normal user distance	2 – 30	Ref 17
Refrigerator	at normal user distance	2 – 5	Ref 17
Electric kettle	at normal user distance	2 – 50	Ref 17
Hair dryer	at normal user distance	10 – 70	Ref 17

[7] Values are for a 400 kV underground cable (stronger than proposed transmission line of 330 kV)
[8] This is a conservative assumption. In reality, the magnetic fields at a Battery enclosure will much lower than for a substation as they operate at voltage <1kV

Table 4-9:- ARPANSA limits – electric and magnetic fields, (2002, updated 2016)

Field type	Public limits		Occupational limits	
	Magnetic Field (μT rms)	Electric Field (volts per meter rms)	Magnetic Field (μT rms)	Electric Field (volts per meter rms)
Reference Levels for Time Varying Fields at 50 Hz (AC)	100	5,000	500	10,000
Guidance Levels for Static Fields (DC)	56,600	14,100	283,000	28,300

For comparison, ten milligauss (mG) equal one microTesla (μT).

The magnitude of the EMF at a location is inversely proportional to the distance from the current carrying elements. As such, increasing the distance between the conductor and the receiver is a valid approach to managing EMF exposure.

The closest public receiver to the site is the WestConnex Fulton Hogan Egis Motorway MCC Office at approximately 50 metres from the site. The building at the DFO, closest to the BESS is at approximately 113 metres from the site. The nearest residential boundary (off Verley Drive) is at approximately 150 metres. At these distances, the effect from electromagnetic fields will be negligible.

4.2.4 External threat of mechanical or thermal damage

Two potential external threats have been identified as needing investigation as part of this PHA:

- Incident unrelated to the BESS, e.g. fire in the nearby area or damage to the light poles and overhead cables which threatens BESS infrastructure (i.e. BESS battery Tesla Megapack):
  - The worst case consequence consists of an impact damage at a battery enclosure which results in a thermal runaway and fire, as evaluated in Section 4.2.1 and 4.2.2 and further in Appendix 2.
  - Damage to infrastructure below a transmission tower is rare, and existing safety measures, as per Australian Standards and Ausgrid internal Codes of Practice suffice to ensure the safety of this infrastructure. In addition, the transmission lines which run within the site are outside of the Project area. HV towers are constructed in steel and well maintained as per Ausgrid internal Codes of Practice. As such, they are not discussed further in this PHA.
  - There are existing light poles and overhead cables transversing within the Project area which may fall and cause damage to the BESS infrastructure.

- BESS construction activity causes damage to the overhead powerlines:
  - Incident during BESS construction may impact the overhead powerlines causing failure and subsequent damage at a battery enclosure which results in a thermal runaway and fire, as evaluated in Section 4.2.1 and 4.2.2 and further in Appendix 2.
  - Control of construction activities near overhead powerlines are well known and understood and covered by Australian Standards and Ausgrid internal Codes of Practice.

4.3 BESS RISK PROFILE

4.3.1 Introduction

The risk matrix approach provides a qualitative/semi-quantitative methodology for determining risk and, as such, is useful for risks requiring a Level 1 or 2 analysis (as defined in the MLRA guidelines). This approach determines the risk by combining the consequence and likelihood of each nominated incident scenario using a risk matrix which has been calibrated in accordance with the risk criteria for land use safety planning in place in NSW (HIPAP4).

As per HIPAP4, risk evaluation considers whether the level of risk meets (a) generally acceptable risk criteria and whether (b) it has been reduced ALARP. The risk evaluation has three possible outcomes:

- *Well below the acceptable criteria*: further risk reduction may be impractical
- *Sufficiently close to or above the acceptable criteria*: further risk reduction controls to be investigated in detail using ALARP principles
- *Well above the acceptable criteria*: further controls need to be found, or continued operation questioned.

Guidelines are provided in the HIPAP4 (Ref 3) to allow for a demonstration that a risk is eliminated or prevented, or where that is not possible, controlled to a level which can be regarded as ALARP.

4.3.2 Risk outside of the site (off-site risk)

The Project risk profile for land use outside of the site is shown in the risk matrix in Figure 4-3. Only the highest risk ranking for each scenario is shown.

The risk profile outside of the outside of the site boundary is ranked as *Acceptable* with no notable effects.

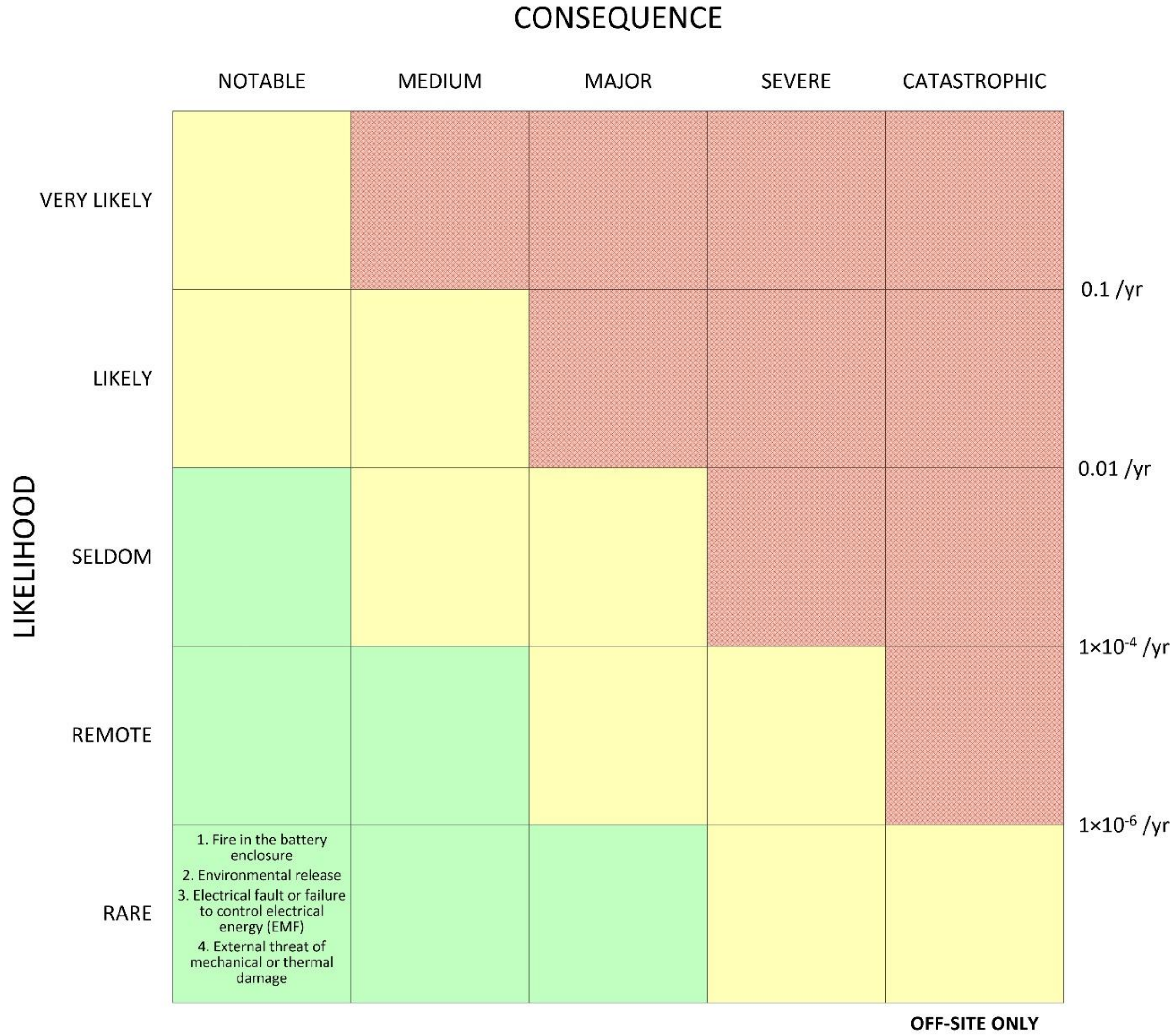

Figure 4-3: Risk profile - Outside of the site land use

4.3.3 Risk within the site (on-site risk)

The Project risk profile for land use within the site is shown in the risk matrix in Figure 4-4. Only the highest risk ranking for each scenario is shown.

The risk inside the site boundary (i.e. on-site risk) is ranked consistently as *ALARP* except for exposure to EMF which is ranked as *Acceptable*. Severe consequences to onsite personnel are associated with the following scenarios:

- Fire in the battery enclosure
- Arc flash and electrocution associated with electrical equipment

- External threat of mechanical or thermal damage, including damage to the light poles and overhead cables, a fire in the nearby area or damage during construction activities causes impact on the battery enclosures and subsequent thermal runaway and fire.

The scenarios are well known and understood and, provided that the requirements in Codes and Standards are implemented, the risk can be managed to ALARP requirements.

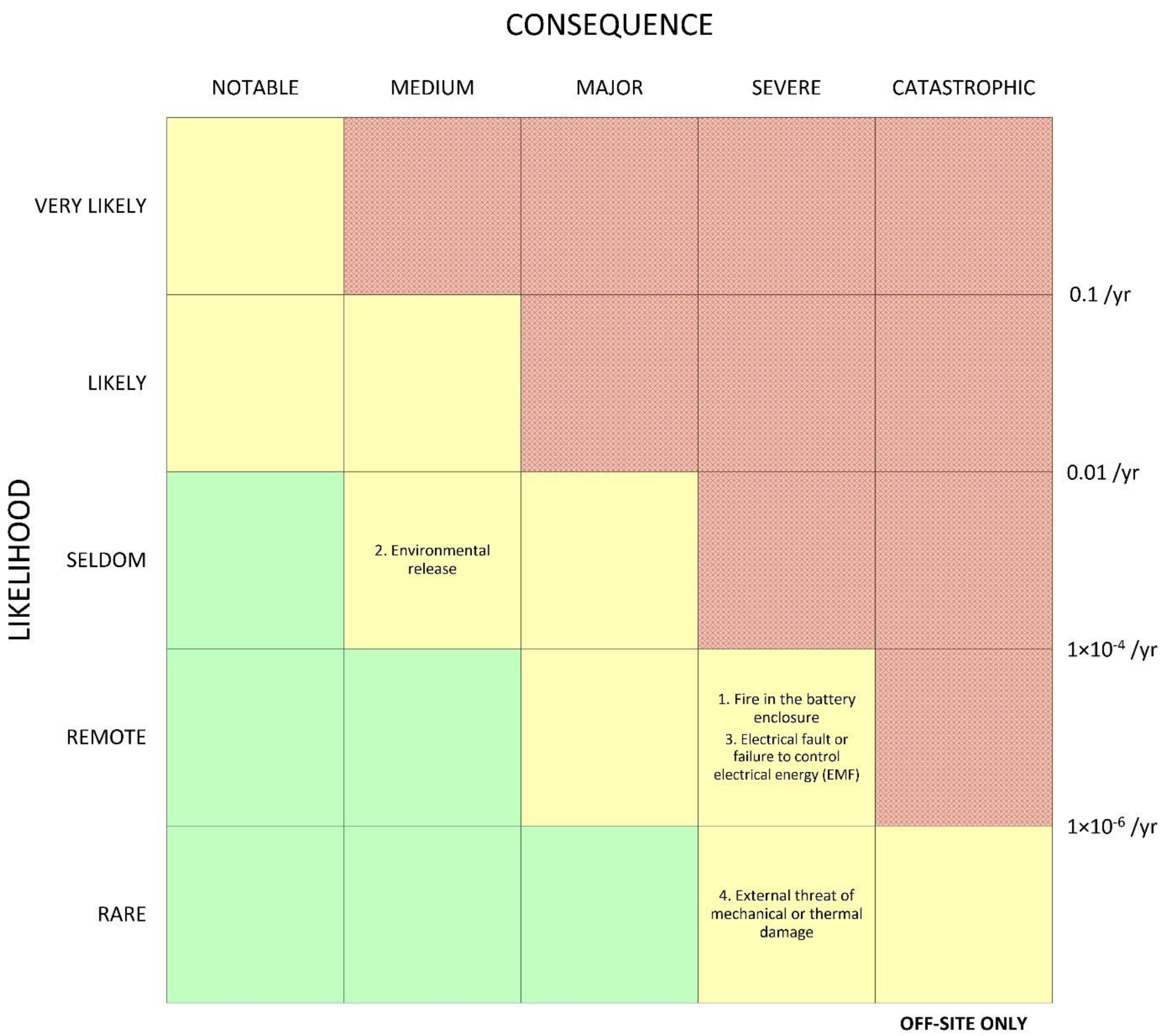

Figure 4-4: Risk profile - Inside the BESS area

4.4 BESS FOOTPRINT

Minimising the risk of a fully developed fire in one battery enclosure from escalating to directly adjacent enclosures in the same row or to those in a facing row represents one of the key requirements of a BESS design.

The worst-case consequences within the scope of the PHA, should an enclosure fire involving several battery modules occur, are consistent with those determined by Tesla (via Fisher Engineering, Ref 15) in Section 4.2.1.

The controls required to minimise the risk of a fire incident associated with the BESS depends on the choice of battery enclosure solution. Essentially, the controls can be divided into *preventative* and *protective* controls, with preventative controls keeping the fire from happening, and protective controls protecting people, the environment or property from exposure to dangerous materials or situations should prevention fail, and the fire occurs.

Preventative and protective controls are discussed in Section 4.1.3 and listed in Appendix 1. The final list of controls would be determined in the detailed design stage, assessed in the Fire Safety Study (Recommendation 2, 3 and 4, including using the FRNSW Technical Information), and critically reviewed by the DPHI and by the FRNSW before the Project receives final approval for construction.

Protective controls are further discussed here, to assess the proposed separation distances between battery enclosures and the resulting BESS footprint, with key BESS controls as follows:

- The separation distance between the battery enclosures and between the enclosures and other BESS infrastructure must be sufficiently large to ensure that the strategy of allowing a Tesla Megapack to burn without firefighting is not compromised, and
- The Project area must be sufficiently large to allow it to be laid out such that sufficient separation between the BESS infrastructure and external boundaries can be achieved in order to minimise off-site risk, with reference to the detailed consequence analysis conducted in the PHA.

Considering the heat radiation for the worst-case scenario determined in Section 4.2.1 and detailed in Appendix 2, allowing for the separation distances between infrastructure to keep fire propagation from occurring as discussed in Appendix 3, the Proponent has used the separation distances and dimensions for the proposed BESS infrastructure to create the indicative Project layout in Figure 2-5 for the Tesla MP2XL enclosure, using a minimum 2.44 metres separation distance between enclosure rows.

As the Project area is small, it is recommended that Ausgrid seeks early clarification with FRNSW on the acceptability of the proposed BESS layout, refer to Recommendation 2.

4.5 CLEARANCE TO OFF-SITE RECEPTORS

4.5.1 Off-site receptors

Clearance between the BESS and off-site receptors is shown in Figure 4-5 below.

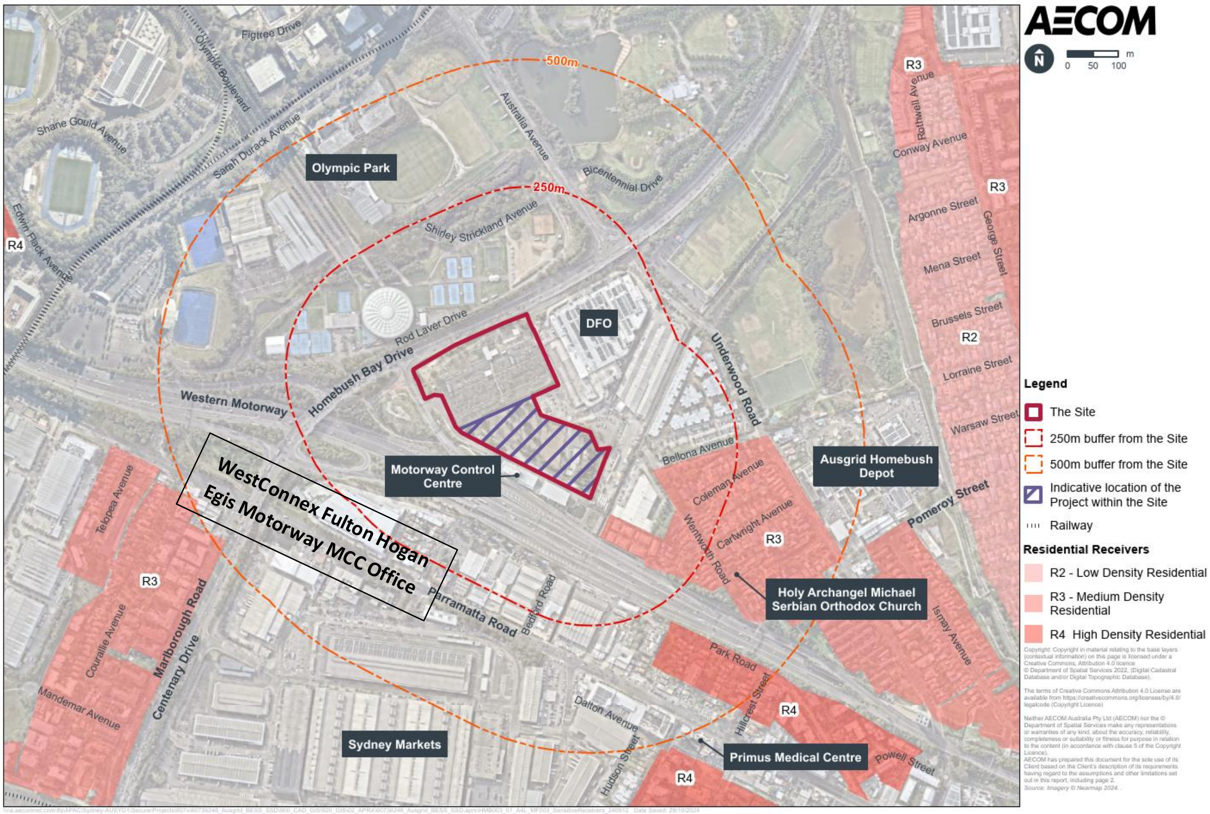

Figure 4-5: Separation to off-site receptors

- *Distance to sensitive receptors:* The closest residential area is at 139 metres (refer Table 4-5) from the closest battery enclosure. At this distance, the heat radiation in case of a battery enclosure fire would be less than 2 kW/m^2, well below any criteria in HIPAP4 (Ref 3). Similar to building fires there is a potential for combustion products to be generated in the fire (soot, gases) to drift off beyond the site boundary.

- *Distance to neighbouring land use:* The closest distance from the closest battery enclosure to the site boundary is 16 metres. When measured from the nearest enclosure, the M4 motorway is separated by more than 76 metres; the DFO and the main carpark by 118 metres and 58.5 metres respectively; the DFO overflow carpark by 17 metres; and the WestConnex Fulton Hogan Egis Motorway MCC Office by more than 40 metres. This is further than the NFPA855 (para. 4.4.3.3) separation distance of 3.048 metres (10 feet) between the BESS infrastructure with no / limited fire-fighting and suppression capability and *buildings, lot lines that can be built upon, public ways,* *stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with electrical grid infrastructure*. The NFPA855 requirement is adhered to, provided such design is allowed by the authority having jurisdiction (***AHJ***), which in this case would be the FRNSW in conjunction with the DPHI (detailed considerations would be included in the Fire Safety Study, see Recommendation 2).

- The UL 9540A cell and module tests have demonstrated that no toxic combustion gases were generated during a thermal runaway with limited battery cell and battery module involvement.
- FRNSW considers a worst case credible incident to be one in which a fire propagates within the battery enclosure with the active fire safety systems disabled and involves a full battery enclosure. This incident is beyond the UL 9540A testing regime, and is more closely aligned with the Destructive Unit Level Test that was conducted by Tesla (discussed in Sections 4.2.1 and 4.2.2).

  No combustion gases were sampled and reported during the Tesla MP2XL Destructive Unit Level Test, and as such gases have been generated in other similar LFP battery tests (Refs 17), the generation of toxic combustion gases cannot categorically be ruled out for the Tesla until demonstrated otherwise.

  While a fire involving a full battery enclosure is a rare event, a prudent approach is recommended and it is recommended that Ausgrid seeks clarification with FRNSW prior to detailed design stage, including whether fire water would be required at the site to aid in the dispersion of any combustion gases, refer to Recommendation 2.

4.5.2 On-site receptors

Clearance between the BESS and on-site receptors is shown in Figure 4-6 below, as follows:

- *BESS to site boundary:* The clearance distance between the closest battery enclosure and the Project area boundary is 16 metres. At this distance, the heat radiation in a worst-case credible enclosure fire is less than 2 kW/m^2, as per the calculations in Section 4.2.1. This is well below any risk criteria specified in HIPAP4 (Ref 3).
- *BESS to HV infrastructure* (including new HV transformer and existing Mason Park STSS, both outside the scope of this PHA): Clearance between the Project area and the nearest HV infrastructure (being the new HV transformer) is 35 metres. At this distance, the heat radiation from a battery enclosure fire would be less than 1 kW/m^2, as per the calculations in Section 4.2.1, well below levels where propagation is likely to occur. This distance also exceeds all requirements in Table 6.1 *Clearance for outdoor transformers* in AS 2067-2016 *Substations & High Voltage Installation*.
- *Clearance for unimpeded access*: The indicative layout in Figure 4-6 uses 2.44 metres between enclosure rows, as per the recommendation by Tesla for their MP2XL enclosure. At the separation distance, the clearance between two enclosures with opposite doors open is in accordance with AS/NZS 3000:2018 Electrical Installations, which requires 600mm egress between open

Megapacks. Distance with the door swing will be defined during detailed design to ensure the minimum distance for safe egress is compliant in accordance with the relevant Australian standard.

- The indicative layout in Figure 4-6 meets with the (US) National Fire Protection Association (NFPA) 855:2020 *Standard for the Installation of Stationary Energy Storage Systems* para 4.4.3.3.4 for an enclosure which meets the requirement of UL 9540 testing requirements. The final approval for the proposed layout is the NSW Government authorities: FRNSW and DPHI (Recommendation 2).

Figure 4-6: Extended indicative BESS layout, separation to on-site receptors

5 CONCLUSION AND RECOMMENDATIONS

5.1 OVERVIEW OF RESULTS AND ALARP CONDITION

This PHA finds that the BESS is not considered *Potentially hazardous* in accordance with the DPHI's definition, based on the intended storage and transport of hazardous material.

Potential hazards from the BESS are predominantly associated with the *Other types of hazards* which are required to be assessed in a PHA (as per the *Applying SEPP 33* guideline, Ref 8) as associated with the risk of a fire associated with the LFP batteries with the potential to cause a thermal runaway and fire in a battery enclosure.

Other hazards with potential worst-case consequences limited to within the site include the potential for loss of containment of pollutant material, electrical fault or failure to control electrical energy, external hazards, damage to the light poles and overhead cables which traverses the Project area, and standard construction related hazards.

An overview of the findings including key controls is as follows:

- *Thermal runaway and fire in a battery enclosure:* The main potential impact from the BESS to receptors outside of the site is associated with a failure to manage propagation from a fire or explosion within an enclosure or a transformer. BESS and transformer fires technically have the potential to propagate and even to initiate a fire in the surrounding area (e.g. grass, vegetation etc.) if the risk of propagation is not managed. Combustion products and smoke may be produced during a worst-case credible event involving a full battery enclosure and could potentially affect nearby land use and/or emergency services personnel.

  The fire tests carried out for the Tesla MP2XL have demonstrated that the battery enclosures are designed to withstand a credible fire scenario as defined by FRNSW, and that sufficient separation is established within the BESS and between the BESS and the nearby infrastructure, to ensure that the risk of propagation can be managed to a level that is ALARP.

  Further, emergency response protocols would be prepared and provided these are implemented, including ensuring the risk to emergency personnel and nearby land use is minimised (measures to be determined during the development of the emergency response plan), the risk to firefighters can be managed to a level that is ALARP.

  If the fire was to spread to further parts of the BESS, including to general construction materials which generate toxic and acrid smoke, the knowledge gained by FRNSW from general building fires, including the rate of formation and dispersion of toxic combustion products from plastics, can be used (Ref 16). In such case, evacuation of people on the site who are not wearing appropriate PPE (e.g. self-contained breathing apparatus) would be prudent. This requirement would need to be integrated into the emergency response plan for the Project and communicated with emergency services. With such emergency response, the risk to on-site receptors can be managed to a level that is ALARP and the risk to off-site receptors can be managed to an acceptable level.

Although the PHA found that the need for external firefighting or fire water to suppress and/or disperse smoke from a fire is unlikely, these conclusions should be discussed in consultation with FRNSW and DPHI, in conjunction with the development of the Fire Safety Study, refer to Recommendation 2.

- *Loss of containment of pollutant material from the BESS infrastructure* to the Project area may occur, subject to detailed design, in the event of a failure to contain pollutants such as transformer oil, coolant in the battery enclosures or construction material. If a spill is not contained, there is a potential to affect BESS and adjacent land. Measures to prevent a loss of containment from occurring, and for secondary containment, would be addressed in the detailed design phase for the BESS.

  Implementing the requirements in Australian Standards and Codes would ensure that the risk of environmental pollution during construction, commissioning and operational phases of the BESS is managed to a level that is ALARP.

- *Electrical fault or failure to control electrical energy at electrical equipment:* Stringent protocols for the control of electric and arc flash hazards would be integrated into the management of the site. Application of these protocols and Australian Codes and Standards are generally sufficient for this Project to ensure that the risk of hazards associated with electrical equipment including from arc flash and EMF is managed to a level which is ALARP.

  The EMF impact assessment (Section 4.2.3) concluded that the EMF levels generated by the BESS are compliant with the applicable Australian and international standards and guidelines, specifically the ICNIRP reference levels.

- *External threat of mechanical or thermal damage (bush / grass fire or light poles and overhead cables) causes damage, or incident during construction activity:* Application of Codes and Standards are generally sufficient for this BESS to ensure that the risks of other hazards are managed to a level that is ALARP (see Section 2.3).

The analysis conducted as part of this PHA has found that the Project can be managed in accordance with the established risk criteria and in accordance with ALARP principles.

The available land for the Project is sufficient to allow for the minimum required separation distance between battery enclosures while preventing fire escalation between enclosure rows.

Most hazards can be prevented by employing a combination of common measures, including following all applicable AS/NZ Standards, separation distances and setbacks, physical protection and control systems measures.

Mitigation measures are available to reduce the severity of the hazards, should they occur, including specific secondary containment, e.g. as built into the battery enclosure, and operational training.

Provided the recommendations in this PHA are adhered to, the risk profile assessed for the Project is as follows:

- *Off-site risk*: The PHA found that the risk profile for land outside of the site boundary is Acceptable.
- *On-site risk*: The PHA found that the risk profile for personnel working within the site boundary the risk is consistently ALARP, except for exposure to EMF which is Acceptable (i.e. lower risk than ALARP level).

The Proponent has used the separation distances and dimensions for the proposed BESS infrastructure to create the indicative site layout in Figure 2-5, using 2.44 metre between Megapack rows as per Tesla's recommendations for their MegaPack 2XL. The layout has been developed based on the heat radiation calculations for the fire scenario evaluated in Section 4.2.1 (as detailed in Appendix 2), and allows for the clearance distances between infrastructure to keep fire propagation from occurring as discussed in Section 4.5. In this configuration, the Project area would fit within the proposed operational footprint of approximately 3.39 hectares.

An overview of the risks associated with the BESS is provided in Table 5-1. This table also includes a brief summary of the ALARP condition, with the details provided in Section 4.2 and Appendix 2.

Table 5-1: Overview of risks evaluation and ALARP conditions

BESS hazardous incident event	Finding	Risk result and ALARP evaluation
1. Thermal runaway (including due to spontaneous ignition) and fire in a battery enclosure	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in a battery escalating into a fire at a battery enclosure. Key controls include continuous battery management system (BMS) with automatic shut-down batteries and battery racks are certified with respect to not posing a fire propagation risk in accordance with international methodologies (e.g. the UL 9540A tests and the Destructive Unit Level Test) and establishment of minimum separation distances within the BESS and between the BESS and the external boundaries (Recommendations 2, 3 and 4). The need for external firefighting or water to suppress/disperse gases evolved in a battery fire is unlikely for electrical and other fires associated with BESS infrastructure but would need to be determined in consultation with FRNSW and DPHI (Recommendation 2). On-site hazardous effects are possible in case of a battery fire, and the risk associated with generation of flammable and toxic combustion products has been minimised in design. Further considerations of safe evacuation routes and procedures for the site or nearby areas (in a worst-case fire scenario) should be established, and the toxicity of combustion gas should be considered in emergency response (Recommendation 3).	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk* Managed to ALARP principles in the early design stage; and with recommended consultation with FRNSW and DPHI in the detailed design to demonstrate non-propagation of a fire considering local weather conditions and the final layout; and to determine any need for external firefighting or water to suppress/disperse gases evolved in a BESS fire
2. Loss of containment of pollutant material from the BESS infrastructure	Environmental pollution may occur from a failure to contain pollutants, and the need for secondary containment of a spill would be considered in detailed design including at the transformers (Recommendation 4). The requirements under the Australian Standards (including AS 1940) are sufficient to ensure the risk associated with environmental pollution at the electrical infrastructure associated with the Project is to be managed to ALARP principles.	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk* Conforms to ALARP provided the applicable requirements in Codes and Standards are followed

BESS hazardous incident event	Finding	Risk result and ALARP evaluation
3. Electrical fault or failure to control electrical energy (EMF; electrical interference) at electrical equipment (inverters, MV transformers, and electrical cabling) causing fire, arc flash, and/or exposure to excessive levels of EMF	The requirements under the Australian Standards (e.g. AS 2067) and typical management practices for Low and Medium Voltage systems are sufficient to ensure the risk associated with fire at the electrical infrastructure associated with the BESS is to be managed to ALARP principles. The EMF impact assessment concluded that the EMF levels generated by the BESS are compliant with the applicable Australian and international standards and guidelines, specifically the ICNIRP reference levels and therefore the on-site risk from EMF is acceptable.	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk* On-site (EMF): *Acceptable risk* Conforms to ALARP provided the applicable criteria are followed as per Codes and Standards
4. External threat of mechanical or thermal damage (neighbouring fire or light poles and overhead cables) causes damage, or incident during construction activity	An incident in a neighbouring area may affect the BESS infrastructure. Key controls include standard control of construction activities and emergency response. The risk associated with the presence of light poles and overhead cables across the Project area is low and can be managed using Australian Standards and Ausgrid Codes of Practice (recommendation 5). Natural hazards from wind, lightning, etc. would be managed using Codes and Standards. Construction risks are well known and understood, and existing Codes and Standards are established within the industry to manage construction risk.	Off-site, external land use: *Acceptable risk* On-site: *ALARP risk* Conforms to ALARP provided the normal control of construction activities and emergency response

5.2 RECOMMENDATIONS

The following recommendations are made as part of the PHA:

1. Vegetation management within the Project Area and provision of an Asset Protection Zone to separate major vegetation, e.g. trees and overhanging tree branches, from the BESS infrastructure on the Project area should be established in accordance with the exposure clearances recommended by the OEM.

2. A Fire Safety Study should be prepared for the Project in consultation with FRNSW and DPHI during the detailed design stage. Adherence to the requirements specified in the FRNSW Fire Safety Guideline, Technical Information entitled "Large-scale external lithium-ion battery energy storage systems - Fire safety study considerations" (current latest version is D22/107002) should be demonstrated. While a fire at the BESS is highly unlikely, given the location of the site, any need for fire water to suppress and/or disperse combustion products that could be generated in a fire (soot, gases) would need to be determined and approved by FRNSW and DPHI.

3. Emergency Management Plan and Procedures should be developed for Project construction and operation, including establishment of evacuation protocols for those not involved in emergency response and any person not wearing appropriate PPE. While highly unlikely, the possibility of gas and pressure release from a battery enclosure during a thermal battery runaway event, including the risk associated with opening a door, should be considered and communicated to first responders with appropriate responses.

4. Measures to prevent leaks from the BESS and transformers, and for containing spills if they occur, should be addressed in the detailed design phase. If fire water is to be used on site, e.g. to suppress and/or disperse combustion products that could be generated in a fire (soot, gases), containment would need to be determined.

5. The wooden light poles which are currently installed within the Project area are to be removed prior to commencement of Project construction. If a pole was to fall over it could damage a BESS enclosure and initiate a thermal runaway and fire.

6 REFERENCES

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Appendix 1

Hazard identification and controls

Preliminary Hazard Analysis for AusGrid's

Homebush Battery Energy Storage System, NSW

Appendix 1 - Hazard identification and controls

Table A1.1: Hazard identification word diagram

Hazardous incident / Event	Possible causes	Worst-case credible consequences (assumes no active controls in place)	Typical preventative and protective safeguards (subject to detailed design)	Potential for impact outside BESS boundary
1) Thermal runaway in a BESS battery enclosure may lead to a fire and generation heat and toxic / flammable gases *i.e. generation of excessive heat inside or outside the cell which keeps on generating more and more heat. The chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell*	Faulty battery causing electrical failure (faulty manufacture or design; short circuit, excessive current/voltage, imbalance charge) Elevated temperature (e.g. external fire from nearby building fire, failure of BMS / cooling system) Surrounding infrastructure failure (e.g. adjacent HV infrastructure) Mechanical failure (internal cell defect, damage, crush/ penetration/ puncture, impact, e.g. during construction and maintenance)	Fire in the battery cell and modules with generation of heat and potentially toxic / flammable gases. Possible escalation to adjacent cells and modules. Potential escalation to neighbouring enclosures, with further escalation to other areas within the site. Possible injury/fatality from heat generation and exposure to toxic combustion products and deflagration overpressure. Environmental pollution e.g. from firefighting medium (firefighting water) or from spill of pollutant material from the enclosure which is not contained.	<u>Prevention:</u> - BESS to be designed and operated to all relevant Australian Standards and to one or more of the major international BESS Codes, e.g. NFPA 855 (refer Recommendation 2) - Battery cells, modules and enclosures designed to prevent initiation of a thermal runaway and potential for propagation to other area (certified to UL 9540A) - Installation and maintenance by trained personnel, and induction of personnel prior to work. Work conducted in accordance with recognised major Codes of Practice, including procedures, using JSAs / SWMS, PTW and isolation, control of modifications, inspection and audit regimes - Warning signs (electrical hazards, arc flash, entry procedures) - Battery enclosures permanently connected to SCADA/BMS (and/or TMS) from their first energisation (unless under supervision). BMS (and/or TMS) likely to include over-temperature, loss of communication, over-voltage, and isolation, defined in design. Automatic isolation and shutdowns where required, also determined in detailed design - Preventative maintenance and condition monitoring ongoing through BESS operations <u>Protection and limitation:</u> - Deflagration venting and venting of toxic or flammable gases, as required, as per Codes and Standards and OEM´s recommendations	Assessed in Section 4.2.1

Hazardous incident / Event	Possible causes	Worst-case credible consequences (assumes no active controls in place)	Typical preventative and protective safeguards (subject to detailed design)	Potential for impact outside BESS boundary
			- Only restricted personnel allowed on site and only certified person to open door and enter enclosures - Separation distance to other infrastructure including battery enclosures minimise risk of escalation in accordance with Codes and Standards and OEM recommendations (Refer to Recommendation 2) <u>Minimising generation of toxic and flammable gases</u> - Battery enclosure venting reduces build-up of toxic and flammable gases inside the enclosure. No entering or opening a battery enclosure during operation unless under direct supervision. Warning signs installed - Enclosures are located outside in an open area to minimise risk of accumulation / ingress of toxic combustion products. Toxic and flammable evacuated via natural dispersion allows escape <u>Emergency response</u> - Fire protection system outside and within the enclosure to Standard requirements determined in detailed design - Escape from BESS area in accordance with Code requirement - Emergency response, including activation of local and/or remote activated emergency shutdown (ESD), and initiation of Emergency Response Plan (Recommendation 3)	
2) Loss of containment of pollutant material from the BESS infrastructure (e.g. oil from the transformers, cooling water from the	Damage to infrastructure due to: - Mechanical failure or damage - Corrosion, wear and tear	Release of pollutant material leading to environmental pollution if not contained.	<u>Prevention</u> - Equipment and systems designed and tested to comply with the relevant international standards and guidelines - Equipment installed by reputable contractors following Contractor Work Health and Safety (WHS) Management Standard, permits, control of modifications etc. Installation and maintenance by trained personnel	NO

Hazardous incident / Event	Possible causes	Worst-case credible consequences (assumes no active controls in place)	Typical preventative and protective safeguards (subject to detailed design)	Potential for impact outside BESS boundary
HVAC system in the BESS	- Fire water applied (e.g. to suppress and/or disperse combustion products during a fire in the BESS)	Possible injury from exposure to irritant material (all routes)	Installation would occur in accordance with the Principal Contractors safe systems of work using SWMS. Induction of all personnel prior to work - Preventative maintenance and condition monitoring as per maintenance schedule - Design of cooling water system prevents release of coolant - Low toxicity / irritation of coolant water system. Protection - Dedicated enclosure(s) i.e. only restricted personnel allowed - PPE and eye wash stations requirements to be determined in detailed design - Transformer oil bunding as per AS 2067 and AS 1940 requirements Detection - Smoke and/or heat detectors at substation and transformers. BMS at battery enclosures indicate fault condition Emergency response - Spill clean-up determined in detailed design - Activation of Pollution Incident Response Management Plan - Activation of shutdown (locally or remote activated) - Emergency response to be determined in detailed design and may include spill clean-up using dry absorbent material and activation of Emergency Response Plan for major spills	
3) Electrical fault or failure to control electrical energy at	Electrical connection fault causes short circuit, due to (e.g.):	Heat, possibly fire if combustible material is	Prevention:	NO in general

Hazardous incident / Event	Possible causes	Worst-case credible consequences (assumes no active controls in place)	Typical preventative and protective safeguards (subject to detailed design)	Potential for impact outside BESS boundary
electrical equipment (inverters, MV transformers, electrical connections (above and below ground) and gantries) causing fire, arc flash, or EMF	- incorrect procedure used during installation/ maintenance - faulty equipment (e.g. corrosion on conductors) - equipment too close to each other or insulation damage Note: Thermal runaway in a battery enclosure due to impact from construction activities is included in scenario #1	ignited by faulty electrical equipment Arc flash / blast may result in fires and pressure waves blasts and resulting heat Potential propagation to adjacent infrastructure (e.g. oil storages at transformers) and domino effects and further fire, release of toxic combustion products Exposure to intense light and noise cause injury Toxic combustion products Burns, injury and/or fatality Pollution (transformer oil) Exposure to voltage Exposure to EMF	- Installation and maintenance by trained and inducted personnel and contractors using HSE Management Standards and policies including JSEAs / SWMSs, PTW and control of modifications - Equipment and systems designed and tested to comply with the relevant Australian and international Standards and guidelines - Prudent avoidance measures for exposure to EMF - Preventative maintenance and condition monitoring as per requirements by asset owner where relevant, and by OEM´s requirements <u>Detection and automatic shut-down:</u> - BMS at battery enclosures and Power Conversion System (PCS) with auto safety shut-off function in case of fault detection. Design of earthing schemes - Current limiting devices and shut-offs (trips) as per manufacturers recommendations - Electrical protection settings designed and commissioned for fault detection <u>Protection and limitation (including to prevent escalation):</u> - Where relevant, equipment housed in dedicated (key-controlled) enclosures; only restricted personnel allowed. No entering or opening a battery enclosure during operation unless under direct supervision. Warning signs installed - Separation distances between infrastructure to minimise risk of escalation as per Codes and Standards and OEM´s recommendations - Fire protection to minimise propagation as per Code requirements, e.g. AS 2067; NFPA855 or equivalent and, for battery enclosures, confirmed via UL 9540 A test and Destructive Unit Level Test - Use of PPE, including to protect against arc flash, as per warning sign	EMF assessed in Section 4.2.2

Hazardous incident / Event	Possible causes	Worst-case credible consequences (assumes no active controls in place)	Typical preventative and protective safeguards (subject to detailed design)	Potential for impact outside BESS boundary
			<u>Minimising generation of toxic combustion products</u> - Battery enclosure venting reduces build-up of toxic or flammable concentrations as per requirements in Codes and Standards - The BESS and other electrical plant located in an open area to minimise risk of accumulation of toxic combustion products <u>Emergency response</u> - Emergency response, incl. emergency shutdown (ESD); Emergency Response Plan (Recommendation 3)	
4) External threat of mechanical or thermal damage (bush / grass fire or light poles and overhead cables) causes damage, or incident during construction activity Other external hazards: lightning, earthquake, flood	Encroachment of off-site fire onto site infrastructure Escalated event from a fire associated with plant and equipment on the BESS area Ignition source may come from faults in electrical equipment; mechanical energy from hot work during operation or construction of BESS; mechanical crashes, human (failure to follow procedures and requirements; arson/	Injury/fatality Asset damage Potential initiation of thermal runaway in the Battery enclosure (refer scenario #1)	<u>Prevention</u> - Lightning study to be completed at detailed design as per AS 1768, including installation of lightning rods - Equipment housed in IP rated enclosures constructed in accordance with relevant Standards and above flood level - Infrastructure designed to earthquake requirements as per AS 1170.4 *Structural design actions – Earthquake actions in Australia* - Wind damage prevented through bracing, fixing and/or tie-downs for the conditions and design to AS1170.2 *Structural design actions - Wind actions* - Company and Contracting Company's Policies and Procedures require appropriate safety measures to prevent incidents and injury during construction activities - Construction Management Plan including key controls - Risk management processes to ensure safe work - Induction, training & competency	Bushfire assessed in Section 4.2.4 Other hazards assessed in Appendix 2

Hazardous incident / Event	Possible causes	Worst-case credible consequences (assumes no active controls in place)	Typical preventative and protective safeguards (subject to detailed design)	Potential for impact outside BESS boundary
	sabotage; uncontrolled smoking) etc.		- Work plans to avoid conflicting tasks, provide adequate space prior to initiating plant manoeuvring and load/unload operations - Management Plans including Traffic, Scaffolding / Elevated Works Platform as / if required - Adherence to SafeWork NSW and other Codes of Practice <u>Protection</u> - Fire water to be available to combat a neighbouring fire - Additional fire protection measures (e.g. hydrants) to protect site infrastructure from a fire in a neighbouring area / facility to be determined in detailed design <u>Emergency response</u> - Emergency response plan to be developed	

Planager
Risk Management Consulting

Appendix 2

Risk assessment

Preliminary Hazard Analysis for AusGrid's
Homebush Battery Energy Storage System, NSW

A2.1 – Risk assessment tool

The Planager risk assessment tool, in the form of a risk matrix, is provided in Figure A2.1. The catastrophic consequence level relates to off-site effects only. Any potential incident which is assessed as having catastrophic consequences should be analysed quantitatively (Level 3 as per MLRA Guideline, see Figure 4-1).

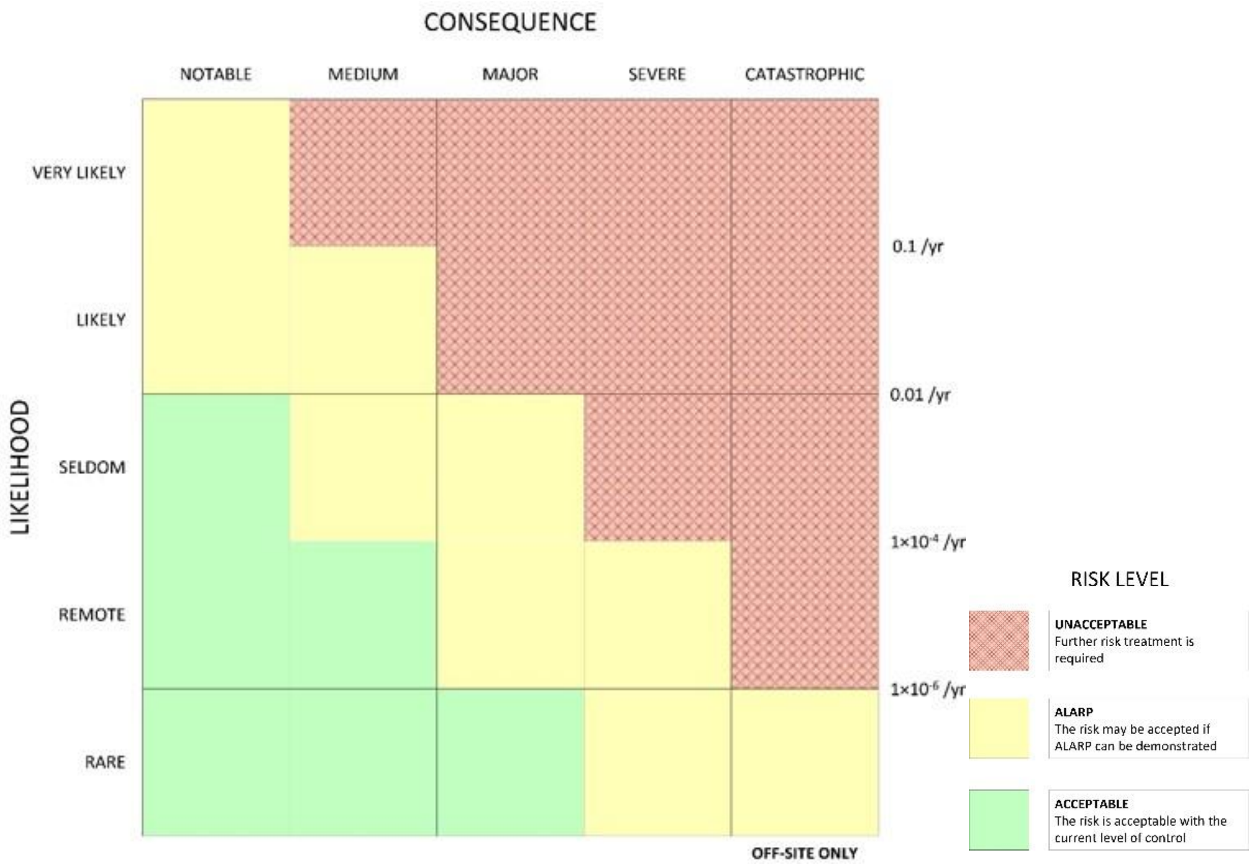

Figure A2.1: Risk Matrix

Table A2.1: Consequence and likelihood ratings

Rating	Description
CONSEQUENCE - HEALTH AND SAFETY:	
Catastrophic	Off-site fatality
Severe	On-site fatality On- or off-site life-threatening injuries (WHS Act 2011 S36, e.g. AEGL3)
Major	Serious injuries with long lasting effects (ego AEGL2)
Medium	Harm causing notable discomfort, irritation etc. Not disabling and transient/reversible effects (e.g. AEGL1)

Rating	Description
Notable	Injury or illness which may require medical treatment or first aid. No lost time
CONSEQUENCE - ENVIRONMENTAL:	
Catastrophic	Severe long-term environmental damage or sustained, widespread community complaints. Any damage to protected environment
Severe	Off-site environmental damage requiring major remediation effort, widespread local community complaint
Major	Reportable environmental damage, local, short-term community complaint
Medium	Environmental clean-up required
Notable	Negligible and short term environmental impact.
LIKELIHOOD:	
Very likely	Happens regularly within the industry. Knowledge/evidence suggests there is a greater than 1 in 10 chance of the event occurring.
Likely	Happens on an irregular basis but frequently enough to be more than a remote possibility. Knowledge/evidence suggests there is a between a 1 in 10 and 1 in 100 chance of the event occurring
Seldom	Has happened on an irregular basis but frequently enough to be more than a remote possibility. Knowledge/evidence suggests there is a between a 1 in 100 and 1 in 10000 chance of the event occurring.
Remote	Has happened very occasionally but only in unusual circumstances. Knowledge/evidence suggests there is between a 1 and 100 chance in a million of the events occurring
Rare	Has not happened but there is a non-zero chance that it could in extremely unusual circumstances. Knowledge/evidence suggests there is a less than 1 chance in a million of the events occurring

A2.2 Risk assessment

The most serious potential impacts are associated with a thermal event in the battery enclosure. which leads to a battery enclosure fire. The event may be initiated by a by electrical system failures (damage to wiring, fuse or breaker failure) or by mechanical interference (mishandling, rodents).

Three possible outcomes are considered:

- Generation of heat from a fire, detailed in Section 4.2.1 with further discussion in Section A2.2.1.

- Generation of toxic combustion gases from a fire as discussed in Section 4.2.2 with further discussion in Section A2.2.1
- Overpressure from a deflagration event, discussed in Section A2.2.3.

Other hazardous events are discussed in Sections A2.2.4 to A2.2.9.

A2.2.1 Thermal runaway (including due to spontaneous ignition) and fire in a battery enclosure

HAZARDOUS EVENT

The event focuses on the conditions under which a fully involved fire event within a battery enclosure could occur. The scenario assumes all protective functions and controls have failed and consists of a fully developed fire or explosion in one battery enclosure caused, for example, by an extreme battery failure event. Such a scenario is considered the worst-case-credible fire.

The Tesla MP2XL configuration is the chosen configuration for the battery enclosure, with Figure A2.2, reproduced from Ref 15, detailing the internal arrangement of the battery enclosure.

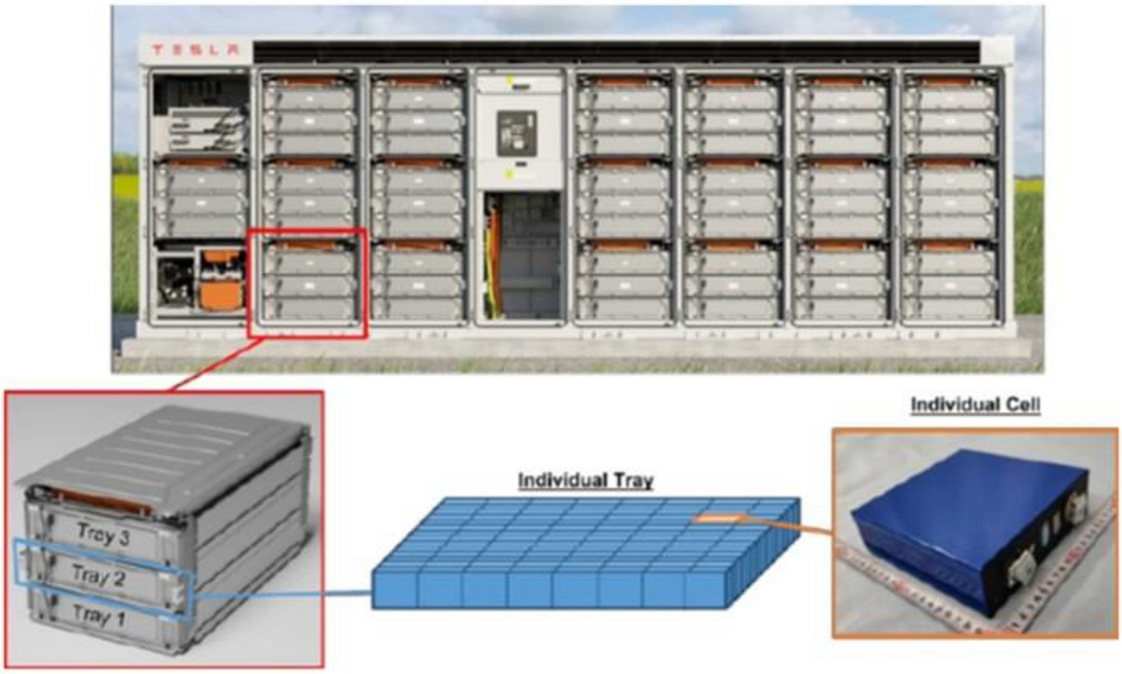

Figure A2.2: Configuration inside the Tesla MP2XL containerised solution

This PHA uses as input the fire scenario reported by Tesla Energy's fire protection engineering analysis conducted by Fisher Engineering (Ref 15), whereby a large scale fire scenario within the Tesla MP2XL was modelled.

Tesla's fire model was developed based on the results from their Destructive Unit Level Test, which was initiated by simultaneously heating 48 cells within a battery tray to thermal runaway.

Tesla's fire engineer investigated the potential for fire propagation potential by calculating the heat flux (Ref 15) as described below:

Heat flux model: Fire behaviours was used as input to a heat flux model to calculate the heat flux that surrounding receptors (*enclosures*) would be exposed to during an enclosure fire under both calm (no wind) and windy weather conditions. The following observed behaviours were used as inputs:

- During the fire test, fire was seen to spread within the battery bays with flames principally exiting through the front door and front grill of the thermal roof for over six hours.
- The maximum observed flame heights was 3.5 m (ground to top of flame), reaching 0.75 m above the top of the unit
- The width at the base of the flame was seen to be 1 m during peak flame intensity
- Estimates of flame dimensions and surface temperature were obtained from the results of the Destructive Unit Level Test, and a flame temperature of 927°C (1200 K) was used.

The report (Ref 15) states that their model predictions were within 20% of the experimental findings.

Two dominant modes of heat transfer were included in the calculations, namely heat flux from the external flames and heat flux from the hot surface of the fire-involved enclosure, as shown in Figure A2.3.

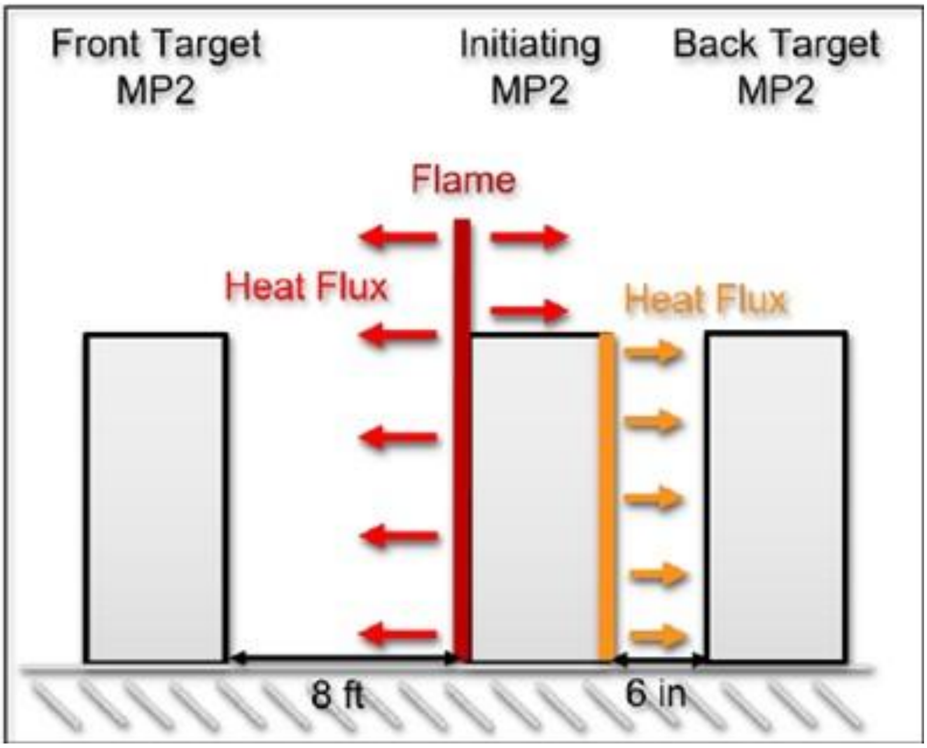

Figure A2.3: Heat flux model conditions: calm weather (Ref 15)

Heat fluxes were calculated using a combination of formulae for solid flame radiation and for high temperature surface radiation between two parallel rectangular plates. Required inputs include flame height, width and temperature for the flame radiation part of model and the external surface temperature of the enclosure for the high temperature surface radiation part.

To predict the maximum heat flux imposed on target enclosures resulting from flame tilt caused by wind, rather than consider specific wind speeds, a flame tilt angle of 45° (see Figure A2.4) was assumed by the Tesla fire engineers, based on the work of Howell[9]).

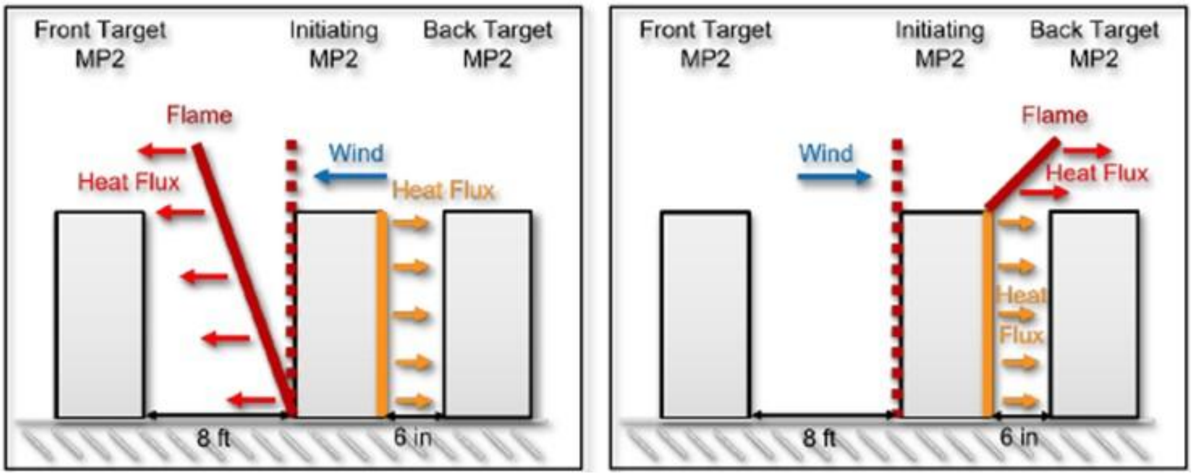

Figure A2.4: Heat flux model conditions: with wind blowing towards the front target and with wind blowing towards the back target with flames exiting the top of the initiating enclosure (Ref 15)

Refer to Tesla MP2XL destructive test model formulae[10] for determination of the heat flux model, including application of the formula for the view factor to take into account the impact of wind-onsite on the shape of the flame and position with respect to the target unit. In Tesla's model, this formula is applied with a worst-case 45 degrees sustained angle for the flame towards the target unit.

Consequences (immediate and ultimate)

The results of the heat radiation calculations using the fire model are presented in Figure A2.5 (heat radiation from the hot surface of the fire-involved enclosure) and Figure A2.6 (heat radiation from the external flames of the fire-involved enclosure) below.

[9] Howell, J.R. (2010). *A catalog of radiation heat transfer configuration factors,* cited in Ref 15.

[10] Tesla (May 2025). *MP2XL Destructive test Model Formulae*

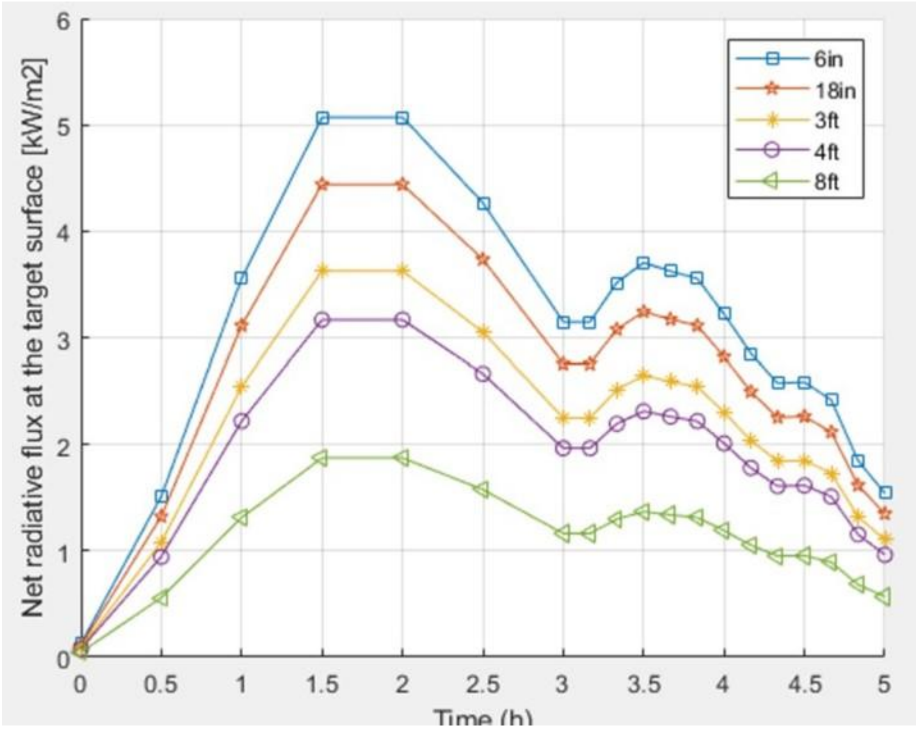

Figure A2.5: Heat radiation from the hot surface of the fire-involved enclosure (based on model for Tesla MP2XL, Ref 15)

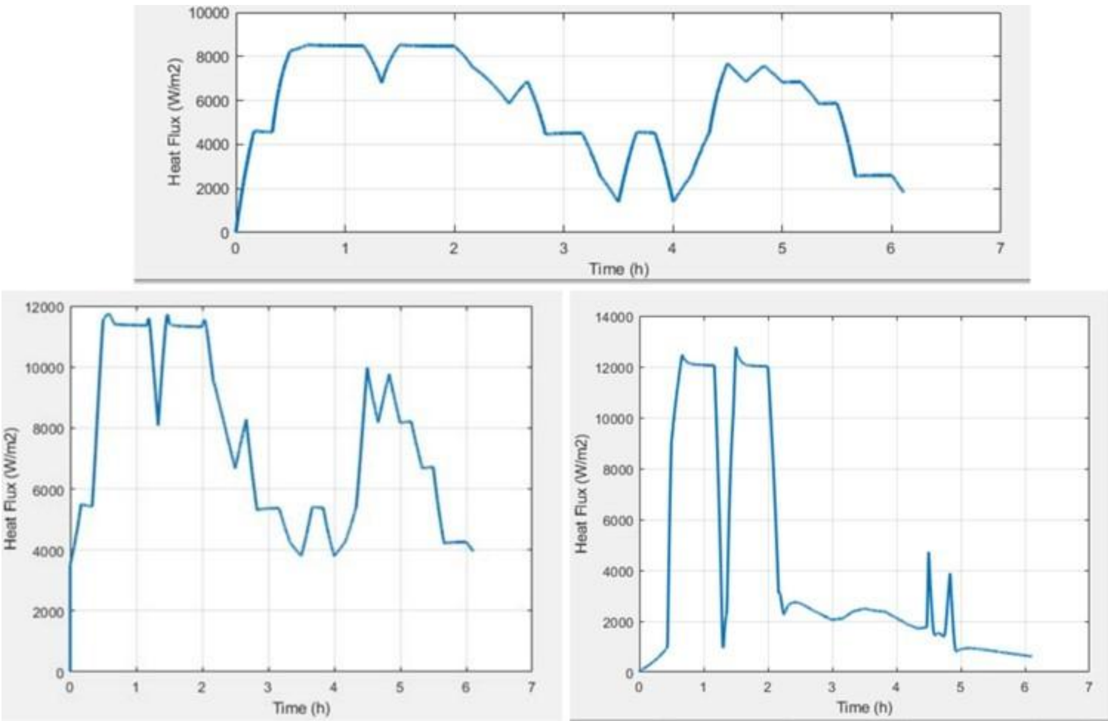

Figure A2.6: Heat radiation from the external flames of the fire-involved enclosure, no wind condition at 8 feet (top); wind blowing towards the front target at 8 feet (bottom left); and wind blowing towards the back target at 6 inches (bottom right), (based on model for Tesla MP2XL, Ref 15)

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A summary of the results from the heat flux calculation model is presented in Table A2.2.

Table A2.2: Heat flux model summary results (based on model for Tesla MP2XL, Ref 15)

Radiation emitting from	Wind weather condition	Target location & distance		Max predicted (modelled) heat flux (kW/m^2)
Cabinet (hot surface)	With or without wind	Back / side targets	0.152 m	5.12
			0.457 m	4.40
			0.914 m	3.65
			1.219 m	3.18
			2.438 m	2.90
Flames: front of the MP2/2XL Cabinet	No wind (vertical flames)	Front target	2.438 m	8.50
	Worst-case wind (45° tilted flames)	Front target	2.438 m	11.77
Flames: top of the MP2/2XL Cabinet	Worst-case wind (45° tilted flames)	Back / side targets	0.152 m	12.83

The closest enclosures are at least 16 metres from the vegetation outside of the site boundary. With this clearance, the heat radiation level associated with a fire at the BESS facility is not likely to exceed 2 kW/m^2 at the boundary (Ref 15), below the 3 kW/m^2 which is commonly defined as the heat radiation level which could cause discomfort. This assessment does not include the potential for embers generated in the fire, starting a fire beyond the site boundary.

There would be no significant impact on adjacent land users expected from this scenario.

The consequence for the worst-case credible scenario is rated as per the consequence scoring table in paragraph A2.1, set as *Major - Permanent disability*, based on the potential for workplace safety leading to a potentially serious injury (environmental consequences are set as *Serious*). The worst-case credible off-site consequence scoring is set as a Level 1, *Negligible*.

Consequence ranking	On-site: *Major* – Serious injuries with long term effects (Medium - Environmental damage) Off-site: *Notable event* – Negligible physical injury and/or environmental consequences

Likelihood and key risk controls

An overview of the fire safety strategy for this BESS is provided in the Hazard Identification Word Diagram in Appendix 1.

The likelihood of the worst-case credible scenario is rated, using the likelihood scoring table in paragraph A2.1, as *Remote*, based on the likelihood for workplace safety leading to a serious injury. The likelihood of off-site injury from this scenario is rated as *Rare*.

Likelihood ranking	On-site: *Remote* Off-site: *Rare*

Risk evaluation	
The risk associated with generation of heat radiation from a battery enclosure fire can be determined by combining the consequences of the fire with the likelihood of the event with reference to the risk matrix in paragraph A2.1. The risk to on-site personnel including first responders is assessed as *ALARP* (a combination of a *Major* safety consequence with a *Remote* likelihood). The environmental risk is assessed as *Acceptable* (a combination of a *Medium* environmental consequence with a *Remote* likelihood). The risk to off-site land uses is assessed as *Acceptable* (a combination of a *Notable event* consequence with a *Rare* likelihood).	
Risk ranking - Site personnel including first responders	ALARP
Risk ranking – On-site: environmental	ACCEPTABLE
Risk ranking – Off-site: public safety and environment	ACCEPTABLE
ALARP evaluation	
Minimum separation distances within the BESS and between the BESS and external boundaries prevents propagation and escalation scenarios, as determined during detailed design and in agreement with the battery enclosure manufacturer, the DPHI and FRNSW, and in accordance with the requirements in Codes and Standards.	
ALARP justification:	
ALARP justified at early design stage with the battery system (cells, modules, unit) certified to UL 9540A; and with recommended consultation with FRNSW in detailed design to demonstrate non-propagation of a fire considering local weather conditions and the final layout. Residual on-site risk can be managed via emergency response procedures and protocols.	Justified

A2.2.2 Toxic combustion products

HAZARDOUS EVENT
The incident initiation and controls are discussed in paragraph A2.2. The event discussed here focuses on the conditions under which a fire event within a battery enclosure results in the generation of toxic combustion products. The scenario assumes all protective functions and passive controls have failed resulting in a major fire within a battery enclosure, with generation of a toxic fume from burning plastic cabling and other combustible material inside the enclosure. Such a scenario is considered the worst-case-credible fire. The toxic fume may be emitted from vents or failed door seals, open door or from the top of the enclosure if the deflagration vent has opened.
Consequences (immediate and ultimate)
The approach used in this PHA to evaluate toxic gas generation and dispersion in a major BESS fire is to develop a qualitative understanding of the release of toxic combustion products during a LFP battery enclosure fire, based on current research and experience from actual fires, including:

- The atmospheric monitoring reported at the EPA AirWatch data at the Moorabool Sites during and after the Victorian Big Battery fire incident at Geelong (which occurred on 31/7/2021) did not identify air quality issues outside the site limits. This indicates that, at least on a windy day, there was only limited toxicity in the fire plume emitted from the fire. While a toxic smoke warning was initially issued to people downwind of the fire by the Fire Rescue Victoria (*FRV*), there appears to have been no real threat to the community from the toxic gases in the smoke, as confirmed by atmospheric monitoring.

  This provides a general understanding of the nature of the toxic combustion products and may be used, with caution, to provide guidance on appropriate locations for evacuation areas.

- Vent gases are likely to include volatile organic compounds (*VOCs*), hydrogen gas, carbon dioxide, carbon monoxide, and soot. The UL 9540A cell and module tests did not detect any toxic combustion gases. Gases were not sampled and analysed during the unit test or during the Destructive Unit Level Test so toxic combustion gases cannot be categorically ruled out, particularly since burning plastic cabling and other combustible material inside the enclosure may participate in rare but potential full scale fire.

- Such a fire may evolve particulates containing oxides of nickel, aluminium, lithium, copper, and cobalt, hydrogen fluoride (*HF*), hydrogen chloride (*HCl*), and hydrogen cyanide (*HCN*) (Ref 16). Gases may irritate the eyes, skin, and throat.

- DNV research[11] (Ref 16) concluded as follows:

  The average emissions rate[12] of a battery during a fire condition is lower per kilogram of material than a plastics fire. However, the peak emissions rate (during thermal runaway of a LFP battery, for example) is higher per kilogram of material than a plastics fire. This illustrates that a smouldering LFP battery on a per kilogram basis can be treated with the same precautions as something like a sofa, mattress, or office fire in terms of toxicity, but during the most intense moments of the fire (during the 2-3 minutes that cells are igniting exothermically) precautions for toxicity and ventilation should be taken.

  The DNV research further goes on to say that: The randomized failure rate limits the toxicity and heat release rate of the fire.

Given the findings in the aforementioned research and actual BESS fire, fumes and smoke may be generated in a major BESS fire, some of which may be toxic.

The fumes may be released from the opening of the deflagration panel, failure of door and other seals, through the vent or if the door was open.

The smoke plume generated by the fire is likely to be at a temperature that is significantly higher than ambient, typically exceeding 600°C. With the limited confinement in the open BESS layout, most of the combustion products are likely to be carried up to an altitude where they would be dispersed to below

[11] Hill D, Warner N, Kovacs W*, Considerations for ESS Fire Safety, Consolidated Edison and NYSERDA New York, NY*, DCN: OAPUS301WIKO(PP151894), Det Norske Veritas (USA) Inc. (DNV GL), Rev. 4, 9 February 2017

[12] Emissions concentration in ppm averaged over total minutes of burn time

hazardous levels, without harm to people in the vicinity. Long term environmental damage is likely to be insignificant.

In line with the findings in the DNV research, the fire plume is predicted to be similar to that generated from a fire involving a sofa, mattress, or office fire in terms of toxicity, but during the most intense moments of the fire precautions for toxicity and ventilation should be taken (DNV cites that this is confined to the 2-3 minutes that cells are igniting exothermically – however, such ignition is likely to be random and staggered in case of a large battery fire and needs to be expected to occur at any time).

It is therefore deduced in this PHA that in an open air, outdoor BESS, the concentrations of toxic gas generated may pose a hazard in the near field and would need to be included in emergency response guidelines. With the large population in the area from the DFO, Sydney olympic Park and local major roads and residential areas, the potential need for external firefighting or water to suppress/disperse gases evolved in a BESS fire should be determined in conjunction with FRNSW. Refer to Recommendation 2.

In the event of a major fire at the BESS, evacuation of the local community would be at the discretion of the emergency services and would be based on real-time atmospheric monitoring undertaken by the fire service's HAZMAT team or NSW EPA.

Higher concentrations, e.g. AEGL3 and above, may be experienced close to the. The risk of exposure to toxic combustion products by first responders should be communicated as part of the emergency services information pack (ESIP) and included in emergency response procedures. Further, people who are not directly required for emergency response should be removed from the site in the event of a major fire at the BESS.

The consequence for the worst-case credible scenario is rated as per the consequence scoring table in Section A2.1, with the worst-case on-site scoring set as *Severe – on-site fatality or life-threatening injuries*, based on the potential for workplace safety leading to a potentially serious injury. The worst-case credible off-site consequence scoring is set as *Notable – short term discomfort/injury*.

Consequence ranking	On-site: *Severe* –on-site fatality or life-threatening injuries Off-site: *Notable event* – short term discomfort/injury

Likelihood and key risk controls

The risk controls for this scenario are largely identical to those for the fire scenario above (*Generation of heat from a fire and potential for fire escalation*). The initiating event is a battery fire and hence the initiating likelihood is the same as that determined for the fire scenario, *generation of heat from a fire and potential for fire escalation*.

Likelihood ranking	On-site: *Remote* Off-site: *Rare*

Risk evaluation

The risk associated with toxic combustion products generated in the battery enclosure fire can be determined by combining the consequences if exposed to credible concentrations of combustion products with the likelihood of the event with reference to the risk matrix in paragraph A2.1.

The risk to on-site personnel including first responders is assessed as *ALARP* (a combination of a *Severe* safety consequence with a *Remote* likelihood).

The risk to off-site land uses is assessed as *Acceptable* (a combination of a *Notable* consequence with a *Rare* likelihood).	
Risk ranking - Site personnel including first responders	ALARP
Risk ranking – Off-site: public safety	ACCEPTABLE
ALARP evaluation	
The ALARP evaluation is the same as for the fire scenario, *generation of heat from a fire and potential for fire escalation*.	
ALARP justification:	
ALARP justified at early design stage with the battery system (cells, modules, unit) certified to UL 9540A; and with recommended consultation with FRNSW to determine the need for external firefighting or water to suppress/disperse gases evolved in a BESS fire. Residual on-site risk can be managed via emergency response procedures and protocols.	Justified

A2.2.3 Deflagration overpressure

HAZARDOUS EVENT
A thermal runaway event in a battery enclosure causes the rapid evolution of hydrogen and other flammable gases. Since one of the major evolved gases is hydrogen, which has a very low ignition energy, ignition of these gases is likely and may result in a fire (discussed above as *generation of heat from a fire and potential for fire escalation*), or if their concentrations are within the explosive region (defined as between the lower and upper explosive limits), in a deflagration. If the thermal runaway is of sufficient size, that is, has propagated beyond the initiating battery module/rack within the battery enclosure, the overpressure associated with the deflagration may not be contained within the enclosure. If the thermal runaway results in a fully developed fire scenario, rather than deflagration, or if the fire is caused by some other event, the accumulation of gases within the explosive range required for deflagration is unlikely to occur. However, if the fire does not fully develop due to a lack of oxygen within a sealed enclosure, the resulting fuel-rich, smouldering fire will generate carbon monoxide, which may react explosively if exposed to an ingress of fresh air (e.g. if the enclosure sides/roof are breached or the door is opened). The scenario requires an accumulation of gases, something which is not likely to occur during a fully developed fire scenario where the flammable gases are more likely to be consumed by the fire as they are generated. In this scenario, the gases must be allowed to evolve in one area of the enclosure before they encounter an ignition source (or before the door opens allowing oxygen back in).
Consequences (immediate and ultimate)
Should a deflagration event occur, and in the event of available deflagration protection failing to provide pressure relief, the resulting overpressure may cause loss of integrity of the battery enclosure and ejection of material which in turn could cause injury to persons present within the BESS, as well as further damage, including potential damage to nearby enclosures.

The damage at a nearby enclosure could in turn initiate a fire, with the worst-case consequences described in the fire scenario, *generation of heat from a fire and potential for fire escalation* above. A subsequent deflagration in a nearby enclosure, damaged by the initial event, is however not considered as a credible consequence. There is also the possibility of an instantaneous release of toxic gases relieved to ground level, which is described in the scenario *toxic combustion products*, above. Only part of the enclosure would be empty space, i.e. not occupied by battery modules, fans, ducting and electrical cabling, limiting the volume of flammable gas that can participate in the deflagration. While injury or damage to people and infrastructure within the site is possible, it is unlikely that the deflagration overpressures would cause any significant effect outside of the site boundary. The deflagration overpressure experienced in any other occupied locations, as detailed in Section 2.2 of this PHA, is likely to be insignificant (though the noise may be heard), including at the nearest residential and recreational areas. The consequence for the worst-case credible scenario is rated as per the consequence scoring table in Section A2.1, with the worst-case on-site scoring set as *Severe – on-site fatality or life-threatening injuries*, based on the potential for workplace safety leading to a potentially serious injury. The worst-case credible off-site consequence scoring is set as *Notable – short term discomfort/injury.* In the Destructive Unit Level Test conducted for the Tesla MP enclosures, the deflagration panel opened and the enclosure doors remained shut and no hazardous pressure waves, debris, shrapnel, or pieces of the cabinet were ejected. The demonstrated that the MP2/2XL cabinets are likely to be capable of safely failing in the extreme case of a catastrophic failure with one of its battery modules.	
Consequence ranking	On-site: *Severe* – on-site fatality or life-threatening injuries Off-site: *Notable event* – short term discomfort/injury
Likelihood and key risk controls	
The key preventative controls for this scenario are largely identical to those listed for the battery enclosure fire scenario, *generation of heat from a fire and potential for fire escalation*. Protective control to minimise the effects in case of a deflagration in an enclosure have been included in the battery enclosure design, and the risk associated with a battery deflagration is minimised to level as that are ALARP. The likelihood of the initiating event (battery fire) is the same as that determined for the fire scenario. The likelihood of causing an on-site injury is set as *Remote*. The likelihood of an off-site injury is set as *Rare*.	
Likelihood ranking	On-site: *Remote* Off-site: *Rare*
Risk evaluation	
The risk associated with deflagration overpressure generated at the battery enclosure can be determined by combining the consequences of exposure to credible levels of overpressure with the likelihood of the event, with reference to the risk matrix in paragraph A2.1. The risk to on-site personnel including first responders is assessed as *ALARP* (a combination of a *Severe* safety consequence with a *Remote* likelihood).	

The risk to off-site land uses is assessed as *Acceptable* (a combination of a *Notable* event consequence with a *Rare* likelihood).	
Risk ranking - Site personnel including first responders	ALARP
Risk ranking – Off-site: public safety	ACCEPTABLE
ALARP evaluation	
The ALARP evaluation is the same as for the fire scenario, *generation of heat from a fire and potential for fire escalation*, together with the design of an appropriate mitigation system such as emergency ventilation and/or venting system (subject to detailed design).	
ALARP justification:	
ALARP justified provided requirements in Codes and Standards and the battery system (cells, modules, unit) designed and constructed to prevent fire propagation, as demonstrated with UL 9540 certification and the Destructive Unit Level Test. The design of the deflagration panel demonstrating protection against the deflagration event during the Destructive Unit Level Test.	Justified

A2.2.4 Loss of containment of pollutant material from the BESS infrastructure

HAZARDOUS EVENT	
Potential pollutant materials associated with this BESS include: • Cooling water from the battery enclosures • Oil in the transformers • Materials used during construction phase and during maintenance activities at the operating site. • Firewater if used during a fire on the site.	
Consequences (immediate and ultimate)	
A loss of containment of pollutants may lead to ground and groundwater contamination and pollution of local surface waters, if not contained. There is also the potential for personal injury arising from exposure to irritant material. WHS and environmental consequences are likely to be limited so long as relevant Codes and Standards are applied and personnel are provided with appropriate PPE and training.	
Consequence ranking	On-site: *Medium* – Environmental clean-up (short term) Off-site: *Notable event* – No environmental consequences
Likelihood and key risk controls	
Preventative and protective strategies are included in Appendix 1.	
Likelihood ranking	On-site: *Seldom* Off-site: *Rare*

Risk evaluation	
The risk associated with loss of containment and environmental pollution can be determined by combining the consequences should a loss of containment occur with the likelihood of the event with reference to the risk matrix in paragraph A2.1. The risk to the on-site environment is assessed as *ALARP* (a combination of a *Medium* environmental consequence with a *Seldom* likelihood). The risk to the off-site environment is assessed as *Acceptable* (a combination of a *Notable* event environmental consequence with a *Rare* likelihood).	
Risk ranking – On-site: environmental	ALARP
Risk ranking – Off-site: environmental	ACCEPTABLE
ALARP evaluation	
Australian Standards are considered as sufficient to specify the safeguards required for the management of pollutants associated with this BESS (refer to the risk classification and prioritisation in Section 3). In addition to Australian Standards, the BESS would comply with the requirements in at least one international standard, e.g. NFPA 855.	
ALARP justification:	
ALARP is justified provided the requirements in Australian Standards, including AS 5139 and international standards, e.g. US NFPA 855 (for the BESS), AS 2067 (for transformers), and AS 1940 (for combustible liquids) and AS 3780 (for corrosive liquids), and management practices are adhered to and that the maximum credible spill at the batteries and transformers can be captured.	Justified

A2.2.5 Electrical fault or failure to control electrical energy at electrical equipment leads to fire, arch flash or exposure to EMF

HAZARDOUS EVENT
The low and medium voltage electrical equipment associated with the BESS would have sufficient energy to cause an arc flash in the case of a short circuit or fault. Arc flashes can be dangerous since they can cause serious burns and electrocution. Arc flash temperatures can be very hot and are therefore capable of melting metal or causing fires and explosions. The energy released in the fault rapidly vaporises the metal conductors involved, blasting molten metal and expanding plasma outward with force. All equipment that is powered by electricity produce EMFs. The BESS will introduce sources of EMF into the BESS area including BESS enclosures, MV inverters and transformers and the connection infrastructure a. EMFs can have harmful effects to human health. The EMF exposure risks associated with the BESS have been assessed in the EMF impact assessment (in Section 4.2.3 in the body of the report).
Consequences (immediate and ultimate)
Consequences from an arc flash include generation of heat and pressure waves which may lead to burns, injury and/or fatality as well as exposure to intense light and noise which may cause injury. Noxious vapours

from combustion of metal can also cause injury and/or fatality. There is also a potential for propagation to adjacent infrastructure and domino effects and further fire, release of toxic combustion products. The intensity and the resultant potential for harm to people is dependent on various factors including voltage, arcing current, arcing time, the amount of energy available, the distance from the arc, the location of the arc and any barriers in place that may direct the arc in a particular direction[13]. Arcing faults may cause catastrophic failure within the electrical equipment unless the fault conditions are quickly removed, e.g. through automated shutdowns and trips. High Voltage electrical equipment has a higher risk of severe arc flash than lower voltage equipment. Arc flash may be caused by operating error, e.g. due to an erroneous grounding attempt, an arc across a broken or contaminated insulator or a phase-to-phase flashover. Given the distance between the BESS and members of the public no significant off-site hazard associated with an arc flash is expected. *On-site risk*: An arc flash can be fatal to people on the site especially to people close to the electrical equipment. This risk is well known and understood by people working with electrical equipment, and Codes and Standards have been developed to ensure that the risk of arc flash is managed to within ALARP levels. The EMF modelling undertaken in the impact assessment identified that the maximum electric and magnetic field levels (on-site exposure) associated with the BESS infrastructure and the existing environment are smaller than 2.5 kV/m and 19 microtesla (µT) respectively. These levels are well below the applied International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines reference limits of 5 kV/m and 200 µT. Further, the closest property boundary is located more than 100 m east from the BESS area. At this distance from the BESS infrastructure, EMF would be much lower than the indicated levels. *Off-site risk*: The closest distance between the electrical equipment on the BESS site and any location occupied by the public is well outside locations of harm from either electrical equipment or EMF.		
Consequence ranking	On-site electrical: *Severe* – fatality/life-threatening injuries Off-site: *Notable event* – no physical injury	
Likelihood and key risk controls		
Key risk controls are listed in Appendix 1. Hence, the likelihood of injury or fatality from an arc flash on the site is considered to be *Remote* taking into account the risk management practices and protocols that will be established. Off-site likelihood is *Rare*.		
Likelihood ranking		On-site: *Remote* Off-site: *Rare*

[13] *Best practice guide, Battery storage equipment - Electrical safety requirements*, Australian Industry Group et. al, 6 July 2018

Risk evaluation	
The risk associated with a failure to manage energy from electrical energy, including arc flash, can be determined by combining the consequences with the likelihood of the event with reference to the risk matrix in Section A2.1. The risk to people on the Project area in the vicinity of electrical equipment is assessed as *ALARP* (a combination of a *Severe* consequence with a *Rare* likelihood). The risk to people at other locations on-site is assessed as *Acceptable* (a combination of a *Medium* consequence with a *Remote* likelihood) The risk to people off-site is assessed as *Acceptable* (a combination of a *Notable event* safety consequence with a *Rare* likelihood). The EMF exposure risk level is based on the assessment in the EMF Section 4.2.3 rather than a separate determination of consequence and likelihood using the matrix in Section 2.1. As per the analysis and discussion in the EMF report, the risk level for this hazard on- and off-site is assessed as acceptable.	
Risk ranking - Site personnel in vicinity of electrical equipment	ALARP
Risk ranking – On-site EMF	ACCEPTABLE
Risk ranking – Off-site: public safety	ACCEPTABLE
ALARP evaluation	
Requirements under the Australian Standards (including AS 2067) and standard management practices in place as per Codes of Practice, the risk associated with an arc flash at the Low Voltage and Medium Voltage infrastructure is managed in accordance with ALARP principles. It is unlikely that an arc flash would affect land uses outside of the site boundary, and the risk is managed in accordance with ALARP principles.	
ALARP justification:	
ALARP justified provided requirements in Codes and Standards are adhered to, including AS 2067	Justified

A2.2.7 Fire involving transformer oil or electrical cable insulation

HAZARDOUS EVENT
Other than a battery fire and an arc flash, the following potential fires may be associated with this BESS: • Transformer oil fire • Electrical cable insulation fire, e.g. in the control and switch room building • General building fire (outside of the scope of this PHA).
Consequences (immediate and ultimate)
A pool fire may occur as a result of loss of containment of combustible oil at the transformer, with subsequent ignition. A pool fire is only applicable for the Low Voltage, Medium Voltage and High Voltage transformer areas. The size of the fire depends on the amount of product spilt and the secondary containment in the location of the spill (i.e. the transformer bund’s capacity to contain the spilled volume of liquid).

There are generally two types of pool fires which may occur, with the *Late ignition* model applicable for the transformer pool fire: • Early ignition, where the released product is ignited early during the release. In this scenario the pool will grow in size until the burn off rate of the fuel, expressed in kg/m^2s, over the area of the pool, is equal to the release rate. Where secondary containment is provided this equilibrium pool size will not be reached if it is larger than the secondary containment area, rather the depth of the pool formed by the unburnt material will increase. Where there is no secondary containment is assumed that the spill will extend to the full equilibrium size. • Late ignition, where the ignition does not occur until after the release has stopped. For a fixed volume release, such as a transformer, this quantity is the full volume of the oil storage. Where the release may be stopped through intervention, such as a safety system relay, this volume is the rate of release for the expected time for an automated response (e.g. Buchholz Relay). This may be contained within secondary containment, or if there is no secondary containment its spread will be uncontrolled. Where there is uncontrolled spread, the pool fire size for a late ignition is generally larger than for an early ignition, as no material has been consumed by fire as the pool forms. A pool fire would burn until either the fuel is exhausted, or a foam blanket is applied to extinguish the fire (where appropriate). Pool fires generate heat which could cause injury or escalation resulting in damage to adjacent assets. Transformer oil burns to mostly carbon dioxide (CO_2) if sufficient air is present, but smoke is also expected to be generated. Generation of toxic and flammable carbon monoxide (CO) is possible if the air supply is restricted. Other toxic and corrosive gases may also be released, such as nitrogen and sulphur oxides - from burning of cable insulation. Cable insulation may cause fire, e.g. in the control and switch room. Fire in a switch room may cause escalation to other areas if not properly managed. Smoke from both transformer oil and from cable insulation fires consists of very fine solid particles and condensed water vapour. In many cases smoke reaches harmful levels before the temperature does. This is especially so when the fire occurs indoors or in confined areas. Smoke particles can cause damage to the respiratory system and may impair vision if they lodge in eyes, with the potential to impair the ability to escape the fire. Heat, smoke and fumes may cause local injury and asset damage. No significant consequences are expected to reach areas outside of the Site boundary from this incident scenario. Smoke, other combustion products and/or fire damage may result in *Medium* level consequence to on-site personnel and the local environment provided the Emergency Response Plan and procedures are developed and any need for fire water to suppress and / or disperse BESS fire combustion products (Recommendations 2 and 3).	
Consequence ranking	On-site: *Medium* – Harm causing notable, transient discomfort/irritation (health and safety) and/or environmental clean-up required. Off-site: *Notable event* – no physical injury nor environmental impact.
Likelihood and key risk controls	
Key risk controls are listed in Appendix 1. The likelihood of an on-site injury is set as *Seldom*. The likelihood of an off-site impact is set as *Rare*.	

Likelihood ranking	On-site: *Seldom* Off-site: *Rare*
Risk evaluation	
The risk associated with a transformer fire or fire in electrical cable insulation can be determined by combining the consequences should a fire occur with the likelihood of the event, with reference to the risk matrix in Section A2.1. The risk to people on-site and the environment within the Project area is assessed as *ALARP* (a combination of a *Medium* – potential for medical treated injury or environmental clean-up – consequence with an *Unlikely* likelihood). The risk to people and the environment off-site is assessed as *Acceptable* (a combination of a *Notable event* consequence with a *Rare* likelihood).	
Risk ranking – On-site: safety and environmental	ALARP
Risk ranking – Off-site: safety and environmental	ACCEPTABLE
ALARP evaluation	
Provided the requirements under the Australian Standards (including AS 2067) and management practices in place by the Operator are adhered to, the risk associated with fire at the transformers and electrical cabling including the control and switch room building is managed ALARP. Provided Standards and Codes are adhered to, the risk associated with this type of fire is managed in accordance with ALARP principles.	
ALARP justification:	
ALARP justified provided requirements in Codes and Standards are adhered to, including AS 2067.	Justified

A2.2.8 Fire in nearby area causes damage and escalation to BESS infrastructure

HAZARDOUS EVENT	
Incidents such as a fire in a nearby area including a bush or grass fire have the potential to cause damage and escalation to BESS infrastructure.	
Consequences (immediate and ultimate)	
There is a theoretical possibility of encroachment of an off-site fire onto site infrastructure leading to injury of site personnel, asset damage and potentially initiation of a thermal runaway in the BESS, including heat radiation, toxic combustion products, and explosion overpressure (events A.2.2.1, A2.2.2 and A2.2.3, respectively). The consequences of a propagation incident from an off-site fire would be the same as that assessed for the battery enclosure scenario (*generation of heat from a fire and potential for fire escalation*), and is rated, in accordance with the risk matrix in Section A2.1, as *Major* for on-site effects and *Notable event* for off-site effects.	
Consequence ranking	On-site: *Major* - Serious injuries with long term effects (Medium - Environmental damage)

	Off-site: *Notable event* – Negligible physical injury and/or environmental consequences
Likelihood and key risk controls	
Measures established to minimise damage potential in case of an incident at a nearby area (excluding any preventative measures) are listed in Appendix 1. Likelihood of an on-site injury is set as *Remote*. Likelihood of an off-site impact exceeding the initiating event is set as *Rare*.	
Likelihood ranking	On-site: *Remote* Off-site: *Rare*
Risk evaluation	
The risk associated with an impact from the neighbouring area can be determined by combining the consequences should a fire or explosion occur with the likelihood of the event, with reference to the risk matrix in Section A2.1. The risk to people on-site is assessed as *ALARP* (a combination of a *Major* consequence with a *Remote* likelihood). The risk to people off-site from knock-on effects emanating from the site, as a result of an incident at a neighbouring area, is assessed as *Acceptable* (a combination of a *Notable event* consequence with a *Rare* likelihood).	
Risk ranking – On-site: safety	ALARP
Risk ranking – Off-site: safety	ACCEPTABLE
Note: The risk relates to the consequences of the propagation incident, not the initiating event which is outside of the scope of this PHA	
ALARP evaluation	
The risk associated with these types of incidents is managed in accordance with ALARP principles.	
ALARP justification:	
ALARP justified due to low levels of vegetation and adherence to the requirements in Codes and Standards	Justified

A2.2.9: Incident during construction activity causes impact with infrastructure or loss of control

HAZARDOUS EVENT	
Construction activities have the potential to cause injury to site personnel (excluded from this PHA) and the potential to damage the electricity poles.	
Consequences (immediate and ultimate)	
Consequences should an event occur would include fire or impact at a battery enclosure	
Consequence ranking	On-site (construction crew): *Severe* – fatality/life-threatening injuries

	Off-site (general public): *Notable event* – no physical injury
Likelihood and key risk controls	
Key risk controls are listed in Appendix 1.	
Likelihood ranking	On-site: *Rare* Off-site (general public): *Rare*
Risk evaluation	
The risk can be determined by combining the consequences with the likelihood of the event, with reference to the risk matrix in Section A2.1. The risk to people on- and off-site is assessed as *Acceptable* (a combination of a *Notable event* consequence with a *Rare* likelihood).	
Risk ranking – On-site: safety	ACCEPTABLE
Risk ranking – Off-site: safety	ACCEPTABLE
ALARP evaluation	
Provided that Codes and Standards are adhered to and that the requirements in Australian Standards and Ausgrid internal Codes of Practice for control during construction activities and management are followed, the risk can be managed to ALARP principles.	
ALARP justification:	
ALARP justified provided BESS conforms to the requirements in Codes and Standards.	Justified

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Appendix 3

Minimal footprint of the BESS

Preliminary Hazard Analysis for AusGrid's

Homebush Battery Energy Storage System, NSW

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Appendix 3 - Minimal footprint of the BESS.

The BESS would consist of large outdoor enclosures installed in rows. Each enclosure would be connected to a power conversion system (PCS) complete with inverter and step-up transformer. The PCS would either be housed within the enclosure or separate as a standalone cubicle. Inverter transformers (33 kV) and switchgear would either be housed on a common skid with the PCS or as a standalone skid.

The battery enclosures provide the building blocks for the BESS, repeated until the desired BESS capacity is reached. An indicative BESS area layout is shown in Figure 2-5 in the body of the report, with an extract of the total BESS layout shown in Figure A3.1 below.

The battery supplier would determine the number of battery enclosures, inverter stations and the electrical connection layout. 112 enclosures, installed in groups of 4, would be required to meet the required storage capacity.

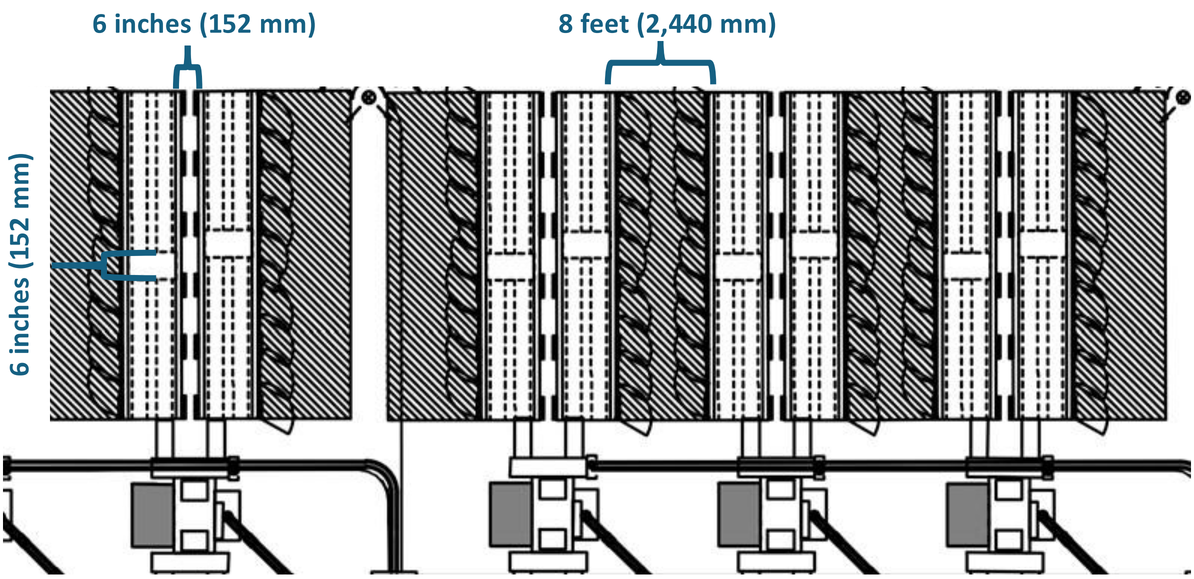

Figure A3.1 - Generic layout for the BESS, repeated for the desired output (Tesla MP2XL used as example enclosure selection)

Minimum separation distance within the BESS (example enclosure used in this PHA, Tesla MP2XL)		
6 inches (152 mm) between the enclosures in the same row	6 inches (152 mm) between adjacent enclosures in the same cluster (sides and back)	8 feet (2,440 mm) to the row directly in front

The separation distances within the BESS form a key control in ensuring that a thermal event in one enclosure does not propagate to adjacent enclosures. The final separation distances within the BESS, and the associated BESS footprint, would be determined during detailed design. The assessment conducted in this PHA, using the example battery enclosure believed to be the most conservative, confirms that the separation distances proposed in the preliminary site layout (Figure 2-5) are likely to be sufficient to prevent a fire in one enclosure from propagating to adjacent enclosures and rows, as based on the following:

- The battery enclosure confirmed no propagation in accordance with a destructive fire test or equivalent[14].
- With no propagation confirmed via the destructive tests including the Destructive Unit Level Test, the separation distances in the indicative BESS layout area (Figure 2-5 for the Tesla MP2XL comply with and exceed the stringent requirements for separation distances between battery enclosures specified in the National Fire Protection Association (NFPA) 855 Standard for the Installation of Stationary Energy Storage Systems, which is widely viewed as one of the most comprehensive Codes of Practice in the industry[15].
- Modelling of the heat radiation from external flames, which was conducted by the manufacturer (Ref 15), demonstrates that the fire would not propagate from one battery enclosure to adjacent enclosures.
- The distance between the site to the nearest off-site residential area is approximately 139 metres from the BESS area. At these separation distances, no significant off-site impact to offsite receptors is expected from a potential BESS fire.
- The closest enclosures are at least 16 metres from the site boundary and populated areas including nearby public roads. It is at least 40.5 metres from the WestConnex Fulton Hogan Egis Motorway MCC Office. This minimises off-site impact from a fire or toxic gas generation, and the heat radiation level associated with a fire at the BESS facility is not likely to exceed 2 kW/m^2 at the boundary (Ref 15), below 3 kW/m^2 which is commonly defined as the heat radiation level which could cause discomfort (refer to Appendix 3). The effects from a BESS unit fire are not expected to extend beyond the BESS site boundary.

Considering the heat radiation calculations for the worst-case scenario presented in Section 4.2.1 and detailed in Appendix 2 (as determined by Tesla via the engineering company Fisher Engineering,

[14] The UL 9540A testing in combination with the Tesla Destructive Unit Level Test consist of a set of destructive tests used for evaluating the thermal runaway impacts in a BESS and gathering data to assist in assessing or developing mitigation measures for the failure event, propagation of the failure, or consequences of an event, such as an explosion or fire.

[15] NFPA 855 para's 4.6.2 to 4.6.4 sets the minimum default separation distances to 914 mm (for maximum allowable energy storage unit at 50 kWh and 600 kWh for the overall BESS installation), with smaller separation allowed if the destructive large-scale fire testing (UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* or equivalent test standard) confirms no propagation, and as approved by the AHJ (in NSW, the FRNSW and the DPHI must approve that the test conducted provides sufficient demonstration, refer to Recommendation 2).

Ref 15), allowing for the separation distances between infrastructure to keep fire propagation from occurring as discussed in Appendix 3, the Proponent has used the separation distances and dimensions for the proposed BESS infrastructure to create the indicative site layout. The Project area would fit within the available area.