PRELIMINARY HAZARD ANALYSIS

STEEL RIVER EAST

BATTERY ENERGY STORAGE SYSTEM

AUSGRID

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Title: **Preliminary Hazard Analysis** **Steel River East** **Battery Energy Storage System**	**QA verified:** **S. Chan** **Date: 20-Mar-2025**

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ABBREVIATIONS

AC	Alternating Current
ADGC	Australian Dangerous Goods Code
AEGL	Acute Exposure Guideline Level
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
APZ	Asset Protection Zone
BESS	Battery Energy Storage System
BMS	Battery Management System
CBD	Central Business District
DA	Development Application
DBYD	Dial Before You Dig
DC	Direct Current
DG	Dangerous Goods
DoP	Department of Planning
DPHI	Department of Planning, Housing and Infrastructure
DVC	Decisive Voltage Classification
EIS	Environmental Impact Study
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Field
FM	Factory Mutual
FRNSW	Fire and Rescue New South Wales
G	Gauss
HAZID	Hazard Identification
HF	Hydrogen Fluoride
HV	High Voltage
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
kV	Kilovolt(s)
kW	Kilowatt(s)
kWh	Kilowatt hour(s)
LFL	Lower Flammability Limit
LFP	Lithium Iron Phosphate
$LiPF_6$	Lithium hexafluorophosphate
M	Metre(s)
MLRA	Multi-Level Risk Assessment
MW	Megawatt(s)
MWh	Megawatt hour(s)
NEM	National Electricity Market
NFPA	National Fire Protection Association
NMC	Nickel Manganese Cobalt
NSW	New South Wales

NZS	New Zealand Standard
OEM	Original Equipment Manufacturer
OH&S	Occupational Health & Safety
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
RFS	Rural Fire Service
RMU	Ring Main Unit
SDS	Safety Data Sheet
SEARs	(Planning) Secretary's Environmental Assessment Requirements
SEPP	State Environment Planning Policy
SPD	Surge Protective Devices
SSD	State Significant Development
T	Tesla
UL	Underwriters' Laboratories
V	Volt(s)
VBB	Victorian Big Battery

TERMINOLOGY

Term	Definition
Applicant	Ausgrid Operator Partnership
BESS facility	The eastern portion of the site designated for the battery enclosures, inverters/ MV transformers and associated infrastructure including BESS substation, control room, switchgear, and other supporting infrastructure.
Off-site	Areas extending beyond the site boundary.
Project area	The area that is located within the site and constitutes the development footprint, i.e. the area that will be physically disturbed for the construction and operation of the Project. The Project Area is around 4.12 ha.
Sensitive receivers	Persons, facilities, structures or organisms that are sensitive to potential noise, vibration, air and visual impacts, such as residents, schools, heritage structures and medical facilities.
The Project	Construction, operation, and maintenance of a battery energy storage (BESS) facility. For the purposes of the PHA, this study covers the 'operation phase' of the BESS facility, high voltage (HV) transmission line connection and ancillary elements
The site	The area of land owned by Ausgrid forming Lot 16, Deposited Plan (DP) 270249, covering an area of 5.06 ha. The address is 1 McIntosh Drive, Mayfield West, NSW 2304. Existing features of the site include the existing 132 kV Mayfield West Zone Substation and the Leading Edge Data Centre (leased on Ausgrid owned land), vacant grassland and vacant vegetated land. The Project would be located in the eastern part of the site, to the east of the Mayfield West Zone Substation.

1. EXECUTIVE SUMMARY

Ausgrid is seeking development consent for the construction, operation and maintenance of a Battery Energy Storage System (BESS) (the Project). The Project would be located in the Steel River East Industrial Estate at 1 McIntosh Drive, Mayfield West NSW 2304 (the site). The BESS would have a nominal capacity of 200 MW, and a two-hour duration (i.e. a 400 MWh BESS). Ausgrid has selected the Tesla Megapack 2 XL product range as the battery technology for the Project.

The Project has been designated a State Significant Development (SSD-77450458) requiring an Environmental Impact Statement (EIS). As such, Secretary's Environmental Assessment Requirements (SEARs) have been issued for the Project. This report specifically addresses the following SEARs:

- Dangerous Goods (DGs) – preliminary risk screening in accordance with State Environmental Planning Policy (SEPP) *SEPP (Resilience and Hazards) 2021*.
- BESS – hazards and risks in compliance with Hazardous Industry Planning Advisory Paper No 6 – Preliminary Hazard Analysis (PHA) (HIPAP 6) using the criteria in HIPAP No 4 – Risk Criteria.
- Health – EMF hazards.

The report makes the following conclusions:

- The proposal is not potentially hazardous in the context of DGs assessed under the State Environmental Planning Policy (SEPP) (Resilience and Hazards) 2021.
- The layout meets the requirements of codes, standards and OEM recommendations to prevent fire propagation.
- A HAZID and consequence analysis found that there are no potential events with significant off-site consequences, and societal risk is negligible. Based on the *Multi-Level Risk Assessment* guideline, Ref [1], the appropriate level of analysis is level 1 (qualitative).
- A fire involving the BESS will not result in fatality or injury at adjacent land uses including the Leading Edge Data Centre, CSIRO Energy Centre and the Laurio Place heliport.
- The level 1 assessment concludes that the Project meets the HIPAP 4 risk criteria and should not be precluded on the basis of land use safety.
- EMF hazards do not exceed recognised criteria'

The report has one recommendation:

1. Include an offsite incident involving the Jemena gas main in the site emergency response plan.

2. INTRODUCTION

2.1. Background

Ausgrid (the Applicant) is seeking development consent for the construction, operation and maintenance of a Battery Energy Storage System (BESS) (the Project). The Project would be located in the Steel River East Industrial Estate at 1 McIntosh Drive, Mayfield West NSW 2304 (the site). The BESS would have a nominal capacity of 200 MW, and a two-hour duration (i.e. a 400MWh BESS).

The Project is a State Significant Development (SSD) and is therefore supported by an Environmental Impact Statement (EIS). Secretary's Environmental Assessment Requirements (SEARs) for the Project, issued by the Department of Planning, Housing and Infrastructure (DPHI) include a requirement to address hazards associated with operation of the Project. The Applicant has engaged Sherpa Consulting Pty Ltd (Sherpa) to prepare this report in response to these SEARs requirements.

2.2. Objectives

The objective of the study was to perform an assessment to address the 'Hazards' component of the SEARs. The SEARs, and reference to where they are addressed in this report, are shown in Table 2.1.

Table 2.1: Hazard analysis requirements

Assessment Requirements	Section Reference
A preliminary risk screening completed in accordance with State Environmental Planning Policy (Hazards and Resilience) 2021.	Section 5
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 (DoP, 2011). The PHA must consider all recent standards and codes and verify separation distances to on-site and off-site receptors to prevent fire propagation and compliance with Hazardous Industry Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning (DoP, 2011).	Section 6-10
An assessment of potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields for the proposed BESS facility against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields.	Section 6-10 Note: The requirement for a bushfire risk assessment is considered elsewhere in the EIS and not addressed in this document.

2.3. Scope

The EIS should be referred for details of the overall Project. The key components that are relevant to the scope of this PHA study are summarised as follows:

- Nominal 200 MW, 2-hour duration BESS, comprising multiple battery enclosures, inverters/MV transformers, switchgear and a control building
- Containerised battery units (112 Tesla Megapack 2 XL) and associated infrastructure including 56 medium voltage (MV) transformers
- A 33kV underground cable connection from the battery units to the Mayfield West substation and infrastructure
- Combined switch room and control room building
- Eight ring main units (RMUs)
- Onsite workshop facility
- Backup diesel generator
- Ancillary infrastructure including:
  - Onsite workshop facility
  - Access to and from McIntosh Drive
  - Internal site access road and car parking
  - Connection to utilities
  - Lighting, fencing and security devices
  - Fire suppression
  - Storm water management.

The grid connection facility is the subject of a separate DA and hence is not included in the scope of this PHA study.

2.4. Exclusions and limitations

The study exclusions and limitations are summarised in Table 2.2.

Table 2.2: Exclusions and limitations

No.	Item	Exclusions and limitations
1	Design elements for the BESS	Design elements for the BESS may be subject to change prior to construction. Sherpa notes that the layout of the BESS megapacks would be finalised during detailed design conducted following the Project's approval. The assessment in this study uses the Tesla Megapack 2 XL battery system which was selected for the Project concept design.
2	Hazards associated with proposed operations	The study identified and assessed credible hazards associated with proposed operation of the Project and excluded hazards relating to construction, commissioning, and decommissioning. This approach is appropriate to support a DA for the Project.
3	Bushfire hazard assessment	The assessment of bushfire risks has been excluded from this assessment.
4	Construction Safety Study	The PHA does not constitute a Construction Safety Study. Any requirement for a Construction Safety Study will be subject to the conditions of consent. For more information, refer to HIPAP No. 7 – *Construction Safety,* Ref [2].
5	Fire Safety Study	The PHA does not constitute a Fire Safety Study. Any requirement for a Fire Safety Study will be subject to the conditions of consent. For more information, refer to HIPAP No. 2 – *Fire Safety Study,* Ref [3].
6	OEM and layout changes	The PHA should be reviewed if there are any changes to the preferred OEM, battery specification or to the site layout. The Applicant is responsible for ensuring the Project is designed and constructed according to the OEM's requirements and specifications.

3. FACILITY DESCRIPTION

The EIS contains the master Project description and should be referred to for the full context and details. Only features that are relevant to this report are summarised here.

3.1. Location and Project area

The site is located at 1 McIntosh Drive, Mayfield West NSW 2304. The site is within the City of Newcastle local government area, approximately 7 km north-west of the Newcastle Central Business District (CBD). Location of the Project is shown in Figure 3.1: Project location

The proposed BESS facility (battery units, invertors, MV transformers etc.) would be located in the Project Area on approximately 1 hectare of land in the eastern part of the site.

Connection of the BESS to the Mayfield West zone substation would be via a 33kV underground cable. Figure 3.1 shows the preliminary site layout.

3.2. Surrounding land use

The land use to the north, east and west of the BESS is mostly industrial. There is a childcare centre (approximately 380 m) and residential area (Groongal Street, approximately 420 m) to the south of the site. The approximate distances of these receptors, as well as other receptors of interest, is provided in Table 3.1 and illustrated in Figure 3.2.

Table 3.1: Off-site receptors

Receptor	Distance (m) from project area to receptor
Data Centre	20
Mayfield West substation	90
Recycling facility building (to the north)	60
Research laboratory (CSIRO)	60
High pressure gas pipeline	7
Childcare centre	380
Heliport (Laurio Place)	400
Closest residential area	420

Figure 3.1: Project location

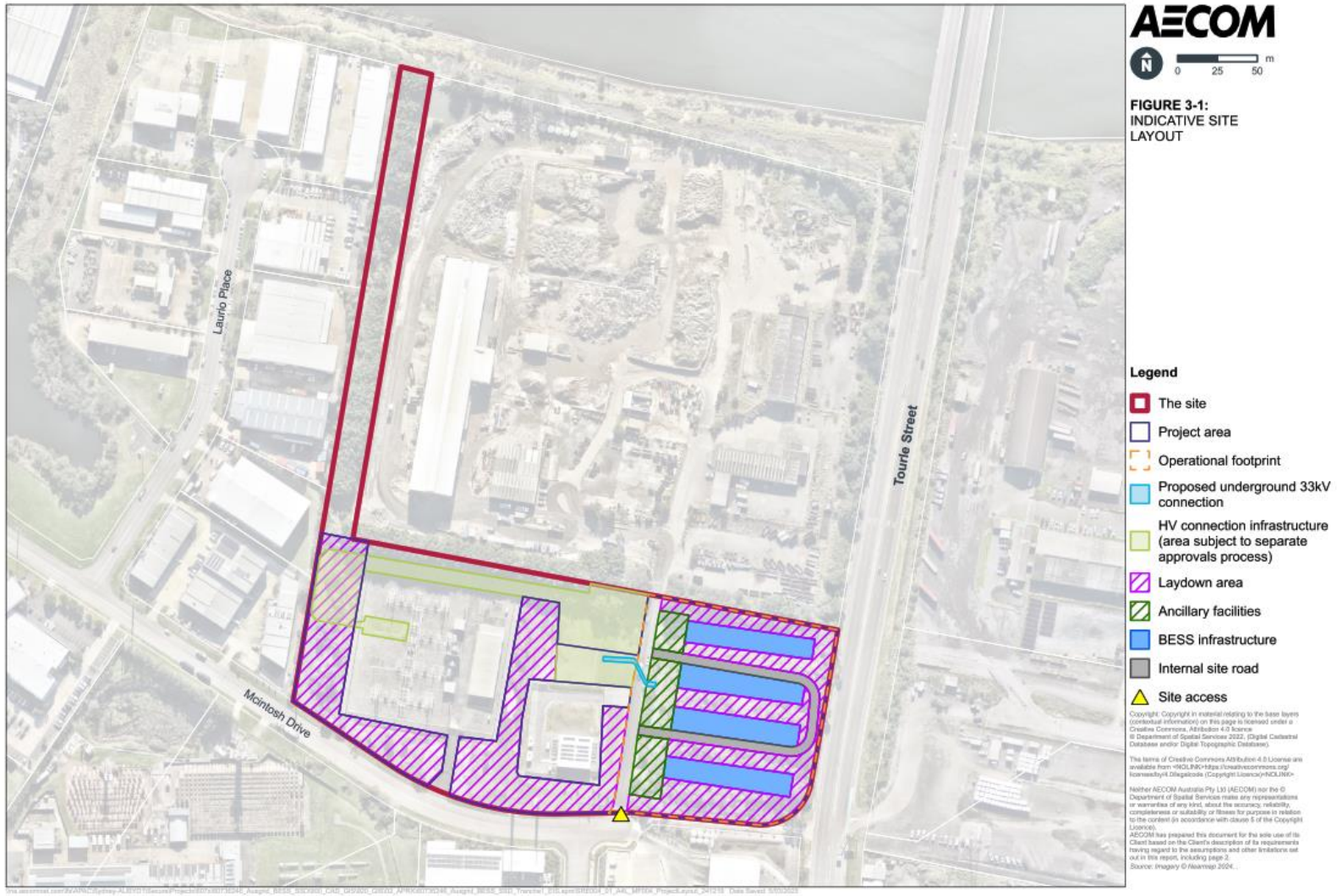


Figure 3.2: Sensitive receptors on the land surrounding the BESS facility

3.3. Project key infrastructure

3.3.1. Battery Energy Storage System

A BESS is a type of energy storage system that utilises batteries to store and discharge energy in the form of electricity. The energy is released as a direct current (DC). A bi-directional inverter converts the electricity from/to alternating current (AC) for transmission to/from the grid.

The BESS would store excess energy during peak production periods to later transmit into the grid when required (e.g. peak demand periods), and would also provide stabilisation services to the National Electricity Market (NEM).

The BESS would have a nominal capacity of 200 MW with a 2 hour discharge period. The assessment made in this study is based on the use of the Tesla Megapack 2 XL, as proposed by the Project's concept design. The Tesla Megapack 2 XL is a Lithium Iron Phosphate (LFP) battery.

Major components and specific features of the battery system are described in Table 3.2. The layout of the BESS would be finalised during detailed design following project consent.

The following key points are noted as the basis for this study:

1. The BESS megapacks will be installed in accordance with the OEM's instructions provided for mitigation of fire propagation, including clearance requirements.
2. The specific BESS (make and model) will be tested to Underwriters' Laboratories (UL) 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* to evaluate the thermal runaway and fire propagation characteristics, informing the required protection for its installation and operation. A UL 9540A test is considered successful if a fire does not propagate from one unit/cabinet to another during the test.
3. The designated area for BESS and associated infrastructure will be sufficient, considering onsite and off-site receptors.

Table 3.2: BESS components

<table>
<tr><th>Component</th><th>Description</th></tr>
<tr><td>Overview</td><td>The Tesla Megapack 2 XL (Megapack) assumed in this assessment is a modular, fully integrated, AC-coupled industrial system which includes the battery modules, inverters, thermal management system, circuit breakers and other controls.</td></tr>
<tr><td>Enclosure</td><td>Each Megapack battery system enclosure is rated to IP66, typically mounted on a compacted gravel bed, screw piles or a concrete pad. Each battery module is enclosed in a module measuring approximately (L) 8.8 m x (W) 1.65 m x (H) 2.75 m.</td></tr>
<tr><td>Battery modules</td><td>The battery system utilises a lithium iron phosphate chemistry technology. Each Megapack unit contains up to 24 battery modules. The rated energy for each unit will be approximately 1.9 MW/ 3.9 MWh (2 hours storage).</td></tr>
<tr><td>Battery Management System (BMS)</td><td>The Megapack BMS is the Tesla Controls Suite, which is the software hosted on the Tesla System Controller. This is a single point of interface for plant operators to monitor and control the entire system. The Tesla Controls Suite manages charge and discharge functions of the battery units, collecting real-time information and using it to optimise commands sent to each.</td></tr>
<tr><td>Thermal management system</td><td>Each Megapack includes a sealed liquid thermal management system with a dual coolant and refrigerant loop system that runs through the battery modules and inverters. The coolant and refrigerant are 50% ethylene glycol aqueous solution and R134A respectively.</td></tr>
<tr><td>Fire and explosion protection system</td><td>The Megapack does not contain built-in smoke, gas, or fire detection or suppression features. The Megapack inherent design minimises risk of a fire spreading from one cabinet to another. Validated large-scale fire testing has shown that in the event of a fire, the Megapacks perform in a safe and controlled manner, consuming themselves slowly without explosive bursts, deflagrations, or unexpected hazards, and without propagating to neighbouring enclosure units, Ref [4].</td></tr>
<tr><td>BESS Transformer</td><td>The Megapacks will be configured with an FM approved distribution transformer containing FR3 dielectric fluid.</td></tr>
<tr><td>Standards, Codes and Testing</td><td>Key standards, tests and/or certifications include:
<table>
<tr><th>Standards/ tests</th><th>Title</th><th>Component</th></tr>
<tr><td>IEC 62619</td><td>Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications</td><td>Cell/ Module</td></tr>
<tr><td>UL 1642</td><td>Standard for lithium-ion batteries</td><td>Cell</td></tr>
<tr><td>UL 1973</td><td>Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications</td><td>Cell/ Module</td></tr>
<tr><td>UL 9540A</td><td>Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems</td><td>System</td></tr>
<tr><td>UN 38.3</td><td>Certification for Lithium Batteries</td><td>Transportation</td></tr>
</table></td></tr>
</table>

3.3.2. Transformers

The project has selected FM Global approved transformers and transformer oil (FR3). The FR3 transformer oil has a high fire point (>300˚C) and when used in an FM approved transformer the requirements for separation distances to combustible material is reduced to 0.9 m.

3.3.3. Supporting infrastructure

The development will be supported by ancillary infrastructure including:

- Site access road
- Car park
- Control room / MV switchroom
- Water tank (for utility use, 20 kL).

3.4. Operations

The BESS will be nominally available 24 hours a day, seven days a week. The Tesla Megapacks will be set for one discharge and charge cycle per 24 hour period.

The BESS will be able to be operated remotely and there will be no need for permanent staff on-site. From time to time, maintenance activities (preventative and corrective) will be undertaken by staff or contractors. Land management activities including weed, pest and landscaping management will be undertaken on a regular basis.

3.5. Decommissioning

The BESS is intended to have an operational life of up to 50 years, with periodic component replacement occurring during this period. Any extension of this would be subject to additional approvals at the time, if necessary. During decommissioning above ground components would be removed and recycled where possible, and the land rehabilitated. The battery units would either be disposed of, repurposed or recycled at a licensed disposal facility.

4. HAZARDS AND RISK ASSESSMENT METHDOLOGY

4.1. Overview

The hazards and risk assessment methodology and relationship between steps is shown in the study flowchart (Figure 4.1). This shows how the overall assessment addresses the five elements as required by the SEARS, being:

1. Undertake a preliminary risk screening.
2. Complete an assessment of EMF hazards.
3. Consider separation distances between equipment to prevent fire propagation.
4. Consider hazards including fires, including spontaneous combustion in a hazard identification.
5. Undertake a PHA.

4.2. Preliminary risk screening

A preliminary risk screening was completed in accordance with SEPP (Hazards and Resilience), following the approach outlined in the Applying SEPP 33 guideline.

4.3. Preliminary Hazard Analysis

The PHA was completed following the methodology specified in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [5].

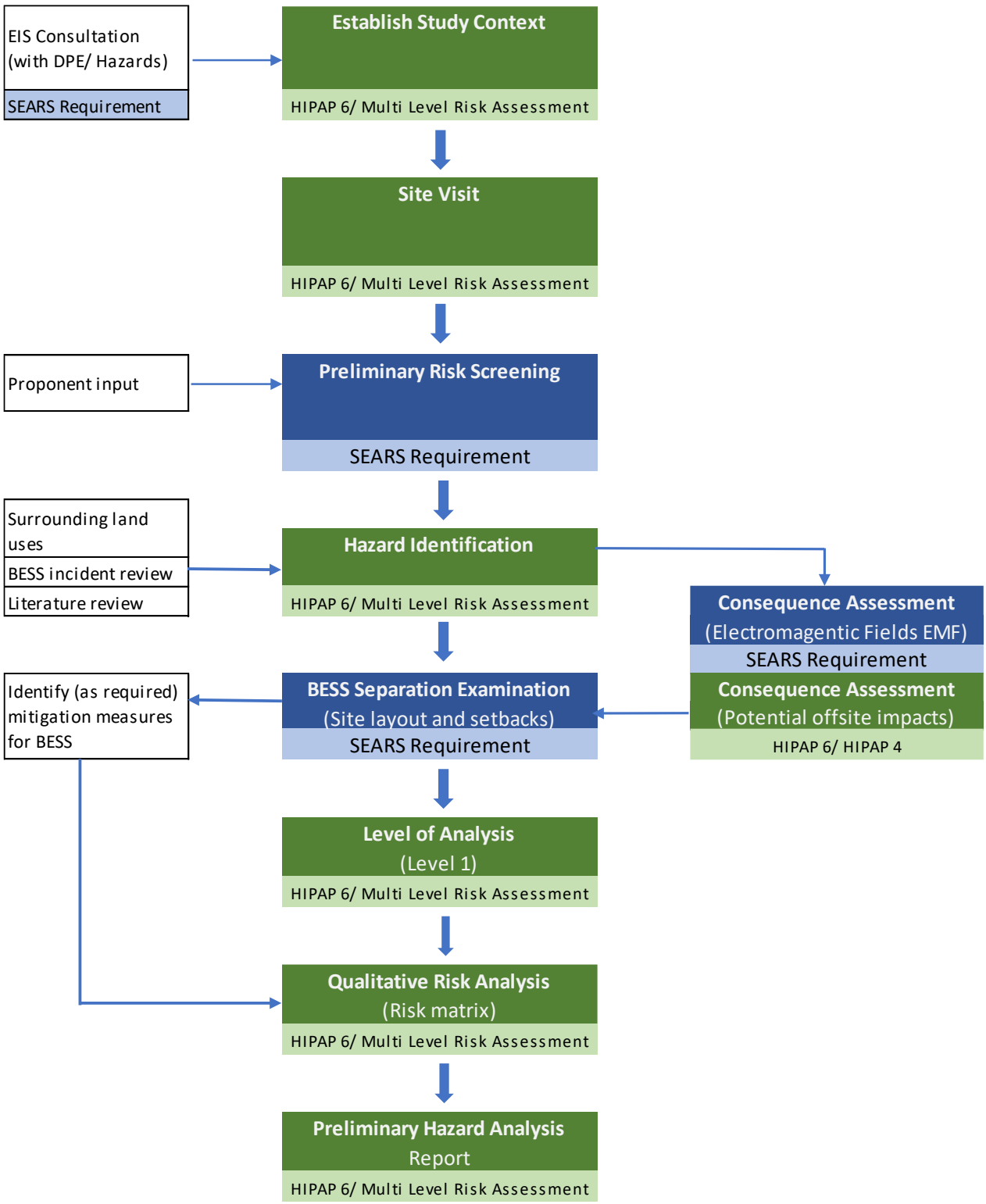
The HIPAP No. 6 methodology includes the following steps:

1. Establish the study context.
2. Identification of hazards resulting from the proposed Project and events with the potential for off-site impact *(Hazard Identification)*.
3. Analysis of the severity of the consequences for the identified events with potential off-site impact, e.g. fires and explosions *(Consequence Analysis)*.
4. Determination of the level of risk analysis required, and the risk assessment criteria.
5. Analysis of the risk of the identified events with off-site impact (*Risk Analysis*).
6. Assessment of the estimated risks from identified events against risk criteria to determine acceptability (*Risk Assessment).*

The PHA assessed the risks associated with proposed operation of the Project only. Construction, commissioning and decommissioning related events were not assessed.

The Hazard Identification included consideration of risks from all sources, including EMF and the potential for spontaneous combustion and fires with the potential for offsite impact.

Figure 4.1: PHA study flowchart – Steel River East BESS facility



4.4. Level of analysis

The *Multi-Level Risk Assessment* guidelines (MLRA), Ref [1], sets out three levels of risk analysis that may be appropriate for a land use safety planning assessment. These levels and a high-level summary of the justification required for each are shown in Table 4.1. The MLRA guidance document was consulted to determine the level of analysis required for this study.

Table 4.1: Level of analysis

Level	Analysis type	Appropriate/ can be justified if
1	Qualitative	There are no potential events with significant off-site consequences and societal risk is negligible.
2	Partially quantitative	The frequency of occurrence of risk contributors having off-site consequences is low.
3	Quantitative	There are significant off-site risk contributors, and a Level 2 analysis is unable to demonstrate that the risk criteria will be met.

The outcomes of the *Hazard Identification* (Section 6) and *Consequence Analysis* (Section 8) were used to determine the level of analysis appropriate for the PHA.

4.5. Risk assessment criteria

The risk criteria used for assessment followed the guidance provided in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [6], and are appropriate for determining the level of analysis and to complete the risk assessment.

4.6. ICNIRP considerations

The SEARs include a requirement to assess potential hazards and risks associated with exposure to EMF against the ICNIRP guidelines. This assessment considers the EMF exposures from the Project components (i.e. invertors, transformers, transmission lines, BESS) and compares it against the ICNIRP time varying electric and magnetic fields reference levels (general public and occupational). The results are used as an input to the BESS risk analysis.

5. PRELIMINARY RISK SCREENING

5.1. Overview

The objective of the preliminary risk screening was to determine whether the Project is considered as 'potentially hazardous' in the context of *SEPP (Resilience and Hazards) 2021*, Ref [7].

SEPP (Resilience and Hazards) 2021 defines potentially hazardous industry as follows:

> *"'Potentially hazardous industry' means a development for the purposes of any industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:*
>
> *(a) to human health, life or property, or*
>
> *(b) to the biophysical environment,*
>
> *and includes a hazardous industry and a hazardous storage establishment."*

Development proposals that are classified as 'potentially hazardous industry' must complete a PHA in accordance with *HIPAP No. 6 Guidelines for Hazard Analysis*, Ref [5], to determine the risk to people, property, and the environment. If the residual risk exceeds the acceptability criteria, the development is considered as a 'hazardous industry' and may not be permissible within NSW.

To determine whether a proposed development is potentially hazardous, the NSW Department of Planning, Housing and Industry (DPHI) *Applying SEPP 33* guideline[1], Ref [8], is used to guide a risk screening process. The risk screening process considers the type and quantity of hazardous materials to be stored on site, distance of the storage area to the nearest site boundary, specific types of industry and operations as well as the expected number of transport movements.

'Hazardous materials' are defined within Applying SEPP 33 as substances that fall within the classification of the Australian Dangerous Goods Code (ADGC), i.e. have a Dangerous Goods (DG) classification. Details of the DG classification are typically obtained from the materials' Safety Data Sheet (SDS).

The *Applying SEPP 33* guideline is based on the 7th edition of ADGC, Ref [9], and refers to hazardous chemicals by their DG classification. Risk screening is undertaken by comparing the storage quantity and the number of road movements of the hazardous materials with the screening threshold specified in the guideline. The screening threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

[1] SEPP No. 33 *Hazardous and Offensive Development* (SEPP 33) has been revoked and incorporated as Chapter 3 of *SEPP (Resilience and Hazards) 2021*. For the preliminary risk screening, the guidance document *Applying SEPP 33* still applies.

5.2. Risk screening

The Project was assessed based on Tesla Megapack 2 XL battery. These batteries are classified as DG class 9 (miscellaneous). Battery refrigerant (R134a) is classified as DG class 2.2 (non-toxic, non-flammable gas). Battery coolant (ethylene glycol aqueous solution) is not classified as a DG, and if not stored with flammable or reactive materials, does not contribute to the screening threshold.

Transformer oil may be a combustible liquid and diesel for the backup generator is a combustible liquid. Combustible liquids do not have a screening threshold if they are segregated from flammable liquids.

A summary of the expected hazardous materials to be stored and handled on site during the operational phase of the Project, transport movements, and the relevant SEPP screening threshold is presented in Table 5.1.

5.3. Other risk factors

Appendix 2 of *Applying SEPP 33* outlines other risk factors for consideration to identify hazards outside the scope of the risk screening method.

A review of these risk factors was completed, and it was noted that the Project would not involve:

- Storage or transport of incompatible materials (i.e. hazardous and non-hazardous). Hazardous materials will be stored in dedicated areas and storage protocols in accordance with standard and guidelines will be followed.
- Generation of hazardous waste.
- Possible generation of dusts within confined areas.
- Storage or processing operations involving high (or extremely low) temperature and/or pressures.
- Activities involving hazardous materials with potential to cause significant off-site impacts.
- Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition.

5.4. Industries that may fall within the Resilience and Hazards SEPP

Appendix 3 of *Applying SEPP 33* provides a list of industries that may be potentially hazardous. It is noted that this list is illustrative rather than exhaustive. The current edition of the guideline does not include BESS facilities in the example industry listings that may fall within the Resilience and Hazards SEPP or considered as potentially hazardous.

5.5. Risk screening assessment conclusion

The preliminary risk screening found that the BESS development is not 'potentially hazardous' and does not require a PHA under SEPP (Resilience and Hazards)

Regardless of the findings of the risk screening, the SEARs require a PHA covering hazards and risks associated with operation of the project, which is presented below.

Table 5.1: Preliminary risk screening summary

Material	DG Class	Category	Storage threshold	Transport threshold		Project storage quantities and applicable SEPP screening	Exceed threshold?
				Movements	Quantities		
BESS battery (Lithium ion-LFP)	9	Miscellaneous DGs	N/A	< 1000 (annual) < 60 (weekly)	No limit	No applicable SEPP screening threshold and excluded from risk screening. Transport movement threshold will not be exceeded. Movements are expected to occur during construction only and minimal post installation (e.g. battery replacement).	No
BESS coolant (50% ethylene glycol aqueous solution)	-	N/A	N/A	N/A	N/A	Not classified as DG. No applicable SEPP screening threshold and excluded from risk screening.	No
BESS refrigerant (R134A)	2.2	Non-flammable non-toxic gases	N/A	N/A	N/A	No applicable SEPP screening threshold and excluded from risk screening. Class 2.2 is not considered to be potentially hazardous with respect to off-site risk.	N/A
BESS MV Transformer oil	C	Combustible	N/A (unless stored with flammable liquids)	N/A	N/A	Transformers and associated oils will be segregated from flammable liquids.	No
Diesel	C	Combustible				Diesel will be segregated form flammables.	No

6. HAZARD IDENTIFICATION

6.1. Overview

Hazard identification is a key step in the PHA process. The primary objective of the Hazard Identification (HAZID) is to identify all reasonably foreseeable hazards and associated events that may arise due to the operation of the BESS through a systematic and structured approach.

The HAZID is representative of the proposed Tesla Megapack 2 XL technology and was completed using the following inputs:

1. Review of Megapack 2 XL specification sheets, Ref [10].
2. Review of other lithium-ion battery system product specification sheets and product brochures, Ref [11], [12], [13], [14].
3. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment,* Ref [15].
4. Literature research of past incidents involving similar BESS systems.
5. Previous risk assessments for similar BESS systems completed by Sherpa.
6. Review of satellite images to understand the potential interactions between the proposed BESS and surrounding land uses.
7. Consultation with the Applicant on separation distances for acceptance.
8. Site visit of the existing Mayfield West substation and surrounds.

6.2. Tesla Megapack 2 XL battery hazards

Currently, LFP batteries are the dominant battery chemistry used in large scale BESS facilities. A typical lithium-ion battery comprises:

- An anode (typically graphite) with a copper current collector
- A cathode (lithium iron phosphate – LiFePO4 or LFP) with an aluminium current collector
- A porous separating layer between the anode and cathode (typically a polymer)
- An electrolyte comprised of a lithium salt (e.g. lithium hexafluorophosphate ($LiPF_6$)) dissolved in a solvent (e.g. ethylene carbonate and diethyl carbonate).

It is important to recognise that there is considerable research and ongoing development in lithium-ion battery chemistry. This hazard identification is based upon available knowledge of the BESS types in mid-2024 and specific features of the Tesla Megapack 2 XL.

Potential hazardous events associated with lithium-ion batteries are:

- Thermal runaway potentially leading to thermal decomposition and potentially a BESS unit fire
- Toxic vapour generation (e.g. decomposition of $LiPF_6$) within the battery electrolyte due to the fire)
- Flammable gas accumulation due to electrolyte decomposition within a confined space (e.g. in an enclosed module) and a vented explosion.

6.2.1. Thermal runaway

Thermal runaway occurs when the internal temperature of a lithium-ion cell increases beyond its design range leading to exothermic decomposition reactions generating additional heat. If the additional heat is not dissipated, the cell temperature is further elevated, accelerating the process of decomposition and heat generation. This becomes a self-sustaining exothermic reaction and can lead to a fire.

The causes of thermal runaway involving lithium-ion batteries may occur from a variety of failure modes including:

- Electrical abuse (e.g. overcharging / discharging)
- Thermal abuse (e.g. overtemperature)
- Mechanical abuse (e.g. external impact)
- Existing, latent defect (e.g. electrolyte leaks, faulty components).

Whilst Tesla provides design measures to eliminate or reduce the potential of these failure mechanisms, the PHA has considered thermal runaway as a credible hazardous event due to reported BESS facility incidents (refer to Section 6.3).

6.2.2. Toxic vapour generation

$LiPF_6$ is widely used as a salt in the electrolytes for LFP chemistry. In the event of a LFP thermal runaway or battery fire involving the electrolyte, there is the potential to generate toxic gases (e.g. hydrogen fluoride - HF). Experiments at a bench scale (Ref [16]) have indicated that for certain lithium-ion LFP batteries, HF can be generated during thermal runaway (pre-ignition) and fire (post ignition).

The Tesla Megapack 2 XL Fire Protection Engineering and UL9540A Interpretation Report by Fire and Risk Alliance Ref: [17] was reviewed to determine the potential for toxic gas generation from a Tesla Megapack 2 XL during UL9540A testing. The report concludes the following:

- Cell level test – Toxic gases sometimes associated with lithium-ion batteries such as HF, HCL, HCN were not vented from the cell during thermal runaway.

- Module level testing – Toxic gases sometimes associated with lithium-ion batteries, such as HF, HCL and HCN were not detected during combustion of a Megapack 2 XL tray.

To provide products of combustion information at a unit level additional sampling and testing was undertaken by Tesla. It is noted that the testing was completed in-house by Tesla following the requirements of UL 9540A, but the results were not certified under UL 9540A.

Samples were taken 20 feet (6 m) upwind and 5 feet (1.5 m) downwind of the unit on fire and were analysed for Mercury and hydrogen fluoride (HF). Samples were collected over 2 ½ hours and the levels reported as the cumulative amount detected over the period of the test and found:

- No trace of Mercury
- HF at concentrations 0.1 ppm and 0.12 ppm at the sampling locations.

HF detection levels were below the AEGL 2 injury level (24 ppm) and AEGL 3 fatality level (44 pm).

Noting there was no HF detection in the cell and module tests, it is possible that the HF came from another battery component or, given the low value detected for a period of 2 ½ hours, the unit and cell levels tests may have generated HF but below detectable levels.

Given the cell and module level tests reported no toxic products of decomposition or combustion and the low level of HF detected in the unit level test, the potential for offsite toxic impact was determined as not being a credible scenario.

6.2.3. Flammable gas

The Tesla Megapack 2 XL Fire Protection Engineering and UL9540A Interpretation Report by Fire and Risk Alliance Ref: [17] was reviewed to determine the potential for flammable gas generation from a Tesla Megapack 2 XL during UL9540A testing. The report concluded the following:

- Cell level test – off gas produced during thermal runaway with no ignition is flammable with an LFL of 6-7%.
- Module level testing – thermal runaway propagates to a fire and was not contained by the module design.
- Unit level testing – cell to cell propagation of fire was observed.

Based on the test results it was concluded that a BESS unit on fire is a credible scenario with potentially harmful levels of heat radiation.

6.2.4. Explosion overpressure

The Tesla Megapack 2 XL Fire Protection Engineering and UL9540A Interpretation Report by Fire and Risk Alliance Ref: [17] was reviewed to determine the potential for damaging levels of explosion overpressure. The report details the key features of the Tesla Megapack 2 XL designed to mitigate the effects of an explosion as:

- Electrical spark system designed to ignite any flammable gas evolved during thermal runaway before it can accumulate inside the unit.
- Explosion events, designed to NFPA 68, designed to open and relieve any overpressure vertically from the unit before it causes damage to the unit.

The report states that during the unit level test there was no indication or observance of: deflagration, projectiles, flying debris, hazardous pressure waves, shrapnel or other explosive discharge of gases. Given the design of the overpressure management system, explosion overpressure sufficient to cause damage at the site boundary was not considered credible.

6.3. Review of incidents

There have been incidents involving large scale lithium-ion BESS facilities as reported in the public domain. Table 6.1 presents an incident summary (2019 to date) of selected events from the Australian Energy Council (Ref [18]), and other recent incidents..

Table 6.1: Selected BESS fire events

Date	Location	Facility Size	Description
April 2019	Arizona McMicken Facility, USA	2 MW/ 2 MWh	**Battery Fire** The investigation found that the following were contributing factors: - Internal defect within the LG Chemical batteries (Li-NMC) which initiated an “extensive cascading thermal runaway event” - Lack of thermal barriers between battery cells - Storage container design did not allow the vapour and gases produced during the incident to vent, leading to a build-up of flammable / explosive gases within the container - Inadequate emergency response plan which did not instruct personnel how to extinguish the fire or specify the entry procedure.
July 2021	Moorabool, Victoria Big BESS facility, Australia	300 MW/ 450 MWh	**Battery Fire** The Tesla Megapack batteries were of NMC type. Energy Safe Victoria investigation found that the probable root cause of the thermal escalation event was a leak in the internal coolant system of the Tesla Megapack 1.0 in combination with

Date	Location	Facility Size	Description
			unmapped SCADA systems during the commissioning. The event started in one Megapack and escalated to another, and thermal radiation from this fire damaged two adjacent megapacks. Recommendations were made that Tesla has since adopted in operation of their batteries.
September 2021, February 2022, September 2022	Monterey County, California Moss Landing BESS facility, USA	400 MW / 1,600 MWh	**Overheating (Sept 2021, Feb 2022)** Li-ion battery modules (Phase 1) were operating above their operational temperature limit. The investigation found overheating of the battery was not the cause of the incident. Rather, it was possibly due to a fan bearing causing smoke which triggered the water system. Due to faulty couplings, the water system improperly sprayed the battery racks which led to overheating of the batteries. A similar incident again occurred in February 2022. **Battery Fire (Sept 2022)** This incident resulted in highway closure due to possible hazardous gas releases during a fire incident. The root causes are not provided. Although there was an earlier incident in that period possibly caused by the overheating incident described above.
September 2023	Boulderombe Battery Project, Queensland, Australia	50MW/ 100MWh	**Battery Fire** One of 40 Tesla Megapack 2 battery units (LFP type) caught fire without propagating to other units. The fire occurred at the final stages of commissioning phase. No injuries were reported.
April 2024	Neermoor, Germany	Unknown	**Battery Fire** A small container fire of a Li-ion battery module resulted in a flame jet and several explosions when firefighters opened the container door (unaware of the contents). Two firefighters were injured and a nearby highway was closed due to smoke. The container was cooled with water and moved with a crane to prevent propagation, with the fire declared extinguished after 10 hours. The cause of the initial fire has not been published as yet.

6.4. Hazard identification

Sherpa developed the HAZID in consultation with the Applicant and based upon site visit observations. The following factors were considered to identify the BESS hazards:

- Lithium-ion battery chemistry, specifically LFP chemistry
- BESS component and type of equipment
- Proposed operation and maintenance activities
- BESS incident history
- External factors (e.g. bushfire, unauthorised personal access, lightning storm).

Events with the potential to result in significant impacts to people (i.e. injury and/ or fatality) were identified. The study excluded hazards related to Occupational Health & Safety (OH&S), e.g. slips, trips and falls as they do not have an offsite impact.

The types of hazards and associated events considered were informed from *AS/NZS 5139*, Ref [19]. The identified hazards and events are presented in Table 6.2.

Table 6.2: Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Release of energy	Arc flash
Fire	Infrastructure fire, scrub fire[1]
Chemical	Release of hazardous materials
Explosive gas	Generation of explosive gas
Reaction	Battery thermal runaway
EMF	Exposure to electric and magnetic fields (EMF)
External factors	Water ingress (rain and flood), unauthorised access/trespasser, lightning storm, high ambient temperature, high pressure gas pipeline. Facility will be designed for the appropriate earthquake period.

Note 1: The requirement for a bushfire study is addressed by others in the EIS. The site visit did note some scrub to the north of the site, and this has been included in the HAZID.

A summary of the hazards present at/applicable to the Steel River East Project is provided in Table 6.3.

Table 6.3: Hazards by component

Hazard	BESS components/ substation			
	Battery modules	BMS	Thermal management system (BESS coolant)	BESS MV transformer
Electrical	✓	✓	-	✓
Energy (arc flash)	✓	✓	-	✓
Fire	✓	✓	✓	✓
Chemical	✓	-	✓	-
Explosive gas	✓	-	-	-
Reaction	✓	-	-	-
EMF	✓	-	-	✓
External factors	✓	✓	✓	✓

6.5. Exposure to EMF

As a part of this PHA, the hazards and risks associated with exposure to EMF against the ICNIRP guidelines have been assessed. The details of this are presented in APPENDIX B.

Based on the detail in APPENDIX B, this study concludes that:

- EMF created from the Project will not exceed the ICNIRP occupational exposure reference level.

As the strengths of EMF attenuate rapidly with distance, this study determined that the ICNIRP reference level for exposure to the general public will not be exceeded, and impact to the general public in surrounding land uses will be negligible.

For the risk assessment, consequence from exposure to EMF was assumed to result in no or minor injury ('Insignificant') in reference to the consequence impact rating shown in Table 10.2.

The identified contributors to the cumulative EMF in the vicinity of the Project are listed in Table 6.4. The cumulative exposure to EMF from the Project and other developments in the vicinity of the Project is considered negligible as the strength of EMF attenuates rapidly with distance. Thus, no off-site impact and no cumulative exceedance of EMF exposure limits is expected from the Project, and it is not carried forward for risk assessment or further assessment.

Table 6.4: EMF sources in Project area

No	Description
1	BESS (proposed)
2	Mayfield West substation (existing)
3	Transmission lines (existing)

6.6. HAZID findings

The HAZID register is provided in APPENDIX A. A total of 17 hazardous events were identified, of which:

- Seven of the hazardous events were determined to involve a BESS Megapack 2 XL on fire with the potential for offsite effects.
- One offsite event (Jemena gas pipeline fire) was identified as having the potential to escalate and result in more BESS unit fires.
- The remaining hazardous events were assessed as having no potential for offsite impact.

The consequences associated with a BESS megapack on fire and a fire from the Jemena gas main were carried forward to consequence modelling.

7. CONSEQUENCE ASSESSMENT

7.1. Overview

Two scenarios were carried forward from the HAZID to consequence modelling:

- Fully developed BESS unit fire
- Rupture and fire of natural gas from the Jemena gas pipeline.

The purpose of the consequence analysis was to determine if offsite injury or fatality was a credible outcome of the scenarios.

The modelling input and assumptions are given in APPENDIX C with the key elements and findings summarised in this section.

7.2. Criteria

The HIPAP 4 criteria for heat radiation were used for the study, as outlined in Table 7.1.

Table 7.1: Heat radiation criteria

Criteria	Level (kW/m^2)	Commentary
Injury	4.7 kW/m^2	Will cause injury after 30 seconds
Fatality	12.6 kW/m^2	Significant chance of fatality for extended exposure. High chance of injury. Thin steel may reach thermal stress levels that cause it to fail.
Escalation	23 kW/m^2	Steel will reach temperatures which can cause failure

7.3. BESS unit fire model

7.3.1. Background

A BESS unit on fire is modelled as a planar fire emitting heat with heat flux calculated for a receptor.

The key inputs are:

1. Area of the fire
2. Surface temperature of the fire
3. Distance to receptor
4. View factor (area of flame visible to the receptor).

7.3.2. Model validation

The general approach of representing a fire as a planar fire and calculating heat flux at a point based on surface temperature and a view factor is well established, and the Sherpa model has been validated against other industry models.

Tesla has developed an in-house model based on test results obtained during a full burndown test of a Megapack 1 unit. While the full tests have not been released the

Sherpa model has been validated against results and commentary in a report provided by Tesla to the Project.

The results of the validation are provided in APPENDIX C. When compared to test data, the Tesla model overpredicted heat flux by approximately 16% and the Sherpa model overpredicts by approximately 20% from the test. The Tesla-provided report states that overpredicting by 20% is acceptable given the uncertainty in collecting outdoor heat flux measurements.

As the basis of the model is well established and the results are comparable to the Tesla test results and model, the Sherpa model is considered appropriate for land use planning.

7.3.3. Scenario

Sherpa modelled a fully developed BESS unit fire. While it is noted that the unit level test for Tesla Megapack 2 XL did not result in a fully developed fire, the method of initiation of the fire (forcing a set of modules into thermal runaway) may represent all possible BESS unit fires (e.g. failure of safety system forcing all modules in thermal runaway).

A fire was modelled for areas representing:

- side (approximately 9 m wide x 2.8 m high)
- end (approximately 1.7 m wide x 2.8 m high).

7.3.4. Consequence modelling results

The modelling found:

- fatality levels (12.6 kw/m^2) ranging from 4 m (side) to 9 m (side)
- injury levels (4.7 kW/m^2) ranging from 7 m (side) to 15 m (side).

The nearest site boundary is the eastern (Tourle Street) boundary, which is approximately 10 m from the side of a BESS unit. Based on the modelling results:

- fatal heat radiation effects are contained onsite for all BESS units
- injury level heat radiation may extend up to 5 m onto the Tourle Street road reserve to the east of the site
- fatal and injury impacts do not reach offsite receptors listed in Table 3.1.

The injury risk criteria for heat radiation is expressed as follows in HIPAP 4:

- Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2 at a frequency greater than 50 chances in a million per year.

The Tourle Street footpath is not a residential or sensitive use area. The injury risk criteria is met.

7.3.5. Off-site and sensitive receptors impact

From the site visit, there are no populated or sensitive areas on the site boundary. While the injury contour extends into a public area on Tourle street, this is a multi-lane road with a narrow footpath and there are no significant populations served by the footpath.

Figure 7.1 shows the location of the BESS with a view looking north on Tourle Street towards the bridge to Kooragang Island.

Figure 7.1: Tourle Street (looking north)

7.4. Jemena gas pipeline

7.4.1. Consequence model and results

A Jemena operated gas pipeline runs along the southern boundary of the site. The consequences of an ignited release from the pipeline were modelled to determine if there was the potential for a gas fire to escalate to a BESS unit.

The modelling is detailed in APPENDIX C with the results presented in Table 7.2.

As the pipe is buried, ignited releases will result in vertical jet fires. The heat radiation values in the table represent a circle centred on the pipeline. They are reported at 3 m above the ground to represent the top of a BESS unit.

The distance from the pipeline to the closest BESS unit is approximately 30 m. The results show that for a full bore rupture of the gas pipeline there is the potential for the heat radiation at 23 kW/m^3 to reach the nearest BESS megapack. This is assumed to be sufficient to cause escalation to a BESS thermal runaway and fire.

Table 7.2 Heat radiation from HP pipeline jet fire

		Maximum distance for 23 kW/m^2 heat radiation (m)
Hole diameter (mm)	**Weather condition**	**3 m receptor height**
50	1.5/F	3
50	5/D	15
100 (full bore rupture)	1.5/F	7
100 (full bore rupture)	5/D	21
150 (full bore rupture)	1.5/F	8
150 (full bore rupture)	5/D	31

7.4.2. Off-site and sensitive receptors impact

Escalation of a fire from the gas main to a BESS unit is unlikely to increase the offsite consequence of the initial event but it should be considered in the site emergency response plan and emergency services, and first responders should be made aware of the potential for a gas jet fire to escalate to involve a BESS unit.

Recommendation: Include an offsite incident involving the Jemena gas main in the site emergency response plan.

8. SEPARATION DISTANCES

8.1. Overview

This section addresses the requirement for the PHA to consider all recent standards and codes and verify separation distances to onsite and offsite receptors to prevent fire propagation.

The review in this section covers OEM separation distances stated in the Tesla megapack battery installation manual and the FM approved distribution transfer solutions data sheet. These are based upon standardised fire tests (e.g. UL9540A unit level test) to prevent fire propagation between battery units and FM approval for transformer fires.

The OEM separation distances are provided for:

- BESS enclosure to BESS enclosure
- Transformer to building walls (2 hour fire rated, non-combustible wall, combustible wall).

8.2. Separation distances between Tesla Megapack 2 XL units

8.2.1. NFPA 855

The National Fire Protection Association (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* is widely viewed as the most comprehensive set of best practice guide in the industry. A review of NFPA 855 was undertaken to determine the required separation distances between the BESS megapacks, Ref [20].

NFPA 855 specifies the default maximum allowable energy storage unit at 50 kWh (and 600 kWh for the overall BESS installation), and minimum separation of 914 mm between units and walls (for indoor installations). NFPA 855 also specifies that the BESS may be installed in units with larger energy capacities or smaller separation if they meet the fire and explosion testing in accordance with UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, or equivalent test standard. As such, the results of the UL 9540A test (performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

The UL 9540A testing is a destructive test method 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. It is currently considered to be the most appropriate published methodology to provide comprehensive, consistent, and reliable data for battery failure testing. Tesla has carried out UL 9540A testing on the Megapack 2 XL.

8.2.2. Manufacturer specified clearances

Tesla provide minimum clearances for the side, back and front of the Megapack 2 XL (Table 8.1). The Applicant confirmed the specified clearances have been considered when developing the preliminary site layout.

Table 8.1: Tesla BESS minimum clearances

Installation	Megapack 2 XL minimum clearance (m)
Side	0.15
Back	0.46 0.23 with prior Tesla approval
Front	2.44

8.3. Layout assessment – onsite receptors

The Steel River East BESS layout has followed the Tesla OEM installation manual and the transformer FM approvals for separation distances:

- Between the BESS megapacks. The separation distances are based upon the UL 9540A tests to demonstrate propagation characteristics based on separation between batteries.
- From transformers the FM approved distances have been used.

8.4. Separation distance review findings

The review of BESS separation distances (for onsite and offsite) found that:

- [Onsite] The Applicant confirmed the preliminary BESS layout (battery and inverters) will meet the recommended clearances specified by Tesla. Additionally, the assessed battery system was tested to UL 9540A, and the unit level results indicate the resiliency to thermal runaway propagation and fire hazard in a single failure event.
- [Onsite] As per the Tesla OEM installation manual, the proposed BESS layout conforms to the minimum separation distances. The water tank and the onsite maintenance building lie closer than 6 m from the nearest BESS; this is acceptable as these receptors do not store ignitable liquids.
- [Offsite] The distance between a BESS megapack and the nearest site boundary is estimated to be 10 m for the units on the east of the BESS facility. This is more than the estimated fatality distance from the BESS unit fire (9 m).
- [Offsite] The distance between a BESS megapack and the nearest residential or sensitive receptor is 380 m. This is more than the estimated injury distance from the larger face of a BESS unit fire (15 m).

9. LEVEL OF ANALYSIS DETERMINATION

9.1. Level of analysis

The HAZID and consequence analysis found there are no potential events with significant off-site consequences and societal risk is negligible.

Based on the above findings and the *Multi-Level Risk Assessment* guideline, Ref [1], the appropriate level (Table 4.1) of analysis for this PHA is a qualitative approach (i.e. Level 1 approach). The risk analysis is presented in Section 10.

9.2. Qualitative risk criteria

HIPAP No. 4, recommends a set of qualitative criteria/ principles be adopted concerning the land use safety acceptability of a development.

The risk assessment against HIPAP No. 4 criteria is provided in Section 10.

10. RISK ANALYSIS AND ASSESSMENT

10.1. Risk analysis

10.1.1. Risk Matrix and acceptance criteria

For this study, acceptance criteria used to assess the risk for off-site populations are:

- Extreme – Unacceptable; immediate action is required
- High – Unsatisfactory; an action plan is required which includes steps for timely risk prevention or mitigation
- Medium/Low – Tolerable; implement additional controls if reasonably practicable
- Very Low – Acceptable; no specific action is required.

The risk matrix (Table 10.1) used for this study is reproduced from *AS/NZS 5139: Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [21].

Table 10.1: Risk matrix

Consequence	Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Catastrophic	Medium	High	High	Extreme	Extreme
Major	Medium	Medium	High	High	Extreme
Moderate	Low	Medium	Medium	High	High
Minor	Very low	Low	Medium	Medium	Medium
Insignificant	Very low	Very low	Low	Medium	Medium

10.1.2. Severity rating

For each event, the severity rating was assigned based on the consequence description identified in the HAZID register and the consequence analysis findings using the category scale and guidance shown in Table 10.2 (adapted from AS/NZS 5139).

Table 10.2: Consequence rating – off-site

Consequence rating	Rating definition
Catastrophic	Fatality (single or multiple).
Major	Non-recoverable occupational illness or permanent injury. Injury or illness requiring admission to hospital.
Moderate	Injury or illness requiring medical treatment by a doctor. Dangerous/reportable electrical incident.
Minor	Injury requiring first aid. Circumstances that lead to a near miss.
Insignificant	No or minor injury.

10.1.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 10.3, which was adapted from *AS 5139.*

The likelihood ratings were assigned based on knowledge of historical incidents in the BESS industry (Section 6) and in consultation with the Applicant.

Table 10.3: Likelihood rating

Likelihood rating	Rating definition
Almost certain	Expected to occur whenever the system is accessed or operated.
Likely	Expected to occur when the system is accessed or operated under typical circumstances.
Possible	Expected to occur in unusual instances when the system is accessed or operated.
Unlikely	Expected to occur in unusual instances for non-standard access or non-standard operation.
Rare	Highly unlikely to occur in any instance related to coming into contact with the system or associated systems.

10.2. Risk analysis findings

Based on the consequence analysis two scenarios were carried forward to risk assessment. The qualitative risk assessment is shown in Table 10.4.

Table 10.4: Steel River East BESS risk assessment

Incident location	Risk analysis (off-site/public impact) – concept layout			Recommendations
	Severity	Likelihood	Risk	
BESS fire	Moderate (Medical treatment for burn)	Rare (area not occupied and escape possible)	Low	None
Jemena gas pipeline full bore rupture and fire.	Minor (BESS fire will be smaller than the initiating event)	Rare (based on historical pipeline rupture data)	Very Low	**Recommendation** to include Jemena pipeline incident in the site emergency response plan

10.3. Risk Assessment

10.3.1. Assessment against AS/NZS 5139 risk criteria

Using the risk matrix from *AS/NZS 5139*, the identified hazardous events were qualitatively risk profiled, and all found to be 'Very Low' or 'Low' risk.

10.4. Assessment against HIPAP No. 4 criteria

Assessment against the *HIPAP No. 4* qualitative land use planning risk criteria is provided in Table 10.5.

Table 10.5: Assessment against HIPAP No. 4 qualitative risk criteria

HIPAP 4 qualitative criteria	Remarks	Complies?
All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	The PHA has identified hazardous events and assessed the risks associated with the proposed Steel River East BESS operations. The BESS location is situated in an industrial area and the BESS facility itself will be in a secure area. There are large separation distances to sensitive receptors (i.e. residential, childcare) to avoid off-site risks. It is not possible to eliminate batteries from a BESS development. The BESS substation is also necessary to connect the BESS to the electricity grid. Selection of the battery technology is a balance of cost and availability, with the most used versions being lithium-ion.	Yes; fatality effects are contained onsite and there are no residential or sensitive areas bordering the site boundary.
The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.	Based on the separation distance to the site boundary and sensitive receptors, consequences from the identified hazardous events are not expected to have significant off-site impacts.	Yes.

HIPAP 4 qualitative criteria	Remarks	Complies?
The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	Events with high probability of occurrence are expected to be contained within the boundaries of the installation. All BESS megapacks are located such a way that a fire will not escalate between units. The majority of units are at least 15 m away from the site boundary, meaning that most BESS fires are not expected to have any impact off site.	Yes.
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	There are no publicly known high risks from hazardous developments (in the context of the Resilience and Hazards SEPP) in the vicinity of the Project. It is assumed other developments have been subject to planning controls that require risks to be managed to acceptable levels.	Yes.

11. CONCLUSION

11.1. Preliminary risk screening

To address the SEARs, a preliminary risk screening was completed in accordance with the applicable SEPP 33 guideline to determine whether the Project is considered as 'potentially hazardous' in the context of SEPP (Resilience and Hazards) 2021.

The preliminary risk screening found that:

- The storage and transport of hazardous materials for the Project will not exceed the relevant risk screening threshold.
- No other risk factors have been identified that could result in significant off-site impacts.

The Project is not considered 'potentially hazardous' in the context of the Resilience and Hazards SEPP and does not require a PHA.

11.2. Preliminary hazard analysis

Notwithstanding the outcome of the preliminary risk screening, the SEARs require (1) a PHA, and (2) an assessment of hazards and risks for the Project to be undertaken. To address these requirements, a PHA was completed to identify the hazards and assess the risks associated with the proposed operations of the Project to determine risk acceptability from a land use safety planning perspective.

The PHA was completed following the methodology specified in HIPAP No. 6 Hazard Analysis and the Multi-Level Risk Assessment guideline for assessment against the HIPAP No. 4 criteria. A Level 1 PHA (qualitative) was completed.

11.3. Outcomes

In conclusion, the hazard related SEARs are addressed in this document with the following conclusions:

- The proposal is not potentially hazardous in the context of SEPP (Resilience and Hazards).
- The HAZID and consequence analysis found there are no identified events with significant off-site consequences and societal risk is negligible. Based on the *Multi-Level Risk Assessment* guideline, Ref [1], the appropriate level of analysis is level 1 (qualitative).
- The consequence analysis found a BESS fire will not impact upon identified receptors including residential and sensitive uses, the Leading Edge Data Centre, CSIRO Energy Centre and the Laurio Place heliport.

- A PHA, including a review of separation distances and health effects has been completed and the level 1 assessment concludes that the project meets the HIPAP 4 risk criteria and should not be precluded on the basis of land use safety.
- There is a residual risk of injury due to heat radiation from a fire extending up to 5 m into the road reserve of Tourle Street. The road is multi lane with a narrow pathway which is infrequently used. The area is not a residential or sensitive use area and hence HIPAP 4 risk criteria are met.

11.4. Recommendations

There is one recommendation in the PHA:

- Include an offsite incident involving the Jemena gas main in the site emergency response plan.

APPENDIX A. HAZARD IDENTIFICATION

This appendix provides the hazard identification (HAZID) table. It covers potential hazard scenarios arising from BESS operations.

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Site specific comments (Steel River East BESS Facility)	Potential off-site Impact. Additional modelling required?
1	Electrical	Battery modules BMS	Exposure to voltage	<u>Short circuit/electrical connection failure</u> - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage <u>Earth potential rise (exposure to step and touch potentials)</u> - Electrical faults	- Electrocution - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential (e.g. transferred through fences). Effects are expected to have only on-site impact.	- DC circuit breakers - Surge Protective Devices (SPD) - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines to minimise touch and step potential - Decisive Voltage Classification (DVC) followed, and equipment marked accordingly - Warning signs (electrical hazards, arc flash) - Engagement of certified electrical contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction/substation training (i.e. high voltage areas) - Electrical switch-in & switch-out protocol - BESS BMS fault detection and safety shut off - Earthing study (mitigate touch and step potentials) - Earthing as per manufacturer and standards requirements - Perimeter security fence with signage (warning of electrical hazard) - Site Emergency Response Plan - Use of appropriate PPE	-	No
2	Energy	Battery modules BMS	Arc flash	- Incorrect procedure (i.e. installation/ maintenance) - Faulty equipment (e.g. corrosion on conductors) - Faulty design - Human error during maintenance - Insufficient isolation/insulation to applied voltage - Mechanical damage - Vibration	- Arc blasts and resulting heat, may result in fires and pressure waves - Burns - Exposure to intense light and noise - Injury and/or fatality to onsite employees Localised effects, the effects are expected to have only on-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Warning signs (arc flash boundary) - Engagement of certified electrical contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction and training (i.e. high voltage areas) - Maintenance procedure (e.g. de-energize equipment) - Preventative maintenance (insulation) - Electrical switch-in & switch-out protocol - Site Emergency Response Plan - Use of appropriate PPE for flash hazard within the arc flash boundary. Conductive items not worn while working on or near energised or live conductive parts (e.g. rings, jewellery)	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Site specific comments (Steel River East BESS Facility)	Potential off-site Impact. Additional modelling required?
3	Fire	Battery modules	BESS fire	- Faulty equipment - Electrical fault - Mechanical damage or failure of battery case (e.g. overload, insulation breakdown, connection failures) - Battery thermal runaway (e.g. short circuit, overheating, overcharge) - External fire (e.g. Substation fire, fire at existing facility, neighbouring sites) - Bushfire (see note below) Note: As per SEARS, a bushfire assessment is not required as the site is located in an industrial area. From the site visit, there is some scrub to the north of the proposed BESS site. It has been included for completeness of this HAZID.	- Fire radiation impact to personnel or possibly off-site - Release of toxic or/and explosive combustible products - Escalation to the entire BESS	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the battery OEM and/or applicable standards - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS BMS temperature monitoring, fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Site Emergency Response Plan - External firefighting protocol (FRNSW & RFS)	- No residential or sensitive areas located within 380m of the site. - Data centre adjacent to west side of BESS facility.	Yes (radiation for Tesla megapacks)
4	Fire	BESS	Bushfire Note: Steel River East BESS location is not in a designated bushfire zone	- Encroachment of off-site bushfire - Escalated event due to fire from other Project infrastructure	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	- Bushfire risk assessment - Vegetation management/ clearance around BESS - Fire Management Plan - Defendable boundary for firefighting will be established - Site Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Inclusion of APZ buffer to minimise bushfire encroachment	Steel River East BESS site is outside a designated bushfire zone. As such there is no potential bushfire impact.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Site specific comments (Steel River East BESS Facility)	Potential off-site Impact. Additional modelling required?
5	Reaction	Battery modules	Thermal runaway in battery	<u>External impact</u> - Scrub fire - External fire on site (e.g. Main Substation) - Fire at neighbouring sites <u>Electrical failure</u> - Short circuit - Excessive current/voltage - Imbalance charge across cells <u>Mechanical failure</u> - Internal cell defect - Damage (crush/ penetration/puncture) - Coolant leak <u>Systems failure</u> - BMS failure - Thermal management system failure	- Fire and/or explosion in battery enclosure - Release of toxic or/and explosive combustible products - Escalation to the entire BESS - Impact to personnel on-site or possibly off-site	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Fire detection, protection, mitigation measures (e.g. deflagration panel) as per OEM design - Warning signs - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - Activation of emergency shutdown - Site Emergency Response Plan - Fire protection for buildings within the BESS facility - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the battery OEM and/or applicable standards - Ventilation requirements as per manufacturer's instruction Refer to ID 1 for proposed electrical failure controls. Refer to ID 3 for additional controls.	See Item 6 whereby bushfire assessment is not required.	Yes (considered as part of BESS fire in ID 3)
6	Chemical	Battery modules BMS Thermal management system	Release of electrolyte (liquid/vented gas) from the battery cell	<u>Mechanical failure/damage</u> - Dropped impact (e.g. during installation/ maintenance) - Damage (e.g. crush/ penetration/puncture)	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Potential injury to off-site if BESS on fire - Potential environmental impact (local/ off-site). Environmental impacts are covered in the EIA <u>Note</u>: Depending on electrolyte, a fire may occur. This has been covered in ID 3.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Each battery pack contains an integrated electrolyte sink, sized to capture all electrolyte contained within the battery pack in the event of substantial damage or pack rupture - Selection of appropriate battery chemistry - Venting and containment requirements of the BESS manufacturer and FRNSW to be followed - Battery modules are enclosed with external casing - Spill clean-up using dry absorbent material - BESS BMS fault detection and shut-off function - Activation of emergency shutdown - Site Emergency Response Plan (and spill cleanup kits) - Use of appropriate PPE Refer to ID 3 for proposed fire controls to minimise escalation.	-	Yes (considered as part of BESS fire in ID 3)

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Site specific comments (Steel River East BESS Facility)	Potential off-site Impact. Additional modelling required?

7	Chemical	Battery modules
		BMS
		Thermal management system
			BESS coolant or refrigerant leak	- Mechanical failure/damage
				- Incorrect maintenance
					- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact)
					- Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to:
					  - short circuit
					  - thermal runaway and fire/explosion (1)
					  - injury and/or fatality to onsite employees
					
					Potential environmental impact (local/ off-site). Environmental impacts are covered in the EIA.
						- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines
						- Independent owner's engineers' endorsement
						- Installation, operations and maintenance by trained personnel in accordance with relevant procedures
						- Each pack is designed to be water resistant (IP 65 rated) and will protect a leak inside the enclosure from entering a pack or cascading between packs
						- BESS BMS fault detection and shut-off function
						- Activation of emergency shutdown
						- Site Emergency Response Plan
						- Containment of leaks and spills
						- Use of appropriate PPE
						
						Refer to ID 3 for proposed fire controls.
							Chosen BESS is a Tesla Megapack 2/2 XL with a Lithium Iron Phosphate (LFP material) LiFePO4.	Yes[2] (considered as part of BESS fire in ID 3 & ID 7)

8	EMF	BESS Transmission line	Exposure to electric and magnetic fields	Operations of energy storage system and associated equipment	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Injury to onsite employees EMF created from the BESS will not exceed the ICNIRP reference level for exposure to the general public. Additionally, the strengths of electric and magnetic fields attenuate rapidly away from the source.	- Location siting and selection (i.e. separation distance to sensitive receptors) - Distribution and low intensity of modules - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. BESS enclosure) - Equipment and systems will be designed and tested to comply with international standards and guidelines - Exposure to personnel is short duration in nature (transient) - Warning signs	-	No

[2] The Victorian Big Battery fire (30-Jul-21) was caused by a short circuit (a coolant leak from the cooling system leading to a fire in an electronic component) and subsequent overheating (thermal runaway). The fire involved 2 battery packs and was locally confined to the area. Energy Safe Victoria reported that the battery was offline and the monitoring and protection systems not being available, allowed the initial fault to go undetected. Tesla has since updated the BESS safety systems with consideration of auxiliary backup power/UPS system that can provide power. This will ensure that the safety systems are still operating in the event of an outage.

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Site specific comments (Steel River East BESS Facility)	Potential off-site Impact. Additional modelling required?
9	External factors	BESS	Water ingress	- Rain - Flood (due to climate change) - Earthquake	- Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees	- Location siting (i.e. outside of flood prone area) - Substation and switchroom will be housed in a dedicated building and constructed in accordance with relevant standards - Drainage system - Preventative maintenance (check for leaks) - BESS BMS fault detection and shut-off function - Activation of emergency shutdown - Site Emergency Response Plan Refer to ID 1 & ID 3 for proposed electrical failure and fire controls.	BESS facilities consider seismic issues as part of detailed design.	No
10	External factors	BESS	Vandalism	- Unauthorised personnel access - Trespassing - Deliberate damage to BESS infrastructure - Asset damage	- Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs onsite.	- Secure battery unit cabinets design - The BESS will be located within a secure area, which is fenced - Warning signs (i.e. trespassers and on-site hazards) - Site security plan for the site (e.g. mobile patrol, monitoring etc.) - BESS BMS has active monitoring. Interface will result in the BESS shutdown	Access road to industrial neighbours (heavy truck movements) runs between the BESS and the transformers. This access road is part of Ausgrid property but leased to the recycling centre. Road is not open to the public.	No
11	External factors	BESS	Lightning strike	Lightning storm	- Fire - Injury and/or fatality to onsite employees	- Lightning protection mast and surge protection devices - Earthing as per manufacturer and standards requirements - BESS BMS monitoring and activation of emergency shutdown for temperature deviations - Site Emergency Response Plan Refer to ID 3 for proposed fire controls.	-	No
12	External factors	Battery modules	BESS overheating	- Extreme temperature or humidity - Dust ingress to BESS	- Potential for escalation to a thermal runaway event - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees - Asset damage	- BESS megapacks designed for worse case ambient condition Refer to ID 3 & ID 5 for proposed thermal runaway and fire controls.	-	Yes (considered as part of BESS fire in ID 3 & ID 5)

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Proposed controls	Site specific comments (Steel River East BESS Facility)	Potential off-site Impact. Additional modelling required?
13	External Factors -	Buried Pressure (HP) gas main	Loss of containment, potential for ignition and fire, escalating to a BESS fire	- Third party interference with pipeline - Corrosion or material defect	- Gas jet fire escalating to a BESS megapack fire - Injury and/or fatality to onsite employees - Asset damage	- Dial Before You Dig (not Ausgrid control) - Pipeline markers (not Ausgrid control) - Pipeline emergency response (not Ausgrid control)	Buried HP gas pipeline runs in easement on south side of the proposed boundary of Ausgrid site.	Yes
14	External Factors	Adjoined Ausgrid transformers	Fire/explosion of existing Ausgrid transformer on adjacent site	- Arc flash - Leak of transformer oil	- Transformer fire that escalates to BESS - Smoke from the transformer fire impacting on the BESS fan intakes (operational issue)	- By design, there is significant distance between the Mayfield West substation transformers and the BESS. Therefore escalation potential is unlikely. - All relevant Ausgrid requirements will be met - Electrical switch-in & switch-out protocol - Circuit breakers provided for the substation - Fire protection for buildings within the BESS facility - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Site Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the battery OEM and/or applicable standards	-	No
15	External Factors	Data Centre	Fire in the data centre	- Data centre electrical equipment fire -	- Fire that escalates to BESS or transformers	- Data centre fire prevention strategy (not Ausgrid control) - Emergency response	Existing data centre is located south of proposed transformer and between existing Ausgrid facility and batteries. Unlikely data centre has hazardous / dangerous goods that could impact the BESS.	No

APPENDIX B. ELECTRIC AND MAGNETIC FIELDS

B1. Overview

EMFs are naturally present in the environment. They are present in the earth's atmosphere as electric fields, while static magnetic fields are created by the earth's core. EMFs are also produced wherever electricity or electrical equipment is in use (e.g. household appliances, powerlines), Ref [22].

Electric fields are created where there is a difference in potential. Electric fields are related to and directly proportional to voltage (i.e. the higher the voltage the stronger the electric field). Electric fields are often described in terms of their strength and commonly expressed in volts per metre (V/m) or kilovolts per metre (kV/m).

Magnetic fields are created whenever electric current flows. Magnetic fields are directly proportional to the current (i.e. the higher the current stronger the magnetic field). Magnetic fields are often described in terms of their flux density and commonly measured in either Tesla (T) or Gauss (G).

Electric and magnetic fields are strongest closest to source and their strength attenuates rapidly away from the source. The strength of electric fields is weakened due to shielding from common materials (i.e. buildings, walls), whereas magnetic fields are not.

Use of electricity means that people are exposed to EMF as part of daily life. The background electric and magnetic fields in a typical home are around 20 V/m and 0.1 µT, respectively. These may vary depending on the number and type of appliances, configuration and positioning, and distances to the other sources (e.g. powerlines). Typical EMF strengths for common household electrical appliances (at distance of 30 cm) are shown in Table B.1, Ref [23].

EMF associated with the generation, distribution and use of electricity power systems in Australia which have a frequency of 50 Hertz (Hz) are classified by Energy Networks Australia[3] as Extremely Low Frequency[4] (ELF) EMF, Ref [22].

[3] Energy Networks Association is the peak national body representing gas distribution and electricity transmission and distribution businesses throughout Australia.

[4] ELF EMF occupy the lower part of the electromagnetic spectrum in the frequency range 0-3000 Hz.

Table B.1: Typical EMF strengths for household appliances

Electric appliance	Electric field strength (V/m)	Magnetic field density (μT)
Refrigerator	120	0.01 – 0.25
Iron	120	0.12 – 0.3
Hair dryer	80	0.01 – 7
Television	60	0.04 – 2
Vacuum cleaner	50	2 – 20
Electric oven	8	0.15 – 0.5

B2. Effects of exposure to EMF

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a federal government agency assigned with the responsibility for protecting the health and safety of people and the environment from EMF.

ARPANSA advises that:

- "The scientific evidence does not establish that exposure to the electric and magnetic fields found around the home, the office or near powerlines causes health effects.", Ref [24]
- "There is no established evidence that ELF EMF is associated with long term health effects. There is some epidemiological research indicating an association between prolonged exposure to higher than normal ELF magnetic fields (which can be associated with residential proximity to transmission lines or other electrical supply infrastructure, or by unusual domestic electrical wiring), and increased rates of childhood leukaemia. However, the epidemiological evidence is weakened by various methodological problems such as potential selection bias and confounding. Furthermore, this association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed.", Ref [25].

B3. Study approach

Although the adverse health impacts have not been established, the possibility of impact due to exposure to EMF has not been ruled out. As part of a precautionary approach, the study assessed the typical exposure levels to EMF for the Project infrastructure.

A task group assembled by the World Health Organisation to assess any potential health risks from exposure to ELF EMF in the frequency range of 0 to 100,000 Hz found that there are no substantive health issues related to ELF electric fields at levels generally encountered by the public, Ref [26]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

B4. Guidelines for limiting EMF exposure

The ICNIRP has produced a publication to establish guidelines for limiting EMF exposure to assist in providing protection against adverse health effects. Separate guidance is given for general public and occupational exposure within the guideline.

The guideline has defined general public and occupational exposures as follows:

- General public – individuals of all ages and of varying health status which might increase the variability of the individual susceptibilities
- Occupational exposure – adults exposed to time-varying EMF from 1 Hz to 10 MHz at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job.

The ICNIRP reference levels for exposure to EMF at 50 Hz is presented in Table B.2, Ref [27]. The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that in many cases the general public are unaware of their exposure to EMF.

Table B.2: Reference levels for EMF levels at 50 Hz

Exposure	ICNIRP Reference Levels	
	Electric field (V/m)	Magnetic field (μT)
General public	5,000	200
Occupational	10,000	1,000

B5. BESS EMF

B5.1. BESS

The magnetic field associated with a BESS will vary depending on a number of factors including configuration, capacity and type of housing. Due to the limited information on typical measurement of magnetic fields around BESSs, this study has assumed the typical magnetic field will not be too dissimilar with that of a substation. This study also assumed that the BESS will be designed in accordance with electrical safety standards and codes which will result in exclusion of general public exposures from these sources.

B5.2. Transmission line

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at 1 m above ground level range between 1-20 μT (directly underneath) and 0.2-5 μT (at the edge of easement), Ref [28].

For underground transmission lines, the cables are typically installed 1 m below ground, whereas the conductors of an overhead line are typically more than 10 m above ground. Therefore, the magnetic field directly above an underground cable is usually higher than

that directly below the equivalent overhead line. However, as the individual cables are installed much closer together than the conductors of an overhead line, the magnetic field attenuates more quickly with distance than the magnetic field from overhead lines. Overall, a larger magnetic field is observed directly above and for a small distance to the sides, but at larger distances to the sides the cable produces a lower field than the overhead line. The typical magnetic fields for a 330 kV underground cable buried 1 m depth are approximately 24 µT (directly above) and 3 µT (5 m from centreline), Ref [29].

B6. Controls to limit exposure to EMF

The following controls were identified to limit exposure to EMF:

- The design, selection and procurement of electrical equipment for the Project will comply with relevant international and Australian standards.
- Location selection for the Project infrastructure (i.e. it accounts for separation distance to surrounding land uses) and fencing within the Project's development footprint will assist to limit the exposure to EMF for the general public.
- Exposure to EMF (specifically magnetic fields) from electrical equipment will be localised and the strength of the field attenuates rapidly with distance.
- Duration of exposure to EMF for personnel onsite will be short.

B7. Conclusion

Based on the review completed in the preceding sections, this study concludes that:

- EMF created from the Project will not exceed the ICNIRP occupational exposure reference level.
- As the strengths of EMF attenuate rapidly with distance, this study determined that the ICNIRP reference level for exposure to the general public will not be exceeded and impact to the general public in surrounding land uses will be negligible.

For the risk assessment, consequence from exposure to EMF was assumed to result in no or minor injury ('Insignificant') in reference to the consequence impact rating shown in Table 10.2.

The cumulative exposure to EMF from other proposed developments in the vicinity of the Project has not been assessed in this study. However, as the strength of EMF attenuates rapidly with distance, cumulative impacts at the closest sensitive receptors are considered unlikely.

APPENDIX C. CONSEQUENCE MODELLING

C1. Overview

Consequence analysis of a BESS megapack on fire was completed to determine the potential for off-site impacts. The following scenarios were analysed:

- Fire involving a BESS megapack (e.g. propagated thermal runaway resulting in a fully developed fire).
- Toxic gas generation from decomposition of battery electrolyte due to fire.
- Impact distances associated with heat radiation due to fire and dispersion of toxic gas were estimated to determine potential for off-site impacts to sensitive receptors.
- A jet fire and vapour cloud generated from a puncture or rupture of the nearby gas pipeline escalating to a BESS megapack.

This appendix summarises the consequence modelling approach, input, assumptions, and results.

C2. BESS fire

C2.1. Modelling approach

Consequence modelling was undertaken based on the Stefan–Boltzmann correlation to analyse the heat transfer effect between two parallel planes, simulating a BESS megapack on fire and the heat radiation exposure to a receptor, as shown in Figure C.1. Distances to heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [6], were calculated.

To estimate the heat radiation generated from a BESS megapack on fire, the emitted heat flux was calculated using the Stefan - Boltzman Law:

$$E_{emitted} = e\sigma T^4$$

Where E is the radiant emittance, e is the emissivity, σ is the Stefan-Boltzmann constant and T is the surface temperature.

The heat flux received was estimated using the view factor method, where d is the receiver distance to BESS megapack on fire:

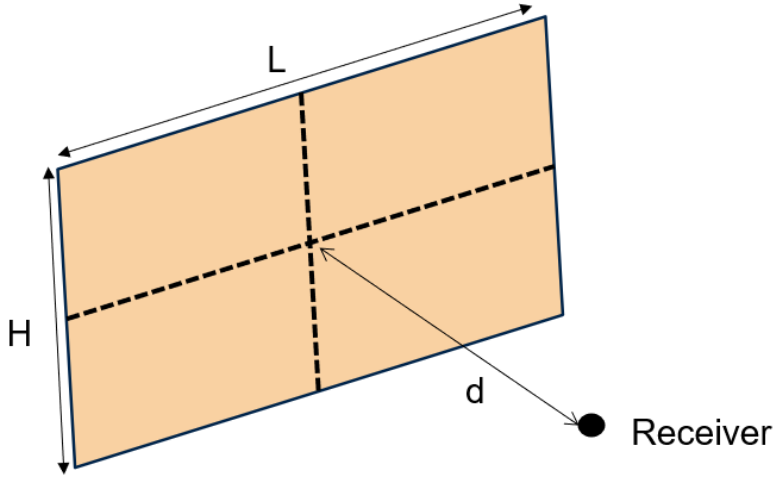
$$\emptyset = \frac{1}{2\pi}\left[\frac{a}{(1+a^2)^{1/2}}tan^{-1}\frac{b}{(1+a^2)^{1/2}} + \frac{b}{(1+b^2)^{1/2}}tan^{-1}\frac{a}{(1+b^2)^{1/2}}\right]$$

$$a = \frac{0.5\,H}{d}\,, a = \frac{0.5\,L}{d}$$

To calculate the heat radiation experienced by the receptor at height 1.5 m (approximately half of the BESS megapack height), the surface area of the BESS megapack (front aspect) is divided into 4 equal sections. Figure C.1 illustrates the graphical depiction of the parameters used in the calculation.

$$E_{received} = 4 \emptyset E_{emitted}$$

Figure C.1: The graphical depiction of the parameters (L, H, D)



C2.2. Comparison with fire tests

Tesla has developed a model to predict heat radiation and consequences from a BESS unit on fire.

The model calculates:

- Heat radiation from a flame exiting the front face of a cabinet
- Effects of heat radiation on adjacent BESS.

The model is primarily intended to set required spacing to prevent fire propagation between BESS units but can also be used to assess heat radiation at a distance from the BESS unit.

The model estimates the heat radiation from a flame based on an assumption of the flame temperature based on typical flame temperatures (i.e. the values are not based on measured Tesla BESS temperatures) and the area of the flame. This approach is consistent with the Sherpa model.

Tesla validated the model by comparing the results with measurements taken during a destructive test of a Megapack 1 unit and reported a correlation of ‘within 20%’ and concluded this level of accuracy is ‘more than acceptable’ given the test was a single event in an outdoor location measured as an average heat flux.

The Megapack 1 fire was reported as:

- Flame dimensions 3.5 m high x 1 m wide
- Heat radiation 15 kW/m^2 measured 8 feet (2.5 m) from the cabinet.

The Sherpa model was run with a flame dimension of 3.5 m x 1 m and the heat radiation level at 2.5 m from the cabinet reported. The test, and Sherpa model are presented in Table C.3.

Table C.1: Heat radiation impact model validation

Source	Heat radiation at 2.5m	Commentary
Tesla Megapack 1 destructive test	15kW/m^2	Measured in outdoor as an average temperature
Sherpa model	18kW/m^2	+20% of the measured value

The validation shows the Sherpa model is consistent with the fire test.

The results show the Sherpa model is valid for assessing heat radiation from a BESS unit on fire.

C2.3. Input and assumptions

The modelling input and assumptions used were as follows:

- The flame temperature of the emitting surface was set at 1000°C, which is the upper bound value measured for lithium metallic fires, Ref [30]. The data shows a range of 800-1000°C with the upper bound selected to ensure a conservative but credible assessment.
- The emissivity value was set at 0.9 (a black body has an emissivity value of 1).
- Receptor height was set at 1.5 m.
- The heat radiation calculation was performed for the front and side aspects of the BESS megapack and assumed a full planar fire. The aspect which is parallel to a given receptor is used to determine the possible heat radiation impact.

Using the full-face fire is conservative but credible. Test results presented by Tesla state that fire propagation was limited to modules 7 to 10 by heating a bank of modules into thermal runaway. However, there are other causes of thermal runaway that could result in additional modules experiencing thermal runaway (e.g. control and safeguarding system failure).

This is deemed appropriate to determine off site consequences from a fully developed fire in a BESS unit.

C2.4. Heat radiation criteria

Consequences of various heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [6], are shown in Table C.2. For this PHA,

distances to 4.7 kW/m^2 (injury), 12.6 kW/m^2 (fatality), and 23 kW/m^2 (structural failure) were calculated.

Table C.2: Consequences of heat radiation

Heat Radiation (kW/m^2)	Effect
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur)
12.6	• Significant chance of fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
23	• Likely fatality for extended exposure and chance of fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved, or failure would occur
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of fatality for people exposed instantaneously

C2.5. Results

The distances to the specified heat radiation levels are presented in Table C.3. Distance to the injury level (4.7 kW/m^2) was used to determine potential for off-site impact, which is approximately 15 m from the front of the BESS megapack, or 7 m from the side of the BESS megapack.

Table C.3: Heat radiation impact – BESS megapack on fire

				Distance (m) at receptor height (1.5 m) to radiation levels		
BESS model	**Aspect**	**Aspect dimensions (L x H, m)**	**Surface Temperature (°C)**	**4.7 kW/m^2 (injury)**	**12.6 kW/m^2 (fatality)**	**23 kW/m^2 (structural failure)**
Megapack 2 XL	Front	8.81 x 2.79	1000	15	9	6
Megapack 2 XL	Side	1.65 x 2.79	1000	7	4	3

C3. Gas release from pipeline

C3.1. Modelling approach

The proposed BESS facility is bordered on the east and south by a high-pressure natural gas pipeline. If the pipe ruptures or develops a leak, the jet fire may affect the BESS. This study provides the distance to the HIPAP 4 heat radiation threshold for causing thermal stress for steel (23 kW/m^2) and potential for heat build-up in the BESS enclosure (10 kW/m^2).

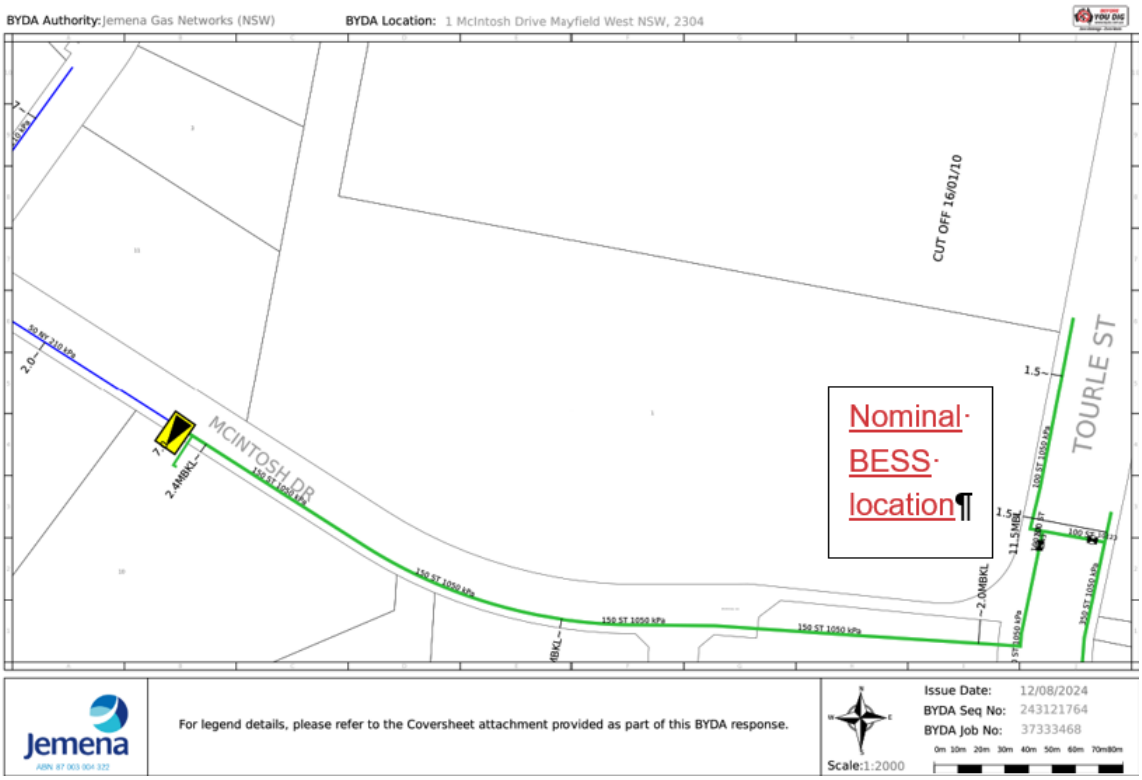
Consequence modelling was performed using the DNV Phast v9.0 software. The crater model for long pipelines was used to simulate these scenarios. The values presented are the maximum value for any receptor height.

C3.2. Input and assumptions

The modelling input is based on Dial Before You Dig (DBYD) information received in August 2024. Key information is shown in Figure C.2 and the following list:

- The diameter of the pipe is 100 mm along the eastern edge of the BESS facility, and 150 mm along the southern edge
- The pressure is 1050 kPa
- The contents of the pipe are 100% methane
- A hole size of 50 mm and full-bore ruptures were modelled
- The temperature of the pipeline contents was assumed to be 25°C
- Weather conditions of 1.5/Fand 5/D were used as a range of different weather cases. The number in each weather case refers to the wind speed at 10 m altitude, and the letter is the Pasquill stability class. Pasquil class ‘D’ indicates neutral conditions, while class ‘F’ indicates moderately stable conditions
- Buried pipeline model with 900 mm depth of cover (Jemena Guideline GAS-98990GL-CN-001 Rev 0) for non-arterial roads and road reserves (secondary main)
- Modelled as a continuous release.

Figure C.2: DBYD Information



C3.3. Results

Table C.4 shows the results of this modelling. As the pipe is buried, ignited releases will result in vertical jet fires. The heat radiation values in the table below represent a circle centred on the pipeline. They are reported at 1.5 m above the ground to represent a person and 3 m above the ground to represent the top of a BESS megapack.

The distance from the pipeline to the closest BESS megapack is approximately 30 m. The results show that for a full bore rupture of the gas pipeline there is the potential for the heat radiation at 23 kW/m^3 (assumed to be sufficient to cause escalation to a BESS thermal runaway and fire) to reach the nearest BESS megapack. This has been carried forward to the risk assessment.

Table C.4: Heat radiation from HP pipeline jet fire

		Maximum distance for 10 kW/m^2 heat radiation (m)		Maximum distance for 23 kW/m^2 heat radiation (m)	
Hole Diameter (mm)	**Weather Condition**	**1.5 m receptor height**	**3 m receptor height**	**1.5 m receptor height**	**3 m receptor height**
50	1.5/F	9	12	N/A	3
50	5/D	23	23	13	15
100 (full bore rupture)	1.5/F	20	18	4	7
100 (full bore rupture)	5/D	28	29	20	21
150 (full bore rupture)	1.5/F	25	28	6	8
150 (full bore rupture)	5/D	43	44	30	31

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