PRELIMINARY HAZARD ANALYSIS

SMITHFIELD BATTERY ENERGY STORAGE SYSTEM (BESS)

SSD-59325460

ARCADIS AUSTRALIA PACIFIC PTY LIMITED

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Title: **Preliminary Hazard Analysis** **Smithfield Battery Energy Storage System (BESS)** **SSD-59325460**	**QA verified:** S. Chan **Date:** 24-Oct-2023

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ABBREVIATIONS

AC	Alternating Current
ADGC	Australian Dangerous Goods Code
AEGLs	Acute Exposure Guideline Levels
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS/NZS	Australian Standard/New Zealand Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
DA	Development Application
DC	Direct Current
DG	Dangerous Good(s)
DoP	Department of Planning
DP	Deposited Plan
DPE	Department of Planning and Environment
DVC	Decisive Voltage Classification
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EP&A	Environmental Planning and Assessment
FHA	Final Hazard Analysis
FRNSW	Fire and Rescue NSW
G	Gauss
HAZID	Hazard Identification
HF	Hydrogen Fluoride
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High Voltage
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
km	Kilometres
kV	Kilovolt
kV/m	Kilovolt per metre
kW	Kilowatt
kWh	Kilowatt hours

LEL	Lower Explosive Limit
LFL	Lower Flammability Level
LFP	Lithium Iron Phosphate
LGA	Local Government Area
MW	Megawatt
MWh	Megawatt hour(s)
NEM	National Electricity Market
NFPA	National Fire Protection Association
NMC	Nickel Manganese Cobalt
NSW	New South Wales
OEM	Original Equipment Manufacturer
OH&S	Occupational Health & Safety
PCU	Power Conversion Unit
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
SDS	Safety Data Sheet
SEARs	(Planning) Secretary's Environmental Assessment Requirements
SEF	Smithfield Energy Facility
SEPP	State Environmental Planning Policy
SRMP	Smithfield Recycling & Manufacturing Precinct
SSD	State Significant Development
T	Tesla
UL	Underwriters' Laboratories
V/m	Volt per metre
VBB	Victorian Big Battery

TERMINOLOGY

Term	Definition
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
BESS development envelope	The maximum area considered for the BESS footprint (also known as the 'BESS planning envelope / BESS Facility footprint').
Development envelope area	The maximum area considered for the project (including construction, operation and decommissioning and asset protection zones).
Non-associated residential dwellings (sensitive receptors)	Residence whose owners do not have any part of their property included in a land agreement with the proponent for the project.
Off-site	Areas extending beyond the development envelope area boundary.
Project	Smithfield Battery Energy Storage System (BESS).
Proponent	Smithfield Power Generation Pty Ltd as owned by Iberdrola Australia Limited.
Risk	Risk is the effect of uncertainty on objectives (ISO31000). It is expressed as a combination of the consequences of an event and the associated likelihood of occurrence. The likelihood of a specified undesired event occurring within a specified period or in specified circumstances may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.

1. INTRODUCTION

1.1. Background

Smithfield BESS Pty Ltd (Smithfield BESS), as owned by Iberdrola Australia Limited (Iberdrola) (the Proponent) is seeking development consent for the construction, operation and maintenance of a Battery Energy Storage System (BESS) at the Smithfield Energy Facility (SEF) (Lot 33, DP850596) at 6 Herbert Place, Smithfield NSW 2164 (the Project Site). The BESS will be up to 72 Megawatt (MW) and would provide up to 260 Megawatt hours (MWh) of battery storage capacity.

When operational, the Project will support the NSW Government's electricity strategy for a reliable, affordable and sustainable electricity future that supports a growing economy. BESS facilities, such as the Project, assist with intermittency risks associated with renewable energy generation in NSW, and are considered a key element of the transformation of the NSW energy sector.

The Project would involve construction and operation of the following:

- A BESS including battery enclosures, inverters, transformers, switch room and control room
- Medium voltage cables between transformers and the existing switchgear building in the northeast corner of the SEF.
- Switchgear building upgrades to facilitate connection of the BESS.
- Site access to the BESS from Herbert Place.
- Utilities to support operation of the BESS.
- Stormwater management infrastructure, lighting, fencing and security.

The Proponent is seeking State Significant Development (SSD) approval for the Project under Part 4, Division 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and has received Planning Secretary's Environmental Assessment Requirements (SEARs), Ref [1] for the Project.

Arcadis has engaged Sherpa Consulting Pty Ltd (Sherpa) to undertake an assessment that addresses the 'Hazards' component of the SEARs.

1.2. Objectives

1.2.1. SEARS requirements

The study objective was to address the 'Hazards' component of the SEARs, Ref [1]. The Hazards assessment requirements and reference to where they are addressed in this report are shown in Table 1.1.

Table 1.1: SEARs hazards assessment requirements

Assessment requirements - *Hazards*	**Section reference**
A preliminary risk screening completed in accordance with the *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development*[1] and *Applying SEPP 33* (DoP, 2011).	Section 3
A Preliminary Hazard Analysis (PHA) must be prepared in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 *Hazard Analysis* and *Multi-Level Risk Assessment* (DoP, 2011). The PHA must consider all recent standards and codes and verify separation distances to onsite and off-site receptors to prevent fire propagation and compliance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning* (DoP, 2011).	Sections 5-6, 9-11
Consultation with the pipeline operator for any nearby high-pressure pipelines and report on the hazard analysis and consultation outcomes.	Section 5
An assessment of potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure against the *International Commission on Non-Ionizing Radiation Protection* (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields.*	Sections 7, 8

1.3. Scope

The proposed Smithfield BESS facility will comprise:

- Battery enclosures (lithium-ion batteries inside battery enclosures/containers).
- Inverters.
- Transformers.
- Control building.

For the PHA, the scope included all infrastructure within the BESS footprint boundary (‘BESS facility’, as shown in Section 2) and covered the BESS during the operations phase.

Sherpa’s scope of work excludes assessment of the existing SEF power plant other than consideration of potential hazard interaction to the BESS facility. The potential for future land contamination is covered in the EIS. However, the impacts of potential hazards associated with existing facility on BESS components has been assessed in this study.

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[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.

1.4. Exclusions and limitations

The study exclusions and limitations are summarised in Table 1.2.

Table 1.2: Exclusions and limitations

No.	Item	Exclusions and limitations
1	Design elements for the BESS	The assessment was based on a concept lithium-ion BESS of up to 72MW within the BESS development envelope. Detailed design will be conducted upon project approval, including confirmation of the BESS Original Equipment Manufacturer (OEM) and layout design within the BESS development envelope (or BESS facility).
2	Hazards associated with proposed operations	The PHA identified and assessed credible hazards associated with proposed operations of the BESS as well as potential hazard interactions with the existing SEF (natural gas supply which is a flammable gas), but excluded specific hazards relating to construction, commissioning, and decommissioning. This approach is appropriate for assessment at the DA stage aimed to obtain approval for the Project.
3	Verification that the BESS would be accommodated within the area designated for the BESS compound	The BESS development envelope (or BESS facility) has been designated by the Proponent. The Proponent will develop the layout with consideration to BESS Original Equipment Manufacturer (OEM) recommendations, latest standards and findings of this PHA. The detailed design will confirm there is sufficient area for the proposed capacity, considering separation distances between BESS sub-units and to site boundary.
4	Bushfire hazard assessment	The SEF is located in an industrial area and there is no surrounding vegetation causing bushfire. Therefore, bushfire is not regarded as a credible event.
5	Land contamination	The PHA excludes assessment of potential hazards and risks of land contamination for the project. A Preliminary Site Investigation has been undertaken and is included in the EIS to address land contamination.
6	Construction Safety Study	The PHA does not constitute a Construction Safety Study. If required, a Construction Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 7 *Construction Safety*.
7	Fire Safety Study	The PHA does not constitute a Fire Safety Study. A Fire Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 2 *Fire Safety Study*.
8	Potentially offensive	This PHA study excludes matters related to ‘potentially offensive’ development.
9	Jemena pipeline	Construction hazards (e.g. driving over pipeline, demolition activities near above ground assets) are not covered by the PHA study as the focus is on operations phase.

No.	Item	Exclusions and limitations
		The PHA study did consider potential for BESS related hazards affecting the electrical integrity of the gas pipeline. This PHA does not cover the AS 2885 safety management system update and would be done as a separate activity by Jemena and the Proponent. AS4853 will be considered as part of detailed design.
10	Fire Response NSW (FRNSW)	The PHA study will be reviewed by FRNSW. The Proponent will need to consider any feedback when finalising the BESS development envelope.

2. FACILITY DESCRIPTION

2.1. Location and surrounding land use

The Project is located at SEF (Lot 33, DP850596) at 6 Herbert Place, Smithfield NSW 2164 (the Project Site). The Project is within the Cumberland local government area (LGA) in Western Sydney.

The Project is located within an existing industrial area, part of the Smithfield Recycling and Manufacturing Precinct (SRMP). SEF is bounded to the south, west and east by the Visy Smithfield Recycling Facility (Visy site), and to the north by Kingspan. The Visy site operates a paper and plastics sorting and recycling facility. The Kingspan site includes a large carparking area and a warehouse used for assembly, service and storage of retail and commercial water tanks. A site visit was undertaken to inspect surrounding areas and the SEF existing infrastructure. The nearest residential receiver is located approximately 400 metres south of the Project site. Sensitive receptors in the vicinity of SEF are shown in Figure 2.1.

Access to the Project is via Herbert Place, a 40 km/hr dual lane local road. Herbert Place is accessed by Cumberland Highway (a state road) from the north and south, and Long Street (a local road) from the west.

2.2. Concept BESS Facility layout

The PHA was based upon a concept BESS facility as shown in Figure 2.2.

The PHA findings have been used to inform the required separation and setback distances to minimise offsite impact. This is considered in Section 6 and Section 8 of this PHA.

2.3. Project key infrastructure

For this PHA, Sherpa conducted a review of battery specifications from various manufacturers and developed the PHA based on typical lithium-ion batteries. Table 2.1 presents examples of BESS models.

Figure 2.1: Project Site and sensitive receptors in the surrounding area

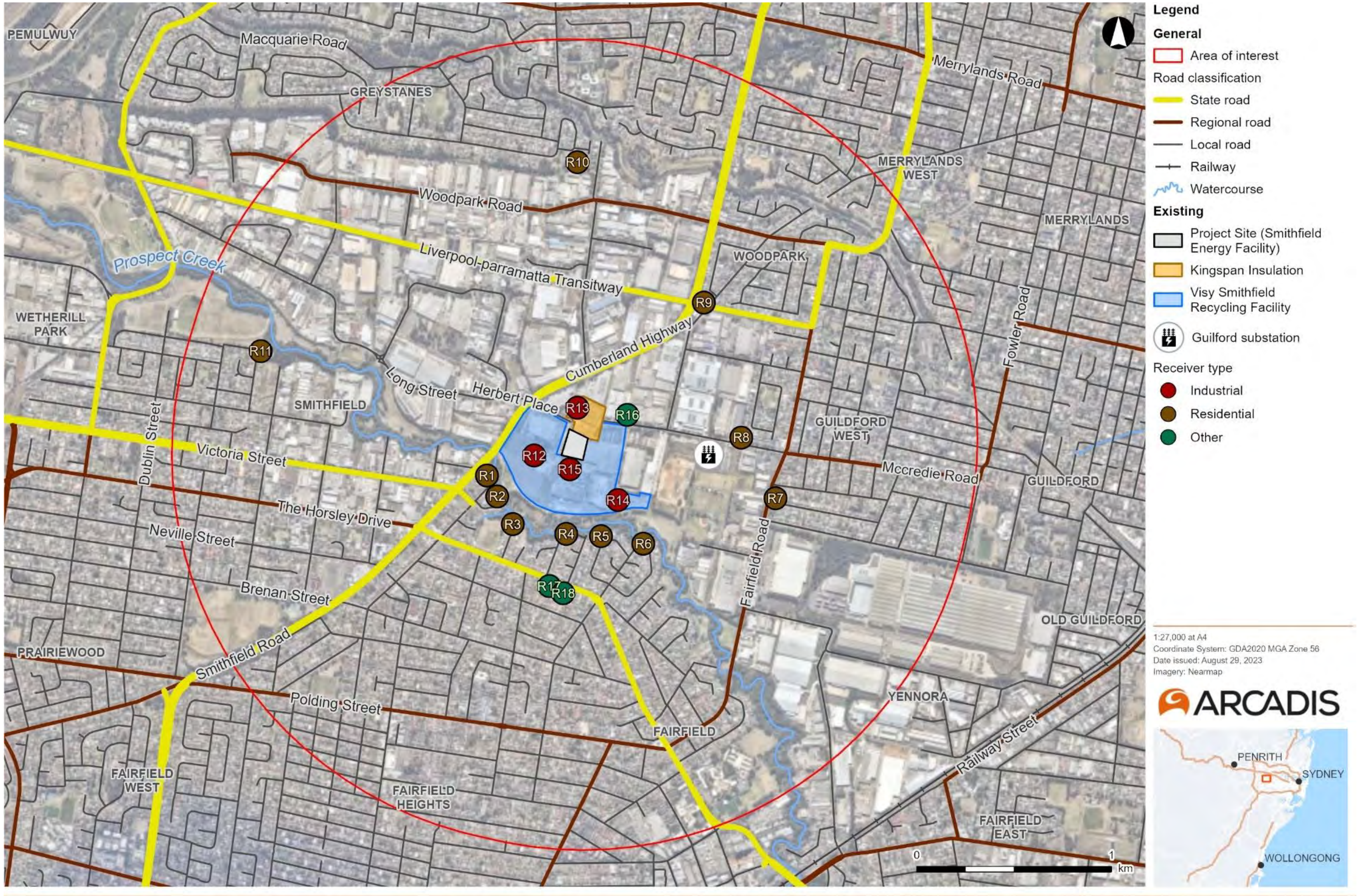

Figure 2.2: Project concept plan (subject to selection of BESS OEM)

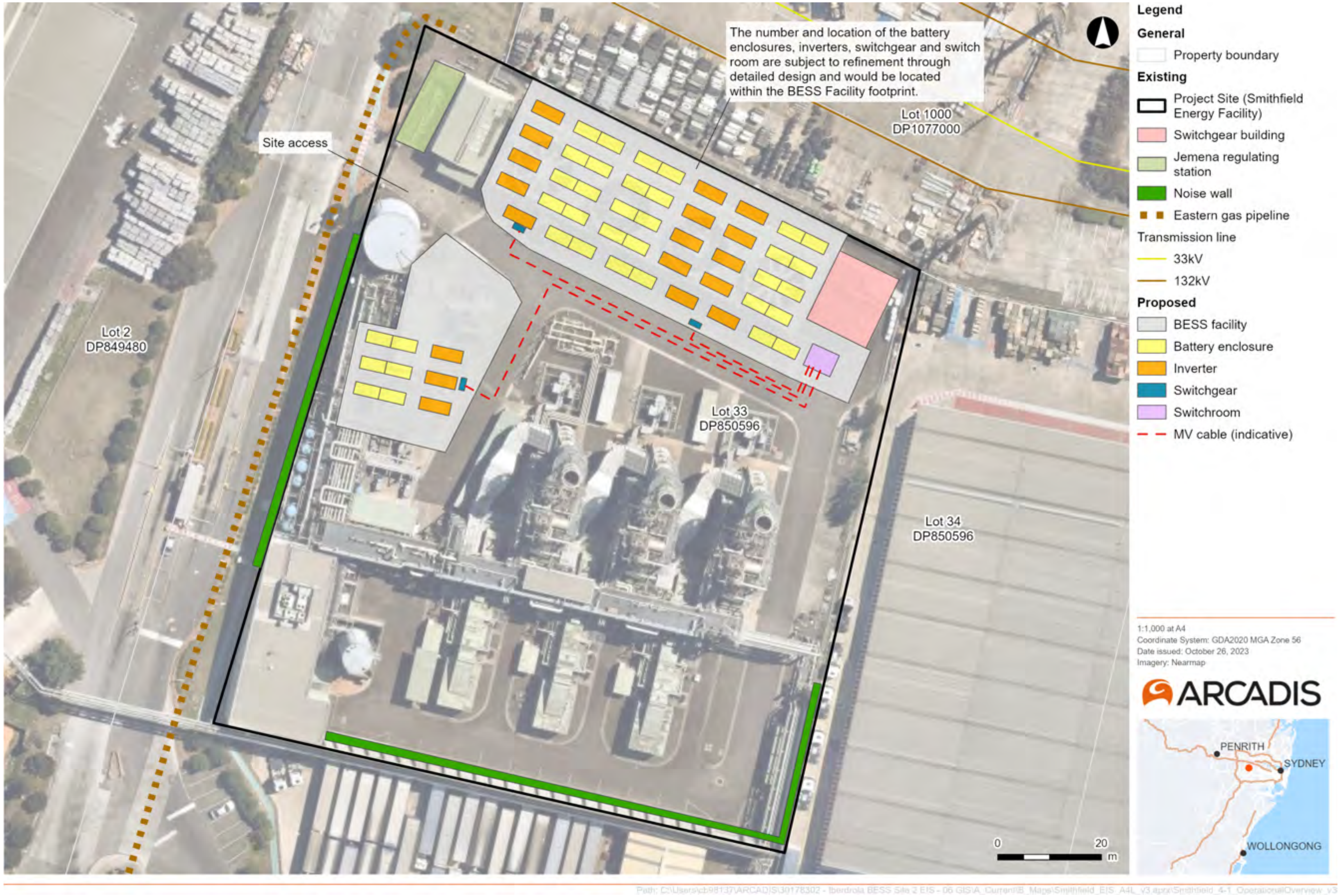

Table 2.1: Examples of BESS models

BESS Manufacturer	Model	Dimensions (w, d, h) (mm)	Rated Energy (MWh)	Battery Chemistry
Wartsila	GridSolv Quantum	3169 x 2076 x 2462	1.5	Lithium-ion
CATL	EnerC	6058 x 2462 x 2896	3.72	Lithium-ion
Tesla	Megapack 2	7267 x 1659 x 2522	3	Lithium-ion
Sungrow	ST2236UX	9340 x 2600 x 1730	2.2	Lithium-ion
Powin	STACK230E (40' enclosure)	12192 x 2438 x 2896	3.2	Lithium-ion

2.3.1. 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 stored in Direct Current (DC) and converted to Alternating Current (AC) via a bi-directional inverter to convert the current between the BESS and 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 support stabilising the supply of electricity to the National Electricity Market (NEM). For this project, the proposed BESS will have an indicative capacity of up to 72 MW/260 MWh and make use of lithium-ion technology. An overview of the concept BESS facility layout is shown in Figure 2.2.

At the time of this PHA (September 2023), the Proponent has not made a decision on the BESS OEM. Therefore, description is provided for a typical lithium-ion BESS. The selection of the BESS OEM and layout will be finalised during detailed design. Detailed design will be conducted upon project approval. The following were assumed for the PHA:

1. The BESS units will be installed in accordance with the OEM's instructions provided for best practice for mitigation of fire propagation, including clearance requirements.
2. The BESS units will be installed and meet requirements of the relevant Australian Standards and other codes and standards such as NFPA 855, AS 5139, IEC 62897, UL 9540.

   Specifically, the chosen 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 installation and operation of the respective BESS. A UL 9540A or similar test is considered successful if a fire does not propagate from one unit/cabinet to another during the test.

Examples of BESS units under consideration are shown in Figure 2.3. The PHA considered fire events involving different battery sizes. Major components and specific features of the commonly used battery systems are described in Table 2.2.

Figure 2.3: Different models of BESS units

(a) CATL

(b) Wartsila

(c) Sungrow

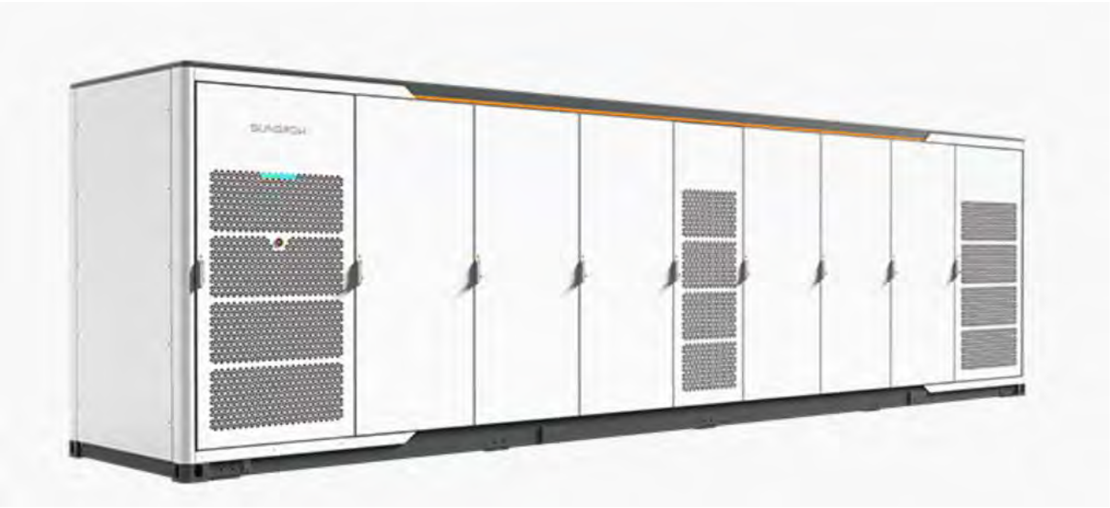

Table 2.2: BESS components

<table>
<tr><th>Component</th><th>Description</th></tr>
<tr><td>Enclosure</td><td>Enclosure is a protective housing that contains the battery components and associated electronics. It shields the batteries from external elements, ensures thermal management, and provides safety measures.</td></tr>
<tr><td>Battery unit</td><td>Battery unit consists of interconnected batteries within a singular module, serving as pivotal components for efficient energy storage and distribution. In this project, Lithium-ion batteries will be utilised.</td></tr>
<tr><td>Power Conversion Units (PCUs) or inverters</td><td>Inverters are electrical devices that convert DC to AC or vice versa (i.e. bi-directional). The inverters will function to convert the current between the battery and the grid.</td></tr>
<tr><td>Battery Management System (BMS)</td><td>A BMS is the electronic system that monitors and manages the battery system electric and thermal states, enabling it to operate within the safe operating region of the battery (e.g. protection against overcurrent, over-charge, over-discharge, overheating, over-voltage). The BMS constantly monitors the battery cell, module, and unit level.</td></tr>
<tr><td>Thermal management system</td><td>A thermal management system regulates the temperature of the battery units to optimise their performance, safety, and longevity. Utilizing active and passive cooling methods, this system ensures that the batteries remain within their optimal operating range, mitigating risks of overheating and thermal degradation.</td></tr>
<tr><td>Fire and explosion protection system</td><td>Safety measures designed to prevent and mitigate the risks of fires and explosions in battery units. This system can include fire detection, and/or suppression, and/or containment mechanisms to swiftly identify and control potential hazards. BESS OEMs provide essential and optional measures based on battery type and specifications.</td></tr>
<tr><td>Standards, tests and/or certification</td><td>Key standards, tests and/or certification claimed include:
<table>
<tr><th>Standards and Tests</th><th>Title</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></tr>
<tr><td>IEC 62477-1</td><td>Safety requirements for power electronic converter systems and equipment - Part 1: General</td></tr>
<tr><td>UL 1973</td><td>Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications</td></tr>
<tr><td>NFPA 855</td><td>Standard for the Installation of Stationary Energy Storage Systems</td></tr>
<tr><td>UL 9540A</td><td>Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems</td></tr>
</table>
</td></tr>
</table>

2.3.2. HV transformer and grid connection

To establish a connection between the BESS and the grid (i.e. the Guildford substation), transformers will be employed to convert the electricity at the BESS to 33 kV.

A 33 kV reticulation system will link those transformers to the existing switchgear building positioned in the northeast corner of the SEF. The existing switchgear building is already connected, via an existing high voltage line to the Endeavour Energy's Guildford substation, situated approximately 570 metres east of the Project Site.

2.3.3. Supporting infrastructure

The following supporting infrastructure is available at the SEF:

- Control room and O&M building located at the southwestern end of the site. The BESS facility will be capable of being controlled and operated both from this location and remotely.
- Workshop which is located adjacent to the operations building.
- Parking facilities and internal access roads.
- Security fencing (and the site shares 24/7 security with Visy).
- Lightning protection.

2.4. BESS Operations

The BESS will be operated remotely (i.e. unmanned) and whilst the BESS will be able to operate 24 hours a day, seven days a week, operations will be based on market conditions (i.e. not continuously).

The exact workforce size will be determined once the BESS OEM is selected, aligning with the requirements for inspections and maintenance activities.

2.5. Existing Jemena Eastern Gas Pipeline and Inlet Yard

The existing Jemena Smithfield lateral is a high-pressure gas transmission pipeline that traverses the western border of the SEF. The pipeline includes a high-pressure regulating station (including inlet line and metering station) at the northwest corner of the SEF as shown in Figure 2.2.

This gas is used to provide fuel for the existing SEF gas turbines. The area is security fenced and accessed by Jemena when conducting maintenance. Jemena provides notification when access is required. As per consultation outcomes with Jemena:

- Jemena notes the BESS facility is located away from the gas inlet yard and pipeline.
- Jemena accepts the proposed development subject to a Safety Management Study being undertaken during detailed design and prior to construction in accordance with Jemena protocols.

- Operational related risks relate to the electrical infrastructure / earthing associated with the BESS. An assessment with regard to AS4853 will be undertaken in detailed design phase and reviewed as part of the Safety Management Study.

The hazard identification considered BESS operation interactions with the existing gas inlet yard.

3. PRELIMINARY RISK SCREENING

3.1. Overview

The objective of the preliminary risk screening was to determine whether the proposed development is considered as ‘potentially hazardous’ in the context of *SEPP (Resilience and Hazards) 2021*, Ref [2].

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 undergo a PHA as per the requirements set in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [3], 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 and Environment (DPE) *Applying SEPP 33* guideline[2], Ref [4], is used to undertake the 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, as well as the expected number of transport movements.

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

The *Applying SEPP 33* guideline is based on the 7th edition of ADGC, Ref [5], 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.

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[2] 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.

3.2. Risk screening

A summary of the expected hazardous materials to be stored and handled in the BESS area for the project, transport movements, and the relevant SEPP screening threshold is presented in Table 3.1.

3.2.1. Proposed BESS facility

The Project would utilise lithium-ion battery technology. These batteries are classified under DG class 9.

Other materials considered as part of the SEPP risk screening include transformer oil and battery coolant (indicatively ethylene glycol aqueous solution). These materials are not classified as DGs and if not stored with other flammable or reactive materials are not considered to be potentially hazardous under the SEPP.

3.2.2. Existing power plant facility

Sherpa reviewed approved PHA studies (Ref [6]) for the SEF and the existing power plant and confirmed that the quantities of DGs (e.g. Class 8 water treatment chemicals) are below the relevant SEPP screening threshold. With the decommissioning of the original cooling towers with a smaller unit (DA 94-165 MOD3), the quantity of the water treatment chemicals will be further reduced.

3.3. 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. Sherpa considered these risk factors in conjunction with a site visit (June 2023) at the SEF and with reference to the preliminary BESS layouts, the review found:

- The proposed BESS facility:
  - Would not involve the storage or transport of incompatible materials (i.e. hazardous and non-hazardous).
  - Would not generate hazardous waste.
  - Would not generate dust within confined areas.
  - Has some BESS modules located in proximity to the northern boundary and may pose an off-site impact in the event of a fire involving the lithium-ion cells.
- The SEF power station includes existing gas filters that are directly opposite the proposed BESS facility. The review identified the possibility for a high-pressure gas leak from the SEF gas yard (unignited or ignited) to reach the BESS modules and result in incident propagation on site. Based upon the location of the SEF gas yard and BESS, this was further examined. Consequence analysis was undertaken to evaluate the potential for a flammable cloud or jet fire affecting BESS units and offsite impact due to incident propagation to BESS units.

3.4. 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 in Applying SEPP 33 that this list is illustrative rather than exhaustive. The current edition of Applying SEPP 33 does not include BESS facilities in the example industry listings that may fall within the Resilience and Hazards SEPP or considered as potentially hazardous.

3.5. Conclusions

The preliminary risk screening found that the BESS development by itself is not considered as 'potentially hazardous' within the meaning of Resilience and Hazards SEPP and would not require a PHA. The main findings of the preliminary risk screening are summarised as follows:

- The storage and transport of hazardous materials for the proposed BESS facility will not exceed the relevant risk screening threshold.

However, when considering other risk factors associated with this site, namely the proximity and location of some proposed BESS modules from a) the SEF gas yard and b) northern boundary, some are considered relevant. To maintain a conservative approach with respect to the hazards and risk, further assessment is considered appropriate to examine the potential for offsite impact in a PHA.

Table 3.1: Preliminary risk screening summary – Proposed BESS

Material	DG Class	Category	Storage threshold	Transport threshold		Project storage quantities and applicable SEPP screening	Exceed threshold?
				Movements	Quantities		
Proposed BESS Development							
BESS battery (Lithium-ion)	9	Miscellaneous dangerous goods	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 during operation and maintenance (e.g. battery replacement).	No

4. HAZARDS AND RISK ASSESSMENT METHDOLOGY

4.1. Overview

In line with the conclusion of the SEPP 33 screening, the *Hazards* assessment section of the SEARs require (1) a PHA, and (2) an assessment of hazards and risks for the proposed BESS facility be undertaken. The objective of these assessments is to identify the hazards and assess the risks associated with the proposed BESS facility when in operation as they are understood at the planning stage of the DA and determine risk acceptability from a land use safety planning perspective.

To address the above requirements, a PHA was completed following the methodology specified in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [3], which is focused on off-site impacts.

The HIPAP No. 6 methodology includes the following steps:

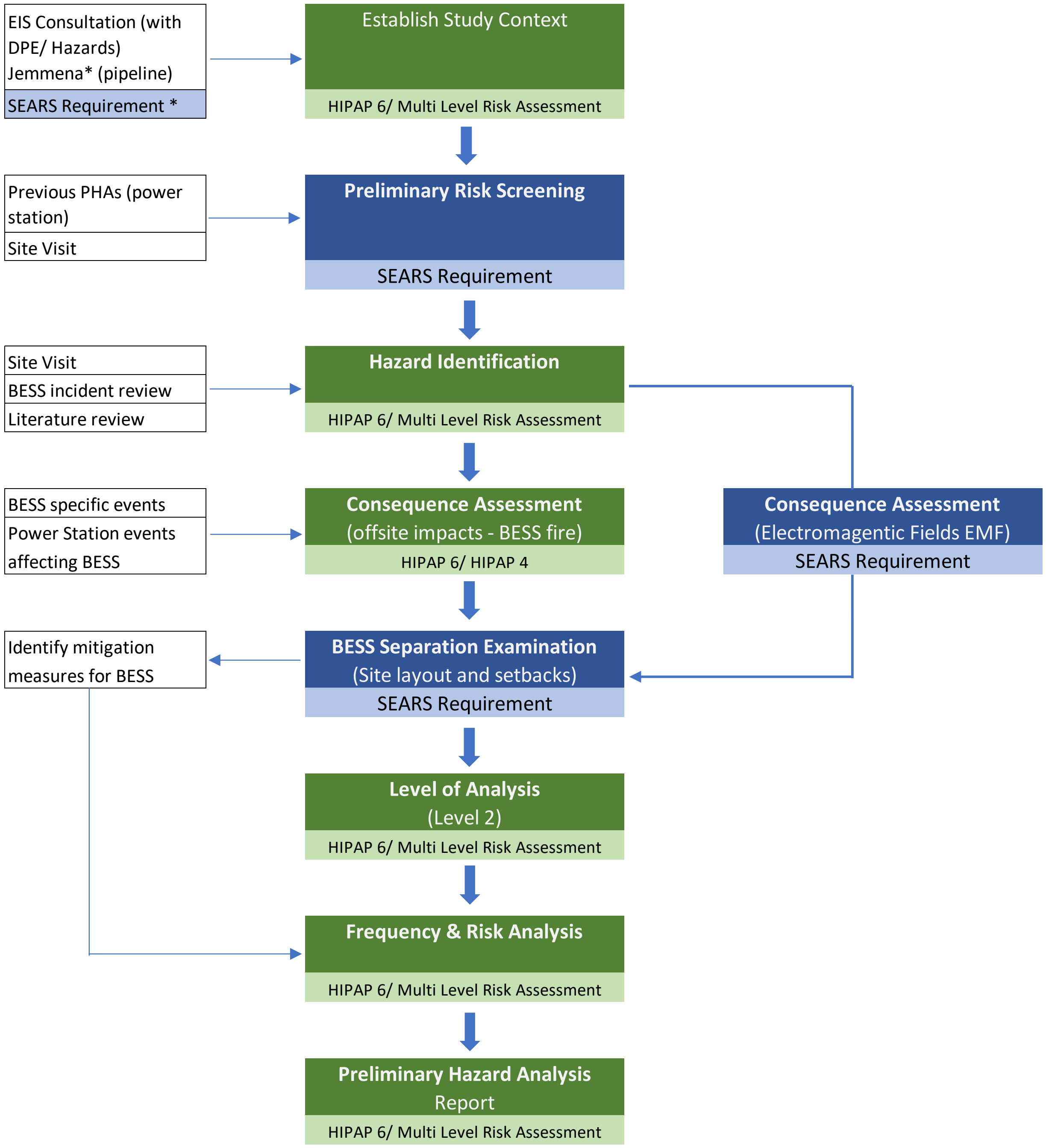
1. Establishment of the study context.
2. Identification of hazards resulting from the proposed BESS operations and events with the potential for off-site impact *(Hazard Identification)*. This also considered consultation outcomes with Jemena, the pipeline operator that provides natural gas for the existing power turbines and past lithium-ion battery incidents (e.g. Big Battery Fire in Victoria 2021) as well as a site visit.
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 analysis and 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 events associated with proposed operation of the BESS (i.e. excluded construction related events). At the DA stage, the PHA is focused on the risk to surrounding land uses (i.e. off-site impacts) and assesses if the development is appropriate for the location.

The boundary of the BESS footprint (‘BESS planning envelope’ in Section 2) and concept layout was used to define and determine off-site impact (i.e. impact extending outside of the BESS footprint boundary). Off-site impact was determined based on potential to impact sensitive receptors.

The study flowchart adopted for the proposed BESS facility is shown in Figure 4.1.

Figure 4.1: PHA Study Flowchart – Smithfield BESS Facility



4.2. Level of analysis

The *Multi-Level Risk Assessment* guidelines, Ref [7], sets out three levels of risk analysis that may be appropriate for a land use safety planning assessment. The levels and a high-level summary of the justification required for each level are shown in Table 4.1. This 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* and *Consequence Analysis* were used to determine the level of analysis appropriate for the PHA.

4.3. 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 [8], appropriate for the level of analysis determined (based on guidance outlined in Table 4.1).

5. HAZARD IDENTIFICATION

5.1. Overview

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 facilities through a systematic and structured approach. The HAZID was extended to include relevant controls and was used as an input to the risk assessment process.

The HAZID is representative of an indicative lithium-ion battery system as the modes of failure and control mechanisms are similar.

The HAZID process was completed using the following inputs:

1. Review of lithium-ion battery system product specification sheets, Ref [9], [10], [11], and product brochure, Ref [12], [13].
2. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [14].
3. Literature research of past incidents involving similar BESS systems.
4. Previous risk assessments for similar BESS systems completed by Sherpa.
5. Outcomes from the site visit to the SEF to understand the potential interactions between the proposed BESS and existing power station.
6. Consultation and feedback from the Proponent for review and acceptance.

5.2. Lithium-ion battery hazards

Currently, lithium-ion type 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 (e.g. 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. LiPF6) dissolved in a solvent (e.g. ethylene carbonate and diethyl carbonate).

It is important to recognise that there is considerable research and development in evolving lithium-ion chemistry and that this hazard identification is based upon available knowledge of the BESS types in August 2023. Table 5.1 summarises the lithium-ion battery chemistry reviewed.

Table 5.1: Battery chemistry overview

Battery chemistry	Advantages	Disadvantages and hazards
<u>Lithium-ion</u> Li-ion chemistries are diverse. Nickel Manganese Cobalt (NMC) and Iron Phosphate formulations are commonly used within BESS facilities.	- Energy efficiency >90%. - High energy density, ranging between 100-265 Watt hours per kilogram (Wh/kg). - Wide availability and cost effective. - Due to high energy density, footprint of land required for facility is comparatively lower than other low energy density formulations.	- Potential for thermal runaway (greater for NMC formulation). Most electrolytes are flammable. - Limited temperature performance window (i.e., not compatible with extreme cold or hot conditions). - Compatibility issues. - Reactive and hazardous in off-nominal conditions. - Previous incidents of failures of safety systems during electrical surges. - Potential for explosion from accumulation of gases produced in a fire.

As indicated in Table 5.1, the potential hazardous events associated with lithium-ion batteries are:

- Thermal runaway leading to a BESS fire.
- Toxic vapour generation from the decomposition of lithium fluoride phosphate and 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.

5.2.1. 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 in the worst case, the consequences could be battery (which is a collection of cells) destruction and 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 the OEMs provide 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 5.3).

5.2.2. Toxic vapour generation

Lithium hexafluorophosphate (LiPF6) is widely used as a salt in the electrolytes for commercial Li-ion BESS. In the event of a BESS fire involving the electrolyte there is the potential to generate hydrogen fluoride (HF) which is a toxic gas. Experiments at a bench scale (Ref [15]) has indicated that HF can be evolved from lithium-ion batteries with LFP.

This PHA study has considered the potential for toxic gas generation in a fire event in Section 6.3.2.

5.2.3. Explosion

In a fire event, decomposition of the electrolyte could result in the generation of flammable gas (e.g. carbon monoxide). A literature review of various BESS UL 9540A test results reported the concentration of generated flammable gas is below the Lower Flammability Limit (LFL). The BESS OEMs under consideration by the Proponent will meet the NFPA 855 (i.e. flammable gas concentration generated not exceeding 25% LEL) and UL 9540A large scale fire test requirements. In this PHA, Sherpa assumes that the BESS selected for the project meets the UL 9540A performance requirements. Based upon this information, explosion was not considered further in this PHA.

Recommendation 1: The Proponent confirms that the selected lithium-ion battery will meet NFPA 855 and/or UL 9540A test performance requirements.

5.3. BESS Incident history

There have been incidents involving large scale lithium-ion BESS facilities as reported in the public domain. The Australian Energy Council (Ref [16]) has provided an incident summary (2017 to date) and selected events that have reported causes are shown in Table 5.2. This table shows that BESS with NMC battery chemistry were more susceptible to fire incidents than LFP chemistry. The Project is proposing LFP chemistry.

Recommendation 2: Review the investigation reports on the Victorian Big Battery Fire (occurred on 31 July 2021) and implement relevant findings for the Project when finalising the design and preparing for operations.

The publicly available investigation reports include a) Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery, Ref [17] *and b) Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire, Ref* [18].

Table 5.2: Selected BESS fire events, REF [16]

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 a Li-NMC chemistry. 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 design in combination with 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.
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.

5.4. Hazard identification

Sherpa developed the HAZID in consultation with the Proponent and Arcadis. The HAZID also considered feedback (managed by Arcadis) from Jemena. The following factors were considered to identify the BESS hazards:

- Lithium-ion battery chemistry.
- BESS component and type of equipment.
- Proposed operation and maintenance activities.
- BESS incident history.
- Hazardous substances/ DG present at the existing SEF power station.
- External factors (e.g. natural gas, power generation units, 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.

The types of hazards and associated events considered were informed from AS/NZS 5139. The identified hazards and events are presented in Table 5.3.

Table 5.3: Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
Fire	Infrastructure fire
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	Existing power station hazards, unauthorised access/trespasser, bushfire, lightning storm, water ingress (rain and flood)

A summary of the hazard present at/applicable to the proposed Smithfield BESS facility is provided in Table 5.4.

Table 5.4: Hazards by BESS component

Hazard	BESS Components			
	Battery modules	**BMS**	**Thermal management system**	**PCUs (inverters)**
Electrical	✓	✓	✓	✓
Energy (arc flash)	✓	-	-	✓
Fire	✓	✓	✓	✓
Chemical	✓	✓	✓	-
Explosive gas	✓	-	✓	-
Reaction	✓	-	-	-
EMF	✓		-	✓
External factors	✓	✓	✓	✓

5.5. Exposure to EMF

The SEARs for '*Hazards*' include a requirement to assess potential hazards and risks associated with EMF exposure against the ICNIRP guidelines. EMF exposure assessment against ICNIRP guideline and reference levels are presented in Section 7.

5.6. HAZID register

The identified hazards, events, applicable infrastructure, and the relationships with causes, consequences and controls are summarised in the HAZID register. The HAZID register is provided in APPENDIX A. The findings indicated that:

- Northern boundary (HAZID No. 3, 8-11, 16) | Due to the proximity of the BESS modules near the northern boundary, a fire due to thermal runaway (from battery specific failure modes) could result in offsite impact to the industrial neighbour by radiation and/or toxic gas generation. This incident was carried forward for further analysis.
- SEF gas yard (HAZID 4) | There is a potential for a flammable gas cloud or jet fire impinging (via radiation) on some BESS modules that could cause result in incident propagation (fire) or toxic gas offsite impact. This incident was carried forward for further analysis.
- Jemena inlet yard (HAZID 5,18,19) | Gas leak and ignited fire event was not considered a credible incident to reach the BESS modules due to obstructions (fire rated building that would also act as a vapour barrier) providing a barrier between this area and the proposed facility. Similarly, BESS fire radiation levels corresponding to incident escalation do not reach the Jemena inlet yard.
- Gas turbine enclosure (HAZID 6) | Due to the large separation distance from the turbine enclosure(s) to the BESS facility and site structures an explosion causing a

BESS fire was not considered credible. The turbines are also provided with gas and fire suppression systems that would minimise the potential for explosion.

Figure 5.1: Indication of major HAZID

a

6. CONSEQUENCE ASSESSMENT (BESS FIRE AND TOXIC GAS)

6.1. Incidents for analysis

The hazard identification (Section 5) of the proposed BESS facility identified a set of scenarios requiring further assessment to determine the potential for off-site impacts. These impacts were identified to be exposure to injurious and fatal levels of thermal radiation and toxic gas. Understanding the level of impact will allow the Proponent to use these consequence results to finalise the BESS facility layout against the chosen lithium-ion battery type and inform the level of assessment in the PHA appropriate to the Project.

The analysed incidents were:

- Fire (for example from thermal runaway) involving a lithium-ion battery module.
- Toxic gas generation from the decomposition of electrolyte due to a battery module fire.

The analysis also considered the potential for incident propagation from:

- Unignited and ignited release from the SEF gas yard impacting the BESS facility with subsequent BESS fire and toxic gas release.
- BESS module on fire escalating to adjacent BESS module.

6.2. Approach

6.2.1. Fire and Gas modelling

As the Proponent is in the process of finalising selection of the preferred BESS type, consequence analysis was conducted on a range of available lithium-ion batteries (Section 2):

- Fire scenario modelling involving the BESS module was undertaken using the Stefan–Boltzmann equation to assess the effect of heat transfer between two parallel planes which represent a BESS module fire and a receptor. Representative sizes of the BESS modules were considered, and thermal radiation effects were compared against the criteria in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*.
- Toxic gas modelling involving the BESS module was undertaken using the Gexcon EFFECTS gas dispersion model that accounted for thermal rise (from the fire). As indicated in Section 5, the generation rate of hydrogen fluoride was based upon published experimental literature for batteries that use lithium fluoride phosphate compound. For the purposes of this study, it has been assumed the lithium-ion batteries have LFP and in a fire, HF is generated from the decomposition. Toxic concentration effects were compared against Acute Exposure Guideline Levels (AEGLs) for hydrogen fluoride.

- Flammable gas (methane) release from the SEF gas yard was undertaken using Gexcon EFFECTS based upon the operating conditions. Jet fire radiation modelling was also undertaken using Gexcon EFFECTS. Thermal radiation effects were compared against the criteria in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*.

APPENDIX B provides further details of the consequence analysis including the impairment criteria, method, assumptions and results.

6.3. Modelling results and findings

6.3.1. BESS Fire – thermal radiation

Results

The distances to the thermal radiation level resulting from a full lithium-ion BESS module fire are shown in Table 6.1 for side-on and end-on views.

Table 6.1: BESS Fire – Radiation Impact Distances

		Distance (m) at Receiver Height (1.5m) to Radiation Levels					
BESS Module Type	**Size (LxHxW, m)**	**4.7 kW/m^2 (injury)**		**12.6 kW/m^2 (fatality)**		**23 kW/m^2 (structural failure)**	
		Side	**End**	**Side**	**End**	**Side**	**End**
Wartsilla	3x3x3	9	9	5	5	4	4
CanadianSolar/ CATL	6x3x3	13	9	7	5	5	4
Sungrow/ Tesla	9x3x1.5	15	6	9	4	6	3
Powin	12x3x3	17	9	10	5	7	4

Findings

The analyses found:

- The radiation impact distance was influenced by the module size, unit orientation, module height and flame (metal) temperature.
- For fire radiation effects from longest side wall, the range of impact distances for the largest (i.e. Powin type) BESS module size to the smallest (i.e. Wartsilla type) for injury ranged from 17 to 9 metres. Similarly, the distance range for fatality was from 10 to 5 metres. As a sensitivity, calculations to simulate two modules alight (longest side wall) only marginally increased the radiation distance to injury and fatality level. Discussion on separation distances from a BESS facility layout perspective to offsite is in Section 6.4. From the site visit, there are no buildings or sensitive receptors at this distance.

- For fire radiation effects from the end wall, the range of impact distances for the largest (i.e. Powin type) BESS module size to the smallest (i.e. Wartsilla type) for injury ranged from 9 to 6 metres. Similarly, the distance range for fatality was from 5 to 4 metres.
- Sensitivity case where the metal flame temperature was reduced to 600°C (comparable to cellulosic fires) found the impact distances reduced the values are presented in Section B2.5.
- Under escalation scenarios, the radiation distances (23 kW/m^2) from the end wall were found to be 3 to 4 metres which is comparable to the typical required separation distances recommended by the BESS manufacturers for face to face. Further discussion on separation distances is provided in Section 6.4.

6.3.2. BESS Toxic gas generation from BESS fire

Results

In the event of a lithium-ion battery fire, there is the potential for generating hydrogen due to the decomposition of LFP electrolyte. APPENDIX B provides details of the toxic gas dispersion analysis including the impairment criteria, method, assumptions and results.

Analysis for the largest and smallest size BESS units under consideration was undertaken to understand the range of impact distances. The distance at receiver height to the 60 minute AEGLs for a one hour hydrogen fluoride release due to a fire and decomposition of the electrolyte are shown in Table 6.2. Hydrogen fluoride was taken as the material of concern due to its toxicity effects.

Table 6.2: BESS Fire – Toxic Impact Distances

			Distance (m) at Receiver Height (1.5m) to AEGL		
BESS Module	**Size (LxWxH, m)**	**Wind Weather Stability**	**AEGL-1 (irritation)**	**AEGL-2 (injury)**	**AEGL-3 (fatality)**
Wartsilla	3x3x3	B3	25	8	5
		D2	5	3	2
		D5	45	14	9
		F1	1	Not reached	Not reached
Powin	12x3x3	B3	21	11	8
		D2	8	5	4
		D5	39	20	14
		F1	2	2	1

Findings

The analyses found:

- The toxic gas plume reaches AEGL-2 (injury) concentration levels at the receiver height between 3-14 metres (smallest BESS unit) and 2-20 metres (largest BESS unit) under a range of wind weather stabilities. From the site visit, there are no buildings or sensitive receptors at this distance.
- The toxic gas plume reaches AEGL-3 (fatality) concentration levels at the receiver height between 2-9 metres (smallest BESS unit) and 1-14 metres (largest BESS unit) under a range of wind weather stabilities. From the site visit, there are no buildings or sensitive receptors at this distance.
- The concentration side profile shows the plume rises quickly due to the flame temperature (fire case) and that the gas itself is lighter than air. The dispersion profile is shown in APPENDIX B. As a sense check, Sherpa viewed the video footage of the Big Battery Fire 2021, and this showed the vapour plume rise profile similar to the modelling.
- Sensitivity analysis was performed reducing the heat release comparable to cellulosic fires. The impact distance to AEGL concentration at the receiver height increased (e.g. Wartsilla type, AEGL-3 was 7 metres).
- Discussion on separation distances from a BESS facility layout perspective to offsite is in Section 6.4.

6.3.3. SEF Gas Yard – flammable gas release and jetfire

Results- flammable gas

Releases from the SEF gas yard equipment ranging from small to large (e.g. flange failure, instrument fitting failure, small bore piping failure) were modelled to determine the extent of the flammable cloud. The results are shown in Table 6.3. APPENDIX B provides further details of the consequence analysis including the impairment criteria, method, assumptions and results.

Table 6.3: SEF Gas Yard – Flammable Gas Distances

Material	Leak Size (mm)	Release Pressure (bar)/ Temperature (degC)	Wind Weather Stability	Distance (m) at Receiver Height to 100% LFL
Natural gas	10	38 barg 25 degC	B3	Not reached
			D2	Not reached
			D5	Not reached
			F1	Not reached
Natural gas	20	38 barg 25 degC	B3	6
			D2	6

Material	Leak Size (mm)	Release Pressure (bar)/ Temperature (degC)	Wind Weather Stability	Distance (m) at Receiver Height to 100% LFL
			D5	6
			F1	6
Natural gas	50	38 barg 25 degC	B3	33
			D2	29
			D5	32
			F1	25

Results- jetfire

In the event the gas release is ignited, a jetfire could result. The radiation impact distances are shown in Table 6.4 for ignited releases (with no isolation).

Table 6.4: Gas yard jetfire – Radiation Impact Distances

		Distance (m) at Receiver Height (1 m) to Radiation Levels		
Material	**Leak Size (mm)**	**4.7 kW/m^2 (injury)**	**12.6 kW/m^2 (fatality)**	**23 kW/m^2 (structural failure/escalation)**
Natural gas	10	15	14	13
Natural gas	20	29	26	25
Natural gas	50	67	60	56

Findings

Based upon the preliminary layout, BESS modules are located approximately 9 metres from the existing gas yard. The analysis found:

- Gas yard natural gas release from the more likely leak sizes (flange leak up to 10mm hole size, instrument fitting failures up to 20mm) would not result in the 100% LFL flammable cloud reaching the BESS units. Whilst noting the likelihood of larger releases (e.g. rupture) is lower than for a smaller leak sizes, the LFL flammable cloud for a large leak (i.e. 50mm leak or above) release could reach the BESS development envelope.
- An ignited gas release for all leak sizes modelled at the gas yard would give rise to a jetfire escalation radiation level (23 kW/m^2) that would reach the BESS development envelope. In the worst case without leak isolation, there is the potential for incident propagation to the BESS modules.

6.4. Site layout considerations

With reference to the consequence assessment and the concept layout shown in Figure 2.2, the following observations are made:

6.4.1. Northern boundary

The concept layout indicates that the BESS modules could be located near the northern boundary. A BESS module fire at this boundary could result in:

- Radiation impact (fatality and injury) offsite for all BESS types considered.
- Toxic gas impact (fatality and injury) offsite for the BESS types considered.

Recommendation 3: Measures to minimise the offsite fatality potential from radiation and toxic gas effects from a full BESS module fire at the northern site boundary will be investigated during detailed design. Mitigation measures could include:

a) the setback of the BESS units as per the radiation fatality distances for the chosen BESS type (separation measure); and/ or

b) fire wall (engineering measure) along the northern boundary; and/ or

c) orientation of BESS units to minimise radiation impact distance.

Recommendation 4: Based upon the final BESS layout, update the SEF Emergency Response Plan to include consideration of:

a) how emergency services can safely access the northern site boundary and respond to a BESS fire and toxic gas (hydrogen fluoride) generation in this area.

b) communication and response to a BESS fire with the current neighbour, Kingspan on the northern site boundary.

6.4.2. SEF gas yard

The concept layout indicates that the nearest BESS development envelope would be located approximately 9 metres opposite from the SEF gas yard. A loss of containment at the gas yard would result in:

- Potential flammable gas ingress into BESS modules for large releases.
- Potential for an ignited event (jet fire) impinging upon adjacent BESS modules.

Any of these events could lead to a fire in the BESS unit and whilst the immediate radiation and toxic gas impact would not be offsite, there is the potential if left unchecked for incident fire escalation to adjacent modules. In discussion with SEF operations, there is no automatic gas detection and gas isolation. As the site is minimally staffed, manual detection and isolation may not occur quickly in the event of a gas leak.

Recommendation 5: Mitigation measures to minimise the potential for a natural gas leak at the SEF gas yard directed towards the BESS modules be investigated. This would minimise the potential for incident propagation as well as provide asset protection. Mitigation measures could include:

a) flange guards on the SEF gas yard pipework; or

b) vapour barrier along the gas yard.

Consideration should also be given to early flammable gas detection and isolation.

Recommendation 6: A Final Hazard Analysis (FHA) be undertaken for the chosen BESS type to confirm that the spacing and setback distances will minimise the potential for offsite radiation and toxic gas impacts from BESS fire events.

7. CONSEQUENCE ASSESSMENT (ELECTRIC & MAGNETIC FIELDS)

The SEARs for '*Hazards*' includes a requirement to assess potential hazards and risks associated with exposure to EMF against the ICNIRP guidelines.

7.1. Overview

EMF 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. EMF are also produced wherever electricity or electrical equipment is in use (e.g. household appliances, powerlines), Ref [19].

Electric fields are created where there is flow of electricity. Electric fields are related to and directly proportional to voltage (i.e. higher the voltage higher 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. higher the current higher 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 effect 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 is 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 Ref [20].

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 [19].

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[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 7.1: 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

7.2. Effects of exposure to EMF

7.2.1. Acute effect

Studies have been conducted to determine the effects of EMF exposure. There have been several well-established acute effects on the nervous system due to exposure to high levels of EMF. These include direct stimulation of the nerve and muscle tissue, and induction of retinal phosphene (i.e. sensation of ring or spot of light on eye ball). However, it should be noted that exposure to high levels of EMF is not normally found in everyday environment from electrical sources. There is also indirect scientific evidence that EMF can transiently affect visual processing and motor coordination. For certain occupational instances, the ICNIRP considered that with appropriate training, it is reasonable for workers to voluntarily experience transient effects such as retinal phosphene and minor changes in brain function since these are not believed to result in long term or pathological health effects, Ref [21].

7.2.2. Chronic effect

Numerous studies have been conducted to understand the effects of long-term exposure to EMF. Some studies have linked prolonged exposure to EMF to increased rates of childhood leukemia. Based largely on limited evidence, the International Agency for Research on Cancer has classified ELF magnetic fields as ‘possibly carcinogenic to humans’. The ICNIRP views that the current existing scientific evidence is too weak to ascertain a causal relationship that prolonged exposure to ELF magnetic fields is related with increased risk of childhood leukemia, Ref [21].

7.2.3. Advice from public authority

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 ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health.”,* Ref [22].

- *"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 [23].

7.3. Study approach

Although the adverse health impacts have not been established, the possibility of impact due to exposure to EMF cannot be ruled out. As part of a precautionary approach, the study will assess the typical exposure levels to EMF for the proposed 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 [24]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

7.4. 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 public and occupational exposure within the guideline. The guideline has defined 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 because of performing their regular or assigned job.

The ICNIRP reference levels for exposure to EMF at 50 Hz is presented in Table 7.2, Ref [21]. The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that the public are unaware of their EMF exposure.

Table 7.2: 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

7.5. BESS and grid connection infrastructure EMF

7.5.1. BESS

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

7.5.2. PCU

Due to the limited EMF information available, this study assumed that EMF generated from PCUs on a grid-scale BESS facility is not dissimilar to PCUs used on a large-scale solar farm facility. A field study was undertaken to characterise the EMF between the frequencies of 0-3 GHz at two large scale solar facilities operated by the Southern California Edison Company in Porterville and San Bernardino, Ref [25].

The field study findings were adopted to estimate the EMF measurements for the project's infrastructures. The findings are as follows:

- The highest DC magnetic fields were measured adjacent to the inverter (277 µT) and transformer (258 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The highest AC magnetic fields were measured adjacent to the inverter (110 µT) and transformer (177 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The strength of the magnetic field attenuated rapidly with distance (i.e. within 23 m away, the fields drop to background levels).
- Electric fields were negligible to non-detectable. This is mostly likely attributed to the enclosures provided for the electricity generating equipment.

7.6. 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. accounts for separation distance to surrounding land uses including neighbouring properties) and will assist to limit the exposure to EMF for the 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 transient.

7.7. Conclusion

Based on the review completed in the preceding sections, the 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, the study determined that the ICNIRP reference level for exposure to the public will not be exceeded and impact to the public[5] 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.

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[5] The closest residential area is 400 metres from the SEF site. The distance from the BESS development envelope to the access road is greater than 20 meters.

8. BESS SEPARATION DISTANCES

8.1. Overview

As per the project SEARs, the PHA includes a requirement to '*consider all recent standards and codes and verify separation distances to on-site and off-site receptors to prevent fire propagation*'. Based on clarification with the DPE, this additional requirement (to that of a conventional PHA) is intended to ensure that fire risks from the BESS[6] have been considered in designing the project.

Specifically, the proponent must demonstrate that the proposed BESS capacity would be able to fit within the land area designated for the BESS accounting for separation distances between the:

- BESS units, to ensure that a fire from a unit does not propagate to neighbouring units; and
- The overall BESS and other on-site or off-site receptors.

This section covers the following:

1. Requirements for separation distances/clearances between the BESS sub-units according to applicable codes and standards and manufacturer specification.
2. Requirements for separation distances between the BESS and onsite receptors.
3. Requirements for separation distances between the BESS and off-site receptors.
4. Requirements for land area for the proposed BESS capacity.

8.2. Separation distances between BESS sub-units

8.2.1. NFPA 855

The National Fire Protection Agency (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 units, Ref [26].

NFPA 855 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

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[6] Applicable for projects that include a BESS exceeding a peak delivery capacity of 30 MW.

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.

In this study, Sherpa has assumed that BESS OEMs will provide completed UL 9540A tests as following:

- Tests at the cell, module and unit level were completed; and
- The tests were successful to demonstrate that:
  - If the battery cells within a battery module go into thermal runaway, it would not propagate to adjacent modules or units.
  - No fire ignited or explosion hazards exhibited.

8.2.2. Manufacturer specified clearances

In addition to the UL 9540A tests, manufacturers recommend clearances between BESS sub-units for reasons of safety, operability, and maintainability. These recommended clearances can vary based on the BESS model and dimensions.

Recommendation 7: The Proponent to ensure that the final BESS layout includes the specified clearances recommended by the OEM.

8.3. Onsite receptors

The closest onsite receptors to the battery units will be other site infrastructure including:

- Inverter.
- Transformer.
- Existing switchgear rooms.
- Existing facility including gas metering station, gas turbines, etc.

Sherpa assumed that the selected OEM will have completed UL 9540A tests to demonstrate propagation characteristics based on separation between batteries. Application of the same separation distance to other onsite receptors will mean propagation is not expected.

8.4. Off-site receptors

The BESS facility will be located within the SEF. The site is in an industrial area surrounded by the Visy industrial estate on all boundaries except the northern boundary which is Kingspan. The separation distance from the proposed BESS area to the nearest residential receptor is about 400 metres. For the PHA, non-associated residential and industrial dwellings, or occupied areas, are considered as sensitive receptors to determine off-site impact.

Potential consequences, including fire events involving the BESS units, and toxic releases have been identified and assessed in Section 6. This assessment aims to specify the separation distance or setback distance between BESS units and the site boundary to minimise off-site impact. The results are significantly influenced by the dimensions of the BESS units and battery specifications. See Section 6 for the consequence analysis results and recommendations for setback distance from the site boundary or engineered control to mitigate offsite effects.

8.5. Land area designated for the BESS

The proposed BESS modules will be in a dedicated area within the BESS footprint. As the OEM has not been selected at the time of this study, further investigation will be conducted during the detailed design phase following the selection of the manufacturer. See Section 6 for the consequence analysis results and recommendation for ensuring the BESS facility layout meets setback distances to minimise offsite impact.

8.6. Summary

Upon reviewing the SEAR requirements for BESS separation distances, the following findings were identified:

- The Proponent has confirmed that the BESS layout will be designed to incorporate the recommended clearances specified by the OEM for safety, operability, and maintainability. This has been captured as a recommendation in Section 8.2.
- Sherpa assumed that the selected manufacturer would present the UL 9540A or a similar test report to demonstrate that key performance requirements have been met.
- A consequence analysis has been conducted to analyse off-site impact from a BESS fire and the potential for a propagated incident from existing site hazards (e.g. gas yard) to the BESS. The results indicate that off-site impact as well as incident propagation can be minimised if the Proponent follows the recommendations presented in Section 6.

9. LEVEL OF ANALYSIS DETERMINATION

9.1. Level of analysis

The HAZID and subsequent consequence analyses of the concept BESS facility layout identified the following two potentially hazardous scenarios:

- Off-site impact (injury and/or fatality) to the Kingspan industrial site from a fire and HF toxic gas (if using fluoride electrolyte) involving proposed BESS modules located along the northern site boundary.
- Potential incident propagation due to loss of containment (unignited/ ignited) of natural gas from the gas yard (supplies natural gas fuel to the power turbines) impinging on BESS modules.

However, these events are not expected to have significant off-site impacts (serious injury and/or fatality) to the:

- Nearest sensitive receptor which is the residential area located 350 metres to the south-west of the SEF site.
- Closest public road (Herbert Place) located 50 metres to the north-west of the proposed BESS facility location.
- Adjacent Visy facilities industrial complex with the nearest building located over 100 metres to the west of the SEF site from the proposed BESS facility location.

Additionally, identified events are expected to present negligible societal risk impact as:

- The proposed BESS facility will be located on the existing SEF which is in an area zoned industrial with limited number of people within the consequence footprint.

Based on the above findings and the *Multi-Level Risk Assessment* guideline, Ref [7], a semi-quantitative approach (i.e. Level 2 analysis) was determined appropriate for this study. As indicated in Section 6, mitigation measures to minimise offsite impact were identified in consultation with the Proponent and Arcadis (August 2023).

The risk analysis that accounts for proposed mitigation measures is in Section 10.

9.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [8], 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 11.

10. FREQUENCY AND RISK ASSESSMENT

10.1. Overview

In this study, risk is defined as the likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in a unit of time) or a probability (the probability of a specified event following a prior event) depending on the circumstances.

For events (Section 5) that have been identified with the potential to have an offsite impact, the risk was qualitatively determined from the resulting severity and likelihood rating pair using the Proponent's risk matrix shown in Table 10.1. The consequence assessment for these events were used to inform the severity rating.

10.2. Risk Matrix and Acceptance Criteria

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

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

Events with risks greater than 'Low' are required for further assessment as per the Proponent's risk management requirements.

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	Low	Low	Medium	Medium	Medium
Non-material	Low	Low	Low	Low	Low

10.2.1. Risk mitigation

Mitigation measures to minimise offsite impact were identified in consultation with the Proponent and Arcadis (August 2023). These have been reflected in this risk assessment.

10.3. 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 shown in Table 10.2 which was reproduced from Risk Classification Standard developed by the Proponent.

The severity scale was then used to assess impact for off-site population. As a conservative measure, should the consequence analyses indicate the potential for offsite fatality impact, a 'catastrophic' rating was assigned. For consequences with an injury potential, then 'moderate' rating was chosen.

Table 10.2: Consequence rating – Offsite

Consequence rating	Rating definition
Catastrophic	Fatality (single or multiple) and/or serious irreversible damage or serious impairment to more than one person.
Major	Serious irreversible damage or serious impairment to one person (e.g. amputation, heart attack).
Moderate	Reversible injury or moderate irreversible damage or impairment to one or more persons. Typically a Recordable Injury (i.e. requiring medical treatment, lost time or restricted duties).
Minor	Reversible injuries requiring minor treatment onsite. Typically a first aid case.
Non-material	Event reported with no first aid required (e.g. bumped or bruised knee, minor strain).

10.4. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 10.3 which was reproduced from Risk Classification Standard.

The likelihood ratings were assigned based on knowledge of historical incidents in the BESS industry (Section 5) and in consultation with the Proponent. The likelihood ratings were assigned accounting for the initiating causes, resulting consequences with controls (prevention and mitigation) in place.

Table 10.3: Likelihood rating

Likelihood rating	Rating definition
Almost certain	The event is expected to occur in most circumstances as there is a history of regular occurrences within similar industries or sites.
	Occurs more than once a year
Likely	There is a strong possibility the event will occur as there is a history of frequent occurrences within similar industries or sites.
	Typically occurs once every 1 - 5 years
Possible	The event might occur at some time as there is a history of casual occurrences within similar industries or sites.
	Typically occurs once every 5 - 20 years
Unlikely	Not expected, but there's a slight possibility it may occur at some time.
	Typically occurs once every 20 - 50 years
Rare	The event may occur in exceptional circumstances. It could happen, but probably never will.
	Greater than a 50-year event

10.5. Risk results and analysis findings

The qualitative risk results for the identified events (taken from the HAZID) are shown in Table 10.4. The risk analysis findings are as follows:

BESS modules on Northern Boundary

- The worst-case consequence results (Section 6) indicated that due to the proximity of the BESS modules (shown on the concept layout) near the boundary, a fire (from battery specific failure modes) and/or toxic gas generation could result in offsite fatality and injury impacts. Based on this consequence impact and assigning a likelihood rating of ‘possible’, gave a ‘High’ risk rating.
- Proposed mitigation measures to minimise offsite fatality impact are provided in Section 6 and Section 8. Implementation of these measures would result in injury impacts extending slightly into the Kingspan (neighbouring property). Site inspection found that this area is used as a laydown yard. The nearest occupied building is located approximately 70 metres away. Applying the rules sets provided a revised consequence rating of ‘moderate’ and a likelihood rating of ‘possible’, providing a ‘medium’ risk overall.

BESS in all other areas

- The consequence results (Section 6) indicated that a BESS fire incident in all other areas would not result in offsite fatality and injury impacts. Assigning a severity rating of ‘non-material’ and likelihood rating of ‘unlikely’, gave a ‘low’ risk rating.

SEF Gas Yard

- The consequence results (Section 6) indicated that BESS modules directly opposite the SEF gas yard could be vulnerable from a leak of natural gas. A continuous leak could result in a flammable cloud reaching a BESS module or if ignited, potential impingement. A fire involving these BESS modules could then propagate and in the worst case, have offsite impact. Based on this consequence impact and assigning a likelihood rating of ‘unlikely’, gave a ‘high’ risk rating.
- Mitigation measures to minimise incident escalation to the BESS units are indicated in Section 6 and Section 8. Applying the rules sets provided a revised consequence rating of ‘insignificant’ and a likelihood rating of ‘unlikely’, providing a ‘low’ risk overall.

Table 10.4: Offsite risk – Smithfield BESS

Hazard/ Event	Incident Location	Consequence	Offsite consequence results (Section 6) and with reference to concept layout	Risk analysis (off-site/ public impact) – concept layout			Recommendation	Risk analysis (off-site/ public impact) – Mitigated		
				Severity	Likeli'd	Risk		Severity	Likeli'd	Risk
BESS fire	BESS modules on northern site boundary	- Release of toxic combustion products - Thermal radiation impact - Escalation to the adjacent BESS units - Escalation to adjacent infrastructure	- Depending upon BESS type, fatality and injury may extend offsite into the Kingspan site.	Catastrophic	Possible	High	BESS setback distance as per consequence analysis (see Table 6.1 and Table 6.2) for selected OEM to minimise fatality distance, and/ other measures in Section 6 and Section 8	Moderate	Unlikely	Medium
BESS fire	All other BESS modules (excluding northern site boundary)	- Release of toxic combustion products - Thermal radiation impact - Escalation to the adjacent BESS units - Escalation to adjacent infrastructure	- No offsite impact expected as the BESS modules and infrastructure have sufficient separation distances.	Non-material	Unlikely	Low	No action identified	Non-material	Unlikely	Low
BESS fire	SEF gas yard – flammable cloud ingress or jetfire impingement upon BESS	- Release of toxic combustion products - Thermal radiation impact - Escalation to the adjacent BESS units - Escalation to adjacent infrastructure	- Modelling shows that BESS units could be affected by the SEF gas yard jetfire. If incident left unchecked, potential for incident propagation. Worst case, offsite impact into Kingspan site.	Catastrophic	Unlikely	High	Mitigation measures as given in Section 6 and Section 8 to minimise incident propagation	Non-material	Unlikely	Low

11. RISK ASSESSMENT AND CONCLUSION

11.1. Assessment against company risk acceptance criteria

Using the study risk matrix provided by the Proponent and the consequence analysis findings, the identified hazardous events were qualitatively risk assessed. Of the event types identified that have the potential for offsite impact, two were identified to be 'High' risk. These high-risk events related to:

- Fire with thermal and toxic gas impact for BESS modules located on near the northern site boundary, and
- Incident escalation involving BESS modules located opposite the high-pressure power station gas letdown yard.

The risk control hierarchy and identified mitigation measures (from separation to engineering controls) would be applied to minimise offsite impact and incident escalation. Applying these measures (i.e. Section 11.4) would reduce the qualitative risk to medium (for BESS modules at the northern boundary) or very low risk (for incident escalation from the SEF gas yard) rating.

The PHA noted that for all other identified events, they would not be expected to have significant offsite impacts.

Based on the study risk acceptance criteria and implementation of recommendations, the risk profile for the proposed Smithfield BESS would be considered acceptable/ tolerable.

11.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 11.1.

Table 11.1: 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 Smithfield BESS operations. The BESS location is situated in an established industrial area and the BESS facility itself will be within the SEF power station which is secure. There are large separation distances to sensitive receptors (i.e. residential) to avoid off-site risks. The EIS has addressed alternative locations and establishes the case for having the BESS facility to support the SEF. It is not possible to eliminate batteries from a BESS development. Selection of the battery technology is a balance of cost and availability with the most used versions being lithium-ion.	Yes
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.	As the Proponent is finalising the selection of the preferred BESS type, the PHA was conducted upon a concept layout. The PHA study has identified a) proposed BESS module locations that could pose an offsite impact to a neighbouring industrial facility, and b) the BESS facility itself be susceptible to incident escalation from an incident at the SEF. Mitigation measures have been identified and developed into engineering related recommendations for Smithfield BESS as input to the final design of the BESS facility. Implementation of these recommendations will ensure that the offsite risk will be reduced as practicable and be acceptable. The PHA supports the recommendation to conduct a Final Hazard Analysis to ensure that the PHA findings and recommendations as well as the BESS manufacturer recommendations are implemented in the final facility design. As the Smithfield site is in an industrial area, consequence impacts from the identified hazardous events to residential areas will not be reached.	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. As reported above, the PHA has identified recommendations that will minimise the offsite fatality impact arising from a BESS fire (thermal radiation and toxic gas). Based on the separation distance to sensitive receptors (i.e. residential areas), consequence impacts from the identified hazardous events (e.g. fire and toxic gas) are not expected to have significant off-site impacts to residential areas and nearby industrial properties.	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 hazardous developments (in the context of the Resilience and Hazards SEPP) in the vicinity of the project site. This PHA has considered the hazards from the existing SEF and provided recommendations to minimise hazard interaction. The Jemena gas pipeline that provides feed to the existing power station is not expected to impact the proposed BESS facility.	Yes

11.3. Conclusion

A PHA was completed to identify the hazards and assess the risks associated with the proposed operations of the Smithfield BESS at the planning stage to determine risk acceptability from land use safety planning perspective.

The PHA included the potential hazard interactions between the existing SEF facility and the proposed BESS facility. The PHA was completed following the methodology specified in HIPAP No. 6 Hazard *Analysis and the Multi-Level Risk Assessment guidelines for assessment against HIPAP No. 4 criteria*. A Level 2 PHA (semi-quantitative) was completed.

The PHA concluded that providing recommendations are implemented, the resulting consequences from identified BESS events are not expected to have significant off-site impacts. The proposed BESS meets the HIPAP No. 4 qualitative risk criteria.

The Proponent has indicated the PHA findings will be used as an input to finalise the BESS facility layout following BESS selection.

11.4. Recommendations

To support the PHA conclusion, the following recommendations are provided:

Recommendation 1: The Proponent confirms that the selected lithium-ion battery will meet NFPA 855 and/or UL 9540A test performance requirements.

Recommendation 2: Review the investigation reports on the Victorian Big Battery Fire (occurred on 31 July 2021) and implement relevant findings for the Project when finalising the design and preparing for operations.

The publicly available investigation reports include a) Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery, Ref [17] and b) Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire, Ref [18].

Recommendation 3: Measures to minimise the offsite fatality potential from radiation and toxic gas effects from a full BESS module fire at the northern site boundary will be investigated during detailed design. Mitigation measures could include:

a) the setback of the BESS units as per the radiation fatality distances for the chosen BESS type (separation measure); and/ or

b) fire wall (engineering measure) along the northern boundary; and/ or

c) orientation of BESS units to minimise radiation impact distance.

Recommendation 4: Based upon the final BESS layout, update the SEF Emergency Response Plan to include consideration of:

a) how emergency services can safely access the northern site boundary and respond to a BESS fire and toxic gas (hydrogen fluoride) generation in this area.

b) communication and response to a BESS fire with the current neighbour, Kingspan on the northern site boundary.

Recommendation 5: Mitigation measures to minimise the potential for a natural gas leak at the SEF gas yard directed towards the BESS modules be investigated. This would minimise the potential for incident propagation as well as provide asset protection. Mitigation measures could include:

a) flange guards on the SEF gas yard pipework; or

b) vapour barrier along the gas yard.

Consideration should also be given to early flammable gas detection and isolation.

Recommendation 6: A Final Hazard Analysis (FHA) be undertaken for the chosen BESS type to confirm that the spacing and setback distances will minimise the potential for offsite radiation and toxic gas impacts from BESS fire events.

Recommendation 7: The Proponent to ensure that the final BESS layout includes the specified clearances recommended by the OEM.

APPENDIX A. HAZARD IDENTIFICATION

A1. Smithfield HAZID

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

- BESS operations, and
- Existing power plant operations upon the BESS.

Table A1: HAZID – Smithfield BESS Facility

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
1.	Electrical	Battery modules BMS PCUs (inverters, transformers)	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) As the BESS will be situated in a secured area, the effects are not expected to have an off-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 - Decisive Voltage Classification (DVC) followed, and equipment marked accordingly - Warning signs (electrical hazards, arc flash) - Engagement of reputable 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) - 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 fence with signage (warning of electrical hazard) - Emergency Response Plan - External firefighting protocol (FRNSW) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)	-	No
2.	Energy	Battery modules BMS PCUs (inverters, transformers)	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 not expected to have an off-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 reputable 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 - Emergency Response Plan - External firefighting protocol (FRNSW) - 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)	Arc flash is an electrical explosion or discharge, which occurs between electrified conductors during a fault or short circuit condition, Ref [14]. Arc flash occurs when electrical current passes through the air between electrified conductors when there is insufficient isolation or insulation to withstand the applied voltage. Arc flash may result in rapid rise in temperature and pressure in the air between electrical conductors, causing an explosion known as an arc blast.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
3.	Fire (internal)	Battery modules BMS PCUs (inverters, transformers)	BESS fire	Battery Specific - Faulty equipment - Arc flash - Mechanical damage or failure of battery case (e.g. overload, insulation breakdown, connection failures) - Battery thermal runaway (e.g. short circuit, overheating, overcharge) - Human error during maintenance	- Release of toxic and/or explosive combustion products - Escalation/ incident propagation - Injury and/or fatality to onsite employees - Potential offsite 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 - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - All relevant TransGrid's requirements for the HV transformer and switchyard will be met - Circuit breakers provided for the HV transformer - 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 manufacturer and/or applicable standards (refer to Section 8) - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Section 2, 8) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - External firefighting protocol (FRNSW)	At SEF, it is proposed to place BESS modules in proximity to the northern boundary. Conduct consequence analysis to - Check for offsite radiation impact and toxic gas impact due to fire in one BESS module and from an escalated fire event - Determine required separation distance from the site boundary The PHA will be used to provide recommendations for finalising separation distances in the BESS facility layout and performing a Final Hazard Analysis on the chosen lithium-ion battery.	Yes
4.	Fire (external)	SEF gas yard	BESS fire	Existing power station infrastructure – SEF Gas Yard - Gas leak (e.g. flange, instrument fitting failure, mechanical failure)	- Release of high-pressure natural gas towards the BESS module. - Potential for gas ingress into the BESS module, vented explosion and fire. - Ignition of gas release and jetfire towards BESS module and incident propagation - BESS fire with release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees - Potential offsite impact	- Preventative maintenance on the SEF gas yard equipment (mechanical integrity program) - Manual gas detection and response action (closing the isolation valve) - Gas isolation from the Jemena gas inlet station. - 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 manufacturer and/or applicable standards (refer to Section 2 and 8) - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Section 8) - Activation of BESS emergency shutdown - Emergency Response Plan - External firefighting protocol (FRNSW)	There are some proposed BESS modules located opposite the SEF gas yard. Conduct consequence analysis to - Check for offsite radiation impact and toxic gas impact due to fire in one BESS module and from an escalated fire event. - Determine potential for incident escalation.	Yes

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
5.	Fire (external)	Jemena gas inlet yard	BESS fire	Existing power station infrastructure – Jemena Inlet yard (located at main road entrance to site) Gas leak (e.g. flange, instrument fitting failure, mechanical failure) Noite: This is an existing hazard present at the SEF power station. Note: See HAZID 18 and HAZID 19 for potential impact upon the Jemena inlet yard from the BESS	- Release of high-pressure natural gas towards the BESS module - Potential for gas ingress into the BESS module, vented explosion and fire - Ignition of gas release and jetfire towards BESS module and incident propagation - BESS fire with release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees - Potential offsite impact from BESS fire	- There is a main structure (fire rated firewater pump building) that provides a natural shield along and beyond the entire length of the Jemena gas inlet pipework. This would block gas reaching the BESS facility. - Controls as for item 4.	The Jemena gas feed line is an existing hazard since the power plant was commissioned. Hazard and risk for this system found to be acceptable as per previous PHA studies. A fire event involving BESS not considered credible.	No
6.	Fire (external)	Gas turbine	BESS fire	Existing power station infrastructure – Gas turbine enclosure - Gas leak (e.g. flange, instrument fitting failure, mechanical failure) within enclosure	- Confined explosion inside the turbine enclosure - Overpressure and shrapnel damage to BESS and incident propagation - BESS fire with release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees	- The gas turbine enclosures are located on the southern end of the site and away from the nearest proposed BESS (~80 metres) - There are steel structures and support infrastructure between the gas turbines and BESS unit. No clear line of sight for shrapnel - Turbine enclosure have gas detection and automatic feed gas isolation - Turbine is provided with automatic fire suppression system - Personnel would initiate site ESD. - Activation of BESS emergency shutdown - Emergency Response Plan - External firefighting protocol (FRNSW)	The gas turbines are an existing hazard. Hazard and risk for this system found to be acceptable as per previous PHA and HAZOP studies. A fire event involving BESS not considered credible.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
7.	Fire	HV transformer	Transformer fire	- Faulty equipment - Transformer oil leak - Arc flash - Vandalism - External fire (e.g. fire escalation from adjacent BESS)	- Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees As the BESS and HV transformer will be situated in a secured area, the effects are not expected to have an off-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 - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - All relevant TransGrid requirements will be met - 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 manufacturer and/or applicable standards (refer to consequence assessment) - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - Electrical switch-in & switch-out protocol - BESS fire and explosion protection system (battery system specific features, refer to Section 8) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External firefighting protocol (FRNSW)	See commentary in Item 3. The PHA will be used to provide recommendations for finalising separation distances in the BESS facility layout and performing a Final Hazard Analysis on the chosen lithium-ion battery.	No
8.	Chemical	Battery modules BMS Thermal management system	Release of electrolyte (liquid/vented gas) from the battery cell	Mechanical failure/damage - Dropped impact (e.g. during installation/ maintenance) - Damage (e.g. crush/ penetration/puncture) Abnormal heating/elevated temperature - Thermal runaway - External fire (e.g. fire from adjacent infrastructure, gas yard)	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Battery cells and modules are enclosed with external casing - Spill clean-up using dry absorbent material - 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 manufacturer and/or applicable standards - Venting and containment requirements of the BESS manufacturer and FRNSW to be followed - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External firefighting protocol (FRNSW) - Use of appropriate PPE	Vented gases are early indicator of a thermal runaway reaction. This incident is covered in Item 3 and consequence analysis to check if there is an offsite impact potential in a fire event (thermal runaway). Covers BESS modules that are located in proximity to the northern boundary.	Yes (part of Item 3)

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
9.	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, resulting in injury and/or fatality to onsite employees The coolant is ethylene glycol aqueous solution. Ethylene glycol is not flammable but does pose a health risk when exposed to personnel in sufficient quantity.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Battery cells and modules are enclosed with external casing - Spill cleanup using dry absorbent material - 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 manufacturer and/or applicable standards (refer to Section 8) - fBESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Section 2, 8). - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW) - Use of appropriate PPE	This incident is covered in Item 3 and consequence analysis to check if there is an offsite impact potential in a fire event (thermal runaway). Covers BESS modules that are located in proximity to the northern boundary.	Yes
10.	Explosive Gas	Battery modules	Generation of explosive gas (e.g. hydrogen) Note: also refer to above item (release of vented gas)	- Thermal runaway - External fire (e.g. fire from adjacent infrastructure, power plant, gas yard, neighbouring sites)	- Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken 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 manufacturer and/or applicable standards - Ventilation requirements as per manufacturer's instruction - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Section 2, 8) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External firefighting protocol (FRNSW & RFS)	This incident is covered in Item 3 and consequence analysis to check if there is an offsite impact potential in a fire event (thermal runaway). Covers BESS modules that are located in proximity to the northern boundary.	Yes

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
11.	Reaction	Battery modules	Thermal runaway in battery	<u>Elevated temperature</u> - External fire (e.g. fire from adjacent infrastructure, power plant, gas yard, 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 - Escalation to the entire BESS - Injury and/or fatality to onsite employees	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken 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 manufacturer and/or applicable standards (refer to Section 8) for assessment) - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system (battery system specific features, refer to Section 2, 8, Table 2.2) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External firefighting protocol (FRNSW)	Thermal runaway refers to a cycle in which excessive heat, initiated from inside/outside the battery cell, keeps generating more heat. Chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell and eventually lead to destruction of the battery. Vented gases are early indicator of a thermal runaway reaction. This incident is covered in Item 3 and consequence analysis to check if there is an offsite impact potential in a fire event (thermal runaway). Covers BESS modules that are located in proximity to the northern boundary.	Yes
12.	EMF	BESS (overall)	Exposure to electric and magnetic fields (See also HAZID 19 for impact to Jemena gas inlet yard)	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 public. Additionally, the strengths of electric and magnetic fields attenuate rapidly away from the source. As the BESS will be situated in an industrial area away from the public, the effects are not expected to have an off-site impact.	- Location siting and selection (i.e. separation distance to sensitive receptors) - Optimising equipment layout and orientation - 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 - Studies found that the EMF for commercial power generation facilities comply with ICNIRP occupational exposure limits. Refer to consequence analysis.	The EMF Review will check that the BESS units are sufficiently located away from the 11kV line that traverses the neighbouring site (north boundary). Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities, Ref [19]. No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA) , Ref [22].	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
13.	External factors	BESS (overall)	Water ingress	- Rain - Flood	- 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) - The BESS is IP 55 rated suitable for outdoor use - The HV transformer and switchyard will be constructed in accordance with relevant standards. - Drainage system - Preventative maintenance (check for leaks) - 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 manufacturer and/or applicable standards (refer to consequence assessment) - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Section 2, 8) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External firefighting protocol (FRNSW)	-	No
14.	External factors	BESS (overall)	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. For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a secured area.	- The BESS will be located within a secure area and will be fenced - There is 24/7 security provided by the security house operated by Visy - Warning signs (i.e. trespassers and on-site hazards) - Security cameras will be provided for the BESS area - Secure battery unit cabinets design	The site was once owned by Visy and part of the overall industrial complex. This arrangement remains in place whereby Visy continues to provide security as the sites share a common private access road.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
15.	External factors	BESS (overall)	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 - Activation of emergency shutdown - 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 manufacturer and/or applicable standards (refer to Sections 2 and 8) - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW)	-	No
16.	External factors	Battery modules	BESS overheating	Extreme temperature or humidity	- Potential for escalation to a thermal runaway event - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees - Asset damage	- Design BESS units for worse case ambient condition - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - 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 manufacturer and/or applicable standards (refer to consequence assessment) - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system (battery system specific features, refer to Section 2 and 8 - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External firefighting protocol (FRNSW)	This incident is covered in Item 3 and consequence analysis to check if there is an offsite impact potential in a fire event (thermal runaway). Covers BESS modules that are located in proximity to the northern boundary.	Yes

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments (SEF Site specific)	Potential off-site impact?
17.	External factors	Battery modules	BESS overheating	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 As the BESS will be situated in a secured area, the effects are not expected to have an off-site impact	- Ventilation system - Maintenance strategy - Thermal and airflow detectors - The BESS facility is in an industrial area with little or no surrounding vegetation - 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 manufacturer and/or applicable standards (refer to consequence assessment) - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system (battery system specific features, refer to Sections 2 and 8) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan External firefighting protocol (FRNSW & RFS)	The SEF site is situated within the Visy industrial complex.	No
18.	External factors	Jemena Inlet Yard Note: This is an existing hazard present at the SEF power station.	BESS fire (e.g. HAZID 1-4)	Thermal runway (described in HAZID 1-4)	Incident escalation to the Jemena infrastructure.	- There exists the fire pump house that shields the entire yard and is fire rated. - Jemena would isolate the line (upon contact by Smithfield BESS)	Radiation causing escalation from the BESS units will not reach the Jemena gas inlet yard (see Section 6) for consequence analysis.	No
19.	External	Jemena Inlet Yard Note: This is an existing hazard present at the SEF power station.	BESS EMF	Accelerated corrosion of metal gas pipeline. Induced currents.	Potential for line corrosion and leak.	- Gas pipeline route does not follow the northern site boundary. - Proposed BESS units are located well away (and there is a natural obstacle in the form of the existing fire pump house) from the Jemena inlet yard	Pipeline is not affected by EMF.	No

APPENDIX B. CONSEQUENCE ANALYSIS

B1. Overview

The hazard identification (HAZID) identified the following BESS specific incidents that may have the potential for offsite impact:

- Fire involving the lithium-ion battery engulfing the module.
- Toxic gas generation from the decomposition of the electrolyte due to the fire.

The HAZID also identified the potential for incident propagation from:

- Unignited and ignited release from the gas letdown yard towards the BESS facility with subsequent fire and toxic gas release.
- BESS module on fire escalating to adjacent BESS module.

This appendix summarises the consequence analysis in terms of modelling approach, assumptions, and assessment results.

B2. BESS Fire

A BESS fire could occur due to thermal runaway or external incidents (escalated events).

B2.1. Modelling Approach

To estimate the fire consequences during BESS unit fire event, the heat flux emitted was calculated using the Stefan - Boltzman Law:

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

Where E is the radiant emittance, e is the emissivity of the container, 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 receiver distance to battery unit wall:

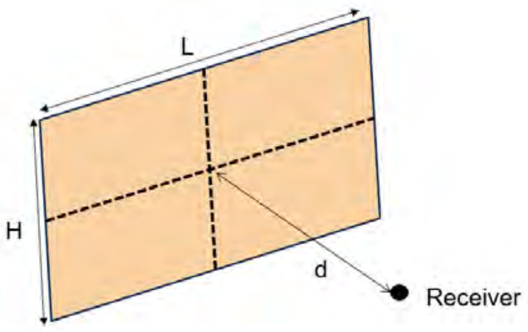
$$\emptyset = \frac{1}{2\pi}\left[\frac{a}{(1+a^2)^{1/2}} tan^{-1}\frac{b}{(1+a^2)^{1/2}} + \frac{b}{(1+b^2)^{1/2}} tan^{-1}\frac{a}{(1+b^2)^{1/2}}\right]$$

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

$$E_{recieved} = 4\,\emptyset\,E_{emitted}$$

Figure B1 illustrates the graphical depiction of the parameters utilised. In this approach, the battery unit side wall is divided into four equal sections to calculate the heat received at a height of 1.5 m, which corresponds to half the height of the BESS units.

Figure B1: The graphical depiction of the parameters (L, H, d)



B2.2. Assumptions

The main modelling assumptions for a BESS fire were:

- The flame temperature of the emitting surface was set at 1000°C which is value typical for lithium metallic fires, Ref [27].
- An emissivity value of 0.9 (it is equal to 1 for black body).
- Receiver height was set at 1.5 m.
- Radiation calculation was performed for the BESS side walls and assumed a full planar fire. This is conservative as this results in the highest heat radiation and appropriate for this PHA in terms of understanding off-site impacts. The impact distances for the end walls were also calculated.
- For escalated events, it is assumed that two adjacent BESS units may catch fire at the same time and representative width is estimated by doubling the longest BESS unit width.

B2.3. Criteria

Thermal radiation results were compared against the criteria in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*. For this PHA, distances to 4.7 (injury), 12.6 (fatality), and 23 kW/m^2 (potential escalation) have been calculated as shown below.

Table B1: Thermal radiation criteria as per HIPAP No.4

Heat Radiation (kW/m²)	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 1 5-20 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

B2.4. Results

As the Proponent is evaluating a range of BESS OEMs, analysis was conducted based on batteries of different sizes. The results for one unit for side-on and end-on views and two units fire are presented in Table B2 and Table B3, respectively.

Table B2: BESS Fire – Radiation Impact Distances (one BESS unit)

			Distance (m) at Receiver Height (1.5m) to Radiation Levels					
Example BESS OEM	Fire Size (LxHxW, m)	Surface Temperature (°C)	4.7 kW/m² (injury)		12.6 kW/m² (fatality)		23 kW/m² (structural failure)	
			Side	End	Side	End	Side	End
Wartsilla	3x3x3	1000	9	9	5	5	4	4
CanadianSolar/ CATL	6x3x3	1000	13	9	7	5	5	4
Sungrow/ Tesla	9x3x1.5	1000	15	6	9	4	6	3
Powin	12x3x3	1000	17	9	10	5	7	4

Table B3: BESS Fire – Radiation Impact Distances (escalated incident)

			Distance (m) at Receiver Height (1.5m) to Radiation Levels		
Example BESS OEM	**Equivalent Fire Size (LxH, m)**	**Surface Temperature (°C)**	**4.7 kW/m^2 (injury)**	**12.6 kW/m^2 (fatality)**	**23 kW/m^2 (structural failure)**
Wartsilla	6x3	1000	13	7	5
CanadianSolar/ CATL	12x3	1000	17	10	7
Sungrow/ Tesla	18x3	1000	21	12	8
Powin	24x3	1000	24	13	8

B2.5. Sensitivity Analysis

As a sensitivity, the fire modelling was repeated for a lower flame temperature equivalent to a cellulosic fire (600 ~ 800°C). Results are shown in Table B4.

Table B4: BESS Fire – Radiation Impact Distances

			Distance (m) at Receiver Height (1.5m) to Radiation Levels		
Example BESS OEM	**Fire Size (LxH, m)**	**Surface Temperature (°C)**	**4.7 kW/m^2 (injury)**	**12.6 kW/m^2 (fatality)**	**23 kW/m^2 (structural failure)**
Wartsilla	3x3	600	4	2	1
Wartsilla	3x3	800	6	4	2
Wartsilla	3x3	1000	9	5	4
Powin	12x3	600	7	3	1
Powin	12x3	800	12	6	4
Powin	12x3	1000	17	10	7

B3. Toxic gas dispersion

In the event of BESS fire, there is the potential for the LFP electrolyte to decompose and form hydrogen fluoride. As the Proponent is evaluating a range of BESS OEMs, it was assumed the lithium-ion battery contained this LFP electrolyte. Dispersion analysis was undertaken for a range of different battery sizes.

B3.1. Modelling Approach

Consequence modelling was performed using the Gexcon EFFECTS v12.1.0 software. Specifically, the "Plume Rise from Fire" model was selected to best represent the dispersion of the ‘lighter than air release’ toxic gas from a fire incident.

B3.2. Assumptions

The main modelling assumptions for a toxic gas plume dispersion were:

- Hydrogen fluoride is considered the most toxic decomposition products from the batteries fire (Ref [15]) .
- A lithium-ion battery cell experiment (Ref [15]) indicates that the quantity of HF released from a 1 Wh battery varies between 20 mg and 200 mg, depending on the battery type and state of charge. To ensure a conservative approach, a value of 200 kg per 1 MWh was adopted for the calculations.
- The HF release takes place steadily over a one-hour period and the release entered into Gexcon was a continuous release.
- The plume was taken to be released at the top of the battery unit. This seemed reasonable from, recent fire incidents (i.e. the VBB 2021) based on the thermal effect of the fire.
- The height of interest (receptor) was set at 1.5 m (breathing height).
- For the purposes of this analysis, wind weather conditions representing F1, B3, D2, D5 were selected for the SEF area.

B3.3. Criteria

The concentrations used to represent toxic fatality, injury, irritation thresholds for Hydrogen Fluoride exposures were established by referring to human exposure data available in the Acute Emergency Guideline Levels (AEGLs) documentation published by the US EPA.

The following approach was taken in the PHA:

- Life-threatening health effects: Occurs due to exposure to the AEGL-3 concentration.
- Serious injury: Occurs due to exposure to the AEGL-2 concentration.
- Irritation: Occurs due to exposure to the AEGL-1 concentration.

The 60-minute AEGL values for HF are shown overleaf.

Table B5: AEGL values for HF (60-minute)

AGL level	Health effects	HF concentration (ppm)
AEGL-1	Irritation threshold	1
AEGL-2	Injury threshold	24
AEGL-1	Life-threatening health effects threshold	44

Note: The AEGLs for Hydrogen Fluoride are almost identical to the corresponding Emergency Response Planning Guideline (ERPG) levels that account for exposure for up to 60 minutes. The difference is for ERPG 3 which is 2ppm.

B3.4. Results

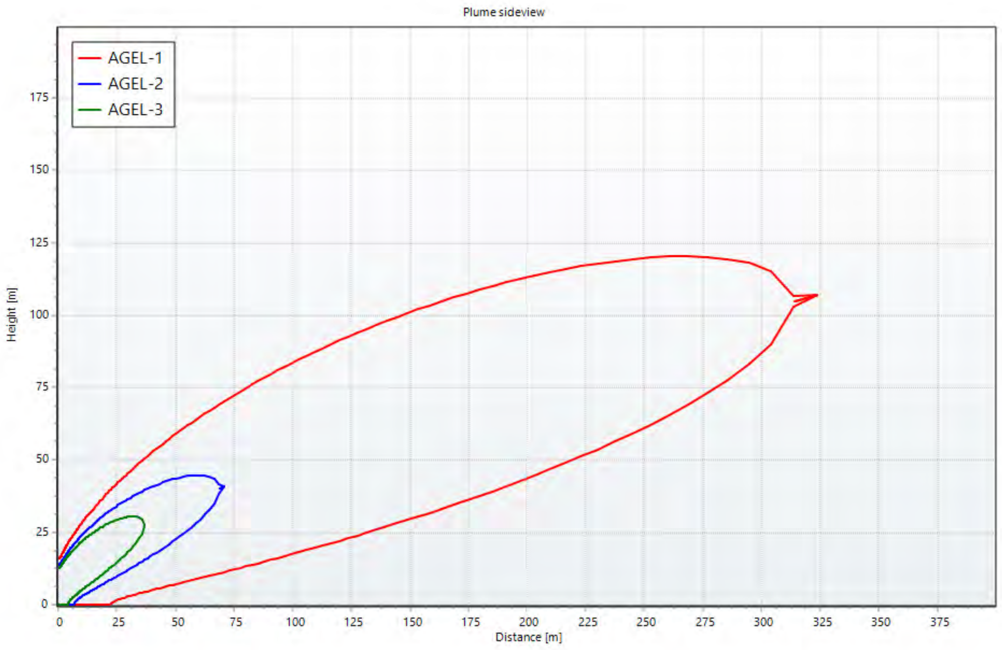
Toxic release was modelled for the smallest and largest battery unit examples. The mass flow rate of HF was calculated based on the capacity of the battery examples (refer to assumptions). Results are presented in Table B6.

As an example, the HF plume side view for the largerst battery example and B3 weather condition is shown in Figure B2 to illustrate how the plume rises.

Table B6: BESS Fire – Toxic Impact Distances

						Distance (m) at Receiver Height (1.5m) to AEGL		
Example BESS OEM	**Size (LxWxH, m)**	**Battery Capacity (MWh)**	**Mass Flow Rate (kg/s)**	**Heat Release (kW/m^2)**	**Wind Weather Stability**	**AEGL-1 (irritation)**	**AEGL-2 (injury)**	**AEGL-3 (fatality)**
Wartsilla	3x3x3	1.5	0.1	882	B3	25	8	5
					D2	5	3	2
					D5	45	14	9
					F1	1	Not reached	Not reached
Powin	12x3x3	3.2	0.2	882	B3	21	11	8
					D2	8	5	4
					D5	39	20	14
					F1	2	2	1

Figure B2: HF plume sideview (Powin- B3)



B4. Gas yard- flammable gas dispersion (unignited)

Releases from the existing gas yard equipment (e.g. flange, instrument fittings, piping leak) could lead to flammable cloud formation and flash fire. Modelling was conducted to identify the flammable gas cloud and potential impacts on BESS.

B4.1. Modelling Approach

Consequence modelling was carried out using the Gexcon EFFECTS v12.1.0 software for pressurised releases.

B4.2. Assumptions

The main assumptions for the gas dispersion modelling was:

- Methane was selected to represent natural gas
- Gas yard pressure is 38 barg.
- Ambient temperature is 25 C.
- Roughness length is 0.5 m appropriate for this site layout.
- Release direction was taken to be horizontal.
- For the purposes of this analysis, wind weather conditions representing B3, D2, D5 was selected for the SEF area.

B4.3. Criteria

LFL represents the minimum concentration of a flammable gas in the air that is required for it to ignite when exposed to a spark or open flame. The LFL for methane is 5%.

For the flammable gas dispersion, 100% LFL contour was generated.

B4.4. Results

Results for different leak sized and weather conditions are presented in Table B7. Refer to section 4. commentary on releases from the SEF gas yard.

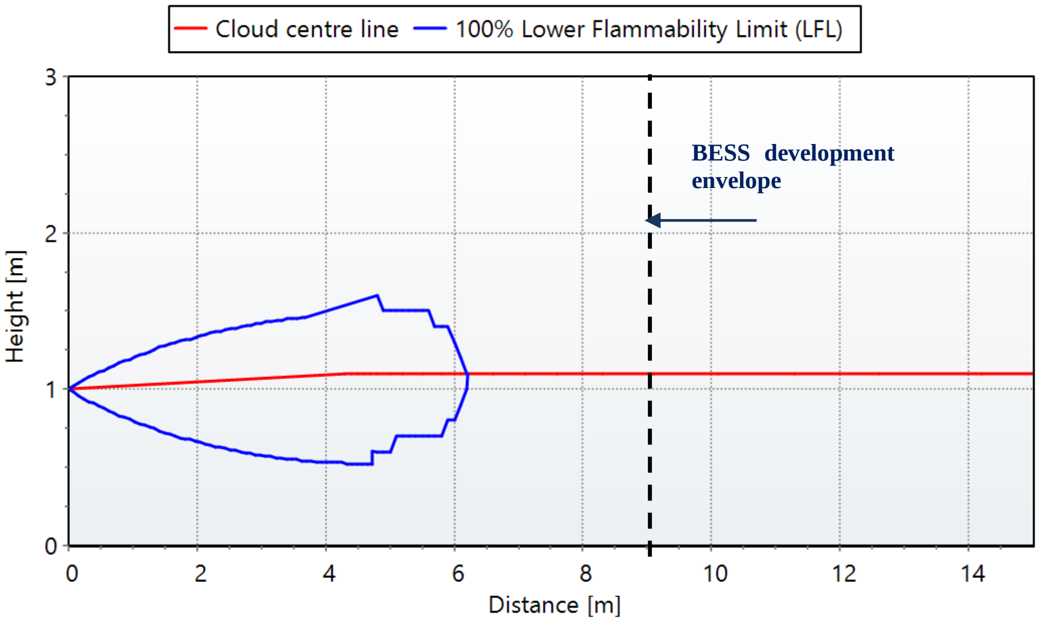
Table B7: BESS Fire –Flammable Gas Distances

Material	Leak Size (mm)	Release Pressure (bar)/ Temperature (degC)	Wind Weather Stability	Distance (m) to 100% LFL at Receiver Height
Natural gas (Methane)	10	38 barg 25 degC	B3	Not reached
			D2	Not reached
			D5	Not reached
			F1	Not reached
Natural gas (Methane)	20	38 barg 25 degC	B3	6
			D2	6

Material	Leak Size (mm)	Release Pressure (bar)/ Temperature (degC)	Wind Weather Stability	Distance (m) to 100% LFL at Receiver Height
			D5	6
			F1	6
Natural gas (Methane)	50	38 barg 25 degC	B3	33
			D2	29
			D5	32
			F1	25

As an example, the 100% LFL contour is shown in Figure B3.

Figure B3: LFL contour sideview (20 mm leak size- F1)



B5. SEF Gas Yard- flammable gas release and jet fire (ignited)

Releases from the existing gas yard equipment (e.g. flange, instrument fittings, piping leak) could lead to a jet fire directed towards the BESS designated area. To identify the impact of fire at gas yard, the jet fire modelling was conducted.

B5.1. Modelling Approach

Consequence jet fire modelling was carried out using the Gexcon EFFECTS v12.1.0 software.

B5.2. Criteria

Thermal radiation results were compared against the criteria in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*. For this PHA, distances to 4.7 (injury), 12.6 (fatality), and 23 kW/m^2 (potential escalation) have been calculated as shown below.

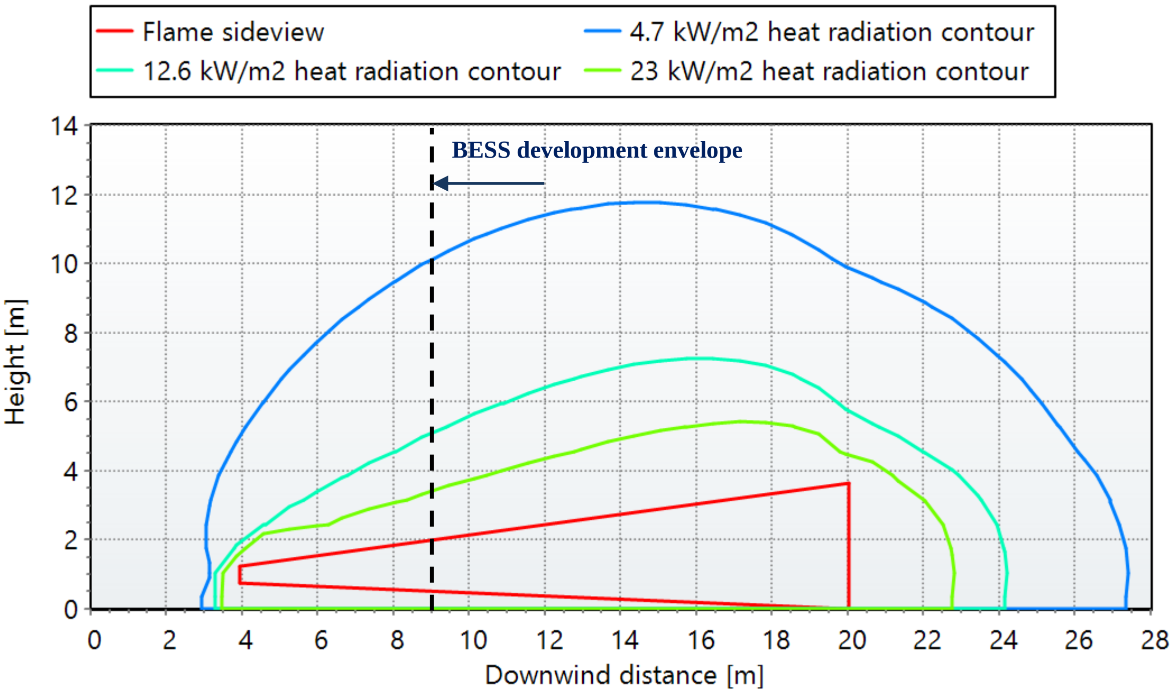
B5.3. Results

Results for different leak sizes and weather conditions are presented in Table B8. Refer to Section 4 of the main report for commentary on the results. The heat radiation sideview for 20 mm leak are shown in Figure B4 as an example.

Table B8: BESS Fire – Radiation Impact Distances

				Distance (m) at Receiver Height (1 m) to Radiation Levels		
Material	**Leak Size (mm)**	**Release Pressure (bar)/ Temperature (degC)**	**Wind Weather Stability**	**4.7 kW/m^2 (injury)**	**12.6 kW/m^2 (fatality)**	**23 kW/m^2 (structural failure)**
Natural gas (Methane)	10	38 barg 25 degC	B3	14	12	11
			D2	14	13	12
			D5	13	11	11
			F1	15	14	13
Natural gas (Methane)	20	38 barg 25 degC	B3	26	23	21
			D2	27	24	23
			D5	25	21	20
			F1	29	26	25
Natural gas (Methane)	50	38 barg 25 degC	B3	60	52	49
			D2	63	56	52
			D5	57	49	46
			F1	67	60	56

Figure B4: Heat radiation sideview (20 mm leak- D2)



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