FIRE SAFETY STUDY

SMITHFIELD BATTERY ENERGY STORAGE SYSTEM

SSD-59325460

SMITHFIELD BESS

PREPARED FOR:	**Smithfield BESS Pty Ltd**
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Title: **Fire Safety Study** **Smithfield Battery Energy Storage System** **SSD-59325460**	**QA verified:** S. Chan
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ABBREVIATIONS & GLOSSARY

AC	Alternating Current
AEGLs	Acute Exposure Guideline Levels
BESS	Battery Energy Storage System
BMS	Battery Management System
CCTV	Closed Circuit TV
DC	Direct Current
DG	Dangerous Good(s)
DPHI	Department of Planning, Housing and Infrastructure
EIS	Environmental Impact Statement
ERP	Emergency Response Plan
FRNSW	Fire and Rescue NSW
FSS	Fire Safety Study
HAZID	Hazard Identification
HF	Hydrogen Fluoride
HIPAP	Hazardous Industry Planning Advisory Paper
IDLH	Immediate Danger to Life and Health
kV	Kilovolt
LFL	Lower Flammability Level
LFP	Lithium Iron Phosphate
LGA	Local Government Area
MW	Megawatt
MWh	Megawatts Per Hour
NEM	National Electricity Market
NMC	Nickel Manganese Cobalt
NSW	New South Wales
OEM	Original Equipment Manufacturer
OH&S	Occupational Health & Safety
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
SEF	Smithfield Energy Facility
SEPP	State Environmental Planning Policy
SRMP	Smithfield Recycling & Manufacturing Precinct

SSD	State Significant Development
TMS	Thermal Management System
UL	Underwriters' Laboratories
VBB	Victorian Big Battery

Glossary

Existing SEF	This refers to the power station and infrastructure
BESS development	This refers to the proposed BESS facility (as per SSD 59325460)
Smithfield facility	The existing SEF and proposed BESS

1. SUMMARY

1.1. Background

Smithfield BESS Pty Ltd (Smithfield BESS), a wholly owned company of Iberdrola Australia Limited (Iberdrola), has received development consent (SSD 59325460), subject to conditions, for the operation of a Battery Energy Storage System (BESS). The BESS will be co-located at the existing Smithfield Energy Facility (SEF) at 6 Herbert Place, Smithfield, NSW. The BESS will utilize the Tesla Megapack 2XL (Tesla Megapack MP2 unit) lithium-ion batteries with a capacity up to 72 Megawatt (MW) delivering 230 Megawatts per hour (MWh).

As per conditions of consent, a Fire Safety Study (FSS) has been undertaken with reference to the NSW Department of Planning Housing Infrastructure (DPHI) Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 '*Fire Safety Study*' guideline, Ref [1]; and Fire Rescue NSW (FRNSW) Fire Safety Guideline *Technical Information – Large scale external lithium ion battery energy storage systems – Fire safety study,* Ref [2].

1.2. Consultation process

To inform the FSS, Smithfield BESS undertook a consultation meeting with the FRNSW (6 August 2024) to explain the BESS Development and to understand FSS study expectations. Consultation was also conducted with Tesla to discuss the Megapack battery fire testing and BESS layout with the SEF operations team to understand emergency response, and the engineering team to review site fire prevention and detection safeguards. Smithfield BESS has also extended an invitation to FRNSW to conduct a site visit as part of this consultation process.

1.3. FSS objectives

The objectives of this FSS were to:

- Identify the fire incidents associated with the proposed BESS development as well as the existing SEF (i.e. power station).
- Understand the consequences and impact from credible fire events for the proposed BESS development and existing SEF.
- Determine the credibility of escalated fire events between the BESS facility and existing SEF, including the potential for an incident at the power station to impact the BESS development.
- Describe the fire prevention, detection and protection measures for the proposed BESS development and overall SEF site.
- Outline the fire safety strategy for the BESS Development done in consultation with Smithfield BESS engineering, SEF operations and Tesla.
- Identify actions to further improve the overall fire detection and protection at the Smithfield facility.

1.4. Scope

The FSS covered the operations phase of the:

- Proposed BESS facility, and
- Existing SEF.

The FSS was undertaken with references to Tesla Megapack fire testing and modelling, the BESS Preliminary Hazard Analysis (PHA) study and SEF safety documentation.

1.5. Fire hazard identification (HAZID)

A hazard identification (HAZID) review was undertaken to identify credible fire related incidents for the BESS development and the existing SEF site. The HAZID considered the potential for escalation of fires between the existing SEF and the BESS. The HAZID considered the hazardous materials, processes and historical incidents associated with the SEF and proposed BESS Development.

The HAZID was based on the PHA for the proposed BESS development, independent Hazard Audits completed for the SEF, third party fire compliance reviews for the SEF and original safety studies for the SEF development approval. Tesla was consulted to identify incidents involving their Megapack lithium-ion batteries in order to understand the nature and extent of credible BESS fire events.

The HAZID screened those incidents (Table 1.1) for consequence assessment review which in turn informed the fire safety strategy. Justification for not carrying forward hazards is provided in Section 5.

Table 1.1: Potential fire incidents carried forward for consequence review

HAZID tag	Description	Carry forward consequence review
Proposed BESS facility		
A	Fire involving a Tesla Megapack MP2 unit	Yes
B	Propagated fire to adjacent Tesla Megapack MP2 unit	Yes
C	Fire involving a BESS transformer	Yes
Existing SEF (power station)		
D	Fire from the Jemena gas inlet line	No
E	Fire from the gas yard (existing SEF)	Yes
F	Fire in the gas turbine unit	No
G	Fire in the administration/ control room/ maintenance building	No
H	Fire in the minor flammable storage (i.e. paint)	No
I	Fire in the fire pump room	No
J	Fire involving an SEF transformer	No

1.6. Consequence assessment review

The identified fire incidents were reviewed to understand their potential consequence from a radiation impact.

For BESS related fires, radiation impact analyses were based on Tesla supplied information (UL9540A[1] and destructive (i.e. burn down) unit test) for the Megapack battery product line. The review was supplemented by Tesla fire specialist modelling and modelling in the BESS Preliminary Hazard Analysis (PHA).

The review found that for the Tesla Megapack unit, UL9540A and unit level destructive fire test results indicated that fire propagation should not occur if the BESS units follow the separation spacing as per the installation manual. Third party fire specialist validation of fire radiation and runaway modelling supported the test results (Ref [3]) The review is in line with observations of actual BESS fires involving the Tesla Megapacks (i.e. Big Battery Fire in Victoria and Bouldercombe BESS fire) where incident propagation was limited to asset damage but no fire propagation involving adjacent battery units.

Fire modelling for the Megapack MP2 batteries indicated that fire incidents do not pose significant offsite fatality or serious injury impacts. Fire test results and modelling confirmed that there will be no propagation to the existing SEF.

For existing SEF fires, ignited releases (unmitigated) from the gas yard have the potential to propagate the BESS facility due to heat radiation (23 kWm^2). The FSS has provided recommendations to minimise the potential for propagation. All other identified SEF incidents did not impact the BESS facility.

1.7. Fire safety strategy

The proposed fire safety strategy for the Smithfield facility is based on the identified fire incidents at the BESS facility and the existing SEF, and an understanding of the escalation potential.

BESS development

For the BESS facility the fire safety strategy is **non-intervention** and covers:

- Fire (and propagated event) involving a Tesla Megapack MP2 unit
- Fire involving a BESS transformer.

The strategy was developed in consultation with Tesla and the SEF operations personnel based upon the MP2XL fire safety design features and Tesla fire testing, to inform unit separation distances to minimize the potential fire propagation.

The proposed design and operational fire prevention, detection and protection safeguards for the BESS facility will minimize the potential for a BESS unit fire and limit the propagation potential.

[1] Unit level test

Existing SEF to BESS – propagation

The FSS identified that a fire in the gas yard (existing SEF) could impact the proposed BESS facility from heat radiation and flame impingement (for larger releases).

The strategy for this event is to minimize the potential for gas leakage towards the BESS facility. Design safety measures including flange guarding and automated fire detection to ensure propagation does not occur.

Existing SEF facility

For the existing SEF, the current fire safety strategy remains **unchanged**.

The adequacy of the existing SEF fire system design has been deemed satisfactory and compliant from the independent Hazard Audit and NSW government approvals. This FSS has found that there is no required change to the existing SEF fire safety strategy. as a result of the proposed BESS facility.

1.8. Recommendations

To support the non-intervention strategy for the BESS facility, the following recommendations were developed with the SEF operations team to improve fire prevention, detection and emergency response controls.

BESS facility

Recommendation 1: Confirm that thermal fire detection provided to cover the BESS facility and transformers will be interfaced to the (existing) Fire Indicator Panel and tested regularly. This will assist in providing early warning for intervention, reducing the potential for battery fire escalation. This will satisfy FRNSW consultation feedback for provision of automated fire prevention and detection.

Recommendation 2: The Smithfield Emergency Response Plan (ERP) be updated to cover Tesla MP2XL battery fire. The Emergency Response Plan should cover the required operational responses to make the power station, including incoming gas lines, safe and outline communication protocols between Smithfield BESS, Tesla and FRNSW.

Recommendation 3: The Smithfield Emergency Response Plan be updated to cover incident notification to Kingspan and possible shelter-in-place or evacuation of the site to avoid smoke and potential nuisance effects from a BESS fire.

Recommendation 4: The Smithfield Emergency Response Plan be updated to cover BESS transformer fire. The Emergency Response Plan should indicate the key decision points to isolate a BESS battery string, associated transformers and/or the BESS facility.

Existing SEF – Gas yard

Recommendation 5: As per PHA study, confirm implementation of proposed measures (e.g. guarding, flame mesh) to prevent flame impingement from the gas yard to the nearest BESS.

Recommendation 6: Confirm that thermal fire detection will be extended to cover the gas yard and interfaced to the (existing) Fire Indicator Panel. This will assist in reducing the fire propagation risk from the existing SEF to the BESS facility. It will also satisfy FRNSW consultation feedback for provision of automated fire detection.

Recommendation 7: Update the Smithfield Emergency Response Plan to cover the response for a leak and fire event at the gas area. The Emergency Response Plan should indicate gas isolation points and decision points for shutdown of the powerplant operations as well as the BESS facility.

2. INTRODUCTION

2.1. Background

Smithfield BESS Pty Ltd (Smithfield BESS), a wholly owned company of Iberdrola Australia Limited (Iberdrola), has received development consent (SSD 59325460), subject to conditions, for the operation of a Battery Energy Storage System (BESS). The BESS will be co-located at the existing Smithfield Energy Facility (SEF) (Lot 33, DP850596), located at 6 Herbert Place, Smithfield, NSW. The Tesla Megapack 2XL lithium-ion batteries will have a delivery capacity up to 72 Megawatt (MW) and provide up to 230 MWh of discharge energy at the connection point.

The conditions of consent (Condition B21) requires that a Fire Safety Study (FSS) be undertaken of the BESS. Smithfield BESS has retained Sherpa Consulting Pty Ltd (Sherpa) to conduct a FSS for the BESS development.

2.2. Study objectives

The FSS has been prepared to be consistent with the Department's Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 '*Fire Safety Study*' guideline; and Fire and Rescue NSW (FRNSW) Fire Safety Guideline *Technical Information – Large scale external lithium ion battery energy storage systems – Fire safety study*.

The objectives of this FSS were to:

- Identify the fire incidents associated with the proposed BESS development as well as the existing SEF (i.e. power station).
- Understand the consequences and impact from credible fire events for the proposed BESS development and existing SEF.
- Determine the credibility of escalated fire events between the BESS facility and existing SEF, including the potential for an incident at the power station to impact the BESS development.
- Describe the fire prevention, detection and protection measures for the proposed BESS development and overall SEF site.
- Outline the fire safety strategy for the BESS Development done in consultation with Smithfield BESS engineering, SEF operations and Tesla.
- Identify actions to further improve the overall fire detection and protection at the Smithfield facility.

2.3. Scope

The FSS covered the operations phase of the:

- Proposed BESS facility, and
- Existing SEF gas turbine power plant.

The Smithfield site has been described in detail in the Environmental Impact Statement (EIS). Information relevant to the FSS has been included in the EIS and supplemented by data provided from the operations and engineering team.

2.4. FRNSW consultation and report structure

Smithfield BESS together with Sherpa undertook a consultation meeting with FRNSW (6 August 2024) to explain the BESS Development and to understand their expectations for the FSS study.

A summary of FRNSW expectations from the meeting is provided in Table 2.1 together with reference to the FSS study report sections.

Table 2.1: FRNSW FSS expectations – consultation meeting (6 Aug 2024)

No.	**FRNSW expectation for proposed BESS development** (references in brackets are to relevant FRNSW Fire Safety Guideline D22/107002 sections)	**FSS comment**	**FSS study section**
1	Assessment of fully developed fire of the LiBESS system and propagation (5.1.3).	Assessment supported by unit level and large scale fire tests of the Tesla Megapack to support modelling from the PHA study.	6.2.1 6.2.2
2	For non-intervention approach, sufficient evidence, including large scale testing results be provided to support the proposed fire safety strategy (5.6.4).	Assessment supported by Tesla Megapack fire tests.	6.2.1
3	Identify potential incidents from the existing facility (SEF) that could impact the BESS. Existing fire protection systems should be described as they may be employed for fire incidents at the SEF (5.4.1, 5.5.6).	Assessment supported by the PHA findings as well as technical safety reviews (e.g. independent Hazard Audits) and third party fire protection reviews.	5

2.5. Study exclusions and assumptions

Exclusions and assumptions applying to this FSS are detailed in Table 2.2.

Table 2.2: FSS exclusions and assumptions

No.	Description	Sherpa comment
1	FSS covers fires that could occur when the BESS battery units are energised.	The FSS covers the phase when the installed BESS units are energised and with existing SEF power plant activities. Construction safety issues (e.g. construction safety review) are addressed separately within the Smithfield BESS HSE management system.
2	Tesla Megapack unit level and large scale fire testing.	Under confidentiality, Sherpa was provided access to Tesla fire testing results and associated fire engineering specialist reviews. As such these documents cannot be attached to the FSS. Smithfield BESS can discuss and share the results with FRNSW. As part of the FSS consultation process, Smithfield BESS has also extended an invitation to FRNSW to visit the site.
3	Existing SEF fire strategy.	Sherpa has relied upon existing SEF safety study reviews, Hazard Audit reports, site insurance reviews and NSW Government approvals to inform the adequacy of the current site fire strategy. SEF operations and Smithfield BESS engineering personnel were consulted to understand the SEF strategy and to identify potential improvements for fire detection and protection covering existing facilities and proposed BESS facility.

3. FACILITY DESCRIPTION

3.1. Overview

This section provides a brief overview of the existing SEF power plant activities as well as the intended BESS operations. This site information was used to inform the fire hazard identification, consequence assessment and layout considerations in terms of the fire strategy.

3.2. Location and site layout

The Smithfield facility is located at 6 Herbert Place, Smithfield NSW 2164 (Lot 33, DP850596). The BESS units will be installed in the north of the site, where the SEF cooling towers are currently located. The cooling towers will be removed as part a separate project. The site layout is provided in Figure 3.1.

3.3. Surrounding land uses

The Smithfield facility is part of the Smithfield Recycling and Manufacturing Precinct (SRMP) located within an industrial zoned area. The SEF is bordered 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. The nearest residential area is located approximately 400 metres south of the SEF.

The neighbouring sites and receptors in the vicinity of the SEF are shown in Figure 3.2 and Figure 3.3 as reproduced from the EIS.

3.4. Description of existing SEF

The SEF comprises three open cycle gas turbines, which generate and supply electricity to the NSW electricity grid. The SEF uses natural gas taken from an offtake of a Jemena gas distribution pipeline to fuel the turbines.

SEF operations team has advised that much of the original plant including a steam turbine and associated balance of plant equipment has been shut down. Some redundant equipment will be removed to provide space for the BESS.

3.5. Description of BESS Development

Iberdrola has received SSD approval, subject to conditions, for a proposed BESS facility at the SEF site. A BESS is a type of energy storage system that utilizes batteries to store and discharge energy in the form of electricity. Smithfield BESS has been granted approval to store up to 72 Megawatt (MW) and deliver up to 230 MWh of discharge energy at the connection point. The ancillary infrastructure and grid connection are already available at the existing power station site. The key additions to the SEF site are the BESS units and BESS transformers.

3.5.1. Battery units

The Tesla Megapack 2XL (MP2XL) model that has been selected makes use of Lithium Iron Phosphate (LFP) battery chemistry. The BESS will utilize the Tesla Megapack 2XL (Tesla Megapack MP2 unit) lithium-ion batteries with a capacity up to 72 Megawatt (MW) delivering 230 MWh.

The battery cells are installed within an IP66 cabinet, designed for outdoor installation. Each battery module is integrated with its own inverter, which eliminates the need for external power conversion systems or inverter modules.

3.5.2. Transformers

A transformer is employed to connect the Megapacks at low voltage to the grid at medium voltage. At the Smithfield BESS site, four Megapacks will be connected to a transformer. As such, a total number of 9 transformers is required.

3.5.3. MV reticulation and grid connection

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

3.5.4. BESS layout

The BESS layout was revised during preliminary design based upon the PHA study to set back (minimum 6 metres) the BESS units from the northern boundary and minimize fire impact to the nearest industrial neighbour. As part of detailed design, Smithfield BESS has consulted with Tesla to finalize the BESS layout as shown in Figure 3.3.

The BESS units and associated infrastructure has been based upon the Tesla Megapack installation manual and the separation distances are shown in Table 3.1.

Table 3.1: BESS equipment separation requirements

Installation	Minimum clearances
Front	2440 mm (96 in)
Back-to-back	- 460 mm (18 in) recommended for access purposes - 230 mm (9 in) with prior Tesla approval
Side	150 mm (6 in)
• Megapack is not intended to be installed within 3050 mm (120 in) from accessible means of egress and exposures (such as buildings, public ways, and hazards not associated with electrical grid infrastructure as defined by the clearance requirements in the International Fire Code and NFPA 855). • Any installation that requires clearances of less than 3050 mm (120 in) to accessible means of egress or exposures may require a freestanding fire barrier per requirements in the International Fire Code and NFPA 855.	

3.6. Shared SEF infrastructure

To support BESS operations, existing SEF infrastructure will be used as follows:

- Switchgear building located in the northeast corner of the SEF
- Control room located at the southwestern end of the site. The BESS can be operated and monitored both from this location and remotely
- Workshop which is located adjacent to the operations building
- Parking facilities and internal access roads
- Security fencing (the site shares 24/7 security with Visy)
- Lightning protection.

3.7. Operating hours, security and access

3.7.1. Existing SEF

The SEF is manned during normal operating hours, which are 6.30 am to 4.00 pm Monday to Friday and covered using a stand-by roster at other times. All personnel gain access via the main gate (by swiping their security passes or by signing in as a visitor / contractor).

3.7.2. BESS

SEF personnel will be trained to operate the BESS. The BESS facility will be operated remotely and, whilst capable of operating 24 hours a day, seven days a week, its operations will be based on market demand and may not be continuous.

Existing maintenance personnel will support both the power station and the BESS facility.

3.7.3. Site security

There will be no change to site security arrangements with the BESS in operation. From a security viewpoint, the Smithfield site is enclosed by fencing, building walls and high concrete noise barriers. A Closed Circuit TV (CCTV) system is also installed. The plant has lighting throughout the night to aid observation and camera surveillance, and non-operating gates / doors are locked (e.g. the gate at the southern corner of the site).

3.7.4. Site access

There will be no change to site access arrangements with the BESS in operation. There is a site on-call phone that will be the primary contact with a 24hrs Operations and Control Centre as the back-up.

The major access / egress point to the site is via the main gate off Herbert Place. An alternate access / egress point is via the gate on the south side of the site.

Figure 3.1: Site location and local surrounds

Figure 3.2: Neighbouring sites and offsite receptors

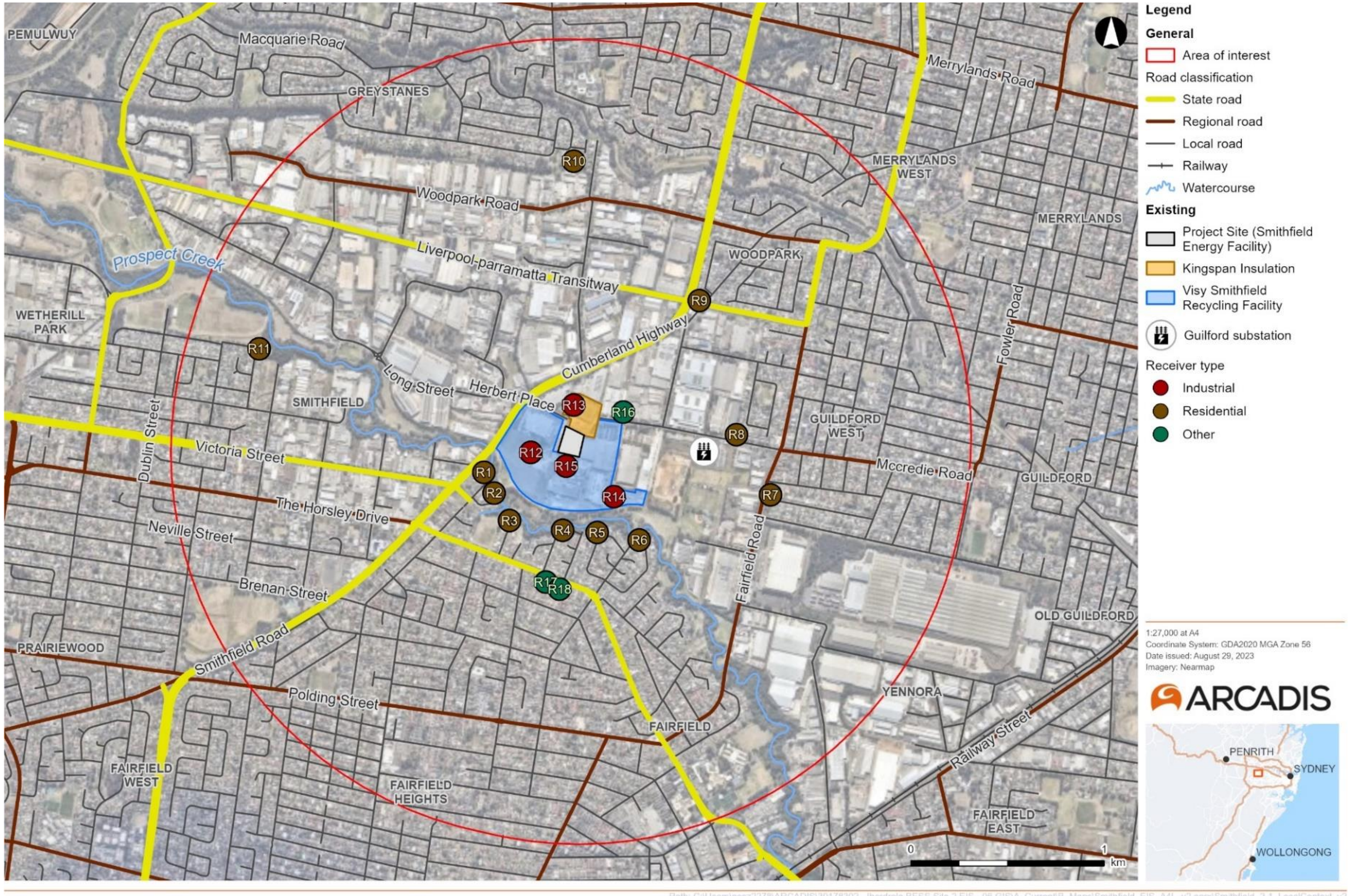
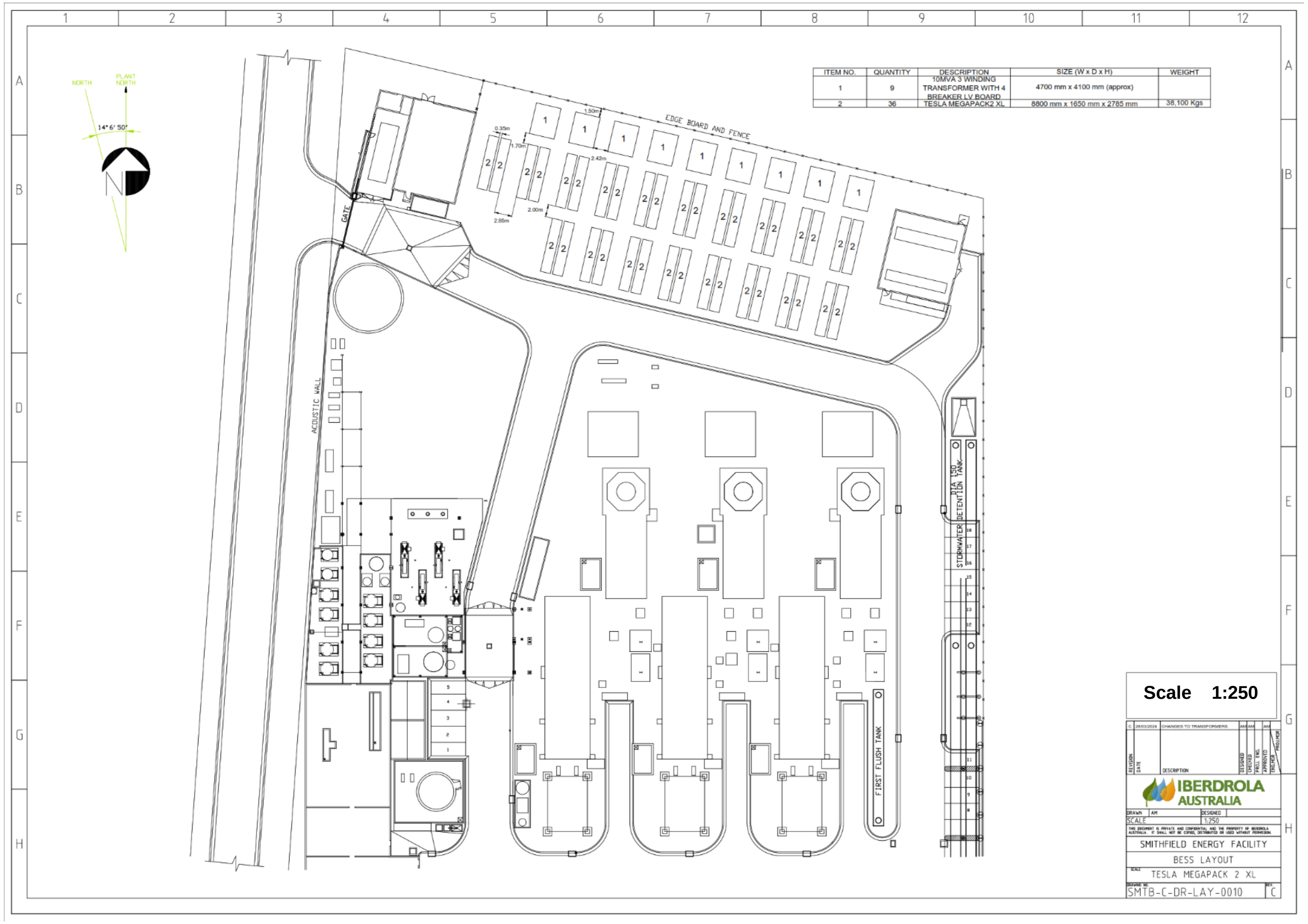


Figure 3.3: Smithfield BESS layout



4. METHODOLOGY

4.1. Overview

This section summarizes the approach adopted by Smithfield BESS in preparing the FSS. The study was prepared with reference to:

- NSW Department of Planning (DOP)[2] (DPHI) (2011): Hazardous Industry Planning Advisory Paper (HIPAP) No 2, *Fire Safety Study Guideline*s, Ref [1].
- Fire and Rescue NSW (FRNSW) (2023): Fire safety guideline technical information, *Large-scale external lithium-ion battery energy storage systems – Fire safety study consideration*, Ref [1].

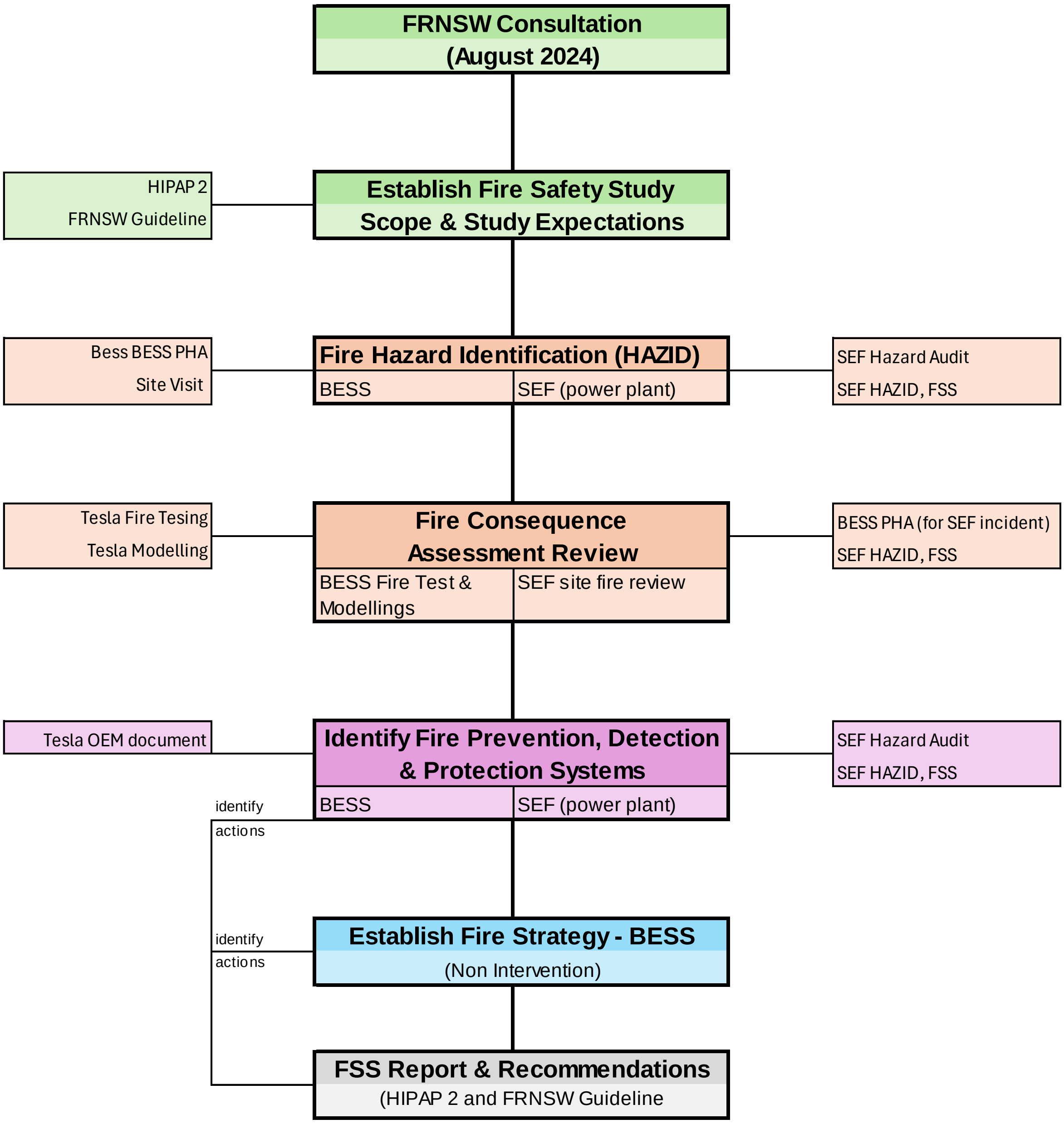
4.2. Study approach

The FSS approach was adapted from HIPAP 2 and is shown in Figure 4.1 as a flow diagram. To address FRNSW expectations and HIPAP 2 requirements, the following steps have been completed covering the existing SEF and proposed BESS facility:

- Establish FSS objectives and expectations with FRSNW
- Literature and Tesla fire test documentation review
- Review of existing SEF operations and safety studies
- Identification of potential fire incidents
- Consequence assessment review of fire incidents
- Review of fire prevention systems
- Review of fire detection and protection measures
- Establish fire safety strategy
- Review findings and identify recommendations to Smithfield BESS to strengthen fire systems and emergency response as needed.

[2] Now known as Department of Planning, Housing and Infrastructure (DPHI)

Figure 4.1: Fire Safety Study flow diagram



5. HAZARD IDENTIFICATION

5.1. Overview

A hazard identification (HAZID) review was undertaken to identify credible fire-related incidents for the BESS Development and the existing SEF. The HAZID included fire propagation between the existing SEF and the proposed BESS facility. The FSS HAZID table is shown in APPENDIX A.

The FSS HAZID considered the hazardous materials and processes associated with the SEF and proposed BESS development as well as reported incidents at other sites that utilise Tesla battery products.

The following information sources were referenced to inform potential fire incidents:

- Preliminary Hazard Analysis (PHA) for the proposed BESS development (Ref [4]).
- Hazard Identification (HAZID) (Ref [5]). Risk assessment study for the existing gas turbines following facility acquisition by Infigen (now part of Iberdrola).
- Fire Safety Study of the existing SEF (Ref [6]). This study was prepared for the gas fired power station covering potential fire hazards and protection systems. It was used to inform this FSS HAZID and identify SEF incidents that could affect the BESS development.
- Hazard Audit of the existing SEF (Ref [7]). As per the current conditions of consent, independent hazard audits are required to be conducted on process hazards. The most recent hazards audit was used to identify potential fire hazards involving the SEF and the effectiveness of the proposed controls.
- Tesla was consulted to identify incidents involving their Megapack lithium-ion batteries to understand the nature and extent of credible BESS fire events.

5.2. Stored hazardous materials

5.2.1. BESS development

The Tesla Megapack MP2XL units utilize lithium-ion battery technology, the batteries are classified as DG Class 9 (Miscellaneous). Potential fire incidents involving this type of battery chemistry type are discussed in Section 5.3.

The PHA (Ref [4]) identified other materials related to the BESS facility with the potential to lead to a fire. Materials include transformer oil, battery coolant (ethylene glycol aqueous solution), and refrigerant. Whilst these materials are not classified as dangerous goods (DGs) there have been numerous incidents associated with transformer oil fires which were carried forward to the HAZID. A summary of materials and their properties is given in APPENDIX B.

5.2.2. Existing SEF

A site visit was conducted with the SEF operations team to identify the location and quantity of hazardous materials, including flammable and combustible liquids, to determine any potential impact on the BESS development. The site visit also considered the process hazards which related to natural gas.

A review of the chemicals stored at the SEF shown in APPENDIX B indicated that they would not pose a fire hazard to the BESS facility. There is minor storage of flammable liquids (e.g. paints, degreasers) - this is in a locked area and well away from the BESS facility. There is a dedicated diesel storage tank (1,000 L) for the site firewater pumps.

5.3. Fire incident summary

5.3.1. BESS development

BESS fire

As indicated in the PHA study, there is a fire potential associated with lithium-ion battery operation. This FSS has identified the following incidents involving the Megapack 2 units that require further investigation:

- Fire (due to thermal runaway) involving the battery module.
- Toxic vapor generated in a battery fire. The combustion products may contain toxic substances (e.g. decomposition of lithium hexafluorophosphate within the battery electrolyte to hydrogen fluoride (HF)).
- Explosion. During a thermal runaway or fire event, flammable gases may accumulate in confined spaces (e.g. enclosed cabinets), potentially leading to an explosion[3].

The HAZID also identified the potential for incident propagation from:

- BESS module on fire escalating to adjacent BESS module.

BESS transformer oil fire

Transformer oil is primarily used for insulation and cooling purposes and is contained within the transformer. Although the oil is not flammable under normal conditions, it can become combustible if excessively heated. The HAZID identified electrical faults, overheating, or mechanical damage that could lead to leaks, and if the oil is ignited resulting in a fire. BESS transformer oil fires were carried forward for further review in this FSS.

[3] In discussion with FRNSW, it was agreed that it is difficult to model an early explosion, and it was acceptable to consider an explosion would lead to a fully developed fire. As shown in Section 6, the Tesla Megapack testing did not result in a unit explosion and Section 7 describes the design safety features for explosion prevention.

5.3.2. Existing SEF

Natural gas – Jemena Pipeline inlet yard

At the SEF, natural gas (DG Class 2.1) is used as the fuel supply for the gas turbines. Gas is supplied via the Jemena pipeline with the inlet point at the Gas Metering Station located northwest of the site.

The PHA (Ref [4]) found that a gas leak and ignited fire event was not a credible incident capable of reaching the BESS units. This was due to the fire-rated building located between the BESS area and the pipeline inlet yard, which provides a physical barrier.

As an existing hazard, an incident involving gas leak from the Jemena[4] inlet yard is covered under the site Emergency Response Plan (Ref [8]).

Natural gas – gas yard

Natural gas from the Jemena inlet yard is delivered to the turbines through the gas yard situated south of the BESS compound. The minimum distance from the nearest BESS unit to the gas yard is 10 metres.

The PHA (Ref [4]) found that small leaks at the gas yard and subsequent jet fires would not affect the BESS units. However, ignition of larger (20mm leak size and above) unmitigated leaks result in a jet fire that exposes BESS units to radiation levels (23 kW/m^2), would result in fire propagation[5] (e.g. thermal runaway) to battery units. This incident was taken forward for further assessment in the FSS.

Gas turbine fire

An explosion and/or fire in the gas turbine enclosure was identified in the existing SEF HAZID (Ref [5]). This study identified that impact would be localised. On this basis as the gas turbines are located more than 70 metres from the nearest BESS unit, incident propagation was not credible.

Transformer fires

Transformer fires at the existing SEF are covered under the site Emergency Response Plan. The SEF has 11kV and 33kV transformer units. However, they are located well away (80 metres) and not in direct line of sight from the BESS facility. A fire involving these units will not reach the BESS units.

[4] The independent Hazard Audit reported that a leak at the Jemena pipeline would be manually isolated, either locally or, via communication with Jemena, by closing an upstream pipeline valve. This method of operation was agreed with the FRNSW and NSW Department of Planning & Environment at plant implementation.

[5] NSW DPHI HIPAP 4 suggests a radiation level 23kW/m^2, unprotected steel will reach thermal stress temperatures which can cause failure. This level has been selected to inform potential incident escalation from radiation impact.

Building fires

At the SEF, there are several buildings including administration/ control, maintenance and the fire pump house building. The administration/ control and maintenance buildings are located 70 metres from the nearest BESS unit. Fires at the buildings would be localized and not cause fire propagation at the BESS development. Building fires are an existing hazard and covered under the site Emergency Response Plan (Ref [8]).

The fire pump house includes the diesel storage and is located immediately adjacent to the BESS facility on the west side. However, this building is fire rated and a fire within this enclosure would not impact the BESS units.

5.3.3. External factors

The overall SEF site is in an industrial area with no surrounding vegetation that could cause bushfires or scrub fires. As indicated in the PHA, bushfire is not considered a credible threat to the BESS development.

The SEF is bounded to the south, west and east by the Visy Smithfield Recycling Facility (Visy site), and to the north by Kingspan. The BESS Development faces the Kingspan site. The Kingspan site includes a large carparking area between the BESS facility and the nearest warehouse (75 metres) used for assembly, service and storage of retail and commercial water tanks. Fire impact from Kingspan operations affecting the BESS Development was not considered credible due to the offset of the BESS units from the site boundary (8 metres).

5.4. Incidents involving Tesla Megapack batteries

To further inform the potential BESS fire incidents at the Smithfield site, an incident literature review was conducted. The review sought to identify whether there have been incidents involving Tesla Megapack batteries. In Australia, there have been two incidents involving Tesla products:

- Victorian Big Battery (VBB) fire incident in 2021, involving Megapack1 (MP1) BESS units (Ref [9]).
- The Queensland (Bouldercombe) fire incident in 2023, involving Megapack2 (MP2) BESS units (Ref [10]). MP2 batteries are proposed for use at Smithfield.

Of relevance to this FSS:

- Despite the differences in battery lithium-ion chemistry (NMC for MP1 and LFP for MP2), both incidents resulted in a fire, involving most of the unit on fire. A fully developed fire in the BESS unit is a credible event.
- The fires did not propagate to involve adjacent battery units. In the VBB fire there was some impact on the adjacent BESS unit. Consideration of a propagated BESS fire event was considered credible for this study.

- In the Bouldercombe incident the Queensland fire brigade was present but did not intervene with the BESS fire, allowing the BESS unit to burn down.
- For both incidents, significant off-site impacts such as injury or fatality from exposure to heat radiation or toxic fumes was not reported. Consideration of fire impacts is discussed in Section 6 based upon Tesla fire testing and modelling.

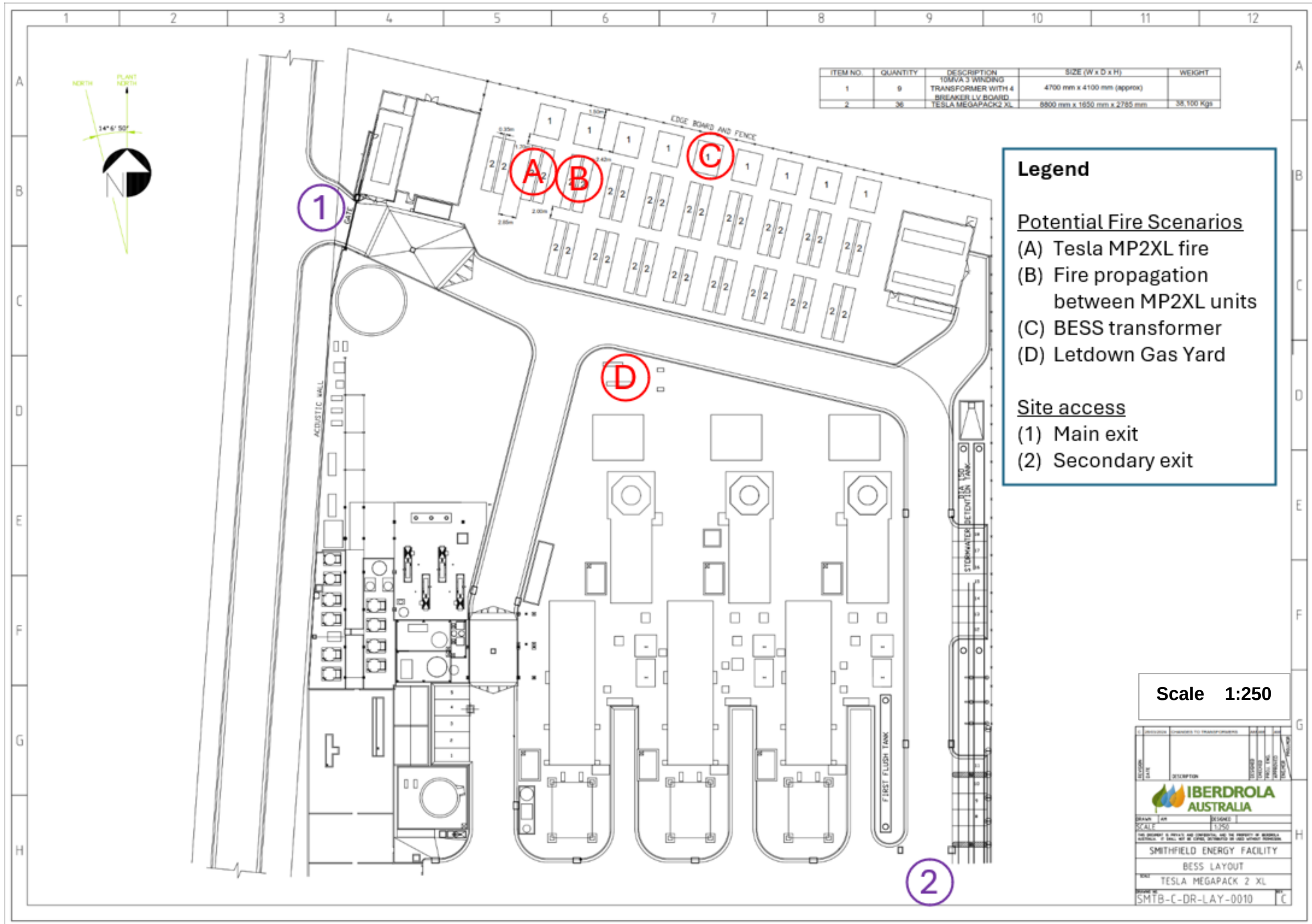
5.5. Fire scenarios for consequence assessment review

The HAZID was used to forward screen those incidents for consequence assessment review and in turn inform the fire safety strategy. A summary of the incidents carried forward are given in Table 5.1 and location shown in Figure 5.1.

Table 5.1: Potential fire incidents carried forward for consequence review

HAZID tag	Description	Carry forward consequence review
Proposed BESS facility		
A	Fire involving a Tesla Megapack MP2 unit	Yes
B	Propagated fire to adjacent Tesla Megapack MP2 unit	Yes
C	Fire involving a BESS transformer	Yes
Existing SEF (power station)		
D	Fire from the Jemena gas inlet line	No
E	Fire from the gas yard (existing SEF)	Yes
F	Fire in the gas turbine unit	No
G	Fire in the administration/ control room/ maintenance building	No
H	Fire in the minor flammable storage (i.e. paint)	No
I	Fire in the fire pump room	No
J	Fire involving an SEF transformer	No

Figure 5.1: Location of fire incidents carried forward for fire consequence review



6. CONSEQUENCE ASSESSMENT REVIEW

6.1. Overview

Fire incidents (Section 5) carried forward from the HAZID were reviewed to understand their potential consequence from a radiation impact and as applicable, toxic gas impact. During the consultation meeting, FRNSW required the FSS consider the potential for incident propagation originating from within the BESS facility or from existing SEF incidents impacting upon the BESS.

For BESS related fires, radiation impact analyses are based on Tesla supplied information for the Megapack (MP) batteries. The review was supplemented by the fire and toxic gas modelling from the PHA (Ref [4]) study. These were used to consider the potential for incident propagation within the BESS.

For incidents involving the existing SEF, consequences are based on the findings in the original FSS (Ref [6]) and supplemented by modelling conducted in the BESS PHA.

The consequence review findings are presented in two parts:

- BESS development
- Existing SEF.

6.2. BESS development

6.2.1. BESS unit fire and propagation potential (Tesla fire testing) [HAZID Tag A & B]

Tesla has performed unit-level tests to demonstrate that fire escalation between units will not occur if the BESS unit layout follows the clearance requirements (Table 3.1).

The fire test reports including details of the setup, measured data and observations, were provided to Smithfield BESS. Key outcomes from the Tesla testing (Ref [3], [11], [12], [13]) are outlined.

UL-9540A test

The UL 9540A test is used to evaluate the potential for BESS thermal runaway and gather data to assess or develop mitigation measures against this failure event, propagation of the failure, or consequences such as explosions or fires. Within industry, the UL-9540A test is considered the most appropriate published methodology for providing comprehensive, consistent, and reliable data for battery failure testing.

The UL 9540A unit-level test was conducted on the Tesla MP2XL unit at the Northern Nevada Research Center and certified by TÜV. The key test outcomes are as follows:

- Thermal runaway did not escalate to a fully developed unit fire and only a few cells were involved in the fire.
- Thermal runaway and resulting fire did not propagate to target MP2 units installed 6 inches behind and 6 inches to the side of the initiating unit.

- Explosion hazards including deflagration, projectiles, flying debris, detonation, or other explosive gas discharge were not observed.
- Small traces of the Hydrogen Fluoride (HF) were detected in collected samples. However, the concentration was well below the immediate danger to life and health (IDLH) value for HF.
- No free-flowing liquid or runoff from the damaged cells was observed.
- All performance criteria specified by UL 9540A were met.

Destructive unit test

MP2

A destructive unit test was performed at the Northern Nevada Research Center in 2022 to assess the fire propagation behaviour of MP2XL battery. This test was conducted under more severe conditions than those required for the UL 9540A test. In this test case, 48 cells were forced into thermal runaway simultaneously, exceeding the worst-case scenario anticipated from Tesla's field assessments. The following was found:

- The test was intended to result in a full unit fire. However, fire propagation did not occur to all battery cells, and only half the MP2XL unit was affected.
- Uncontrolled explosion (deflagration) did not occur.
- Flames were observed coming out of the front doors (which had opened).

MP1

The UL 9540A test was performed on a MP1 unit and progressed to a large-scale fire involving the entire unit (destructive). The key observations were:

- Fire did not spread from the initiating MP1 unit to the target units installed 6 inches to the back and side.
- No projectiles, deflagration, or flying debris were observed. The explosion protection system, including overpressure vents was found effective in mitigating explosion hazards.
- Radiation levels measured at the 8 feet spacing was below the radiation level required for escalation.

6.2.2. BESS unit fire and propagation potential (Tesla fire model) [HAZID Tag B]

MP2 fire modelling

Based upon the destructive unit test, Tesla engaged a third-party engineering fire specialist (Ref [3]) to validate dynamic (time response) fire radiation (heat flux) and propagation models. The results of the modelling were:

- Heat flux model: For a MP2XL unit on fire, the model estimated a peak heat flux of 12.8 kW/m^2 at a distance 6 inches (back and side) and 11.8 kW/m^2 at the distance of 8 feet[6] (front), considering worst-case wind conditions. The model was also validated against MP1 test results (described above).

- Thermal runaway model: This model predicts if a fire could escalate from the initiating unit to neighboring units. The dynamic model predicts the temperature rise in neighboring units of a burning MP2XL unit against estimated heat fluxes over time (covering best and worst-case wind conditions). The model demonstrated that the temperature of unit cells in neighboring units located 8 feet in front, 6 inches behind, or 6 inches to the side of the initiating MP2XL unit would not reach the thermal runaway temperature (239°C) and propagation would not occur.

6.2.3. BESS unit fire and propagation potential (PHA modelling) [HAZID Tag A & B]

Offsite impact

The heat radiation and toxic gas (hydrogen fluoride) modelling conducted in the PHA study (Ref [4]) was updated to cover the MP2XL battery unit. The calculations for a complete BESS unit on fire are show in APPENDIX C.

The PHA modelling is useful in terms of estimating the 'stand back' distance for emergency response and public. Of note:

- The distance to a heat flux level of 23 kW/m^2 (escalation) was 8 metres (module long side) and 3 metres (module end side). Based upon the BESS layout, the predicted heat radiation impact to the neighbouring sites from a BESS unit on fire is not expected.
- The distance to a heat flux level of 4.7 kW/m^2 (injury) was up to 7 metres. Based upon the BESS layout, radiation impact would slightly extend offsite into Kingspan yard. Update to the site Emergency Response Plan is discussed in Section 7.
- Depending on the weather condition and wind direction, toxic gas could potentially extend off-site into the Kingspan yard. However, the toxic gas (injury) is not expected to reach the occupied building at Kingspan. Update to the site Emergency Response Plan is discussed in Section 7.

6.3. BESS transformer fire [HAZID Tag C]

Fire modelling was undertaken for a transformer oil (natural ester FR3) leak and fire and the calculations are shown in APPENDIX C. The results indicate that:

- A transformer fire would not result in heat flux of 23 kW/m^2 (potential for escalation) reaching the BESS unit (end side).

Improvements to fire detection and response are discussed in Section 7.

[6] The 8 foot (2.4 metre) spacing is the recommended separation spacing in the Tesla MP1 and MP2 Installation Manual.

6.4. Fire at the SEF gas yard [HAZID Tag E]

The PHA assessed the impact of an ignited release from the gas yard and the modelling is given in APPENDIX C. The BESS modules are located approximately 15 metres from the gas yard and 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.
- An ignited gas release for all leak sizes modelled at the gas yard could give rise to a heat radiation level above 23 kW/m^2 at a BESS unit. If the leak is not isolated, there is the potential for incident propagation to a BESS unit and with thermal runaway.

Improvements to leak and fire detection are discussed in Section 7.

6.5. Findings

The Tesla Megapack unit fire (UL9540A) and destructive unit test results indicated that fire propagation should not occur if the BESS units adhere to the required separation spacing as per installation manual.

Third party fire specialist validation of Tesla fire radiation and subsequent runaway modelling also supports the fire test results. These findings are in line with observations of actual BESS fires involving the Tesla Megapacks (Section 5).

For incidents involving the existing SEF, unisolated ignited releases from the gas yard have the potential to propagate to a BESS unit resulting in thermal runaway. Section 7 provides discussion of protection measures against this incident scenario.

All other identified SEF incidents did not impact the BESS facility. No fires at the BESS were identified that could escalate to the SEF.

7. SITE FIRE PREVENTION, DETECTION & PROTECTION SYSTEMS

7.1. Overview

This section summarizes the fire prevention, detection and protection systems for the:

- BESS facility. These measures have been provided by Telsa for the MP2XL batteries from the installation manual (Ref [14]) and fire test documentation (Ref. [3]).
- Existing SEF. These measures have been provided by the operations team as well as from the independent Hazard Audit (Ref [7]) and HAZID study (Ref [5]).

The FRNSW guideline (Ref [2]) was used to prompt the SEF Operations personnel to identify additional or improvements to fire safety measures, for enhancing prevention, detection and emergency response controls.

The adequacy of the existing SEF fire system design has been deemed satisfactory from the independent Hazard Audit (Ref [7] , and NSW government approvals (Ref [15]). This FSS has found that there is no required change to the physical SEF fire protection system.

As detailed in this section, the FSS has identified required improvements to the site fire detection and emergency response.

7.2. BESS Megapack incidents [HAZID Tag A & B]

7.2.1. Fire prevention and protection systems

Consultation was undertaken with Tesla to identify the safety design features for the MP2XL battery units and is summarized in Table 7.1.

Table 7.1: Tesla MP2XL – fire safety systems

No	Description	Role in fire strategy
1	Battery Management System (BMS)	Each battery module has its own BMS. The BMS is designed to detect and automatically react to fault conditions (i.e. over-temperature, loss of communication, over-voltage) that could lead to thermal runaway. Depending on the alarm and trip limits, the BMS automatically isolates the affected battery module or permanently disconnects the module.
2	Thermal Management System (TMS)	To prevent the thermal runaway (from operating in high external temperature), the TMS maintains the temperature inside the BESS cabinet within an optimum range via a closed-loop liquid system. The cooling liquid is a mixture of water and ethylene glycol solution. Key components of the TMS are a thermal bay within the BESS cabinet and a thermal roof, which contains fans and radiators and provides a ventilation airspace for the battery cabinet.

No	Description	Role in Fire Prevention
3	Overcurrent protection	The MP2XL have several passive and active safety control mechanisms installed within the battery module circuit and distribution circuit that would be available to interrupt a fault current. Electrical fault protection features cover a) Battery module overcurrent protection b) Inverter DC protection: c) Inverter AC protection d) Ground fault protection:
4	Explosion prevention and mitigation	Explosion control systems for the MP2XL units include: a) Overpressure vents: The overpressure vents are installed in the ceiling of the sealed battery bay's IP66 enclosure. Once opened, the overpressure vents permit gases, products of combustion, and flames to safely exhaust from the battery bays into the thermal roof and out of the MP2XL via the roof vents. By designing this natural ventilation flow path, flammable gases are not permitted to accumulate within the MP2XL cabinet, reducing the risk of a deflagration or explosion that could compromise the cabinet's integrity, push open the front doors, or expel projectiles from the cabinet. This was observed in the fires involving Megapack batteries (Section 5). b) Sparker system: The system is designed to ignite flammable gases at very short intervals. By continuously sparking, the flammable gases will ignite near their lower flammable limit (LFL) very early in a thermal runaway event before they accumulate within the enclosure and become an explosion hazard. They are installed at a variety of locations throughout the battery module bays.

7.2.2. Fire detection

When the site is manned, incident detection may be by SEF personnel. In discussion with the operations team, there is a project underway to enhance the gas and fire detection for the entire site including the BESS. As outlined in the Tesla documents (Ref [14]), multi-spectrum IR flame detectors can be used to detect a developed fire (i.e. visible flame).

Recommendation 1: Confirm that thermal fire detection provided to cover the BESS facility and transformers will be interfaced to the (existing) Fire Indicator Panel and regularly tested. This will assist in providing early warning for intervention reducing the potential for battery fire escalation. This will satisfy FRNSW consultation feedback for provision of automated fire prevention and detection

7.2.3. Fire protection and response

Iberdrola (parent company of Smithfield BESS) advised that their global insurer for existing BESS facilities has advised that fire protection measures must follow the BESS OEM recommendations.

Tesla in their *Industrial Lithium-Ion Battery Emergency Response Guide* (Ref [16]) has advised that firewater systems are not required. In terms of responding to a fire for the MP2XL batteries:

- Allow the affected unit to consume itself as it is designed to do. Applying water to the burning unit will have minimal effect and will only slow its eventual combustion.

From a propagation viewpoint, adherence to the recommended separation distances between the MP2XL battery units will minimize escalation. This finding has been based upon the Tesla unit level and destructive testing as described in the consequence assessment review (Section 6).

7.2.4. Emergency response for BESS fire

In the event of a MP2XL battery fire, Smithfield BESS has advised the following would occur:

<u>Notification of confirmed fire to FRNSW</u>

- Both Tesla and the Smithfield BESS operations teams will have real time cell temperature monitoring and alarms through the SCADA system. Operational anomalies are addressed and as necessary system shutdown.
- In the event of a confirmed fire event, the SCADA and thermal cameras will link to the fire panel for emergency notification to operations personnel as well as the FRNSW. See recommendation 1 in Section 7.2.

<u>Subject matter expert support</u>

- As per Tesla's Emergency Response Guide, there is a 24/7 hotline whereby a Tesla product support engineer will provide information and advice for handling the fire event.
- Post event, Iberdrola and Tesla product support engineer will provide information in terms of cleanup and safe access (i.e. electrical hazards).

<u>Notification of emergency to surrounding neighbours</u>

- The consequence assessment has indicated there could be irritation effects at the Kingspan facility from toxic fume generation and injury from radiation effects.

Recommendation 2: The Smithfield Emergency Response Plan be updated to cover Tesla MP2XL battery fire. The Emergency Response Plan should cover the required operational responses to make the power station, including incoming gas lines safe and outline communication protocols between Smithfield BESS, Tesla and FRNSW.

Recommendation 3: The Smithfield Emergency Response Plan be updated to cover incident notification to Kingspan and possible shelter in place or evacuation of the site to avoid smoke and potential nuisance effects from a BESS fire.

7.3. BESS transformers [HAZID Tag C]

As shown in the site layout, there is a transformer unit that is provided for each row of BESS units. The consequence review has identified that heat radiation from a transformer fire would not affect the BESS units.

However, the limited volume of transformer oil would result in a short duration fire and the potential for propagation is considered low. The following measures (design and operational) are implemented:

Fire prevention and detection

- By design, the transformers have over-temperature protection that trips the unit.
- The transformers are separated from the BESS unit as per installation requirements.
- Thermal detection covering the transformers interfaced to the (existing) Fire Indicator Panel.

Fire protection

In discussion with the SEF operations team, the fire safety philosophy is to adopt a non-intervention philosophy and allow the transformer on fire to consume itself. This incident is considered an asset loss issue rather than a safety issue.

If required, the site fire main supply is located on the north-west corner and could be used to apply cooling water (Figure 7.1). SEF operations advised the BESS facility may need to be isolated in an emergency event involving a transformer fire.

Recommendation 4: The Smithfield Emergency Response Plan be updated to cover BESS transformer fire. The Emergency Response Plan should indicate the key decision points to isolate a BESS battery string, associated transformers and/or the BESS facility.

7.4. Existing SEF [Site Wide]

With reference to the technical safety studies (Ref [5], [6], [7], [15]) conducted at the Smithfield site, the following fire prevention, detection and protection systems are installed. These systems have been installed to cover the potential fires outlined in the HAZID (APPENDIX A). As reported in the latest Hazard Audit (Ref [7]) the FSS covering the existing SEF was approved as part of the Conditions of Consent.

7.4.1. Fire detection and protection (buildings and enclosures)

- The carbon dioxide flooding system at the exciter compartments for each gas turbine (isolation of CO_2 system prior to entering is required – failure to re-open CO_2 system when exiting is alarmed in control room). The CO_2 system is tested and maintained by plant operators.
- Packaged Electrical Electronic Control Cubicle (PEEC) is controlled via FM200 inert gas.

- Switch room is protected via Inergen. Door seal integrity tested (door fan test) and found to pass AS/ISO 14520-2009.

7.4.2. Fire protection system (site wide)

- Fire extinguishers and fire hoses throughout plant areas, clearly visible and accessible. Fire hose reels are located at each building exit and throughout the site to ensure adequate coverage across each floor level.
- Hoses and extinguishers are tested by Wormald (extinguishers checked twice yearly).
- Cooling water sprays over the high voltage room roller door for protection from any fires on the adjacent site.
- The site fire hydrant network is presented in Figure 7.1. The fire hydrant water is supplied from a Sydney water main. There is an interconnecting pipe system and shut-off valve between the hydrant system and the fire booster pump system, which allows water to be manually regulated into the hydrant system to boost the hydrant water supply. There are three (3) dual valve fire water hydrants and associated hose stations located in protective cabinets. These are located next to the base of each power train stack.
- The firewater pump system consists of a jacking pump and, for larger demands, a diesel pump for boosting pressure in the supply mains. The pumps are fed with potable water directly from the mains. Wormald maintains and tests the fire water pump (monthly tests) including actual pump discharge testing.
- The independent Hazard Audit noted that should contaminated fire water occur, then it would be captured in the stormwater system that includes a separator. The BESS design is based upon using the site SEF stormwater system.

7.4.3. Fire audits and certification

This FSS has assumed that the existing SEF fire systems are adequate to manage potential fire incidents based on the following:

- Annual audits are performed by FM Global for fire water and fire protection (FM Global latest report reviewed during the audit).
- The fire protection system at the SEF is subjected to annual audit and the NSW Government Annual Fire Safety Certificate (Ref [15]) is in place to demonstrate continuing compliance to AS1670 Automatic Fire Detection and Alarm Systems, AS4214 Automatic Fire Suppression, AS2419 Fire Hydrants, AS2441 Hose Reel Systems and AS2444 Fire Extinguishers as well as the Building Code of Australia.

7.4.4. Emergency response

A site Emergency Response Plan (ERP) exists for the facility with copies held by various staff, e.g. the Security Office (VISY), Operations Manager's office, Control Room.

The latest Hazard Audit confirmed that the ERP met the expectations of HIPAP No.1, Industrial Emergency Planning Guidelines. The ERP in its current form covers events including fires, natural gas leaks and explosions. Recommendations have been provided to update the ERP to cover a) BESS units fires, and b) gas yard fire.

7.5. Existing SEF [HAZID Tag E]

7.5.1. Gas yard

The consequence review identified that heat radiation from an ignited release at the gas area may reach BESS units. The PHA found that a fire (for larger release sizes), if left unmitigated (i.e. no detection and isolation), may result in a propagation event. The following measures (design and operational) are available:

Fire prevention and detection

- The gas itself is dry and Smithfield BESS has reported no issues with internal corrosion and the gas yard is under a regular preventative maintenance program.
- The gas yard is hazardous area zone classified and managed in accordance with Australian Standards to prevent ignition sources.
- Guarding over connections that face the BESS units (prevention measure) will prevent the jet fire from being directed to the BESS units. This is a PHA recommendation and will be implemented.
- Operator detection and isolation. In the event of a gas leak from aboveground piping and equipment, manual isolation is performed by closing isolation valve(s) upstream and downstream of this area. In discussion with SEF Operations these valves are located away from the gas yard and can be safely accessed. As indicated (Section 7), there is a project underway by the SEF operations team to enhance the gas and fire detection for the entire site including the BESS.

Recommendation 5: As per PHA study, confirm implementation of proposed measures (e.g. guarding, flame mesh) to prevent flame impingement from the gas yard to the nearest BESS.

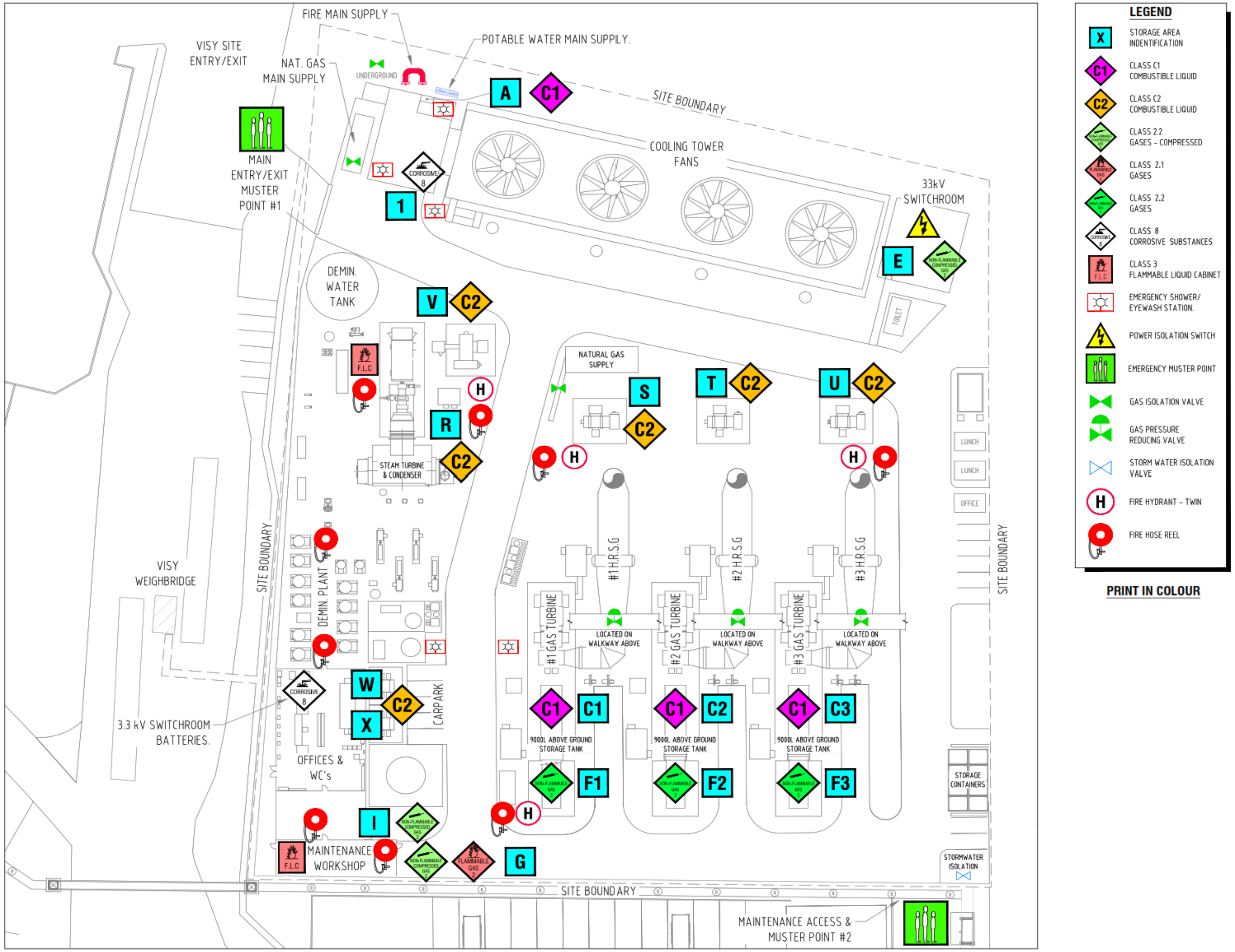
Recommendation 6: Confirm that thermal fire detection will be extended to cover the gas yard and interfaced to the (existing) Fire Indicator Panel. This will assist in reducing the fire propagation risk from the existing SEF to the BESS facility. It will also satisfy FRNSW Consultation feedback for provision of automated fire detection.

Recommendation 7: Update the Smithfield Emergency Response Plan to cover the response for a leak and fire event at the gas yard area. The Emergency Response Plan should indicate gas isolation points and decision points for shutdown of the powerplant operations as well as the BESS facility (e.g. stop charging and/or disconnection).

Fire protection

- In discussion with the SEF operations team, there is no change to the existing fire protection strategy. A fire in this area is primarily controlled through detection and isolation and as required, the power generation operations would be suspended. If required, hydrants to apply water (Figure 7.1) are available to provide cooling to nearby structures. SEF operations advised there are no hazardous material or flammable materials within the vicinity of the gas yard.

Figure 7.1: SEF fire equipment



8. SITE FIRE SAFETY STRATEGY

The FRNSW requires (Ref [2]) Smithfield BESS to establish a fire safety strategy in terms of the organization *approach to minimize the likelihood, severity and extent of a fire incident and minimize the potential for propagation of an incident*.

The proposed fire safety strategy for the overall Smithfield facility is based on the identified fire incidents of the BESS facility and the existing SEF.

8.1. BESS facility

For the BESS facility the fire safety strategy will be **non-intervention**.

The strategy was developed in consultation with Tesla and the SEF operations personnel based upon the MP2XL fire safety design features (Section 8) and Tesla fire testing (Section 7) to inform unit separation distances to minimize the potential of fire propagation.

The proposed design and operational fire prevention, detection and protection safeguards for the BESS Facility will also minimize the potential for a BESS unit fire and limit the propagation potential.

This approach covers incidents for:

- Fire at the BESS unit
- Fire at the BESS transformer

To support the non-intervention strategy, this FSS has made recommendations to enhance the automated fire detection and response including process isolation, system shutdown and updating the Emergency Response Plan.

The Emergency Response Plan requires updating to cover the BESS related fire incidents, communication protocols with Telsa and FRSNW, and notification to industrial neighbours (i.e. Kingspan).

As part of emergency response, Smithfield BESS will have access to Tesla who will be independently monitoring the Megapack battery performance and alarms. In a BESS fire incident, Telsa will provide subject matter expert to both FRNSW and Smithfield BESS during and post emergency event.

The BESS development does not introduce fires that can escalate to the existing SEF.

8.2. Existing SEF impact upon BESS facility

The FSS identified an ignited release (unmitigated) at the gas yard area may reach the nearest BESS units and result in propagation. The fire safety strategy for this event is **non-intervention** and based upon SEF implementing design safety measures to minimize the potential for gas leak and fire directed towards the BESS facility.

This FSS has made recommendations to implement automated fire detection and response including gas isolation, system shutdown and updating the Emergency Response Plan.

The Emergency Response Plan is required to be updated to cover specific actions related to gas isolation, decision points to isolate the BESS facility and response actions for the power station gas turbine(s).

8.3. Existing SEF

For the existing SEF that covers the power plant operations, the current fire safety strategy remains **unchanged**. The existing SEF fire prevention, detection and protection systems have been outlined in Section 8. The SEF fire protection system has been deemed acceptable and compliant by the independent Hazard Audit, original FSS and annual fire safety certification.

APPENDIX A. FIRE HAZARD IDENTIFICATION TABLE

ID	Event	Cause	Consequence	Controls	Reference
A, B	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 - Emergency Response Plan	- PHA HAZID
A, B	Generation of explosive gas (e.g. hydrogen) Note: covered as a fire in a BESS unit	- 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	- PHA HAZID

ID	Event	Cause	Consequence	Controls	Reference
A, B	Thermal runaway in battery Note: covered as a BESS fire	<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) - Automated thermal detection and response - Activation of emergency shutdown - Emergency Response Plan	- PHA HAZID
A, B	BESS overheating	Extreme temperature or humidity Note: covered as a BESS fire	- 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 - Automated thermal detection and response - Activation of emergency shutdown - Emergency Response Plan	- PHA HAZID

ID	Event	Cause	Consequence	Controls	Reference
A, B	Vandalism Note: covered as a BESS fire	- 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 - Automated thermal detection and response - Emergency response plan	- PHA HAZID
C	BESS 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) - Automated thermal detection and response - Activation of emergency shutdown - Emergency Response Plan	- PHA HAZID

ID	Event	Cause	Consequence	Controls	Reference
D	Fire in gas inlet (Jemena)	Existing power station infrastructure – Jemena Inlet yard (located at main road entrance to site) Gas leak (e.g. flange, instrument fitting failure, mechanical failure) Note: This is an existing hazard present at the SEF power station.	- 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 jet fire 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. - A manual isolation valve is located outside of the power station complex and can be easily accessed by emergency services (note, the t-handle is stored inside the pump house, depending on the location of the fire, access to the pump house could be restricted) - A manual isolation valve is provided within the facility downstream of the gas metering yard and prior to the pressure regulation to the gas turbines - Gas supply pressure is maintained by Jemena at Horsley Park, the equipment within the metering yard is fully rated for the supply pressure - An operational protocol exists to contact Jemena to remotely shut down the Smithfield Lateral at the Horsley Park metering station - In the event of an emergency blocking egress through the main access gate, a secondary evacuation pathway is provided through the southern access point - An agreement has been established between Jemena and Infigen for keys to be available to Infigen for access to the metering yard if required - 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 - Cathodic protection - Permit to dig procedures in place - Shut off valve at site boundary	- PHA HAZID - SEF HAZID
E	Fire in let down gas yard	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 jet fire 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) - Automated thermal detection and response - Guarding over connections - 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	- PHA HAZID

ID	Event	Cause	Consequence	Controls	Reference
F	Fire in turbine enclosure	<u>Existing power station infrastructure – Gas turbine enclosure</u> - Gas leak (e.g. flange, instrument fitting failure, mechanical failure) within enclosure Note: This is on existing HAZID for the SEF.	- A gas leak within the enclosure results in the accumulation of gas and ignition - 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 is provided with automatic fire suppression system - Personnel would initiate site ESD. - Activation of BESS emergency shutdown - Emergency Response Plan - When the Gas Turbine is offline, gas is excluded from the module via separate, external isolation valves. These isolation valves are managed by the DCS as part of the purge credit system - The enclosure is ventilated (draws in filtered air) to dilute and exhaust any minor leaks and prevent a hazardous area (zone 1) condition. Duty/standby ventilation fans are provided with pressure monitoring to confirm fan operation - The enclosure is fitted with a gas detection system which will trigger a GT shutdown and closure of the external isolation valves. The gas detection system is also used as a start permissive (i.e. gas detection system cannot be in fault)	- PHA HAZID - SEF HAZID
F	Fire in turbine area	- Corrosion - Mechanical failure	- A gas leak or loss of containment event occurs within the gas delivery area leading to ignition or a fire - If ignited, a gas leak is likely to result in a jet fire and potential injury to personnel	- All gas delivery equipment is rated at or above the gas supply pressure - Hazardous Area classification for the gas delivery area and procedural control of ignition sources - All works are completed under the permitting system. At the completion of maintenance, a gas leak test is conducted to confirm sealing prior to returning equipment to service - The gas is odourised meaning a leak is likely to be identified during daily operator rounds. Gas detectors are available at site to confirm an identified gas leak	- SEF HAZID
F	Loss of containment in process area Lube oil fire	- Failure of lube oil tanks or associated lines	- Can result in a fire - Spill of product may enter the stormwater system and Prospect Creek - Can cause short term damage to aquatic life in the creek	- All turbines using lube oil tanks are fitted with spill containment curbs. Any spills may be pumped out - Sprinkler fire protection over lube area - CO_2 deluge over gas turbines - Under manual control, the First Flush Holding Tank can be pumped to the Oily Water separator, where oily waste is recovered. The water phase flows under gravity to the 2 Storm Water (SW) Detention Tanks. The SW Retention tanks are fitted with penstock outlet valve	- SEF HAZID - Original PHA

ID	Event	Cause	Consequence	Controls	Reference
I	Loss of containment day tanks Loss of containment while road tanker is on site	- Failure of diesel day tanks - Failure of diesel fuel lines - Failure of road tanker - Failure of unloading hose - Overfill day tanks - Road tanker collision	- Pool fire - Spill into creek - Pool fire - Spill into creek	- All diesel tanks are 100% bunded - Road tanker unloading points are hard paved and lower than surrounding areas. Each unloading point is valved and can be drained to the First Flush holding tank - Under manual control, the First Flush Holding Tank can be pumped to the Oily Water separator, where oily waste is recovered. The water phase flows under gravity to the 2 Storm Water (SW) Detention Tanks. The SW Retention tanks are fitted with penstock outlet valve (normally open)	- SEF HAZID - Original PHA
J	Transformer fire or failure, generating high heat radiation Oil leak or failure of the transformer (11kV/ 33kV)	- Failure of transformer - Short circuit	- A transformer failure or fire has the potential to result in a fatality and significant equipment damage - Access to site via the main entry gate is likely to be impeded	- The transformer electrical protection systems are likely to trip the transformer prior to a significant fault occurring - For the current operating regime, the majority of operations are performed remotely from site. When personnel are operating the power station from site, the control room is located on the opposing side of the facility from the transformers (and HV switch room) - A fire deluge system is provided for each transformer - A secondary access/egress path is provided on the southern side of the facility - All stormwater collected onsite is treated via an oil-water separator prior to discharge	- SEF HAZID
J	Transformer fire or failure, generating high heat radiation (33kV/ 3.3kV)	- Failure of transformer - Short circuit	- A transformer failure or fire has the potential to result in a fatality and significant equipment damage	- The transformer electrical protection systems are likely to trip the transformer prior to a significant fault occurring - A concrete block fire wall and partial roof separate the transformers into individual bunds and provide a partition from the LV Switch room and administration building - A fire deluge system has been retrofitted to each transformer - All stormwater collected onsite is treated via an oil-water separator prior to discharge	- SEF HAZID

APPENDIX B. MATERIALS STORED AT SMITHFIELD

The tables overleaf summarise the materials that are stored at Smithfield. These cover the BESS facility and existing SEF (power plant).

Table B 1: Potentially hazardous materials (BESS development)

Material	DG Class	Category	Commentary	Considered in FSS
BESS battery (Lithium ion-LFP)	9	Miscellaneous DGs	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).	Yes
BESS coolant (50% ethylene glycol aqueous solution)	-	-	Not classified as DG.	No
BESS refrigerant (R134a)	2.2	Non-flammable Non-toxic	No applicable SEPP screening threshold and excluded from risk screening. Class 2.2 is not considered to be potentially hazardous with respect to off-site risk.	No
Transformer oil (natural ester FS3)	-	-	Not classified as DG. It has a high boiling point > 260ºC. However, considered in the FSS HAZID as a potential fire source.	Yes

Table B.2: hazardous and dangerous goods at existing SEF

Product/ common name	Storage type	Class	Quantity (Litres)	Location	Sherpa commentary	Fire Impact on BESS?
Natural Gas	n/a	2.1	n/a	Feed for gas turbines	See FSS HAZID (Appendix A). Feed gas is supplied from the Jemena pipeline and pressure reduced in the gas yard to the gas turbines. PHA identified that loss of containment of natural gas could result in a fire impact to the nearest BESS units.	Yes
Diesel	Above ground steel tank	C1	1000	Fire pump room	No effect on the BESS in case of a LOC and pool fire as the storage tank is located within a fire rated building.	No
Diesel	Above ground steel tank	C1	3 x 800	Gas turbine #1, #2, #3	Diesel is stored in small quantities, and each diesel tank is bunded. Due to the separation distance of approximately 15 m between the diesel tanks and BESS units, no escalation to BESS unit is expected in the event of a gasoline loss of containment and a pool fire.	No
Intergern	Cylinder	2.2	2,608	South wall 33 kV switch room	Non-flammable gas- does not pose a fire hazard to the BESS facility.	No
Carbon dioxide	Storage tank	2.2	7,680	Gas turbine #1, #2, #3	Non-flammable gas- does not pose a fire hazard to the BESS facility.	No
Acetylene	Cylinder	2.1	146	Gas Bottle Store	No long-term fire would occur in case of a leak in the cylinders (small, limited inventory). Additionally, the cylinders are stored near the southern boundary,	No

Product/ common name	Storage type	Class	Quantity (Litres)	Location	Sherpa commentary	Fire Impact on BESS?
					which is approximately 100 m away from the BESS units.	
Oxygen	Cylinder	2.2	97.4	Gas Bottle Store	Non-flammable gas- does not pose a fire hazard to the BESS facility.	No
Nitrogen	Mobile	2.2	97.4	Gas Bottle Store	Non-flammable gas- does not pose a fire hazard to the BESS facility.	No
Intergern	Cylinder	2.2	4,156	Outside the Office	Non-flammable gas- does not pose a fire hazard to the BESS facility.	No
Sodium Hypochlorite	Above ground fixed fibreglass tank	8	11.350	Pump House	Corrosive substance- does not pose a fire hazard to the BESS facility.	No
Corrosion Inhibitor 3DT222	Above ground porta feeder tank	8	1,000	Cooling tower chemical skid	Corrosive substance- does not pose a fire hazard to the BESS facility.	No
Non-oxidising Biocide 7330	Above ground porta feeder tank	8	1,000	Cooling tower chemical skid	Corrosive substance- does not pose a fire hazard to the BESS facility.	No
Lubricating Oil	Above ground steel tank	C2	7,500	Steam turbine area	-	No
Insulating Oil	Above ground steel tank	C2	3 x 11,500	Gas turbine #1, #2, #3	-	No

Product/ common name	Storage type	Class	Quantity (Litres)	Location	Sherpa commentary	Fire Impact on BESS?
Insulating Oil	Above ground steel tank	C2	16,200	Steam turbine transformers	-	No
Insulating Oil	Above ground steel tank	C2	2,729	Auxiliary transformer #1, #2	-	No

APPENDIX C. CONSEQUENCE ANALYSIS

C1. BESS unit on fire

C1.1. Modelling approach

Consequence modelling was undertaken based on the Stefan–Boltzmann correlation to analyse the heat transfer effect between two parallel planes, simulating a BESS unit on fire and the heat radiation exposure to a receptor, as shown in Figure C.1. Distances to heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [17], were calculated.

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

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

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

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

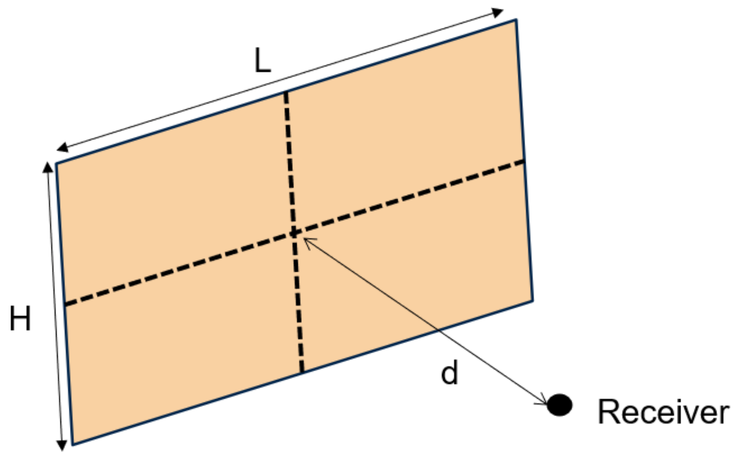
$$\emptyset = \frac{1}{2\pi}\left[\frac{a}{(1+a^2)^{1/2}} tan^{-1}\frac{b}{(1+a^2)^{1/2}} + \frac{b}{(1+b^2)^{1/2}} tan^{-1}\frac{a}{(1+b^2)^{1/2}}\right]$$

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

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

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

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



C1.2. Input and assumptions

The modelling input and assumptions used were as follows:

- The flame temperature of the emitting surface was set at 1000°C, which is value typical for lithium metallic fires, Ref [18].
- An emissivity value of 0.9 (a black body has an emissivity value of 1).
- Receptor height was set at 1.5 m.
- The heat radiation calculation was performed for the front aspect of the BESS unit and assumed a full planar fire. This is conservative as the front aspect has the largest surface area and consequently highest heat radiation impact. This approach is deemed appropriate to determine off-site impacts.

C1.3. Heat radiation criteria

Consequences of various heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [17], are shown Table C.1. For this PHA, distances to 4.7 kW/m^2 (injury), 12.6 kW/m^2 (fatality), and 23 kW/m^2 (structural failure) were calculated.

Table C.1: Consequences of heat radiation

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

C1.4. Results

The distances to the specified heat radiation levels are presented in Table C.2. Distance to the injury level (4.7 kW/m^2) was used to determine potential for off-site impact.

Table C.2: Heat radiation impact – BESS unit on fire

BESS	Dimension (mm)	Surface temperature (°C)	Distance (m) at receptor height (1.5 m) to radiation levels		
			4.7 kW/m² (injury)	**12.6 kW/m²** (fatality)	**23 kW/m²** (structural failure)
Front					
MP2XL	8,800 x 2,785	1000	15	9	6
Side					
MP2XL	1,650 x 2,785	1000	7	4	3

C2. Dispersion of toxic gas

C2.1. Modelling approach

In the event of a BESS fire, there is a potential for toxic gas to be generated (1) from decomposition of the battery electrolyte, and/or (2) as a result of combustion products. For LFP batteries, there is a potential for hydrogen fluoride (HF) to be formed following electrolyte decomposition from a BESS fire event. In this study, as HF is considered to be the most toxic decomposition product, dispersion of HF was modelled to better understand the impact to receptors.

Consequence modelling was performed using the Gexcon EFFECTS v12.3.0 software (Plume Rise from Fire model) to simulate HF dispersion during a BESS fire. The HF generation rate was based upon published experimental literature for LFP batteries. The downwind distances to the Acute Exposure Guideline Level (AEGL) concentrations for HF were determined.

C2.2. Input and assumptions

The modelling input and assumptions used were as follows:

- Hydrogen fluoride is considered the most toxic decomposition products from the batteries fire, Ref [19].
- A lithium-ion battery cell experiment, Ref [19], indicates that the HF quantity released from a 1 Wh battery varies between 20 mg and 200 mg, depending on the battery type and state of charge. As a conservative approach, generation rate of 200 kg per 1 MWh was adopted for the analysis. The HF generation rate was calculated based on the capacity a single BESS unit and fire duration of 1 hour. The resulting HF generation rate used for analysis is conservative as typically the fire duration is longer than 1 hour.
- Release is continuous, with concentration averaging time of 60 minutes used for reporting.
- Surface roughness factor of 0.1 m was used (represents low crops and occasional large obstacles).
- The heat release rate from the battery (with 100% state of charge) is estimated to be 882 kW/m^2, Ref [20].
- The plume was assumed to be released from the top of the BESS unit. This is viewed as a reasonable approach, based on observation from recent BESS fire incidents (e.g. VBB fire).
- Receptor height was set at 1.5 m.
- A range of wind and weather stability conditions was selected.

C2.3. Dispersion criteria

The AEGL concentration levels (60-minute exposure) for HF are presented in Table C.3. These concentrations were used to inform harm levels following exposure (irritation, injury and fatality).

Table C.3: AEGL values for HF (60-minute)

AEGL level	Health effects	HF concentration (ppm)
AEGL-1	Irritation threshold	1
AEGL-2	Injury threshold	24
AEGL-3	Life-threatening health effects threshold	44

C2.4. Results

The distances to AEGL concentrations at receptor height of 1.5 m are presented in Table C.4. The distance to the injury level (AEGL-2) was used to determine potential for off-site impact.

Table C.4: Toxic dispersion impact (HF) – BESS unit on fire

						Distance (m) at Receiver Height (1.5m) to AEGL		
BESS model	Size (LxWxH, mm)	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)
MP2XL	8,800 x 1,650 x 2,785	3.9	0.2	882	B3	40	12	9
					D2	7	5	4
					D5	68	21	17
					F1	2	1	1

C3. SEF gas yard- flammable gas release and jet fire

Releases from the 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.

C3.1. Software

Consequence jet fire modelling was carried out using the Gexcon EFFECTS v12.3.0 software.

C3.2. 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.

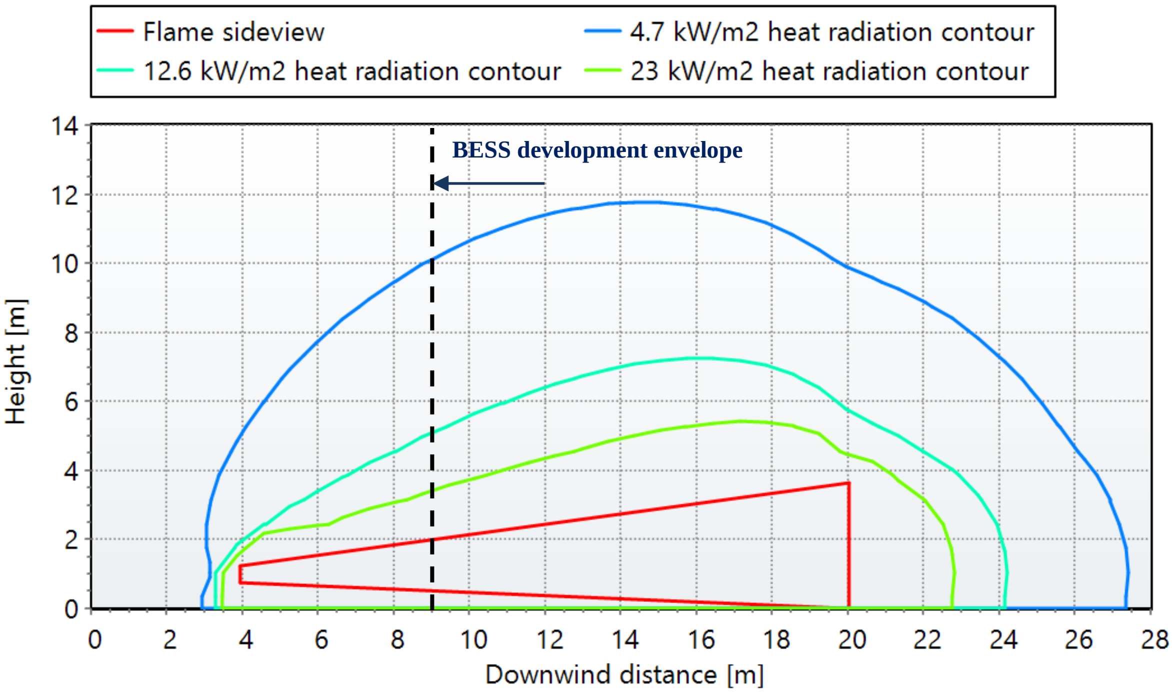
C3.3. Results

Results for different leak sizes and weather conditions are presented in Table C.5. 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 C.2 as an example.

Table C.5: 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 C.2: Heat radiation sideview (20 mm leak- D2)



C4. Transformer fire

C4.1. Modelling approach

A loss of containment of transformer oil could result in a pool fire. The distance to the 23 kW/m^2 heat radian was used to determine the potential fire escalation to the BESS units. The pool fire modelling was conducted using the Gexcon EFFECTS v12.3 software.

C4.2. Input and assumptions

The key inputs and assumptions are as follows:

- Surface area: equivalent to the transformer footprint (3.7m x 3.3m), with 25% assumed to be occupied by the transformer structure.
- Material: natural ester (FS3) or soybean oil with a flash point of >265°C and a molecular weight of 800-900 kg/kmol. In EFFECTS, beta-cholesterol with a flash point of 271°C and a molecular weight of 387 kg/kmol was identified as the closest available match to FS3.
- Total volume in overall unit: 7,500 litres.
- Wind speed: 5 m/s.

C4.3. Results

The modelling indicates that the distance to the 23 kW/m^2 (escalation) from the centre of the pool is approximately 4 m. Given that the distance from the transformer centre to the nearest BESS unit is more than 4 m, a transformer fire would not impact the BESS units.

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