Appendix I:

Hazards & Risk Assessment

Hazard & Risk Assessment

Cobden Battery Energy Storage System (BESS)

Cobden BESS Pty Ltd

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Prepared by:

SLR Consulting Australia

SLR Project No.: 620.041534.00021

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Making Sustainability Happen

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
R01-v3.0	12 May 2026	Dr Peter Georgiou	Dr Craig Simpson	Katie Yang
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Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Cobden BESS Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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Acronyms and Abbreviations

ADG	Australian Dangerous Goods (colloquial), as in the ADG Code: Commonwealth Government, National Transport Commission, “Australian Code for the Transport of Dangerous Goods by Road and Rail”, Edition 7.9, 2024.
ALARP	As Low as Reasonably Practical
APS	Arizona Public Service
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
BESS	Battery Energy Storage System
BMP	Bushfire Management Plan
BMS	Battery Management System
CFA	(Victoria’s) Country Fire Authority
CFA-RDG-v4.4	CFA, *Design Guidelines and Model Requirements for Renewable Energy Facilities*, v4.4 (June 2025), CFA Specialist Risk and Fire Safety Unit.
CIV	Capital investment Value
EIB	Equipment Information Book
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Field
EMR	Electromagnetic Radiation
EOL	End-of-Life
EPA	Environment Protection Authority
EPC	Engineering, Procurement and Construction
EPRI	(US) Electric Power Research Institute
ERP	Emergency Response Plan
FEMP	Fire & Emergency Management Plan
FRV	Fire & Rescue Victoria
FSS	Fire Safety Study
HF	Hydrogen Fluoride
HIPAP	Hazardous Industry Planning Advisory Paper
HRA	Hazard and Risk Assessment
HSE	(UK) Health and Safety Executive
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IPA	Inner Protection Area
IRPA	International Radiation Protection Association
LCO	Lithium Cobalt Oxide
LFP	Lithium Iron Phosphate ($LiFePO_4$) – common type of lithium battery chemistry
LTO	Lithium Titanate
LGA	Local Government Area

MLRA	Multi-Level Risk Assessment
MW	Megawatt
MWh	Megawatt hour
NHMRC	National Health and Medical Research Council
NMC	Nickel Manganese Cobalt ($LiNi_xMn_yCo_zO_2$) -) – common type of lithium battery chemistry
NSW	New South Wales
O&M	Operations and Maintenance
PCB	Polychlorinated Biphenyl
PHA	Preliminary Hazard Analysis
PPE	Personal Protection Equipment
PRS	Preliminary Risk Screening
R&D	Research and Development
RMP	Risk Management Plan
SME	Subject Matter Expert
SWMS	Safe Work Method Statement
TIA	Transport Impact Assessment
TL	Transmission Line
TNO	Netherlands Organisation for Applied Scientific Research
UN	United Nations
VBB	Victoria Big Battery
VESDA	Very Early Smoke Detection Apparatus
WMP	Waste Management Plan

Units

ha	hectare (10,000 m^2)
kL	Kilolitre (1,000 litres)
km	Kilometre (1,000 metres)
kV	Kilovolt (1,000 volts)
kVA	Kilovolt Amps
kW	Kilowatt (1,000 watts)
m	Metre
mG	Milli-Gauss
μT	Micro-Tesla
MW	Megawatt (1 x 10^6 watts)
MWh	Megawatt-Hour
V	Volt

1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Cobden BESS Pty Ltd (Cobden BESS) to undertake a Hazard & Risk Assessment (HRA) for the proposed Cobden Battery Energy Storage System (BESS) with a capacity of 75 MW / approximately 300 MWh at the point of connection, and associated infrastructure, located at 89 Cobden-Port Campbell Road, Cobden, Victoria, formally known as Lot 1 TP863659 and Lot 2 TP863659 (the Project).

This study forms part of the Planning Permit application for the Project and has been prepared in accordance with the relevant regulatory documents listed in Section 1.2.

1.1 Assessment Terminology

In this assessment, the following terminology applies:

- *Project* – the proposed Cobden BESS.
- *Subject Site* – consisting of Lot 1 of TP863659 and Lot 2 of TP863659;
- *Project Area* – the area as marked in **Figure 3** associated with the Project within the Subject Site, consisting of all compounds, buildings and equipment within the Project boundary fence, including:
  - *BESS Compound* – the area of the BESS battery containers.
  - *Substation Compound* – the area of the Project substation.
  - *Switch Room / Control Room.*
  - *O&M Buildings.*

1.2 Relevant Regulatory Documents

The HRA has been undertaken according to the following regulatory standards and guidelines (listed by sub-category):

Australian Standards (AS)

- AS/NZS 5139:2019 *Electrical Installations – Safety of Battery Systems for Use with Power Conversion Equipment*.
- *AS1940-2017: The storage and handling of flammable and combustible liquids*.
- AS3780-2023 *The storage and handling of corrosive substances*.
- AS4452-1997: *The storage and handling of toxic substances*.
- AS/NZS 1851: *Maintenance of fire protection equipment*.
- AS/NZS 1850: *Portable fire extinguishers*.
- AS 3439-2002: *Low voltage switchgear and control gear assemblies*.

International Standards (ISO)

- ISO 31000 (2018) – *Risk Management – Guidelines.*

Commonwealth of Australia

- Commonwealth Government, National Transport Commission, *Australian Code for the Transport of Dangerous Goods by Road and Rail*, Edition 7.9, 2024.

VIC

- VIC Country Fire Authority (CFA), *Design Guidelines and Model Requirements for Renewable Energy Facilities*, v4.4 (June 2025), CFA Specialist Risk and Fire Safety Unit.

  Herein: **CFA RDG-v4.4**

NSW

- Planning NSW, 2011a, *Risk Criteria for Land Use Safety Planning – Hazardous Industry Planning Advisory Paper No 4*, New South Wales Government.
- Planning NSW, 2011b, *Hazard Analysis*, Hazardous Industry Planning Advisory Paper No.6 (HIPAP 6).
- Planning NSW, 2011c, *Multi-Level Risk Assessment (MLRA).*

EMF & EMR

- ARPANSA (Australian Radiation Protection and Nuclear Safety Agency), *Report by the ARPANSA Radiofrequency Expert Panel on Review of Radiofrequency Health Effects Research – Scientific Literature 2000-2012*, ARPANSA Technical Report No 164, 2014.
- ARPANSA (Australian Radiation Protection and Nuclear Safety Agency), *Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz*, Radiation Protection Series S-1 (Rev.1), February 2021.
- ICNIRP (International Commission on Non-Ionizing Radiation Protection) 1998, *Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz)*, 2020.
- United States Environmental Protection Agency, 2021. About Acute Exposure Guideline Levels.

General Guidance

- ASC/ESC 5000: The Australian Battery Guide, Energy Storage Council, March 2023.
- DNVGL Report No. OAPUS301WIKO(PP151894, Rev.4), *Considerations for ESS Fire Safety*, prepared for Consolidated Edison and NYSERDA, NY, February 2017.
- Fire Protection Research Foundation, 2016. *Hazard Assessment of Lithium Ion Battery Energy Storage Systems*.
- FM Global, 2020. Property Loss Prevention Data Sheet 5-33, *Electrical Energy Storage Systems*.
- National Fire Protection Association, 2023 - NFPA 855 *Standard for the Installation of Stationary Energy Storage Systems*.
- Underwriters Laboratory, 2017. UL 9540A Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.
- Underwriters Laboratory, 2020. UL 9540 Standard for Safety of Energy Storage Systems and Equipment.
- UK Department for Energy Security & Net Zero - *Guidance: Health and Safety in Grid Scale Electrical Energy Storage Systems*, April 2024.

1.3 Assessment Methodology - Background

The HRA developed for the Project conforms to the requirements contained in:

- ISO 31000 (2018) - *Risk Management – Guidelines.*
- CFA RDG-v4.4

The HRA will provide key inputs to the post-consent development of the Project Risk Management Plan (RMP), whose linkage with other management plans for the Project is shown in **Figure 1**.

An HRA is a systematic process (achieved through communication and consultation) for assessing, treating, monitoring, reviewing, recording and reporting risk.

The process is illustrated in **Figure 1.**

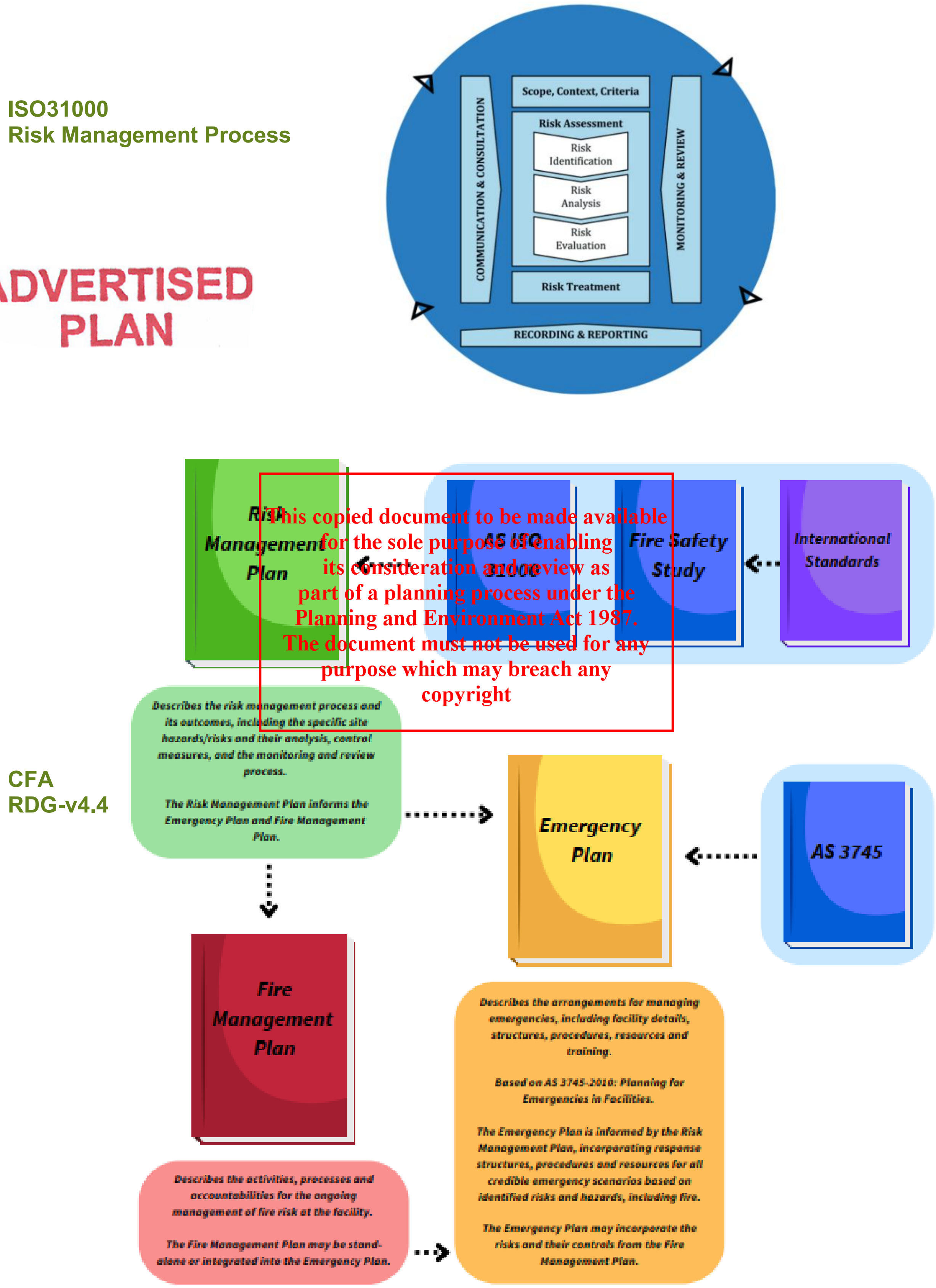
1.4 Structure of Report

Table 1 outlines the remaining sections which form this HRA.

Table 1 Hazard & Risk Assessment Report Structure

Section	Description
Section 2	Description of the Project
Section 3	Preliminary Risk Screening
Section 4	Preliminary Hazard Analysis
Section 5	BESS Hazards and Risk Management
Section 6	BESS Incident Case Studies & Lessons Learned
Section 7	Substation Main Transformer Risk Management
Section 8	EMF Hazards and Risk Management
Section 9	Conclusion

Figure 1 Key Management Plan Linkages



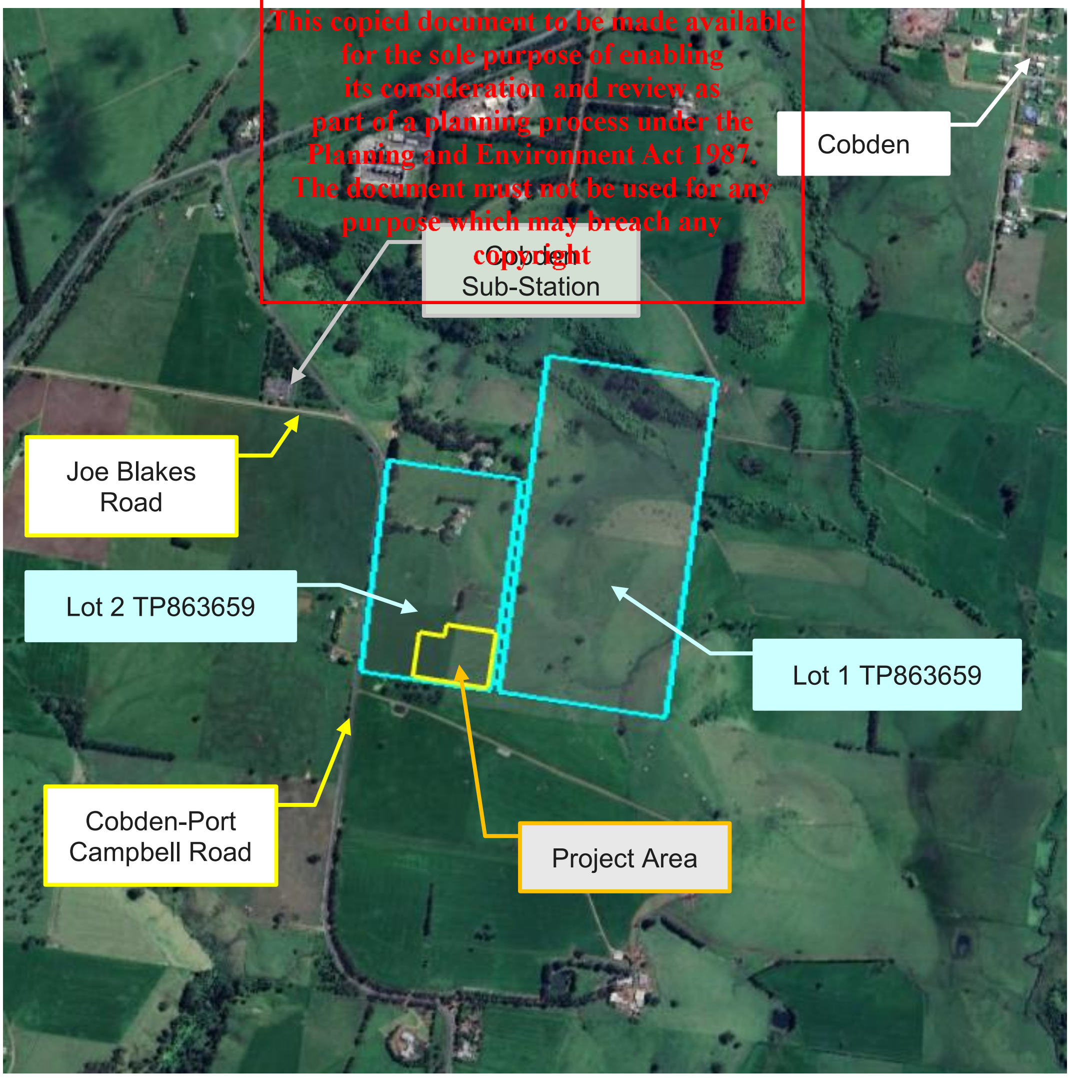
2.0 Project Description

2.1 Subject Site Location

The Cobden Battery Energy Storge System (BESS), herein “the Project”, will involve the development, construction, operation, and eventual decommissioning of a BESS with capacity of 75 MW and approximately 300 MWh at the point of connection - refer **Figure 2**.

- The Project is located at 89 Cobden-Port Campbell Road, Cobden, Victoria, formally known as Lot 1 TP863659 and Lot 2 TP863659 (the Subject Site).
- The 49.3 ha Subject Site is located within the Corangamite Shire Council Local Government Area (LGA) and lies just over 2 km to the southwest of the outskirts of Cobden.
- The footprint of the Project Area within the Subject Site is approximately 2.4 ha.
- The BESS will be connected into the 66 kilovolt (kV) sub-transmission line which runs from Cobden Zone Substation to Camperdown Zone Substation in a line-in-line-out configuration. Powercor, as the network provider, will facilitate effective integration into the existing power grid.

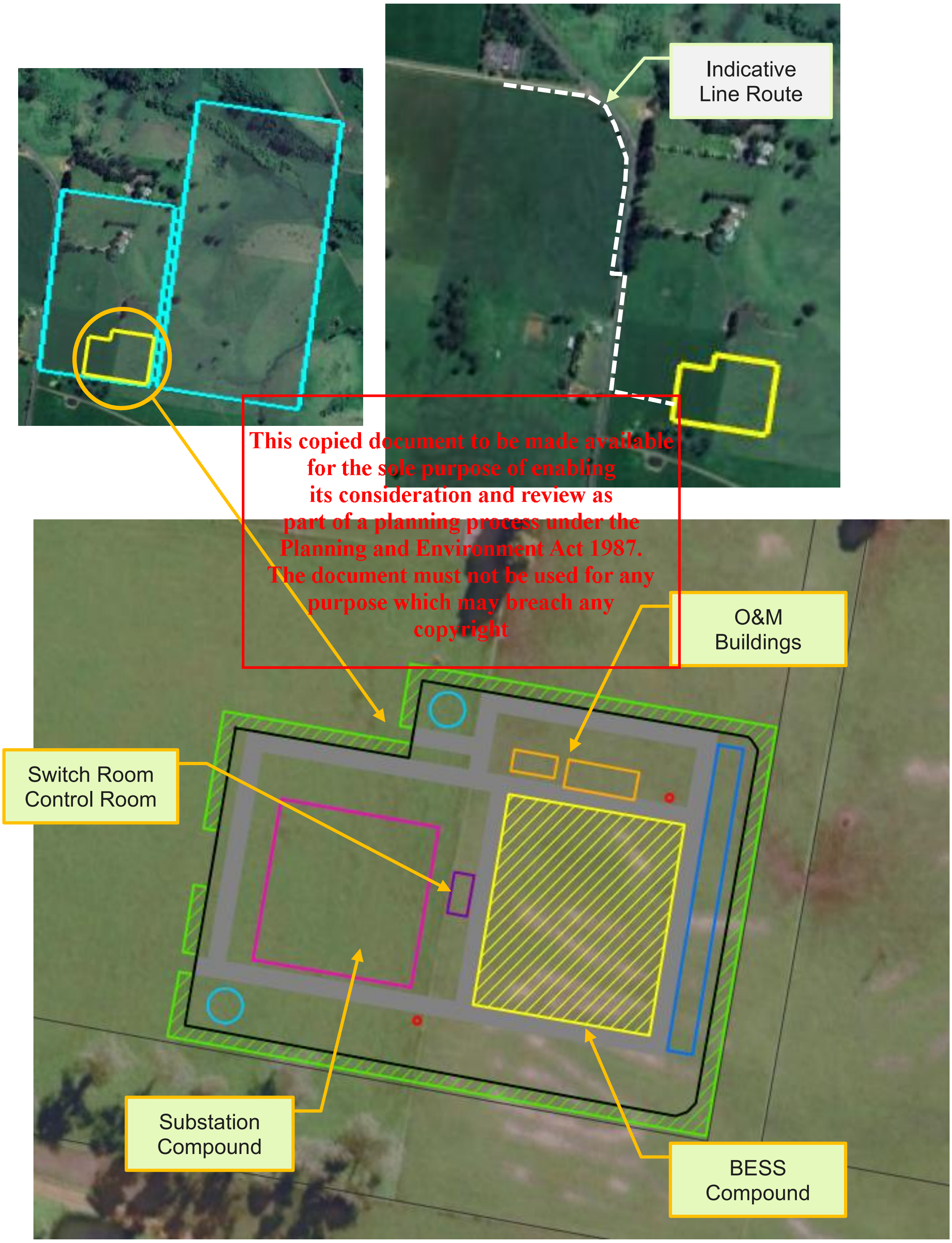
Figure 2 Project Location



2.2 Project Layout

The layout of the Project is shown in **Figure 3**, along with a concept diagram showing the position of the BESS Compound and Substation Compound.

Figure 3 Project Layout



2.3 Development Description

2.3.1 Construction

Construction of the Project would require heavy vehicles, plant, and equipment for the transportation of components and installation of the components on the Subject Site. Construction laydown areas and temporary buildings may also be established on the Subject Site outside the Project Area. Earth-moving machinery, cable-trenching equipment, forklifts, and cranes will be required, subject to detailed design, to install the BESS and undertake associated civil and ancillary works.

It is anticipated that the construction and commissioning phase will last approximately 24 months. Over that time, the main construction activities will include:

- Pre-construction activities including driveway apron.
- Project establishment works including vegetation clearing within the Project Area fencing boundary, bulk earthworks, and temporary construction compound.
- Construction of hardstand, gravel all weather access road and BESS internal roads and drainage;
- Installation of a substation including installation of earthing grid, benching works, transformer bunding, installation of 66/33 kV main transformers, outdoor switchgear, high voltage (HV) busbar and support structure, overhead gantry structures, harmonic filters, and reactive plant;
- Construction of an overhead power line from the substation, connecting west to the road reserve and then up towards the north, to cut into existing overhead lines located along Cobden-Port Campbell Road. These works will be undertaken by Powercor;
- Installation of underground 33 kV reticulated cabling, auxiliary transformers, battery containers, and the PCS;

- Construction of ancillary works including parking areas, water tank, storage structures, stormwater management infrastructure, water containment infrastructure, and security lighting and fencing, including vegetation screening;
- Construction of Operations & Maintenance building, and delivery and installation of Control Room and Switch Room;
- Transport of construction personnel, associated heavy and light vehicles, and materials to and from the Subject Site on a day-to-day basis, dependent on construction schedule;
- Cold and hot commissioning of BESS and substation equipment;
- Hold point testing and Final Acceptance; and
- Removal of temporary construction facilities, and rehabilitation of disturbed areas following completion of construction of the Project.

2.3.2 Operation

During operation, the Project is proposed to self-operate 24 hours a day 7 days a week and will only require periodic maintenance by authorised staff. The Project Area would otherwise be restricted to the public.

Minimal plant and equipment will be required for operation of the Project, primarily for staff access and maintenance vehicles.

The operation of the Project would involve, but not be limited, to the following general activities:

- Maintenance and management of equipment, site buildings, and landscaping.
- General administrative activities.
- Receipt of equipment or goods.
- Waste removal from maintenance and administration activities.

Emergency responses and maintenance activities may be required to be undertaken out of hours.

The operational life of the Project will be determined by the evolving nature of the technology. It is currently envisaged that the lifespan will be approximately 25-30 years.

Key Access Characteristics:

- Access to and from the Project Area would be provided by a dedicated road within the Subject Site (Lot 2 TP863659) from Cobden-Port Campbell Road. Access would be enabled from both the north (Cobden) and south (Scott's Creek and Timboon).
- Internal roads are proposed to accommodate firefighting access during an emergency situation.

2.3.3 Decommissioning

The Project is proposed to be decommissioned and the infrastructure removed following the End of Life (EOL) of the Project, with works required to return the Subject Site as close as possible to its original state and use.

All decommissioning and restoration activities would be in accordance with regulatory requirements at the time.

2.3.4 Project Equipment

Essential specifications for key Project equipment items are shown in **Table 2**, with an example of a BESS module installation shown in **Figure 4**.

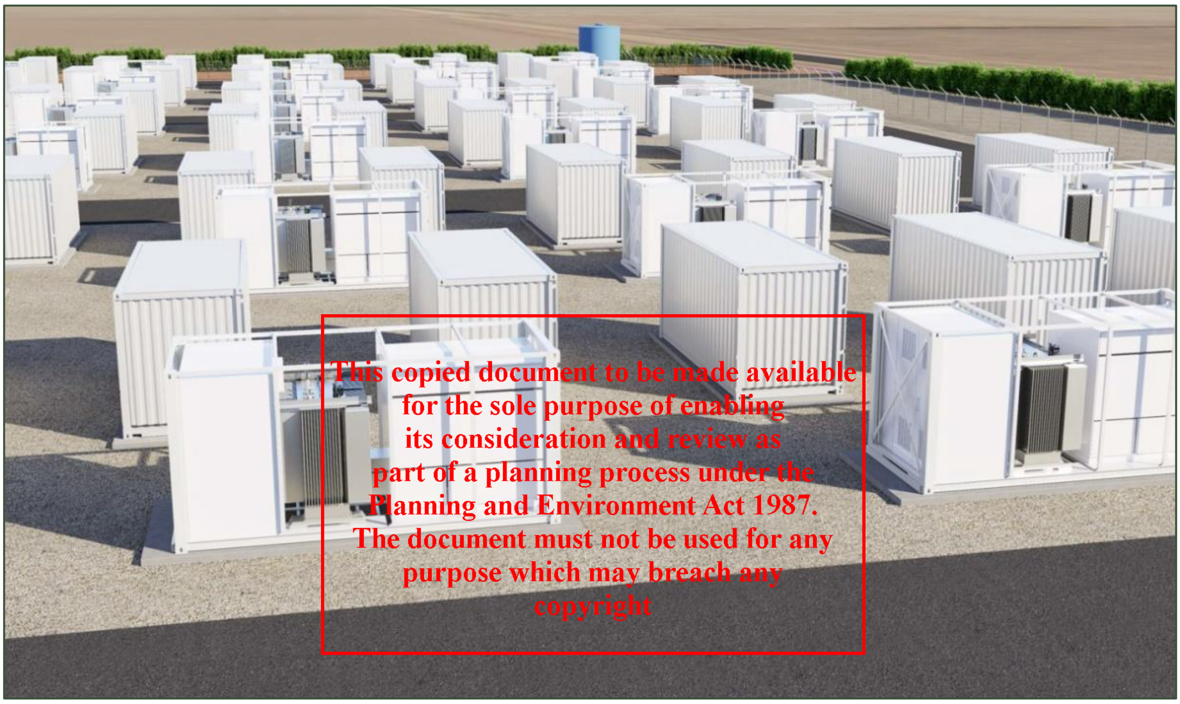
Table 2 Project Specifications[1]

Specification	Details
No. of Battery Containers	Up to 66
No. of Battery Racks per Enclosure	4-6
Battery Container	20 ft Battery Energy Storage System
Storage Inverter	4600.0 kVA
Power Conversion system	4.6 MVA, 0.69/33.0kV
Dimensions	L: 6058mm x W: 2438mm x H: 2896mm (20 ft high cube shipping container)

[1] Final BESS specifications will be subject to detailed design

Specification	Details
Battery Chemistry	Lithium-iron-phosphate (LFP)
Inverters	22
MV Transformers	22
Substation	1 x 66/33 kV Transformer, 2 x 66 kV lines out

Figure 4 Indicative Image of BESS Modules



2.3.5 Grid Connection

The BESS will be connected into the 66 kV sub-transmission line which runs from Cobden Zone Substation to Camperdown Zone Substation in a line-in-line-out configuration. Electricity stored within the BESS will be converted from DC to AC by onsite inverters and transferred through underground 33 kV cables to the proposed onsite 66/33kV substation, where it will be increased to 66 kV for discharge into the electricity network.

The proposed overhead sub-transmission line will originate from the Project substation and connect west to the existing overhead lines located along Cobden-Port Campbell Road. Network provider Powercor will facilitate effective integration into the existing power grid. All approvals required outside the Subject Site are the responsibility of Powercor.

2.3.6 Removal of Vegetation

The proposed BESS and Substation Compounds, external access and connecting sub-transmission line easement will require minimal clearing of Subject Site vegetation.

2.3.7 Water Usage

As noted above, water will be required during the construction phase for dust suppression, general construction, and maintenance activities. This water will be brought to the Subject Site in water tankers.

Construction water requirements for the Project are anticipated to be sourced from local bulk water supply.

Wastewater during construction will be captured and appropriately removed from the Subject Site and disposed of in accordance with the council/water authority requirements.

Potable water may be transported to the Project in bottles for use by the construction workforce.

If utilised, toilet facilities will involve waterless toilets (or equivalent) that are emptied off-site.

A 288 kL static water supply comprising two 144 kL tanks available for firefighting purposes will be constructed at an early stage of the Construction phase.

- These tanks will remain available for firefighting purposes during the Construction, Operation and De-commissioning phases of the project.

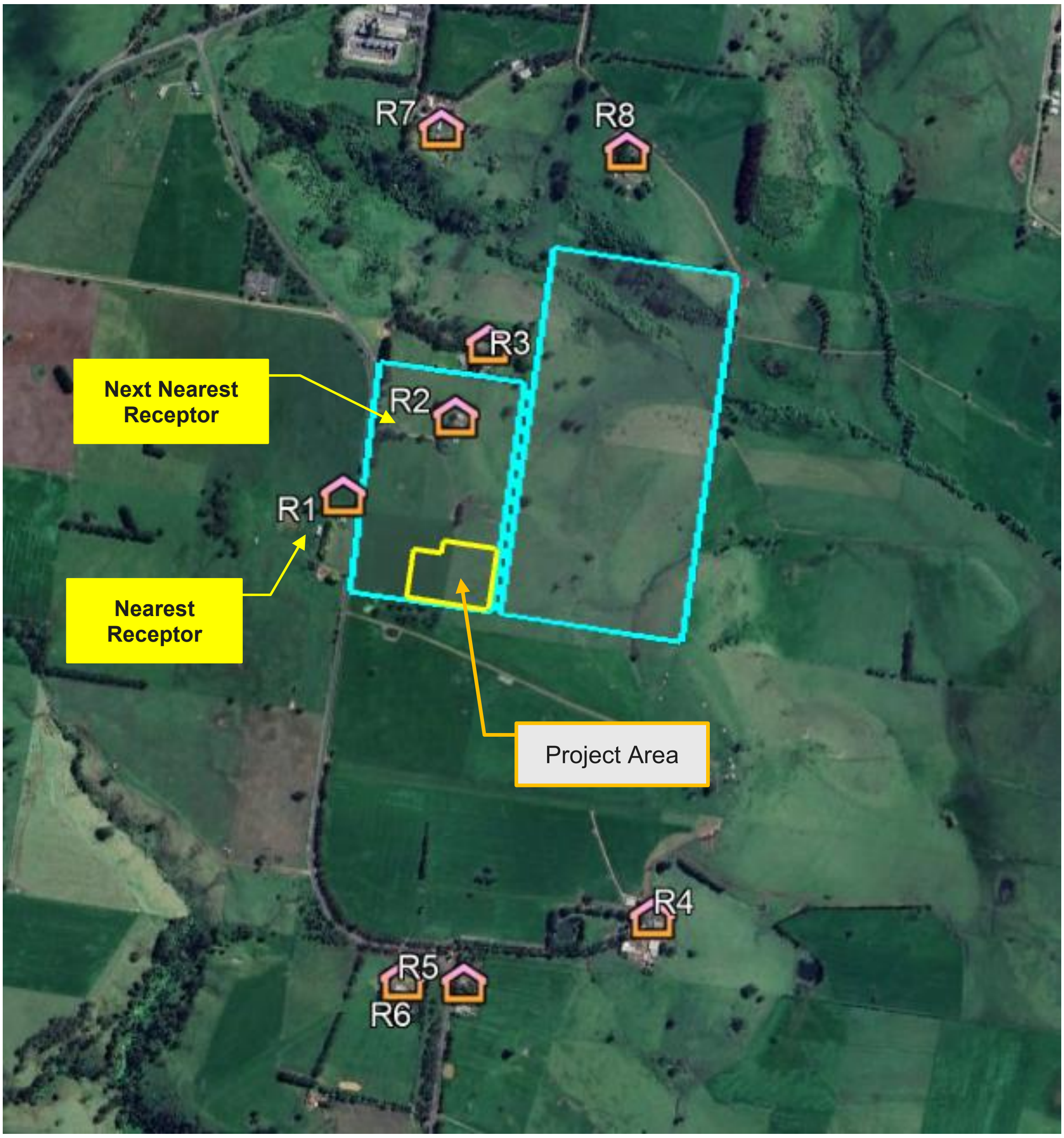
2.4 Nearest Sensitive Receptors

The nearest sensitive receptors to the project are shown in **Figure 5**. The closest receptors to the Project Area centroid are just under 300 m – refer **Table 3**.

Table 3 Nearest Sensitive Receptors

Receiver ID	Approximate Distance to BESS Centroid
R1	280 m
R2	290 m
R3	450 m
R4	860 m
R5	910 m
R6	900 m
R7	920 m
R8	930 m

Figure 5 Nearest Sensitive Receptors



3.0 Preliminary Risk Screening (PRS)

Preliminary Risk Screening (PRS) of the Project is required to determine the need for a Preliminary Hazard Analysis (PHA).

PRS assesses the storage and transport of dangerous goods classes that have the potential for significant off-site effects. Specifically, PRS involves the identification of classes and quantities of all dangerous goods to be used, stored or produced within the Project Area.

The Project's hazardous materials and associated potential risks are:

- Materials/Activities involved in Construction Phase Activities;
- Materials/Activities involved in Operational Phase Activities;
- Materials/Activities involved in De-Commissioning Phase Activities; and
- Electrical Equipment other than the Project BESS units.

The hazards and risks related to the BESS element of the Project are examined separately within the PHA section of this report.

3.1 Dangerous Goods or Other Hazardous Materials

3.1.1 Construction Phase Materials / Activities

The key elements of the Construction phase of the Project were described in **Section 2.3.1**.

No toxic chemicals or processes will be involved in the Construction stage of the Project.

Dangerous goods during this phase will therefore consist of:

- Fuel for use by construction plant and equipment, which will be stored on-site.
- Tiny amounts of clinical waste stored safely by medical or first aid staff at the Project First Aid Station – these will be disposed of at the nearest district hospital or another suitable facility as required.
- Fire extinguishers, machine oils and lubricants and hydraulic fluid.
- Herbicides for pest and vegetation management.

3.1.2 Operational Phase Materials / Activities

Key elements of the Operational phase of the Project are as follows:

- No hazardous chemicals will be produced during operation of the Project.
- Quantities of regulated substances will be stored on-site (for maintenance, repair, emergency, etc, purposes) which are expected to be used entirely, leaving no waste.
- These will be stored in a properly maintained (and code-compliant) storage area with suitable signage, any Personal Protection Equipment (PPE) requirements if relevant, etc.
- They will include fire extinguishers, machine oils and lubricants, hydraulic fluid and spare (emergency) fuel.
- Maintenance of the Project Area will require vegetation throughout to be kept low, both for occupational health and safety reasons and fire safety.

- In relation to such maintenance:
  - If any herbicides are used, the Project is committed to only using general use, over-the-counter, herbicides, as opposed to restricted use herbicides sometimes used in intensive commercial operations where such herbicides require a special restricted use license.
  - Similarly, if a growth regulator is used in order to slow down vegetation growth, only commonly-used products will be chosen such as those regularly used on highway roadsides, golf courses, etc.

3.1.3 De-Commissioning Phase Materials / Activities

The De-Commissioning phase of the Project will mirror the Construction phase in terms of materials and equipment activities. Note that disposal of the BESS unit Lithium-ion battery components is dealt with in the PHA section of this report.

3.1.4 Other Electrical Equipment (excluding BESS Units)

In relation to other equipment:

- Transformers contain transformer oil for insulation and cooling. Toxic Polychlorinated Biphenyls (PCBs) are no longer used as a cooling fluid. Instead, non-toxic mineral or biodegradable oils are used.

3.2 PRS Assessment

The dangerous goods that will require storage at, and transportation to/from the Project Area are identified in **Table 4** and **Table 5** respectively, along with their respective ADG Thresholds.

The final storage quantity and transportation parameters of the materials listed in **Table 4** and **Table 5** will be confirmed during detailed design but, as currently foreseen, they do not exceed the relevant storage (or transport) thresholds.

Storage protocols will comply with relevant guidelines and standards, e.g. AS 1940-2017 for the storage of fuels and pesticides/herbicides at the Project Area.

The storage and handling of dangerous goods to be used, stored and/or transported to/from the Project Area are therefore not considered potentially hazardous with regards to the ADG screening thresholds.

Further detailed analysis, i.e. via a Preliminary Hazard Analysis, is therefore not required for those materials.

3.3 Dangerous Goods: BESS and Diesel

BESS Units

The Project's BESS units are battery powerpacks consisting of lithium-ion batteries.

- Lithium-ion batteries are classed as Class 9 Miscellaneous Dangerous Substances and articles, which are normally excluded from the PRS process.
- However, the hazards associated with these batteries mandate that a Preliminary Hazard Analysis (PHA) is required to further assess the hazards and risks associated with their installation and operation.
- This is covered in subsequent sections of this report.

Table 4 ADG Classification of Dangerous Goods – Storage

Class	Category	Item / Usage	Thresholds	Project Storage
Class 2.2	Non-flammable Non-toxic	Fire Extinguishers . Fire Suppression Gas	N/A	N/A
Class 2.2	Non-flammable Non-toxic	BESS Refrigerant	N/A	N/A
Class 3	Flammable Liquids	Fuel (diesel) [1] . CONSTRUCTION . OPERATION	5 tonne refer also **Section 3.3**	1 tonne
	Mineral Oils	Transformer Oils (TOP-UP) (e.g. Insulating Oil)		1,000 L
Class 6.1	Toxic Substances	Pesticides (Herbicides) . ground cover management	2.5 tonne	< 100 kg
Class 9	Miscellaneous Dangerous Substances and Articles	BESS Li-ion batteries	N/A refer also **Section 3.3**	Refer PHA **Section 4**
N/A	Mineral Oils	Transformer Oils (TOP-UP) (e.g. Insulating Oil)	N/A	1,000 L

Note 1 Diesel is only classified as a potential Dangerous Good if stored in the presence of other flammable liquids.

Table 5 ADG Classification of Dangerous Goods - Transport

Class	Category	Threshold		Project	
		Quantity	Movements	Quantity	Movements
Class 2.2	Fire Suppression Gas	N/A			
Class 3 PGII	Fuel (diesel) [1] . CONSTRUCTION . OPERATION	3 tonne (bulk) 10 tonne (packs)	>750/yr cumul. >45/wk	1 tonne	10/yr cumul. 1/mo
Class 3 PGII	Transformer Oil (Top-Up Only)			1,000 L	10/yr cumul. 1/mo
Class 6.1 PGII	Pesticides (Herbicides)	1 tonne (bulk) 3 tonne (packs)	All	< 100 kg	1 per 3-4mo
Class 9	Li-ion batteries	N/A	200/yr cumul. 10/wk (max)	N/A	Refer PHA **Section 4**

Note 1 Diesel is only classified as a potential Dangerous Good if stored in the presence of other flammable liquids.

Diesel and Transformer Oil

Diesel fuel to be stored on site, is not classed as a Dangerous Good, but is classed as a C1 Combustible Liquid, provided no flammable liquids are stored with the diesel.

Similarly, top-up Transformer Oil to be stored within the Project Area, is not classed as a Dangerous Good, but is classed as a C1 Combustible Liquid, provided no flammable liquids are co-located.

SLR has been advised by the Proponent that the modest amounts of diesel and transformer oil stored at the Project Area will not be co-located.

While C1 Combustible Liquids are not a Dangerous Good under UN (United Nations) classification, they are defined as Dangerous Goods under the workplace legislation adopted throughout Australia.

For the Project, reference is made to the manifest quantities from Schedule 2 of the Dangerous Goods (Storage and Handling) Regulations 2022 (Regulations).

The proposed inventory of diesel and top-up transformer oil, and classification is provided in **Table 6** below.

Table 6 Classification of Diesel in Storage

Substance	Hazardous Class / Packing Group	Combustible Liquid Class	Total Storage on Site	Manifest Quantity	Threshold Level Determination
Diesel	N/A / N/A	**C1**	1 tonne	100 tonnes 100,000 litres	Worksafe Victoria Notification **NOT required**
Transformer Oil (Top-Up)			1,000 L		

It can be seen that the storage of diesel and transformer oil at the Project Area during the Operational stage of the Project is well below the threshold for Worksafe Victoria notification.

Separation distances of the stored diesel and transformer oil at the Project Area will be as per AS1940-2017 *Storage and Handling of Flammable and Combustible Liquids* – Table 4.2.

4.0 Preliminary Hazard Analysis (PHA)

Where a development is considered to be potentially hazardous and/or offensive, the developments is required to undertake a Preliminary Hazard Analysis (PHA) to determine the level of risk to people, property and the environment at the proposed location and in the presence of controls.

The hazard analysis and risk assessment approach relies on a systematic and analytical approach to the identification and analysis of hazards and the quantification of off-site risks to assess risk tolerability and land use safety implications.

4.1 PHA Methodology

The PHA methodology adopted in this HRA involves the following steps:

Step 1: Hazard Identification;

Step 2: Hazard Analysis (Consequence and Probability Estimations); and

Step 3: Risk Evaluation and Assessment against Specific Criteria.

4.1.1 Step 1: Hazard Identification

This step involves the identification of all theoretically possible hazardous events as the basis for further quantification and analysis. This does not in any way imply that the hazards identified or the theoretically possible impacts will occur in practice.

For this Project, a survey of operations was carried out to identify events outside of normal operating conditions with the potential to impact both the Project Area itself and surrounding areas. Such events would normally be considered atypical or abnormal, compared to normal Project operations .

4.1.2 Step 2: Hazard Analysis

After a review of the events identified in the Hazard Identification stage and a parallel review of any prevention/protection measures already incorporated into the Project design, events which have the potential to result in adverse impacts off-site or which have the potential to escalate to larger incidents are carried to the next stage of analysis.

Consequence Estimation

Consequence Estimation involves analysis and modelling of any credible events which remain following the Hazard Identification process. These events typically include explosion, fire, smoke, dispersion/propagation and stormwater contamination and their potential effects on people and/or damage to property.

Probability Likelihood Estimation

Where necessary, the likelihood of incidents quantified as a result of consequence estimation are determined by adopting probability and likelihood factors derived from published data or via detailed analysis.

4.1.3 Step 3: Risk Evaluation and Assessment

Risk analysis involves estimating the consequences of a hazardous event and the frequency of the relevant initiating failure. The results of consequence calculations (radiation and overpressure contours, and toxic exposure levels) together with the probabilities and estimated likelihoods are then compared against the nominated criteria. The need or otherwise for detailed computations is based on the probabilities and likelihood estimated and if the relevant risk criteria are exceeded.

4.2 MLRA (Multi-Level Risk Assessment) Risk Criteria

As part of the MLRA, hazards are identified and the risk from the hazards estimated. Risk criteria take into consideration surrounding land uses, and the category of risk. They encompass such elements as injury/irritation, individual and societal risk of fatality, property damage and harm to the biophysical environment. Criteria may be expressed in qualitative or quantitative terms.

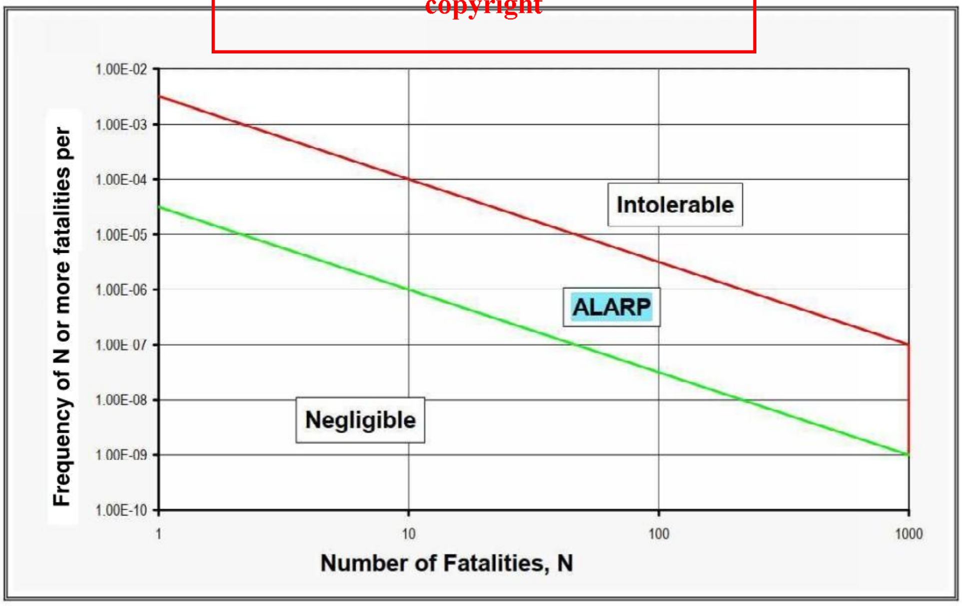
A key concept is that societal risks should be "As Low as Reasonably Practical", known as the ALARP principle.

ALARP has been described by the UK Health and Safety Executive (HSE) in the following terms:

- *"In weighing the costs of extra safety measures the principle of reasonable practicability (ALARP) applies in such a way that the higher or more unacceptable a risk is, the more, proportionately, an employer is expected to spend to reduce it".*

The indicative societal risk criteria reflect these regions as three societal risk bands: negligible, ALARP and intolerable, as shown in the example below in **Figure 6**.

Figure 6 Indicative Societal Risk Criteria



Source: Planning NSW, HIPAP 4, New South Wales Government, Figure 3

In relation to **Figure 6:**

- Below the *Negligible* line, provided other individual criteria are met, societal risk is not considered significant.
- Above the *Intolerable* level, an activity is considered undesirable, even if individual risk criteria are met.
- Within the *ALARP* region, the emphasis is on reducing risks as far as possible towards the negligible line.
- Provided other quantitative and qualitative criteria are met, the risks from the activity would be considered tolerable in the ALARP region.

4.2.1 Risk Matrix

The risk assessment in the current study was based on hazard identification, consequence assessment and likelihood assessment, to create an overall risk assessment – refer **Figure 7**.

Figure 7 Risk Matrix

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	ALARP	ALARP	Intolerable	Intolerable	Intolerable
Likely	Low	ALARP	ALARP	Intolerable	Intolerable
Possible	Low	Low	ALARP	ALARP	Intolerable
Unlikely	Low	Low	Low	ALARP	ALARP
Rare	Low	Low	Low	Low	ALARP

In assessing the tolerability of risk from potentially hazardous development, the relevant general principles are:

- the avoidance of all avoidable risks;
- the risk from a major hazard should be reduced wherever practicable, even where the likelihood of exposure is relatively low;
- the effects of significant events should, wherever possible be contained within the site boundary; and
- where the risk from an existing installation is already high, further development should not pose any incremental risk.

With regard to the latter bullet point, the proximity of the Project BESS Compound and Substation Compound within the Project Area is noted as being significant.

However, the location of the nearby Cobden Substation on Joe Blakes Road is not considered significant, given the distance separation involved.

4.2.2 Risk of Property Damage and Accident Propagation

The siting of an installation must account for the potential for propagation of an accident causing a “domino” effect on adjoining premises. In the current study, there exists a potential risk, albeit modest, for property damage and accident propagation to adjoining residential properties, based on the distances to nearest residences and site boundaries noted in **Section 2.4**.

4.3 Risk Criteria

Risk criteria are required for the following:

- Individual Fatality Risk, Individual Injury Risk and Risk of Property Damage and Accident Propagation.

The criteria used throughout Australia are shown in **Table 7, 8 and 9** respectively.

These contain both:

- A physical element (e.g. a value of heat flux radiation or explosion overpressure); AND
- A probability of occurrence element (e.g. an annual probability of occurrence of 50 in a million, 0.005%).

Table 7 HIPAP Criteria – Individual Fatality Risk

Land Use	Risk Criteria (fatal injuries per million per year)
Hospitals, schools, child-care facilities, old age housing	0.5
Residential, hotels, motels, tourist resorts	1
Commercial developments including retail centres, offices and entertainment	5
Sporting complexes and active open space	10
Industrial Applications	50

Table 8 HIPAP Criteria – Individual Injury Risk

Injury Risk Event	Risk Criteria (fatal injuries per million per year)
Heat Radiation (4.7 kW/m^2)	50
Explosion Overpressure (7 kW/m^2)	50
Exposure to Toxic Gas/Smoke/Dust (resulting in serious injury upon short-term exposure)	10
Exposure to Toxic Gas/Smoke/Dust (resulting in irritation on term exposure)	50
Industrial Applications	50

Table 9 HIPAP Criteria – Risk of Property Damage and Accident Propagation

Injury Risk Event	Risk Criteria (property damage per million per year)
Heat Radiation (23 kW/m^2)	50
Explosion Overpressure (14 kW/m^2)	50

4.4 Potential Hazardous Incidents Identified for Review

Following a review of the Project, potentially hazardous events or scenarios were evaluated to establish if further comprehensive qualitative analysis was required.

These have been subject to discussion with the Proponent and their experts.

A summary of the hazardous events, causes, consequences and controls has been set out in **Table 10** covering the Construction, Operational and De-Commissioning phases of the Project.

Two categories of risk are identified in **Table 10**:

- Risk levels which can be reduced to the Negligible or ALARP level via standard engineering design approaches, adherence to the relevant design codes, etc.
  - An example of this category is ensuring that all equipment at the Project Area is designed to withstand the impact of extreme winds (via compliance with AS 1170.2-2021) or seismic loads (via compliance with AS 1170.4-2024).
- Risk levels which require detailed, site-specific or non-standard management and mitigation measures to achieve at least an ALARP risk rating.
  - These risks require a detailed hazard assessment, achieved via a Level 1 (qualitative), Level 2 (semi-quantitative) or Level 3 (quantitative) assessment.

The following hazards were deemed to lie within the second category:

External

- Bushfire Risk

Internal

- BESS Unit fire-related and/or explosion-related risk, potentially caused by:
  - A thermal runaway event.
  - Radiation from an adjacent fire (e.g. MV Skids).
- Transformer Pool Fire risk – relevant to both the BESS compound transformers (MV Skids) and the Main Substation Transformer.
- BESS Container fire-related Toxic Plume Risk – containing potentially hazardous substances, e.g. Hydrogen Fluoride (HF), and the risk of downstream firewater contamination.

The above hazards are addressed in subsequent sections of this HRA.

Table 10 Summary of Potential Major Incident Scenarios, Uncontrolled Risk & Residual Risk after Implementation of Controls

Note 1: Project Phase: ○ **= Construction | ■ = Operation | ▲ = De-Commissioning**

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
Traffic Accident	○ ▲	Traffic into and out of the site during peak construction phase could lead to vehicle collisions.	Equipment damage Road closure Driver fatality	Possible	Moderate to Catastrophic	Medium to High	Construction Traffic Management Plan will implement all recommendations from the Traffic Impact Assessment, (TIA) including: • drivers to follow the Project Driver Code of Conduct (refer TIA) and obey all VIC road rules • Subject Site entry design consistent with Australian Standards and Austroad Guidelines • additional Advisory signage to be provided near site entry • drivers to obey 10 kph speed limit within the Project Area boundary.	Negligible to ALARP
Break up of Soil Structure	○ ▲	Ground works and vehicle transport break	Mobilisation of soil / sediments into surface water and	Possible	Moderate	Medium	Project design to include secondary containment, bunding / sediment traps if needed to retain as much	Negligible

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
		up soil structure.	nearby catchments				water and sediment as possible on site	
Concreting (hardstands etc)	○	Accidents arising from concrete pumps, booms, etc	Serious to critical injury to personnel	Possible	Major to Catastrophic	Medium to High	Spotter, trained personnel allowed in vicinity of works only, equipment only used on stable, level ground, SWMS, PPE, etc.	Negligible to ALARP
Vandalism	○ ■ ▲	Illegal site entry and damage to equipment. Damage to equipment from outside boundary, e.g. gunshot	Structural damage ranging from minimal to major. Vandals may also suffer electric shock or other accidents while on site.	Unlikely	Minor to Major	Medium	Project Area has security measures in place, such as secure fences, gates, etc to restrict unauthorised access to Project Area	Negligible
Physical Damage to Transformers (no combustion)	○ ■ ▲	Transformers damaged during installation, vehicle collision or from acts of vandalism	Release of oils from transformers which will be slowly absorbed into the ground.	Unlikely	Minor to Major	Low to Medium	Suite of controls covering: • On-site personnel to have relevant training in receiving equipment, unloading, temporary placement, etc. • Operational personnel to have relevant training in installation and initial	Negligible

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
							equipment checks of transformers. • Substation design to include secondary containment to contain spill. Design to follow guidance in relevant standards such as AS 1940 The storage and handling of flammable and combustible liquids, and AS2067-2016 Substations and high voltage installations greater than 1kV(ac). • The Project Area has security measures in place, such as secure fences, gates, etc to restrict unauthorised access to transformers and fire barriers for the transformer itself. • FEMP – Fire & Emergency Management Plan will deal with emergency	

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
							response to physical damage to transformers, HAZMAT, etc. The areas of soil directly contaminated by oil may be removed to a suitable depth, for example 10cm - 20cm based on advice from a Land Contamination expert. The soil removed to be taken off site for suitable disposal based on a waste classification of the soil	
Physical Damage to BESS Containers (no combustion)	● ■ ▲	BESS unit damaged during installation, vehicle collision or from acts of vandalism	Limited release of electrolyte. The main chemicals released may be gases, such as carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), ethylene (C_2H_4) and ethane (C_2H_6)	Unlikely	Minor ● ▲ to Moderate ■	Low to Medium	Suite of controls covering: • Handling – operational personnel to have relevant training in routine installation and maintenance of BESS units. • BESS Compound has security measures in place, such as secure fences, gates, etc to restrict unauthorised access. • FEMP – Fire & Emergency	Negligible

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
							Management Plan will deal with emergency response to physical damage to transformers, HAZMAT, etc.	
External Fire Impact (e.g. Bushfire)	○ ■ ▲	Fire starts off site, moves on site and impinges on BESS units, transformers and other equipment and buildings	Fire damage to BESS and other equipment on site, including Transmission Line connection. Loss of connection of the facility and the ability of the Site to complete commissioning testing; or loss of ability of the Site to provide power to the grid in an emergency; or interruption to grid prior top isolation during de-commissioning	Possible	Major ○ ▲ Catastrophic ■	Medium to High	Suite of controls covering: • Asset Protection Zone and internal access roads allowing unimpeded firefighting capacity at the Site. • Adequate Project Area access (internal and external). • Adequate water supply. • Vegetation Management. • FEMP – Fire & Emergency Management Plan for dealing with the threat of an external bushfire attack. • Emergency Response Training – operational personnel to have completed relevant	Negligible to ALARP

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
							training in dealing with an external bushfire attack.	
Internal Fire Impact from any Internal Source	○ ■ ▲	Fire starts in another section of the site and impinges on BESS Containers or main transformers	Combustion of a BESS fire may release a range of combustion products in the smoke plume and as fire residues. Combustion of the electrolyte releases toxic gases including hydrogen fluoride (HF), phosphoryl fluoride (POF_3) and phosphorus pentafluoride (PF_5). Other gasses released during combustion will include volatile organic compounds	Unlikely	Moderate ○ ▲ Catastrophic ■	Medium to High	Project Area design to include adequate separation distances between main transformer and BESS units and between battery enclosures. Taking into consideration advice from battery manufactures, CFA and relevant codes of practice and standards. In a non-BESS initiated fire, firefighting practice would protect BESS units by keeping batteries cool with water. Project Area will have two dedicated 144 kL water tanks (288 kL total). Regarding contaminated firewater, have in place a dedicated plan to safely manage and dispose of water from a firefighting incident.	Negligible

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
			(VOCs) and volatile polyaromatic hydrocarbons (PAHs). Smoke plume carries particulate contaminants off site. Potentially contaminated water on site generated by firefighter's operations on site. Potential for environmental contamination of surface water and to a lesser extent ground water. Transformer (pool) fire can release significant				Project Area design to include secondary containment, bunding / sediment traps to retain as much water as possible on site. Once the fire is extinguished, where possible the water may be collected and removed for offsite disposal. Once the fire is extinguished, the areas of soil directly contaminated by the fire may be removed to a suitable depth, for example 10cm - 20cm based on advice from a Land Contamination expert. The soil removed to be taken off site for suitable disposal based on a waste classification of the soil	

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
			amounts of oil plus smoke plume impacts.					
BESS Container Fire	● ■ ▲	Thermal runaway starts fire in one of the batteries. Overvoltage / Overcharge in one of the batteries leads to a build-up of pressure in battery culminating in a catastrophic venting of gases and fire. External short circuit Sustained electrical arch fault Ignites surrounding materials. Excessive discharge	Combustion of a BESS fire releases a range of combustion products in the smoke plume and as fire residues. Combustion of the electrolyte releases toxic gases including hydrogen fluoride (HF), phosphoryl fluoride (POF_3) and phosphorus pentafluoride (PF_5). Other gasses released during combustion will include volatile organic compounds	Unlikely	Major	Medium	Using established systems and relevant standards to prevent a thermal runaway or short circuit or other fault within the battery from occurring. Battery management system, including automatic shut down in case of any safe limits of voltage, current and temperature being exceeded. Project Area design to include adequate separation distances between battery enclosures. Taking into consideration advice from battery manufactures, VIC CFA and relevant codes of practice and standards. In a BESS fire, the standard firefighting practice is to let burning batteries burn out and to avoid the spread of fire to adjoining batteries,	Negligible Refer UL9540A Test Results

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
		demand on battery outside design parameters Inadequate ventilation leads to build up and ignition of flammable gases (hydrogen) Inadequate management of operating environment (temperature, humidity, dusts, etc) Cascading failure/ thermal effects from adjacent battery cells within pack	(VOCs) and volatile polyaromatic hydrocarbons (PAHs). Smoke plume carries particulate contaminants off-site. Potentially contaminated water on site generated by firefighter's operations on site. Potential for environmental contamination of surface water and to a lesser extent ground water				protecting the surrounding BESS by keeping those unaffected batteries cool with water. Project Area will have two dedicated 144 kL water tanks (288 kL total).Regarding contaminated firewater, have in place a dedicated plan to safely manage and dispose of water from a firefighting incident. Project Area design to include secondary containment, bunding / sediment traps to retain as much water as possible on site. Once the fire is extinguished, where possible the water may be collected and removed for offsite disposal. Once the fire is extinguished, the areas of soil directly contaminated by the fire may be removed to a	

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
							suitable depth, for example 10cm - 20cm based on advice from a Land Contamination expert. The soil removed for suitable disposal based on a waste classification of the soil	
Extreme ambient temperatures	● ■ ▲	Extreme temperatures	Equipment Related: System failures in any equipment due to heat	Rare	Insignificant to Major	Low	The temperature data at the Mortlake weather station from 1990-2024 were as follows: mean annual maxima and minima were 26.3ºC in Dec/Jan and 4.6ºC in July respectively, whilst the highest and lowest temperatures in the past 30 years were 46ºC and -5.3ºC. The proposed BESS units for the Project should be designed for safe operation at the highest historical temperature of 46ºC, plus an appropriate climate change-related temperature buffer determined during detailed design.	Negligible

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
Contact with High Voltage	○ ■ ▲	Contact during wiring and connection activities, or through inadvertent cabling left exposed	Serious to critical injury to personnel	Possible	Major to Catastrophic	Medium to High	Licensed electricians only; wiring in accordance with standards (AS3000/AS3012). Barricading around relevant works areas. PPE. Insulated tools	Negligible to ALARP
Seismic Activity	○ ■ ▲	Earthquake	Consequences depend on the extent of seismic activity, ranging from minimal to major structural damage to the site	Rare	Insignificant to Major	Low	All equipment design in accordance with AS/NZS 1170.4 Design of Structures – Seismic Risk	Negligible
Wind	○ ■ ▲	Gale force / extreme winds Windborne debris impact	Consequences depend on the extent of seismic activity, ranging from minimal to major structural damage to the site	Unlikely	Insignificant to moderate	Low to Medium	All equipment design in accordance with AS/NZS 1170.2:2021 Structural design actions Wind actions.	Negligible
Lightning Strike	○ ■ ▲	Incidence of lightning	Injury, electric shock.	Possible	Major ○ ▲	Medium ○ ▲	FEMP procedures for dealing with lightning:	Negligible ○ ▲

Hazard or Incident	Project Phase [1]	Scenario	Consequence Range	WITHOUT Controls			Controls	Risk WITH Controls
				Likelihood	Consequence	Risk		
			Grass fire.		Catastrophic ■	High ■	weather monitoring, safe harbour locations, etc. Project to satisfy the applicable requirements for lightning protection specified in AS/NZ 1768 Lightning protection.	ALARP ■
Flooding isolation	● ■ ▲	Road access cut off to the site due to severe flooding of local roads.	Access to the site for emergency services would temporarily not be obtainable	Rare	Moderate ● ▲ Major ■	Low	Emergency response plan to consider options in this rare event. Note two access paths to site from the north and south along Cobden-Port Campbell Road	Negligible
Climatic concerns	● ■ ▲	Working in extreme cold or extreme heat	Workers on-site suffer heat stress or hypothermia	Likely	Moderate ● ▲ Major ■	Medium ● ▲ High ■	WHS Plan on-site to manage workloads during days of extreme heat or cold, including monitoring weather forecasts, proper attire, work breaks, hydration, etc	Negligible

5.0 BESS Unit Hazards and Risk Management

The safety measures involved in BESS component of the Project are addressed in this section of the report to demonstrate that the BESS will not increase the extent or severity of hazards identified in **Section 4** to surrounding property, community and environment.

5.1 General Background

Fire is recognised as the main hazard associated with lithium ion batteries. Fires associated with BESS powerpacks in containerised BESS modules have been designed so as not to spread easily to adjacent containerised modules, when constructed and installed according to relevant standards and guidelines. For example, full-scale fire testing of powerpacks including the scenarios of external heat sources, internal fires in a powerpack and forced thermal runaway reactions in a powerpack, reported the fires were self-limiting in a powerpack and unlikely to spread to adjacent powerpacks - refer NFPA: *Hazard Assessment of Lithium Ion Battery Energy Storage Systems*.

The general control measures, provided below, are designed to maintain and contain the risks within the site boundary and reduce the risk to areas outside the site boundary. The technical and management safeguards required for BESS units are self-evident and readily implemented as part of plant safety engineering. Following these safeguards, including codes and standards, will ensure that the resulting risk level is ALARP and that the proposed Cobden BESS component meets the principles of:

- the circumvention of all avoidable risks;
- the risk from a major hazard should be reduced wherever practicable, even where the likelihood of exposure is low;
- the effects of significant events should, wherever possible, be contained within the Subject Site boundary; and
- where the risk from an existing installation is already high, further development should not pose any incremental risk.

Technical and management safeguards relevant to the Project include but are not limited to guidance set out in the following:

- AS1768:2020 Lightning Protection
- AS 5139 Electrical Installations – Safety of Battery Systems for Use with Power Conversion Equipment
- Ditch, Ben & Zeng, Dong. (2019). Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems (FM Global Research Technical Report)
- FM Global Property Loss Prevention Data Sheets 5-33, Electrical Energy Storage
- IEC 62485-1:2015 Safety requirements for secondary batteries and battery installations – Part 1: General safety information
- IEC 62485-2:2010 Safety requirements for secondary batteries and battery installations – Part 2: Stationary Batteries
- IEC 62619:2017 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications

- IEC 62897 Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements
- IEC 62933:2018 Electrical Energy Storage (ESS) Systems
- NFPA 855: 2023 Standard for the Installation of Stationary Energy Storage Systems
- UL 9540 Standard for Energy Storage Systems and Equipment
- UL 9540A ANSI/CAN/UL Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

5.2 BESS Related Fire Hazards

BESS-related hazards include:

- Thermal Runaway; Fire; Explosion, Toxic Gas Venting; Flammable Gas Venting; Electric Arc Flash; Hot Surfaces and Electric Shock.

The above arise from the following two broad areas.

Risks Associated with Non-Battery Fire Events

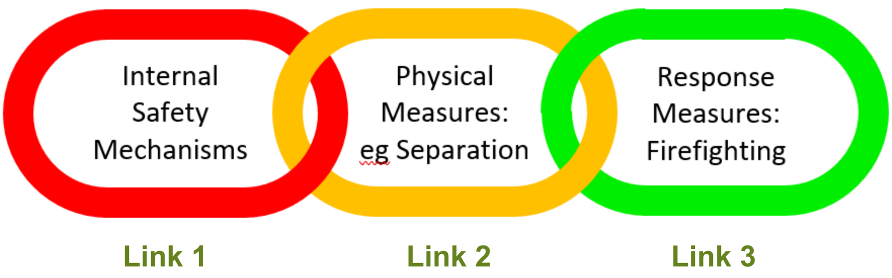
- Wiring Issues, e.g. short circuits.
- Electrical Safety System Failures, e.g. fuses, breakers, insulation, etc.
- Mechanical Interference, e.g. bugs, rodents, mishandling, vandalism, etc.

Thermal Runaway

- Causes: manufacturer defect, overcharge, over-discharge, mechanical damage, environmental (too hot, too cold).
- Hazards Produced: heat, flame, off-gassing of mainly H_2 and CO, off-gassing of other toxic gases, deflagration/explosion risk.

The key “links” in managing fire-related risks within a BESS facility are illustrated in the “Fire Response Chain” shown in **Figure 8**.

Figure 8 The “Fire Response Chain” – Key Strategic Links in Managing BESS Fire-Related Risks



In reference to **Figure 8**:

- **Link 1**: Globally manufactured, commercially available BESS units (battery packs, convertors, etc) come with a range of sophisticated in-built hazard reduction mechanisms to (1) avoid the onset of a fire event; (2) detect a fire and "announce" it to relevant "stakeholders", and (3) contain and suppress the fire until external firefighting resources can be brought to bear to shut the fire down, if it has not already been contained.
- **Link 2**: In between the **Link 1** automatic fire-management systems and the **Link 3** intervention of fire-fighting resources are a series of physical measures, e.g. separation of BESS units, APZ zones, etc, designed to limit the spread of a fire event until firefighting resources arrive to shut down the fire, if it has not already been contained.
- **Link 3**: Appropriate access for firefighting vehicles, availability of an adequate water supply for firefighting, emergency response planning, etc, form the last link aimed at being able to shut a fire down before it has the chance to spread beyond the Project Area perimeter and into the surrounding community.

In relation to **Figure 8**:

- A strong **Link 1** places less onus on **Links 2 and 3**, and
- Strong **Links 1 and 2** place less onus on **Link 3**.

5.3 Link 1

It is worth re-stating that grid-scale BESS units provided currently by global manufacturers typically contain a hierarchy of fire management controls which create layers of protection:

- The final selection of the actual BESS unit for the Project has not yet been made.
- It is understood that the preferred candidate will feature LFP (Lithium Iron Phosphate) chemistry:
  - LFP chemistry is preferred over NMC Nickel Manganese Cobalt chemistry because of the higher onset temperature for Thermal Runaway (270°C for LFP versus 210°C for NMC).
  - LFP also has a significantly lower self-heating rate than NMC chemistry batteries.
- BESS units in general obtain testing certification via a range of international standards, including UL9540/UL9540A, UL 1973, UL 1741SA, CSA, UN 38.3, FCC part 15 and AS4777.
  - The selected BESS unit will carry the above appropriate certifications.
- Modern BESS units contain Electrical Protection enabled via Current Interrupt Devices and Module and Rack Level Fuse Protection.
- Modern BESS units also feature Mechanical Protection enabled via Pressure Relief Valves at cell level, providing an explosive venting capability.
- BESS units come with a BMS (Battery Management System) which monitors a range of variables related to the onset or incidence of a fire event (temperatures, over and under-voltage, over-currents, etc). The BMS will then trigger alarms, instigate internal fire suppression equipment and automatically disconnect each BESS unit in the event of a fire.

- Containerised BESS units are designed for blast loading to minimise the impact of any potential deflagration/explosion, including roof panel rupture. This is normally a “last resort” design feature as the BESS’s ventilation system is designed to avoid the build-up of gases, etc.
- Standard internal fire suppression systems include a “dry pipe” sprinkler head and heat-activated aerosols once internal temperatures exceed a given temperature limit (usually in the range 140°C to 150°C). The dry pipe provides a water connection for fire services if required and would be certified to NFPA855, NFPA 68, IP55 / IP56 protection levels.
- Container internal walls would have a 60/60/60 fire rating.
- Intelligent Management is delivered via 24/7 protection through the BMS which monitors the battery health status 24/7 and identifies unhealthy batteries in advance.
- Intelligent Temperature Control features automatic temperature adjustment to cope with cold and heat. The intelligent thermal management system effectively avoids the bucket effect caused by the series connection of cells, ensuring a temperature difference of cells in the container within 5°C.
- Integrated liquid-cooled units feature adaptive adjustment of the operating state.
- It is a general industry observations that intelligent internal short-circuit detection with early warning of battery fire hazards has been shown to reduce the probability of relevant fires by more than 90%.

All of the above BESS Unit Safety Systems discussed above have benefited greatly from the Lessons Learned from a number of major BESS incidents. These are discussed in **Section 6** of this Report.

5.4 Link 2

The key to **Link 2** (refer **Figure 8**) is to provide sufficient clearance between rows of adjacent BESS units (whether modular/cabinet type or containerised type) and between BESS units and the BESS enclosure perimeter.

- Typically, BESS containers have a minimum clearance distance to the nearest boundary of their enclosure of between 5 m to 6 m. This is based on the radiant heat flux from a theoretical BESS battery pack fire that might be experienced by site personnel – note that heat flux is measured during the UL9540A certification testing.
- Rows of adjacent BESS battery pack units will also be separated by a minimum clearance which will vary in terms of the front and end walls and side walls. This is based on the radiant heat flux from a theoretical BESS battery pack fire that an adjacent BESS unit might experience in relation to its structural integrity.

BESS Unit Separation Distances via Regulatory Guidelines

Some information is available amongst international standards and guidelines regarding minimum separation distances between BESS packs and between BESS packs and surrounding personnel access areas.

For example, NFPA 855 Standard for *the Installation of Stationary Energy Storage Systems*, (US) National Fire Protection Association (latest edition 2020) specifies:

- A minimum of 10 feet (3.05 m) separation to lot perimeters, public ways, buildings, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with the electrical grid.

AS/NZS 5139:2019 *Electrical Installations – Safety of Battery Systems for Use with Power Conversion Equipment* also provides guidance with respect to minimum separation distances from personnel and buildings and other equipment.

- The minimum separation distances (which range from 600 mm to 900 mm) do not apply in the present instance as the BESS units would be located in an enclosed (secure) area, isolated from personnel by the BESS perimeter fence as shown in **Figure 2**.

BESS Unit Separation Distances via Quantitative Fire Modelling

SLR has reviewed the literature of credible fire scenarios for comparable containerised BESS systems.

Guidance for example in relation to a fire event relevant to BESS units can be found in:

- AS 1530.4:2014, *"Methods for fire tests on building materials, components and structures – Fire resistance tests for elements of construction"*.

Other relevant international standards include:

- SFPE S.01, *Standard on Calculation Fire Exposures to Structures,* Society of Fire Protection Engineers; Gaithersburg MD, 2011.
- SFPE S.02, *Standard on Calculation Methods to Predict the Thermal Performance of Structural and Fire Resistive Assemblies*, Society of Fire Protection Engineers; Gaithersburg MD, 2015.
- ISO 23932-1:2018, *Fire Safety Engineering – General Principles – Part 1: General*.
- CIBSE Guide E, *Fire Engineering*, 3rd Edition, Chartered Institute of Building Services Engineers, UK, 2010.

The above standards provide parametric fire curves which can be used to estimate the upper bound of the likely fire temperatures relevant to a BESS unit.

SLR's literature search of worst-case BESS fire simulations based on the above assumptions indicate the following approximate minimum separation distances:

- 6 m = minimum distance from either the front, end or side walls of any BESS container to the associated enclosure fence perimeter (based on the 4.7 kW/m^2 criterion).
- <1 m = minimum distance between adjacent BESS containers back-to-back (based on the 12.6 kW/m^2 criterion).

On the basis of the above, various possible configurations of BESS container within a rectangular area can then be assessed for a given total area allocated to the facility.

Alternatively, if large-scale fire tests are available, the test results can be used to refine the BESS-to-BESS and BESS-to-Inverter minimum separation distances during detailed design.

5.5 SLR BESS Unit Fire Simulations

As previously noted, the preferred candidate for the BESS units will feature LiFePO4 (LFP) chemistry.

A conservative approach has been taken by SLR in carrying out a "generic" BESS unit fire simulation, in which no special mitigation conditions are assumed, e.g. enclosure behaviour, explosive venting, etc.

Fire simulations were carried out via the so-called TNO Multi-Energy Method, described in:

- Bosch C. and Weterings R., *Methods for the calculation of physical effects due to*
- Bosch C. and Weterings R., *Methods for the calculation of physical effects due to releases of hazardous materials, liquids and gases*, Yellow Book (2005).

Predictive equations for radiant heat, etc, were also sourced from:

- US Nuclear Regulatory Commission, *Fire Dynamics Tools (FDTS) – Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program*, December 2004.

The methodology is as follows:

- The BESS unit is initially assumed to be a "black body" and fire spread is via the Stefan-Boltzmann Law, with uniform heat loss.
- The methodology requires an estimate of the likely fire temperatures relevant to a BESS unit, typically in the range:
  - 800°C -1,000°C at an "open" side of a containerised unit.
  - 600°C at a "closed" side of a containerised unit – refer the SPFE and CIBSE Handbooks above, for a severe, fully developed fire in a containerised unit.
  - 700-800°C for sides between an "open" and "closed" side.

The following assumptions are made, noting that no special mitigation conditions are assumed, e.g. enclosure behaviour, explosive venting, etc.

- The flame temperature of the emitting BESS surface was set at 1000°C.
- The (ambient) temperature was set at 20°C (not a critical input).
- Emissivity value = 0.9
- Receptor height = 1.5 m

Realistic assumptions based on the energy density of the BESS units include the following:

- The Heat of Combustion for vapour cloud explosions is approximately 40-50 MJ/kg for most hydrocarbon mixtures relevant to BESS units, at stoichiometric concentration with air – refer below:
  - Bjerketvedt, D., Bakke, J.R., Wingerden, K.V. (1992). *Gas explosion handbook*. Bergen.
- Typically, the volume occupied within a BESS container by all equipment is approximately 60% of the total enclosed space. This implies that the total available gas volume which could be involved in a BESS unit fire event is 40% of the total enclosed space. The above can then be used to calculate the total combustion heat input involved in a worst-case BESS fire based on an assumed combustion energy per unit volume of 3.5 MJ/m^3.

The emitted heat flux is calculated using the Stefan-Boltzman Law:

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

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

The heat flux received, $E_{received}$, is calculated using the view factor method:

$$E_{received} = 4 \cdot \phi \cdot E_{emitted}$$

Φ = standard View Factor (the visible area of the flame that can be seen from a certain point) calculated according to the TNO Yellow book.

- Bosch, C.V. (2005). *Methods for the calculation of physical effects* 'Yellow book' CPR 14E. The Hague: Ministerie van Verkeer en Waterstaat.

The above methodology is conservative given the following:

- The primary impact of a fire is the thermal impact by radiation to any nearby equipment and site personnel.
- The fraction of energy radiated from a fire is equal to the ratio of the total radiative emission from the fire normalized by the idealized fire heat release rate.
- The flame radiation fraction (of the total energy of burning) can be calculated theoretically. Based on a series of measurements available in the literature, this fraction is of the order of 30% of the total energy of burning.

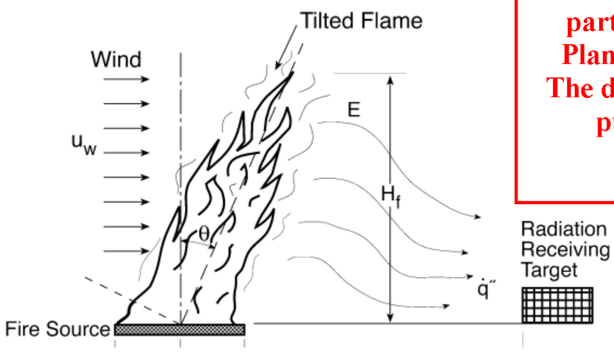
No-Wind Scenario

Under a no-wind scenario, heat radiation can be categorised into three regimes: conduction controlled (very close to the fire source), convection (a small region just outside of the conduction zone) and radiation controlled (within a metre or so of the fire flame). In practical fire scenarios, the burning is usually controlled by radiation and the flame profile can be reasonably approximated by a vertically symmetric sphere or cylinder.

Wind Scenario

In the presence of wind, thermal radiation to surrounding objects will alter to follow a curved path responding to the tilt angle of the flame - refer **Figure 9**.

Figure 9 Effect of Ambient Wind on Flame Profile

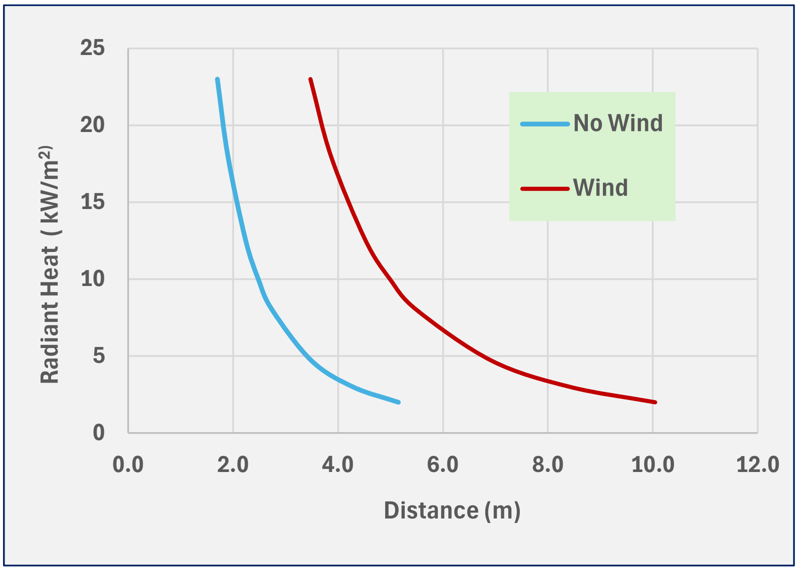


SLR Modelling Results

SLR's TNO Multi-Energy Assessment BESS Fire modelling results are shown in **Figure 10** based on an emitting heat flux of 150 kW/m^2.

The "with wind" scenario is based on a mean wind speed of 7 m/s where the effect is essentially to double the distance where a specific radiant heat level is experienced.

Figure 10 BESS Fire Simulation – Radiant Heat to Surrounds



Some benchmark results of interest are:

	NO Wind	WITH Wind
• 3 kW/m^2	4.3 m	8.4 m
• 4.7 kW/m^2	3.5 m	6.9 m
• 12.6 kW/m^2	2.3 m	4.5 m
• 23 kW/m^2	1.7 m	3.5 m

SLR's simulated BESS unit modelling has yielded the following results:

Radiant Heat

- Separation distances between individual BESS units in relation to their openable walls should be approximately 4.5 m (relevant to the 12.6 kW/m^2 target).
- The modelling suggests that critical firefighting equipment (e.g. fire hydrants) should be kept at least 8.5 m from the nearest BESS unit based on the 3 kW/m^2 target.
  - For the Project, this distance is greater than 10 m for all hydrant locations.

Comment

In relation to the above results:

- The above "generic" fire simulation results are conservative with respect to the radiant heat distance predictions.
- Given that the final chosen BESS units will almost certainly be provided with fire event mitigation (e.g. enclosure design, explosive venting), the minimum BESS-to-BESS and BESS-to-Inverter separation distance requirements will be less than suggested above.

BESS Unit Separation Distances via Certified Tests – UL9540A

The standard certification test for establishing (amongst a number of design parameters) the minimum fire-related clearances for commercially available BESS containerised units is UL 9540A:

- UL 9540A ANSI/CAN/UL *Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage System*.

In fact, UL has established a database of its BESS container fire tests and provides free access to this database:

Refer https://www.ul.com

The UL 9540A Test results for the final BESS candidate will be available to guide the design.

An examples BESS installation is shown in **Figure 11**. The BESS spacing shown in the installations was supported by the fire testing carried out under UL9540A.

Figure 11 Example BESS Installation

Ballarat BESS Project

Cobden BESS

In relation to the BESS Compound within the Project Area:

- The proposed storage capacity at the Project Area would be enabled by up to 66 individual BESS units.
- The BESS Compound area is approximately 5,600 m^2.
- On the basis of the conservative separation distances discussed above, there should be sufficient area to accommodate the storage capacity proposed for the Project Area.

5.6 Link 3

The following issues, related to Link 3, are addressed separately in the stand-alone Bushfire Risk Assessment Report.:

- **Asset Protection Zones, Landscaping and Construction Standards:** including non-combustible security fencing to be installed around BESS units and related infrastructure and the APZ around the external boundary fence, to be managed as an Inner Protection Area (IPA).
- **Access:** the Project Area will be provided with an internal perimeter access road and internal roads around all compounds and buildings satisfying CFA RDG-v4.4 requirements.
- **Water Supply:** includes two 144 kL static water tanks (288 kL total), positioned close to the two entry points into the Project Area and close to the BESS Compound and Substation Compound.
- **Straightforward Access** for emergency vehicles.
- **Bushfire Management Plan:** (to be developed as part of detailed design).

5.7 BESS Hazard Risk Conclusion

This section has shown that:

- BESS-related and other equipment-related fire risk issues can be adequately mitigated.
- Accordingly, the Project's BESS component will not in itself pose an additional fire hazard that has the potential to increase the extent or severity of a bushfire event on surrounding property, people and the environment.
- Finally, the proposed 300 MWh storage capacity can be comfortably accommodated within the Project Area space with appropriate separation distance for protection of both personnel and equipment.

On the basis of the Risk Matrix shown in **Figure 7**, SLR considers the residual risk associated with the BESS-initiated or other equipment-related fire hazard to be **LOW**, and hence adequately mitigated.

6.0 Case Studies Relevant to BESS Safety Development

Traditionally, the safety of engineering systems (civil, structural, mechanical, electrical, etc) has evolved through three main avenues:

R&D: especially in the early stages of development of a new product or system;

Standards: compliance with standards provides an avenue for underpinning safety; and

"Lessons Learned": typically, through failures, accidents, etc, where low probability failure mechanisms are discovered, and mitigation measures developed to prevent their occurrence in the future.

6.1 Two Important Case Studies

Two important case studies contributing to the body of "Lessons Learned" incidents are:

- Victorian Big Battery (VBB) Fire – 30 July 2021
- Arizona Public Service (APS) Utility BESS Fire and Explosion – 17 April 2019

The above are detailed in **Appendix A**.

6.2 Key Lessons Learned Relevant to the Project

Key lessons learned from the **Appendix A** case studies are summarised in **Table 11**.

Table 11 Case Study Key Learnings

Area	Key Weakness/Flaw Identified	Cobden BESS Project Response
Victoria Big Battery (VBB) Fire (2021)		
Commissioning	Limited supervision/monitoring of telemetry data during the first 24 hours of commissioning. Use of the keylock switch during commissioning and testing.	The power supply arrangement for the Cobden BESS containers will include an independent low voltage supply for the monitoring and telemetry systems. This ensures data will be available consistently from the commencement of commissioning and prior to the BESS units being energised.
Electrical Fault Protection Devices	Coolant leak alarms not being active. Pyro disconnect being unable to interrupt fault currents when the Megapack was off via the keylock switch. Pyro disconnect likely being disabled due to a power supply loss to the circuit that actuates it.	The independent low voltage supply described above will also ensure protection and safety devices are powered even if the main DC power system is isolated.
Fire Propagation	The significant role external, environmental conditions (such as wind) can have on a BESS fire.	The Cobden BESS container design will likely not include direct ventilation of the battery compartments under normal operation and thus no path for external flames to directly enter the battery bays.

Area	Key Weakness/Flaw Identified	Cobden BESS Project Response
	The identification of a weakness in the thermal roof design (unprotected, plastic overpressure vents in the ceiling of the battery bays) that permitted Megapack-to-Megapack fire propagation.	
Emergency Response	Amount of firefighting water used at the site was subsequently deemed excessive by fire and emergency services.	It is expected that the chosen BESS manufacturer will have design procedures that are in line with the latest best practice, regularly workshopped with fire authorities. This includes clear response plans recommending not to apply water directly onto a BESS unit on fire. Application of water to other equipment near a BESS fire (such as transformers) may be used as a tactic to protect that equipment. The Proponent is also cognisant of potential contamination of firefighting water and is implementing features in the civil design that prevent contaminated firewater from entering the environment. Clean up and disposal of contaminated material, should a fire occur, is also a key design consideration.
Battery Chemistry	The VBB fire event BESS units (Megapack) incorporate NMC (Nickel Manganese Cobalt) chemistry.	The Project will select LFP (Lithium Iron Phosphate) battery chemistry due to its superior thermal stability and safety credentials compared to NMC. This is in line with trends across the large-scale battery energy storage industry globally.
Arizona Public Service BESS Fire (2019)		
Fire Suppression "Clean Agent" Systems	The assumption regarding the effectiveness of relying solely on clean agent systems to subdue a BESS fire was made evident.	Clean agent systems may still be appropriate for use in BESS facilities to manage incipient fires, but they must be used in conjunction with additional practices: i.e. ventilation, extinguishing, and cooling to manage thermal runaway scenarios. Clean agent or aerosol extinguishing methods should not be the only barrier against thermal runaway. For the Cobden BESS container design, fire suppression systems will be incorporated based on their effectiveness in dealing with a battery fire and thermal runaway.

Area	Key Weakness/Flaw Identified	Cobden BESS Project Response
		The Project approach to BESS fire and thermal runaway is aligned with the latest globally recognised standards. This includes fire and thermal runaway off-gas detectors, battery management system monitoring, automatic system shutdown and isolation, and venting of dangerous gasses (as per NFPA 69).
Project Team Communications	The APS event exposed weaknesses in the communications covering fire safety between the roles of the Individual Equipment Manufacturer, Systems Integrator, Engineering, Procurement and Construction (EPC) Contractor, and Operations and Maintenance (O&M) personnel.	The Proponent's approach to the Project is to have the chosen BESS manufacturer train personnel employed for the Project O&M crew. The O&M procurement preference will be to utilise a system integrator, who will be responsible for the supply of the BESS and inverter equipment, as well as the integration and controls. The Project will have 24/7 remote monitoring and an O&M crew member will be on-call at all times. It is intended that the successful EPC Contractor will have previously constructed a large-scale BESS.
Emergency Response	The APS event also exposed weaknesses in relation to the understanding of hazards and training provided to first responders, critical to the safety of emergency service personnel.	The Project Team will develop clear fire and emergency response plans in conjunction with the local emergency services, BESS manufacturer, O&M contractors, etc, in line with current best practice. This will include training and familiarisation with the specific Project Area.

6.3 Project Management Pans

The key learnings summarised in **Table 11** will also be considered in relation to the development of the Project's various post-approval management plans covering:

- Fire & Emergency Management Plan (FEMP).

… that needs to be aligned with:

  - Fire Safety Study – focussing on BESS-related hazards and lessons learned from past BESS incidents.
  - Spill Management Plan.
  - Bushfire Management Plan.

6.4 Global Progress in Implementing BESS Safeguards from Failure Analysis

The above two examples are just two of a number of significant events that have led to significant improvements in BESS safety, particularly in relation to fire and explosion safety.

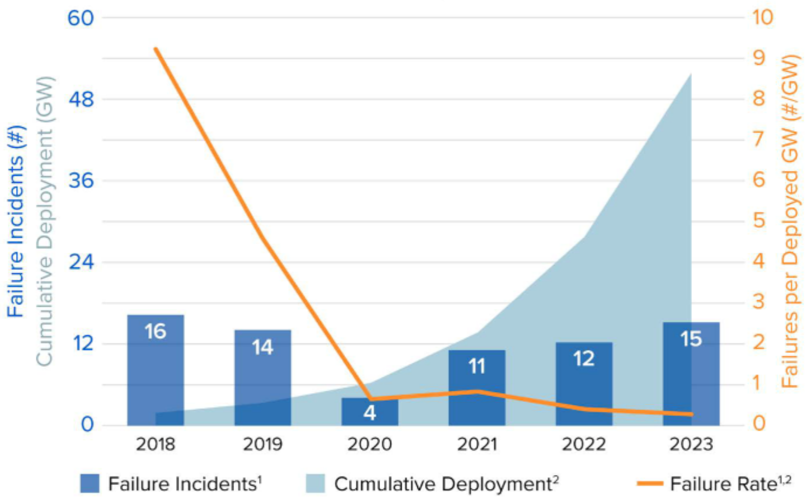
An excellent summary of the progress that has been made can be found in:

- EPRI, *"Insights from APRI's Battery Energy Storage Systems (BESS) Failure Incident Database – Analysis of Failure Root Cause"*, White Paper, 2024.

The EPRI White Paper documents the sharp decrease in rate of BESS-related incidents, as lessons learned from early failure incidents have been incorporated into new designs and best practice.

As can be seen in **Figure 12**, between 2018 and 2023, the global BESS failure rate has **decreased 97%,** even as deployment has increased exponentially.

Figure 12 Global Grid-Scale BESS Deployment and Failure Statistics



The EPRI White Paper analyses failures by root cause in the following categories:

- Design
- Manufacturing
- Integration, Assembly & Construction
- Operation

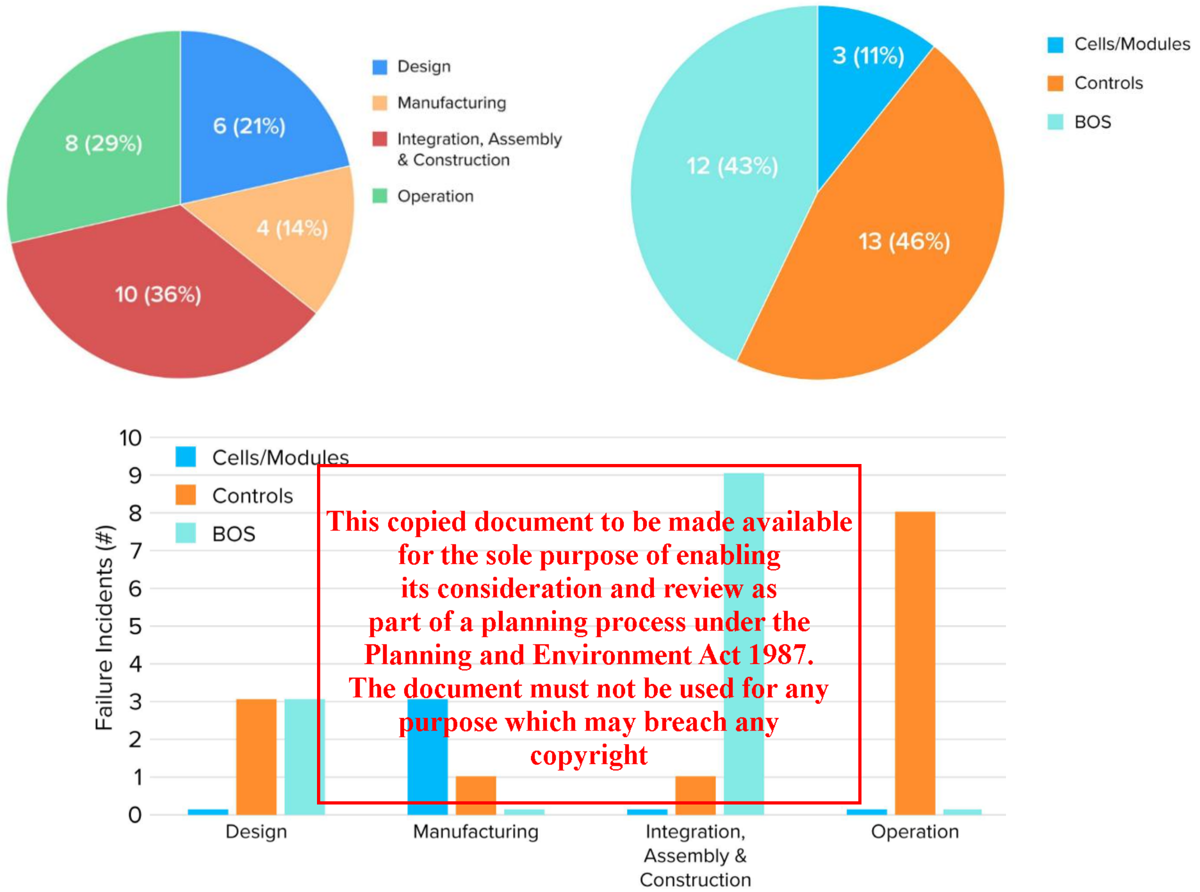
The EPRI White Paper also analyses failures by system element:

- Cell/Module
- Controls (e.g. Battery Management System)
- Balance of System (cabling, power conversion, transformers, etc)

Figure 13 shows the above breakdown for the EPRI BESS Incident Database.

- Cell/Module issues account for the majority of the Manufacturing stage failures.
- Controls account for the majority of the Operational stage failures.

Figure 13 Root Causes of BESS Incidents



The EPRI White Paper produced a summary of recommended mitigations for each root cause – refer **Table 12**.

Table 12 Mitigations and Recommendations for Each Root Cause

ROOT CAUSE	FAILED ELEMENT	MITIGATIONS AND RECOMMENDATIONS
Design	Controls, BOS	• Compliance with relevant codes and standards (UL, NFPA). Latest revisions have incorporated lessons learned from past failures. • Site-specific hazard assessments to consider all risks and failures. • Robust sensing and monitoring to provide early alert for design failures.
Integration/Assembly/ Construction	BOS, Controls	• Workforce training and quality checks during energy storage commissioning and installation. • System-level failure analysis, especially for interfaces between components.
Manufacturing	Cell/Module, Controls	• Increased manufacturing quality controls. • Supplier quality verification. • Robust system specifications. • Factory acceptance testing.
Operation	Controls	• Battery monitoring and analytics to augment BMS operation, generating trends and predictive analyses to identify potential failures early.

6.5 Case Study Summary

Key learnings from past BESS incidents have been critical in advancing the safety features of BESS units.

This is reflected in the multi-layers of protection that will be featured by the chosen BESS container for the Project, and the understanding of the Proponent of the need for widespread engagement with all stakeholders, especially emergency responders if they are ever required to handle critical incidents at the Project Area.

Finally, it is understood that all of the technical information related to the chosen BESS container will be made available within the EIB (Equipment Information Book) required under the Project's FEMP (Fire & Emergency Management Plan).

7.0 Substation Transformer Fire

7.1 Australian Standard Compliance

Guidance in relation to a Substation transformer fire mitigation can be found in:

- AS2067-2016 *Substations and High Voltage Installations Exceeding 1 kV a.c.*

Transformer Inputs

A final selection has not been made for the Substation power transformer.

Based on the options being considered, the following has conservatively been assumed:

- Mineral oil-filled transformer: 20,000-45,000 L oil.

Risk Scenario Considered

The Substation transformer fire risk scenario considered is:

- A pool fire involving the Substation transformer mineral oil located within the transformer's bunding.

Project Substation

At this stage, the Substation transformer and relevant separation distances are:

Substation Transformer to Switchroom/Control Room	> 10 m
Substation Transformer to Nearest BESS units	> 20m

7.1.1 AS2067-2016 Clearances for Outdoor Transformers

Reference is made to Table 6.1 of AS2067-2016 – reproduced in **Table 13**.

The relevant section is highlighted in **ochre**.

Compliance of Facility

Table 13 shows that:

- The separation distance of the Substation Transformer to (i) the Switchroom/ Control Room, and (ii) BESS Containers / Inverters, are all comfortably satisfied.

On the basis of the Risk Matrix shown in **Figure 7**, SLR considers the residual risk associated with a Substation transformer-initiated fire hazard to be **LOW** and hence adequately mitigated.

Table 13 AS2067-2016 Table 6.1

CLEARANCES FOR OUTDOOR TRANSFORMERS

Transformer type	Liquid volume	Clearances to other transformers or equipment	Clearances to buildings		
		Horizontal separation G_1 to other transformers or non-combustible surfaces	Horizontal clearance G_2 to combustible surfaces	Horizontal clearance G_3 to 2 hour fire resistant surfaces of buildings	Vertical extent G_4 for 2 hour fire resistant surfaces of buildings
	L	m	m	m	m
Oil-insulated transformers (O)	100 ≤1000	1	6	1	4.5
	>1000 ≤2000	3	7.5	1.5	7.5
	>2000 ≤20 000	5	10	4.5	15
	>20 000 ≤45 000	10	20	7.5	30
	>45 000 ≤60 000	15	30	7.5	30
	>60 000	23	30	7.5	30
Less combustible liquid-insulated transformers (K) without enhanced protection	100 ≤1000	1	6	1	4.5
	>1000 ≤38 000	1.5	7.5	1.5	7.5
	>38 000	4.5	15	4.5	15
Less combustible liquid-insulated transformers (K) with enhanced protection (refer to Note 1)	Clearance G_1 to other transformers or building surfaces				Vertical extent G_4 for 2 hour fire resistant surfaces of buildings
	Horizontal m				Vertical m
	0.9				1.5
Dry-type transformers (A) Fire behaviour class F_0	1.5				3.0

8.0 EMF Hazards

SLR recognises community concerns regarding the potential for adverse health impacts associated with exposure to Electric and Magnetic Fields (EMFs). The following sections will demonstrate that the EMFs associated with the Project at the Project Area boundary will be well below the levels commonly encountered in most homes arising from household wiring, household appliances and earth return currents.

8.1 Electric and Magnetic Fields (EMFs)

Electric and Magnetic Fields (EMFs) are part of the natural environment. They are present within the Earth's core and in the atmosphere. Whenever a power line (or household power cord) is energized, an Electric Field is created with a strength that depends directly on the voltage across the line creating it. A Magnetic Field is created whenever current flows through a power line (or household power cord), at any voltage.

EMFs associated with the generation, distribution and use of electricity power systems in Australia are classified by Energy Networks Australia as being Extremely Low Frequency (ELF). **Table 14** illustrates the basic features of EMFs.

Table 14 EMF Characteristics

Characteristic	Electric Field	Magnetic Field
Field is produced by …	Voltage	Current
Field is measured in units of …	Volts/metre (V/m) or kV/m	milli-Gauss (mG) or micro-Tesla (μT) 1 μT = 10 mG
The field exists when a source is turned off …	Yes	No
Field strength decreases rapidly with distance from source …	Yes	Yes
Field strength is reduced if shielded by insulation, an enclosure, trees, buildings, etc …	Yes	No

Source: (NIEHS 2002)

EMF Observation 1: EMF is not EMR

It is not uncommon for EMF to be confused with electromagnetic radiation (EMR), which is the movement of electromagnetic energy through the propagation of a wave, e.g. light from the sun or a radio-frequency signal from a television station transmitter.

- No such energy propagation occurs with EMFs.

Accordingly, the following is noted:

- EMFs around power lines or household electrical appliances are not a form of radiation. As noted above, the ELF EMF fields relevant to this Project do not radiate away from their source but are fixed in place around it. Consequently, they do not propagate energy away from their source and bear no relationship, in their physical nature or effects on the body, to EMR such as x-rays or microwaves.

EMF Observation 2: Electrical versus Magnetic Fields

When assessing EMFs, the focus on attention regarding health risk is usually on the magnetic field rather than the electric field.

- Electric fields are shielded by most objects, including trees, buildings and human skin. For this reason, there are negligible electric fields above underground cables.
- Furthermore, electric fields quickly reduce in strength with distance from the source.
- Like electric fields, magnetic fields also quickly reduce in strength with distance from the source. However, unlike electric fields, magnetic fields cannot easily be shielded and pass through most materials.

EMF risk assessments therefore focus on the potential strength of the magnetic field component of an EMF source.

8.2 Typical EMF Strengths

Typical examples of the strength of commonly encountered EMF magnetic fields are shown in **Table 15**.

Table 15 Typical Magnetic Field Strength Examples

Domestic Source	Magnetic Field	Power Source	Magnetic Field
TV, Pedestal Fan	0.2 - 2 mG	Sub-Station (at perimeter fence)	1 - 8 mG
Refrigerator Toaster, Electric Kettle	2 - 5 mG 2 - 10 mG	Suburban power line: . Under the line . 10m away	2 - 30 mG 0.5 - 10 mG
PC, Laptop	2 - 20 mG	High Voltage power line: . Under the line . Easement (20-25m away)	10 - 200 mG 2 – 50 mG
Electric Stove, Electric Blanket Hair Dryer	2 - 30 mG 5 - 30 mG 10 – 70 mG	Underground Cables . close to above cable . 10m away	5 - 200 mG 1 - 40 mG

Source: (ARPANSA 2006)

8.3 EMF Guidelines – Magnetic Field Exposure Limits

EMF standards and guidelines have evolved over time, and include:

- Energy Networks Association (ENA), *EMF Management Handbook*, January 2016.
- VicGrid, *Transmission Lines and Electric and Magnetic Fields*, March 2024.
- Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2020. *Code for Radiation Protection in Planned Exposure Situations*, Radiation Protection Series C-1 (Rev.1).
- International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2009. *Guidelines on limits of exposure to static magnetic fields*, Health Physics, 96(4):504-514.

- International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2010. *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 HZ – 100 kHz),* Health Physics, 99(6):818-836.
- International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2020. *ICNIRP Statement Principles for Non-ionizing Radiation Protection*, Health Physics, 118(5):477–482.
- IEEE Standard C95.6, *Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz*, 2002.

ARPANSA (the Australian Radiation Protection and Nuclear Safety Agency) generally adopts the ICNIRP guidelines and advises that …

- *"On balance, the scientific evidence does not indicate that exposure to 50 Hz EMFs found around the home, the office or near power lines is a hazard to human health".*

  and
- *"The majority of scientists and Australian radiation health authorities in particular, do not regard chronic exposure to 50 Hz EMFs at the levels commonly found in the environment as a proven health risk. Moreover, the evidence we have is inconclusive and does not allow health authorities to decide whether there is a specific Magnetic Field level above which chronic exposure is dangerous or compromises human health".*

A simplified set of peak Magnetic Field exposure limits, expressed as units of mG, obtained from the standards discussed above, has been reproduced in **Table 16**. As noted above, ARPANSA generally aligns with the ICNIRP exposure limits.

Table 16 Magnetic Field Peak Exposure Limits

Exposure Class	ICNIRP (ARPANSA)	IEEE
Members of the Public	2,000 mG (general exposure)	9,040 mG (head/torso exposure) 748,000 mG (arms/legs exposure)
Occupational Worker	10,000 mG (general exposure)	27,100 mG (head/torso exposure) 748,000 mG (arms/legs exposure)

A comparison of the typical magnetic field levels shown in **Table 15** with the 2,000 mG limit given in **Table 16** shows the relatively benign EMF levels found at home and for typical power system equipment, including power lines.

8.4 EMF for the Project

It is a project commitment that the Project's electrical equipment will comply with relevant Australian and International Standards for exposure to EMFs.

Accordingly, the magnitude of the EMFs from all equipment types at the Project Area, in particular their magnetic fields, will be highly localized and will remain well below the exposure limits shown in **Table 16**.

8.4.1 Relevant EPRI EMF Study

Reference is made to the following US EPRI-funded study of EMFs at two large-scale solar facilities operated by the Southern California Edison Company in Porterville, CA, and San Bernardino, CA.

- Tell, R.A., Hooper, H.C, Sias, G.G, Mezei, G., Hung, P. and Kavet, R., *"Electromagnetic Fields Associated with Commercial Solar Photovoltaic Electric Power Generating Facilities"*, Journal of Occupational Environmental Hygiene, 2015 12(11) pp795-803.

The EPRI study included the measurement of static magnetic fields, power-frequency AC and radio-frequency EMFs and involved inverters relevant to the Project.

- None of the equipment surveyed exhibited significant power-frequency electric field levels, due to the housing and enclosures typically deployed in power generation facilities.
- The major sources of magnetic fields were power cables, inverters, transformers and switchgear, ranging up to a maximum of 1,000 mG immediately adjacent to the relevant equipment.
- All measured magnetic fields were within ICNIRP and IEEE exposure limits at equipment compound perimeters.
- The highest magnetic fields were measured immediately adjacent to inverters and fuse boxes. The EMF strength attenuated quickly with distance – in fact EMF magnitudes were found to attenuate with the **cube of the distance** from the source.

The above study shows that the magnetic fields associated with all of the equipment within the Project Area will be:

- comfortably below the exposure limits shown in **Table 16** even at close distances from the relevant equipment; and
- at "background" levels at the nearest relevant perimeter fence of the Project Area (background meaning from the earth's own magnetic field).

8.4.2 BESS Containers

As a general observation, it is not expected that the Project BESS units themselves would be associated with measurable EMFs.

The principle of a Li-ion battery is the chemical reaction that occurs on the electrodes of the individual battery cells within the unit which is then converted to electricity. Such chemical reactions do not produce radiation – this would include EMF radiation. However, the battery cells are used to power the remaining equipment within the Project Area (inverters, etc) which do have the potential to generate measurable, albeit small, amounts of EMF.

8.4.3 Inverter (Systems)

Modern grid-scale inverter systems are normally a dual component system comprising a large-scale inverter coupled with a step-up transformer.

The proposed Project inverters will be designed to comply with international standards and guidelines that ensure their conformance to performance criteria with respect to EMFs, including:

- UL 1741 and UL 1741 Sb, CSA 22.2 No.107.1-16, IEC 62109-1, IEC 62109-2, NEC 2020, IEEE 1547:2018. IEC 621165:2014.

The step-up transformers connected to the inverters are essentially identical to those installed within residential distribution kiosks commonly found in public spaces. All of the inverter stations planned for the Project will be positioned at a sufficient distance from the Project Area security fence such that no further assessment is necessary to confirm that the impact to the public will be negligible.

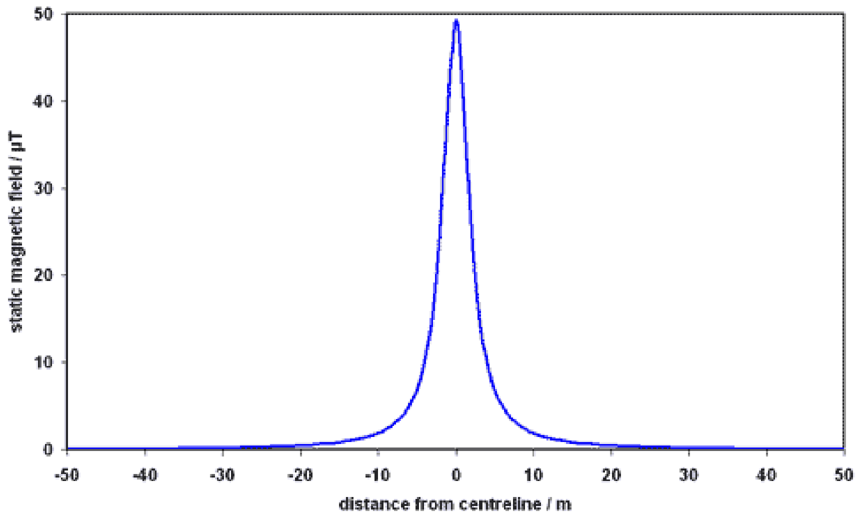
8.4.4 Underground Cabling

Underground cables always include a metal sheath which screens the electric field. Given the additional shielding from the surrounding soil mass, an underground cable will only produce a discernible magnetic field.

A typical underground cable will produce a maximum magnetic field of about 200 mG immediately at ground level and 100 mG approximately 1 m distance horizontally displaced from the immediate above-ground position.

Figure 14 shows an example field test obtained from the UK's PHE (Public Health England) Radiation Protection Division (formerly an amalgamation of the Health Protection Agency and National Radiological Protection Board). As can be seen, the magnetic field falls rapidly relative to distance either side of the cable. At distances beyond about 15 m, the magnetic field strength would be indistinguishable from the earth's own magnetic field.

Figure 14 Typical Underground Cable Magnetic Field Distance Attenuation



8.4.5 Main Transformer

It is expected that the location of the Project Substation Compound along with its own security fencing will ensure that EMF exposure to the public is well below the limits found in the guidelines provided in **Table 16**.

The UK's National Grid Company conducted a 2004 substation survey involving measurements 0.5 m above ground level and 1 m from substation enclosures.

- Magnetic Field strength averaged 19 mG and became indistinguishable from background levels within 5 m.

8.4.6 Summary

The only measurable EMFs associated with the Project Area would almost entirely be from the grid connection transmission lines.

Despite the above, and in line with a generally precautionary approach, in addition to compliance with the ARPANSA exposure limits shown in **Table 16**, the Proponent has made the following commitment:

- The design of the facility will be developed considering Energy Networks Association (ENA), *"ENA Policy Statement on Electric and Magnetic Fields",* adopted by the ESAA Board in 1991 and reconfirmed by the ENA EMF Committee, March 2006; and Nutall, K., Flanagan, P. and Melik, G., *"Prudent Avoidance Guidelines for Power Frequency Magnetic Fields"*, 23rd Annual Conference of the Australasian Radiation Protection Society, 1998; and
- The integrity of all Project Area site security fencing will be maintained through the lifetime of the Project to ensure adequate exposure separation for all members of the public.

8.4.7 Construction & De-Commissioning

During the Project Construction phase, construction staff may be intermittently exposed to EMFs when working near selected equipment (e.g. inverters) once testing of the Project begins. Potential EMF impacts are possible, in particular for sensitive workers (e.g. workers with implanted medical devices). They are however likely to be short term and negligible and will be managed according to the Project's Occupational Health & Safety Management Plan.

8.5 EMF Hazard Risk Conclusion

This section has shown that:

- EMF risk issues can be adequately mitigated, for both the public and site workers.

On the basis of the Risk Matrix shown in **Figure 7**, SLR considers the residual risk associated with the Project-related EMF hazard to be **LOW**, and hence adequately mitigated.

9.0 Conclusion

Preliminary Risk Screening

Preliminary Risk Screening has found that the quantity (in terms of storage and transport) of dangerous goods and associated potential hazards comply with the screening requirements of the ADG (Australian Code for the Transport of Dangerous Goods by Road and Rail", Edition 7.7, 2020) Code.

Preliminary Hazard Analysis

The Preliminary Hazard Analysis in this report found that the hazards rated as "high" and hence needing further detailed assessment were:

- Hazards associated with Bushfire.
- Hazards associated with the Project equipment, including BESS unit thermal runaway, Substation pool fire, etc.

Accordingly, a detailed hazard analysis was undertaken to quantify these hazards.

Bushfire Risk

Bushfire hazards have been addressed separately in a stand-alone Bushfire Risk Assessment report. In relation to Bushfire Risk:

- The stand-alone Bushfire Risk Assessment Report concludes that bushfire risk issues can be adequately mitigated. Accordingly, the Project will be adequately protected from the threat of a bushfire event.
- In relation to the Risk Matrix shown in **Figure 7**, SLR considers the residual risk associated with bushfire fire hazard to be **low**, and hence adequately mitigated.

Project-Related Risks

Project-related hazards are addressed in detail in **Sections 5, 6, 7 and 8**.

Section 5 of this report dealt with BESS-Related Risks.

- **Section 5** showed that BESS-related and other equipment-related fire risk issues can be adequately mitigated.
- Accordingly, the Project will not it itself pose an additional fire hazard that has the potential to increase the extent or severity of a bushfire event on surrounding property, people and the environment.
- Finally, the proposed 300 MWh storage capacity can be accommodated within the Project Area space with separation distances that provide adequate protection to personnel and property.
- In relation to the Risk Matrix shown in **Figure 7**, SLR considers the residual risk associated with the BESS-initiated or other equipment-related fire hazard to be **low**, and hence adequately mitigated.

Section 7

- **Section 7** showed that Substation Transformer fire risk issues can be adequately mitigated.
- In relation to the Risk Matrix shown in **Figure 7**, SLR considers the residual risk associated with the Substation transformer fire hazard to be **low**, and hence adequately mitigated.

Section 8 of this report dealt with EMF-related Risk.

- **Section 8** demonstrated that EMF hazard issues can be adequately mitigated, for both the public and site workers.
- On the basis of the Risk Matrix shown in **Figure 7**, SLR considers the residual risk associated with the EMF hazard to be **low**, and hence adequately mitigated.

It is the overall conclusion of this Hazard Analysis Report that the risks associated with the Project would be adequately managed, with suitable engineering controls, operational controls and management controls in place.

It is expected that all of the above controls will be enabled by the post-consent development of comprehensive management plans covering the following:

- Bushfire Management Plan (BMP)
- Fire Safety Study (FSS).
- Fire & Emergency Management Plan (FEMP)

Appendix A Lessons Learned from Selected Case Studies

Hazard & Risk Assessment

Cobden Battery Energy Storage System (BESS)

Cobden BESS Pty Ltd

SLR Project No.: 620.041534.00021

Revision: R01-v3.0

12 May 2026

SLR

A-1 Victorian Big Battery (VBB) Fire – 30 July 2021

Neoen's VBB is a 300MW/450MWh BESS facility located in Geelong, Victoria, fitted with 212 Tesla Megapacks, each measuring approximately: 7.2 m (length) x 1.6 m (width) x 2.5 m (height).

On Friday, 30 July 2021:

- A single Megapack (MP1) caught fire and spread to a neighbouring Megapack (MP2) during the installation and commissioning phase of the facility.
- At that time, approximately half of the Megapacks had been installed at the site and some were undergoing testing and commissioning.
- MP1 was NOT scheduled for testing that day and was shut down manually at around 7:20 am. When it was shut down, it was not displaying abnormal conditions to site personnel.
- At around 10:00 am, smoke was observed emitting from MP1 by site personnel, who then electrically isolated ALL the Megapacks on-site and called emergency services.
- Victoria's Country Fire Authority (CFA) arrived shortly thereafter and set up a 25 m perimeter around MP1.
- They also began applying cooling water to nearby exposures (e.g., transformers) as recommended in Tesla's Lithium-Ion Battery Emergency Response Guide (ERG).
- At around Noon, the fire spread to the neighbouring MP2, which was installed 15 cm behind MP1. Wind was the dominant contributory factor in this case. At the time of the fire, sustained winds of over 50 km/hr impacted the site from the north. These pushed the flames exiting out of the top of MP1 towards the roof of MP2 leading to direct flame impingement on the thermal roof of MP2.
- The CFA permitted MP1 and MP2 to burn themselves out and did not directly apply water into or onto either Megapack, as recommended in Tesla's ERG.

- The fire did not spread beyond MP1 and MP2, which burned themselves out over the course of approximately six hours.
- There were no injuries to the general public, to site personnel or to emergency first responders as MP1 and MP2 failed "safely", ie they slowly burned themselves out with no explosions or deflagrations, as they are designed to do in the event of a fire, and as per the guidance in Tesla's ERG.
- By around 4:00 pm, visible fire had subdued, and a fire watch was instituted.
- The CFA monitored the site for the next three days before deeming it under control on 2 August 2021, at which time, the CFA handed the site over for a formal fire investigation to begin.

Lessons Learned

The VBB fire exposed a number of unlikely factors that, when combined, contributed to the fire initiation as well as its propagation from unit MP1 to MP2. This collection of factors had never before been encountered during previous Megapack installations, operation and/or regulatory product testing.

Below is a summary of the lessons learned from the incident and the new safety mitigation measures since implemented.

Commissioning

- Key weaknesses identified: (i) limited supervision/monitoring of telemetry data during the first 24 hours of commissioning, and (ii) use of the keylock switch during commissioning and testing.
- These two factors prevented MP1 from transmitting telemetry data (internal temperatures, fault alarms, etc) to Tesla's control facility and placed critical electrical fault safety devices (such as the pyro disconnect) in a state of limited functionality, reducing the Megapack's ability to actively monitor and interrupt electrical fault conditions prior to them escalating into a fire event.
- Since the VBB fire, Tesla has modified their commissioning procedures to reduce the telemetry setup connection time from 24 hours to 1 hour and to avoid utilizing the Megapack's keylock switch unless the unit is actively being serviced.

Electrical Fault Protection Devices

- Key lessons learned covered the following: (i) coolant leak alarms not being active, (ii) the pyro disconnect being unable to interrupt fault currents when the Megapack is off via the keylock switch, and (iii) the pyro disconnect likely being disabled due to a power supply loss to the circuit that actuates it.
- These factors prevented MP1's pyro disconnect from actively monitoring and interrupting the electrical fault conditions before escalating into a fire event.
- Since the VBB fire, Tesla has implemented a number of firmware mitigations that keep all electrical safety protection devices active, regardless of keylock switch position or system state, and actively monitor and control the pyro disconnect's power supply circuit.
- Furthermore, Tesla has added additional alarms to better identify and respond (either manually or automatically) to coolant leaks. Additionally, although this fire event was almost certainly initiated by a coolant leak, potential unexpected failures of other internal components of the Megapack that could create similar damage to the battery modules have been explored.
- Accordingly, the new firmware mitigations do not ONLY address damage from a coolant leak. They also permit the Megapack to better identify, respond, contain and isolate issues within the battery modules due to failures of other internal components, should they occur in the future.

Fire Propagation

- Key lessons learned included: (i) the significant role external, environmental conditions (such as wind) can have on a Megapack fire, and (ii) the identification of a weakness in the thermal roof design (unprotected, plastic overpressure vents in the ceiling of the battery bays) that permitted Megapack-to-Megapack fire propagation.
- These two factors led to direct flame impingement on the plastic overpressure vents that seal the battery bay from the thermal roof. With a direct path for flames and hot gases to enter into the battery bays, the cells within the battery modules of MP2 failed and became involved in the fire.
- This weakness had not been identified previously during product or regulatory testing as the relevant UL9540A tests are undertaken with wind speeds reaching only up to 20 km/hr. The fire therefore did not invalidate the Megapack's UL9540A certification, as the fire occurred as result of an environmental condition that is not captured by the UL9540A test method.

- Since the VBB fire, Tesla has devised (and validated through extensive testing) a hardware solution that protects the overpressure vents from direct flame impingement or hot gas intrusion via the installation of new, thermally insulated, steel vent shields.
- The vent shields are placed on top of the overpressure vents and NOW COME STANDARD on all NEW Megapack installations.
- For EXISTING Megapacks, the vent shields can be easily RETROFITTED in the field.

Megapack Spacing

- Investigation of the VBB fire concluded that NO changes were required to the installation practices of the Megapack ONCE the vent shield mitigation (as described above) was in place.
- Based on an analysis of MP2's telemetry data during the VBB fire, a Megapack's thermal insulation provides significant thermal protection in the event of a fire within an adjacent Megapack installed 15 cm away. The internal cell temperatures of MP2 only increased by 1°C, from 40°C to 41°C, before communication was lost to the unit, presumably due to fire, around 11:57 am (approximately 2 hours into the fire event). Fire propagation was triggered by the weakness in the thermal roof, as described above, and NOT due to heat transfer via the 150 mm gap between Megapacks.
- With the new vent shield mitigation in place, the weakness has been addressed and since validated through unit level fire testing (i.e., tests involving the ignition of the Megapack's thermal roof).
- These tests have confirmed that, even with the thermal roof fully involved in a fire, the overpressure vents will not ignite, and the battery modules remain relatively unaffected with internal cell temperatures rising less than 1°C.

Emergency Response

Lessons learned from the emergency response to the VBB fire:

- Effective pre-incident planning is invaluable and can reduce the likelihood of injuries;
- Coordination with "Subject Matter Experts" (SMEs), either on site or remotely, can provide critical expertise and system information for emergency responders to draw upon;
- The effectiveness of applying water directly to adjacent Megapacks appears to provide limited benefits. However, water application to other electrical equipment, with inherently less fire protection built into their designs (such as transformers), can be a useful tactic to protect that equipment;
- The fire protection design approach of the Megapack was shown to be very robust;
- Victoria's EPA indicated that there was "good" air quality two hours after the fire, demonstrating that no long-lasting air quality concerns arose from the fire event;
- Water samples indicated that the likelihood of the fire having a material impact on firefighting water was minimal; and
- Prior community engagement during the project planning stages proved to be invaluable as it enabled Neoen to quickly update the local community and address immediate questions and concerns. Early, factual and where possible, face-to-face

engagement with the local community is essential when a fire event is unfolding to keep the general public informed.

Summary

- The VBB fire event proceeded in accordance with its fire protection design and pre-incident planning.
- It presented no unusual, unexpected, or surprising characteristics (ie explosions).
- It did not result in any injuries to site personnel, the general public or emergency responders.
- It was isolated to the units directly involved and had minimal environmental impact.
- It did not adversely impact the electrical grid and had appreciably short mission interruption.

Relevance to the Cobden BESS Design

SLR understands that key learnings from the VBB fire event, including monitoring and supervision procedures during commissioning and unit-to-unit wall/roof vent fire mitigation measures, have been considered during the design evolution of the proposed Cobden BESS Project.

Further, it is understood that the NMC (Nickel Manganese Cobalt) chemistry used in the Tesla megapacks involved in the VBB fire event have now switched to LFP (lithium iron phosphate) chemistry, further improving the fire prevention controls within these units.

A-2 Arizona Public Service (APS) Utility BESS Fire and Explosion – 17 April 2019

On Friday, 17 April 2019, a fire and explosion occurred at a BESS facility owned by Arizona Public Service (APS), injuring four firefighters. This occurred while the four hazmat firefighters were working to extinguish a BESS fire that had already commenced at the facility.

The BESS had been installed in late 2016 as part of an agreement between APS and AES Energy Storage involving AES Advancion battery arrays.

The event has become known as the “McMicken BESS Event”.

In summary:

- The BESS was commissioned and integrated by AES, on behalf of APS.
- The BESS was assembled with Lithium ion (Li-ion) batteries manufactured by LG Chem using NMC (Nickel Manganese Cobalt) chemistry.
- On 19 April 2019, 25 months after the BESS was placed into service, a suspected fire was reported at the BESS.
- At 17:48 local time, first responders arrived to investigate.
- Several hours later, at approximately 20:04, an explosion occurred from inside the BESS.
- The explosion injured several firefighters and essentially destroyed the BESS and its container.

A detailed investigation into the incident was carried out by APS and a far-ranging report completed in 2020, in partnership with DNV GL. This investigation included experts from APS, the manufacturers and third-party engineering and safety experts.

The report led to several important new safety requirements aimed at preventing future failures and fires at BESS facilities.

Key Event Elements:

- The suspected fire was actually an extensive cascading thermal runaway event, initiated by an internal cell failure within one battery cell in the BESS: cell pair 7, module 2, rack 15 (battery 7-2).
- It is believed to a reasonable degree of scientific certainty that this internal failure was caused by an internal cell defect, specifically abnormal Lithium metal deposition and dendritic growth within the cell.
- The total flooding clean agent fire suppression system installed in the BESS operated early in the incident and in accordance with its design. However, clean agent fire suppression systems are designed to extinguish incipient fires in ordinary combustibles. Such systems were not, at the time, capable of preventing or stopping cascading thermal runaway in a BESS.
- As a result, thermal runaway cascaded and propagated from cell 7-2 through every cell and module in Rack 15, via heat transfer.
- This propagation was facilitated by the absence of adequate thermal barrier protections between battery cells, which may have stopped or slowed the propagation of thermal runaway.

- The uncontrolled cascading of thermal runaway from cell-to-cell and then module-to-module in Rack 15 led to the production of a large quantity of flammable gases within the BESS.
- Analysis and modeling from experts in this investigation confirmed that these gases were sufficient to create a flammable atmosphere within the BESS container.
- Approximately three hours after thermal runaway began, the BESS door was opened by firefighters, agitating the remaining flammable gases, and allowing the gases to make contact with a heat source or spark, leading to the explosion.

Key Contributing Factors Leading to the Explosion:

- #1: Internal failure in a battery cell initiated thermal runaway.
- #2: The fire suppression system was incapable of stopping thermal runaway.
- #3: Lack of thermal barriers between cells led to cascading thermal runaway.
- #4: Flammable off-gases concentrated without a means to ventilate.
- #5: The facility's Emergency Response Plan (ERP) did not have an extinguishing, ventilation, and entry procedure.

Conclusions:

The report concluded that the then-current (i.e., 2020) standards had improved and were able to better address hazard assessment and training for first responders, although the industry expectation should go even further and require that hazard assessments and training take place before and during the commissioning of energy storage systems.

The report stated the following:

- *Today's standards better address hazard assessment and training for first responders, although the industry expectation should go even further and require that hazard assessments and training take place before and during the commissioning of energy storage systems.*
- *In today's practice, the systems integrator and EPC contractor typically coordinate safety response plans on behalf of the owner, and then train the operations and maintenance (O&M) personnel to execute them.*
- *While today's energy storage safety codes and standards acknowledge cascading thermal runaway as a risk, they stop short of prohibiting it, and fail to address the risk of non-flaming heat transfer to neighbouring cells, modules, and racks. Standards today (referring to 2020) focus on the means to manage a fire, but have so far avoided prescribing solutions that restrict or slow cell-to-cell and module-to-module thermal runaway propagation.*
- *Standards today (again referring to 2020), therefore, also fall short in addressing the issue and risks associated with off-gassing. However, there are commercially available technologies and design methods available that can address thermal runaway propagation, and the standards should be appropriately updated to acknowledge these methods and technologies. The main codes examined in this report are National Fire Protection Agency (NFPA) 855 and past and current versions of the International Fire Code, along with Underwriters' Laboratories (UL) 1973, UL 9540 and the UL 9540A test method.*

- *In addition, better practices for ventilation, extinguishing, and cooling thermal runaway scenarios exist today and should be implemented in future energy storage systems.*
- *Finally, clean agent systems may still be appropriate for use in energy storage facilities to manage incipient fires, but they must be used in conjunction with additional practices: i.e., ventilation, extinguishing, and cooling—to manage thermal runaway scenarios. Clean agent or aerosol extinguishing methods should not be the only barrier against thermal runaway.*

Fire Protection System Observations

The BESS was equipped with a Novec 1230 "total flooding" clean agent fire suppression system. At the time of commissioning, clean agent systems were a common method for managing fire suppression in energy storage containers because clean agents are electrically nonconductive and do not leave a residue.

- When the fire detection system detects a fire, the fire suppression system discharges the agent through a piping system with nozzles mounted on the BESS container ceiling, which emits the agent in a fine mist, dispersing and evaporating in the atmosphere.
- Clean agents are typically used to extinguish incipient (i.e., small) fires before significant damage occurs to the remaining equipment.

In an August 2017 letter to the NFPA 855 committee during drafts of the next edition of the NFPA standard, clean agent manufacturer 3M stated that:

- *Clean agents cannot prevent or suppress cascading thermal runaway in Li-ion battery systems.*

While this statement was made more than a year after the design of the McMicken BESS, it was not widely circulated.

Following the commissioning of the McMicken BESS, the comment did serve to inform future designs and standards development.

The McMicken BESS also contained a Very Early Smoke Detection Apparatus (VESDA) laser-based smoke detection system. The VESDA could detect fine particles and diminishing visibility (due to smoke) within a room, by monitoring for any interference of a laser beam. The sensors were placed evenly along the ceiling of the BESS container and were fed to a central power unit with data storage. Upon smoke detection, the VESDA system sent a signal to a Honeywell Notifier RP 2002 fire alarm control and releasing panel, which in turn sent a signal to discharge the Novec 1230 system, manufactured by Kidde.

The ultimate failure in the design of the fire suppression system was the decision to rely solely on a clean agent fire suppression system to combat thermal runaway.

The Novec 1230 clean agent was inadequate and inappropriate to stop or prevent cascading thermal runaway of multiple battery cells or modules. As noted above, a 3M representative, the developer of the Novec 1230 fire suppression agent, publicly acknowledged this limitation in August 2017.

In the McMicken BESS, the Novec 1230 properly discharged shortly after the first battery cell failed, but over time, the agent-air mixture began to dissipate, negating its fire suppression effectiveness. At the same time, thermal runaway continued to propagate through Rack 15 emitting large quantities of flammable gases into the container.

One of the investigation experts from CP Fire proposed that the Novec 1230 suppressant may have played a role in preventing the ignition of flammable gases as they were released from the thermal runaway in Rack 15, thus allowing these gases to accumulate in the BESS and create an explosion hazard.

Lesson Learned

In relation to CURRENT BESS DESIGN, clean agent fire suppression systems can play an important role in BESS facilities, because they are effective at extinguishing incipient fires and could potentially prevent the initiation of thermal runaway by external (non-thermal runaway) fire hazards.

However, these clean agent systems should be used in conjunction with other fire protection measures and firefighting practices, including ventilation and cooling systems designed to handle thermal runaway and potential explosion

Another outcome of the above consideration has been the advent of flammable gas concentration meters which are now routinely installed in BESS facilities. These allow operators to continuously monitor any flammable mixture or vapor accumulation, and ensure that flammable gas concentrations remain well below the lower flammable limit.

Emergency Response

The emergency response plan (ERP) provided by AES to APS did not have instructions on how to respond to a potential explosion or how to enter the system after the fire suppression system had been discharged.

Most of the detail in the ERP was associated with electrical shut down procedures and roles and responsibilities between APS and Fluence (as the O&M contractor), as well as when/if to notify the fire department. A smoke alarm and fire suppression trigger procedure was in place, but it did not address when or how to initiate entry into the system.

At the time of the development of the ERP, none of the BESS suppliers (including AES and LG Chem) had conveyed that a large flammable gas hazard or cell-to-cell and module-to-module cascading thermal runaway was possible.

Lesson Learned

A key lesson learned from the McMicken Event was that there has to be open and full communication of BESS hazards and risks between ALL parties involved in the design, installation, commissioning and operation of a BESS, operators, maintenance personnel and emergency/firefighting responders.

The apparent breakdown which occurred in relation to the McMicken Event can be understood using a technique called the “Johari Window,” which is used in risk analysis and hazard identification exercises to heuristically identify the known-knowns, known-unknowns, and unknown-unknowns of a technology, process, or operation.

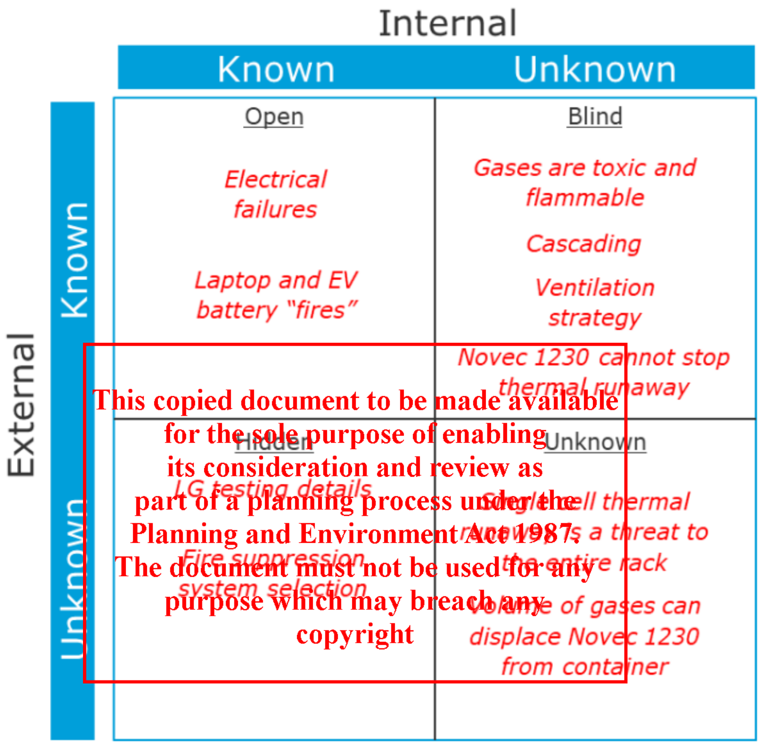
Figure 10 shows a Johari window used to analyze the state of knowledge (both known and unknown) by APS (via its EPC contractor and their subcontractors), at the time the ERP was drafted. In this simplified Johari window:

- “Internal” refers to APS’ collective knowledge as an organization
- “External” is the realm of knowledge available to APS from their supplier and subcontractors.

In **Figure A-2.1**, the following is noted:

"Open" hazards and risks were known by all parties at the time the ERP was drafted. All parties (including APS) were likely aware of common electrical hazards and risks, as well as commonly cited public battery fire hazards from other industries. Indeed, electrical hazards were addressed in the ERP. These hazards are depicted in the upper left quadrant of **Figure A-2.1** and represent as the known-knowns.

Figure A-2.1 Johari Window Covering the McMicken Event



"Hidden" hazards and risks were known by APS at the time the ERP was drafted, but disclosure of information was limited or incomplete. APS was likely aware that LG Chem had test data with regard to battery thermal runaway, such as UL 1973 or UL 1642 and UN 38.3. However, it is highly likely that information presented from these tests was limited to a pass/fail notification without detail. In other words, it is highly doubtful that AES was provided any information about the condition of the cells and modules after the tests. Because these details were not shared with AES, they could not be shared with APS. Similarly, APS likely knew there was a process that AES was following to design the fire suppression system, but the details of that analysis were evidently not shared with APS. These hazards are depicted in the lower left quadrant of **Figure A-2.1** and represent the known-unknowns.

"Blind" hazards and risks may or may not have been known to external parties but were unknown to APS at the time the ERP was drafted. It cannot be stated with any degree of certainty what any party knew or did not know regarding the threat of cascading thermal runaway when the BESS was commissioned. However, it can be inferred through interviews and design documentation that APS was unaware of the threat of cascading thermal runaway - including the risk of flammable off-gases, the need for ventilation, and whether clean agents and aerosols could stop thermal runaway. These "blind" hazards are depicted in the upper right hand quadrant of **Figure A-2.1** and represent the known-unknowns in the external world, yet blind unknowns to APS - these are areas where APS likely did not know what they didn't know.

"Unknown" hazards and risks were unknown to all parties at the time the ERP was drafted. It is not possible to conclusively say what each party knew during the design and commissioning of the McMicken BESS. However, based on a review of the design documentation, it is unlikely that, at the time, either APS or AES were aware of the fact that a single cell thermal runaway was a threat to the entire rack, and the volume of gases from that thermal runaway event could displace Novec 1230 from the container.

However, it is possible AES (and perhaps APS) could have recognized the cascading thermal runaway threat if LG Chem had shared more information concerning their battery cell and module testing. The collection of gases and displacement of Novec 1230, as demonstrated by the analyses from experts in the investigation, would have been much more difficult to predict. These hazards are depicted in the lower right quadrant in **Figure A-2.1** and represent the unknown-unknowns to APS and AES.

Summary

Although AES drafted the ERP, had APS known of all the hazards and risks associated with the BESS, it could have better analysed the sufficiency and adequacy of the ERP prior to commissioning.

Many (most?) of the above shortcomings would likely not occur today, given the advances that have taken place in the management of BESS risks, involving extensive two-way dialogue between the various parties involved in the development of a BESS Project including, importantly, the emergency and fire services charged with responding to emergency events at such facilities.

As was the case for the VBB Fire, today's BESS risk management practices have evolved to a significant degree thanks to failure events such as the McMicken Event.

Key Lesson Learned Re Stakeholders

The McMicken Event has led to an understanding of the need to have all parties kept informed of BESS hazards and risks, especially in relation to the response to a potential fire and/or thermal runaway event.

In relation to key stakeholders, the following is now expected to occur with the development of BESS facilities.

First Responders

First responders, emergency services, fire fighters and ambulance, must receive training as to how to respond, assess, and extinguish BESS fires and treat the injured.

They therefore need to be informed and hence understand the operating and risk characteristics of BESS facilities.

Firefighters in particular must safely mitigate the hazard and stay at the scene as long as necessary to deem the hazard under control, so that they can then relinquish the scene to the parties who have control over it.

Operations & Maintenance (O&M) Staff

O&M staff monitor BESS management systems and make decisions based on system status and public and personnel safety risk. O&M staff are already on call and are typically expected to respond to a site within a limited time depending on location. The response staff from the O&M party are expected to be knowledgeable of the site, able to access the site, and provide guidance to the first responders. They should be in possession of the applicable documents that constitute an emergency response approach. O&M staff typically take control of the site after first responders depart.

Staff Representing the Owner

The "Owner" staff, if applicable and local, may also be involved in response to the site. In the case of the McMicken Event, APS, a utility not unfamiliar with managing, maintaining, and responding to calls involving project sites, had a response to the event that would have been uniquely different than, for example, a private equity firm or project owner that may not have the technical staff or capability to respond.

Recommendations

SLR recommends that key learnings from the McMicken Event are considered during the design evolution of the proposed Cobden BESS design, especially in relation to the development of the site's various management plans, to be undertaken post-approval, covering:

- Fire & Emergency Management Plan (FEMP).

… that needs to be aligned with:

  - Fire Safety Study – focussing on BESS-related hazards and lessons learned from past BESS incidents.
  - Spill Management Plan.
  - Bushfire Management Plan.

Making Sustainability Happen