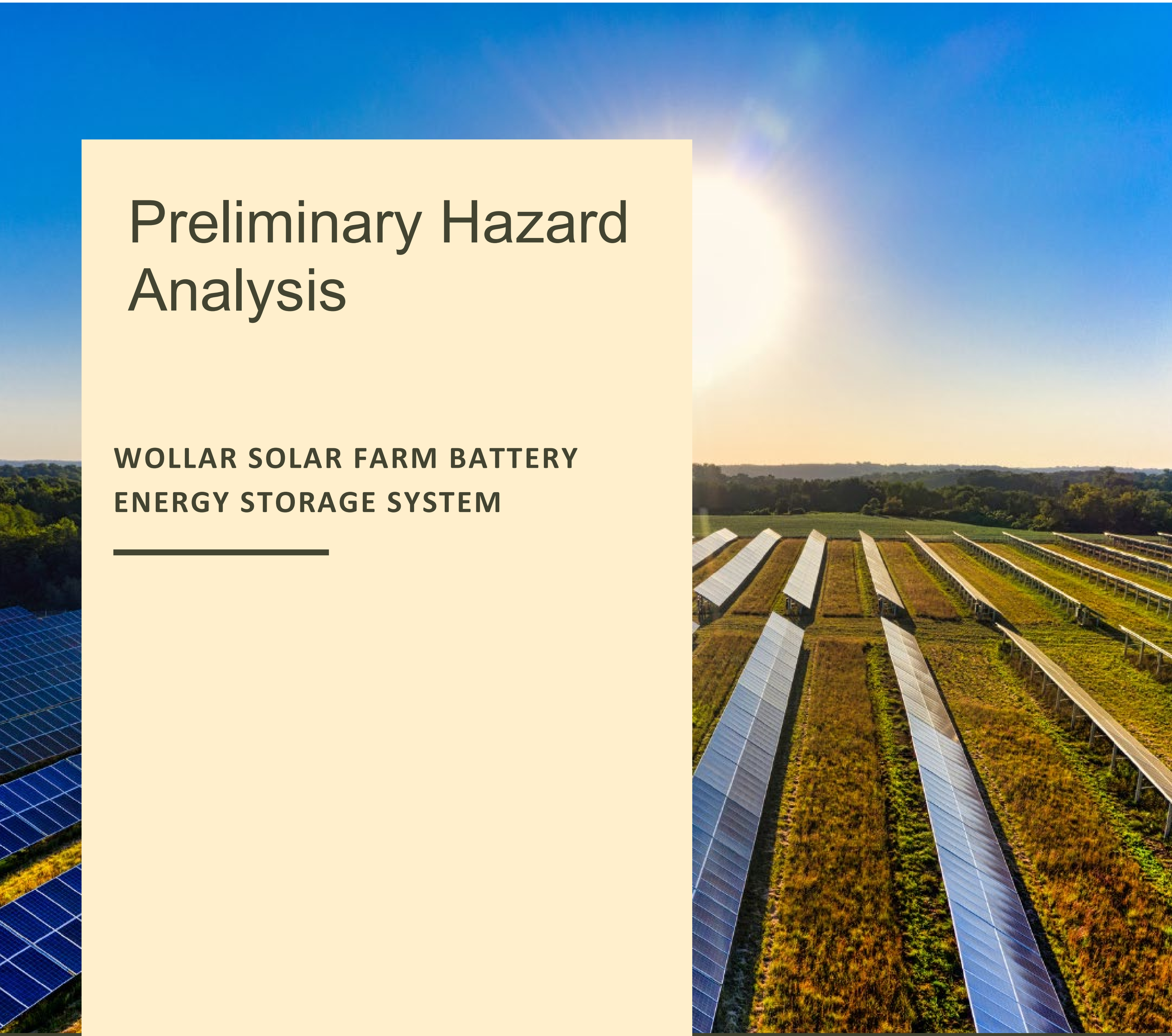

Preliminary Hazard Analysis

WOLLAR SOLAR FARM BATTERY ENERGY STORAGE SYSTEM

NOVEMBER 2024

Prepared for: Wollar Solar Development Pty Ltd

PANDO CONSULTING

Version control

Revision	Date	Task	By	Organisation	File name
Rev0.1	19/07/2024	Draft for client review	Scott McGrath	Pando Consulting	23-002 Wollar Solar Farm BESS PHA Rev0.1 20240709
Rev0.2	4/09/2024	Updated to address client comments	Scott McGrath	Pando Consulting	23-020 Wollar Solar Farm BESS PHA Rev0.2 20240904
Rev0.3	4/09/2024	Minor changes	Scott McGrath	Pando Consulting	23-020 Wollar Solar Farm BESS PHA Rev0.3 20241127

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Acronyms & abbreviations

AC	Alternating Current
APZ	Asset Protection Zone
AUX TX	Auxiliary Transformer
BESS	Battery Energy Storage System
CCTV	Closed-circuit television
DC	Direct Current
DPE	Department of Planning and Environment (NSW) (now DPHI)
DPHI	Department of Planning, Housing and Infrastructure
EIS	Environmental Impact Statement
EMFs	Electric and Magnetic Fields
FRNSW	Fire and Rescue NSW
ha	hectares
HV	High Voltage
km	kilometres
kV	kilovolts
LEP	Local Environment Plan
LFP	Lithium Iron Phosphate ($LiFePO_4$)
LGA	Local Government Area
MV	Medium Voltage
MVPS	Medium Voltage Power Supply
MV TX	Medium Voltage Transformer
m	metres
MW	Megawatt
MWh	Megawatt hours
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
PHA	Preliminary Hazard Analysis

PPE	Personal Protective Equipment
PV	Photovoltaic
RFS	(NSW) Rural Fire Service
SEARs	Secretary’s Environmental Assessment Requirements
SFARP	So Far As Is Reasonably Practicable
WHS	Work Health and Safety

1 Introduction

The Wollar Solar Farm (the Project) includes the construction, operation and eventual decommissioning or reconditioning (subject to future approvals) of a Photovoltaic (PV) solar facility and associated infrastructure with a capacity of up to 290 megawatts (MW) Alternating Current (AC).

The Proponent, Wollar Solar Development Pty Ltd, is proposing to modify the Project to increase the Battery Energy Storage System (BESS) capacity from the approved 30 Megawatt (MW)/30 Megawatt hour (MWh) to approximately 280MW (2 hour storage duration) (the Modification; Mod-4).

The BESS Original Equipment Manufacturer (OEM) will be selected during detailed design. As the OEM is currently unknown, this PHA presents the results of a generalised BESS PHA.

1.1 Objectives

The objectives of this PHA are to:

- Develop a comprehensive understanding of the hazards and risks associated with the operation of a generalised BESS for the Modification and the adequacy of safeguards.
- Detail commitments made by the Proponent, including separation distances, and justify that the land area required for the BESS, including separation distances, is sufficient.

1.2 Scope

This PHA has been prepared in accordance with the *Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis* (DoP, 2011) (HIPAP 6) and *Multi-Level Risk Assessment* (DoP, 2011) (MLRA). This PHA provides a basis for an informed judgment to be made on the acceptability of the Project.

This PHA has assessed a generalised AC coupled co-located BESS and considered Lithium Iron Phosphate ($LiFePO_4$) (LFP) batteries only. No other BESS chemistry has been considered.

1.3 Exclusion and limitations

This PHA is based on concept design, industry design standards and guidelines, and standard safety controls. Some information is limited as complete data on the design and precise controls is not available at the concept design stage.

The scope of this PHA does not include a transport route analysis and/or assessment of other risks, including, but not limited to, aviation safety, health, landslide/subsidence, telecommunications and electromagnetic field.

2 Site location and description

2.1 Site location

The Project is located off Barigan Road, approximately seven kilometres (km) south of Wollar in the Central West and Orana region of NSW (refer to Figure 2-1).

The Project is located within the Mid-Western Regional Local Government Area (LGA). Mudgee is approximately 38km southwest from the Project and is the closest regional centre for residents of

Wollar to access services.

2.2 Surrounds

The land immediately surrounding the Project includes agricultural land, Crown Land, coal mining and a 500/330kV TransGrid substation. Coal mining is the main local industry for employment in the Mid-Western Regional LGA, followed by beef cattle farming and primary education (ABS, 2016).

2.3 Sensitive receivers

One residence that is owned by the current landowner (associated receiver #9) is located greater than 2km from the Modification. No other residences are located within 2km of the Project (refer to Figure 2-2).

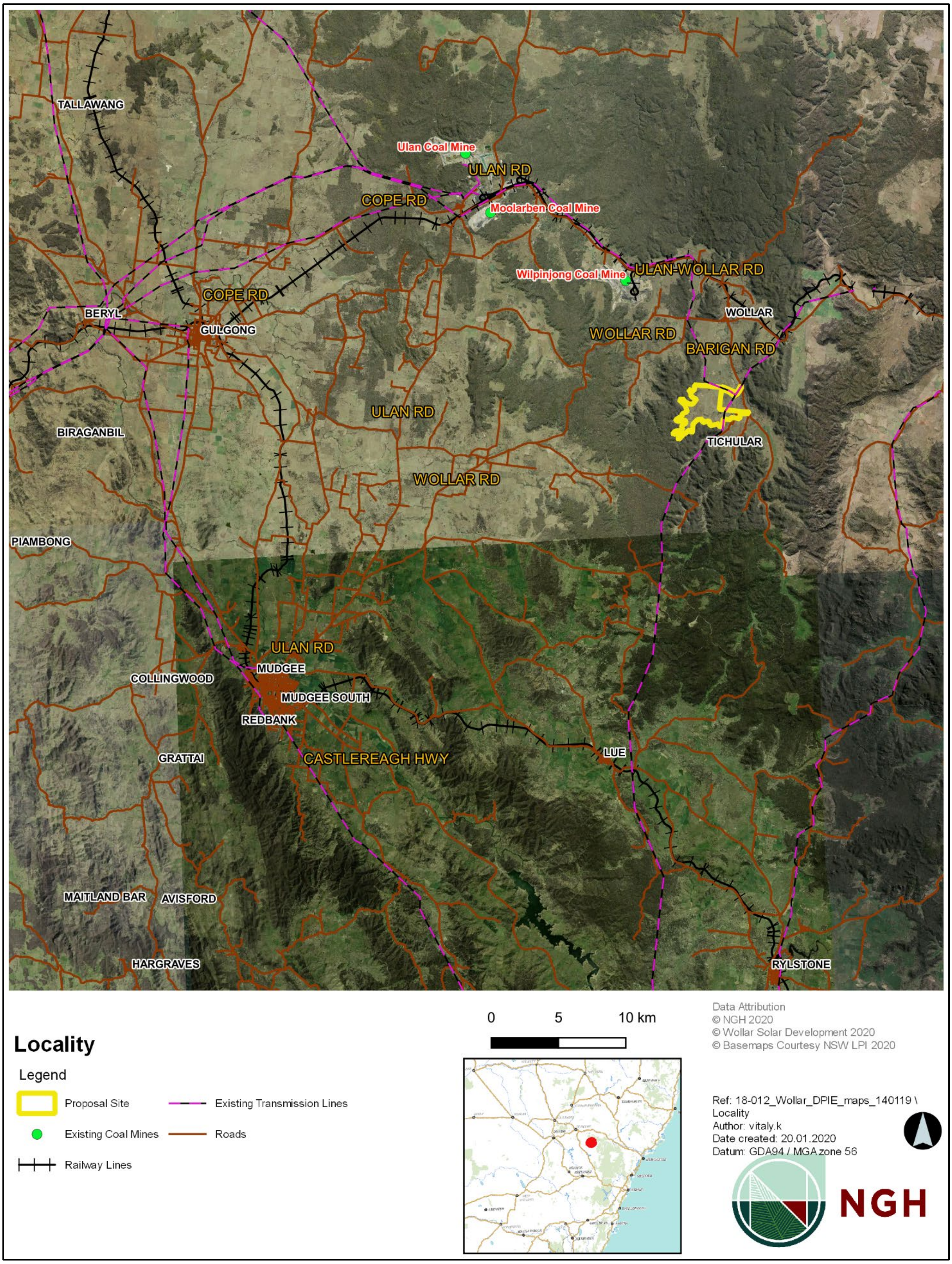

Figure 2-1 Regional setting of the Project (source: NGH)

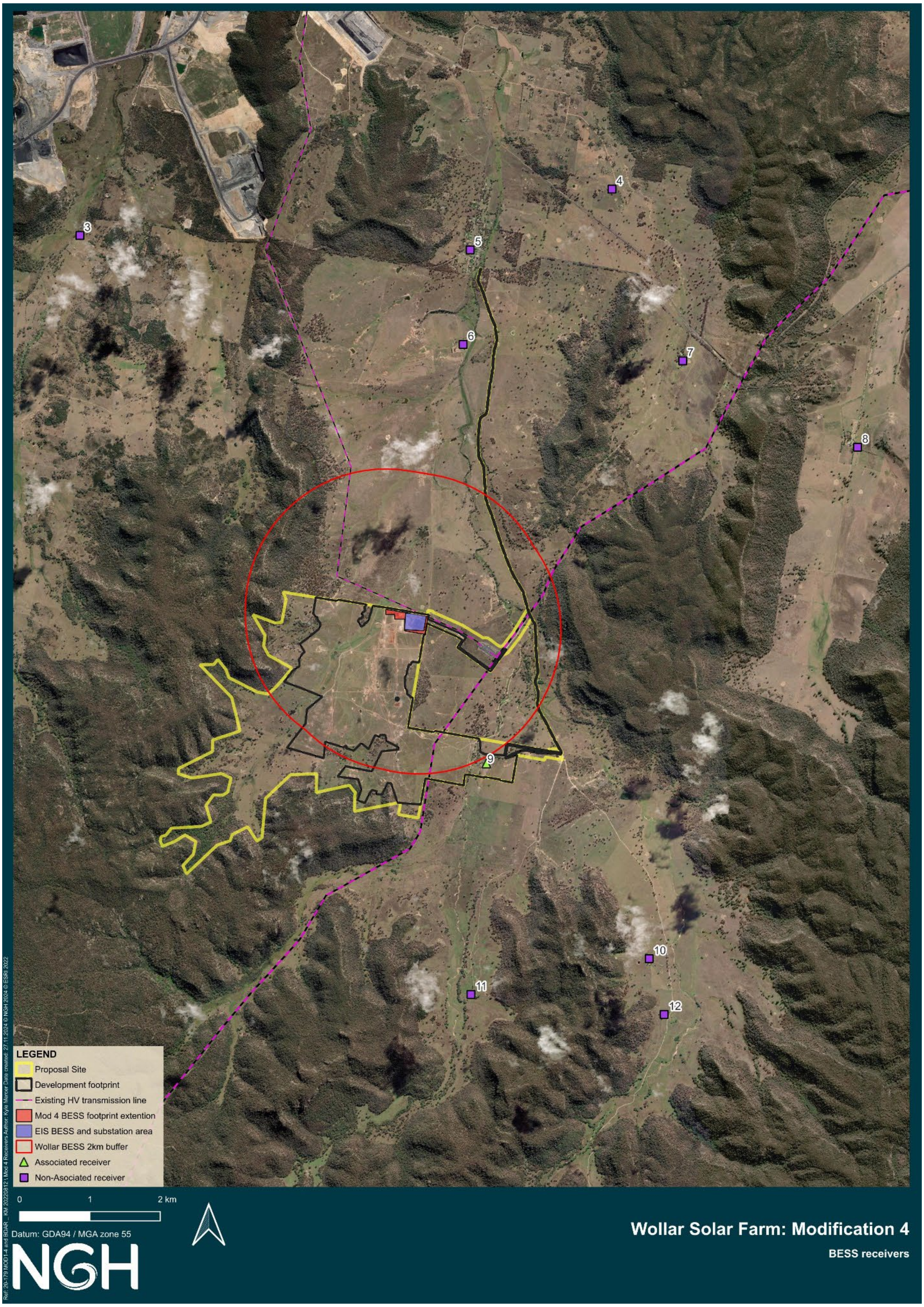

Figure 2-2 BESS receivers (source: NGH)

3 Modification description

The Proponent is proposing to modify the Project to increase the BESS capacity from the approved 30MW/30MWh to approximately 280MW (2 hour storage duration).

The capacity, layout and separation distances of the BESS may be modified during detailed design and following selection of the battery OEM. Any modifications will comply with the OEM product specifications, UL9540A test report recommendations and BESS detailed design standards (refer to 3.1.3).

The proposed Modification, as presented in Figure 3-1, is expected to include (to be determined in detailed design):

- Approximately 13 ‘BESS blocks’ (BESS BLOCK 1 to BESS BLOCK 13)
- Each BESS block includes approximately 6 or 7 ‘battery blocks’ (total of 90) and a ~0.85 megavolt-amperes (MVA) auxiliary transformer. The battery blocks may be racks or containerised.
- Each battery block has a Medium Voltage Power Supply (MVPS) (inverter and transformer)
- Medium Voltage (MV) underground cables
- BESS MV switchroom
- BESS High Voltage Transformer (HV TX)
- Control room
- Operation and maintenance (O&M) building.

Racks or containerised BESS are designed to be modular and scalable, making them easy to expand or contract based on the requirements of the energy storage application. The use of standard-sized containers also makes it easier to transport and install the system, reducing the time and cost of construction.

The AC coupled BESS arrangement allows for the use of grid-forming battery inverters with advanced capabilities, including:

- Provide system strength services to the local network
- Provide more fast frequency response
- Provide improved fault ride through capability
- Provide active power oscillation dampening
- Provide System Restoration Support (if contract is agreed with Australian Energy Market Operator (AEMO)).

Risk mitigation strategies considered in siting the BESS include:

- Ten metre wide Asset Protection Zone (APZ)
- Provision of fire safety separation distances
- Four metre wide internal roads suitable for emergency access and/or exit.

3.1.1 BESS safeguards

Subject to detailed design and OEM recommendations, each battery block would include:

- Gas detection and suppression
- Fire suppression
- Pressure relief vent
- Pressure blast panels.

In accordance with NFPA 855 14.3.2.2, the BESS would be designed to include a 2-hour fire resistance rating, a fire alarm system, and an automatic sprinkler system. Other safeguards include:

- Emergency stop
- Ground fault detection
- Manual Service Disconnect (MSD) switch
- Overcurrent protection
- Battery Management System (BMS).

3.1.2 BESS separation distances

Separation distance may be the most effective control to reduce the likelihood and consequence of fire propagation as a result of thermal runaway event. The separation distances for the BESS will be determined during detailed design. A typical layout is presented in Figure 3-1 and Figure 3-2 including:

- Project APZ of 10 m and 4 m internal roads
- Substation exclusion zone of 20 m
- Separation distance of approximately 4 m between battery blocks
- Separation distance of approximately 5 m between battery blocks and MVPS

In accordance with the National Fire Protection Agency (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* (NFPA 855), the minimum clearance to enclosures for outdoor stationary Energy Storage Systems (ESS) installations is 10 feet (3.05 metres). The separation distance will be confirmed during the detailed design and will exceed the NFPA 855 guidelines.

Publicly available UL9540A test reports for utility scale Lithium Iron Phosphate (LiFePO4 or LFP) batteries, indicates that 10 mm to 160 mm separation is suitable to prevent thermal runaway from propagating from battery unit to battery unit (refer to Table 3-1).

Table 3-1 OEM recommended minimum separation distances

OEM	Minimum required spacing between battery units	Product (if known)
Sungrow	160 mm	Sungrow ST2752UX
CATL (Contemporary Amperex Technology Co., Limited)	10 mm	
EVE Power	160 mm	

OEM	Minimum required spacing between battery units	Product (if known)
Ruipu Energy	160 mm	

The separation distance between battery blocks will exceed the minimum required spacing between battery units of readily available UL9540A test reports.

A review of the NSW major projects website identified that the Beresfield BESS EIS included a PHA for a 170 MW generalised BESS (i.e., OEM not yet selected). The Beresfield BESS PHA did not include heat radiation modelling and concluded that, as the minimum separation distance between BESS units is 3.1 m in compliance with NFPA 855, the risks at the site boundary are not considered to exceed the acceptable risk criteria.

Any separation distance greater than 3.05m exceeds NFPA 855 and readily available UL9540A test reports (for LFP only), therefore it is considered appropriate at the planning phase of the development. Following the implementation of the recommendations of this PHA, including the proposed separation distances, the likelihood of a multi-module fire would be minimised to a non-credible event

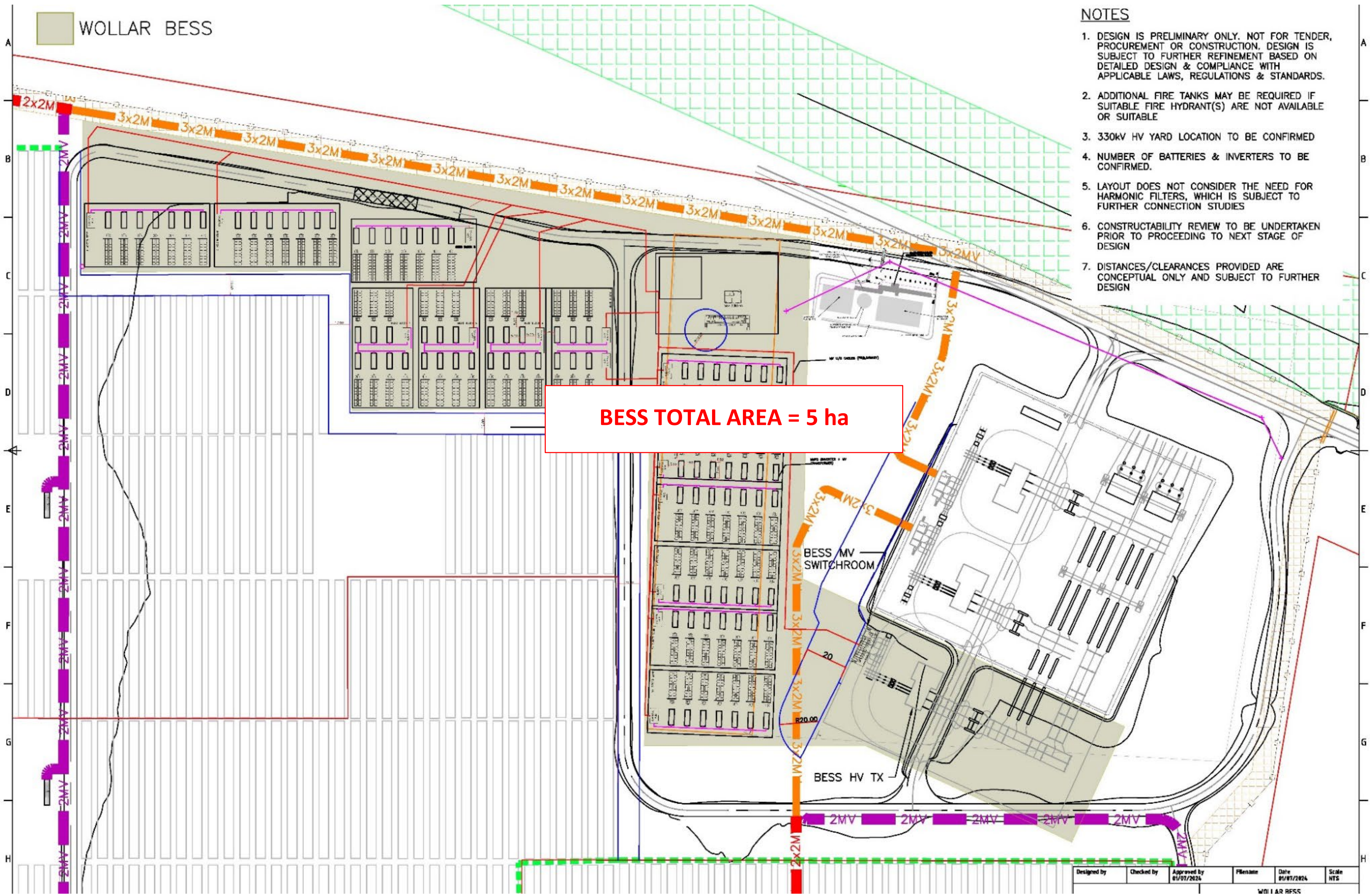

Figure 3-1 BESS layout (source: Wollar Solar Development Pty Ltd; indicative only and not to scale)

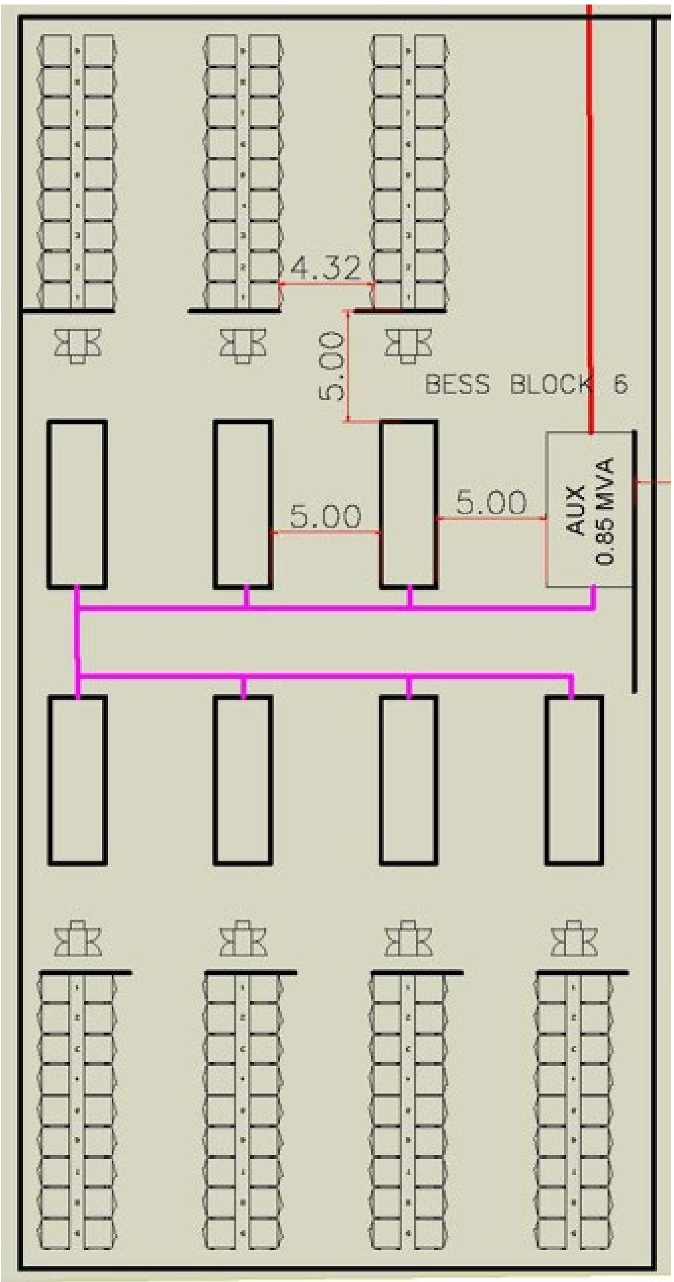

Figure 3-2 BESS separation distances (source: Wollar Solar Development Pty Ltd; indicative only and not to scale)

3.1.3 BESS detailed design standards

The detailed design of the BESS will be in accordance with standards provided in Table 3-2 and Table 3-3. The detailed design will also review and comply with OEM product specifications, UL9540A test report recommendations and the fire safety study.

Table 3-2 Consideration of standards and codes in BESS design

Standard / code	Consideration
AS 2067	Substations and high voltage installations exceeding 1.0kVAC considering electrical, operation and safety separation

Standard / code	Consideration
FM Global DS 5-33	Property Loss Prevention Data Sheets
FM Global	Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems
IEC 61000-6	Electromagnetic compatibility (EMC)
IEC 62477-1	Safety requirements for power electronic converter systems and equipment
IEC 62619	Safety requirements for secondary lithium cells and batteries, for use in industrial applications
IEC 62897	Stationary Energy Storage Systems with Lithium Batteries - Safety Requirements
NFPA 855	Standard for the Installation of Stationary Energy Storage Systems
NSW Fire + Rescue	Large-scale external lithium-ion battery energy storage systems – fire safety study considerations
UL 1973	Standard for Safety Batteries for Use in Stationary and Motive Auxiliary Power Applications
UL 9540	Standard for Energy Storage Systems and Equipment
UL 9540A	Test method - testing the fire safety hazards associated with propagating thermal runaway within battery systems
UN 38.3	Transportation Testing for Lithium Batteries and Cells

Table 3-3 Consideration of standards and codes for BESS separation distances

Source	Infrastructure	Safety Clearance
NPFA 855	BESS	Minimum clearance to enclosures for outdoor stationary ESS installations is 10 feet (3.05 metres). Battery containers must be 0.9 m from other battery collection containers and combustible materials.
FM Global DS 5-33	BESS	For containerized Lithium Nickel Manganese Cobolt Oxide (NMC) Lithium-Ion BESS, where wall construction is documented as having at least a 1 hour rating in accordance with ASTM E119, aisle separation of at least 8 ft (2.4 m) is acceptable. **For containerized Lithium-Ion BESS comprised of Lithium Iron Phosphate (LFP) cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors or deflagration vents.**

Source	Infrastructure	Safety Clearance
ASNZS 5139.2019 6.2.6.2	MV power station	Minimum of 900mm distance between battery system and Power Conversion Equipment

4 Recommendations following the Victorian Big Battery Fire

Recommendations were provided in the *Victorian Big Battery Fire Statement of Technical Findings* – Victorian Government 2021 following an investigation into the Victorian Big Battery Fire. In response to the recommendations, the Proponent, Wollar Solar Development Pty Ltd, makes the commitments presented in Table 4-1.

Table 4-1 The Proponents response to recommendations of the Victorian Big Battery Fire

Victorian Big Battery Fire Statement of Technical Findings - lessons learned and preventing a recurrence	Proponents' commitment
Tesla Megapack	The Proponent is unlikely to use the Tesla Megapack. If they do, they will implement all recommendations from the Victorian Big Battery Fire Statement of Technical Findings – Victorian Government 2021
Each Megapack cooling system is to be fully functionally and pressure tested when installed on site and before it is put into service	Following installation, the Proponent will commission any liquid chillers and cooling pipes to check they are fully functional and undertake subsequent pressure tests.
Each Megapack cooling system in its entirety is to be physically inspected for leaks after it has been functionally, and pressure tested on site	The Proponent will undertake physical inspections of any liquid chillers following commissioning and pressure testing.
The Supervisory Control And Data Acquisition (SCADA) system has been modified such that it now 'maps' in one hour and this is to be verified before power flow is enabled to ensure real-time data is available to operators	The Proponent is unlikely to use the Tesla Megapack. If they do, the SCADA will be modified in accordance with this recommendation.
A new 'battery module isolation loss' alarm has been added to the firmware; this modification also automatically removes the battery module from service until the alarm is investigated	The Proponent is unlikely to use the Tesla Megapack. Any selected BESS units will include a battery module isolation loss alarm that automatically removes the battery module from service until the alarm is investigated.
Changes have been made to the procedure for the usage of the key lock for Megapacks during commissioning and operation to ensure the telemetry system is operational	The Proponent is unlikely to use the Tesla Megapack. If they do, the procedure for the usage of the key lock for Megapacks during commissioning and operation will ensure the telemetry system is operational
The high voltage controller (HVC) that operates the pyrotechnic fuse remains in service when the key lock is isolated	DC fuses remain in service for protection purpose no matter if the key lock is isolated or not.

5 Preliminary hazard analysis

5.1 PHA methodology

The methodology undertaken to prepare this PHA includes:

- Identification of the nature and scale of all hazards at the proposed development, and the selection of representative incident scenarios.
- Analysis of the consequences of these incidents on people, property, and the biophysical environment.
- Evaluation of the likelihood of such events occurring and the adequacy of safeguards.
- Calculation of the resulting risk levels of the facility.
- Comparison of these risk levels with established risk criteria and identification of opportunities for risk reduction.

A schematic of the hazard analysis process is included below in Figure 5-1.

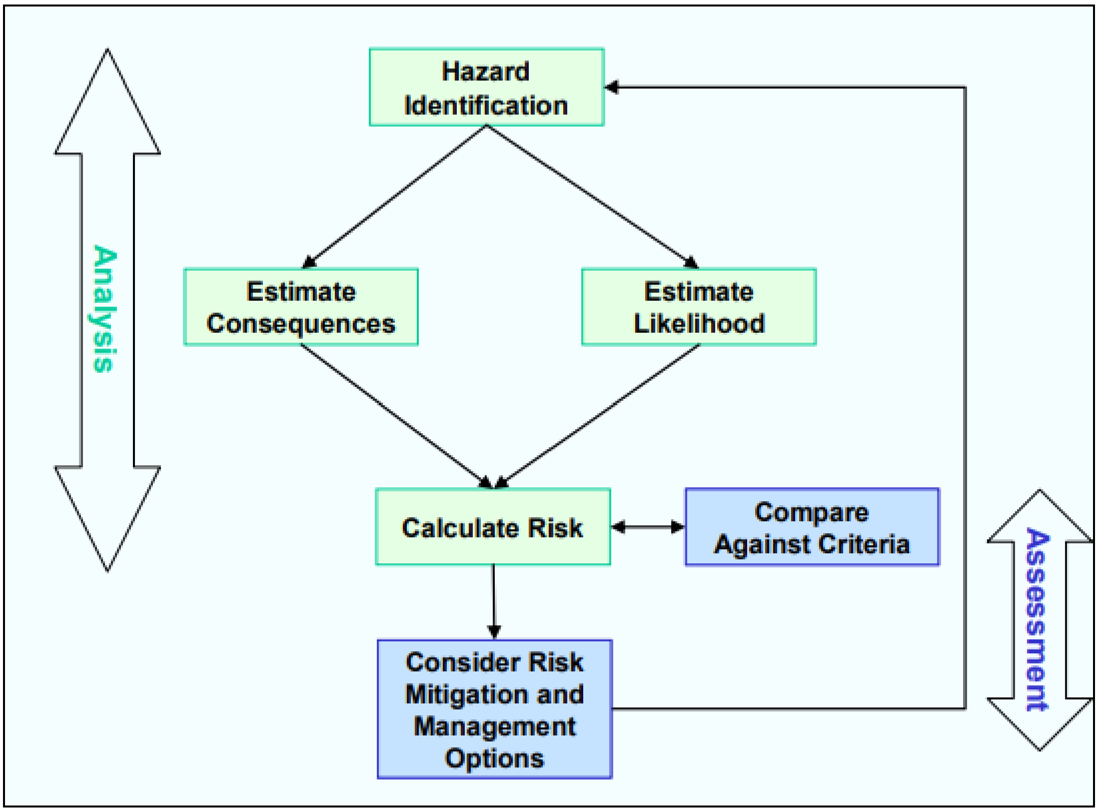

Figure 5-1 Basic methodology for hazard analysis (Source: HIPAP 6)

5.2 Hazard Identification

Hazard identification includes the systematic identification of possible hazards, both on-site and off-site including:

- BESS activities and infrastructure
- Type of equipment
- Hazardous materials present

- Natural events such as floods, cyclones, earthquakes, or lightning strikes
- Hazardous events on neighbouring sites.

The identified hazards and events are presented in Table 5-1.

Table 5-1 Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
Electric and Magnetic Fields (EMF)	Exposure to EMF
Fire	Infrastructure fire
Chemical	Release of hazardous materials
Reaction	Battery thermal runaway
External factors	Vandalism, flooding

5.3 Consequence analysis

Consequence

For each identified event, the resulting consequence was qualitatively described. These include impacts to personnel (e.g., fatality/injury), environment and/or assets.

Likelihood

Using a qualitative approach, the likelihood of an event was estimated using the category scale shown in Table 5-2. The likelihood ratings were assigned based on knowledge of historical incidents in the industry. The likelihood ratings were assigned accounting for the initiating causes, resulting consequences with controls (prevention and mitigation) in place.

Table 5-2 Likelihood category

Category	Description
1. Extremely Unlikely	Never heard of in the industry, not realistically expected to occur
2. Very Unlikely	Heard of in the industry, but not expected to occur
3. Unlikely	Could occur in the next 10 years
4. Likely	Could occur in the next year

5.4 Hazard Register

The identified hazards, events, applicable infrastructure and the relationships with causes, consequences, controls, and likelihood ratings are summarised in the hazard register. Information contained in the hazard register is provided in Table 5-3.

The hazard register for the project is presented in Table 5-4.

Table 5-3 Information used in hazard register

Column Heading	Description
Hazard	Description of the source of potential harm
Infrastructure/Area	Project infrastructure or area the hazard/event is applicable to
Event	Description of mechanism by which the hazard potential is realised
Cause	Description of the potential ways in which the event could arise
Consequence	Description of consequences of the event and potential impact to people, environment and/or asset
Controls	Any existing aspects of the design which prevent and/or mitigate against the event and resulting consequences
Likelihood Rating	Likelihood rating assigned for the event accounting for the initiating causes, resulting consequences with controls in place

Table 5-4 Hazard register

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
1	Electrical	Exposure to voltage	Short circuit/electrical connection failure Faulty equipment Incorrect installation Incorrect maintenance Human error during maintenance Safety device/circuit compromised Battery casing/enclosure damage	Electrocution Injury and/or fatality Fire	Equipment and systems will be designed and tested to comply with international standards and guidelines Engagement of reputable contractors Independent certifiers/owner's engineers Installation and maintenance will be done by trained personnel Electrical switch-in & switch-out protocol (pad lock) BMS including fault detection and shut-off function Ground fault detection Manual Service Disconnect (MSD) switch Overcurrent protection Warning signs (electrical hazards, arc flash) Emergency Response Plan External assistance for firefighting (FRNSW & RFS) Use of appropriate PPE Rescue kits (i.e., insulated hooks)	Very Unlikely
2	Arc flash	Arc flash	Incorrect procedure (i.e., installation/ maintenance) Faulty equipment (e.g., corrosion on conductors) Faulty design (e.g., equipment too close to each other) Insulation damage Human error during maintenance	Burns Injury and/or fatality Exposure to intense light and noise Arc blasts and resulting heat, may result in fires and pressure waves	Equipment and systems will be designed and tested to comply with international standards and guidelines Engagement of reputable contractors Independent certifiers/owner's engineers Site induction/substation training (i.e., high voltage areas) Installation and maintenance will be done by trained personnel Maintenance procedure (e.g., deenergize equipment) Preventative maintenance (insulation) Emergency Response Plan External assistance for firefighting (FRNSW & RFS) Warning signs (arc flash boundary) Use of appropriate PPE for flash hazard	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
3	EMF	Exposure to electric and magnetic fields	Operations of power generation equipment	High level exposure (i.e., exceeding the reference limits) may affect function of the nervous system (i.e., direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) Personnel injury	Location siting and selection (incl. separation distance) Optimising equipment layout and orientation Reducing conductor spacing Balancing phases and minimising residual current Incidental shielding (i.e., BESS building/enclosure, switchroom) Equipment and systems will be designed and tested to comply with international standards and guidelines Exposure to personnel is short duration in nature (transient) Physical warning signs (e.g., danger or restricted access) Studies found that the EMF for commercial solar power generation facilities comply with ICNIRP occupational exposure limits	Extremely Unlikely
4	Fire	Fire	Transformer oil leak Faulty equipment Arc flash External fire (e.g., bushfire, adjacent infrastructure)	Fire in switchyard and escalation to switchroom Release of toxic combustion products Injury/fatality Asset damage Interruption in power supply	Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines Equipment will be procured from reputable supplier Independent certifiers/owner's engineers All relevant Transgrid's requirements will be met Installation, operations and maintenance by trained personnel (e.g., reputable third party) in accordance with relevant procedures Preventative maintenance (e.g., insulation, replacement of faulty equipment) Activation of emergency shutdown (ESD button) Fire Management Plan Emergency Response Plan External assistance for firefighting (FRNSW & RFS)	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
5	Fire	Switchroom fire	Equipment failure Arc flash Vandalism External fire (e.g., bushfire, adjacent infrastructure)	Fire in substation and escalation to switchyard Release of toxic combustion products Injury/fatality Asset damage Interruption in power supply	Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines Equipment will be procured from reputable supplier Compliance auditing by independent certifiers/owner's engineers All relevant Transgrid's requirements will be met Inverter/transformers (MVPSs) are in designated area Installation, operations and maintenance by trained personnel (e.g., reputable third party) in accordance with relevant procedures Preventative maintenance (e.g., insulation, replacement of faulty equipment) Electrical switch-in & switch-out protocol (pad lock) Circuit breakers Substation is locked and located in designated area Security fence and controlled access Activation of emergency shutdown (ESD button) Fire Management Plan Emergency Response Plan External assistance for firefighting (FRNSW & RFS)	Extremely Unlikely
6	Fire	Fire in temporary construction facilities	Kitchen fire Paper fire Smoking	Injury/fatality Asset damage	Fire Management Plan Cooling water supply on-site Defendable boundary for firefighting will be established (i.e., asset protection zone) Dedicated smoking area Fire protection system in the temporary construction facilities Emergency Response Plan External assistance for firefighting (FRNSW & RFS) Use of appropriate PPE	Very Unlikely
7	Fire	Bushfire	Encroachment of off-site bushfire Escalated event from facility fire	Injury/fatality Asset damage	Fire Management Plan Cooling water supply on-site Defendable boundary for firefighting will be established (i.e., APZ)	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
					Emergency Response Plan External assistance for firefighting (FRNSW & RFS) Use of appropriate PPE	
8	Reaction	Thermal runaway in battery	Elevated temperature Bushfire External fire (e.g., substation, transformer) Electrical failure Short circuit Excessive current/voltage Imbalance charge across cells Mechanical failure • Internal cell defect • Damage (crush/penetration/puncture) Systems failure • Battery Management System (BMS) failure • HVAC failure	Fire in the battery cell Injury/fatality Escalation to the enclosure/ building Escalation to the entire BESS	Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines Equipment will be procured from reputable supplier Independent certifiers/owner's engineers Fire protection system including gas detection and suppression and possible water suppression system Separation distances in accordance with OEM UL9540A test reports Pressure relief vent Pressure blast panels BMS including fault detection and shut-off function Emergency stop Ground fault detection Overcurrent protection Temperature monitoring Safety shut-off function HVAC system Cell chemistry selection (minimise runaway) Battery cell/pack design ESS blocks housed in dedicated containers designed with 2-hour resistance rating Activation of emergency shutdown (ESD button; outside of BESS or remotely from the O&M building) Fire Management Plan Emergency Response Plan External assistance for firefighting (FRNSW & RFS)	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
9	Chemical	Release of electrolyte (liquid/ vented gas) from the battery cell	Mechanical failure/damage Dropped impact (installation/maintenance) Damage (crush/penetration/puncture) Abnormal heating/elevated temperature Thermal runaway Bushfire External fire (e.g., substation, transformer)	Release of flammable liquid electrolyte Vapourisation of liquid electrolyte Release of vented gas from cells Fire and/or explosion in battery enclosure/building Release of toxic combustion products Injury/fatality	Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines Equipment will be procured from reputable supplier Independent certifiers/owner's engineers Engagement of reputable contractors Installation and maintenance will be done by trained personnel Layers of battery case (pod and external casing) Spill cleanup using dry absorbent material BMS including fault detection and shut-off function HVAC system BESS fire protection system	Very Unlikely
10	Chemical	Coolant leak	Mechanical failure/damage Incorrect maintenance	Irritation/injury for personnel on exposure (inhalation)	Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines Equipment will be procured from reputable supplier Independent certifiers/owner's engineers Engagement of reputable contractors Maintenance will be done by trained personnel Layers of battery case (pod and external casing) Spill cleanup using dry absorbent material BMS fault detection and shut-off function PPE	Very Unlikely
11	Chemical	Refrigerant leak	Mechanical failure/damage Incorrect maintenance	Irritation/injury for personnel on exposure (skin contact)	Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines Equipment will be procured from reputable supplier Independent certifiers/owner's engineers Engagement of reputable contractors Maintenance will be done by trained personnel BESS layers of battery case (pod and external casing) BESS BMS fault detection and shut-off function Chiller Unit separation distance to other	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
					equipment PPE	
12	Chemical	Exposure to hazardous material	Inappropriate storage use and handling of pesticides/herbicides for vegetation management and landscaping	Irritation/injury for personnel on exposure	Product will be stored in dedicated storage area in a bund A spill kit will be kept near the dedicated storage area Quantity kept in work area will be minimised No spraying will be done during high wind Limited usage prior to and during rain events PPE (as required by Safety Data Sheet)	Very Unlikely
13	Diesel	Release of diesel from storage tank or filling point Release of diesel during handling/ transfer to generator set	Mechanical failure Human error during transfer	Fire (if ignited) Injury/fatality	Equipment and systems will be designed and tested to comply with Australian standards & guidelines (e.g., AS 1940) Engagement of reputable contractors Installation and maintenance will be done by trained personnel Diesel is a combustible liquid and will be stored away from other flammable materials (e.g., gasoline) Secondary containment (i.e., bunding) Warning signs (combustible material) Fire Management Plan Defendable boundary for firefighting will be established Emergency Response Plan External assistance for firefighting (FRNSW & RFS) Use of appropriate PPE	Very Unlikely

ID	Hazard	Event	Cause	Consequence	Controls	Likelihood Rating
14	Gasoline	Release of gasoline from storage tank or filling point	Mechanical failure Human error during transfer	Fire Injury/fatality	Equipment and systems will be designed and tested to comply with Australian standards & guidelines (e.g., AS 1940) Engagement of reputable contractors Installation and maintenance will be done by trained personnel Secondary containment (i.e., bunding) Warning signs (flammable material) Fire Management Plan Defendable boundary for firefighting will be established Emergency Response Plan External assistance for firefighting (FRNSW & RFS) Use of appropriate PPE	Very Unlikely
15	External factors	Fire (BESS, Inverter/transformers (MVPSs), substation switchrooms)	Water ingress (e.g., rain, flood)	Electrical fault/short circuit Fire Injury/fatality	Location siting (i.e., outside of flood prone area) Switchrooms and BESS are housed in dedicated enclosure/building. which will be constructed in accordance with relevant standards Drainage system Preventative maintenance (check for leaks)	Extremely Unlikely
16	External factors	Vandalism	Unauthorised personnel access	Asset damage Potential hazard to unauthorized person (e.g., electrocution)	Project infrastructures are in secure fenced area Onsite security protocol Warning signs During construction, the area will be patrolled, and fence will be installed	Unlikely
17	External factors	Lightning strike	Lightning storm	Injury/fatality Fire Asset damage	Earthing Lightning protection mast (Substations) PPE	Very Unlikely

6 Risk assessment

Risk is the likelihood of a defined adverse outcome. To calculate risk, it is necessary to consider the likelihood and the consequences of each of the hazardous scenarios identified.

Using a qualitative approach, the risk of an event was estimated using the study risk matrix shown in Figure 6-1.

For each identified hazard and associated event, the resulting consequences and likelihood pair was determined from the hazard register. The consequence and likelihood of the identified events are presented in Table 6-1.

			Likelihood			
			1 Extremely Unlikely	2 Very Unlikely	3 Unlikely	4 Likely
			Never heard of in the industry, not realistically expected to occur	Heard of in the industry, but not expected to occur	Could occur in the next 10 years	Could occur in the next year
Severity	4 Major	Fatality / Permanent Injury				
	3 Moderate	Severe injury / Lost time				
	2 Minor	Minor Injury / Visit to Doctor				
	1 Insignificant	Slight injury / First aid				

Risk Acceptance Criteria

High	Unlikely to be tolerable - review if activity should proceed.
Medium	Tolerable, if so far as reasonably practicable
Low	Broadly acceptable

Figure 6-1 Qualitative risk matrix

Table 6-1 Risk assessment

Hazard	Event	Consequence (Impact to People)	Likelihood	Risk
Electrical	Exposure to voltage	Major	Very unlikely	Medium
Arc flash	Arc flash	Major	Very unlikely	Medium
EMF	Exposure to EMF	Insignificant	Extremely unlikely	Low
Fire	Fire – transformers and MVPSs	Major	Very unlikely	Medium
	Fire – substation	Major	Extremely unlikely	Medium
	Fire – temporary construction facilities	Major	Very unlikely	Medium
	Bushfire	Major	Very unlikely	Medium
Reaction	Thermal runaway in battery	Major	Very unlikely	Medium
Chemical	Release of electrolyte from the battery cell (liquid/vented gas) resulting in fire and/or explosion	Major	Very unlikely	Medium
	Battery coolant leak	Minor	Very unlikely	Low
	Refrigerant leak (BESS and refrigeration/chiller units)	Minor	Very unlikely	Low
	Exposure to hazardous material (herbicide/pesticide)	Minor	Very unlikely	Low
	Release of diesel from storage tank, filling point or during handling resulting in fire	Major	Very unlikely	Medium

Hazard	Event	Consequence (Impact to People)	Likelihood	Risk
	Release of gasoline from storage tank or filling point resulting in fire	Major	Very unlikely	Medium
External factors	Water ingress resulting in fire (BESS, MVPSs or switchrooms)	Major	Extremely unlikely	Medium
	Vandalism due to unauthorised personnel access	Moderate	Unlikely	Medium
	Lightning strike	Major	Very unlikely	Medium

7 Risk assessment results

7.1 Consequence

The risk assessment indicates that the worst-case consequence is a fire from a variety of causes (e.g., release of flammable materials, battery thermal runaway, transformer fire). These fires may have the potential to initiate bushfire to surrounding areas.

7.2 Likelihood

The risk assessment indicates that the highest likelihood rating for the identified events is unlikely (i.e., could occur in the next 10 years). This relates to unauthorised personnel access to the Modification resulting in vandalism/asset damage to the project infrastructure.

7.3 Risk assessment

A total of 17 risk events were identified. The breakdown of these events according to their risk ratings is as follows:

- 13 medium-risk events
- 4 low-risk events.

Based on the risk acceptance criteria used for the study, the risk profile for the project is considered tolerable, given the measures taken So Far As Is Reasonably Practicable (SFARP).

Most of the medium-risk events are related to fire incidents resulting from various causes, such as the release of flammable materials, battery thermal runaway, transformer fire, and bushfires, among others. The analysis identified proposed prevention controls to reduce the likelihood of these fire events, as well as mitigation controls to contain fires and minimize the potential for escalation (e.g., fire management plan). Considering the identified controls, the highest likelihood for these events was rated as very unlikely, indicating that while such incidents have been heard of in the industry, they are not expected to occur.

Considering the size of the Modification area, the proposed location of project infrastructure within that footprint, the proposed controls, and the distance to neighbouring land uses (including neighbouring properties and agricultural operations), the exposure to fire events will primarily affect the Project's construction and operations workforce. Offsite impacts are expected to be minimal.

The risk assessment concluded that there is negligible potential for offsite fatalities or injuries. Therefore, the Project aligns with land use planning criteria. The identified risk events pertain to onsite impacts and were assessed against the requirements of the *Work Health and Safety (WHS) Act* to reduce risk to SFARP. The Project deemed these risks as tolerable, considering the measures taken SFARP.

7.3.1 Qualitative risk assessment against Hazard Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning (DoP, 2011)

An assessment of the BESS against the qualitative land use planning risk criteria from HIPAP 4 is provided in Table 7-1.

Table 7-1 HIPAP 4 qualitative risk criteria assessment

HIPAP 4 qualitative risk criteria	AC-coupled co-located
All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	Alternative locations: No other locations, outside the Project area, have been considered as this would introduce avoidable risks to a new area. The separation distances and distances to nearby receivers will reduce the fire risks from the BESS. Alternative technologies: LFP BESS are the most common electrochemical BESS type for grid scale developments due to their safety, high energy densities, high efficiency and size. All 'avoidable' risks have been avoided and no feasible alternatives are possible or justified.
The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.	The risk assessment presented in section 7 includes feasible controls that reduce hazards wherever practicable. The outcome of the risk assessment (SFARP), including the separation distances described in Section 3 and the distances to nearby receivers, indicates that the controls are adequate and relevant.
The consequences (effects) of the more likely hazardous events (i.e., those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	The risk assessment presented in section 7 indicates that hazardous events are likely to be contained within the boundaries of the development footprint. The separation distances described in section 3 will minimise fire propagating between BESS modules and reduce the intensity of any fire (and therefore reduce the likelihood of fire extending beyond the development site).
Where there is an existing high risk from a hazardous	There are no other known high risk

HIPAP 4 qualitative risk criteria	AC-coupled co-located
installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	hazardous installations in the area.

8 Conclusion

This PHA has been conducted to demonstrate that the risk levels associated with the BESS do not impede the approval of the Modification. The PHA findings did not identify any significant offsite consequences or societal risks.

The steps undertaken to prepare this PHA include:

- Identification of BESS hazards. It analysed potential incident scenarios arising from these hazards and assessed the resulting consequences for people, property, and the environment
- Estimation of the likelihood of hazardous incidents that could have significant consequences
- Recommendations for controls to mitigate the consequences and reduce the likelihood of potentially hazardous incidents.

Based on the risk assessment, it was determined that the risk profile for the Modification is considered tolerable under the principle of SFARP. Most of the medium-risk events are related to fire events. The primary exposure to fire events will be to the Modifications construction and operations workforce, with minimal offsite impacts anticipated. The risk assessment concluded that there is negligible potential for offsite fatality or injury identified, thus meeting the land use planning criteria.

The qualitative assessment of a thermal runaway event indicates that, due to the separation distances, a multi module fire (i.e., fire propagating from battery container to battery container or battery unit to battery unit) is a non-credible event.

9 Recommendations

It is recommended that the results of this PHA should be used as inputs into other safety studies required including:

- Emergency response plan
- Fire safety study and subsequent fire management plan.

In addition to the above it is required that:

- Following a decision of the BESS OEM, the detailed design of the BESS will be undertaken to comply with the requirements of section 3.2, including separation distances, UL9540A test reports and OEM recommendations or product specifications
- If the Proponent chooses to use the Tesla Megapack, all recommendations from the Victorian Big Battery Fire Statement of Technical Findings – Victorian Government 2021 will be implemented.