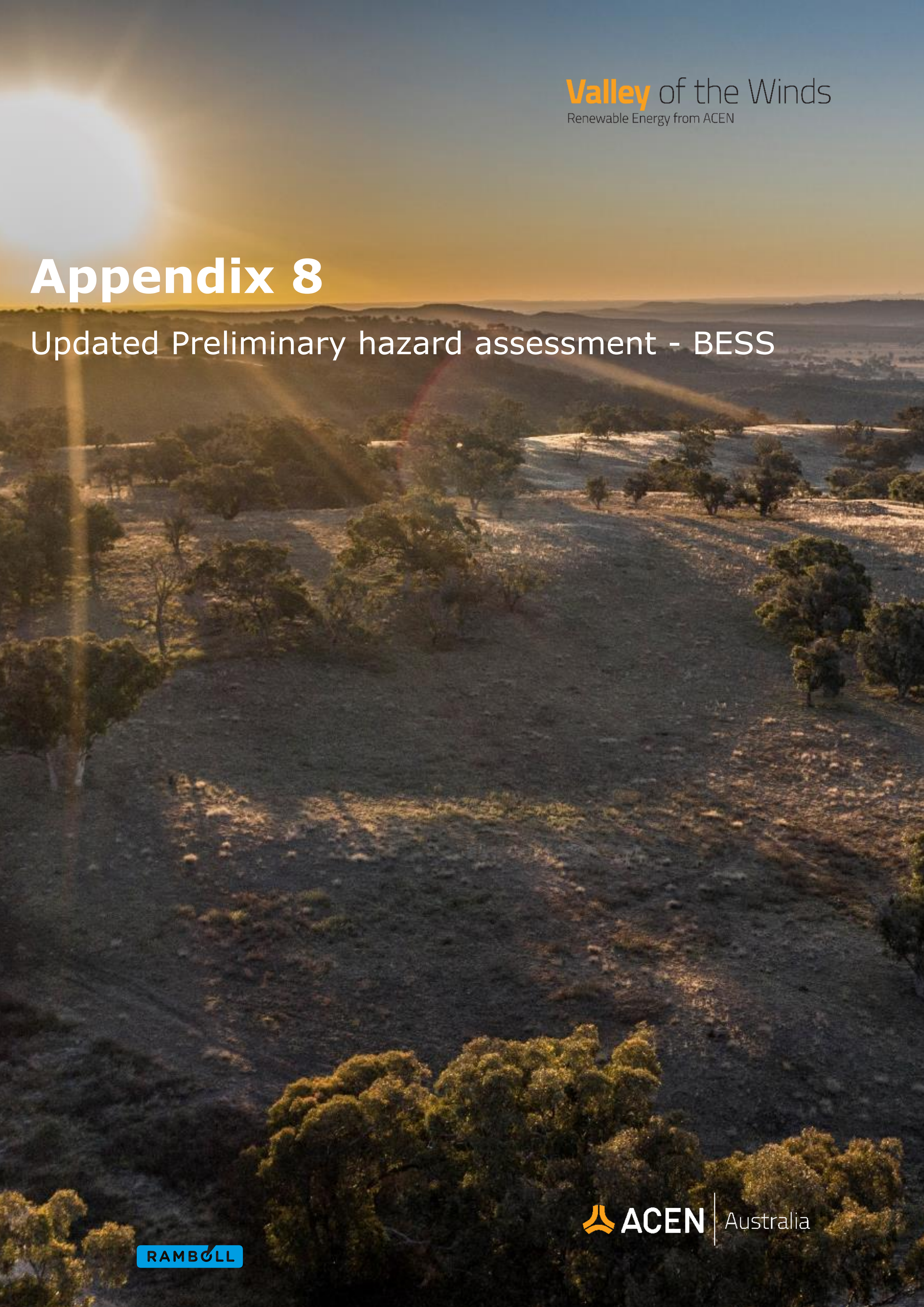
Valley of the Winds
Renewable Energy from ACEN



Appendix 8

Updated Preliminary hazard assessment - BESS

ACEN | Australia

RAMBOLL

REPORT

PRELIMINARY HAZARD ANALYSIS

BATTERY ENERGY STORAGE SYSTEM

VALLEY OF THE WINDS WIND FARM

RAMBOLL AUSTRALIA PTY LTD

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Title: **Report** **Preliminary Hazard Analysis** **Battery Energy Storage System** **Valley of the Winds Wind Farm**	**QA verified:** K. Shen **Date:** 04-Jul-2023

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TABLES

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ABBREVIATIONS

AC	Alternating Current
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS/NZS	Australian Standard/New Zealand Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
CWO-REZ	Central West Orana
DA	Development Application
DC	Direct Current
DPE	Department of Planning and Environment
DVC	Decisive Voltage Classification
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EP&A	Environmental Planning and Assessment
FRNSW	Fire and Rescue NSW
GA	General Arrangement
ha	Hectare
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
HVAC	Heating Ventilation & Air Conditioning
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IP	Ingress Protection
km	Kilometres
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hours
LEP	Local Environmental Plan

LGA	Local Government Area
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt hours
NEM	National Electricity Market
NFPA	National Fire Protection Association
NSW	New South Wales
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OH&S	Occupational Health & Safety
PCU	Power Conversion Unit
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
RFS	Rural Fire Service
RTS	Response to Submissions
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SSD	State Significant Development
UL	Underwriters' Laboratories
VBB	Victorian Big Battery
WTG	Wind Turbine Generator

TERMINOLOGY

Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
Development footprint	The area to be developed within land where the proponent holds landholder agreements. All operational components of the Project will be within the development footprint.
Non-associated dwelling	A dwelling that is not associated with the Project, with no landholder agreement with the proponent.
Off-site	Areas extending beyond the development footprint boundary.
Project	Valley of the Winds Wind Farm.
Project area	The Project area comprises the maximum area considered for the Project based on the extent of land where landholder agreements are held.
Risk	The likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.

1. INTRODUCTION

1.1. Background

ACEN Australia Pty Ltd (ACEN) proposes to develop the Valley of the Winds Wind Farm (the Project), a grid-connected wind powered electricity generation facility located south of Coolah, in the Warrumbungle Shire Council Local Government Area (LGA) in Central West NSW.

The Project consists of 131 wind turbines and supporting infrastructure including substations, internal electrical connections and a Battery Energy Storage System (BESS). The Project involves the construction of three clusters of wind turbines (Mount Hope, Girragulang Road and Leadville) and would supply approximately 800 MW of electricity. A BESS with capacity of approximately 320 MW with two-hour energy storage is proposed to support stabilising the supply of electricity to the National Electricity Market (NEM).

The Project is a State Significant Development (SSD) under the *State Environmental Planning Policy (Planning Systems) 2021* (Planning Systems SEPP) and requires an Environmental Impact Statement (EIS) to accompany the Development Application (DA) submission, in accordance with the Environmental Planning and Assessment (EP&A) Act 1979.

An EIS was prepared by Ramboll Australia Pty Ltd (Ramboll), Ref [1]. Following the EIS submission, NSW Department of Planning and Environment (DPE) publicly exhibited the EIS and has provided copies of Agency and community submissions. Ramboll has prepared the Response to Submissions Report and the EIS Amendment Report. A revised Preliminary Hazard Analysis (PHA) for the Project's BESS is required to address DPE's assessment requirements.

1.2. Objectives

A PHA was completed by Ramboll for the EIS, Ref [2]. As part of the RTS, DPE requires the following *Hazards* assessment requirement be completed:

> **Hazards**: Prepare a revised Preliminary Hazard Analysis for the BESS that provides site-specific details, including the indicative BESS location/s and separation distance of battery units.

To guide the assessment, Sherpa reviewed the recent BESS PHA assessment requirements for similar wind farm SSD projects, which require:

> *Battery Storage – a Preliminary Hazard Analysis (PHA), prepared in accordance with the Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis' and Multi-level Risk Assessment (DoP, 2011). The PHA must consider all recent standards and codes and verify separation distances to on-site and off-site receptors to prevent fire propagation and compliance with Hazardous Industry Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning (DoP, 2011).*

1.3. Scope

The scope of the study is limited to the proposed BESS facility for the Project to address DPE's assessment requirements.

1.4. Exclusions and limitations

The study exclusions and limitations are summarised in Table 1.1.

Table 1.1: Exclusions and limitations

No.	Item	Exclusions and limitations
1	Bushfire hazard and risk assessment	A bushfire hazard and risk assessment has been completed for the Project and accompanies the EIS, Ref [3]. Risk events associated with bushfire and the identified control (i.e. asset protection zone minimum requirements) have been included in this study to demonstrate that this event has been considered and assessed.
2	Blade throw assessment	A blade throw assessment has been completed for the Project for input to the EIS, Ref [4]. Risk events associated with blade throw impact to the BESS have been included in the PHA based on the blade throw assessment.
3	Hazards associated with proposed BESS operations	This PHA identifies and assesses credible hazards associated with proposed BESS operations of the Project and excludes specific hazards relating to construction, commissioning, and decommissioning. This approach is considered appropriate for the EIS assessment stage.
4	Design elements for the BESS	Design elements for the BESS may be subject to change prior to construction. Sherpa notes that the selection of the BESS Original Equipment Manufacturer (OEM) and layout of the BESS units will be finalised during detailed design. Detailed design will be conducted upon Project approval.
5	Indicative BESS layouts	Verification that the areas designated for the BESS would be sufficient for the proposed capacity, taking into account separation distances between BESS sub-units was based on the conceptual BESS design (i.e. make and model) adopted at the time of the study. Indicative BESS general arrangement drawings reflecting the potential BESS configurations were assessed. These are provided in Section 5.
6	Construction Safety Study	The PHA does not constitute a Construction Safety Study. Requirement for a Construction Safety Study will be subject to the conditions of consent of the Project approval. For more information, refer to Hazardous Industry Planning Advisory Paper (HIPAP) No. 7 *Construction Safety*.
7	Fire Safety Study	This PHA does not constitute a Fire Safety Study. Requirement for a Fire Safety Study will be subject to the conditions of consent of the Project approval. For more information, refer to HIPAP No. 2 *Fire Safety Study*.

2. PROJECT DESCRIPTION

2.1. Location and Project site

The Project will be located between Coolah and Leadville within the Warrumbungle Shire Council LGA, in central NSW. The Project site is located within the Central-West Orana Renewable Energy Zone (CWO-REZ).

The Project would involve three clusters that would be connected electrically, with substations in each cluster and a step-up facility at the connection to the CWO-REZ transmission line. The three clusters include Leadville, Girragulang Road, and Mount Hope. During operation, the development footprint of the Project will be approximately 549 hectares, equivalent to approximately 2% of the overall Project area.

The BESS will be located at the Girragulang Road cluster, within the 'Substation and Operation & Maintenance' area (hereinafter referred to as the 'Girragulang Substation and O&M area'). The location of the Project site and the BESS are shown in Figure 2.1.

2.2. Surrounding land use

The Project site comprises land zoned RU1 (Primary Production) under the Warrumbungle Local Environmental Plan (LEP) 2013.

Land surrounding the Project area is characterised by rolling pastoral hills, open flat valleys, and ridgelines with scattered vegetation. The surrounding area also contains rural residences and farming of predominantly grazing cattle and sheep.

The nearest township to the Project is Coolah, approximately 4 km north. Other settlements include Leadville and Uarbry, located approximately 3 km from the Leadville cluster.

From the proposed BESS location[1], the closest:

- Associated residential dwelling is approximately 2,580 m away (ID 257).
- Non-associated residential dwelling is approximately 3,725 m away (ID 278).

[1] Measured from the closest boundary of the Girragulang Substation and O&M area.

Figure 2.1: Project area and location

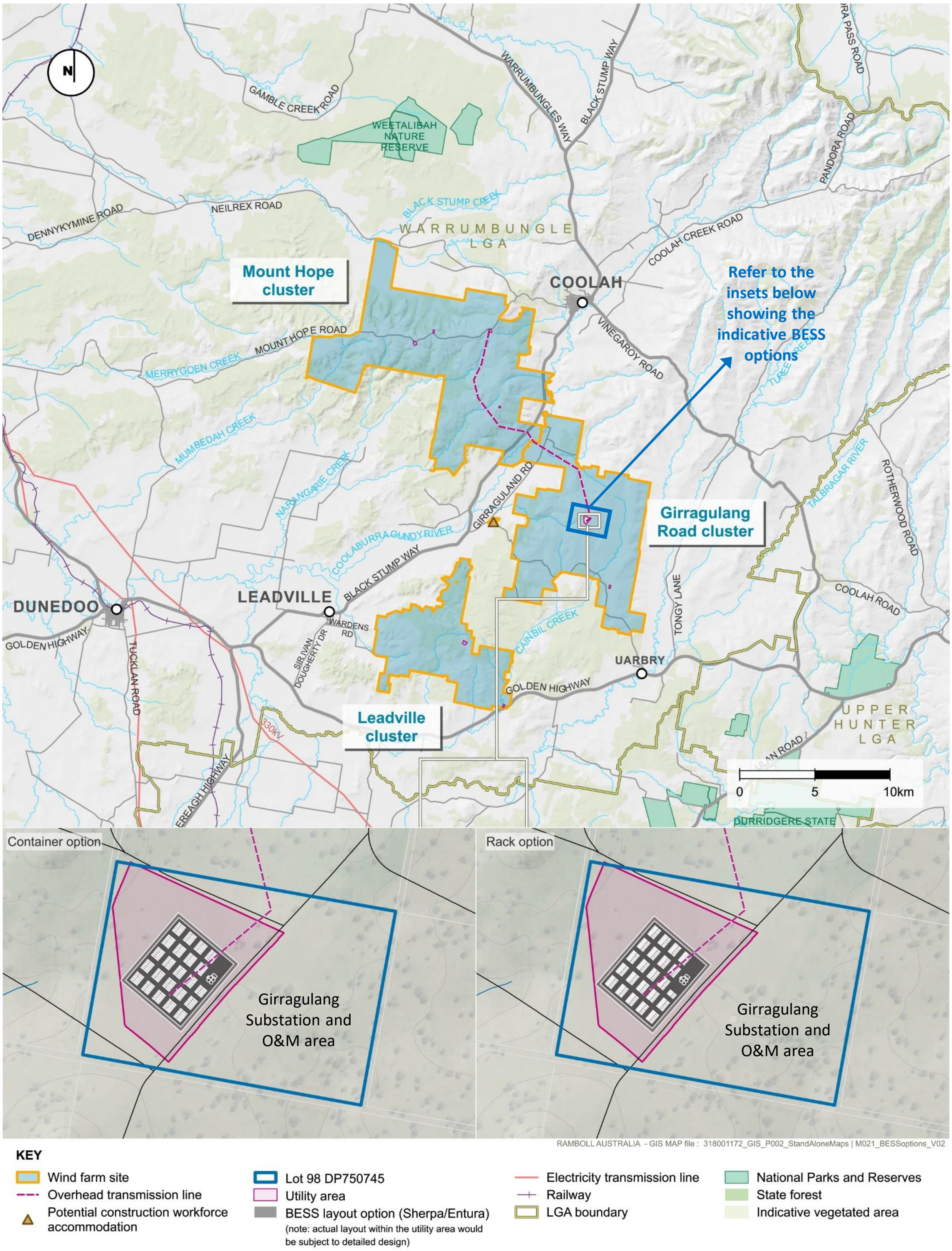


Figure 2-1 | Valley of The Winds site and indicative BESS location

2.3. Project key infrastructure

A summary of the indicative Project key infrastructure and specification is provided in Table 2.1. A more detailed description is provided in the EIS. It should be noted that only the BESS is of relevance in this study.

Table 2.1: Indicative Project infrastructure and specification

Component	Feature	Specification
Electricity generation	Wind turbine generators	The Project will consist of approximately 131 wind turbine generators (WTGs) with a combined installed capacity of approximately 800 MW. The turbines will have a maximum tip height of 250 m.
Electrical infrastructure	On-site substations and step-up facility	The Project will include substations to transform electricity generated into a higher voltage, allowing it to be dispatched from each cluster and onto the NEM via the CWO-REZ transmission line. The substations required will include: • two collector substations in the Mount Hope cluster and 1 substation in the Leadville cluster (converting from 33 kV to 220 kV), and • one central substation at the Girragulang Road cluster which will both (1) collect electricity generated from the Girragulang and Mount Hope clusters, and (2) transform the collected electricity from 220 kV to 330 kV for export via the overhead transmission line and connection to the CWO-REZ transmission line. The Leadville substation will dispatch electricity directly to the CWO-REZ transmission line via a step-up facility at the connection point. A 20 m Asset Protection Zone (APZ) will be provided for the substations. Each substation will be provided with security fence around the perimeter.
	Underground electrical reticulation (33 kV & 330 kV)	The Project will include an internal reticulation (33 kV underground cables) connecting the WTGs to the substation at each cluster. There will also be a 330 kV underground connection between the two Mount Hope substations. Underground cables will be co-located with the access tracks.
	Overhead internal transmission line (330 kV)	The Project will include an overhead internal transmission line (330 kV) to connect the Mount Hope cluster with the central substation at the Girragulang Road cluster.
Battery storage	BESS	A BESS of 320 MW/640 MWh capacity (two-hour energy storage) capacity will be located at the Girragulang Substation and O&M area). Indicatively, the BESS would utilise lithium-ion technology. Further information on the BESS is provided in Section 2.4. A minimum of 10 m APZ will be provided around the BESS. Fire water tanks will also be provided (4 x 150,000 litres) at the BESS compound to provide fire-fighting water supply.

Component	Feature	Specification
Operation and Maintenance (O&M) facility	Control room, offices, stores, amenities	At each cluster, O&M facilities will be provided to support the Project's operational activities. Each will generally comprise a control room (including offices and monitoring equipment), storage and maintenance facilities, laydown areas and parking.
Meteorological masts	Monitoring of meteorological conditions	The Project will include up to 10 permanent meteorological masts allowing for continuous monitoring of meteorological conditions.
Access track network	Access tracks	Internal access track network connecting the turbines and associated infrastructure. The access tracks will be established for construction and maintained for use as operational access tracks.

2.4. Battery Energy Storage System

A BESS is a type of energy storage system that utilises batteries to store and discharge energy in the form of electricity. The energy is stored in Direct Current (DC) and converted to Alternating Current (AC) via a bi-directional inverter to convert the current between the BESS and the grid.

The BESS capability to store and discharge electricity when required provides capacity to deliver electricity to the transmission network on peak demand and support stabilising the supply of electricity to the NEM. The BESS for the Project will have a capacity of up to 320 MW/640 MWh and make use of lithium-ion technology.

The BESS will be located within the Girragulang Substation and O&M area, near or adjacent to the central substation. The footprint of this area is approximately 15.6 ha and its indicative location is shown in Figure 2.1. A minimum of 10 m APZ will be provided around the BESS with security fencing around the area perimeter, Ref [5].

At the time of this study, ACEN has not made a final decision on the BESS OEM. Two different types of enclosures are being considered by ACEN for the battery system, including containerised and outdoor rack options. Examples are illustrated in Figure 2.2. The following battery systems were used for the Valley of the Winds BESS Design Considerations[2] study, Ref [5]:

- Narada NESP NWI Series BESS containers
- CATL EnerOne outdoor rack BESS.

Major components of the BESS and specific features for the battery systems for the various enclosures considered are provided in Table 2.2, Ref [5].

[2] The BESS examples were chosen to represent equipment classes typically available which could be employed on the Project. These are subject to change during the detailed design.

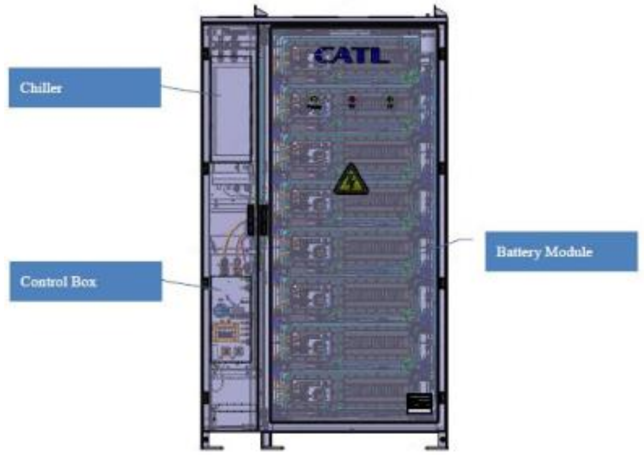
The selection of the OEM and layout of the BESS units within the BESS compound will be finalised during detailed design. Detailed design will be conducted upon Project approval. The following were assumed for the PHA:

1. The BESS units will be installed in accordance with the OEM's instructions provided for best practice for mitigation of fire propagation, including clearance requirements.
2. The BESS units will be installed and meet requirements of the relevant Australian Standards and other codes and standards.
3. The specific BESS (make and model) has been tested to Underwriters' Laboratories (UL) 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* to evaluate the thermal runaway and fire propagation characteristics, informing the required protection for installation and operation of the respective BESS. A UL 9540A test is considered successful if a fire does not propagate from one unit/cabinet to another during the test.

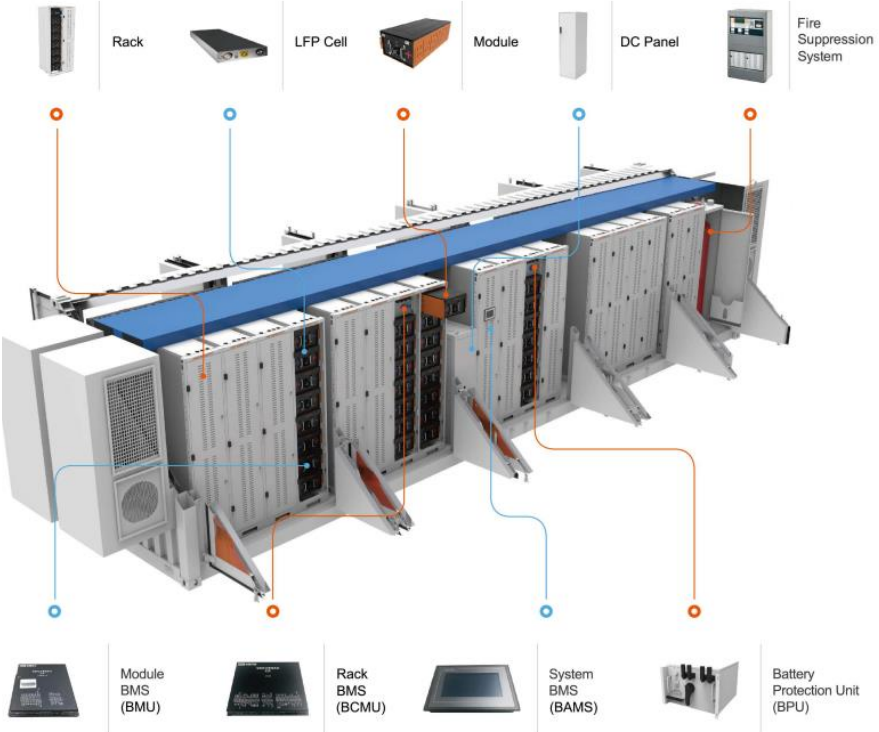
Figure 2.2: BESS enclosures considered for the Project

(a) Containerised

(b) Outdoor rack



Containerised solution subsystems



Product Specification	0852280-E	0852280-P
Duration (h)	h≥2	1≤h<2
Nominal Capacity (kWh)	372.7	
Dimension (L*W*H)(mm)	1,300*1,300*2,280	
Cooling	Outdoor Liquid	

Table 2.2: BESS components

Component	Containerised	Outdoor rack
Description	Modular design where the battery modules are assembled in standard 40-foot ISO containers (L 12,190 mm x W 2,440 mm x H 2,990 mm) with top mounted Heating Ventilation & Air Conditioning (HVAC) system.	Modular design where the battery modules are assembled in outdoor-rated battery racks. Each battery rack consists of battery modules, a control box, chiller and fire protection system. The size of each battery rack is approximately: L 1,300 mm x W 1,300 mm x H 2,280 mm.
Battery modules	Each container will be rated for 2.88 MW/5.76 MWh. Accounting for AC/DC losses and usable capacity, to achieve the proposed capacity (320 MW) a total of 137 containers and 137 Power Conversion Unit (PCU) skids will be installed.	Each battery rack consists of eight battery modules and rated for 0.372 MW. Accounting for AC/DC losses and usable capacity, to achieve the proposed capacity (320 MW) a total of 2,160 battery racks and 135 PCU skids will be installed. Each PCU will feed 16 battery racks via a DC combiner box.
Power Conversion Unit (PCU)	Inverters are electrical devices that convert DC to AC or vice versa (i.e. bi-directional). The inverters will function to convert the current between the battery and grid. A turnkey solution skid (e.g. Power Electronics MV Skid) is considered as a base. It contains a transformer and low voltage distribution panel, the inverter, and a medium voltage switchgear able to be connected in a ring main unit configuration.	
Battery Management System (BMS)	A BMS is the electronic system that monitors and manages the battery system electric and thermal states enabling it to operate within the safe operating region of the battery (e.g. protection against overcurrent, over-charge, over-discharge, overheating, over voltage). The BMS gathers status data from cell, module and rack and exchange information with other components, Ref [5].	
Thermal management system	Redundant wall-mounted reverse cycle air conditioning (air cooling) HVAC systems will be provided for temperature control.	Each battery rack includes a sealed liquid cooling system (8 kW chiller) using a 50% ethylene glycol aqueous solution as coolant.
Fire protection system	Battery container will be equipped with: • Fire detection systems control panel • Smoke and temperature detectors • Automatic gas fire extinguishing system including fire suppression system (gas agent, gas cylinder, spray pipes, passive gas release and exhaust fans). When a smoke or temperature sensor alarms, fans and alarms will start. If any two sensors alarm simultaneously, fire suppression system will be discharged after 30-seconds delay. Once the fire extinguishing gas agent is released, the internal pressure will increase resulting in the pressure release valve to open to reduce the pressure. Water sprinkler system may also be added (subject to detailed design outcome).	Each battery rack is provided with an aerosol fire extinguishing system, which includes a smoke detector, temperature detector and aerosol fire extinguishing device. When both smoke and temperature detectors are triggered, the aerosol spray will be released.

2.5. Construction

Construction of the Project is anticipated to take approximately 24 to 42 months to complete. During the peak construction period, a workforce of approximately 400 people will be required.

A temporary construction infrastructure will be established before construction work commences. This will include:

- Potential construction workforce accommodation
- Construction compounds
- Laydown areas
- Storage areas
- Concrete batching plant
- Quarries
- Access tracks.

Most of the infrastructure would be prefabricated off-site, delivered and then assembled on-site. Following construction, the workforce accommodation area and construction compounds will be dismantled, and its footprint rehabilitated once the Project is built and moves into the operational stage.

2.6. Operations

The operational lifespan of the Project is expected to be around 30 years unless the facility is re-powered at the end of its operational life.

The Project will operate 24 hours per day, seven days per week, 365 days per year, with the operations and maintenance team attendance typically 5 days per week. The BESS will operate 24 hours per day, seven days per week, 365 days per year and normally unmanned (i.e. remote operation).

During the operations phase, there will be approximately 50 full time employees to support the ongoing Project operations and maintenance activities including:

- Infrastructure and equipment maintenance and replacement, as required.
- Site maintenance (e.g. vegetation management, weed and pest management, fence and access tracks maintenance).
- General security and housekeeping.

2.7. Decommissioning

Once the Project reaches the end of its operational life, a decision will be made to either decommission or re-power the facility, subject to approval requirements.

If the Project is decommissioned, all above ground structures built as part of the Project will be removed and site rehabilitated generally to its pre-existing land use, as far as practicable. The disposal and recycling of the Project infrastructure will be done in accordance with current waste management legislation at the time of decommissioning.

Most of the cabling will be buried between 600 to 1,000 mm below ground, which will be removed as part of the decommission process. Any cabling below 1,000 mm is proposed to remain in-situ following decommissioning as this would not interfere with safe farming practices.

If re-powering is proposed, an appropriate stakeholder consultation process will be undertaken, and all necessary approvals will be sought.

3. METHODOLOGY

3.1. Overview

The PHA objective was to identify the hazards and assess the risks associated with the proposed operations of the BESS at the planning stage to determine risk acceptability from land use safety planning perspective. The PHA was completed following the methodology specified in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [6], which is focused on off-site impacts.

The HIPAP No. 6 methodology included the following steps:

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

The PHA assessed events associated with proposed operation of the Project (i.e. excluded construction related events). At the DA stage, the PHA is focused on the risk to surrounding land uses (off-site impacts) and assesses if the development is appropriate for the location.

The BESS compound boundary was used to define and determine off-site impact (i.e. impact extending outside of this boundary). Off-site impact was determined based on potential to impact sensitive receptors (i.e. non-associated residential dwellings). Associated residences were not considered as off-site receptors as they have an agreement in place with the proponent and consent to the risk exposed by the development and proposed infrastructure.

3.2. Level of analysis

The Multi-Level Risk Assessment guidelines, Ref [7], sets out three levels of risk analysis that may be appropriate for a land use safety planning assessment, as shown in Table 3.1. This guidance document was consulted to determine the level of analysis required for this study.

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

Table 3.1: Level of analysis

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

3.3. Risk assessment criteria

The risk criteria used for assessment followed the guidance provided in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [8], appropriate for the level of analysis determined (based on guidance outlined in Table 3.1).

4. HAZARD IDENTIFICATION

4.1. Overview

Hazard Identification (HAZID) aims to identify all reasonably foreseeable hazards and associated events that may arise due to the operation of the facilities and defining the relevant controls through a systematic and structured approach.

The HAZID process was completed using the following input:

1. Review of the existing Valley of the Winds Wind Farm PHA report, Ref [2].
2. Review of the Valley of the Winds BESS Design Considerations report, Ref [5].
3. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [9].
4. Previous risk assessments for similar BESS systems completed by Sherpa.
5. Consultation and feedback from ACEN for review and acceptance.

4.2. Identified hazard and events

The following factors were considered to identify the hazards:

- BESS component and type of equipment
- Hazardous materials present
- Proposed operation and maintenance activities
- External factors (e.g. unauthorised personal access, lightning storm).

The types of hazards and associated events considered were informed from AS/NZS 5139 which were deemed suitable for the Project infrastructure assessed in this study. The identified hazards and events for the Project are presented in Table 4.1.

Events with the potential to result in significant impacts to people (i.e. injury and/or fatality) were identified. The study excluded hazards related with Occupational Health & Safety (OH&S), e.g. slips, trips and falls.

Table 4.1: Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
Fire	Infrastructure fire
Chemical	Release of hazardous materials
Explosive gas	Generation of explosive gas
Reaction	Battery thermal runaway
EMF	Exposure to Electric and Magnetic Fields (EMF)
External factors	Unauthorised access/trespasser, bushfire, lightning storm, blade throw, turbine collapse, water ingress (rain and flood)

In this study, bushfire was considered as a cause of fire resulting from encroachment of an off-site bushfire impacting the Project infrastructure. A bushfire hazard assessment was completed for the Project as part of the EIS, Ref [3]. Identified control (i.e. APZ) has been referenced in this study, where applicable. A minimum APZ of 10 m is to be included around the WTGs, substations, BESS and O&M buildings, Ref [3].

Blade throw impacting the BESS was considered as a cause of BESS damage and potential fire. A blade throw impact assessment was completed for the Project as part of the EIS, Ref [4]. The impact zone was reviewed to determine if a blade throw may impact the proposed BESS facility.

A summary of the hazards present at/applicable to the BESS is provided in Table 4.2.

Table 4.2: Hazards by BESS component

	BESS Components			
Hazard	**Battery modules**	**Battery Management System (BMS)**	**Thermal Management System/HVAC**	**PCU**
Electrical	✓	✓	-	✓
Energy (arc flash)	✓	✓	-	✓
Fire	✓	✓	✓	✓
Chemical	✓	✓	✓	-
Explosive Gas	✓	-	✓	-
Reaction	✓	-	-	-
EMF	✓	✓	-	✓
External factors	✓	✓	✓	✓

4.3. Separation distances to off-site receptors

To inform whether the consequence of a hazardous event has the potential to impact off-site receptors, separation distances from the Girragulang Substation and O&M area boundary to the nearest non-associated residential dwellings (sensitive receptors) were reviewed. This review is provided in Section 5.

4.4. HAZID register

The identified hazards, events, applicable infrastructure and the relationships with causes, consequences and controls are summarised in the HAZID register.

The HAZID register is provided in Table 4.3. The findings are as follows:

- A total of 16 hazardous events were identified.
- The exact location of the BESS compound within the Girragulang Substation and O&M area is unknown at this stage. Conservatively, Sherpa assumed that some hazardous events with potential for escalated fire may extend beyond the BESS compound boundary (i.e. off-site impact in the context of HIPAP No. 6). However, the consequences from these events are not expected to result in significant off-site impact (serious injury and/or fatality to the public or off-site population) as:
  - The BESS will be situated in a rural area.
  - The nearest sensitive receptor/non-associated residential dwelling (ID 278) is located at least 3,725 m from the proposed BESS location.

Table 4.3: HAZID register

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
1.	Electrical	Battery modules BMS PCU (inverters, transformers)	Exposure to voltage	<u>Short circuit/electrical connection failure</u> - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage <u>Earth potential rise (exposure to step and touch potentials)</u> - Electrical faults	- Electrocution - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential (e.g. transferred through fences). As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Decisive Voltage Classification (DVC) followed and equipment marked accordingly - Warning signs (electrical hazards, arc flash) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction/substation training (i.e. high voltage areas) - Electrical switch-in & switch-out protocol - BESS BMS fault detection and safety shut-off - Earthing study (mitigate touch and step potentials) - Earthing as per manufacturer and standards requirements - Perimeter fence with signage (warning of electrical hazard) - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)	-	No
2.	Energy	Battery modules BMS PCU (inverters, transformers)	Arc flash	- Incorrect procedure (i.e. installation/ maintenance) - Faulty equipment (e.g. corrosion on conductors) - Faulty design - Human error during maintenance - Insufficient isolation/insulation to applied voltage - Mechanical damage - Vibration	- Arc blasts and resulting heat, may result in fires and pressure waves - Burns - Exposure to intense light and noise - Injury and/or fatality to onsite employees Localised effects, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Warning signs (arc flash boundary) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction and training (i.e. high voltage areas) - Maintenance procedure (e.g. de-energize equipment) - Preventative maintenance (insulation) - Electrical switch-in & switch-out protocol - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Use of appropriate PPE for flash hazard within the arc flash boundary. Conductive items not worn while working on or near energised or live conductive parts (e.g. rings, jewellery).	Arc flash is an electrical explosion or discharge, which occurs between electrified conductors during a fault or short circuit condition, Ref [9]. Arc flash occurs when electrical current passes through the air between electrified conductors when there is insufficient isolation or insulation to withstand the applied voltage. Arc flash may result in rapid rise in temperature and pressure in the air between electrical conductors, causing an explosion known as an arc blast.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
3.	Fire	Battery modules BMS PCU (inverters, transformers)	BESS fire	- Faulty equipment - Arc flash - Mechanical damage or failure of battery case (e.g. overload, insulation breakdown, connection failures) - Battery thermal runaway (e.g. short circuit, overheating, overcharge) - External fire (e.g. Substation fire) - Bushfire (e.g. encroachment of off-site bushfire, escalated event due to fire from other Project infrastructure)	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - All relevant TransGrid's requirements for the substation will be met - Circuit breakers provided for the substation - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.2) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	-	No
4.	Fire	BESS (overall)	Bushfire	- Encroachment of off-site bushfire - Escalated event due to fire from other Project infrastructure	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Inclusion of APZ buffer to minimise bushfire encroachment - Use of appropriate PPE	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
5.	Fire	Supporting infrastructure (gasoline tank and filling system)	Loss of containment of gasoline from storage tank or filling point	- Mechanical failure - Human error during transfer	- Fire, if ignited. - Injury to onsite employees Based on the storage quantity, the effects will be localised and not expected to have an off-site impact	- Equipment and systems will be designed and tested to comply with relevant Australian standards (e.g. AS 1940) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Secondary containment (i.e. bunding) - Warning signs (flammable material) - Fire Management Plan - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Use of appropriate PPE	Storage of gasoline tank and filling system will be within the Girragulang Substation and O&M area.	No
6.	Chemical	Chemical storage (vegetation management and landscaping)	Exposure to hazardous material (herbicide/ pesticide)	Inappropriate storage, use and handling of pesticides/herbicides for vegetation management and landscaping	Irritation/injury for personnel on exposure. Localised effects, the effects are not expected to have an off-site impact.	- Product will be stored in dedicated storage area - Quantity kept in work area will be minimised - No spraying will be done during high wind conditions - Limited usage prior to and during rain events - PPE (as required by Safety Data Sheet)	Storage of chemicals used for vegetation management and landscaping will be within the Girragulang Substation and O&M area.	No
7.	Chemical	Battery modules BMS Thermal management system	Release of electrolyte (liquid/vented gas) from the battery cell	Mechanical failure/damage - Dropped impact (e.g. during installation/ maintenance) - Damage (e.g. crush/ penetration/puncture) Abnormal heating/elevated temperature - Thermal runaway - Bushfire - External fire (e.g. Main Substation)	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Venting and containment requirements of the BESS manufacturer and FRNSW to be followed - Battery modules are enclosed with external casing - Spill clean-up using dry absorbent material - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.2) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	Vented gases are early indicator of a thermal runaway reaction	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
8.	Chemical	Battery modules BMS Thermal management system	BESS coolant or refrigerant leak	- Mechanical failure/damage - Incorrect maintenance	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to short circuit, thermal runaway and fire/explosion, resulting in injury and/or fatality to onsite employees. As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Battery modules are enclosed with external casing - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.2) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS)	A typical coolant for an outdoor rack BESS enclosure is 50% ethylene glycol aqueous solution (as is used in CATL EnerOne). Containerised BESS enclosures typically use redundant wall-mounted reverse-cycle air-conditioning (air cooling) HVAC systems for temperature control. Typical refrigerants include R407C and R134A.	No[3]
9.	Explosive Gas	Battery modules	Generation of explosive gas (e.g. hydrogen) Note: see above scenario (vented gas)	- Thermal runaway - Bushfire - External fire (e.g. substation fire, fire from adjacent infrastructure)	- Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Ventilation requirements as per manufacturer's instruction - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.2) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	-	No

[3] The Victorian Big Battery (VBB) fire (30-Jul-21) was caused by a short circuit (a coolant leak from the cooling system leading to a fire in an electronic component) and subsequent overheating (thermal runaway). The fire involved 2 battery packs and was locally confined to the area. Energy Safe Victoria reported that the battery was offline and the monitoring and protection systems not being available, allowed the initial fault to go undetected. The learnings from the VBB incident which uses the Tesla Megapack battery system are provided in the Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire, Ref [14].

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
10.	Reaction	Battery modules	Thermal runaway in battery	Elevated temperature - Bushfire - External fire (e.g. Main Substation) Electrical failure - Short circuit - Excessive current/voltage - Imbalance charge across cells Mechanical failure - Internal cell defect - Damage (crush/ penetration/puncture) Systems failure - BMS failure - Thermal management system failure	- Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system (battery system specific features, refer to Table 2.2) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	Thermal runaway refers to a cycle in which excessive heat, initiated from inside/outside the battery cell, keeps generating more heat. Chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell and eventually lead to destruction of the battery. Vented gases are early indicator of a thermal runaway reaction.	No
11.	EMF	BESS (overall)	Exposure to electric and magnetic fields	Operations of energy storage system and associated equipment	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Injury to onsite employees EMF created from the BESS will not exceed the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference level for exposure to the general public. Additionally, the strengths of electric and magnetic fields attenuate rapidly away from the source. As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Location siting and selection (i.e. separation distance to sensitive receptors) - Optimising equipment layout and orientation - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. BESS enclosure) - Equipment and systems will be designed and tested to comply with international standards and guidelines - Exposure to personnel is short duration in nature (transient) - Warning signs - Studies found that the EMF for commercial power generation facilities comply with ICNIRP occupational exposure limits	Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities, Ref [10]. No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA) , Ref [11].	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
12.	External factors	BESS (overall)	Water ingress	- Rain - Flood	- Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Location siting (i.e. outside of flood prone area) - BESS will be housed in dedicated enclosure which will be constructed in accordance with relevant standards - Outdoor rack BESS enclosure will be IP rated for water ingress protection - Drainage system - Preventative maintenance (check for leaks) - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.2) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS)	-	No
13.	External factors	BESS (overall)	Vandalism	- Unauthorised personnel access - Trespassing - Sabotage (vehicle impact into BESS area) - Deliberate damage to BESS infrastructure	- Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs onsite. For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	- The BESS will be located in a rural location - The BESS will be located within a secure area and will be fenced - Warning signs (i.e. trespassers and on-site hazards) - Security cameras will be provided at the substation and at the BESS compound. - Onsite security protocol - Presence of staff	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
14.	External factors	BESS (overall)	Blade throw	- Blade fragment detaches from rotor - Instantaneous failure of the bearing or hub flange fastening system	- Damage to BESS infrastructure and/or fire - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Early detection of abnormalities (e.g. vibration, imbalance, under power) by WTG control system may prevent progression of instantaneous failure of the bearing or hub flange fastening system. - Separation distance between the BESS and the closest WTG (GR26) is at least 236 m. Note: The maximum potential throw distances for the Project turbines are expected to be in the order of 200 m for an entire blade and 580 m for a blade fragment under normal operating conditions at the nominal rated rotor speed, and 250 m for an entire blade and 930 m for a blade fragment at the maximum rated rotor speed, Ref [4]. The BESS location within Girragulang Substation and O&M area will be finalised during detailed design. Sherpa recommends that the BESS compound to be located outside of the blade throw zone based on the design case opted by ACEN.	A blade throw incident can occur when an entire wind turbine blade becomes separated from its hub at the metal to metal root joint.	No
15.	External factors	BESS (overall)	Turbine collapse	Mechanical failure	- Damage to BESS infrastructure and/or fire - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Separation distance between the BESS and the closest WTG (GR26) is at least 236 m. Note: The estimated impact distance from a WTG collapse is 250 m based on the WTG maximum tip height. The BESS location within Girragulang Substation and O&M area will be finalised during detailed design. Sherpa recommends that the BESS compound to be located outside of the blade throw zone (>250 m).	-	No
16.	External factors	BESS (overall)	Lightning strike	Lightning storm	- Fire - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Lightning protection mast and surge protection devices - Earthing as per manufacturer and standards requirements - Activation of emergency shutdown - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS)	-	No

5. BESS SEPARATION DISTANCES

5.1. Overview

To ensure that all aspects of the PHA for the BESS have been assessed, Sherpa reviewed the most recent Hazards assessment requirement for similar SSD projects with BESS exceeding peak delivery capacity of 30 MW. This includes a requirement to '*consider all recent standards and codes'* and *'demonstrate that the separation distances between the BESS to onsite or off-site receptors and the separation distances between BESS sub-units prevent fire propagation'*.

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

- BESS sub-units (racks, modules, enclosures, etc.), to ensure that a fire from a sub-unit do not propagate to neighbouring sub-units; and
- the overall BESS and other onsite or off-site receptors.

This section covers the following:

1. Review of separation distances/clearances provided between the BESS sub-units against applicable codes and standards.
2. Verification that the required land area for the proposed BESS capacity would fit within the land area designated for the BESS.
3. Review of separation distances between the BESS and onsite and off-site receptors.

5.2. Separation distances between BESS sub-units

The National Fire Protection Agency (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* is widely viewed as the most comprehensive set of best practice guide in the industry. A review of NFPA 855, Ref [12], was undertaken by Entura as part of the Valley of the Winds BESS Design Considerations study, Ref [5]. This included a review to determine the required separation distances between (1) the BESS units and (2) the BESS and other infrastructure.

Clause 4.6 of NFPA 855 sets the default maximum allowable energy storage unit at 50 kWh and minimum separation of 914 mm for units that are contained in (1) non-dedicated buildings, or (2) outdoor installation near exposures. However, NFPA 855 also specifies that BESS can be installed in larger energy groups and smaller separation if they meet the large-scale fire testing requirements set by UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, or equivalent test standard[4]. As such, the result of the UL 9540A test results

[4] Clause 4.1.5 of NFPA 855 (Large-scale fire test).

(performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

The following clearances for the BESS components were identified by Entura, Ref [5]:

- Minimum clearances

  These are manufacturer specified minimum clearances between the equipment to prevent thermal propagation during fire or explosion (i.e. basis for UL 9540A test). These were determined from Original Equipment Manufacturer (OEM) specifications from multiple surveyed manufacturers.

- Additional clearances for operability

  These are specified by manufacturer or based on AS 3000 *Wiring Rules* and AS 2067 *Substations and high voltage installations exceeding 1 kV a.c* as a guide to operability requirements.

The clearances for the BESS components are shown in Table 5.1. These clearances form an input to the concept General Arrangement (GA) drawings produced for the Project.

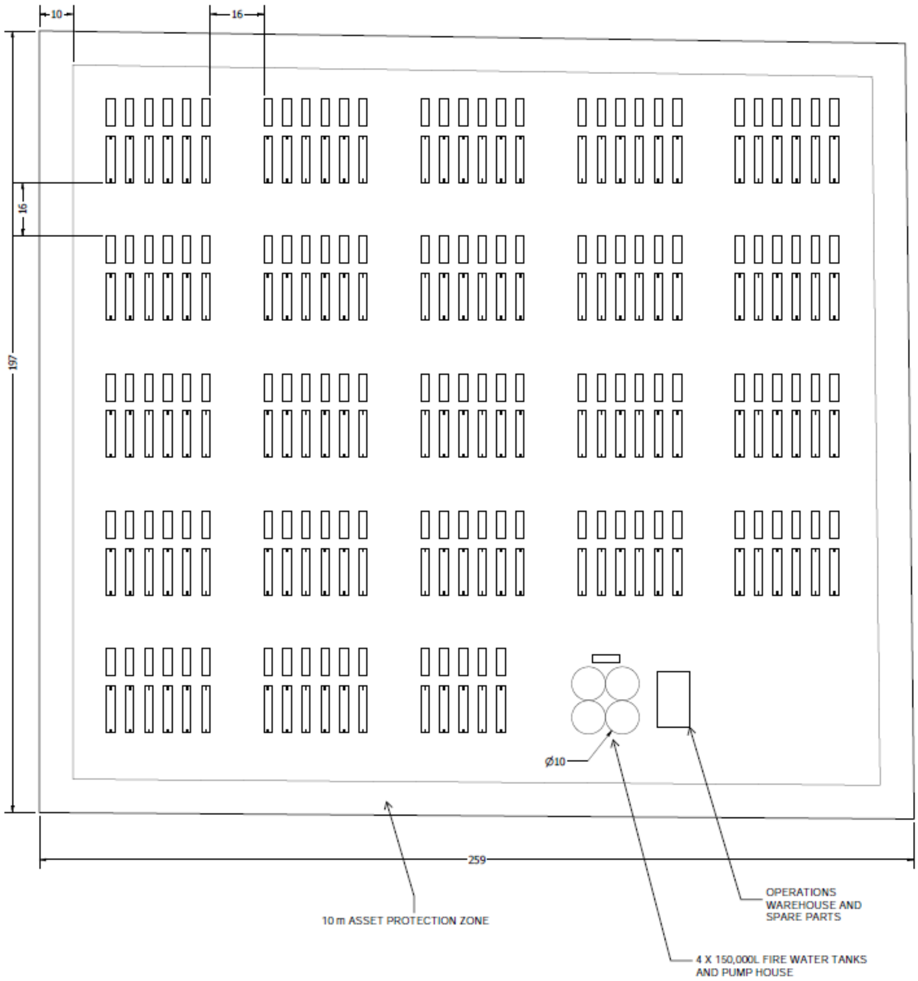
The conceptual GA drawings for the two BESS options, Ref [5], showing the clearances are shown in Figure 5.1 (Containerised BESS) and Figure 5.2 (Outdoor racks BESS).

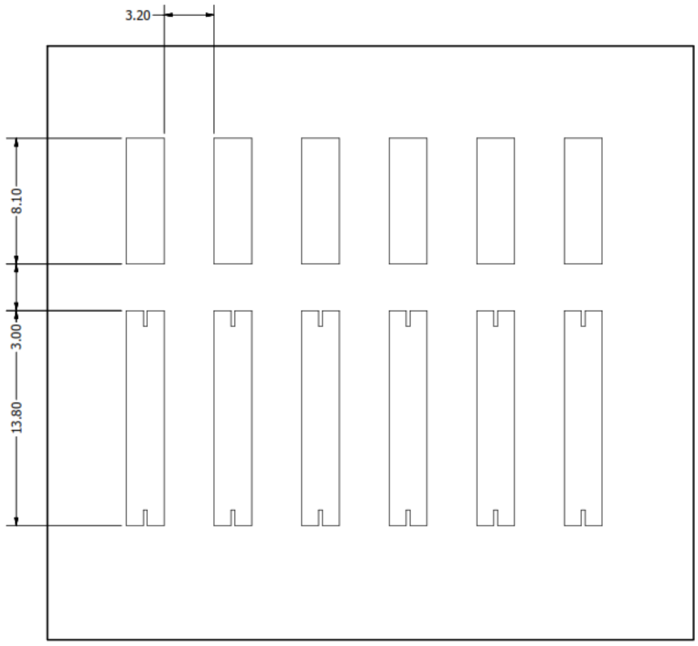
Table 5.1: Summary of clearances for BESS[5]

Source	Target	Clearance (Safety)	Clearance (Recommended operability)	Comment	Reference
Battery rack	Other battery racks Non-combustible surfaces	0.1 - 0.15 m (indoor or outdoor)	1.0 m (indoor) 1.5 m (outdoor)	Operability clearance relevant to front cabinet door.	• OEM specifications from 2 surveyed manufacturers. • AS 3000:2018 accessibility requirement.
Battery container	Other battery racks Non-combustible surfaces	0.1 - 0.15 m	1.9 m	Operability clearance includes door (1,300 mm) and access (600 mm). Access may be shared with adjacent containers.	• OEM specifications from 2 surveyed manufacturers. • AS 3000:2018 accessibility requirement.
Integrated Power Conversion Unit	Any other equipment	2 m	2 - 4 m	-	• OEM specifications from 3 surveyed manufacturers.
Inverter or switchgear	Any other equipment	2 m	2 - 4 m	-	• OEM specifications from 3 surveyed manufacturers.
Transformer	Non-combustible equipment, including other transformers or fire-resistant building materials	1 m	-	-	• AS 2067:2016
Transformer	Combustible surfaces	6 m	-	-	• AS 2067:2016
All equipment	Perimeter fence	10 m	10 m	APZ (perimeter) Allows semi-trailer turning with minimal clearance. May include clearance required for adjacent equipment.	• Victorian Rural Fire Service (2022) Design Guidelines and Model Requirements for Renewable Energy Facilities. • Austroads turning templates.
Internal roads	All other equipment	N/A	10 - 16 m	May include clearance required for adjacent equipment.	• Entura experience. • Austroads turning templates.

[5] Reproduced from Table 3.2 of the Valley of the Winds BESS Design Considerations report, Ref [5].

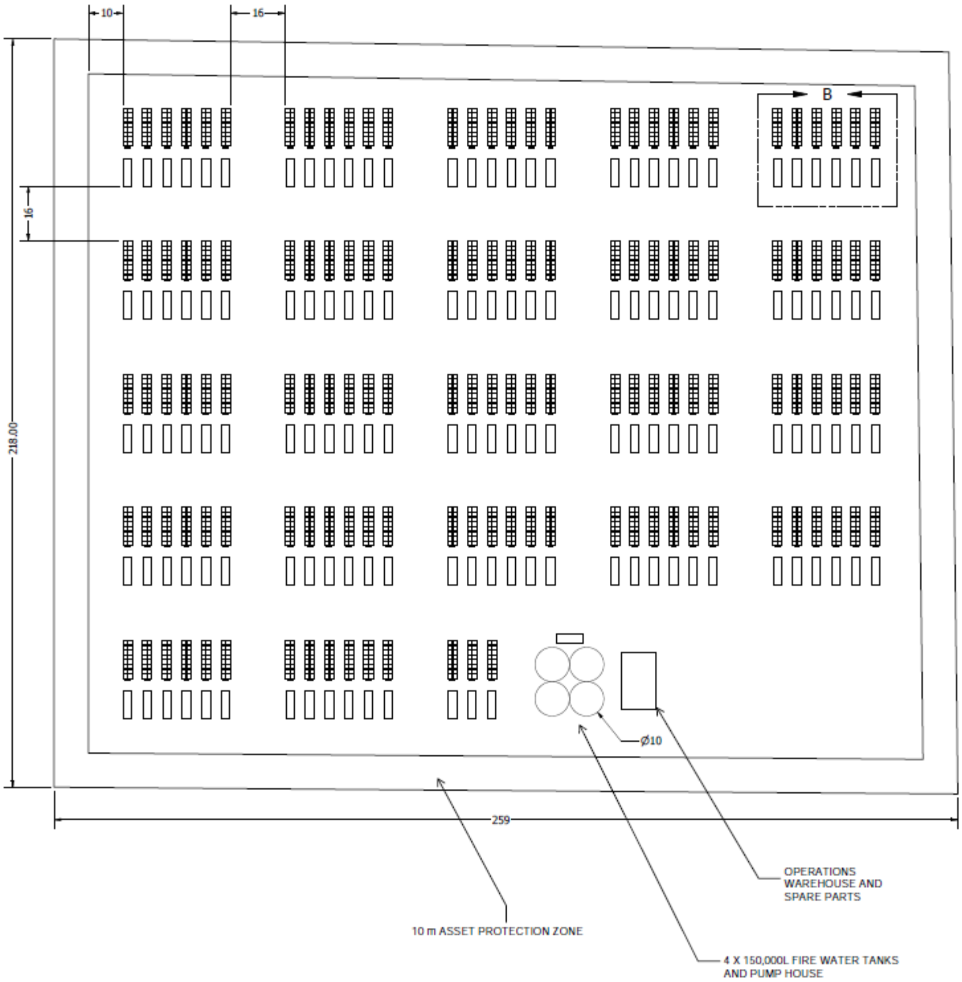
Figure 5.1: Concept BESS layout – Containerised

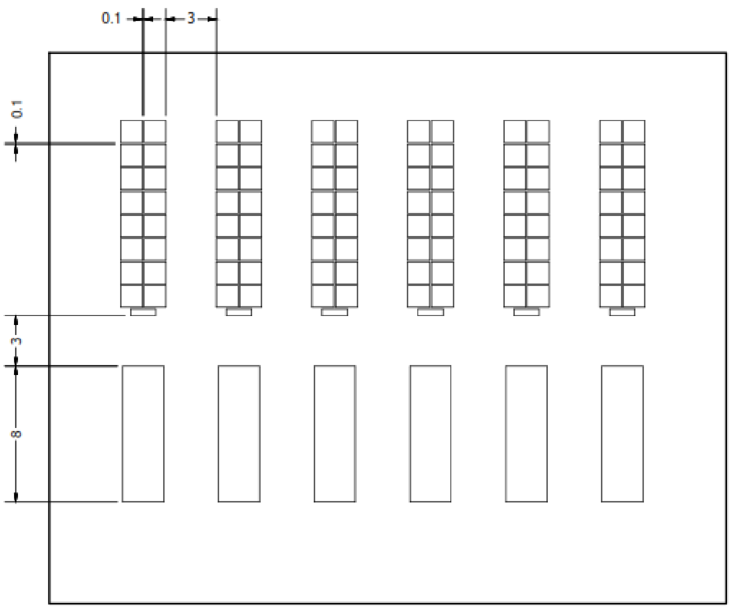




DETAIL A
SCALE 1 / 200

Figure 5.2: Concept BESS layout – Outdoor racks





DETAIL B
SCALE 1 / 200

5.3. Land area designated for the BESS

The land area required for both BESS enclosure types considered were determined in the Valley of the Winds BESS Design Considerations study, Ref [5], and summarised in Table 5.2.

The BESS will be located within the Girragulang Substation and O&M area, near or adjacent to the Project's substation. The footprint of this area is approximately 15.6 ha and its indicative location is shown in Figure 2.1.

At the time of this study, the layout of the Girragulang Substation and O&M area and the land area designated for the BESS were not available. Detailed layout configuration will be informed by technical assessments performed during the preparation of the EIS and the detailed design stage of the Project. Subsequently, verification of whether the required land area for the BESS would fit within the designated land area was performed by comparing the required area against the overall Girragulang Substation and O&M area (expressed in percentage coverage).

The outdoor rack option requires a larger footprint of the two enclosure types. As shown in Table 5.2, the containerised and outdoor rack options will cover approximately 33% and 36% of the Girragulang Substation and O&M area, respectively. The proposed location was determined as adequate to fit the required land for the BESS as well as other infrastructure to be developed within the Substation and O&M area.

Table 5.2: Land area required for the BESS

	BESS enclosure	
	Containerised	**Outdoor rack**
Dimension	259 m x 197 m	259 m x 218 m
Required land area	5.1 ha	5.6 ha
% of the Girragulang Substation and O&M area	33%	36%
Fits the designated land area for the BESS (Y/N)?	Yes	Yes

5.4. Onsite receptors

The BESS will be located within the Girragulang Substation and O&M area. The closest onsite receptors will be other Project infrastructure located within the Substation and O&M area, including:

- A control room (including offices)
- The central substation
- Storage and maintenance facilities.

At the time of this study, the layout of the Substation and O&M area was not available. Detailed layout configuration will be informed by technical assessments performed during the preparation of the EIS and the detailed design stage of the Project. A 20 m APZ will be provided for the substations, Ref [1]. A minimum of 10 m APZ will be provided around the BESS and O&M building, Ref [3].

5.5. Off-site receptors

For the PHA, the non-associated residential dwellings or occupied areas are considered as sensitive receptors for determination of off-site impact. The nearest township(s) or settlements are Uarbry (11 km south) and Coolah (14 km north).

For fire events involving the BESS, the separation distances from the Girragulang Substation and O&M area boundary to the sensitive receptors were used to determine off-site impact. This is conservative as the Substation and O&M area layout has not yet been determined.

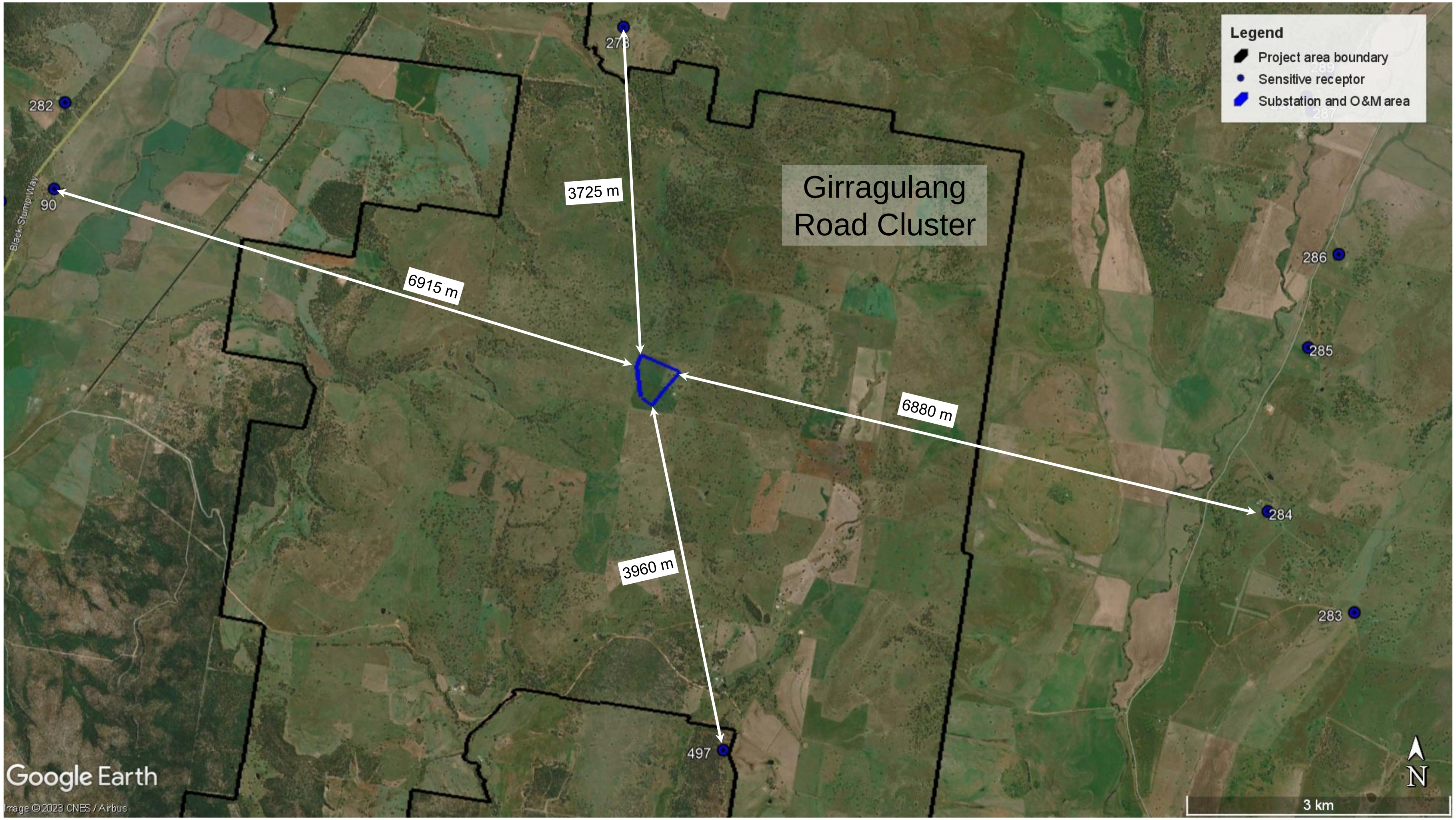
A review of the separation distances to off-site receptors is shown in Figure 5.3. The separation distance from the proposed BESS location to the nearest sensitive receptor is at least 3,725 m (dwelling ID 278).

5.6. Review findings

The review of BESS separation distances found that:

- The conceptual GA for the two BESS options included clearances between the sub-units that would meet the minimum or recommended clearances specified by the manufacturer. Additionally, the BESS options considered for the Project are required to meet the UL 9540A large-scale fire test requirements.
- The Girragulang Substation and O&M area can accommodate the required land for the BESS including the clearances between the sub-units.
- Within the Substation and O&M area, a 20 m APZ will be provided for the substation and a minimum of 10 m APZ will be provided around the BESS and O&M building.
- The nearest sensitive receptor (dwelling ID 278) is at least 3,725 m away from the proposed BESS. No off-site impact is expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.

Figure 5.3: Separation distance to off-site receptors



6. LEVEL OF ANALYSIS DETERMINATION

6.1. Level of analysis

The HAZID found that for all identified events the resulting consequences are not expected to have significant off-site impacts (serious injury and/or fatality to the public or off-site population), based on the following considerations:

- The Project will be situated in a rural area.
- The nearest sensitive receptor is located at least 3,725 m away from the proposed BESS location (dwelling ID 278; as shown in Figure 5.3).

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

- The Project site is located in a rural area with scattered residential dwellings. The nearest sensitive receptor is located at least 3,725 m away from the proposed BESS location (dwelling ID 278).
- The nearest township(s) or settlements are Uarbry (11 km south) and Coolah (14 km north).

Based on the above findings and the *Multi-Level Risk Assessment*, Ref [7], and guidance to determine the required level of analysis for the PHA (Table 3.1), a fully qualitative approach (i.e. Level 1 analysis) was determined appropriate for this study. The risk analysis is presented in Section 7.

6.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [8], recommends a set of qualitative criteria/principles to be adopted concerning the land use safety acceptability of a development.

The risk assessment against HIPAP No. 4 criteria is provided in Section 0.

7. RISK ANALYSIS

7.1. Overview

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

For each identified event, the risk to off-site population was qualitatively determined from the resulting severity and likelihood rating pair using the risk matrix shown in Table 7.1, Ref [2].

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

- High and Extreme – Unlikely to be tolerable, review if activity should proceed.
- Medium – Tolerable, if So Far As Reasonably Practicable.
- Negligible and Low – Broadly acceptable.

Table 7.1: Risk matrix

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Very likely	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Unlikely	Negligible	Low	Medium	High	High
Very unlikely	Negligible	Low	Medium	Medium	High
Extremely unlikely	Negligible	Negligible	Low	Medium	Medium

7.2. Severity rating

For each event, the severity rating was qualitatively assigned based on the consequence description identified in the HAZID register using the category scale shown in Table 7.2.

For this study, the severity scale was used to assess impact for off-site population. For example, an event with consequence outcome identified as “localised effects” or “effects are not expected to have an off-site impact”, was assigned an ‘Insignificant’ rating to indicate minimal impact to off-site population.

Table 7.2: Consequence rating

Consequence rating	Rating definition
Catastrophic	One or more fatalities or permanent disabilities.
Major	Minor injury or illness between 100 and 1000 individuals/Major injury or illness to between 10 and 100 individuals.
Moderate	Minor injury or illness between 10 and 100 individuals/Major injury or illness to between 1 and 10 individuals.
Minor	Minor injury or illness to less than 10 individuals/Major injury or illness to 1 individual.
Insignificant	No injury or illness associated with the Project.

7.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 7.3.

Table 7.3: Likelihood rating

Likelihood rating	Rating definition
Very likely	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Unlikely	The event could occur
Very unlikely	The event could occur but not expected
Extremely unlikely	The event occurs only in exceptional circumstances

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

7.4. Risk results and analysis findings

The qualitative risk results for the identified events are shown in Table 7.4.

The risk analysis findings are as follows:

- **Consequence**: The worst-case consequence for the identified events is a fire and/or explosive gas event at the BESS compound which may result from causes such as battery thermal runaway, encroachment from off-site bushfire or a substation fire. The study found that for all events the consequence impacts are not expected to have significant off-site impacts. This was assessed based on the location of the proposed BESS (rural area) and separation distance between the BESS and sensitive receptors (i.e. non-associated residential dwellings).
- **Likelihood**: The highest likelihood rating for the identified events is 'Very unlikely' (i.e. the event could occur but not expected).

- **Risk analysis**: A total of 16 hazardous events were identified. The breakdown of these events according to their risk ratings are as follows:
  - 'Medium' risk event: 1

    This event relates to unauthorised person access to the Project site/development footprint resulting in vandalism/asset damage to the infrastructure, with no significant off-site impact expected. Severity rating of 'Major' was assigned to account for the trespasser potentially injuring themselves in the act.

    The PHA noted that the controls for this event are well understood and will be implemented accordingly. In addition to the rural location of the site, it is anticipated that security fencing, cameras and warning signs will be provided. Mitigation measures would also include onsite security protocol and presence of staff. In combination, these prevention and mitigation measures are expected to significantly reduce the likelihood of this event. The likelihood rating for this event was rated as 'Very unlikely'.
  - 'Negligible' risk events: 15

    Most of these events relate to fire and/or explosion events, with no significant off-site impact expected (i.e. more likely to affect onsite employees). The study identified proposed prevention controls to reduce the likelihood of these fire events and mitigation controls to contain the fires to minimise potential for escalated events (e.g. fire management plan). Based on the identified controls, the highest likelihood for these events was rated as 'Very unlikely'.

Table 7.4: Risk results

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Electrical	Exposure to voltage	- Electrocution - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
Arc flash	Arc flash	- Arc blasts and resulting heat, may result in fires and pressure waves - Burns - Exposure to intense light and noise - Injury and/or fatality to onsite employees	Localised effects, the effects are not expected to have an off-site impact.	No	Insignificant	Very unlikely	Negligible
Fire	BESS fire	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
	Bushfire	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
	Loss of containment of gasoline from storage tank or filling point	- Fire, if ignited. - Injury to onsite employees	Based on the storage quantity, the effects will be localised and not expected to have an off-site impact.	No	Insignificant	Very unlikely	Negligible
Chemical	Exposure to hazardous material (herbicide/ pesticide)	Irritation/injury for personnel on exposure.	Localised effects, the effects are not expected to have an off-site impact.	No	Insignificant	Very unlikely	Negligible
	Release of battery electrolyte (liquid/vented gas) from the battery cell	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Chemical	BESS coolant or refrigerant leak	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to short circuit, thermal runaway and fire/explosion, resulting in injury and/or fatality to onsite employees.	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
Explosive Gas	Generation of explosive gas	- Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
Reaction	Thermal runaway in battery	- Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
EMF	Exposure to EMF	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Injury to onsite employees	EMF created from the BESS will not exceed the ICNIRP reference level for exposure to the general public. No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Extremely unlikely	Negligible
External factors	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Extremely unlikely	Negligible

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
External factors	Vandalism due to unauthorised personnel access and deliberate damage to Project infrastructure	Asset damage and potential hazard to unauthorised person (e.g. electrocution)	Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs onsite. For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Major	Very unlikely	Medium
	Blade throw	- Damage to BESS infrastructure and/or fire - Injury and/or fatality to on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
	Turbine collapse	- Damage to BESS infrastructure and/or fire - Injury and/or fatality to on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible
	Lightning strike	- Fire - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Very unlikely	Negligible

8. RISK ASSESSMENT

8.1. Assessment against study risk acceptance criteria

Using the study risk matrix, Ref [2], the identified hazardous events were qualitatively risk profiled. Of the 16 events identified, all were rated as 'Negligible' risks except for one 'Medium' risk event. This event is related to unauthorised person access to the development footprint, resulting in vandalism/asset damage to the infrastructure with the potential for self-injury during the act. This study noted that the controls for this event are well understood and will be implemented accordingly. In addition to the rural location of the site, the Project infrastructure will be located within a secure area with fencing and cameras, and warning signs will be provided. Mitigation measures would also include onsite security protocol and presence of staff. In combination, these prevention and mitigation measures are expected to significantly reduce the likelihood of this event. The likelihood rating for this event was rated as 'Very unlikely'.

All identified events are not expected to have significant off-site impacts. Based on the study risk acceptance criteria, the risk profile for the Project is considered to be tolerable.

8.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 8.1.

Table 8.1: Assessment against HIPAP qualitative risk criteria

HIPAP No. 4 qualitative criteria	Remarks	Complies?
All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	The PHA has identified hazardous events and assessed the risks associated with the proposed operations of the Project. The Project location is suited for the proposed operation, situated within the CWO REZ, in a rural area with considerable separation distance to sensitive receptors to avoid off-site risks. It is not possible to eliminate batteries from a BESS development. Selection of the battery technology is a balance of cost and availability with the most commonly used versions being lithium ion.	Yes
The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.	Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events are not expected to have significant off-site impacts.	Yes
The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	Events with high probability of occurrence are expected to be contained within the boundaries of the installation. Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events (e.g. fire and explosion) are not expected to have significant off-site impacts.	Yes
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	There are no hazardous developments (in the context of the Resilience and Hazards SEPP) in the vicinity of the Project site.	Yes

8.3. Conclusion and recommendations

This PHA identifies the hazards and assesses the risks associated with the proposed operations of the Project at the planning stage of the DA to determine risk acceptability from land use safety planning perspective.

This PHA follows the methodology specified in HIPAP No. 6 *Hazard Analysis* and the *Multi-Level Risk Assessment* guidelines for assessment against the HIPAP No. 4 criteria. A Level 1 PHA (qualitative) has been completed for the Project.

This PHA concludes that:

- For all identified events associated with the proposed operation of the Project, the resulting consequences are not expected to have significant off-site impacts.
- The Project meets the HIPAP No.4 qualitative risk criteria.

The following recommendations were identified:

1. ACEN to locate the BESS compound outside of the blade throw impact zone based on the opted design case. The BESS location within Girragulang Substation and O&M area will be finalised during detailed design. The separation distance from the Girragulang Substation and O&M area boundary to the nearest WTG (GR26) is approximately 236 m.

   Note: The maximum potential throw distances for the turbines are expected to be in the order of 200 m for an entire blade and 580 m for a blade fragment under normal operating conditions at the nominal rated rotor speed, and 250 m for an entire blade and 930 m for a blade fragment at the maximum rated rotor speed, Ref [4].

2. ACEN to review the investigation reports on the Victorian Big Battery (VBB) Fire (occurred on 31 July 2021) and confirm with the BESS supplier that the BESS systems have been designed and/or improved to address the lessons learnt from the VBB fire incident. Additionally, ACEN to ensure that the BESS supplier's requirements on equipment clearances, installation, commissioning, operations and maintenance, and emergency response are met. The publicly available investigation reports include:
   - Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery, Ref [13].
   - Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire, Ref [14].

3. ACEN to consult with Fire and Rescue NSW (FRNSW) to ensure that the relevant aspects of fire protection measures have been included in the design. These may include: (i) type of firefighting or control medium (ii) demand, storage and containment measures for the medium. The above aspects will form an input to the Fire Safety Study which may be required as part of the development consent conditions, for review and approval by FRNSW.

9. REFERENCES

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[3] Cool Burn Pty Ltd, "Valley of the Winds Wind Farm Bushfire Risk Assessment, version 1.2," February 2022.

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